Agroforestry and Shifting Cultivation in Liberia:

Livelihood Impacts, Carbon Tradeoffs, and Socio-political Obstacles

By Lisa Fouladbash

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Faculty advisor(s):

Professor William Currie
Professor Rebecca Hardin

Abstract

In Liberia emphases have been placed on reducing deforestation and increasing food security through improved agricultural practices. One proposed strategy is the transition of smallholder farmers from shifting cultivation to tree cropping and agroforestry systems. A structured survey instrument was administered to 80 households in Bong and Lofa counties, Liberia to assess the cultural and socio-political feasibility of increasing tree cropping and agroforestry among smallholder farmers. The survey investigated current household use, perceptions and impediments towards tree cropping and agroforestry, and impacts of these practices on income diversification and food security. Income was the driving motivation for households to engage in tree cropping, and insecure land tenure was the most significant impediment. Household demographics also had an effect, as tree-cropping households were predominantly male-headed, with an average of 2 more youth members than non-tree cropping households (0-20 years). Agroforestry was practiced by one-third of the sample, and had positive effects on income diversification and food security. Agroforestry did not replace shifting cultivation as a livelihood practice. Chapter 1 reveals the importance of addressing socio-political factors, including cultural perceptions, land tenure, gender, and household demographics, when designing agroforestry programs.

In attempts to reduce deforestation, the Government of Liberia has proposed setting aside 30% of forests into protected areas where shifting cultivation would be prohibited. Chapter 2 describes use of a coupled human-natural systems model, created using STELLA dynamic systems modeling software (ISEE Systems, inc.), to quantify and compare carbon storage and food production tradeoffs that would occur under the designation of different proportions of the landscape into Protected Areas. Model results showed that designation of

land into Protected Areas would increase landscape carbon storage, but significantly decrease rice production, with livelihood implications.

Chapter 3 concludes with an analysis of the political ecology and historical context underlying agricultural underdevelopment and rural poverty in Liberia, beyond the dominant discourse of the "post-conflict" state. I argue that the current state of rural poverty was shaped by the interacting forces of colonization, foreign investment, and neoliberalism in Liberia. These forces have enabled foreign financial exploitation, the shift to an export based economy, and a resulting dependence on global markets, which have become among the most significant contributors to underdevelopment and rural poverty in Liberia. I argue that a continued reliance on market-based mechanisms will exacerbate rural poverty, through the continued commodification of Liberia's land, natural resources, and her people.

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Chapter 1: Agroforestry in Liberia: Household Practices, Perceptions and Livelihood Benefits

Lisa Fouladbash, William Currie[1]

Abstract

In Liberia emphases have been placed on reducing deforestation and increasing food security through improved agricultural practices. One proposed strategy is the transition of smallholder farmers from shifting cultivation to tree cropping and agroforestry systems. A structured survey instrument was administered to 80 households in Bong and Lofa counties, Liberia to assess the cultural and socio-political feasibility of increasing tree cropping and agroforestry among smallholder farmers. The survey investigated current household use, perceptions and impediments towards tree cropping and agroforestry, and impacts of these practices on income diversification and food security. Income was the driving motivation for households to engage in tree cropping, and insecure land tenure was the most significant impediment. Household demographics also had an effect, as tree-cropping households were predominantly male-headed, with an average of 2 more youth members than non-tree cropping households (0-20 years). Agroforestry was practiced by one-third of the sample, and had positive effects on income diversification and food security. This study reveals the importance of addressing socio-political factors, including cultural perceptions, land tenure, gender, and household demographics, when designing agroforestry programs.

[1] This piece is currently in review for Agroforestry Systems

Keywords: agroforestry, food security, income diversification, Liberia, shifting cultivation

Abbreviations:

ACDI-VOCA – Agricultural Cooperative Development International and Volunteers in Overseas Cooperative Assistance
CIA – Central Intelligence Agency
FDA – Forest Development Authority
GDP – Gross Domestic Product
ICRAF – World Agroforestry Centre
IMF – International Monetary Fund
MOA – Ministry of Agriculture
MoFA – Ministry of Foreign Affairs
NGO – Non-Governmental Organization
Non-TCH – non-tree-cropping households
TCH – Tree-cropping households
TRC– Truth and Reconciliation Commission
UNDP – United Nations Development Programme
USDA – United States Department of Agriculture

1. Introduction

After 14 years of civil conflicts, Liberia is ranked as the 13th lowest country in terms of human development by the United Nations Development Program (UNDP 2012), with 60% of her people subject to poverty and 40% highly vulnerable to food insecurity (UNDP 2012). As the government of Liberia seeks to reduce rural poverty, they have placed emphases on the improvement of smallholder agriculture and the

conservation of tropical rainforest, which are viewed as pivotal aspects to national recovery (IMF 2012; MOA 2007). Agroforestry systems are one proposed strategy towards accomplishing these goals, as they have been shown to improve food security (Sanchez et al 1997a), increase income diversification (Feintrenie et al. 2010), and potentially reduce deforestation and environmental degradation through increased land use efficiency (Cooper et al. 1996; Schroth et al. 2004: 9).

Not-for-profit extension programs are currently being employed to increase agroforestry practices in Liberia (ACDI-VOCA 2011). However, little if any data are available regarding the cultural or socio-political feasibility of tree cropping as related to household livelihoods and perceptions (Wilcox *unpublished manuscript*). To help inform these programs and policies, the present study was designed to assess 1) the current state of tree cropping and agroforestry practices by smallholder farmers in Liberia; 2) the socio-political impediments towards adoption of these practices, including household perceptions, demographics, gender, and land tenure; and 3) the relation of agricultural practices to livelihood impacts, including food security and income diversification.

Forty percent of Liberia's population currently relies on smallholder agriculture for their food and income (MOA 2007), which consists of both shifting cultivation and tree cropping practices. Shifting cultivation, or "slash and burn farming", has been used for at least 300 years in Liberia (Fairhead and Leach 1997). This practice consists of clearing and burning vegetation to prepare land, cultivating crops for one or more years, and then leaving the land fallow for several years before returning to repeat the process (Watters 1971). Leaving the land fallow allows natural reforestation of the land, while replenishing soil fertility. Despite its long term use, shifting cultivation is often viewed as

a cause of deforestation and a threat to biodiversity (Brady 1996; MOA 2007; UNDP 2006). According to an environmental study by the United Nations Development Program (UNDP 2006), Liberia has lost 50% of its tropical rainforests in recent years due to logging, mining, commercial agriculture, charcoal production and shifting cultivation. Though this statistic is contended (Fairhead and Leach 1997), shifting cultivation is a primary concern to the government of Liberia and international conservation NGOs, to whom rainforest conservation has become a top priority (World Bank 2010). Liberia holds the largest remaining tract (40%) of remaining West Guinean tropical rainforest, which are valued for their rich biodiversity and economic assets, as well as their carbon storage potential (FDA 2006, 2008; Fearnside 2000; World Bank 2010).

To help reduce deforestation and conserve national rainforest, the Government of Liberia has proposed the establishment of protected areas where shifting cultivation would be prohibited (World Bank 2010). Removal of local people from these areas into surrounding lands would reduce their access to land for shifting cultivation and threaten their ability to produce food and harvest forest products (World Bank 2010). To compensate for these lost livelihoods, the national government, in cooperation with Liberian NGOs and the World Bank, has suggested that alternative livelihoods be developed to help transition farmers from shifting cultivation towards more permanent agricultural systems, including tree-cropping systems (MOA 2008; World Bank 2010). Specifically, a significant emphasis has been placed on increasing the smallholder production of cash crops produced by trees (herein referred to as “tree cash crops”) such as rubber, cocoa, and coffee (MOA 2008).

The cultivation of tree cash crops already occurs in Liberia at large-commercial, medium and small-holder scales, with the large-scale production of rubber and other export crops contributing 76% to Liberia's Gross Domestic Product (GDP) (CIA 2013). With these economic rewards, cash crops are seen as a potential source of livelihoods for smallholder farmers. At the commercial scale, cash crops are cultivated in monoculture plantations, which are shown to impair soil fertility, decrease biodiversity, and increase vulnerability to pest and disease outbreaks (Andow 1982; UNDP 2006). While commercial plantations may counteract these affects with fertilizers, herbicides and pesticides, smallholder farmers have limited access to affordable inputs. For these reasons, cash crop monocultures may leave smallholders vulnerable to crop failures and reduced yields. Furthermore, the reliance on a single cash crop can also increase household vulnerability to shocks, such as droughts, floods, and storms, and fluctuations in market prices.

Agroforestry, the integration of one or more tree crops into an agricultural ecosystem with herbaceous crops (ICRAF 2005), has the potential to offer greater ecological and social benefits to smallholders than monoculture tree-cropping (Altieri 1995, 1999; Lal 1991; Montagnini and Nair 2004; Schroth et al. 2004). In Liberia, agroforestry systems can potentially reduce deforestation from shifting cultivation by increasing land use efficiency and reducing the need of the farmer to clear new land as frequently (Sanchez et al 2001), which Schroth et al. (2004) denotes the "agroforestry-deforestation hypothesis". Agroforestry systems can also reduce land degradation (Cooper et al. 1996) through ecosystem services that include increased carbon storage, enhanced nutrient cycling, reduced erosion, and improvements in soil quality (Altieri

1995; Lal 1991; Montagnini and Nair 2004; Penot 2004). Additionally, agroforestry can improve food security through the replenishment of soil fertility, enhanced crop yields, and the provision of a wider variety of food and fuel products (Altieri 1995; Cardoso et al. 2001; Jamnadass et al 2013; Lal 1991; Oduol and Aluma 1990; Nath et al. 2005; Sanchez et al. 1997b). The provision of tree products can provide income diversification for households, protecting them against fluctuations in the market prices of any particular goods (Feintrenie et al. 2010). Agroforestry systems can be more self-regulating, requiring fewer inputs, less maintenance, and less labor than monoculture plantations (Altieri 1999; Feintrenie et al. 2010). As opposed to monoculture systems, the enhanced biodiversity and system complexity of agroforestry systems (Altieri 1999; Perfecto and Vandermeer 2008; Schroth et al 2004) may reduce their susceptibility to pest and disease outbreaks (Gurr et al. 2003; Thies and Tscharntke 1999), leaving households less vulnerable to such disturbances. Agroforestry systems may also support livestock through the provision of fodder in the form of fallen leaves, branches, and weeds, at little or no extra cost to households (Tajuddin 1986).

In Liberia, agroforestry may have the potential to improve household food security, supplement incomes, and provide more ecological benefits than monoculture tree cropping. Despite current efforts by NGOs to increase agroforestry practices, however, their widespread adoption remains hindered by cultural and socio-political factors, including the insecure state of land tenure (MOA 2007; World Bank 2010). Households without land tenure are hesitant to plant trees, as they can make the land more attractive and increase the risk of others claiming the land as their own (MOA 2007). Tree cropping systems also require a higher initial investment (Cardoso et al.

2001) and take several years before becoming productive (Rodrigo 2005), which can deter households.

There is a paucity of data regarding the current state of tree cropping and agroforestry practices by smallholders in Bong and Lofa counties, Liberia, and how these are informed by cultural and social factors, including household perceptions, demographics, and gender. The lack of available data is at least partially due to the 14 years of Liberian civil wars that occurred between 1989 and 2003, when research in-country would have been challenging and dangerous. The result is that in-country agroforestry programs seem to lack a strong basis in site-specific data about local practices and perceptions, which are critical to designing effective agroforestry programs as they can provide insights about the motivations for, and impediments against, adoption of these systems (Scherr 1991, Belsky 1993). This study hopes to inform policy makers and not-for-profits about the current state of agroforestry practices by smallholder farmers in Liberia.

2. Materials and Methods

2.1 Study site

Liberia is located in the tropical rainforest belt of West Africa. The study site included Bong and southern Lofa counties with the range in Lofa extending as far north as the village of Zorzor (N07°45.325' W009°23.761'), as far west as Palala (N07°05.00.121' W009°17.277') and as far southeast as Gboquelema (N06°50.396' W009°50.616'). Bong and S. Lofa counties were chosen for their high level of tree crop production (MOA 2007) and their accessibility during the study. Bong County is slightly

more developed than Lofa County, which is covered by denser regions of rainforest (MOA 2007). Inclusion of both counties was meant to provide some variability in terms of the villages' level of development and proximity to dense tropical rainforest. This region receives between 2000-3000 mm of rain annually, with the rainy season extending between June and October and the dry season from November to February (MOA 2007). The study was conducted during Liberia's rainy season when many roads were not traversable, and surveys were limited to accessible villages.

We developed the survey instrument with consultation from the Social Research Institute and received approval from the Institutional Review Board IRB at the University of Michigan. Consultations were conducted in-country with international not-for-profits (ACDI-VOCA's LIFE and PROSPER programs) for information about current agroforestry programs. The survey was refined after consultation with Liberian agriculture students at Cuttington University, Gbarnga, Liberia, to assure it was culturally appropriate and translatable. Students were trained to help administer and translate the survey, which was given orally in Liberian English or Kpelle. The instrument was pilot-tested villages near Cuttington Campus, in Gbarnga, Liberia. The tested and refined survey instrument was then administered to households in 30 villages that were randomly selected along four major roads in the study site, stretching north, south, east and west from Gbarnga, and some feeder roads that were accessible. Upon entering each village, the Chief was first consulted for permission, and 2-4 households were selected based on the size of the community. Respondents were selected based on their visible presence at the time of surveying and their involvement in upland agriculture. A total of 80 households were surveyed overall (60 in Bong County, 20 in Lofa County).

2.2 Survey Design

The survey instrument was designed to investigate the cultural, socio-economic and demographic differences between households in relation to their use of tree cropping and/or agroforestry practices (see Table 1 for definition of groups). To facilitate these comparisons, respondents were relegated into two groups based on their responses: tree-cropping households ("TCH" group) and households that did not engage in tree cropping ("non-TCH" group) (Table 1a). The TCH group was further subdivided based on whether the household cultivated trees using agroforestry practices (the "agroforestry group") or in monoculture (the "monoculture group") (see Table 1b for definitions). Group-wise comparisons were made between TCH and non-TCH groups and between agroforestry and monoculture groups where appropriate.

The survey was comprehensive, including both ecological and social topics. Ecological topics included: the type of agriculture practiced (shifting cultivation and tree cropping), with descriptions of the practice (eg. length of fallow, cultivation time, type of vegetation cleared, types of crops planted), and use of agroforestry practices (whether tree crops were cultivated in monoculture or intercropped). The survey followed a structured format, consisting primarily of closed questions, though open questions were used to help determine whether the household used agroforestry practices (eg, are the tree crops planted separately? Do you cultivate food crops beneath the tree crops?).

Table 1a: Definitions of groups that survey respondents were relegated to based on their farming practices. Group-wise comparisons of survey results were made between tree-cropping (TCH) and non-tree-cropping households (non-TCH groups), and between Agroforestry and Monoculture groups, to assess effects of agricultural practices on socio-economic factors.

Group Labels	Definition
TCH	*Tree-Cropping Households*, or those which cultivate trees for food and/or cash crops. Note: This does not include forest products harvested from trees.
Non-TCH	*Non-Tree-Cropping Households*, or those which do not cultivate any trees
Agroforestry	Of tree-cropping households (TCH), those which cultivate trees using agroforestry practices
Monoculture	Of non-tree-cropping households, those which cultivate trees in monoculture

Table 1b: Definitions of terms commonly used in the study. †Note: though fruit from trees may be sold, they are not considered cash crops in this study; cash crops only refer to tree crops sold for export. †Bananas/plantains are not considered trees in this study, despite their tree-like form, due to their herbaceous nature. †Food crops may also be sold, but are considered food crops in this study, as they are mainly produced for consumption.

Terms	Definitions
Tree crops	Products cultivated from trees, including fruit and/or cash crops†
Cash crops	Herein refers to commodity products cultivated from trees, and includes rubber, cocoa, coffee.
Food Crops	Herbaceous crops cultivated by the household for consumption†. Includes rice, bitterball, cassava, banana†, and other vegetables.
Forest Products	Products that are harvested from trees in nearby forests, which are not necessarily cultivated by the households. Includes timber and fuelwood.
Agroforestry	The integration (or "intercropping") of one or more species of trees into the agroecological system, social and ecological benefits
Monoculture	The cultivation of only one trees species, separate from other species, on a plot of land

Households reported two main types of agroforestry practices, spatial and temporal. Spatial agroforestry, otherwise known as simultaneous agroforestry, is used here in reference to the physical intercropping of different tree crops, or annual crops with tree crops, together on the same land. Temporal agroforestry refers here to the intercropping or rotating of crops at different times, on the same land. In this study, temporal agroforestry specifically refers to the practice of cultivating food crops between young trees before they become productive (eg. rice between young rubber).

Social topics covered in the instrument included household perceptions, demographics, land tenure, gender, food security and income diversification, and used a combination of closed questions and activities. Household demographics were measured with questions about gender of the household head, household size (number of members), age distribution (number of members in three age groupings: youth =0-20 years, middle aged=20-50 years, elderly >50 years), and farm labor availability (the number of members in each age grouping that works on the farm). Respondents were questioned about land tenure, which was defined here as either ownership with a legal deed (statutory tenure), or customary ownership, which respondents referred to as "family land". Designations were not made between the two forms of tenure, due to the sensitive nature of tenure issues, the difficulty of confirming legal tenure, and the lack of a formal land tenure registry in Liberia (MOA 2007). Lack of ownership was defined by either renting, squatting or borrowing.

Due to the sensitive nature regarding income, as well as the lack of higher education and formal accounting of farm income by most households, an activity was developed to measure income diversification. Four sets of pictures were printed on a sheet, which represented categories of products the household could sell for income: forest products

(charcoal and timber), tree crops (rubber, cocoa, coffee, and tree fruits), food crops (rice, corn, cucumbers, bitterball, etc.) and livestock (chickens, goats, pigs, and sheep) (Table 1b). Each respondent was provided 10 pieces of corn to represent the household's total farm income during the rainy season, and asked to divide the corn accordingly between the categories to provide a sense of the different relative proportions of income received by the household from the different product groups. The activity was repeated for both wet and dry seasons, to assess seasonal differences.

Food security was measured through three simplified metrics: 1) the average number of meals consumed per day by adults and children in households; 2) the kinds of livestock owned by the household; and 3) Two questions adopted from the United States Department of Agriculture (USDA). These two USDA questions were as follows (Appendix):

Q1: How often do you have enough food to satisfy you?

Answers: a) Always enough food, and always the kinds of food I want, b) Always enough food, but not always the kinds of food I want, c) Sometimes not enough food, d) often not enough food.

Q2. How often do you cut portions because there is not enough food?

Answers: a) never, b) rarely, c) sometimes, d) often

For both questions, responses (a) and (b) were designated as food secure, and questions (c) and (d) were food insecure. It became apparent during the study that most respondents did not understand Q2, due to confusion during translation from English to Liberian-English or Kpelle. For this reason, results from the second question were discarded. Our measures of food security were constrained to these few metrics due to the time restrictions of the study, and are not intended to be exhaustive.

2.3 Survey Statistics

Statistical tests were applied to assess group-wise differences in survey responses as they related to household agricultural practices. Specifically, survey responses were compared between TCH and non-TCH groups and between Agroforestry and Monoculture groups where appropriate. Numerical responses were compared using either independent samples t-tests, or the non-parametric substitute where data was not normally distributed (Wilcoxon two-sample test), which was often the case. Chi-squared tests of independence were used to assess group-wise differences for categorical questions, such as relating to gender and land tenure. When sample sizes were too small to use chi-squared tests, a Fisher's Exact test was used in its place. Repeated measures linear mixed-effects models (ANOVA) were applied to income diversification data, as measured by the activity described above. These models compared differences in the proportion of household income earned from tree crops, food crops and livestock. Forest product income was not tested with this approach, due to the high proportion of 0 data which resulted in a non-normal distribution. Income from forest products was instead treated as a categorical binary variable (either the household sold, or didn't sell, forest products) and compared using a mixed effects logistic model. For all tests, an alpha value of 0.05 was used to determine significance.

3. Results

3.1 Tree cropping

Across the 80 households surveyed, there was no overall difference in use of shifting cultivation between tree-cropping households and non-tree-cropping households. Shifting cultivation was practiced by 87.5% of respondents, with an average fallow of 6.8 years (SD=

2.1). The vast majority (85%) of survey respondents using shifting cultivation farmed on the land for only 1 year before leaving it to fallow, whereas 15% planted for 2-4 years consecutively before leaving the land to fallow. The few households that planted consecutively on the same land for more than one year tended to engage in conservation farming, which involves tilling weeds into the soil between planting seasons, to act as a green manure. Both groups cleared mainly secondary forest (54%) as compared to primary forests (39%) or other land types, although this difference was not statistically significant.

Almost two-thirds of our sample cultivated tree crops, with income as the driving motivation. Of the tree-cropping households, 44% cultivated tree cash crops, 43% cultivated fruit/nut trees and 21% cultivated both kinds (Table 2). Thirty-nine percent of households did not cultivate any tree crops. TCH respondents listed income as the dominant motivation for cultivating tree crops (77% of TCH), followed by provision of fruit (11% of TCH). Respondents mentioned additional benefits, including long term production, land protection, wind blocking, wood for charcoal production, and tree products as gifts. The majority of TCH respondents reported learning to cultivate trees from their relatives (40%) or from watching others (38%). Other TCH respondents reported learning tree-cultivation practices from school, industry (Firestone Rubber Company), and other organizations. Households reported learning rubber tree cultivation mainly from friends, relatives, and watching others (75%).

TCH respondents reported having secure land tenure more frequently than non-TCH respondents (Table 3). Additionally, insecure land tenure was reported by 45% of non-TCH respondents as the largest impediment to tree cultivation (Table 2). Respondents also listed

lack of knowledge about tree cropping (23% of non-TCH), insufficient money (14%), and that burning the land would harm trees, as additional impediments to tree cropping.

3.2 Agroforestry

Of the tree-cropping households surveyed, 47% reported using either spatial (22%) or temporal (23%) agroforestry practices (Table 2). Spatial intercropping was more common amongst fruit trees than with cash crop trees, and included the intercropping of different fruit trees (eg. orange and kola), and the intercropping of food crops between fruit trees (eg. rice or corn under palm) (Table 2). Tree cash crops were occasionally spatially intercropped (eg. cocoa and coffee, cocoa and palm, coffee and kola), but were planted in spatially separate areas the majority of the time (Table 2). Rubber was the most popular tree cash crop overall (32% of TCH). Mature plantations of rubber were always monoculture, though temporal intercropping of rice between young rubber trees was fairly common (46% of rubber tree owners) (Table 2).

Table 2: Household survey results for agroforestry use and intercropping combinations with different kinds of tree crops. Table 2 shows the number of surveyed households in each category that cultivated tree types listed in column headings. TCH refers to all tree-cropping households, including both households which use agroforestry and those which don't. Temporal agroforestry denotes planting food crops between young trees, while spatial agroforestry denotes planting trees and non-tree crops in a spatially heterogeneous system. Number of spatial and temporal agroforestry-practicing households sum to total agroforestry households. Mature rubber trees are never spatially intercropped and fruit trees are rarely temporally intercropped.

Category	Tree Crops	**Cash Crops**	Rubber	Coffee	Cocoa	**Fruit Trees**	Palm	Orange	Kola	Mango
TCH (Total)	49	**35**	26	26	12	**34**	18	16	15	9
Agroforestry	23	19	12	4	5	10	4	5	3	3
	Spatial Agroforestry	6	0	4	4	9	3	5	3	3
	Combinations		None	kola (1), cocoa (2), rice(1)	coffee(2), palm(1), rice(1)		cocoa (1), rice & corn(1) , pineapple(1)	kola (1), w/ fruit trees(3), banana (1)	coffee (1), orange(1), mango(1)	kola (1), cocoa & coffee (1), fruit (2)
	Temporal Agroforestry	13	12	0	1	1	1	0	0	0
	Combinations		rice (10), bitterball(1), cassava (1)	none	pepper (1)		rice (1)	none	none	none

When respondents were questioned about why they cultivate trees in monoculture, the majority said that intercropping would harm crop production. Specifically, respondents didn't intercrop herbaceous food crops under trees because they believed: (1) shade from the trees would harm herbaceous crop production (71% of monoculture group); (2) they would not grow well together (25%); (3) intercropping would attract pests (6%); and (4) burning the litter and surface soil (a common means of preparation for cultivation of herbaceous crops) would hurt the trees (4%). The most prevalent reason respondents gave for not intercropping different tree crops was the belief that they would not grow well together, due to competition for nutrients (65%), shading (19%) or root competition (6%).

3.3 Demographics

Household demographics, including gender, land tenure, and age distribution, differed between tree-cropping and non-tree-cropping households. TCH households were mostly headed by males (65%), while non-TCH were predominantly female headed (68%) (Table 3). We hypothesized that males might engage in tree cropping more frequently than females because they have greater access to land tenure. The survey results did not support this hypothesis, however, as male and female heads reported equal rates of land ownership. There did seem to be gender-based differences in the types of tree cultivated, with fruit tree cultivation more common among male-headed households than female-headed households (Figure 1).

Age distribution differed based on the household's use of tree cropping; tree-cropping households reported having two additional youth per household relative to non-non-tree-

cropping households (Table 3). The presence of additional youth in tree-cropping households was thought to be due to additional labor requirements of tree cultivation. Our results did not seem to support this hypothesis, however, as both groups reported having the same number of youth working on the farm.

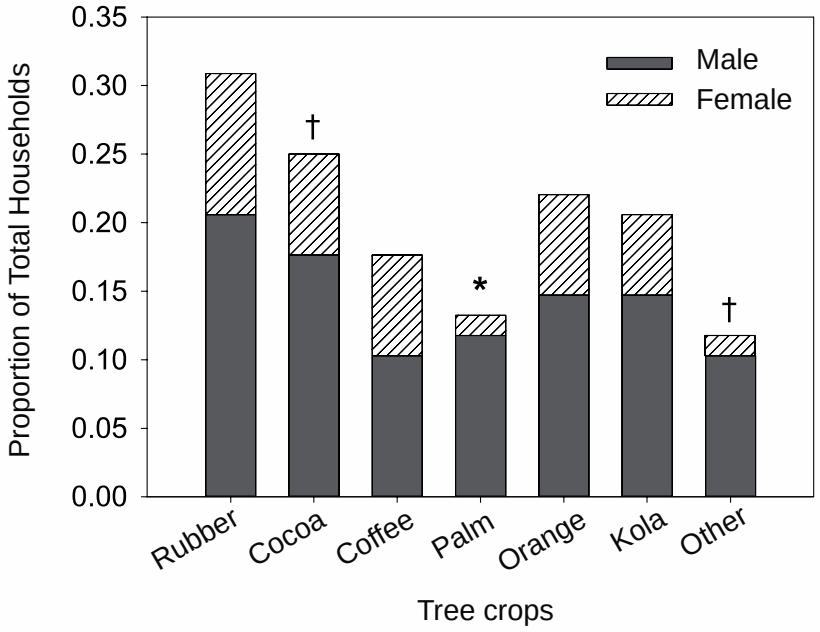

Figure 1: Types of tree crops cultivated as they differ between male and female-headed households. Overall, male-headed households cultivate more fruit trees than female ones. Specifically, male heads cultivate more cocoa, palm, and other fruit trees not displayed. *denotes significant differences in type of tree crop based on gender, at p<0.05. † denotes partial significance at p<0.1.

Table 3: Demographics of households with different agricultural practices, as found from household survey results. Tree cropping households (TCH) tend to own land, be headed by males, and have on average two additional youth per household than non-TCH. (N= the number of households in each group at left; values on the left side of table are proportions of households in each group, values on right are the mean number of household members in each group, with standard error reported in parentheses). *denotes significance at p<0.05.

Group		Land Tenure		Gender of Head		Household Age Distribution			
	N	*Own*	*Doesn't own*	*Male*	*Female*	*Total (members)*	*Youth (0-20 yrs)*	*Middle (20-50 yrs)*	*Elder (> 50 yrs)*
Tree cropping (TCH)	49	0.94*	0.06*	0.65*	0.35*	11.5 (0.9)	6.2 (0.5)*	4.0 (0.1)	1.2 (0.2)
Non-tree cropping (non-TCH)	31	0.61*	0.39*	0.32*	0.68*	9.5 (1.7)	4.5 (0.4)*	3.7 (0.1)	1.3 (0.3)
Agroforestry	23	1	0	0.55	0.45	11.7 (1.4)	6.3 (0.8)	3.8 (0.6)	1.6 (0.3)
Monoculture	26	0.88	0.12	0.74	0.26	11.2(1.1)	6.1 (0.7)	4.2 (0.5)	1 (0.2)
All households	*80*	0.81	0.19	0.53	0.47	10.7(0.6)	5.5 (0.4)	3.9 (0.1)	1.2 (0.1)

3.4 Food Security and Income Diversification

As survey results showed, households which practiced agroforestry seemed to be more food secure than the households that cultivated trees in monoculture (Table 4). Households that used agroforestry practices consumed more meals per day than those which used monoculture practices (Table 4). Specifically, twenty-two percent of the Agroforestry group consumed 3 meals per adult per day, as compared to only 2% of the Monoculture group (Table 4). Additionally, a higher proportion of Agroforestry households reported that always had enough food (70% of Agroforestry group) as compared to Monoculture households (31% of Monoculture group), in response to USDA Q1(Table 4).

Our survey did not reveal any strong differences in food security between households that cultivated trees, and those which didn't (Table 4). In response to the USDA Q1, half of both groups answered that they sometimes or often did not have enough food (Table 4). Additionally, both TCH and non-TCH groups consumed the same number of meals per adult per day (Table 4). While tree-cropping did not seem to directly improve food security in this study, having trees did seem to support a household's ability to own livestock. A higher proportion of TCH seemed to own pigs as compared to non-TCH households, though this result was not quite significant (p-value = 0.077). The majority of TCH households with livestock (58%) reported allowing their livestock graze under trees.

Though tree-cropping did not directly influence food security in this study, it did seem to influence income diversification. Overall, households spent 50% of their total expenditures for food purchases and received 78% of their income from farm products, independent of whether they cultivated trees.

Table 4: In household survey results, food security metrics of households with different agricultural practices (N = number of households in each group at left; other numbers refer to proportions of households in each Group that fall in each column, see Table 1 for group definitions). *Among tree-cropping households (TCH), those using agroforestry consumed more meals per adult per day and had enough food more often (United States Department of Agriculture [USDA] question 1, "How often do you have enough food?").

Group	N	Meals per day (per adult)			Food Security Q1 (USDA)		Hooved Livestock		Sells Forest Products	
		One	*Two*	*Three*	*Always enough*	*Not enough*	*Goats*	*Pigs*	*Wood*	*Charcoal*
Tree cropping (TCH)	49	0.55	0.35	0.10	0.52	0.48	0.29	0.12	0.29	0.47
Non-tree cropping (non-TCH)	31	0.52	0.45	0.03	0.49	0.51	0.23	0	0.10	0.45
Agroforestry	23	0.52	0.26*	0.22*	0.70*	0.30*	0.35	0.13	0.26	0.35
Monoculture	26	0.58	0.42*	0*	0.31*	0.69*	0.23	0.12	0.31	0.58
All households	80	0.54	0.38	0.08	0.50	0.50	0.26	0.08	0.21	0.46

The sources of income differed between groups however, as TCH households received 17% less of their income from herbaceous food crops and 21% more of their income from tree crops, as compared to non-TCH households (Figure 2). A higher proportion of TCH households sold wood (29%) than the non-TCH households (12%) though this was not quite significant (Table 4).This difference was not reflected in forest product income, however, as both groups seems to receive the same proportion of income from forest products (Table 4; Figure 2). This proportion is captured as a group average, however, and the highly skewed nature of the data on forest product income likely affected this result.

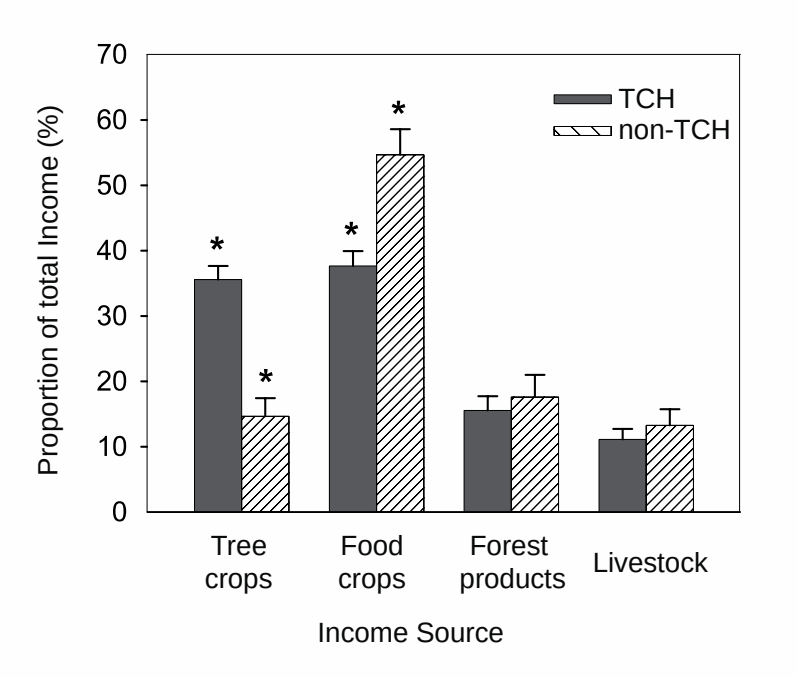

Fig 2: Income diversification as it differs between tree-cropping (TCH) and non-tree-cropping households (non-TCH), with the proportion of household income earned from four income sources (tree crops, food crops, forest products, and livestock). * denotes significant differences ($p<0.05$) between TCH and non-TCH groups, in income earned from tree crops and food crops.

4. Discussion

4.1 Impediments to Tree-Cropping

Insecure land tenure was the largest impediment to tree cropping in this region, which is consistent with an agricultural assessment conducted by the Ministry of Agriculture (MOA 2007). In our study, households that engaged in tree cropping almost always owned their land under either customary ("family land") or statutory (legal) land tenure, the two forms of ownership that make up the dual tenure system in Liberia (Alden Wiley 2007). As our finding emphasizes, households require land tenure before they will engage in tree cultivation. This is consistent with the findings in an agricultural assessment conducted by the Liberian government, which states that households that rent, borrow or lease the land are hesitant to engage in the long term practice of tree cropping for fear that the owner will seize the land after the trees become productive (MOA 2007). Land tenure requires attention before the adoption of tree cropping practices can increase (Alden Wiley 2007; TRC 2008; MOA 2007).

Our results showed that male-headed households were more likely to cultivate trees than female-headed households, which is consistent with the findings of an assessment by the Ministry of Agriculture (MOA 2007). There are several possible reasons for these gender-based differences in tree cultivation. Women in Liberia generally have reduced access to land tenure, which is an important asset for tree cultivation (Unruh 2009). Though our study did not find gender-based differences in land tenure, it is possible that insecure land tenure may be having a hidden or residual effect. An inheritance law was passed only within the past decade (MoFA 2003), allowing women legal rights over land inherited under customary tenure (Unruh 2003). Despite these policy changes, there is still resistance among rural men

against allowing women full ownership under customary tenure (Unruh 2003). For these reasons, women may not feel secure enough over their land rights to invest in trees. Additionally, this policy change may be too recent to allow sufficient time for widespread adoption of tree cropping practices by women.

There are other possible reasons why households headed by females are less likely to cultivate trees. Women in Liberia are subject to marginalization and exclusion, which may limit their access to the knowledge, materials or markets necessary for tree crop cultivation (MOA 2007; Kiptot and Franzel 2011). Gender-based differences in labor roles and availability may also affect the ability of female-headed households to engage in tree-cropping (MOA 2007). A report by Kiptot and Franzel (2011) showed that, though women generally do the majority of agricultural work in sub-Saharan Africa, they are often ignored by policy makers and extension officers, who tend to target men. As a result, women are often excluded from technological change in the agricultural sector (Kiptot and Franzel 2011). Women may also be discouraged from tree cropping due to cultural taboos, such as the case in Kenya where women are believed to fall barren if they plant trees (Chavangi 1994). Such gender inequalities in technology and access to resources can contribute to decreased agricultural production and poverty (Kiptot and Franzel 2011). With current efforts to improve gender equality in Liberia (MOA 2007), further research should investigate the extent to which women are excluded from tree cropping and which cultural and socio-political factors are driving such gender-based dynamics.

There were also unexpected gender-based differences in the types of tree crops cultivated. While male-headed households were more likely to cultivate fruit trees, equal proportions of female and male-headed households cultivated cash crops. This is counter-

intuitive, as gender-based labor divisions in sub-Saharan Africa generally leave men responsible for cash crops and women responsible for the cultivation of subsistence products, such as fruit trees (Kiptot and Franzel 2011). While this general pattern is purported to be the case in Liberia (MOA 2007), our results suggest that women may currently be more engaged in cultivation of cash crops than is previously thought.

Household age distribution also differed between TCH and non-TCH households, with TCH households having an additional two youth (0-20 years) as compared to non-TCH households. The presence of additional youth in TCH households may be a product of the differential labor requirements involved in tree cultivation. Though tree cultivation generally requires less labor over the long term, it requires more labor in the initial phase (Cardoso et al. 2001), which may be facilitated by having additional youth in the household. Youth may also be better suited for climbing trees to harvest tree products. It is also possible that the supplementary income and/or tree fruits from tree crops may enable the household to support more members, and possibly the addition of non-resident youth, or youth from other households (Dewees and Saxena 1997). The income provided by tree crops may also reduce household need for additional income, potentially decreasing out-migration of youth from the households to conduct wage labor in the city or for Firestone Rubber Company.

4.2 Agroforestry vs. Shifting Cultivation

Contrary to the belief that agroforestry may replace shifting cultivation as a dominant livelihood strategy, our results show that nearly all households used shifting cultivation independent of whether or not they cultivated trees. This may be due to a cultural perception that food crops and tree crops should be planted on separate plots of land, as most households

believed that intercropping would lead to reduced yields. The act of separating food and tree crops may also be due to the cultural norm of burning the land before cultivation, as some households stated that "burning would harm the trees". This still leaves the question of whether agroforestry could reduce the amount of land under shifting cultivation if food crops were to be intercropped with tree crops, rather than cultivated separately. This would rely, however, on the household's access to secure land rights, without which the production of tree crops is too risky (MOA 2007). To consolidate food and tree crops on the same land would, furthermore, add the additional risk of losing food crops if the land were to be seized from the household.

We had hypothesized that use of agroforestry would indirectly affect shifting cultivation practices through increased land use efficiency, potentially reducing the area of new land needed by farmers under shifting cultivation, and enabling them to adopt longer fallow times for increased soil fertility. Our results did not support this hypothesis, as all households used the same length of fallow (6.8 years), independent of agricultural practices. Our study does reveal that households left land to fallow on average 2.2 years less than the 9 year fallow statistic provided by the Government of Liberia agricultural assessment (MOA 2007). This might be due to regional differences, as the 9 year fallow was given for Liberia as a whole. It is also possible that households are shortening their fallow. Further research is suggested, as shortened fallow can significantly impact carbon storage, soil fertility, and crop yields (Toky and Ramakrishnan 1981; Silva-Forsberg and Fearnside 1997) with negative implications for food security. Nearly all households only cultivated on the land for a single year before leaving the land to fallow, probably due to weed invasion or nutrient loss after the first year (de Ruow 1994). Interestingly, a few households which practiced conservation

farming, cultivated continuously on the same land for 2-4 years, probably due to an increase in soil organic matter and nutrients from the green compost (Hartwig and Ammon 2002; Sharma and Mittra 1988). This practice may enable households to clear new land less frequently, which could both reduce labor costs and decrease rates of deforestation (Shriar 2002). Whether this practice provides enough additional nutrients to support crop yields, and livelihoods, however, requires further analysis.

4.3 Agroforestry vs. Tree Monocultures

Households in our study used both spatial and temporal agroforestry practices, with spatial agroforestry practices more commonly employed among fruit trees than cash crop trees. This may be due to the more unstructured nature of planting fruit trees, which may be planted around the house, in nearby forests, or on field boundaries (Kiptot and Franzel 2012). Cash crop trees were rarely spatially intercropped, though there were few exceptions (eg. Cocoa and coffee, cocoa and kola, etc.), which may be a result of recent in-country extension programs based around improving cocoa diversification (ACDI-VOCA 2011).

Though households believed that rubber cannot be spatially intercropped, studies suggest that rubber intercropping may be feasible in this region. A report by the Sustainable Tree Crops Program (Wilcox *unpublished manuscript*) states that rubber intercropping with cocoa, coffee and oil palm occurs to a small degree in Nimba county, which borders our study region. This suggests that the prevalence of rubber monocultures among survey respondents may be more likely a result of social factors than ecological ones. Concurrently, studies show that rubber is successfully intercropped in other tropical countries with similar climates, such as Nigeria, Indonesia and Sri Lanka (Okafor and Fernandes 1987; Penot 2004; Leakey 1998)

with food crops such as bananas, and that intercropping can actually improve yields and provide additional ecological benefits (Rodrigo et al. 2005).

Considering the context of how rubber cultivation was introduced throughout Liberia, it seems likely that planting in monoculture may be more a result of the cash crop model- the idea that cash crops must be cultivated using intensive, monoculture practices in order to maximize profits- rather than the development of best practices. The cash crop model is the legacy of Firestone Rubber Company, which introduced rubber into Liberia in the early 1920s, and came to dominate the Liberian economy with its expansive monoculture plantations. Through training programs and the hiring of thousands of wage laborers, Firestone taught farmers to cultivate rubber in intensified monoculture plantations (Mclaughlin 1966). With a long history of the dominance of plantation cropping, farmers may have come to associate plantation cropping with profit maximization, which is often a primary motivation of smallholder farmers (Feintreni et al. 2001). Consistent with this idea, households in our study listed income generation as the primary reason for tree cropping.

It is also plausible that households cultivate rubber in monoculture because their knowledge about intercropping is minimal or non-existent. Agroforestry extension programs are not as prevalent in Bong and Lofa counties as they are in Nimba, where they are centrally located. Additionally, Most of the respondents in our study said they learned about rubber cultivation from watching others, which we term as “practice mimicry”. Without knowledge of alternative practices, practice mimicry may be facilitating the spread of plantation cropping across villages.

4.4 Livelihood Benefits of Agroforestry

Our results suggest that agroforestry may benefit livelihoods through provision of diversified sources of income, improved food security, and provision of wood and charcoal. We found that households which practiced agroforestry consumed more meals per day and were hungry less of the time. This may be due to additional income and/or food provided by tree products. Agroforestry systems also tend to require less labor over the long term than monocultures, due to their low-input requirements (Feintrenie et al. 2010), which may enable households more time for cooking and meal consumption.

Tree cropping led to increased income diversification as hypothesized, with tree cropping households relying less on income from food crops. The reduced reliance on income from food crops can free up food for household subsistence, with positive implications for food security. The additional sources of income from tree crops may help buffer households from unpredictable fluctuations in the market prices of goods (Feintrenie et al. 2010). Tree-cropping households in this study often received wood and charcoal from their trees, and were more likely to sell wood. This is especially likely for smallholder rubber cultivators, as rubber trees become unproductive after 25-35 years, and then provide a free source of wood for fuel or charcoal production (Koopmans and Koppejan 1997). The provision of wood for fuel from tree products may reduce the need to harvest these products from nearby forests, potentially decreasing deforestation and habitat loss (Nath et al. 2005).

4.5 Can Agroforestry be expanded?

Our findings suggest several potential routes to increase agroforestry among smallholder farmers, by expanding on pre-existing practices. For example, though mature rubber was

always planted in monoculture, a substantial portion of households intercropped rice with rubber when the trees were young and not yet productive. This practice, here denoted as "temporal agroforestry", enables households to utilize the space between young trees to produce food while rubber trees are unproductive, in the first 5-7 years (Rodrigo et al. 2005). A relatively simple technology, temporal agroforestry can benefit households through enhanced crop yields, additional food sources, and income diversification (Rodrigo et al. 2003, 2005). This practice is already used by farmers in Liberia, requires minimal change to pre-existing systems, and has been shown to have little or no negative effects (Rodrigo et al. 2005). Despite the benefits and minimal risk of temporal agroforestry, it was only practiced among half of rubber producers and almost never with fruit trees. Education about this temporal agroforestry would be a simple way to potentially support food security among households during the early years of tree cultivation.

The integration of banana crops into rubber –tree systems is another potential technology that may be feasible in this region. Households in our study always cultivated bananas and plantains separately from rubber trees. Studies show, however, that the temporal intercropping of banana and rubber can improve growth of rubber trees, reduce the length of the initial unproductive phase, and increase yields of both the rubber trees and banana crops (Rodrigo et al. 2005). There are similar positive results of intercropping rubber with sugarcane (Rodrigo et al. 2000), and banana and pineapple (Jessy et al. 1997), each of which may be feasible in Liberia. Another potential agroforestry technique is the incorporation of livestock into tree cropping systems in Liberia, as our study found that tree-cropping households often let livestock graze under their trees. Incorporating sheep within rubber plantations could help reduce weed competition, take advantage of free fodder from the trees,

and help fertilize the soils to increase tree production, while providing an additional source of food for the households (Tajuddin 1986).

4.6 Agroforestry: an "Alternative Livelihood Strategy"?

Though our results suggest that agroforestry may benefit food security, these findings must be considered within the broader socio-political context of food security in Liberia. Households in our study spent half of their expenditures on food purchases, which is consistent with Liberia's heavy reliance on food imports. Liberia's reliance on food imports is intimately tied to the extraction and export economics of natural resources such as rubber, iron ore, timber, diamonds, by foreign investors such as Firestone (Broudic 2008; Mayson and Sawyer 1979). The export economy has focused development efforts towards these centers of extraction and away from domestic agricultural production, hindering the development of rural transportation and market infrastructures (Broudic 2008; Tiepoh 2000; Mayson and Sawyer 1979). The result is a national reliance on food imports, which leaves households vulnerable to the unpredictable fluctuations of global market prices (Broudic 2008; Tiepoh 2000), and with less money to invest in education, household goods, and agriculture technologies.

The export economy has left smallholder farmers heavily disadvantaged by the high costs associated with transporting goods, import competition, and undeveloped markets, which impede the transition to permanent tree cropping systems (Broudic 2008; Tiepoh 2000; Mayson and Sawyer 1979; MOA 2007). In addition to these socio-economic barriers, smallholders may be deterred from tree cropping by its higher initial investment (Cardoso et

al. 2001) and the longer time required for trees to become productive (Rodrigo et al. 2005). For these reasons, tree cultivation may be risky investment for some smallholders.

Shifting cultivation may help households circumvent these risks, through its impermanent and flexible nature, and short term investment. It is likely that households will continue to use shifting cultivation until they achieve tenure security, knowledge and confidence about tree cropping and agroforestry, the resources to engage in these practices, and the means to transport and sell tree crops products on the market. Accordingly, our study found that households continued to use shifting cultivation, even after engaging in tree cultivation. For these reasons, we believe that agroforestry is unlikely to replace shifting cultivation as an alternative livelihood practice in Liberia in the near future. Instead, we pose the question: should efforts really be placed on transitioning people completely away from shifting cultivation systems? The motivation for such a transition is largely guided by the belief that shifting cultivation causes increased deforestation in Liberia. Yet, a national forest assessment by the Liberian Government states that there is insufficient data quantifying rates of deforestation from local land use practices, including shifting cultivation (World Bank 2010). Additionally, studies show that forest loss from agriculture was more severe in Liberia 300 years ago than it currently is today (Mayer 1951:25; Fairhead and Leach 1997), and that population loss from disease, warfare, and slavery have allowed forest regrowth during the 19th century (Voohoevre 1979). The belief that households clear mostly primary forest for may also be misguided, as Voohoevre (1979) shows that most of Liberia's forests have been altered at some point by human use. Accordingly, our study shows that households cleared mostly secondary forest, due to the large labor requirements associated with felling and transporting large trees. For these reasons, the claim that local people are to blame for

increased deforestation in Liberia deserves closer inspection and further research. Claims such these tend to place blame on local people for environmental degradation and can often be used by NGOs, governments and other actors to legitimize intervention in forest management issues (Fairhead and Leach 1997). Consequently, this claim is currently being used to justify the designation of protected areas in Liberia, and the displacement of rural people from these areas (World Bank 2010).

Though it may not feasibly *replace* shifting cultivation in the near future, our study reveals compelling evidence that adoption of agroforestry practices *alongside* traditional agriculture can potentially improve rural livelihoods. We argue that research foci should be placed, not on transitioning away from traditional systems, but on improving and incorporating agroforestry practices *into* existing systems to better support local livelihoods. We suggest several potential routes to accomplish this, such as the temporal intercropping of rice and vegetables under tree crops (mainly rubber), and potentially the intercropping of rubber and banana. Further participatory in-country research is needed to determine which agroforestry techniques and intercropping combinations will be most effective specific to Liberia, and have the greatest potential to improve livelihoods. Furthermore, stronger efforts are required from the Government of Liberia towards improving land tenure, developing markets, and transportation infrastructure, which continue to impede the adoption of tree cropping practices. Finally, current and future agroforestry programs should place more emphasis and research on cultural and social factors, including gender roles, household dynamics, and perceptions about intercropping, which, as our study reveals, impact the adoption of tree cropping and agroforestry practices by households in Liberia.

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Chapter 2: Modeling Carbon Dynamics in Shifting Cultivation and Protected Area Landscapes of Liberia

1. Introduction

With the progression of climate change, global emphases have been placed on mitigating carbon emissions and increasing carbon storage through avoided deforestation. Tropical rainforests in particular have attracted increased attention for their carbon storage capacity, with approximately 216 Pg C (10^{15} g) in aboveground biomass (Brown et al 1993), 1.6 Pg of which is lost from land use change and deforestation annually (Brown et al 1996). To incentivize reduced deforestation at the national level, tropical countries can elect to participate in the REDD+ program (Reducing Emissions from Deforestation and Degradation), which offers payments in the form of carbon credits for forest left standing.

In post-conflict Liberia, tropical rainforests have been recognized as a major asset to economic revitalization for their carbon potential. Recent initiation into the REDD+ program has made Liberian forests potentially saleable through carbon credits and Payments for Ecosystem Services. Liberia contains 40% of the remaining West Guinean rainforests, which has purportedly decreased by 50% in recent years due to illegal logging, commercial agriculture, charcoal production and shifting cultivation (UNDP 2006). Though contended (Fairhead and Leach 1997) and inconsistently measured (World Bank 2010), these purportedly high rates of deforestation are a concern to conservation agencies and the Government of Liberia, which have placed emphases on rainforest conservation.

Shifting cultivation, or "slash and burn farming", in particular has attracted concern for its perceived relation to deforestation. Shifting cultivation has been used in Liberia for at least 300 years (Fairhead and Leach 1997) and currently provides livelihoods for 40% of the population. Shifting cultivation is a traditional agricultural practice that involves clearing and burning vegetation to prepare land, cultivating for one or more years, and then abandoning the land to fallow for several years before returning. Burning the land helps farmers reduce high rates of weed invasion that occur in tropical ecosystems, while supplementing the poor tropical soils with a pulse of nutrients to facilitate short term crop production (De Rouw 1994, Giardina et al 2000, Nye and Greenland 1960). Leaving the land fallow allows the regrowth of forest biomass, to help regenerate the depleted soil carbon and nutrients (Watson et al 2000). If fallow times are sufficient to allow for regeneration of soil carbon and nutrients, shifting cultivation may be sustainable over the long term (Watson et al 2000). Land shortages may lead to decreased fallow length (Finegan and Nasi 2004), which can result soil carbon and nutrient depletion and reduced crop yields (Toky and Ramakrishnan 1981, Silva-Forsberg and Fearnside 1997)

Despite its widespread use in Liberia, and a paucity of data on its contribution to deforestation (World Bank 2010), shifting cultivation often receives disproportionate blame for tropical deforestation (Brady 1996; MOA 2007; UNDP 2006). In attempts to reduce deforestation, the Government of Liberia has proposed setting aside 30% of forests into protected areas where shifting cultivation would be prohibited (World Bank 2010). Protected areas would purportedly support rainforest conservation, habitat protection, and increased carbon storage, the latter of which would translate into direct economic benefits for the national government through carbon credits.

While the designation of land into protected areas will provide certain ecological and economic benefits, it will threaten the livelihoods of indigenous people displaced from these lands, who depend on forests for hunting, fishing, fuel wood, forest products, and land for shifting cultivation (World Bank 2010). The decision to designate protected areas is therefore really a decision between tradeoffs: should forests be protected for increased carbon storage and its concomitant economic benefits, with the adverse effect of displacing thousands from their livelihoods? Or should humans be allowed to use the forests for shifting cultivation, as they have for thousands of years, despite its perceived relation to deforestation?

This chapter, while in no way attempting to answer this complex question, provides a preliminary attempt toward quantifying the tradeoffs between carbon storage and livelihoods under different land use scenarios. The scenarios represent different ways of apportioning the forest landscape between land that is designated Protected Area, where agriculture is prohibited, and land used for shifting cultivation. A coupled human-natural systems model was created to quantify and compare carbon storage alongside human livelihood benefits, for each scenario. Food production on agricultural land is used as an indicator of human livelihoods. The present modeling exercise compares tradeoffs between carbon storage and food production that might occur under a REDD+ scenario. Total landscape area (100 ha) is kept consistent across scenarios. As more land becomes designated Protected Area across scenarios, the same area of land is kept is cultivated under shifting cultivation. To accomplish this, land is removed from fallow rotation, resulting in reduced fallow lengths. This subsequently impacts rice yields, which are proportional to length of fallow (details described below). The paper concludes with a broader contextualization of the results as they relate to the environmental justice implications of REDD+ in Liberia.

Scenario 1: 100% of the land is under shifting cultivation,
Fallow= 7 years, Rotation= 8 years

Scenario 2: 25% of the land is protected area (PA), 75% of land for shifting cultivation,
Fallow= 5 years, Rotation=6 years

Scenario 3: 50% of the land is protected area (PA), 50% of land for shifting cultivation
Fallow= 3 years, Rotation=4 years

Scenario 4: 75% of the land is protected area (PA), 25% is shifting cultivation
Fallow= 1 year, Rotation =5 years

2. Methods

2.1 Shifting Cultivation Carbon Model

A coupled human-natural systems model was created using STELLA dynamic systems modeling software (ISEE Systems, inc.), to simulate the carbon storage dynamics of the above scenarios. The model is informed by data on shifting cultivation processes collected from a smallholder survey administered to 80 farmers in Bong and Lofa counties, Liberia, in August 2012. Cultivation and fallow times are parameterized from survey data, and are 1 and 7 years respectively. The model simulates the loss of carbon that occurs from slash and burn agriculture, and the natural accumulation of carbon during regrowth after the field has been left to fallow.

The model runs in yearly time increments, using an interval function (TIME-(INT(TIME/Tsd2)*Tsd2) with a "time since disturbance" (Tsd2) converter that simulates the rotational effects of land clearing after fallow is complete (Tsd = elapsed cultivation time + fallow time at a particular spatial location since the most recent slash-and-burn event).

Cultivation and fallow time are converters feeding into Tsd2, and can be changed to simulate altering the length of fallow.

Stocks in the model represent carbon stocks in the forest ecosystem, and include Total Carbon, Aboveground Carbon (AGC), Belowground Carbon (BGC), Foliar Litter, Dead wood, Fuel wood, Surface Soil Organic Carbon (SOC), and Total Soil Organic Carbon. Inflows and outflows represent the natural changes to carbon stocks that occur through net primary production, decomposition and respiration, as well as the human-induced effects of wood harvesting and slash and burn events. Pulse functions are used in conjunction with outflows to simulate the sudden losses in carbon that occur with slash and burn events, and are set to occur at rotational increments based on the Tsd function.

2.2 Above Ground Carbon Dynamics

Total carbon increases through net primary production (NPP inflow), which is a graphical function based on time (the Tsd function). The graphical function is used to capture the changing rates of NPP as succession progresses, which rises exponentially in the first 7-10 years after establishment to around 9 tC/ha, then levels off, and decreases as the forest becomes mature. These NPP values are estimated from a study on carbon dynamics in shifting cultivation sites in tropical rainforests in Cameroon (Kotto-Same et al 1997). The NPP inflow is connected with the time since disturbance function, to re-set after slash and burn events.

Total carbon is allocated to the AGC and BGC stocks based on the 80%-20% ratio, respectively, which is generally used in studies of tropical biomass (Achard et al 2001, Gibbs et al 2007). The AGC stock represents the total aboveground carbon, and includes standing

carbon, leaf litter, and dead wood debris. AGC is set to initially hold 40 tC/ha before the first slash and burn event, which is typical of a mid-aged tropical secondary forest rainforest in West Africa. This is using the assumption that secondary forest is more likely to be cleared than old growth forest, which the survey data shows is true in this region. A tropical old-growth forest would generally hold up to 200 tC/ha or more in this region (Kotto-Same et al 1997, Palm et al 2001).

AGC loses carbon from ecological and social processes. Ecological outflows include annual litter loss ("litter fall") and tree mortality ("wood fall"). With foliar biomass a graphical function of AGC that increases from 1.7 to 4 ton C ha^{-1} yr^{-1} as AGC increases from 0 to 80 ton C ha^{-1} yr^{-1} (Greenland and Nye 1959). Litter fall was parameterized to shed 80% of foliar biomass annually. Wood fall, or the loss of standing woody carbon to tree mortality, is set using a graphical function that rises with succession of the forest from 0 to a maximum of 2 ton C ha^{-1} yr^{-1} (Chambers et al 2000). The carbon removed from "wood fall" flows into a "Dead Wood" stock, that is either removed through harvesting by humans ("Harvest" outflow) , decomposition ("Dead wood decomp" outflow) or burning ("burned" outflow). Annual harvesting of dead wood for fuel is conservatively set to 5%, but would vary based on the site and population density of nearby villages. Both foliar litter and dead wood return carbon to the atmosphere through respiration ("decomposition" outflows) and also transfer carbon to surface soil ("Surface SOC" stock) through humification processes. Decomposition of the dead wood is estimated to return 19% of the carbon produced from wood fall back to the atmosphere annually (Chambers et al 2000). Litter decomposition is modeled using the exponential decay function: $W_t = W_0 * e^{-kt}$, with the decomposition constant (k) set to 2.33 (Aerts 1997). Humification of dead wood and litter is a long process, and estimated to

contribute only 2- 2.47% of these carbon stocks to surface SOM annually (Nye and Greenland 1989).

In tropical ecosystems, the aboveground carbon stock is the most vulnerable during slash and burn events, with most of the carbon lost through the physical clearing and burning of vegetation. This model assumes that after vegetation is cleared, 34% of the wood is harvested for use by humans ("Slash harvest" outflow) (Ewel et al 2013). This is an estimate, and is likely to vary across sites depending on the size and age of the cleared trees, and the labor availability to remove the trees. Burning of the cleared vegetation ("slash burn" outflow) is estimated to remove 39% of AGC, and and leaching ("post-burn leaching" outflow) 6% of AGC (Ewel et al 2013). Thirty percent of AGC is left after burning, to account for trees that are two large to be felled and woody debris that are too large to completely burn. These outflows are set with the pulse function to occur after cultivation and fallow times are completed (Tsd) (eg. "slash burn" outflow= PULSE((0.39*Aboveground Carbon),0,Tsd). Carbon is removed from the "dead wood" and "foliar litter" stocks with slash and burn events using similar processes.

2.3 Belowground Carbon Dynamics

Belowground carbon is represented through belowground carbon in the form of living and dead roots (BGC) and soil organic carbon (SOC) stocks. This model only induces effects on soil organic carbon (top 60 cm), which tends to lose SOC during burning due to the volatilization of carbon, increased respiration rates, and post-burn erosion (Ewel et al 1981, Ramakrishnan and Toky 1981). Though studies on the amount of surface SOC vary in methodology and consistency, initial surface SOC is estimated to be 20 tC/ha in this model.

Surface SOC receives inflows from root death, humification of foliar litter (2.47%) (Greenland and Nye 1960) and dead wood decomposition. Surface SOC is lost to respiration ("Soil C Decomp" outflow, 3%), and from burning. There seems to be consensus that burning causes an immediate loss of soil carbon from surface layers (above 60 cm), ranging from 10-50%, but that total soil carbon remains relatively stable. In this model, a conservative estimate of 20% surface SOC loss from burning was used (Detwiler et al 1986, Murty et al 2002, Schlesinger 1984). Post-fire leaching of surface SOC was estimated to be 6% (Ewel et al 1981).

SOC at depth (below 60 cm) is not greatly affected by burning in tropical forests (Kotto-Same et al. 1997, Schroth et al 2002), and is kept at a stable 80 tC/ha. A converter alongside the model adds the carbon in the surface soil ("Surface SOC" stock) to the carbon in the deeper levels of soil ("SOC below 60 cm" stock, 80 tC/ha), to show the total SOC at any given point ("Total SOC" stock). There is considerable variation across studies on soil organic carbon dynamics in tropical forests, and the amount lost from slash and burn, due to differences across study sites and sampling methods (Vagen et al 2005). While this model attempts to quantify large-scale patterns in Total SOC dynamics, it is limited in its ability to provide accurate estimates of carbon amounts due to the absence of site-specific data on soil organic carbon in Liberia.

Carbon enters the BGC stock through root production (coarse and fine roots), an outflow that allocates 20% of Total Carbon to the BGC stock. BGC is set initially to 20 ton C/ha, representing living and dead roots residing in the soil from before the forest was cleared for agriculture, and accounting for 20% of the total AGC a mature forest in this region might have (100-200 tonC/ha) (Gibbs et al 2007). Eighty percent of the carbon that

enters the BGC stock annually is removed to the atmosphere through respiration of fine roots ("respiration" outflow, 80%) , 9% is retained in BGC as coarse root, and 11% leaves BGC through the death of fine roots ("root death"), which enters the Surface SOC stock (Giardina et al 2004).

2.4 Modeling Carbon: Landscape Scenarios

The model was used to estimate carbon values per hectare, in each of the four scenarios, which are applied across a 100 ha landscape, over a 50 year period. For each scenario, carbon stocks are quantified separately for land under shifting cultivation and protected area land, and then summed to provide landscape estimates. This is done to account for carbon differences that occur on shifting cultivation land when fallow times are changed across scenarios. Rice cultivation is assumed to contribute minimally to carbon, and is not considered in this study, which is one of the limitations of the model.

To quantify carbon on land used for shifting cultivation, the model is run with the rotation time (fallow time + cultivation time) specific to the scenario being used, and carbon is averaged in aboveground (AGC) and belowground (BGC) stocks across the 50 year period (Table 1). A single average is reported, as carbon tended to fluctuate in a consistent pattern between fallow rotations.

For protected areas land, the model applies an initial burn event to simulate the regrowth of forest on land that was once used for agriculture. The model is run for a 50 year period (with no rotations), allowing carbon to accumulate. Carbon stocks in protected areas are averaged over 5 10-year intervals, revealing the gradual increase in carbon over time and providing more accurate estimates of carbon averages. Carbon stocks are modeled per

hectare, and then multiplied by the area of land used for each land use type (shifting cultivation and protected area), to provide estimated landscape carbon for each scenario (Table 3).

2.5 Rice Production

Total production of rice (Zea mays) on the landscape was used as a human livelihood indicator. For the sake of simplicity, this model assumes that shifting cultivation is the only agricultural practice used, and that rice (the staple food) is the only crop cultivated. The model also assumes that no food production occurs on "protected area" land, though in reality illegal harvesting, hunting and agriculture are likely to provide some food to households.

Rice production was modeled in relation to the area of land cultivated and the length of fallow, with rice yields decreasing as fallow times were reduced. Only a portion of the total land under shifting cultivation is cultivated at any point in time, and the rest is at different stages of fallow regrowth. To calculate the total area of land under cultivation, the land area under shifting cultivation is divided by the rotation time (cultivation time + fallow time) to apportion the landscape into sections based on time left fallow (1 yr, 2 yr, etc). For example, in scenario 1 100 ha are in shifting cultivation with a 7 year fallow, which is an 8 year rotation (1 year of cultivation + 7 years of fallow). The results is 8 sections of land at different ages of regrowth (0 yr, 1 yr, 2 yr… 7 yr), each 12.5 ha on area. Consequentially, 12.5 ha of land are under cultivation.

The scenarios simulate a decrease in land availability for shifting cultivation, as protected areas expand. As less land becomes available for agriculture, two adaptive

strategies are possible: 1) Land is farmed more intensively and length of fallow is shortened, to maintain the same amount of land under production at any given time, which will lead to reduced soil quality and smaller yields on each plot, or 2) Length of fallow is kept the same, but less land is cultivated at any given time. Option 1 is used for this study under the assumption that people will try to cultivate as much land as possible, in attempts to produce the same amount of food regardless of land availability. In this model, they respond by increasingly intensifying agricultural practices, as opposed to removing land from production. Under this assumption, as land under "protected area" increases, and land for agriculture decreases, fallow time will be shortened, and production of rice per hectare will decrease significantly.

To estimate this effect, we used data on rice yields (ton/ha) after varying lengths from data provided by Ramakrishnan and Toky (1981) in northeastern India. Rice yields in India after 5, 10 and 30 year fallows were 30, 397, 770 kg/ha dry weight yield, respectively. Data were converted to ton/ha dry weight yield, plotted, and fit with a logarithmic line of best fit (Figure 2). Using the trend line equation $y=0.448 \ln(x) -0.6521$ (x=fallow time, y= rice yield (ton/ha), $R^2=0.9844$), rice yields per hectare were estimated for scenario 1 and 2, which had 7 and 5 year fallow respectively (Figure 2). For scenarios 3 and 4 averages were taken for rice yield estimates, as fallow times were too small to provide values under the logarithmic equation.

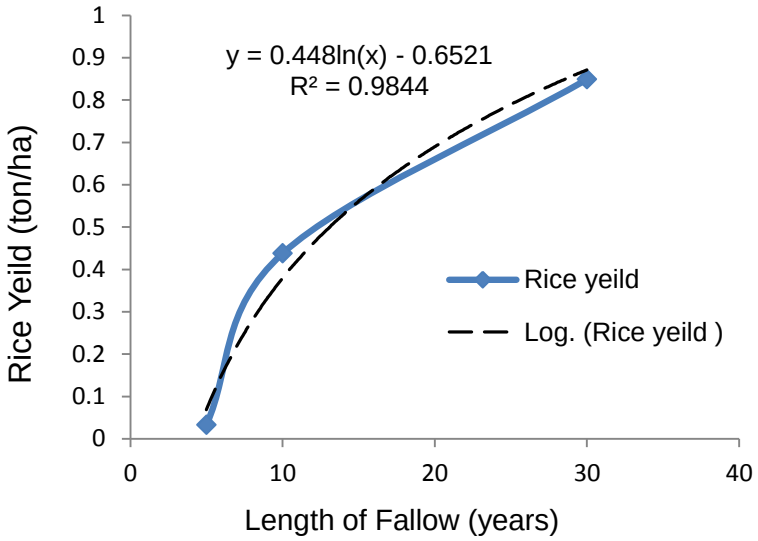

Figure 1: Plot of rice (Zea mays) dry weight yield (ton/ha) as given at 5, 10 and 30 year fallow by Ramakrishnan and Toky (1981). Data was plotted with logarithmic line of best fit, to provide estimations in rice yields for the study site.

3. Results

As expected, AGC storage was highest in Protected Areas, averaging 64.5 ton C/ha over the 50 year period (Table 1). AGC in Protected Areas steadily increased from 4 ton C/ha to a maximum of 79.1 ton C/ha after 32 years, and then decreased slightly due to tree mortality and woody decomposition (Figure 3). Land under shifting cultivation displayed a recurring pattern of rising and falling carbon stocks, with AGC stocks dropping sharply after slash and burn events, and then rising steeply until the next disturbance (Figure 4). Average AGC storage was substantially less on shifting cultivation land, decreasing directly with reductions in fallow. As fallow was reduced from 7 to 1 years, AGC on shifting cultivation land experienced an 86% reduction, from an average of 17.4 ton C/ha in Scenario 1 (7 year fallow) to only 2.5 ton C/ha in Scenario 4 (1 year fallow) (Table 2). This was a result of the limiting of tree growth that occurred from shortening fallow time, which resulted in overall

reductions in standing carbon storage on land used for shifting-cultivation. Total belowground carbon (BGC and total SOC) was slightly higher in Protected Areas (125 ton C/ha) than in shifting cultivation landscapes (116.5-119.6 ton C/ha), but did not vary greatly based on land use or length of fallow (Table 1, Table 2).

At the landscape level, total carbon storage increased directly with the amount of Protected Area. Specifically, total carbon increased by 25% after a 75% increase in Protected Area, from scenario 1 (13,700 ton C) to scenario 4 (17,180 ton C) (Table 3). The majority of this increase occurred in the aboveground carbon stock (AGC), which experienced a 213% increase from scenario 1 (1,740 ton C/ha) to Scenario 4 (5,460 ton C/ha). Total belowground carbon (BGC and total SOC) only increased by 2% from Scenario 1 to Scenario 4, but was the most stable carbon stock. Slight increases in total BGC occurred when land was removed from shifting cultivation and designated Protected Area (Table 3). However, as more land was placed under Protected Area, land under shifting cultivation was farmed more intensively, experiencing a greater loss in surface soil carbon (SSOC) as fallow times were reduced (Table 3).

As Protected Area overtook land once used for shifting cultivation, rice production decreased drastically. With each 25% increase in Protected Area land, and corresponding 25% loss in shifting cultivation land, fallow rotations were decreased by 2 years to maintain 12.5 hectare under rice cultivation (Table 4). The reduction in fallow from 7 years (Sc. 1) to 1 year (Sc. 4) resulted in a 93.6% decrease in annual rice yields (ton rice/ $hayr^{-1}$) (Table

Table 1: Aboveground carbon values (tC/ha) for protected area land, as averaged over 10-year intervals, shows AGC increase in all stocks. Here, AGC includes standing carbon, foliar litter and dead wood. BGC was fairly stable at 125 tC/ha (Soil organic carbon=97 tC/ha, belowground biomass C=28 tC/ha). "Average" refers to the temporal average over the entire 50 year time horizon.

Protected Areas	AGC (tC/ha)			
Time interval (yr)	Standing carbon	Foliar litter	Dead wood	Total AGC
0-10	17.5	1.3	1.5	20.3
10-20	42.6	2.9	5.9	51.3
20-30	68.3	3.2	9.4	80.9
30-40	76.3	3.3	10.1	89.7
40-50	67.2	3.2	10.1	80.5
Average	**54.4**	**2.8**	**7.4**	**64.5**

Table 2: Above and belowground carbon values (tC/ha) for land under shifting cultivation in each land-use scenario, as estimated by carbon model. Values here represent averages over shifting-cultivation land use over the entire 50 y time horizon. AGC sharply decreases as length of fallow is reduced, but BGC is not greatly affected.

		Above ground carbon (tC/ha)				Belowground Carbon (tC/ ha)		
Scenario	Fallow (yrs)	Standing carbon	Foliar litter	Dead wood	**Average AGC**	Roots	Total SOC	**Average BGC**
Sc. 1	7	14.7	1.3	1.4	**17.4**	27.6	92.0	**119.6**
Sc. 2	5	10.0	1.2	0.7	**11.9**	27.0	91.5	**118.5**
Sc. 3	3	5.5	1.0	0.3	**6.7**	27.0	91.0	**118.0**
Sc. 4	1	1.7	0.8	0.0	**2.5**	26.0	90.5	**116.5**

Table 1: Landscape carbon (1000tC) as estimated for each land use scenario over the total landscape (100 ha), with land apportioned differently between shifting cultivation and protected area. AGC is most greatly affected by changing land use, and total carbon increases most drastically when protected area increases from 0 to 25% of landscape area.

			Landscape carbon (1000tC)		
Scenario	Land use	Area (ha)	AGC	BGC	Total
Sc. 1	Protected area	0	0	0	0
	Shifting cultivation	100	1.74	12.00	13.7
	Total	100	**1.74**	**12.00**	**13.7**
Sc. 2	Protected area	75	1.61	3.12	4.73
	Shifting cultivation	25	0.99	9.89	9.78
	Total	100	**2.60**	**12.01**	**14.51**
Sc. 3	Protected area	50	3.22	6.25	9.48
	Shifting cultivation	50	0.34	5.9	6.23
	Total	100	**3.56**	**12.15**	**15.71**
Sc. 4	Protected area	25	4.83	9.38	14.2
	Shifting cultivation	75	0.63	2.91	2.98
	Total	100	**5.46**	**12.29**	**17.18**

Table 2: Annual rice yields (dry weight ton ha^{-1} yr^{-1}) on land cultivated using shifting cultivation, predicted under different land use scenarios, as estimated from data provided by Ramakrishnan and Toky (1981) of rice yields under 5, 10 and 30 year fallows. Per-hectare yields decrease exponentially with reduced fallow, as area is removed from cultivation. Total Landscape Yield column at right provides estimated total annual rice yields for the landscape, and is equal to the rice dry weight yield (ton ha^{-1} yr^{-1}) (as predicted for that specific scenario) multiplied by the total area of cultivated land (12.5 acres).

	Shifting Cultivation (ha)	Protected Area (ha)	Fallow (yrs)	Rice dry weight yield (ton ha^{-1} yr^{-1})	Land cult. (ha)	Total Landscape Rice yield (ton yr^{-1})
Scenario 1	100	0	7	0.220	12.5	2.7
Scenario 2	75	25	5	0.069	12.5	0.9
Scenario 3	50	50	3	0.041	12.5	0.5
Scenario 4	25	75	1	0.014	12.5	0.2

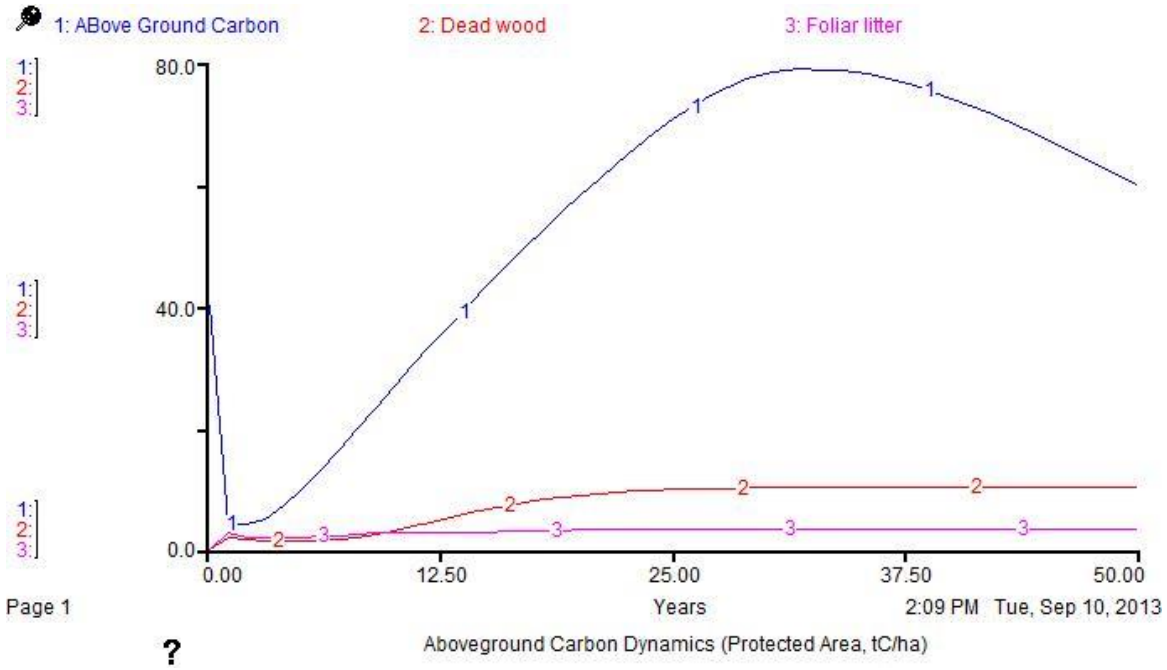

Figure 1: Aboveground carbon (tC/ha) in Protected Areas increases steadily over time in all stocks after year 2, reaching a maximum of 79.1 tonC/ ha at about 32 years, and then decreases slightly due to tree mortality.

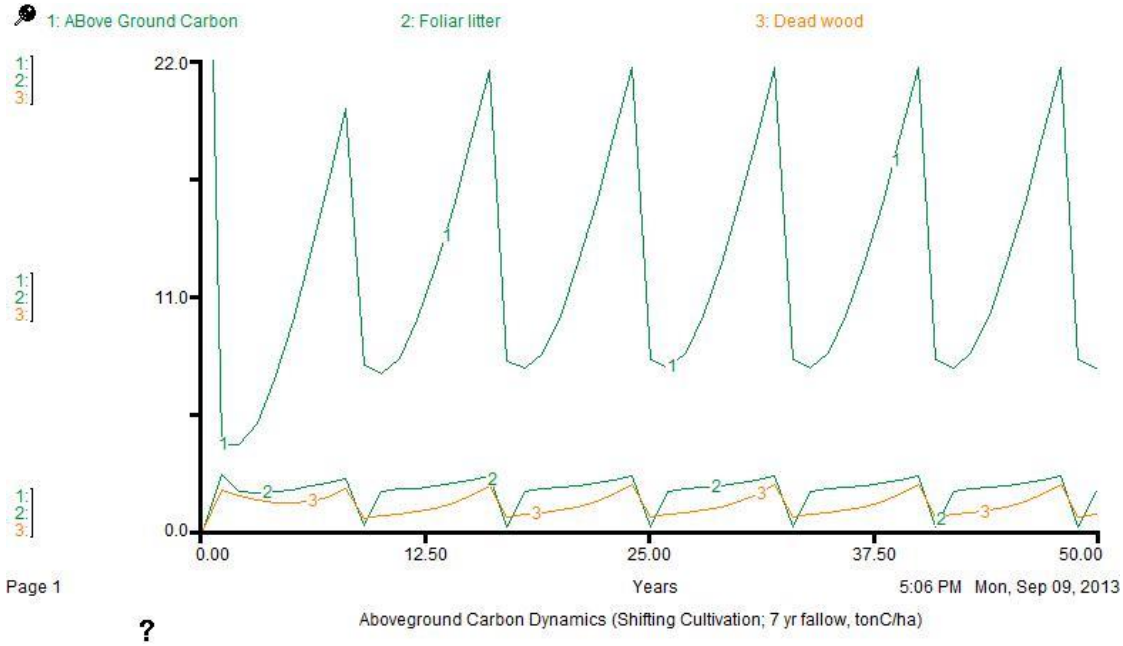

Figure 2: Aboveground carbon dynamics in a single spatial location within a shifting cultivation system with a 7 year fallow, exhibiting a repetitive pattern as carbon accumulates to a maximum of 22 tC/ha, and then drops after each slash-and-burn episode.

4. Discussion

4.1 Protected Areas: Impacts to Carbon and Food Production

As expected, Protected Areas stored higher rates of aboveground carbon than land used for shifting cultivation, but at a high cost to food production. In the absence of agricultural disturbances, aboveground carbon accumulated steadily to its full potential in Protected Areas. Shifting cultivation land also accumulated AGC carbon, but frequent slash and burn events reduced average carbon storage over time. Disturbances never completely depleted AGC, however, due to the presence of few trees and woody debris that are too large to clear and/or burn. Belowground carbon was minimally affected and stayed relatively stable on both lands used for protected area and shifting cultivation. Surface SOC and belowground carbon decreased slightly as fallow times were reduced, but this did not greatly affect total belowground carbon.

While Protected Area land did store more carbon, it required the removal of land from shifting cultivation. Land use intensification with shortened fallow times led to reduced carbon storage on shifting cultivation land. The increased frequency of slash and burn events allowed aboveground carbon less time to accumulate, while also impacting belowground carbon stocks, though not as severely. Shorter fallows allowed soil organic carbon stocks less time to naturally accumulate, and increased frequency of burning resulted in losses of surface soil organic carbon.

As Ramakrishnan and Toky (1981) show, reduced fallow can lead to sharp decreases in agricultural yields through soil nutrient loss, erosion, and the loss of soil organic carbon. Consequently, the designation of Protected Areas had severe impacts on rice production in

this model, with a 75% increase in Protected Areas corresponding to a 93% reduction in rice yields. This could have severe impacts on the food security and livelihoods of agricultural families in Liberia, which make up 40% of the population. Eighty percent of these households are already moderately vulnerable to food insecurity, and shifting cultivation provides half of their rice consumption needs (MOA 2007).

4.2 REDD+ and Livelihood Dispossession

As the Forest Development Authority proceeds in its attempts to make Liberia a REDD+ country, serious attention should be given to the livelihoods that would be displaced from Protected Areas. Conservation agencies prioritize rainforest conservation, but can sometimes overlook the communities within the forests. For example, Jessica Donovan, CI's Liberian Program Director states "At CI we believe that innovations such as carbon offsets and conservation incentive agreements can ensure that biodiversity conservation is not only delivering economic opportunities at a national level but also that the benefits reach the forest fringe communities who need them most" (Matarasso and Goldstein 2008). This statement reflects the priority that Conservation International is placing on forests over communities in Liberia. Despite the fact that many communities live within the interior of forests, Donovan uses the terminology "forest-fringe communities", implying that they inhabit areas "outside" of the forest, or are in some way, separate to the forest. If they weren't "forest-fringe" communities before, then this statement implies that they will become so, through re-location to buffer zones outside forests.

Additionally, this statement suggests that communities will benefit from a trickle down of the "economic opportunities" that carbon offsets will provide. Whether these

benefits can truly compensate for lost livelihoods, however, is uncertain. Historically, corporations such as Samling, Firestone Rubber Company, and Sime Darby have displaced communities from their lands for commercial logging, mining or agriculture, under the guise that communities will be compensated through benefits such as development projects or monetary compensation (CICR 2010). These companies have often failed to deliver on these promises, leaving displaced communities without alternative sources of livelihoods (CICR 2012).

The pivotal question to ask then, is would REDD+ be any different in its ability to deliver benefits to rural communities that now depend on forests for their livelihoods? While decision makers claim that REDD+ will provide benefits to communities, they remain uninformed on the actual value that forests hold to communities, due to a paucity of data on current land-use practices (World Bank 2010). According the Strategic Environmental Assessment of the Liberian Forest Sector "Despite a stated policy of coherence between the 3Cs [community, conservation and commercial aspects of forest management], currently there remains a severe paucity of economic data on the "community" and "conservation" aspects…and the economic decision making excludes the actual and potential benefits of forest management options, resulting in the undervaluation of forest resources" (World Bank 2010). There is therefore, the risk that monetary compensation would fail to account for the non-monetary value that forests provide to communities, such as through agriculture, hunting, fishing, and non-timber forest products (SDI 2011).

Additionally, the negotiation process of REDD+ mirrors those of foreign investment negotiations, which have failed to include community representatives in the decision making processes. REDD+ decision making remains top-down, with committees composed of large

international NGOs, government officials and foreign investors. For example, the Readiness Program Idea Note (R-PIN) (2008) that the government of Liberia prepared for submission to World Bank Forest Carbon Partnership was prepared by a consultation group that consisted of representatives from FAO, Conservation International, and several foundations, but did not include representatives from communities, such as village chiefs. Additionally, the Liberian Forest Initiative, which assisted the Forest Development Authority in crafting this proposal, consisted of representatives from large conservation agencies (Again, Conservation International) and multilateral corporations (World Bank), and again lacked community representation.

5. Conclusion

The designation of Protected Areas may lead to increased carbon storage, and the potential for carbon credits, but at what cost to human livelihoods? The designation of Protected Areas will cause the displacement of households from these lands, and reduce available land for agriculture. Households have limited adaptive strategies to land shortages, and are likely to intensify their practices through reduced fallow, which can accelerate soil degradation and reduce crop yields. As this model shows, the displacement of communities from Protected Areas will reduce their ability to produce enough rice, with potentially severe impacts to food security.

As the Government of Liberia continues to develop forest management plans, thorough consideration should be placed on the potential effects that the designation of Protected Areas could have on human livelihoods and food security. The people who inhabit and depend on these forests should be an active part of the decision-making process around

the establishment of Protected Areas in Liberia, as they will be most affected by management policies. Furthermore, research efforts should be placed on finding social-environmental solutions that will incorporate rural Liberians, rather than dis-include or displace them. The issue at hand, after all, is more than one of simple tradeoffs- it's an issue of human livelihoods.

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Chapter 3: The Political Ecology of Rural Poverty in Liberia: The Impacts of Colonization, Market Dominance, and Neoliberalism

1. Introduction

Despite hosting a wealth of natural resources, a rich cultural history, and the largest tract of West Guinean rainforest in Africa, Liberia is notorious for its rampant rates of poverty, and the 14 years of war that devastated infrastructure and stalled development. Almost ten years after the devastation of two civil wars, over 76% of Liberia's population live on less than $1 a day (MOA 2007). The majority of this poverty is focused in rural areas, where 56% of the population reside (MOA 2007). Despite hosting a majority of the population, rural areas remain the most underdeveloped parts of the country, often lacking paved roads, electricity, sewage treatment systems, and clean water. This lack of infrastructure and resources has led to widespread food insecurity, affecting over two-thirds of the population (MOA 2007).

What are the causes and events that have led to the rampant spread of poverty, food insecurity, and underdevelopment in the agricultural sector of rural Liberia? The dominant discourse used to explain these phenomena is that of the "post-conflict state", which places the entirety of the blame for rural poverty on the 14 year civil war. According to the Food and Agricultural Policy and Strategy, a series of strategies drawn up by the National Government's Ministry of Agriculture to address agricultural development, "Fourteen years

of civil war, which ended in 2003, seriously disrupted the Liberian economy, leading to an overall impoverishment of the country" (MOA 2008).

This national document is the primary source of information advising policy makers and governmental agencies on Liberia's agricultural sector, and its entire premise is based on the discourse that the war created the current state of poverty. While it is certainly true that the wars have *contributed* to rural poverty and underdevelopment in Liberia, by seizing the lives of over 150,000, physically displacing 1.3 million, and causing widespread destruction of infrastructure, this one-dimensional focus on a "post-conflict" discourse essentially "erases" the deeper underlying causes of poverty and social tensions in which these problems are rooted. These causes of rural poverty extend beyond the wars, and include insecure land rights, social inequalities between urban and rural Liberians, the marginalization of rural peoples, and the dominant force of foreign investment.

The danger of depending on such a one-dimensional narrative lies in overlooking the pre-war historical events, actors, and policy decisions that shaped poverty, at the risk of repeating such events. To fully understand the current state of rural poverty, it is necessary to deconstruct the historical and political context, and the associated underlying governmental and institutional failings, that have led to and perpetuated these conditions of poverty in the first place. These failings extend deep into Liberia's history, and are a product of the interacting forces of colonization, social marginalization, market integration, and neoliberalism. These forces have shaped the creation of a political economy based on market exchange, described by Robbins (2012) as "the systems that govern use … of the environment … [which are] structured into a larger social engine, which revolves around the

control of nature and labor". This political economy has favored the interests of foreign investors, elites, and the national government at the expense of the rural peasant class.

Through a 150 year historical and literature analysis, I will deconstruct the political economy and historical context that underlies agricultural underdevelopment and associated rural poverty in Liberia, beyond the dominant discourse of the "post-conflict" state. I argue that the current state of rural poverty extends beyond the 14 year civil war, and was shaped by the interacting forces of colonization, foreign investment, and neoliberalism in Liberia. These forces have enabled foreign financial exploitation, the shift to an export based economy, and a resulting dependence on global markets, which have become among the most significant contributors to underdevelopment and rural poverty in Liberia.

Contrary to dominant narratives of "foreign investment contributing to development", I argue that the integration of the Liberian economy into the global market deepened rural poverty, through widespread dispossession and commodification of Liberia's land, natural assets, and even human bodies. Castree (2003) defines commodification as '. . . a process where qualitatively distinct things are rendered equivalent and saleable through the medium of money'. Through commodification of Liberia's natural assets, and its rural population, foreign investors accumulated and diverted the wealth of Liberia's natural resources out of Liberia, and into the hands of host countries for these investments. This diversion of resources toward foreign accumulation has significantly impeded development in the domestic agricultural sector, and contributed to poverty in rural communities.

This widespread foreign investment was enabled by the insecure and informal state of land rights for indigenous Liberians, which fostered the seizing of their lands by foreign

corporations. Through an analysis of historical and political events, I will describe how Liberia's integration into the global market was based on an insecure dual-tenure system, which was built from pre-existing social divisions that extend to the colonization of the state in 1822, and dispossession of the rural peasant class.

Finally, I will argue that Liberia's integration into the global market resulted in a dependence on food imports, which deepened poverty for rural communities by increasing their vulnerability to fluctuating market prices for food that households need to purchase. Furthermore, the neoliberal strategies introduced in the late 1970s to address these vulnerabilities were rooted in the same market-based mechanisms that had created the food insecurities in the first place, and have only enhanced the problem. Through a detailed historical and political contextualization, I will move beyond the traditional "post-conflict discourse" to that argue that it was the interaction of the forces of colonialism, foreign investment, and neoliberalism that have shaped the political economy of poverty of current-day Liberia. Through this holistic framework, I also argue that a continued reliance on market-based mechanisms for solutions to rural poverty will only exacerbate these problems: they will deepen poverty by continuing the commodification of Liberia's land, natural resources, and her people.

2. Historical Context: Colonization, Ethnic divisions, and the Dual Tenure System

The impoverished state of Liberia's economy and development are integrally dependent on and connected to the state of land rights in Liberia, which arose as an indirect product of colonization. As I will outline below, the colonization of Liberia by freed American slaves resulted in societal divisions between the settlers (termed Americo-

Liberians) and the indigenous Liberian tribes that had been occupying the interior forests of Liberia. These divisions were materialized and deepened through the creation of a dual tenure system, which provided informal customary ownership rights to indigenous communities, and formal statutory rights to Americo-Liberians. The dual tenure system has been perhaps the most important factor influencing the vulnerability and displacement of indigenous communities over the last 150 years, as it has limited the rights indigenous Liberians and enabled the seizing of their lands by the elite class, the Liberian government, and foreign investors.

America first sent its freed slaves to colonize Liberia in 1822, under the guise of repatriation- having their own country to begin anew. While this ideological view was provided to the American public as the reason for the colonization, another likely motivation was the widespread fear among the American public that keeping the newly liberated black Americans in the population might "undermine" societal structure. Considered to be an "inferior" portion of the population, it was feared that a "surplus" of black people could pose a threat to white laborers by providing a surplus of cheap labor (Hansen 1947; PBS 2009). While the primary motivation of the American Colonization Society is unclear, the colonization by Americo-Liberians resulted in the creation of the Republic of Liberia in 1847.

When the Americo-Liberians settled Liberia in 1822 they remained on the coastlands, allowing the indigenous Liberians to stay in the dense interior forests (termed the "Hinterland"), perhaps because the forests were difficult for the settlers to penetrate (Alden Wiley 2007). The indigenous tribes living near the coast, however, were displaced, enslaved and treated as inferior by the Americo-Liberians, who quickly became the elite ruling class.

Initially the interior forest lands held no value to Americo-Liberians, and the Liberian government recognized the ownership rights of indigenous Liberians through the passing of the The Hinterland law of 1923, which established a system of customary land tenure (Alden Wiley 2007). If an indigenous family or community had been occupying and using a parcel of land, it was recognized that this land belonged to them without necessity of formal deeds or other legal proof of ownership. In contrast to this informal system, a statutory system of land ownership was established among Americo-Liberians in the coastal area, and property ownership was made official through parceling of land and awarding of deeds. Hence, the dual-tenure system of statutory and customary land rights was created as both a material and symbolic representation of the class divisions between indigenous tribes and Americo-Liberians. Despite current attempts to improve this system, the unsteady state of land rights for rural agricultural communities remains in place to this day.

3. Firestone Rubber Company and the Beginning of Market Imperialism

While it is clear that the dual tenure system was created out of the deeper societal divisions between Americo-Liberians and indigenous Liberians, it is important to consider the reasons why this system has remained in place for the last 150 years, and why subsequent acts of legislation have failed to produce clear land rights for indigenous Liberians. To this day indigenous Liberians have no security or formal rights over their land. It is then vital to ask, for whose benefit, and what cost, have indigenous Liberians been denied secure access to land?

Through a deeper historical analysis of Liberia and its role in international events in the early to mid- 1900s, it becomes clear that the perpetuation of the dual tenure system was

dependent on and deepened by the wave of foreign investments that were to occur in the 1950s. These investments began in 1926 with an agreement between Firestone Rubber Company and the government of Liberia that enabled Firestone to develop large plantations for rubber production. This first negotiation ignited a wave of foreign investments in Liberia that would transition Liberia from an economy based in subsistence agriculture, to a cash-crop export economy dominated by foreign businesses. The dual tenure system and the class divisions upon which it is based would come to facilitate this spread of foreign investments and liberalism in Liberia, by enabling the quick and dirty dispossession of both land and labor from indigenous Liberian tribes.

But how did this wave of foreign investments begin? It required the right economic and political climate, with conditions that would encourage foreign corporations to invest in Liberia. Initially, America had little economic interest in Liberia; the dense rainforests held little potential for material worth and were difficult to penetrate. It wasn't until the 1920s, when America's Secretary of Commerce, Herbert Hoover, emphasized the need to secure raw materials for the development of industry in America that interest in foreign investment in Liberia ignited.

This occurred at a time when "market imperialism" - the spread of foreign influence and control through market processes- was replacing traditional colonialism, and America had begun funding expeditions worldwide to find and develop markets for the export of raw materials into the United States (Mittman and Erickson 2010). Rubber was of particular focus; it was a key material in the development of the booming automobile industry in America (Mittman and Erickson 2010). Britain held a monopoly on rubber production, and when it implemented the Stevenson Plan to restrict the exports of crude rubber and ensure its

financial control, import prices increased drastically (Mittman and Erickson 2010). America's automobile industries became desperate to find their own source of rubber, and Firestone Rubber Company was on such company that set off on expeditions to secure its own rubber plantations.

With the perfect climate, well-established connections with America and an abundance of land and natural resources, Liberia became the focus for Firestone Rubber Company's investment. In 1925 Firestone embarked on a tentative agreement with the Liberian government to lease up to 1 million acres of land for 99 years to develop rubber plantations, at only 6 cents an acre (Church 1969; Mclaughlin 1966). The Liberian government would also contribute $300,000 towards the building of a large marine port for the shipment of crude rubber out of the country, which Firestone was to undertake. As a stipulation of the concessionary agreement, Firestone Rubber Company required the government to adopt a $5 million loan from the Finance Corporation of America (Church 1969; Chalk 1967). The loan was under the guise of securing "protection" over Firestone's large investment. It was later revealed that the Finance Corporation of America was a subsidiary of Firestone, and the loan carried with it several terms by which Firestone could restrict the sovereignty of the Liberian Government (Chalk 1967). These terms gave the US government significant control over the shaping of the governmental budget in Liberia, and restricted Liberia from accepting loans from other countries (Chalk 1967). At a time when Liberia was desperate- and on the verge of bankruptcy- Firestone Rubber Company had manipulated the Liberian government into accepting a deal that would provide Firestone with substantial fiscal and political control- a deal that would restrict the sovereignty of the Liberian government for the next 100 years (Chalk 1967; Mclaughlin 1966). Desperate to

climb out of its considerable debt, Liberia accepted the agreement and the loans, and the restriction of its own sovereignty that followed. This poignant and telling example is illustrative of how foreign companies would come to exert considerable financial and political control over Liberia through the use of market exchange; control that would come to benefit these outsider countries at the expense of Liberia's development.

4. Liberia's Initiation into the Global Market

The Firestone Rubber Company negotiation played a pivotal role in opening Liberia's economy to a wave of foreign investments that would result in Liberia's initiation into and dependence on the global market economy. In addition to this first pivotal event, three other significant events in the early to mid-1900s created the perfect set of conditions for a wave of new foreign investment opportunities in Liberia. First, Liberia declared war on Germany during World War II, due to pressure from the US and Britain (Maria-Claasen and Salin 1991). Germany had been Liberia's largest trade partner, and this act left Liberia's economy crippled with debt (Maria-Claasen and Salin 1991). This heavy debt made Liberia more financially desperate and more susceptible to signing deals with foreign investors that often included loans and stipulations; deals that would increase financial dependence and weaken the economy in the long-term, but provide financial stability in the short-term. An important example of this was the $5 million loan that the government of Liberia signed with Finance Corporation of America, the subsidiary of Firestone, through which Firestone significantly restricted the sovereignty of the Liberian government. Through underhanded and manipulative dealings such as these, capitalist countries began to exert significant financial control over Liberia at its weakest moments, and gained significant future control of Liberia's government and economy.

The second event that helped integrate Liberia into the global economy was the adoption of US currency, which facilitated foreign investments and transactions (Maria-Claasen and Salin 1991). The third event was the creation of the Open Door Policy, implemented by Liberian president Tubman in 1944 (Clower et al. 1966). The Open Door Policy was strategically designed to enhance Liberia's economic and political connections with America, by encouraging more foreign businesses to invest in country (Clower et al. 1966). For the purpose intended, this policy was wildly successful, and Liberia saw a three-fold increase in the contribution of raw exports to GDP; between 1950 and 1960, the GDP provided from exports increased from $58 million to over $171 million USD, mostly due to the rapid expansion of iron ore extraction (Clower et al 1966).

This economic and political climate, and the chain of events that ensued, opened Liberia to the global market economy in the mid-1900s. The boom in investments that followed transitioned Liberia into an export-dominated economy, with a focus on production of raw materials for export: rubber, timber, iron-ore and diamonds. It became an enclave economy, dominated by disjointed production sectors that lacked integration, which was controlled by an oligopoly of foreign investors. It seemed a time of economic growth, and the benefits of these investments cannot be ignored: a three-fold rise in GDP, the creation of jobs, and development of infrastructure around centers of production, including roads, schools and hospitals (Church 1969, Clower et al 1966).

Yet while this economic transition was "building" up the Liberian economy and filling the coffers of elites and the national government, it was further deepening poverty for rural Liberians by perpetuating insecure land rights, deepening pre-existing social divisions, and exploiting the land, labor and natural resources upon which rural communities depended.

The transition of the national economy towards export production was dominated and controlled by those with the political influence and capital to negotiate such deals: large foreign investors, the elite ruling class, and the Liberian government. These negotiations were made with the motivation to maximize profit, and they often excluded the voices and considerations of the indigenous Liberians. For these foreign firms to secure the social, economic and natural capital necessary to accumulate profit, they dispossessed land, labor, and natural assets from the rural indigenous Liberians, and deepened the class divisions and concomitant social tensions that were already in place since the colonization of Liberia in 1822. One illustrative example of the dispossession of rural communities by investors is that of Firestone Rubber Company and the development of its rubber plantations in Liberia.

5. 1 A Case Study: Firestone Rubber Company

Firestone Rubber Company was the first and most significant foreign corporation to invest in Liberia. After negotiation of the initial agreement between Firestone and the Government of Liberia in 1926, the Harvard African Expedition proceeded to assess the strength and size of the Liberian labor force needed to work the plantations (Mittman and Erickson, 2010). Led by Richard Pearson Strong, a physician at Harvard's Tropical Medicine Department, the expedition underwent a medical and biological survey of Liberia's interior and found indigenous Liberians to be "backwards", and "diseased" by tropical pathogens (Mittman and Erickson, 2010). Indigenous Liberians were depicted and portrayed as inferior through the use of film, through which Strong could share his own imperial gaze with American audiences (Mittman and Erickson, 2010). This became a powerful tool to justify the need for "development" of Liberia's rural communities (Mittman and Erickson, 2010).

As the expedition progressed, Strong determined that the largest impediment to the development of Firestone's rubber plantations would be the availability of a cheap and able-bodied labor force (Mittman and Erickson, 2010). Strong and Firestone would find their "cheap and able-bodied" labor force through the recruitment and forced labor of displaced indigenous Liberians (Clower et al, 1966; Mayson and Sawyer 1979; Mittman and Erickson, 2010). It had already been common practice in the 1930s among Americo-Liberians to enslave and force indigenous people into labor, and despite America's attempts to address forced labor issues, Strong himself resorted to tying up Liberian indigenous men and using physical violence when he grew desperate (Mittman and Erickson 2010). Workers were selected based on their "intellectual superiority", determined by a hierarchy of "superiority" that Strong created between the different tribes of Liberia (Mittman and Erickson 2010). The government was complicit in these acts, by enlisting village chiefs to send a certain quota of men from their villages to be wage workers for Firestone Rubber Company (Mayson and Sawyer 1979). By 1928, the forced recruitment of men supplied Firestone with twenty thousand wage workers, whom received very little pay and were made to work excruciatingly long hours (Clower et al, 1966; Mittman and Erickson 2010). In 1936, Firestone was only paying its workers 14 cents a day for 12 or more hours of work, and did not offer compensation when workers fell sick or died (Mayson and Sawyer 1979). Firestone Rubber Company acquired its labor force through the unjust dispossession of rural Liberians from their land, communities, and livelihoods as subsistence agriculturists. In this way, Firestone was built from the violence acts of dispossession: dispossession of the freedom and humanity of rural indigenous Liberians (Mayson and Sawyer 1979).

These acts of violence against rural Liberians were not new; the elite ruling class and the national government had been using the indigenous as a "reservoir of cheap labor" since the colonization of the state (Mayson and Sawyer 1979). The advent of foreign investment, however, perpetuated these social divisions and the marginalized state of rural Liberians, by commodifying their very bodies for production. Villagers were robbed of their humanity to be treated as objects of labor that could be "exchanged" on the market for a saleable value; they were physically recruited from their villages and forced to work in Firestone's plantations. In a sick twist of irony, the Liberian state- which was settled on the premise of "freedom" by liberate slaves- came to be built on practices that very closely mirrored American slavery.

Firestone would come to benefit significantly off of this source of "cheap" labor, by undercutting costs at the base of the labor force: through low wages, unreasonably high quotas, and labor rights abuses (ILRF 2009; Mayson and Sawyer 1979). This was a tactic of rent accumulation practiced by the elites- extracting surplus through undercutting the basis of production (Marx 1990). It was also a significant form of both direct and what could be thought of as "silent violence", the less overt ways in which Firestone caused harm to indigenous groups. These include the objectification of rural Liberians based on tribal ethnicity, their commodification for labor, and the self-perpetuating cycle of poverty that these acts created: by diverting labor, resources and development away from agricultural development, to leave rural Liberians ultimately dependent on Firestone as their only viable source of employment.

Today, over 80 years later, these injustices continue, though they have been brought to the forefront of justice organizations. In 2005, the International Labor Rights Forum began

working with the international Stop Firestone Coalition to bring awareness to labor rights abuses committed against workers at Firestone plantations, which include low wages, poor living conditions, weak health and safety standards in the workplace, violations of workers' rights, and lack of union representation (ILRF 2009). The majority of workers are rubber tappers that collect latex from trees and carry it to collection points, where it is sent overseas for processing (ILRF 2009). Rubber tappers are given a quota of rubber trees that is often too high for a single worker to meet, and workers often bring their children and wives to help them complete the quota (ILRF 2009). The additional workers are not compensated, however, and the tapper still only makes about $3.19 a day, a wage that Firestone feels is adequate. While this wage is fairly standard for a single worker in Liberia, it does not account for the labor hours spent by the entire family, or the additional significant social costs to the families and communities. Children report being forced to work and miss school, and are not compensated for their work, and women have reported to sexual harassment that sometimes occurs when tapping in more isolated regions of the plantation (ILRF 2009). Additionally, many children are not provided with birth certificates and cannot access social services or receive education, as they live a long distance from schools (ILRF 2009)

Workers have tried to organize unions to change these systems, but Firestone has made this extremely difficult. Up until recently, FAWUL, the Firestone Agricultural Workers Union of Liberia, was run by Firestone company and led by their own hired staff, and did not represent the voices of the workers (ILRF 2009). Workers were not allowed to vote on membership or participate in decisions, and began to voice their dissent in strikes, which was often met with violence from Firestone-hired law enforcement (ILRF 2009). A strike in 2007 was violently broken up by police, through the release of tear gas and the wounding of six

plantation workers (Intl Herald Tribune, 2007). It wasn't until the inauguration of Liberian President Ellen Johnson Sirleaf in 2005 that workers were finally able to create the Aggrieved Workers Committee and create a new collective bargaining agreement (ILRF 2009). This however, is still being sabotaged by Firestone, which agrees to certain portions of the agreement, such as not allowing children to work, but neglects others, such as minimizing the quota (Butty, 2009; ILRF 2009).

5.2 Firestone and the Dispossession of Land

Firestone Rubber Company built its empire not only through the dispossession of human labor, but through the dispossession of lands from indigenous Liberians. This was enabled by dual tenure system which provided an informal and insecure state of land rights for indigenous Liberians, a physical manifestation of the social divisions that extend to Liberia's colonization. The dual tenure system would come to foster the spread of foreign investment by allowing the corporations to acquire cheap land through the forced displacement of indigenous Liberians. This is illustrated dramatically in the case of Firestone Rubber Company, which forcibly displaced Liberians from the 1 million acres received by the company in its 1912 negotiation (Mayson and Sawyer 1979). To this day, rural Liberians with customary tenure are at risk of displacement by "land grabs" from large corporations, which include Sime Darby, a major palm oil company, as well as logging industries (York 2012).

Interestingly, this is a two-way street: as the dual tenure system enabled widespread foreign investment, it was also *strengthened and perpetuated by* policies that were initiated to encourage more companies to invest. To attract additional foreign investors, the ruling class

and national government instituted land alienation policies that would further enable the acquisition of "cheap" land and "surplus" labor, through the dispossession of indigenous Liberians from their lands (Mayson and Sawyer 1979).

Before foreign investors had taken interest in Liberia, the land rights of indigenous Liberians had been recognized by the Americo-Liberians through The Hinterland Law of 1923, which provided rural Liberians with the "right of title" to their land (Alden Wiley, 2008; Lamb et al 2009). If a person, family, or community had been living on a land and their family and ancestors had been using that land for a while, it was recognized that the land belonged to them through customary tenure. This form of tenure, however, lacked any formal proof of ownership, such as a deed, and did not hold up well in courts. When land disputes occurred between indigenous Liberians displaced from their lands and large foreign investors, it was relatively easy to neglect these rights for the benefit of the investor.

In the late 1950s a new act was passed which stripped indigenous Liberians of their ownership rights altogether. The Aborigines Law of 1956 removed the "right of title" that indigenous Liberians held to their lands, guaranteed to them by The Hinterland Law of 1923, with the "right of use" to the *materials* on the land, such as non-timber forest products (Alden Wiley, 2008; Lamb et al 2009). This important act of legislation stripped away the ownership rights of indigenous Liberians altogether, by making the lands and forests of Liberia "public lands" (Alden Wiley, 2007). This law was passed only a few years after the Open Door Policy implemented by Tubman, which encouraged the privatization of land and the transition of Liberia's economy to foreign investors (Clower et al 1966).

To the discerning eye, it is no coincidence that the removal of land rights for indigenous Liberians would occur in lock-step with the spread of foreign investment, which required "cheap" land for production. In the 1950s, land had become a hot commodity for foreign business owners, and a change in tenure policy had made it a cheap one, by allowing the dispossession of indigenous Liberians from their lands. In this way, the dual tenure system was perpetuated by Liberia's integration into the global market economy, and economic "growth" was built on a foundation of inequality between the elite ruling class and rural Liberians.

5.3 Firestone and the Dispossession of Natural Assets

A trip through history has revealed the ways in which Firestone has dispossessed land and labor from rural Liberians. Accordingly, as Firestone has undercut the base of its production chain through exploitation of its laborers, it has also benefited from the exploitation of Liberia's natural assets by externalizing the costs of environmental degradation.

The production and processing of rubber requires large tracts of land, which Firestone has cleared for development of monoculture plantations. Monocultures have many negative environmental impacts, including reduced habitat and organismal biodiversity, altered nutrient cycling, soil erosion, and increased susceptibility to pests (Wu et al, 2001). Additionally, rubber processing plants along the Farmington River have been found to pollute the primary water source for nearby communities. A report by BBC News stated that a Firestone plant located 38 miles from Monrovia was found to be adding high amounts of orthophosphate to local streams (2009). While Firestone declared that these were harmless

and that its waste water treatment facility was working properly, community members complained of receiving skin rashes from using the water (BBC 2009). A video news report from Newslook (undated) describes how the discharge of over 700,000 gallons of waste water from Liberia's rubber treatment plant has polluted local rivers of a village, which are an important source of water for drinking, bathing, farming and fishing for local livelihoods. Villagers in the town complained of a variety of illnesses, rashes and child deformities, which they attributed to the contaminated water (Newslook *undated*).

Through the use and mismanagement of Liberia's land and water resources, Firestone has been able to accumulate profit by displacing the external costs of environmental pollution onto local communities. This is another example of "silent violence" committed against indigenous groups by foreign investors, through what may be considered a different kind of "dispossession": the dispossession of communities from access to clean water, and healthy livelihoods.

6. The Economic Transition and Impediments to Development

While Firestone Rubber Company has claimed, and still does to this day, to contribute to the development of Liberia, a closer inspection reveals Firestone's actions to mirror more closely those of neo- colonialism or market imperialism, than "development". It is true that Firestone has created some jobs, built schools and hospitals, and made rubber exports the highest contribution to Liberia's GDP (Church 1969). However, the dispossession of communities, control and degradation of natural assets, exploitation of raw materials and labor rights abuses that Firestone has committed have contributed to what Clower et al (1966) calls "growth without development", in which the rent accumulation of

foreign corporations removes the true wealth of these assets from the country, and rural communities are left impoverished.

Most of the wealth accumulated by Firestone is filtered out of country or into the pockets of the elite ruling class and little trickles down to communities or translates into development efforts. For example, while Firestone has claimed to have built roads, they have only built roads that connect plantations with main routes of transport. Most of the country is still left with unpaved roads, muddy and ripped apart by large trucks that passed during the war, which often become completely impassable during the worst moments of the rainy season . While Firestone has claimed to help improve quality of life through development of schools and hospitals, it does not even provide education for a large proportion of children born on its plantations, who lack transportation to the schools (ILRF 2009). While the company claims to provide jobs to the people, it did so through a history of marginalization, displacement, forced labor, and labor rights abuses (Mittman and Erickson 2010).

Though Firestone has profited billions of dollars from its use of the lands, it has returned almost nothing to the people. The high proportion of GDP that rubber exports provide to Liberia occur mostly through taxes and government revenues, and the people in villages don't ever see that money- most of Liberia still lives in extreme poverty. While this is partly due to the destruction and infrastructure collapse of two civil wars, it is also due to a stark inequality in income distribution that exists between the elite ruling class and rural Liberians. An initial product of colonization, these deeply rooted social inequalities were deepened by the spread of foreign investments, which filtered money into the pockets of elites, foreign investors, and the national government, at the expense of the poor rural class

(Broudic, 2008). The result is that the vast majority of Liberia's population lives in absolute poverty, while foreign investors continue to accumulate exorbitant amounts of profit.

7. The Violence of the Cash Crop Economy

While the prominent discourse about rural poverty continues to rely on the post-conflict narrative, historical contextualization reveals that rural underdevelopment is intimately connected with Liberia's integration into the global market system as an export-dominated enclave economy, and the associated social inequalities that resulted (Broudic, 2008). Through the diversion of land, labor, and natural assets towards the export of goods, this economic shift has resulted in a stagnation of agricultural development in rural Liberia (Tiepoh 2000; Broudic 2008, Mayson and Sawyer 1979). The result is that the majority of the population, which depends on subsistence agriculture to meet consumption needs, continues to remain crippled by poverty.

A major component of underdevelopment in rural communities is tied to the diversion of labor towards cash crop production, which is illustrated by the Firestone case study. Though this labor diversion began through forced labor practices, it has continued through a self-perpetuating cycle of poverty that has left rural Liberians dependent on wage labor, and ensured the continued existence of a "cheap labor" supply for investors (Broudic 2008). To illustrate how this cycle works, consider the Firestone case: Firestone first created conditions for poverty in rural Liberian communities, by diverting land and human labor resources away from agricultural development. The result was stagnation in rural development, which left communities impoverished. The rural poverty and underdevelopment that resulted further detracted rural Liberians away from livelihoods of subsistence agriculture, towards wage

labor for Firestone, which became a more attractive livelihood choice. While on the surface it seems that these people are electing to work for Firestone of their own volition, a closer inspection reveals that they were, in a sense, coerced into wage labor by the invisible hand of foreign investment, which created the conditions of rural poverty that left them no better choice.

In this way, foreign investors have ensured the continued existence of a "cheap" rural labor pool to work their plantations. An additional tactic has been the shift towards more capital intensive production techniques, which that has enabled investors to reduce the workforce, and created a surplus of laborers (Mayson and Sawyer 1979). This surplus has enabled investors to offer very low wages, poor working conditions, and commit labor rights abuses to their workers (Mayson and Sawyer 1979). An additional budget-cutting tactic employed by foreign investors is the import of foreign workers for more skilled positions. By importing human capital, investors do not need to train or educate workers for skilled positions, and do not need invest in in-country training programs (Mayson and Sawyer 1979; CICR 2012). This keeps the Liberian wage labor work force at the lowest rung of labor, and doesn't offer room for educational improvement or advancement of their positions.

This import of skilled human labor also impedes development, by filtering the capital and knowledge acquired in these higher positions back to the investing country. Additionally, due to the high costs of energy and transportation in country, many of the foreign investors try to reduce spending by exporting materials in their raw form, rather than investing in manufacturing plants in country (CICR 2012, Mayson and Sawyer 1979). This profit-maximizing strategy reinforces the stagnation of development, wherein production is entirely dependent on base-line resource extraction, with no room for development of infrastructure

for processing of the resources, or training of the workforce. The export of raw unprocessed materials has enabled the different centers of production to exist independently, with almost no integration, which has contributed to the lack of development and economic opportunities (Mayson and Sawyer 1979).

In addition to the diversion of land, labor and natural assets towards export production, foreign investment in Liberia has diverted the material efforts of development away from domestic agriculture, towards these centers of production (Broudic 2008; Mayson and Sawyer 1979). As the cash crop economy began to generate governmental money through taxes and revenues, development efforts gained traction around these centers of production, and slowed everywhere else (Broudic 2008). For example, roads and schools were built near Firestone plantations, but the government had no financial incentive to pave feeder roads through the rural countryside to villages. As a result, most roads throughout the country remain unpaved to this day, and often become impassable mud traps for large trucks and cars during the rainy season. This lack of transportation development has made transport of people and goods expensive and difficult, which has reinforced the lack of development in the rural regions, and contributed to the demise of the domestic food market.

In these ways, Firestone and other foreign investors have shifted the entire Liberian economy from one based on domestic agricultural production, to an export-dominated enclave economy. The result of this shift has been a stagnation in rural development that has contributed to rural poverty, and the continued marginalization or rural communities. This diversion of land, labor, and development efforts away from rural communities and towards centers of production has created a self-reinforcing cycle of dependence whereby the people

rely on these investors for labor, as livelihoods based on agricultural production continue to become less profitable.

8. Dependence of Food Imports

The shift away to an export economy has also enhanced rural poverty through a concomitant dependence on food imports that has left the people of Liberia increasingly vulnerable to market fluctuations (Mayson and Sawyer, 1979; Tiepoh 2000). Imports became necessary when the production of domestic rice dramatically fell, due to the diversion of labor from agriculture to Firestone's plantations. In the 1950s and1960s, Liberia was profiting enough from exports that it could afford to import rice-the staple food of the nation (Tiepoh 2000). The import of cheap rice from Asian countries actually became cheaper than domestic rice production in the 1970s, when the Green Revolution introduced new irrigation techniques that made intensive rice production less costly. While an increase of food imports lowered the price of rice in the short term, however, it came at several serious hidden costs to the welfare of the country and its people.

The first serious cost of rice imports was the increased competition between imported rice and domestic rice that occurred by the dumping of cheap rice into domestic markets (Tiepoh 2000). This harmed the livelihoods of local farmers selling domestic rice and continued to discourage development of domestic agriculture. The continued degradation of domestic production increased Liberia's dependence of rice imports, and made the country vulnerable to the volatility of price fluctuations in international markets (Broudic 2008). When the global debt crisis of the 1970s resulted in increased prices of rice, Liberia was hit hard (Broudic 2008). The government tried to address this problem by adding a 20% levy to

rice imports to encourage domestic production. However, adding a tax without addressing the deeper institutional failings of the agricultural system-including lack of infrastructure and the high costs of transportation- simply exacerbated the problem, and in 1979 a bloody riot broke out in Monrovia against the heightened prices of rice.

In response to the global food and economic crises that occurred in the 1970s, capitalist governments began a wave of neo-liberal strategies, including the initiation of structural adjustment programs in many developing countries. The goal of these programs was to liberate international trade and open developing countries to market exchange (Heynen et al 2007). The World Bank and the IMF believed that the "natural forces" of the market could solve the food and economic crises afflicting developing countries. Perhaps they were blind to the fact that it was a dependence on market forces that had *created* many of these conditions for poverty in the first place. Despite the altruistic narratives of "alleviating poverty" perpetuated by these multi-lateral corporations, their attempts to open up the markets of developing economies seem to be just another motive towards rent accumulation. Indeed, many of these structural adjustment programs resulted in increased food prices and food riots, rather the alleviation of food security (Walton and Seddon 1994).

In Liberia, the heightened dependence on global food markets resulted in increased vulnerability when the price of rice rose in the 1970s. In the 1980s, 25-35% of Liberia's rice came from food aid and rice imports (Broudic 2008; Tiepoh 2000). In 1998, to address these problems, the IMF began a program of structural adjustment to liberalize rice imports to Liberia (Tiepoh 2000). The program would eliminate import restrictions and price controls. However, this strategy does not address the underlying problems of this system, and will only deepen the dependence of Liberia on rice imports fluctuations. The neo-liberalization of rice

imports would only repeat the same problems caused by liberalization in the first place- increased competition between foreign and domestic providers, a weakened domestic agricultural system, and a country more vulnerable to control by large foreign investors.

9. Conclusion: How Liberalism and Neoliberalism Perpetuate Poverty

As the Liberian government begins post war reconstruction, it has placed a special emphasis on developing agriculture to alleviate poverty in rural communities. Through the creation of The Food and Agricultural Policy and Strategy, the Ministry of Agriculture has attempted to make suggestions for policy improvements in the agricultural sector (MOA 2008). This report was created as an extension of the government's larger Poverty Reduction Strategy, which was developed to address causes of the war and suggestions for post-conflict reconstruction, with the vision of a "nation that is peaceful, secured, and prosperous".

In an introductory statement for The Food and Agriculture Strategy, President Ellen Johnson Sirleaf addresses the rampant rates of poverty among the population. She describes the urgent need to address agricultural development, upon which "70% of our people depend… for their livelihood". Despite what appears to be a conviction to improve rural poverty, however, the document quickly reverts to a focus on the development of the *commercial* agricultural sector. The report states that commercial agriculture has created "employment for nearly 70% of the economically active population", and continues with a primary focus on developing incomes among the "economically active" portion of the population. The strategies it lists include "enhanced competitiveness and linkages to markets; increasing public investments and creating and enabling environment for agricultural and

agribusiness development; and creating more and better opportunities for much greater involvement of the private sector in the agriculture sector".

The report lists economic growth as the primary goal, but only for the "economically active" portion of the population. Despite the devastation of two wars that culminated from social inequalities, this important document fails to address the social inequalities and disparate distribution of economic growth that has created these conditions of rural poverty in the first place. Instead, this report relies primarily on market-based strategies, such as "increasing privatization", "linkages to markets", and "public investments", strategies which mirror those that created the conditions of rural poverty over the past 150 years: through the forces of foreign investment and neoliberalism. As the historical contextualization of this piece has hopefully show, reliance on these strategies has perpetuated the marginalization and dispossession of the rural class, and deepened very social inequalities - which the government admits- have *led to the war* in the first place (PRS 2008).

Herein lies the danger of the "post-conflict" discourse for explaining rural poverty: reliance on this one-dimensional narrative has enabled policy makers to "over-look" the deeper underlying causes of rural poverty, and continue their reliance on market-based strategies. "Over-look" is in quotes, because I find it difficult to believe that policy makers proceed with these suggestions out of ignorance, when it is clear that the implementation of these strategies would continue to filter rent into the hands of the elite ruling class and the national government- the decision makers who are crafting these very policies.

I argue that a continued reliance on the very market-based strategies that created conditions of poverty in Liberia, will only lead to the reinforcement of these conditions. To

effectively address the state of rural poverty in Liberia requires a deeper contextualized understanding of the institutional and political failings that have perpetuated poverty in the first place. Through a 150 year historical analysis of the interacting forces of colonization, land rights and social divisions, market integration, and neoliberalism in Liberia, I argue that a history of foreign financial exploitation, the shift to an export based economy, and a resulting dependence on global markets are some of the most significant contributors to underdevelopment and the state of poverty in Liberia. These events are intertwined with and reinforcing of the social divisions between Americo-Liberians and indigenous Liberians, which extend back to the colonization of the freed state in 1847. The result of these events has been the continued marginalization and violence against rural indigenous Liberians, through the dispossession of their lands, resources, and even bodies for labor. The dual tenure system has enabled these injustices to continue, by limiting the land rights of rural Liberians.

To this very day, the customary land rights of indigenous Liberians remain unclear and undefined, and Liberians are at risk of dispossession by actors as diverse as conservation agencies and palm oil corporations (CICR 2012). Over 100 years and two civil wars later, property rights for the indigenous are still undefined. I argue that these acts are purposeful, and constitute a form of silent violence against indigenous Liberians, for the profit and benefit of rent-seeking foreign investors. And while it is clear that the dual tenure system, the marginalization of Liberians, and the inequalities between classes in Liberia have all contributed to the escalation of tension that culminated in civil war, these underlying problems continue to infiltrate Liberia to this very day. To truly address the social and economic instability, the state of poverty, and the potential for conflict to reignite, the focus

should be on addressing these deeper underlying problems. A continued reliance on market based mechanisms is likely to lead to the failure of such attempts, and result in the inevitable: history continuing to repeat itself, at the cost of violence –again and again- against the indigenous rural Liberians.

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