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DOES SECURE COMMUNITY FOREST TENURE AFFECT FOREST CONDITION? NEW PRE-TREATMENT EVIDENCE FROM A QUASI-EXPERIMENTAL EVALUATION OF A REDD+ PROJECT IN ZAMBIA¹

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Abstract

Although the global literature suggests stronger forest tenure is associated with better forest condition, several recent meta-analyses of this relationship have resulted in “mixed and heavily qualified” findings (Seymour et al., 2014, p. 2). There are numerous factors influencing these mixed econometric results, including, inter alia, selection biases and inconsistent definitions or methods, and the global literature is limited to selected geographies, with few rigorous case studies from Africa (Seymour et al. 2014). This paper seeks to begin to address these gaps by analyzing an original data set collected as part of a prospective impact evaluation of the Community based Forest management Project (CFP), a USAID-funded reducing emissions from deforestation and forest degradation (REDD+) program in eastern Zambia. Drawing on survey data from 2,822 households, including 1,052 female-headed households and supplemented with contextual and spatially-derived statistics, our analysis will contribute novel evidence on the relationships among forest tenure, governance, and condition.

Introduction

Although the global literature suggests that stronger local forest tenure, especially for indigenous communities, is associated with better forest condition (e.g., Nepstad et al., 2006; Sandbrook et al., 2010; Wynberg and Laird, 2007), several recent meta-analyses of the relationship between forest tenure and forest condition have resulted in “mixed and heavily qualified” findings (Seymour et al., 2014, p. 2). For example, Ferretti-Gallon and Busch (2014) found no consistent association of land tenure security with either increased or decreased deforestation in their meta-analysis of 117 studies. In contrast, Robinson et al. (2014) reviewed 118 cases studying the spatially-explicit relationship between forest tenure and forest change and found that land tenure security *is* associated with reduced deforestation, regardless of tenure form.

Seymour et al. 2014 note that there are several factors influencing these mixed econometric results, including, *inter alia*, selection biases and inconsistent definitions or methods. For example, in their review of the carbon sequestration impacts of community forest management, Bowler et al. (2010) noted the lack of rigorous impact evaluations with before/after and control/intervention (BACI) research designs and the fact that most of the 42 studies they reviewed did not explicitly assess the local tenure systems. Importantly, Robinson et al. (2014) note that the terms “land tenure” and “property rights” are often used synonymously and may only refer to rights held by individual landholders, rather than the larger bundle of property rights that govern the use, management, and transfer of assets or the broader set of institutions and policies that constitute the local land tenure system. The authors also highlight the increasing recognition that landholders’ perceived (*de facto*) land tenure often has a greater influence on their land use decisions than their *de jure* tenure status (Broegaard, 2005; Unruh et al., 2005). Their findings not only strongly demand greater attention to the various forms of land tenure relevant to different forests, but also caution against assuming that any one form of tenure is more secure than others (Robinson et al., 2014).

Moreover, the global literature linking forest tenure and forest condition is heavily biased toward a few sites in South Asia, East Africa, and Latin America, with very limited evidence from elsewhere in Africa (Seymour et al., 2014). Given the difficulty of deriving clear policy recommendations from the existing literature, the authors call for additional research to address key research gaps. These include, *inter alia*, expanding the geographic evidence base, disaggregating the impacts of different property rights (e.g. withdrawal, management, alienation), analyzing the gendered nature of forest tenure and governance, and examining the relationship between customary and statutory rights and the impacts of government rules on communally managed lands.

This paper seeks to begin to address these evidence gaps through a cross-sectional analysis of an original baseline data set collected as part of a prospective impact evaluation of the Community based Forest management Project (CFP), a Reducing Emissions from Deforestation and Forest Degradation (REDD+) program in eastern Zambia. Launched in 2014, CFP aims to empower communities living near forests to establish and implement participatory forest and natural resource management plans and to promote alternative livelihoods that provide forest-dependent communities with sustainable livelihoods. Both the intervention and the impact evaluation are supported by the United States Agency for International Development (USAID).

This paper aims to contribute more reliable evidence to the global evidence base linking community-level land tenure and forest condition by exploring the association between perceptions of forest tenure security and forest condition using improved proxies for local tenure and land governance, filling a gap in the geographic coverage and spatial variability, and incorporating greater attention to the gendered nature of forest tenure, governance, and management. Our results are expected to inform on-going and future efforts to promote sustainable forest management, including in the context of recent global agreements that are likely to accelerate REDD+ implementation around the world. In particular, we hope that our more nuanced examination of local forest tenure and governance systems and the security they provide to forest-dependent land and resource users in eastern Zambia will influence the design and implementation of the multiple REDD+ projects targeting these forests, including a new landscape-scale BioCarbon Fund project, to ensure these efforts at least safeguard and ideally strengthen the rights of both de facto and de jure rights holders.

Forest tenure and deforestation challenges in Zambia

Zambia is of interest to global debates on forest tenure and condition as a result of both the continued dominance of customary tenure systems in rural areas and its high annual rate of deforestation. The Government of the Republic of Zambia (GRZ) recognizes private property rights in two tenure categories: statutory (leasehold) and customary. Statutory lands, which cover as little as 6% of all land in the country, are administered by the Government and subject to ground rents (taxes). By contrast, customary land, which covers most of the remainder (with the exception of protected areas), is governed by customary chiefs and their representatives, including village headmen and *indunas* (advisors), through largely informal and unrecorded systems for land allocation and dispute resolution (Persha et al., 2015).

Clear ownership and tenure security have increasingly been recognized as essential pre-conditions for successful REDD+ implementation (Larson et al., 2013), and overlapping formal and informal (including

customary) tenure systems could complicate REDD+ implementation in Zambia, particularly if forest-dependent communities are inadequately compensated (in kind or in cash) for the forest management (and, therefore, livelihood) changes that will be required to produce emissions reductions. Despite the lack of formal registration of customary land, recent findings from another USAID-supported study elsewhere in eastern Zambia suggest that overall, customary landholders perceive their (farm)land rights to be fairly secure from arbitrary and uncompensated encroachment or expropriation (Persha et al., 2015). Nevertheless, the GRZ retains rights to all trees (and wildlife) in Zambia, even those located on customarily administered lands (GRZ, 2015a, b).

Thus, in Zambia, as elsewhere, REDD+ highlights the need to clarify who holds specific property rights to forest resources (access, use, withdrawal, transfer) and the respective roles and responsibilities of various customary and formal government tenure and management systems (USAID, 2015). Although these forest tenure and governance issues are acknowledged as being critically important to REDD+, including by the Forest Carbon Partnership Facility, a World Bank-administered readiness and carbon fund, the processes through which REDD+ projects could effectively clarify and strengthen forest tenure and safeguard local communities' de facto rights and livelihoods are in general not clearly articulated (Naughton-Treves & Wendland, 2014; Sommerville, 2015).

At the same time, Zambia's roughly 50 million hectares (ha) are significantly threatened by demand for charcoal as a primary energy source and agricultural practices that rely on slash-and-burn methods to access and clear land for farming. While the country currently has the 4th highest forest cover in Africa, Zambia's forests are declining at an estimated annual rate of 250,000-300,000 ha, earning Zambia the distinction of being among the top 5 deforesters globally (UN-REDD, 2015).

Although Zambia is in the process of developing additional hydroelectric power capacity, the Zambian electric utility currently maintains a regular schedule of blackouts to address declining power capacity (Circle of Blue, 2015). Zambia is struggling to keep up with growing urban and industrial demand for affordable energy even as a majority of rural households live without electricity (Tembo & Sitko, 2013; World Bank, 2015a). The country has an annual population growth rate of 3.1%, among the highest in the world, and more than 64% of households live on less than \$1.90 a day (World Bank, 2015b). In the absence of more sustainable livelihood approaches and energy supplies, Zambia risks depleting its forest resources by 2030 if current rates of deforestation continue (USAID, 2013).

Study area

As shown in **Figure 1**, Eastern Province is located in eastern Zambia along the border with Malawi. The province contains globally significant biodiversity and large areas of intact forest. The climate is semi-tropical, with a single rainy season from November to April, and rainfall varies between 500-1400 mm per year. Average temperatures vary from 6-26 degrees in the cold season (April-August) and from 17-35 degrees in the hot season (September-October).

Roughly 1.5 million people live in Eastern Province, of which 87% reside in rural areas. The majority of households rely primarily on charcoal production and subsistence agriculture activities. More than 75% of households are poor, and roughly 60% live in extreme poverty (Tembo & Sitko, 2013).

Charcoal production is a significant driver of deforestation in the study area. The production, distribution, and marketing of charcoal are estimated to provide livelihood benefits to over half a million people in Eastern Province (Kalinda et al., 2008). Rural households often use charcoal to diversify and smooth their household incomes during periods of poor agricultural production in response to rising demand for charcoal from growing urban populations, particularly from low-income households (Vinya et al., 2011).

Other major drivers of deforestation and forest degradation in the area include logging, fuel wood collection, agricultural expansion, and the frequent use of fires. Land clearing through slash-and-burn is the second most important driver of deforestation in Zambia. A majority of Zambians depend on subsistence agriculture as their primary source of food and income (Ministry of Tourism, Environment and Natural Resources, 2002). A rising population coupled with the use of slash-and-burn and overgrazing (by both domestic and wild animals in the study area) may be simultaneously reducing the fallowing periods while increasing the required forest regeneration time. Fire is often used to hunt wild game, clear fields for cultivation, control brush, and manage pastures. When poorly managed, wild fires, particularly late in the dry season, can devastate forest cover and condition by slowing the regeneration and survival of young plants (USAID, 2015).

Ultimately, all of these drivers of deforestation and forest degradation are related to extremely high rates of rural poverty, which leaves households dependent on natural resource-based livelihoods, and high urban demand for charcoal in the absence of affordable alternative energy sources (USAID, 2015). A distinct (non-random) spatial pattern of deforestation in the study area appears to corroborate these trends.

Statistically significant hotspots of deforestation within the selected spatial extent are highlighted in red in **Figure 2**².

In light of these deforestation trends, it is not surprising that Eastern Province is the target of several REDD+ initiatives. These include USAID's CFP, as well as civil society-led activities to enhance soil carbon sequestration and a new landscape-scale BioCarbon Fund program. The BioCarbon Fund Zambia Integrated Forest Landscape Program aims to build on existing REDD+ strategies and action plans in country and cover 6 million ha over the next 10 years across Eastern and neighboring Muchinga Province, including through improved sustainable land management practices on 5 million ha and the protection of threatened intact forest on a further 1 million ha (BioCarbon Fund, 2015).

The CFP, which is perhaps the most advanced REDD+ program operating in forested areas in Eastern Province, aims to establish the largest site-based REDD+ program in Zambia, covering 700,000 ha of forests in Eastern, Lusaka, and Muchinga Provinces. The project is designed to reduce deforestation on customary lands, including in GMAs, and is defined by four primary objectives:

- Empower and equip communities to lessen the drivers of deforestation;
- Establish and improve forest and natural resource management plans;
- Promote alternative livelihoods to unsustainable charcoal and timber production; and
- Implement pay-for-performance and/or revenue-sharing programs for forest conservation and carbon sequestration.

Given that all of these projects depend on land use changes that reduce current levels of deforestation, the results of our analysis are expected to inform not only the CFP, but also other REDD+ projects operating in Eastern Province and even other on-going land use planning and forest management activities in Eastern and neighboring provinces.

² To detect hot spots of contiguous deforestation, historical areas of forest cover loss (2001-2014) were grouped into contiguous areas using an area threshold of 1 ha. After testing for spatial clustering, hot spots of forest cover loss were identified using area values and methods based on the Getis-Ord G_i^* statistic (Getis and Ord 1992). These methods identify statistically significant spatial clusters of high values (hot spots of larger contiguous deforested areas) and low values (cold spots of deforested areas).

Research Methods

Data and Analysis

Our analysis draws on three sources of data, including household and community perceptions of forest tenure, governance, and condition, as well as spatially-explicit data on biophysical and demographic characteristics. The data includes survey data from 2,822 households and 249 village surveys collected across three districts in eastern Zambia (Nyimba, Mambwe, and Lundazi). This survey data was collected in 2015 as part of the baseline data collection effort for an impact evaluation – designed in part to examine the relationships among forest tenure, governance, and condition – of the CFP REDD+ program in Zambia. The research design employed a multi-stage sampling methodology with villages selected by probability proportionate to size and household respondents identified through random selection following stratification by female-headed respondents, wealthier households, and youth-headed households. The village survey represents a survey of each village’s headman or headwoman. From the original baseline datasets, we restrict the observations for this study to include households with access to one primary forest for livelihoods and consumption. We also use spatially-derived statistics constructed from secondary data to control for contextual factors that may affect our outcomes of interest (Ferraro et al., 2011; Buntaine et al., 2014).

The structure of the data used in this analysis represents cross-sectional data, with households nested in villages nested in spatially correlated village clusters. Surveyed villages are often located very close to each other (some village centers are just 120 m apart). Given this clustering, the standard assumptions of independent observations are violated due to dependence among household and village observations. A modeling approach is required that takes into consideration within-cluster correlations. Two methodological techniques are employed to address these methodological issues.

First, we cluster villages in close proximity to each other using 2 km and 5 km buffers. Because neither household lands nor villages in Zambia have clearly defined or mapped boundaries, we created buffers in ArcGIS to approximate the area of forest access around sampled households and villages (DeFrees et al., 2005; DeFries et al., 2010). To do so, we first created a buffer around each village center coordinate based on the average reported distance to the edge of the forest (2 km) to approximate the distance to the nearest forest. Due to the close proximity of villages (some only 120 m apart) in the study area, we then constructed village clusters by merging the buffers around the villages that are clustered together to create one aggregate buffer zone around each village cluster and avoid double counting overlapping areas. A group of village clusters based on a 5km buffer was also created to account for longer distances that users might travel into the forests to access various forest products. This clustering exercise produced 41

clusters using the 2 km buffer and 18 clusters using the 5 km buffer. The aggregated buffers around the village clusters are shown in **Figure 3** along with patterns of forest loss.

Second, given the clustered nature of the data, the analysis uses applied multi-level modeling – or random-intercept models – to explore the relationship between forest condition and perceptions of tenure security, as well as the drivers of tenure security. Multi-level mixed effects regression models are used to correct for dependence among observations within the same cluster and to exploit the variance within and across levels to more accurately determine the effects of key covariates on outcomes of interest (Rabe-Heskith and Skrondal 2008). We include village and spatial cluster random effects in our models to explicitly take into account variation within and across these units. Our regression model is built with four components: a level-2 random intercept at the village level, a level-3 random intercept at the village cluster level, and a level-1 residual for household observations within villages. A sandwich estimator is used to produce “robust” standard errors for the coefficient estimates. As we have a different number of observations across clusters, our case is unbalanced.³ We run a mixed effects linear model for our two continuous outcomes of interest – perceptions of forest condition and tenure security.

Clustering complicates the use of buffers to extract biophysical and land cover characteristics (DeFreese et al., 2005 and DeFries et al., 2010). Spatial analysis of model residuals for the 2km buffer model indicates that spatial patterns can be distinguished for model residuals (**Figure 4**). A test using Getis-Ord G_i^* statistic shows two statistically significant cluster patterns⁴ for under-predictions (Lundazi District) and over-predictions (Nyimba District). These results suggest a geographic model may improve model performance in these areas.

The study investigates two primary research objectives. The first question is whether stronger forest tenure is associated with better forest condition. The second objective is an investigation of the household and village level factors that motivate variation in perceptions of tenure security among individual respondents and village leaders. To investigate heterogeneous outcomes by gender, we include an indicator for self-identified female heads of household.

³ Maximum likelihood estimates generated from the mixed methods approach will tend to weight smaller clusters more heavily than a standard ordinary least squares regression model.

⁴ These 2 clusters are consistent across the three models and also present when examining only residual outliers (above 2 standard deviations).

Independent and Dependent Variables

Our key relationship of interest is the association between tenure security and forest condition. We include the subjective perceptions of forest users as our measure of forest condition (Agarwal and Chhatre, 2006). By comparing assessments of change in 53 forests across 5 countries based on forest plots and user assessments, Nagendra and Ostrom (2011) demonstrated that user assessments of changes in tree density are strongly and significantly associated with field assessments based on statistical analyses of randomly distributed plots. As such, we developed an index of forest condition based on forest user responses to a series of five questions collected through the household surveys on various aspects of forest condition using principle component analysis (PCA).

Tenure security represents both an outcome and key independent variable of interest. As previously noted, Robinson et al. (2014) found that, although tenure form is not significantly associated with increased or decreased deforestation, increased security of tenure is significantly associated with positive forest condition outcomes. Given the centrality of rights to exclude others to both tenure security and successful efforts to reduce deforestation and forest degradation (REDD) (Larson et al., 2013), we asked households about the potential for forestland encroachment or reallocation by elites, chiefs, investors, and government authorities and used PCA to transform their responses into a tenure security perception index.

Building on the work of Razzaz (1993), Feder and Onchan (1987), Deacon (1994, 1999), and others, and given the extremely low prevalence of formal land registration and land transactions in the greater study area of eastern Zambia (Persha et al., 2015), we seek to measure perceived (*de facto*) tenure security over forest resources at the household and village level. Following Sjaastad and Bromley (2000) and others, we define tenure security here primarily as a measure of assurance that existing rights will be upheld for the foreseeable future.

For the purposes of measuring tenure security, we focus on the perceived risk of encroachment or reallocation by local elites, chiefs, investors, or government authorities in the near (1-3 years) and distant future (beyond 3 years) as reported by households and headpersons. Given the nested nature of customary forest governance in the study area, we investigated measures of tenure security as perceived by both households, as semi-autonomous resource users, as well as headpersons, who may have additional information on potential threats to tenure security given their role in representing their villages. For both households and headpersons, a higher score on our tenure security scale, which we created using PCA, indicates more secure perceived forest tenure. Our measures of tenure security draw from other studies

that have measured the perceived risk of disruption of rights through eviction or expropriation, including Sjaastad and Bromley (1997), Holden and Yohannes (2002), Jacoby et al. (2002), and Robinson (2005).

Our model covariates are designed to proxy and control for bio-physical, geographic, demographic, socio-economic, institutional, management, and governance related factors that have been identified in the literature on common pool resource (CPR) governance (e.g., Gibson et al., 2005; Ostrom, 1990, 2009; Robinson et al., 2014) and the drivers of deforestation (e.g., Ferretti-Gallon and Busch, 2014; Chomitz et al., 2007) as having an important impact on forest condition. **Table 1** describes and provides summary statistics for our household and village covariates.

Following Ferraro et al. (2011), Buntaine et al. (2014), and other studies aiming to control for deforestation-related covariates, we include a number of biophysical and geographic variables generated from available secondary data that have been shown to be associated with greater rates of deforestation. These include proximity to roads, which is consistently associated with greater deforestation (Ferretti-Gallon and Busch, 2014) through infrastructure's role in increasing land values and enabling greater access to forest resources (Nepstad et al., 2001; Arima et al., 2005; Rudel et al., 2009). We also measure distance to the nearest urban market area as a proxy for market pressure. Since rainfall and elevation are also determinants of both forest type (Buntaine et al., 2014) and – through their relevance to alternative land uses, in particular agriculture, and access (Yackulic et al., 2011) – deforestation (Ferretti-Gallon and Busch, 2014), we examine these biophysical variables, as well. Although increased population density is associated with increased resource use intensity (Laurence et al., 2002), the precise relationship between greater population and greater deforestation is difficult to untangle (Rosero-Bixby, 1998). Nonetheless, greater population is strongly associated with greater deforestation globally (Ferretti-Gallon and Busch, 2014), so we include population density in our model specifications.

In addition, we incorporate a number of institutional, management, and governance variables from our household and village surveys that build on the seminal research on CPR by Ostrom (1990), as well as more recent work by Agrawal and Chhatre (2006), Persha et al. (2011), and other affiliates of the International Forestry Resources and Institutions (IFRI) research program. Given the focus of this study on commonly managed forests, we build on Ostrom's theory of governance issues relevant to CPRs and focus on customary rights of forest access, use, and withdrawal conferred by traditional authorities (some of which are in fact contradicted by Zambian law) and the role of local forest users and traditional authorities in forest management and governance.

We therefore include several variables at the household and village levels related to local forest governance that draw from Ostrom's CPR governance theory and recent studies linking various aspects of forest governance to forest condition. The existence of rules governing forest resource use and the monitoring, enforcement, and sanctioning of rule violation has consistently been shown to be positively associated with improvements in forest condition. Gibson et al. (2005) found that regular monitoring and sanctioning are strongly associated with better forest conditions, irrespective of levels of social capital, formal organization, or forest dependence. Similarly, Hayes (2006) also found that the presence of rules was positively correlated with vegetation density. Chhatre and Agrawal (2008) reviewed data from 152 forests across 9 countries and determined that local enforcement was strongly and positively associated with forest regeneration.

The presence of local forest governance institutions, their effectiveness, and local participation therein, also key components of effective CPR governance and have similarly been positively associated with forest cover. For instance, Hayes (2006) found that the ability of users to make forest rules was positively associated with vegetation density. Chhatre and Agrawal (2009) studied trade-offs and synergies between the carbon storage and livelihood benefits derived from forests and concluded that the degree of rulemaking autonomy, as measured by forest user satisfaction with forest conservation measures, was positively associated with high carbon storage and livelihood benefits and negatively associated with the converse. Van Laerhoven (2010) came to similar conclusions from a cross-national dataset, finding that forest user group organization, leadership, and rule-making autonomy appear to contribute significantly to a group's ability to overcome collective action dilemmas and effectively govern their common forest.

As such, we include variables on the presence of local forest governance institutions, including forest user groups, and opportunities for local participation in these institutions. We also incorporate variables on the perceived effectiveness of these institutions, including household confidence about the capacity of local village governing institutions to enforce household rights in the context of a forest related dispute and household satisfaction with local leaders' management of forests, in our model specifications.

Similarly building on the IFRI research program, we include a series of indicators to measure livelihood strategies and household dependence on the forest. The literature on the relationship between forest dependence and forest condition is somewhat mixed. Some studies build on the assumption that a household that is highly dependent on the forest to meet their livelihood needs is more likely to value the forest's long-term sustainability – and therefore more willing to accept higher costs to follow rules and monitor others' compliance – than a household that is not dependent on the forest (Gibson 2001). For example, Persha et al. (2011) reviewed 84 cases across 6 countries and demonstrated that sustainable

forest outcomes were more likely where forests provided a higher proportion of commercial household livelihoods. Likewise, in their study of 95 sites in India's Himachal Pradesh state, Agrawal and Chhatre (2006) found that sites characterized by higher levels of subsistence benefits were associated with better forest condition and conclude that communities are more likely to protect and maintain forests on which they rely for subsistence livelihoods.

In contrast, Chhatre and Agrawal (2008) found that forest regeneration was more likely in forests with low levels of subsistence dependence, while degradation was more likely in forests with high subsistence dependence. Gibson et al. (2005) also found that forest dependence was less relevant than other factors, such as rule enforcement, in determining forest outcomes. Given the contradictory evidence on the relationship between forest dependence and forest condition, we seek to contribute new evidence and therefore include variables to capture household dependence on forest products, including the number of forest products collected for income and for consumption, as well as a variable to capture household perceptions of the tangible (e.g., community development, livelihood) benefits of forests as an additional measure of forest dependence.

Finally, greater poverty has been shown to be consistently associated with lower rates of deforestation (Ferretti-Gallon and Busch, 2014). As such, we include a constructed variable to proxy household wealth based on a sample of key assets in the study area, as well as a village wealth proxy (the proportion of houses with roofing materials other than grass thatch). While Ferretti-Gallon and Busch (2014) did not find either education or gender to be consistently associated with either higher or lower levels of deforestation in their meta-analysis of 117 studies, for completeness we include a variable for the highest level of education attained by anyone in each household and the gender of the respondent (initially limited to the household head).

Moreover, as noted by Meinzen-Dick, et al. (2011), a considerable body of literature documents women's knowledge of and dependence on forest products, on the one hand (Shanley and Gaia, 2001; Howard, 2003; Colfer, 2005), as well as inequities in their participation in forestry co-management (Tinker, 1994; Locke, 1999, Agarwal, 2001) and devolution (Blessings, et al., 2006; Jumbe and Angelsen, 2007), on the other. In many societies, women face significant legal and social barriers to equal access to and control over forest lands and resources (Place, 1995; Meinzen-Dick, et al., 1997) and are excluded from decision-making at household, community, and national levels (Agarwal 2001). Women are also often excluded from or disadvantaged in their access to important services that may have an impact on forests, such as credit, extension, and technology (Doss, 2011; German, et al., 2008).

Even where they are nominally included in forest decision-making, women typically are less capable of influencing these decisions, as a result of both socio-cultural barriers and gendered differences in levels of formal education, employment, income, and personal networks (Agarwal, 2001; Coleman and Mwangi, 2013; Crewe and Harrison, 1998; Mwangi et al., 2011). Importantly, Agarwal (2001) outlined a typology of participation, varying from nominal, which is limited to membership in a group, to interactive (empowering), which is characterized by having voice and influence in the group's decisions. We therefore seek to understand the extent to which women and men participate to varying degrees in forest management.

Despite general agreement that increasing women's access to forest resources and participation in forest management are potentially important strategies for reducing gender inequalities and improving the efficiency of forest management (Agarwal, 2001; Meinzen-Dick, et al., 1997), the literature includes contradictory evidence on the influence of women's participation on forest management and condition. This may help to explain the insignificance of gender in the meta-analysis completed by Ferretti-Gallon and Busch (2014). For example, although Bina Agarwal hypothesized (2001) that increasing women's participation in forest management would result in more efficient forest management outcomes based on her field research among community forest groups in India and Nepal, her later research (2007; 2009) suggests that women's participation in household and community decision-making does not necessarily result in improved forest regeneration. Likewise, Mwangi, et al. (2011) studied a total of 151 forest user groups across Bolivia, Kenya, Mexico, and Uganda and found that female-dominated groups were less likely than mixed or male-dominated groups to undertake several management strategies associated with improved forest outcomes, including the adoption of improved technologies, such as bee-keeping, as well as participation in monitoring and sanctioning forest rules. The authors present a number of plausible explanations for these findings, including constraints on women's access to new technologies and extension services and their more limited availability of labor, especially physically demanding labor, as compared to men. At the same time, more recent analysis by Coleman and Mwangi (2013) on these and other data suggest that a history of women's participation in forest management, particularly in leadership positions, is associated with less disruptive conflict. As such, our research seeks to contribute to a more nuanced understanding of the role of gender in influencing forest management and condition, particularly given that women continue to be among the poorest and to rely on forests for their subsistence, income, and safety nets in many developing country contexts (CIFOR 2008).

Study Context and Background

In addition to average sample statistics, Table 1 presents descriptive statistics for our independent and dependent variables of interest across Nyimba, Mambwe, and Lundazi districts, including by male-headed and female-headed households. The results provide insight into the level of forest degradation in the study sample. 25% of household respondents rank forest condition as degraded, and over half of respondents 55% (1707) note that the trees, undergrowth, and the capacity of the forest to provide resources for the community has worsened over the past 3 years. Respondents note a decrease in forest condition across the categories of forest thickness 50% (1557), area 46% (1425), and availability of products 44% (1362).

Despite concerns about a worsening of forest condition, 59% (160) of headmen/women said that forest degradation was not a problem facing their community's development. Similarly, 58% (2152) of households did not identify forest degradation as a problem for their households. Although forest degradation is not ranked as the largest challenge to the majority of households or communities, these concerns vary across the sample. 9% (25) of village leaders rank it as the largest problem facing their village, and 34% (1253) of households report that forest resources are one of the top five important things for community development. Correspondingly, forest dependence varies across households. 15% (558) of households in the sample are not dependent on the forest for consumption or income benefits; however, 85% (3172) depend on the forest for consumption, and 21% (794) depend on the forest for income.

The sample is predominately characterized by a customary tenure regime for forest use and access. 85% (2119) of households note use and reliance on forests that are on communal land, whereas 13% (390) use forests on state land or game management areas (GMAs). In this predominantly customary context, the headperson and chief are reported as being the primary rule and decision-makers regarding forest use and management. 75% (2780) of household respondents note that the chief is the most important decision-maker regarding forest use and management, whereas 23% (838) say that the headman is most important. Overall, 77% (2858) of households are satisfied with the way that local leaders govern forest resources, with responses generally ranging from 72-78% depending on questions about fairness of use, fairness of access, transparency, etc. The exception to this includes corruption and enforcement. Here we see that 37% of respondents expressed the likelihood of bribe taking by local leaders, and 32% did not feel confident that local leaders would enforce their rights during forest related disputes.

There are similar levels of concern about unauthorized expropriation across households and headpersons. The category of greatest concern to respondents is that the chief will reallocate or take land without village consultation – this is expressed by 27% (973) of households and 29% (78) of headpersons. Next,

the government is seen as a source of unauthorized reallocation by 27% (950) of households and 25% (68) headpersons. Approximately 18% of households express concern over potential land confiscation by elites and investors, whereas these figures are 17% and 22% for headpersons, respectively. This level of concern may be explained – in part – by actual experiences with expropriation and loss of land in the past. Out of 272 villages in the sample, 5% (13) said that customary land under forest cover had been sold or leased to someone from outside the village in the past five years, and 24% (66) report no longer being able to access previously accessible forests. Thus, the results suggest that most people feel fairly secure in their rights to forests, although a significant minority report tenure insecurity that may only partly be explained by people's own prior experiences.

Results—Association between tenure security and perceptions of forest condition

Table 2 presents the results of the models measuring an association between household perceptions of tenure security and perceptions of forest condition outcomes. The first model specification represents a two level model with household observations nested in village clusters. The second and third specifications are three level models that include households nested in villages, which are themselves nested in village groups defined by 2 km and 5 km buffer zones, respectively. The output generally shows that the models are robust to variations in these three specifications, although there are differences in the level of significance for some indicators. The exception to this is the requirement of a permit for harvesting forest products, which loses statistical significance in the 5 km model. In this section, we report the results of the three level model with village clusters generated through the 2 km buffer, which is based on the average distance to the edge of the forest (2 km) as reported by the household survey.

For our key independent variable of interest, the results show a small but statistically significant positive marginal effect of .08 for household perceptions of tenure security on forest condition. Lending empirical support to Robinson et al. (2014), our findings provide evidence that stronger forest tenure is associated with better forest conditions.

Among the village level spatially-derived measures, elevation, travel time to markets, and distance to tarmac road are all statistically significant. In contrast to the literature, the results show an extremely small but negative significant association between forest condition and higher elevation. Our study area is not defined by widespread variation in elevation and does not include areas with steep terrain or high altitude. Thus, the elevation results may suggest that trees located in hard to access swampy lowland areas may be better protected than trees at higher elevations.

Counter to the scholarship, we also see a negative relationship between distance to the main tarmac road and forest condition. This could be an indication that forest clearing is targeting areas farther from the main road to avoid detection. However, in line with the deforestation literature, the regression output shows a small but significant effect on forest condition of travel time from villages to the urban center of Chipata town in Eastern Province. This finding supports the argument that there is less pressure on forests farther from markets and areas undergoing urbanization. There is no relationship in our models between forest condition and precipitation or population density. The lack of influence of these variables, which are often found to be key indicators in other empirical work, is most likely due to the lack of biophysical and geographic variation in our study area. As the summary statistics in Table 1 indicate, our rainfall frequency has a short range of just 20 to 23 days per year, and the population density ranges from 5 to 56 per square km.

Although, as noted above, the evidence on the relationship between forest dependence and forest condition is somewhat mixed, our results support the argument that greater dependence on the forest for livelihoods translates into worse forest condition. In particular, for our livelihood, dependence, and wealth indicators, greater subsistence dependence on the forest and higher levels of village wealth both trend with deteriorating forest conditions. With the exception of chieftdom and presence of permits, these two covariates also reflect relatively high marginal effects compared to other indicators in our models. Specifically, the marginal effect of consumption dependence on condition is $-.11$ and the marginal effect of village wealth is $-.62$. Our quadratic measure of forest dependence for income shows that as the number of products harvested for income increases, the effect of this covariate on negative forest condition is strengthened. However, the value of the forest for community development and headperson wealth did not represent significant covariates in our models. These results could reflect greater overharvesting of forest products or deforestation due to the lack of alternative livelihoods. It may also be the case that forests that users deem less important are less subject to resource extraction and related degradation, highlighting the need to carefully examine the concept of dependence (Beckley, 1998; McSweeney, 2002).

Among the governance proxies, the results show a positive relationship between permit requirements for the harvesting of forest products and better forest conditions, in line with what we would expect to see. There is a significant inverse trend between the presence of a greater number of rules and degraded forest condition, which most likely indicates that we are observing the endogeneity of increased rules in forests that have been overexploited. Contrary to the literature, we do not see a significant influence on forest conditions for village participation in forest related decision-making, the existence of a village institution for forest management, or the capacity of local village institutions to enforce rights in the event of a

dispute. However, it could be the case that communities in the study area rely more heavily on institutions larger than the village level (e.g. at the chiefdom level) to facilitate community representation in forest decisions, effective forest management, and dispute resolution.

In line with the findings of Ferretti-Gallon and Busch (2014), we do not find that the gender of the household head is statistically significant in this model. This suggests that there is not a strong direct association between the gender of the household head and forest condition. Indeed, Coleman and Mwangi (2013) find that women's participation in forest management is more likely in households with more education and where economic inequalities are limited, particularly across genders, suggesting that other socio-economic factors may influence the effect of gender on participation in forest management. Even though resource rights and use often differ by gender, it may also be the case that there is less variance in overall forest use and participation in forest governance at the level of a household, *ceteris paribus*, regardless of the gender of the household head (Meinzen-Dick et al., 1997). Still, these initial findings merit additional attention, particularly given the considerable literature documenting the differences in the ways that women and men use and manage forests and resulting differences in forest outcomes (e.g., Agarwal, 2001, 2007, 2009; Mwangi et al., 2011). It is also possible that, as a result of their exclusion from forest governance decision-making, female-headed households are less aware of potential issues and threats related to their community forests (e.g., Agarwal, 2001). Nonetheless, future analyses will attempt to isolate the effects of female-headedness from other potential sources of vulnerability (age, wealth, education) and will incorporate the results of our survey of female spouses within male-headed households to better represent the diversity of women's experiences in the study area (Meinzen-Dick et al., 1997; Crewe and Harrison, 1998).

Why variation in tenure security?

The second key research question motivating the study is: What factors explain variations in tenure security? The outcome indicator under analysis – tenure security – represents the key independent variable used in our models on the relationship between forest condition and tenure security. We asked households about the potential for forestland encroachment or reallocation by elites, chiefs, investors, and government authorities and used PCA to transform their responses into a tenure security perception index.

In this section we seek to explore what factors motivate variation in perceptions of forest tenure security with a focus on the influence of customary governance and local land pressure. We include a discussion of how past circumstances and current pressures motivate variation in the study sample's assessment of secure access to forest resources.

Our model for assessing possible drivers of tenure security combines several closely related but often distinct fields of study around common property resource governance, customary tenure, and the recent trend of medium- and large-scale land acquisitions in Africa. Building on the broader literature on CPR (e.g. Meinzen-Dick et al., 2002; Ostrom, 1990, 2000, 2009; Schlager and Ostrom 1992), we hypothesize that a number of factors related to the governance of CPR may help explain existing forest tenure (in)security in the study area. These include the extent to which forest management is decentralized, as measured by several household and headperson assessments of the most important forest decision-makers; the existence of rules governing forest use by individuals outside the village; the extent to which village forest rules are seen as fair, as reported by headpersons; and are enforced, as proxied by the identification of persons responsible for forest rule enforcement; and the extent to which forest governance is participatory, as measured by the existence of village-level forest decision-making bodies and the participation of village members in negotiations with outsiders over forest access and use. Our model therefore assumes that overall good governance of the forest, an important common property resource, is likely to be associated with higher levels of forest tenure security for households and villages.

Similarly, drawing from the broader literature on customary tenure systems, particularly in Africa, we note that although they are often assumed to be equitable, customary tenure systems, where rights are typically derived from group (“community”) membership, do not necessarily provide equal security (or rights) to all group members. Historically, many African tenure systems resembled feudal systems, characterized by landlordism and the exclusion of poorer members of society (Alden Wily 2012). There is even some emerging evidence from West Africa that traditional tribute payments given in exchange for land allocation [called a “gift” or “chicken” in parts of eastern Zambia (Sommerville et al., 2016)] may be constraining land access by the poor and youth (Alden Wily 2012). We therefore include a variable capturing whether a household is in the bottom quarter of a socio-economic asset-based scale⁵ for their village. We also include a variable measuring human capacity (the highest level of education obtained by any member of the household) as an additional proxy for vulnerability (households with low levels of education) or elite status (high levels of education).

Moreover, given that customary systems typically confer only indirect or secondary rights to women through their relationships to male relatives (FAO 2007), we are interested in the extent to which tenure

⁵ The socio-economic asset scale is comprised of durables, livestock assets, landholdings, and house materials.

security differs for women as compared to men.⁶ Much literature has documented inequalities in women's access to and control over land and other natural resources, including trees, as compared to men (e.g., Meinzen-Dick, et al., 1997; Place, 1995). Importantly for this context, Meinzen-Dick, et al. (1997) note that women's property rights to land in forest-dominated landscapes may be limited by their relative inability to invest the considerable labor required to clear forest land for cultivation, which is typically a prerequisite for claiming rights in these landscapes. Women may also be differentially able to enforce their claims to land as compared to men, particularly through formal institutions (Adoko, et al., 2011).

Of course, it is also imperative to understand differences among women, in particular related to class, marital status, inheritance systems (patrilineal vs. matrilineal), and power relationships, that may affect their *de jure* and *de facto* property rights (Meinzen-Dick, et al., 1997). While female-headed households are often naively assumed to be disadvantaged as compared to male-headed households, Ahlers (1995) has reported that some wealthy widows have similar opportunities for investment and returns as a typical wealthy male household. Recognizing this complexity, we thus include a variable indicating the gender of the household head to test whether the property rights of female-headed households are, in fact, disadvantaged as compared to male-headed households in our study area, which is located within a forested landscape that has historically been characterized by both matrilineal and patrilineal inheritance traditions.

Finally, although a thorough overview of recent land acquisition trends in the region is beyond the scope of this paper,⁷ we note that Zambia, like many countries in sub-Saharan Africa, is pursuing the development of large-scale agricultural investments ("farm blocks") as part of its agricultural development strategy (Deininger et al. 2011). While these investments do not explicitly target forested areas, central government efforts to strengthen forest management and conservation, including through REDD+, game management areas, and protected areas, do target forests, and any of these interventions may (inadvertently) affect the customary rights of local forest users, as evidenced, for example, by reforestation efforts in neighboring Uganda (Land and Byakola 2006). As such, we include a variable indicating whether the village has previously lost access to a forest (as reported by the village headperson) as a proxy for land pressure and a possible driver of tenure insecurity. Moreover, the growing area under medium-scale, statutory farms acquired primarily by urban elites may be driving pockets of land scarcity in Zambia, particularly near urban settlements (Sitko and Jayne, 2014; Jayne et al., 2014). We therefore

⁶ Our initial model includes a variable for the gender of the head of the household. However, our baseline data set also includes tenure security perception data collected from females within male-headed households, and we plan to incorporate this additional sub-group of women in future analyses.

⁷ See, for example, Deininger et al. (2011) or Schoneveld (2014) for comprehensive overviews of this trend.

include a variable measuring the hours of travel to the nearest urban market (as reported by the village headperson) as a proxy for pressure on land. In addition, we include the incidence of forest-related conflict and the presence of local conflict resolution mechanisms, as these are posited to be relevant drivers of tenure (in)security, particularly in the context of REDD+ and other investments that potentially affect customary land rights (Deininger et al., 2011; USAID, 2013).

Results 2—Factors driving variation in tenure security

Table 3 presents the analysis results for factors driving variation in tenure security. Similar to the multi-level model set-up for our forest condition series above, the first model specification represents household observations nested in village clusters followed by three level models that include households nested in villages, nested in village groups defined by 2 km and 5 km buffer zones, respectively. Model results are for the most part robust across specifications, although there are differences in the level of significance for some indicators.

There are some notable exceptions, however, including the presence of a village conflict, which is not significant in the 2 km model. In the village and 5 km models, the presence of a village conflict is significant and associated with lower tenure security, which is in line with what we would expect and also appears to support other recent findings from a nearby area in Zambia (Persha, et al., 2015).

Also, the number of forest rules is only slightly significant in the village model but loses significance in the 2 km and 5 km models. At the village level, more forest rules are associated with less security of forest tenure, which suggests that this variable may actually be measuring the latent intensity of forest use rather than the quality of forest governance. We found similar results related to rules for farmland and tenure security in another study site in eastern Zambia (Persha, et al., 2015).

Dependence on the forest for subsistence use is not significant for the village or 2 km models, but in the 5 km model, greater subsistence dependence is significantly associated with lower tenure security. This suggests that greater dependence on the forest for subsistence use may be associated with increased pressure on – and competition over – the resource, in line with our finding that increased dependence is associated with lower forest condition.

At the village level, relations of the chief reported higher levels of tenure security, which is in line with what we might expect based on the literature (Alden Wily, 2012). However, the effect is very small and only marginally significant at the village level and is not significant in either the 2 km or 5 km models.

In this section, we report the results of the three level model with village clusters generated through the 2 km buffer, which is based on the average distance to the edge of the forest (2 km) reported by households. Several household and village level measures of governance are statistically significant in the models. One trend across both levels is that greater involvement and influence of the headperson in forest management and decision-making is associated with higher perceived household tenure security. Not surprisingly, moving from the headperson as the primary decision-maker regarding forest management and rules to uncertainty about leadership and decision-making is strongly associated with lower tenure security. However, moving from the headperson to the chief as the primary decision-maker regarding forest management and rules is also associated with lower tenure security. This significant association is present in both village and household level indicators. At the household level, as the headman moves up in influence on the forest management “ladder of power,”⁸ we see a small but significant association with increased tenure security. By contrast, as the chief moves up in influence on the forest the forest management “ladder of power,” we see a negative association with tenure security.

We do not see significant results with other governance proxies included in the model. We do not see a significant association of tenure security with moving from the headperson as the primary decision-maker to a government entity (such as the *Zambian Wildlife Authority [ZAWA]* or the *District Forest Officer [DFO]*) or to village elders or a village committee. The presence of more formal forest management processes or institutions in the village also do not track with perceptions of tenure security, nor does our household level index of satisfaction with local governance.

Proxies for forest dependence indicate mixed results. Greater reliance on or use of the forest for income is associated with greater tenure security, which may reflect more dependable or unrestricted access, although we do not see this result for consumption use. On the other hand, there is a negative relationship between the importance of the forest for community development and tenure security. This could indicate feelings of threat for more desirable areas – for example, due to the presence of safari lodges or other eco-tourism investments that are linked with employment but also the loss of forest access.

Two other key village level factors predicted to have a significant effect are not associated with variation in tenure security. Interestingly, having lost access to a forest in the past is not a significant predictor for current levels of forest tenure security, nor is travel time to urban centers, which serves as our proxy for market pressure. This could be because of the remoteness of our study area, or because forests in the

⁸ The survey question defines a ladder of power from 1 to 10 with people at the top of the ladder (10) having the most decision-making power in the village regarding forest use and access. Those at (1) on the ladder have ‘no say’ in forest related decision-making.

study area are still perceived to be adequately abundant. For household level demographics, greater household wealth is associated with slightly lower levels of tenure security; however, education is not significant, and results do not indicate a significant difference between male- and female-headed households. The lack of significance of the household head gender may indicate that this characteristic is less important than other household qualities, such as wealth, in determining tenure security, as suggested by Meinzen-Dick, et al. (1997) and others. As discussed above with respect to the forest condition results, women may also be less aware of potential threats to their tenure if they are less involved in community decisions regarding forest management. Overall, this finding merits further attention, and, as noted already, we intend to conduct additional analyses to tease out these nuances and to incorporate the results of a survey of female spouses to better understand the experiences of different women in the community.

Conclusion and Discussion

On the relationship between forest tenure and forest condition, many of our initial results are in line with what we would expect. For example, more secure tenure and the existence of permits are both associated with better forest condition, as is greater distance from urban areas. Moreover, greater wealth and greater dependence on forest products are associated with lower forest condition. However, some of our results require further examination, including to understand whether the number of forest rules is a better proxy for forest access than forest governance and why we do not see significant effects of local forest governance institutions or proximity to tarmac roads, as we would expect. We also intend to explore our gender findings in greater detail to determine whether women in male-headed households report similar experiences with respect to forest management and forest outcomes as those reported by women heads of households.

Similarly, on the drivers of secure forest tenure, several of our results are in line with the existing literature, in particular the role of decentralized (village level) governance in securing tenure and the higher levels of security experienced by local elites as compared to average community members, the latter of which appears to corroborate other recent research showing an increasing concentration of land in the hands of urban-based elites (Jayne et al., 2015; Sitko and Jayne, 2014). However, some of our results require additional analysis, including to understand whether higher dependence on forests and the existence of more rules governing forest use may again be latent proxies for pressure on and competition over forest resources and whether women in male-headed households report different levels of tenure security as compared to their spouses, particularly since we do not initially observe differences between levels of tenure security reported by male- and female-headed households.

Policy and program implications

Our data suggest that the existing customary tenure system may indeed provide more secure tenure to local elites than average community members, which has important equity implications, particularly in the context of REDD+ and other rural investments, where relatively more wealthy members of communities may be better positioned to negotiate REDD+ agreements and benefits to their advantage. For example, elites may be better able to ensure that REDD+ agreements do not affect their livelihood strategies, to modify their livelihood strategies to account for reduced forest access if necessary, and to access REDD+ benefits, including both direct payments and indirect benefits, such as technical assistance related to alternative livelihoods. Moreover, while overall our household survey findings suggest that most forest users perceive their forest tenure to be relatively secure, it is important to note these findings are limited to households that currently access the forest. As such, there may be other vulnerable groups that have lost forest access whose perceptions are not reflected in the results above. Indeed, our qualitative findings (not reported here) do highlight weak exclusion rights and multiple instances of lost forest access and local user rights among women, youth, and other vulnerable groups, which further underlines equity concerns in the context of agreements and benefit sharing related to REDD+ and associated activities that seek to reward forest users for reducing forest loss.

Furthermore, our findings highlight the need to understand local accountability in existing customary governance structures and local forest dependence in the context of designing and enforcing REDD+ agreements. In particular, although stronger chiefs may appear to be better partners for reducing deforestation and forest degradation, our results suggest that forest governance and tenure security suffer when chiefs' power overshadows village-level institutions, including headmen. Again, this has important implications not only for the ability of REDD+ to actually achieve changes in forest conditions, but also for the equity of REDD+ benefit sharing mechanisms, as the risk of elite capture appears quite salient in the program area.

At the same time, our results suggest that increased forest dependence is highly correlated with reduced forest condition in the study area, which highlights the importance of carefully designing alternative livelihood activities that will replace subsistence and income-generating opportunities foregone as part of REDD+ agreements. In the absence of sustainable alternatives, it is likely that REDD+ agreements will either not be enforced in practice or could inadvertently lead to further impoverishment among the targeted beneficiaries. We therefore hope that this paper will contribute to a better understanding of these and other contextual issues and trends in the study area that can ultimately inform the implementation of the CFP and other REDD+ programs in Zambia.

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(CONTINUED) TABLE 1—Summary statistics for household and village covariates

Variable Name	Variable Descriptions	Overall			Nyimba - District			Mambwe - District			Lundazi - District			Males			Females		
		Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
Level 2- Village																			
Lost access	binary if 1, village lost access to a forest	0.25	0.43	277	0.38	0.49	129	0.17	0.38	78	.10	0.31	68						
Rule maker	1=Headman, 2=Village elders, 3=Chief, 4=No one, uncertain 5=Local government	2.49	1.42	259	2.42	1.50	128	2.57	1.22	76	2.50	1.45	65						
Forest type	1=State or GMA, 2=Communal land in this village, 3=Communal land in another village, 4=Private/other	2.11	0.37	277	2.14	0.29	129	2.19	0.46	70	2.0	0.41	67						
Market pressure	Travel time to markets A in hours	6.54	2.58	277	7.01	2.67	129	6.61	1.80	78	5.33	2.27	68						
Village conflict	total village conflicts, across all conflict types	.40	0.72	277	0.56	0.82	129	0.29	0.61	78	0.19	0.43	68						
Rules	index from rules+rules_outsiders - higher score has more rules	3.36	2.29	277	4.1	2.15	129	3.29	2.18	78	2.27	1.98	68						
Institutions	existence of griev mech or budgeting or planning (0/1)	.30	0.46	277	0.35	0.48	129	0.31	0.46	78	0.18	0.39	68						
Headperson socio-econ	1=Grass thatched, 2=Iron/tin/zinc sheets/other non grass	1.58	0.58	277	1.65	0.61	129	1.75	0.44	78	1.28	0.45	68						
Distance to roads	Distance from village center to nearest tarmac road (km)	30.42	28.65	276	12.12	10.79	129	42.17	12.91	78	53.84	40.06	67						
Headperson participation	Participation of the headperson in forest management	0.27	0.44	277	0.36	0.48	129	.20	.40	78	0.16	0.37	68						
Village socio-econ	Higher means a wealthier village	1.33	0.21	277	1.38	0.19	129	1.44	0.17	78	1.16	0.14	68						
Headperson tenure security	Scale of 1-6, higher means reduced perception of reallocation or encroachment	4.69	1.55	264	4.09	1.74	122	4.72	1.46	74	5.48	0.93	68						
enforce_effectivec	Effective village rule enforcement	2.45	1.08	264	2.48	0.99	122	2.45	1.15	74	2.41	1.17	68						
Level 3 - Cluster																			
Elevation (2km)	Elevation by 2km group cluster	19.00	13.33	277	6.38	4.07	129	33.13	4.71	78	28.26	6.64	68						
Elevation (5km)	Elevation by 5km group cluster	8.11	5.50	277	2.99	1.62	129	14.57	1.83	78	11.01	2.76	68						
Rainfall frequency (2km)	Yearly rainfall frequency by days by 2km group cluster	21.43	0.50	277	21.43	0.63	129	21.47	0.32	78	21.32	0.36	68						
Rainfall frequency (5km)	Yearly rainfall frequency by days by 5km group cluster	21.44	0.46	277	21.42	0.61	129	21.54	.20	78	21.33	.30	68						

TABLE 2—Results of the models measuring an association between household perceptions of tenure security and perceptions of forest condition outcomes

	Model A	Model B	Model C	Model D	Model E	Model F
VARIABLES	Forest condition	Forest condition				
Village socio-econ	-0.610** (0.257)	-0.591** (0.256)	-0.610** (0.243)	-0.591** (0.240)	-0.610*** (0.213)	-0.621*** (0.197)
Headperson tenure security			0.0386 (0.0310)			0.0386 (0.0250)
HH participation (meetings)	0.0764 (0.0994)	0.0731 (0.0996)	0.0764 (0.0736)	0.0731 (0.0730)	0.0764 (0.0747)	0.0741 (0.0751)
Income dependence	0.0960** (0.0463)	0.0954** (0.0463)	0.0960*** (0.0349)	0.0954*** (0.0351)	0.0960** (0.0409)	0.0957** (0.0403)
Forest livelihoods	-0.0711 (0.0746)	-0.0766 (0.0747)	-0.0711 (0.0829)	-0.0766 (0.0824)	-0.0711 (0.0722)	-0.0788 (0.0715)
Consumption	-0.111*** (0.0380)	-0.109*** (0.0381)	-0.111** (0.0443)	-0.109** (0.0432)	-0.111** (0.0542)	-0.109** (0.0538)
Income	-0.272** (0.119)	-0.272** (0.119)	-0.272*** (0.0925)	-0.272*** (0.0920)	-0.272** (0.113)	-0.274** (0.111)
Average elevation	-0.00117** (0.000472)	-0.00124** (0.000486)	-0.00117** (0.000538)	-0.00124** (0.000553)	-0.00117** (0.000486)	-0.000935 (0.000603)
Ranfall	-0.164 (0.150)	-0.159 (0.153)	-0.164 (0.157)	-0.159 (0.163)	-0.164 (0.170)	-0.227 (0.154)
Population Density	-0.00395 (0.00441)	-0.00340 (0.00442)	-0.00395 (0.00462)	-0.00340 (0.00466)	-0.00395 (0.00446)	-0.00139 (0.00360)
Forest type	-0.0754 (0.0650)	-0.0821 (0.0652)	-0.0754 (0.0876)	-0.0821 (0.0845)	-0.0754 (0.0796)	-0.0759 (0.0785)
Household tenure security	0.0838*** (0.0215)	0.0819*** (0.0215)	0.0838*** (0.0303)	0.0819*** (0.0301)	0.0838*** (0.0278)	0.0827*** (0.0276)
Headperson socio-econ	-0.0906 (0.0870)	-0.0792 (0.0860)	-0.0906 (0.0899)	-0.0792 (0.0884)	-0.0906 (0.0910)	-0.0811 (0.0829)
Distance to roads	-0.0175*** (0.00670)	-0.0172** (0.00673)	-0.0175** (0.00836)	-0.0172** (0.00869)	-0.000157325	-0.0124 (0.00850)
Market pressure	0.0878*** (0.0252)	0.0887*** (0.0249)	0.0878*** (0.0243)	0.0887*** (0.0243)	0.0878*** (0.0255)	0.0809*** (0.0249)
Headperson participation (management)	0.137 (0.103)	0.159 (0.104)	0.137 (0.123)	0.159 (0.128)	0.137 (0.125)	0.175 (0.123)
Rules	-0.0593** (0.0277)	-0.00156638	-0.0593** (0.0284)	-0.00155012	-0.0020755	-0.0543 (0.0343)
Institution	0.0843 (0.105)	0.0619 (0.111)	0.0843 (0.0832)	0.0619 (0.0865)	0.0843 (0.0859)	0.0596 (0.0849)
Permits	0.218** (0.104)	0.211** (0.104)	0.218* (0.118)	0.211* (0.121)	0.218 (0.155)	0.211 (0.154)
Enforcement	-0.0230 (0.0467)	-0.0151 (0.0472)	-0.0230 (0.0509)	-0.0151 (0.0485)	-0.0230 (0.0464)	-0.0185 (0.0447)
Nualungwe	2.237*** (0.116)	2.273*** (0.120)	2.237*** (0.106)	2.273*** (0.101)	2.237*** (0.115)	2.265*** (0.113)
Malama	1.694*** (0.217)	1.741*** (0.224)	1.694*** (0.211)	1.741*** (0.218)	1.694*** (0.198)	1.676*** (0.205)
Mwnya	3.517*** (0.478)	3.467*** (0.492)	3.517*** (0.616)	3.467*** (0.652)	3.517*** (0.566)	3.274*** (0.561)
Msoro	3.125*** (0.515)	3.081*** (0.518)	3.125*** (0.713)	3.081*** (0.737)	3.125*** (0.791)	2.645*** (0.720)
Masemphangwe	1.870*** (0.268)	1.870*** (0.270)	1.870*** (0.322)	1.870*** (0.327)	1.870*** (0.291)	1.565*** (0.251)
Female-headed households	-0.0643 (0.0718)	-0.0624 (0.0717)	-0.0643 (0.0625)	-0.0624 (0.0624)	-0.0643 (0.0728)	-0.0618 (0.0729)
Constant	-0.0711 (3.115)	-0.0766 (3.224)	2.101 (3.386)	1.760 (3.516)	2.101 (3.578)	3.030 (3.279)
Observations	2,823	2,823	2,823	2,823	2,823	2,823
Number of groups	233	233	31	31	12	12

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

TABLE 3—Analysis results for factors driving variation in tenure security

	Model A	Model B	Model C	Model D	Model E	Model F
VARIABLES	Tenure security					
Youth		0.0327 (0.0783)		0.0326 (0.0526)		0.0327 (0.0742)
HH participation	0.0840 (0.107)	0.111 (0.114)	0.0776 (0.119)	0.111 (0.137)	0.0840 (0.151)	0.111 (0.152)
Lost access	-0.00937 (0.146)	0.0469 (0.156)	-0.0238 (0.149)	0.0463 (0.173)	-0.00937 (0.0930)	0.0469 (0.0956)
Elders - rulemaker	-0.0232 (0.188)	-0.00904 (0.206)	-0.0240 (0.122)	-0.00890 (0.150)	-0.0232 (0.150)	-0.00904 (0.174)
Chief - rulemaker	-0.290** (0.116)	-0.325*** (0.121)	-0.274*** (0.0921)	-0.325*** (0.0870)	-0.290*** (0.105)	-0.325*** (0.0873)
None - rulemaker	-0.537*** (0.180)	-0.598*** (0.181)	-0.466*** (0.139)	-0.597*** (0.139)	-0.537*** (0.110)	-0.598*** (0.0919)
State/government - rulemaker	-0.269 (0.166)	-0.323** (0.161)	-0.199 (0.161)	-0.321** (0.155)	-0.043309	-0.323** (0.147)
Livelihoods	-0.250*** (0.0916)	-0.283*** (0.0945)	-0.254** (0.119)	-0.283** (0.132)	-0.03425	-0.044431
Consumption	-0.0604 (0.0459)	-0.0501 (0.0486)	-0.00232254	-0.0502 (0.0411)	-0.0604*** (0.0234)	-0.0501 (0.0357)
Income	0.107** (0.0519)	0.135** (0.0531)	0.109** (0.0494)	0.135*** (0.0504)	0.107** (0.0422)	0.135*** (0.0397)
Headman influence	0.0873*** (0.0186)	0.0858*** (0.0196)	0.0868*** (0.0272)	0.0858*** (0.0276)	0.0873*** (0.0193)	0.0858*** (0.0173)
Chief influence	-0.0821*** (0.0178)	-0.0800*** (0.0183)	-0.0830*** (0.0206)	-0.0801*** (0.0213)	-0.0821*** (0.0168)	-0.0800*** (0.0172)
State or GMA	0.215 (0.141)	0.253* (0.142)	0.230* (0.140)	0.254* (0.144)	0.215** (0.104)	0.253** (0.107)
Communal	0.251 (0.156)	0.279* (0.162)	0.260 (0.169)	0.280* (0.169)	0.251* (0.141)	0.279* (0.161)
Private	0.0222 (0.315)	0.0380 (0.318)	0.0554 (0.290)	0.0387 (0.297)	0.0222 (0.124)	0.0380 (0.157)
Market pressure	-0.0266 (0.0352)	-0.0677** (0.0336)	-0.0188 (0.0400)	-0.00242325	-0.0266 (0.0322)	-0.0677** (0.0314)
Elite status, network	0.202* (0.107)	0.225** (0.110)	0.205 (0.131)	0.225 (0.141)	0.202 (0.207)	0.225 (0.225)
Village conflict	-0.0077395	-0.0109671	-0.111 (0.0817)	-0.139 (0.0939)	-0.115** (0.0552)	-0.139*** (0.0422)
Governance satisfaction	-0.0602 (0.0483)	-0.0599 (0.0506)	-0.0615 (0.0454)	-0.0600 (0.0508)	-0.0602 (0.0537)	-0.0599 (0.0618)
Rules	-0.00126496	-0.00147384	-0.0416 (0.0310)	-0.00168428	-0.0472 (0.0395)	-0.0534 (0.0378)
HH socio-econ	-0.0087192	-0.0648 (0.0735)	-0.0081303	-0.0647 (0.0733)	-0.0086688	-0.0648 (0.0747)
Female-headed households	0.0699 (0.0856)	0.0622 (0.0890)	0.0707 (0.0830)	0.0623 (0.0872)	0.0699 (0.0831)	0.0622 (0.0760)
Education	-0.0402 (0.0321)	-0.00206856	-0.0362 (0.0371)	-0.0611 (0.0390)	-0.0402 (0.0524)	-0.0612 (0.0569)
Institute	0.0306 (0.130)	0.0695 (0.134)	0.0317 (0.103)	0.0695 (0.105)	0.0306 (0.117)	0.0695 (0.120)
chiefd1	-0.374 (0.281)	-0.191 (0.254)	-0.334 (0.463)	-0.192 (0.260)	-0.374 (0.299)	-0.191 (0.196)
chiefd2	-0.456** (0.192)	-0.472** (0.194)	-0.537*** (0.198)	-0.473*** (0.158)	-0.456*** (0.122)	-0.472*** (0.0839)
chiefd3	-0.0273 (0.343)	0.115 (0.352)	-0.0586 (0.357)	0.114 (0.353)	-0.0273 (0.186)	0.115 (0.148)
chiefd4	-0.0876 (0.212)	0.103 (0.213)	-0.145 (0.221)	0.102 (0.219)	-0.0876 (0.157)	0.103 (0.168)
chiefd5	-0.280 (0.200)	-0.129 (0.198)	-0.240 (0.214)	-0.128 (0.179)	-0.280** (0.120)	-0.129 (0.103)
Constant	3.300*** (0.383)	3.365*** (0.384)	3.245*** (0.425)	3.364*** (0.451)	3.300*** (0.518)	3.365*** (0.523)
Observations	2,716	2,430	2,716	2,430	2,716	2,430
Number of groups	249	241	40	39	16	16

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figures

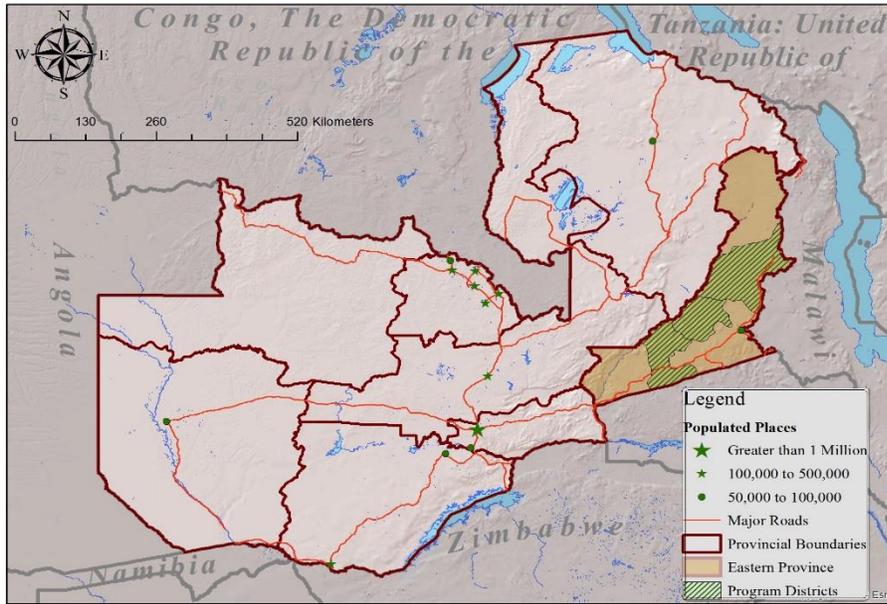


FIGURE 1—Location of Eastern Province and Program Districts in Zambia

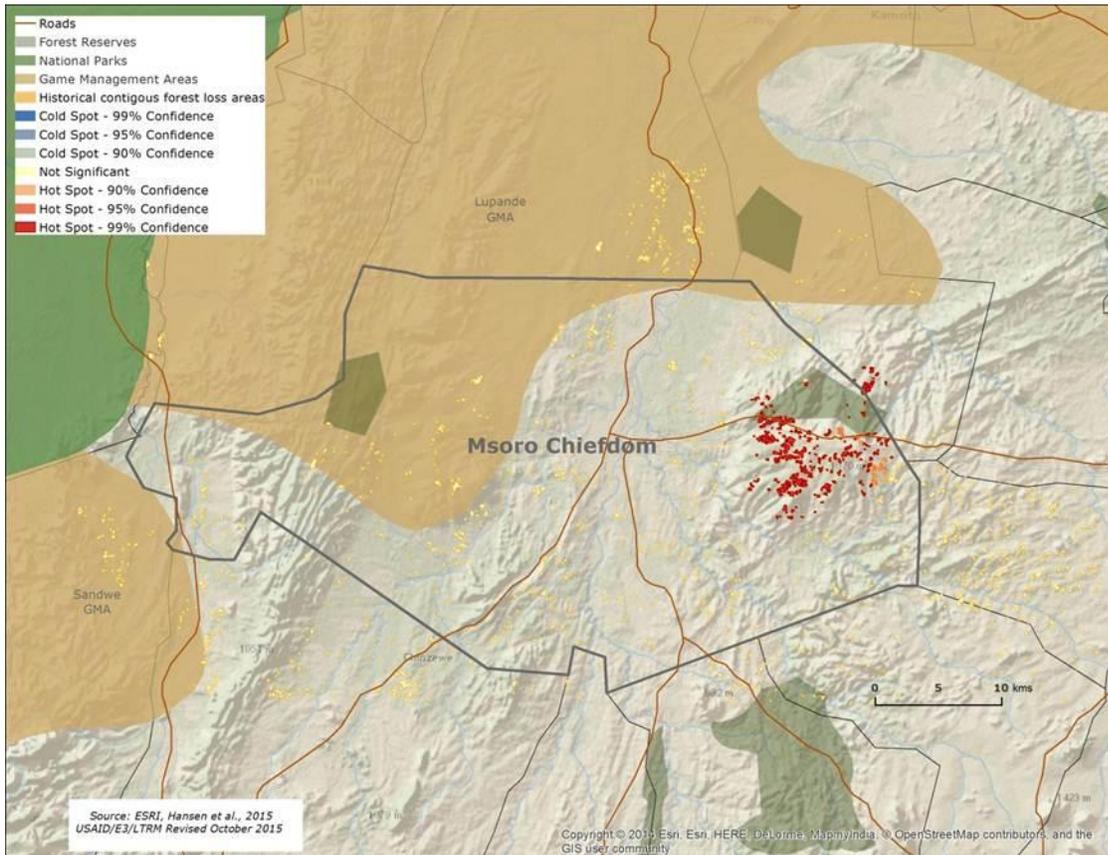


FIGURE 2—Hotspots of tree cover loss in Msoro Chiefdom

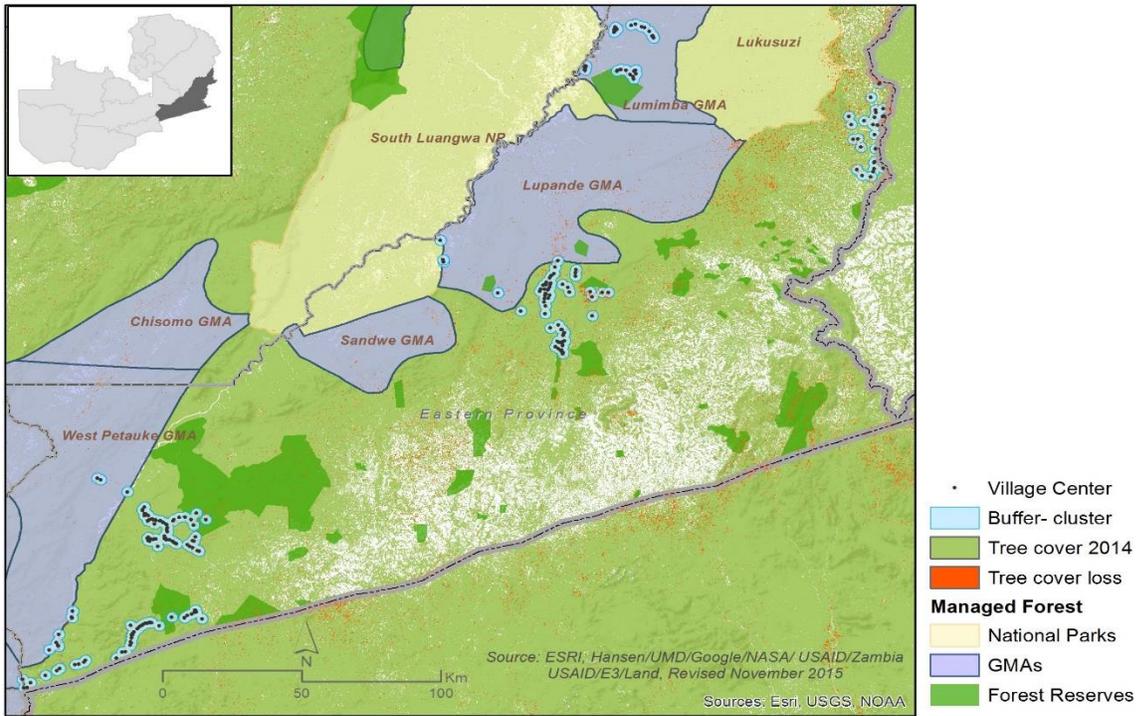


FIGURE 3—Distribution of aggregated buffers around village centers and forest cover loss

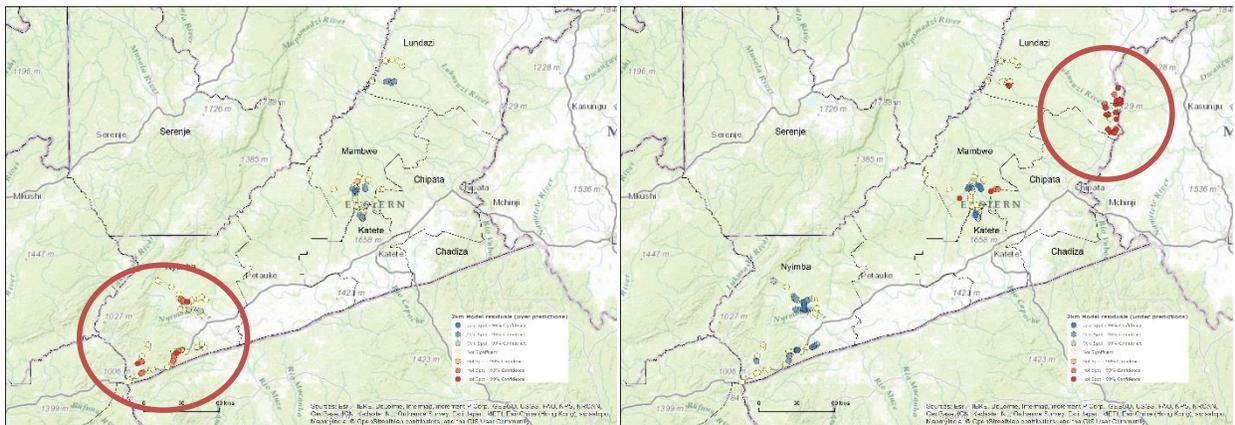


FIGURE 4—Model residuals showing clustered over- (L) and under-predictions (R)