Forest Landscapes and Institutional Transition: Essays Examining Sociopolitical and Forest Cover Change in Indonesia

By

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Dedication

To my supportive friends, my loving family, and *bumi manusia*.

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List of Acronyms

AFI	Adjusted for inflation
BIG	*Badan Informasi Geospasial* (Geospatial Information Agency)
BPS	*Badan Pusat Statistik* (Central Statistics Agency)
CAR	Compounded annual rate
CIESIN	Center for International Earth Science Information Network
CPR	Common Pool Resource
DHS	Demographic Health Survey
DPD	*Dewan Perwakilan Daerah* (Regional Representative Assembly)
DPR	*Dewan Perwakilan Rakyat* (People's Representative Assembly)
EU	European Union
FLEGT	Forest law enforcement, governance, and trade
GNI	Gross National Income
GR	Governmental regulation (*Peraturan Pemerintah*)
ICDP	Integrated conservation and development project
IDR	Indonesian Rupiah
IFR	International Forset Regime
IHS	Inverse hyperbolic sine
Ln	Natural log
PES	Payments for ecosystem services

PI	Presidential Instruction (*Instruksi Presiden*)
KLHK	Ministry of Environment and Forestry (*Kementerian Lingkungan Hidup dan Kehutanan*)
KS-ICDP	Kerinci-Seblat Integrated Conservation and Development Project
KSNP	Kerinci-Seblat National Park
LSS	Land systems science
MDVDI	Multidimensional village deprivation indicator
MPI	Multidimensional poverty index
PA	Protected Area
PD	Presidential Decree (*Keputusan Presiden*)
PR	Presidential Regulation (*Peraturan Presiden*)
PSU	Primary sampling unit
PODES	Indonesian Village Census (*Sensus Potensi Desa*)
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SRTM	Shuttle RADAR Topography Mission
SSU	Secondary sampling unit
SVLK	Timber Legality Verification System (*Sistem Verifikasi Legalitas Kayu*)
TRMM	Tropical Rainfall Measuring Mission
VPA	Voluntary Partnership Agreement
WWF	World Wildlife Foundation/Fund

Abstract

This dissertation analyzes how institutional change affects social-ecological outcomes, with a focus on forests, over the first two decades of Indonesian democracy (1999 to 2016). Canonical research concludes that self-organized groups can employ rules, norms, or behaviors (i.e. institutions) that permit the sustainable management of natural resources for long-term benefit. However, institutions are not static. Periods and places of institutional transition may generate outcomes for people and natural resources that differ drastically over time and space. With sweeping changes in contemporary land cover occurring alongside shifts in governance across the Global South, it is of crucial importance to study institutional transitions and environmental change together.

Over the past two decades, Indonesia has experienced two revolutions rarely studied in tandem. The first revolution is political. After the fall of Suharto in 1998, Indonesia transitioned to become the world's third largest democracy amid a succession of policies that mandate direct, proportionate elections for political positions and increase the decentralization of government authority. The second revolution is environmental. Since Indonesia's turn toward democracy, it has lost over 15% total tree cover, demonstrating the second greatest loss (24.4 Mha), and the greatest acceleration in tree cover loss, of any tropical nation in the world over the same period. Although research often examines these changes separately, analyzing them in tandem provides insight into how institutional transitions generated outcomes for forests and people in contemporary Indonesia.

To examine changes in institutions, forest cover, and livelihoods this dissertation draws on institutional analysis and land systems science. It uses a mixed-methods approach, combining analysis and interpretation of policy content, land cover change, and survey data. Specifically, it provides analysis of national forest-related policy from 1999 to 2016 to determine if and how policy changes reflect national pledges to reduce forest cover loss. Then, it combines remotely sensed land cover change with the Village Census (*Sensus Potensi Desa*) to measure the impact of decentralization on forest cover loss from 2000 to 2014 using statistical matching and fixed-effect models. Finally, it combines land cover and primary survey data (n=1,304) from the Kerinci-Seblat National Park landscape to understand the legacy of international conservation assistance on forests and communities.

This dissertation makes several novel contributions. First, it introduces a new method for policy network visualization and provides the most comprehensive analysis of Indonesian forest-related policy to date. Second, it performs the first analysis of regulatory dispersal on forest cover change through the creation and analysis of a social-ecological dataset with higher spatial and temporal resolution of any other published study. Third, it provides the first study of social-ecological legacies from Indonesia's largest Integrated Conservation and Development Project. Together, these contributions demonstrate how overarching political trends affect forest-related outcomes in Indonesia. In doing so, it demonstrates the benefits and potential for analyzing institutional change as transitional processes when studying social-ecological outcomes.

Chapter 1

Introduction

The first two decades of the 21st century have witnessed rapid environmental change. The conversion and modification of land cover from human activities has generated ecological changes in all well-studied, marine, freshwater, and terrestrial systems (Parmesan 2006). This conversion continues through processes of deforestation, intensification of agriculture, desertification, and urbanization (Ellis et al. 2017; Hansen et al. 2013; Mahmood et al. 2014; Potapov et al. 2017b; Seto, Guneralp, and Hutyra 2012). However, the type, scale, and magnitude of environmental change does not necessarily follow from one or many antecedent causes (Meyfroidt 2016a). Rather, these changes are the consequences of different rules, norms, and behaviors that combine to influence how, when, and where people interact with one another and the environment. Studying environmental change in the Anthropocene requires an understanding of how institutions operate across space, scales, and time to structure human-environment relationships.

Institutions are the the set of rules, norms, and behaviors that shape human interaction (North 1990), and which structure how people access, use, and benefit from environmental goods (Ribot and Peluso 2003). Environmental goods include supporting, provisioning, regulating, and cultural services (Duraiappah et al. 2005). Common-pool resources (CPRs) are one type of environmental resource that provide ecosystem services. CPRs are defined by the difficulty for people to monitor them (excludability) and their depletion upon use (extractability) (Ostrom, Gardner, and Walker 1994). Classic examples of CPRs include forests, fisheries, and irrigation systems (Ostrom 1990). In challenging the tragedy of the commons, canonical research on collective institutions finds that action shaped by specific "design principles," such as ensuring those affected by resource use rules can participate in modifying them or providing low cost means for dispute resolution, can lead to long-term and sustainable CPR management (Becker and Ostrom 1995; Ostrom 2005). Social-ecological systems (SES) research builds on foundational institutionalist research, recognizing that natural resources, people, institutions, and environments comprise multi-scalar and interconnected wholes that, together, produce outcomes (Ostrom 2009). Extending these insights, national or global governance that promotes polycentric management of natural resources and incorporates design principles holds promise for lage-scale, sustainable resource use (Ostrom 1999, 2010; Ostrom and Cox 2010). Understanding the relationship between institutions and social-ecological outcomes is thus key for Sustainability Science (Kates et al. 2001).

Initial research on institutions and social-ecological outcomes focused on conditions that facilitate the sustainable management of CPRs over time (Baland and Platteau 1996; Ostrom 1990; Wade 1988). A number of subsequent studies incorporated empirical research to understand how institutions influence SES outcomes for CPRs (Agrawal 2001; Nagendra 2007; Persha, Agrawal, and Chhatre 2011). However, reconciling data on natural resource stocks and flows with socioeconomic and institutional data from user groups or proximate communities regarding rules and norms posed considerable challenges, and the difficulty of collecting social and ecological data across systems limited empirical study. More recently, the increase in publically available remotely sensed imagery and enhanced computing capacity enabled a wave of rigorous empirical studies that examine the impact of specific institutions on land cover change (Ostrom and Nagendra 2006). These contemporary studies have provided valuable insight into the effectiveness of protected areas (Andam *et al.*, 2008; Honey-Rosés, Baylis and Ramírez, 2011; Nolte *et al.*, 2013; Ferraro *et al.*, 2015; Shah and Baylis, 2015; den Braber, Evans and Oldekop, 2018) and the drivers of forest cover change (Blackman 2013; Blackman et al. 2017; Heilmayr and Lambin 2016; Wright et al. 2016). With a focus on spatially defined "treatments" and counterfactual "controls," this research often seeks to compare the most similar units—be they parcels of land, households, or administrative units—to draw conclusions about the causal impact a rule has on a group of people or a resource (Ferraro and Hanauer, 2014). In these studies, it is standard to control for overarching institutional changes, such as new political leadership, altered administrative boundaries, or shifts in relative or overall funding. However, failing to investigate how overarching institutional change interacts with the specific rule, norm, or behavior under examination to produce social-ecological outcomes is problematic on three fronts.

First, ignoring institutional histories can produce "baseline blindness." Baseline blindness refers to how studies that specify a baseline can overlook significant changes that occur before the study period (Kotiaho, ten Brink, and Harris 2016). This is a potential problem for all empirical work, but it can be alleviated by matching questions with appropriate temporal windows and controlling for parallel trends pre-baseline. Selecting appropriate baselines for empirical study of social-ecological outcomes requires careful attention to an institution's legacy, and controlling for pre-baseline trends requires attention to an outcome's history. Second, overarching institutional change may drive the outcome of interest. For example, it is common to overlook administrative boundary and leadership changes when evaluating the efficacy of an environmental policy. However, it is possible that systematic institutional change, such as elections or new boundaries, mediate or drive the effect of an environmental policy on a social-ecological outcome (Agrawal 2014). Incorporating information on SES history and governance into analysis can help guard against such oversight. And third, assessing how the effect of a rule, norm, or behavior shifts as a result of overarching institutional transitions can lead to better scholarship, more informed implementation of policy, or both. Major institutional changes influence SES. Ignoring them can lead to biased estimates or, in a worst-case scenario, spurious outcomes. Although scholarship that examines institutional and social-ecological change in tandem poses additional difficulties, contemporary trends demand it.

Along with rapid environmental change, the first two decades of the 21st century have witnessed significant social, political, and economic shifts. For example, migration connects families and generates environmental impacts across continents (Chen et al. 2014; Gray and Bilsborrow 2014; Oldekop et al. 2018; Qin 2010); through large flows of international finance, investors affect relationships between labor and land thousands of miles away (Liu et al. 2013; Margulis, Mckeon, and Jr 2013; Tscharntke et al. 2012); and governments across the Global South are decentralizing and deconcentrating administrative powers and redrawing jurisdictional maps (Grossman and Lewis 2014; Pierskalla 2016). SES researach must study human-environmental interactions *under the assumption* of overarching institutional change, not despite it. It is no longer enough to study how the “rules of the game” effect social-ecological change by attempting to control for social, economic, or political shifts. Rather, institutional studies of social-ecological outcomes must examine how periods of institutional change unfold through an examination of how timing and spaces of change generate social-ecological outcomes.

This dissertation examines how institutional change affects social-ecological outcomes, with a focus on forests, over the first two decades of Indonesian democracy (1999 to 2016). The remainder of this introduction provides the foundation for understanding how institutional transitions and forest cover change in Indonesia are related. Section 1.1 elucidates the concept of institutional transition. Section 1.2 explains the relevance of studying tropical forest cover. Section 1.3 provides information on institutional transitions and forest cover change in Indonesia, and Section 1.4 outlines the rest of this dissertation.

1.1 Institutional transitions: Institutionalism meets land system science

Institutionalist studies of natural resource use frequently consider institutional change, but they less often engage with institutional transition. Institutional change refers to the alteration or implementation of a rule, norm, or behavior setting is altered (North 1990, Eggerston 1996). A common form of research that examines institutional change is policy-focused causal inference (Angrist and Pischke 2009, 2017; Athey and Imbens 2016; Imbens and Wooldridge 2009). Policy-focused causal inference often seeks to understand whether or not a formal rule (policy) is responsible for generating outcomes different than would be expected had the rule not been implemented. For example, in the realm of forest management, causal inference studies show that providing communities with collective-use rights promoted sustainable forest use in Bolivia (Wright et al. 2016) and that increasing the amount of formal land titles decreased forest loss in Peru (Blackman et al. 2017). Rigorous impact evaluations provide valuable information on whether institutional change generates an effect on a particular outcome; however, they often overlook investigating if and how institutional changes generate environmental outcomes over time and space.

Land systems science (LSS) is an interdisciplinary research field dedicated to observing, understanding, and modeling land use and land cover change and its relationship to human-environmental vulnerability, resilience, and sustainability (Meyfroidt 2016b; Turner, Lambin, and Reenberg 2007; Verburg et al. 2015). Although many studies of social-ecological outcomes do not focus on land cover, using the analytical underpinnings of LSS with the topical focus institutionalist studies generates a novel and important insight: Institutional change arises from social processes that occur over space and time.

Empirical analyses of institutional change often operationalize change as discrete. Although it may be possible to identify units—pixels, households, villages, or forest parcels—that have undergone an institutional change, binary identification can be problematic. For example, because a forest parcel is within the boundary of a protected area (PA) does not necessarily indicate that the institutions which govern how people interact with resources represented by that pixel have changed. It can take years to establish offices, begin monitoring, and formalize sanctions involved in PA governance. Further, there are many examples of "paper parks" that, though they may have official recognition, do not have sufficient budgets or personnel to monitor territory or enforce sanctions (Blackman, Pfaff, and Robalino 2015; Bonham, Sacayon, and Tzi 2008; Bruner et al. 2001). Although rigorous empirical study has established to what extent PAs are effecting changes in conservation goals, the assumption of discrete institutional change can hinder further investigation. Understanding institutional change as formed from transitional practices enhances the ability to identify and understand causal mechanisms that produce social-ecological outcomes. To guide analysis of social-ecological outcomes, this dissertation deconstructs institutional change as "institutional transitions" that occur over space and time.

Analyzing institutional transitions includes three opportuninites for investigation. First, *timing/sequence* refers to the combination of when and where institutional change occurs. The sequence of events that occur before an institutional change can alter social-ecological outcomes

(Pierson 2000). For example, the moment in time when a payments for ecosystem services (PES) project is implemented in relation to previous weather patterns or commodity prices can alter the extent to which an ecosystem service is protected (Brunner and Grêt-Regamey 2016). Also, when participants are paid for protecting ecosystem services, in relation to their economic concerns, can affect their willingness to participate (Jayachandran et al. 2017). Investigating timing/sequencing requires knowledge of a system, and as discussed previously, conscientious selection of the baseline and period of a study.

Second, the *longitudinal effect* refers to how the effect of an institutional change on social-ecological outcomes fluctuates over time. For example, institutional histories that reflect path dependencies of resource extraction can be difficult to reverse. Voluntary forest certification may not immediately promote sustainable forest management in such contexts (Ulybina and Fennell 2013), but as resource extraction becomes part of a more diversified set of economic activities, concessions managed in line with certified standards may demonstrate more sustainable harvest regimens (Rana and Sills 2018). Measuring the impact of forest certification on harvest practices in the first one or two years immediately following certification can produce different results than measuring impact over longer time horizons. Explicitly addressing time through baseline selection, selecting a period of study based on SES knowledge, and examining longitudinal effects can strengthen findings.

Where institutional change occurs can explain variation in transition, cause, and effect. The difference in institutional change over space is the *spatial variation* of institutional transition. Both spatial variation, and lack of spatial variation, are important for understanding how institutional change affects social-ecological outcomes. For example, the technical and human resources necessary to monitor fishing vessels and enforce catch quotas varies depending on the range of the species in question; oceanic, transboundary species require greater resources than others (Caddy and Seijo 2005). Research that seeks to understand the efficacy of institutional change related to fisheries management must consider the spatial, and spatio-political, variation of enforcement. Additionally, institutional change can generate social-ecological outcomes that take identifiable spatial patterns in different locations (Brown, Aspinall, and Bennett 2006; Turner et al. 2013), thus lending additional insight into when, where, and how institutional change and land cover change are related. Perhaps one of the most well-known spatial patterns linked to land change process is that of the "fishbone pattern of deforestation" in Amazonia that follows from land parcel allotments for frontier agriculturalists (De Oliveira Filho and Metzger 2006). Clustering standard errors enables a practitioner to demonstrate that an effect is robust to different and higher-level spatial patterns (Abadie et al. 2017) and data pre-processing or model specifivation can help control for the differential impact of an effect over political space (i.e. administrative boundaries) or geographical space (Angrist and Pischke 2009; Ho et al. 2007). However, removing the spatial signals of institutional transition, rather than investigating them, represents a missed opportunity.

Empirical research that investigates how institutional change affects social-ecological outcomes should concern itself with institutional transitions. In institutional studies of social-ecological outcomes the sequential, longitudinal, and spatial variation of an effect are often considered nuisance parameters. These same transitional elements are not nuisance parameters, but often the focus of inquiry in LSS research (Lambin and Meyfroidt 2010; Turner, Lambin, and Reenberg 2007). Drawing on institutionalist studies and land systems science, this dissertation analyzes political transitions and social-ecological outcomes, focusing on change in tropical forest cover.

1.2 Tropical forests: A Common-pool resource of inter-scalar concern

Concern about global environmental change has led governments and donors to identify cost effective initiatives to reduce global carbon emissions while conserving biodiversity and contributing to rural livelihoods and well-being. Many analyses conclude that conserving and sustainably managing tropical forests are two of the most cost effective methods for reducing global carbon emissions, conserving biodiversity, and providing livelihood benefits for forest proximate people (Houghton, 2005; Gullison *et al.*, 2007). Despite international agreement that tropical forests are indispensable for reducing global carbon emissions and conserving biodiversity, there is no consensus on how to manage them sustainably. This lack of consensus, at international and national levels, continues amid the consistent decrease in global tropical forest area (Hansen et al. 2013).

Tropical forests are valuable as both income and assets, leading to the difficulty with which they are managed. As a source of wood, fiber, and non-timber forest products, tropical forests provide direct and indirect contributions to millions of rural livelihoods (Agrawal and Chhatre 2006; Newton et al. 2016). From 2000 to 2012, global deforestation was four times that of reforestation (Hansen et al. 2013). A variety of state- and market-based efforts seek to stem this trend of global deforestation and forest degradation in the tropics and change the nature of global forest governance (Agrawal, Chhatre, and Hardin 2008). With the third largest area of forest of any country in the world, Indonesian forest cover change is of crucial importance for climate change mitigation, biodiversity conservation, and millions of livelihoods.

1.3 Indonesian forest cover change and institutional transition, 1999 to 2016

Understanding how, where, and why Indonesian political changes and forest cover changes co-occur, and with what environmental and socioeconomic impacts, is of global importance. Indonesia is home to over 250 million people, over 35 % of whom live within five kilometers of primary or secondary forest (Hansen et al. 2013; Oak Ridge National Laboratory 2012). Approximately 63% of all Indonesian land is managed by the state as national forest area (*Kawasan Hutan*) (Ministry of Environment and Forestry 2018). As Indonesia has transitioned to become the world's third largest democracy, it has experienced a period of forest cover loss unprecedented across Southeast Asia (Woodruff 2010). Between 2000 and 2012, tree cover in Indonesia disappeared at a faster rate than any other country, and Indonesian tree cover loss in 2016 was the highest of any year since 2000 (Hansen et al. 2013). Analyzing changes in forest cover and proximate populations considering institutional change that occurred across the Indonesian archipelago from 1999 to 2016 is the central task of this dissertation.

Between 1999 and 2016, Indonesia transitioned from an authoritarian state to the world's third largest democracy. This shift in government generated a drastic reconfiguration of government and authority, achieved through a series of policies that decentralized power across provinces, districts, and villages and gave citizens the right to select their political representatives (Vickers 2013). Following the fall of Suharto's New Order government in 1998, a period of *reformasi* ushered in new laws that mandated independent monitoring of elections, established the freedom to create new political parties, and prevented the military from aligning itself with any one political group. In 1999, Indonesians directly elected national, provincial, and district parliaments to office. The newly elected People's Consultative Assembly (*Majelis Permusyawaratan Rakyat)* selected presidents until 2004. Following 2004, the People's Consultative Assembly became a bicameral legislature, comprised of the Regional Representatives Council (DPD) and the People's Representative Council (DPR). Also, after 2004, the President of the Republic of Indonesia became a directly elected position. Indonesian candidates are selected through an open-list, proportionately representative system. Citizens select both party and individual candidates. Since the fall of the New Order, Indonesians have elected national legislative representatives four times and have held three presidential elections. As with the selection of political respresenatives, Indonesian environmental governance changed rapidly from 1999 to 2016 (Agrawal and Lemos 2007). Specifically, increases in formalization, decentralization, and globalized governance reshaped forest governance in the first 18 years of Indonesian democracy.

The formalization of forest governance in Indonesia occurred through a variety of policy reforms, enacted throughout the 1999 to 2016 period. Formalization refers to the extent to which citizens interact with formal organizations that monitor and/or structure behavior, as well as the predictiability with which these interactions unfold (Guha-Khasnobis, Kanbur, and Ostrom 2006). Governmental technologies that produce policy, mandate methods of implementation, and specify regulation and enforcement often determine the actors and practices associated with increased formalization (Putzel et al. 2015). From 1999 to 2016 , Indonesian political actors have sought to formalize the governance of land (Kelly and Peluso 2015) and the production of forest products (Obidzinski and Kusters 2015). By specifying who has rights to land and forests, what these rights entail, and how to obtain them, the Indonesian state has increased the codification of land use, management, as well as the production of timber and agricultural commodities. Although contemporary scholarship often focuses on how contemporary environmental governance in Indonesia remains informal, with overlapping land claims leading to unpredictable patterns of land use (Gaveau et al. 2017), the legal role, capacity, and resources of the Indonesian state have steadily increased over the period preceding Indonesian democracy (Bedner 2016; van der Eng 2017; Mccarthy and Robinson 2016). This process of formalization has occurred along with and through increased decentralization.

The rights and responsibilities over forest areas afforded to different levels of Indonesian government has changed repeatedly over the past two decades. Political actors issued a series of policies to alternately distribute rights and responsibilities to province and district governments at different periods, from 1999 to 2016. Some scholars suggest that shifting certain powers from provinces and districts aimed to weaken secessionist movements across the archipelago (Barr et al. 2006; Kimura 2013). One key aspect of this strategy was to alternate the way in which provinces and districts provided access and received rents from Indonesian forests. More recently, laws, pledges, and judicial rulings have begun to increase village-level rights over land use (Antlöv, Wetterberg, and Dharmawan 2016; Myers, Intarini, Thomas, et al. 2017; Santika et al. 2017). In addition to the decentralization and deconcentration of political authority (Ribot, Agrawal, and Larson 2006), the number of provinces, districts, sub-districts, and villages increased precipitously. As the Indonesian state reconfigured rights and responsibilities within its borders, it enacted policy to promote trade and diplomacy beyond its borders.

International rules, norms, and market incentives increased the impact of international actors on Indonesian forest governance from 1999 to 2016 (Bernstein and Cashore 2012). Complying with international rules regarding timber trade, Indonesian timber is now verified as legal through third party auditing (Cashore et al. 2007; Lesniewska and McDermott 2014). International norms for reducing carbon emissions have been formalized through multiple, national policies (Law 17/2004 and Law 16/2016) and have resulted in Indonesia receiving increasing amount of conservation aid dedicated to tropical forest conservation and rural livelihood improvement (Angelsen 2017; Wells, Michael; Guggenheim, Scott; Khan, Asmeen;

Wardojo, Wahjudi; Jepson 1999; A. Wibowo and Giessen 2015). And international sustainability certification seeks to ensure that the production of timber and agricultural commodities, including coffee and palm oil, are not contributing to illegal forest loss and promote positive livelihood outcomes (Carlson et al. 2017; Miteva, Loucks, and Pattanayak 2015).

The combination of striking political change and unprecedented forest cover loss make Indonesia an ideal region in which to study how institutional transitions affect social-ecological outcomes. Although formalization, decentralization, and globalized governance are not exhaustive of all political change in Indonesia from 1999 to 2016, they represent a set of key shifts in forest governance (Agrawal, Chhatre, and Hardin 2008). This dissertation examines these shifts through a series of chapters that analyze them as institutional transitions and discusses their impact on Indonesian forests and people.

1.4 Dissertation overview

Understanding how institutional transitions shape social-ecological outcomes requires the combination of different data sources to analyze information from the halls of government, remotely sensed satellite imagery, and field-based observations and measurements (Ostrom and Nagendra 2006). This dissertation uses a combination of data and methods to examine three overarching institutional changes that occurred in Indonesia from 1999 to 2016 and influenced social-ecological outcomes related to forests. Chapter 2 examines the formalization of Indonesian forest governance through an analysis of forest-related policy content. Chapter 3 examines decentralization by analyzing the effect of regulatory dispersal on forest cover change. And Chapter 4 provides insight into how globalized governance, implemented through international conservation funding and commodity demand, combine to generate conservation legacies from Indonesia's largest Integrated Conservation and Development Project. Together, these chapters provide specific insights on political change, forests, and people in Indonesia, and they support future research of institutional transitions and social-ecological outcomes.

Chapter 2 provides insight into the initial stages of formalization through an analysis of forest-related policy. Using a dataset of coded forest-related policies legislated since 1999, this chapter assesses general policy trends to determine if and how forest-related policy has changed across three five-year periods that coincide with Indonesia's transition to full democracy. By doing so, it examines the period and timing of institutional transition, as recorded in Indonesian law. This chapter concludes that Indonesian forest-related policy changed to promote more conservation-friendly policy during the first 18 years following democritization, but these policies permit interpretable flexibility via policy layering. Ambiguity related to policy layering helps explain the paradox of increasingly pro-conservation policy and consistently increasing rates of Indonesian forest loss.

Since its transition to democracy, thousands of new villages, hundreds of new sub-districts and districts, and eight new provinces have proliferated across Indonesia (BPS, 2015). Each of these proliferations requires the establishment of new administrations. In establishing new administrations, governments disperse regulation across a greater number of units. Chapter 3 examines the effect of regulatory dispersal on forest cover change in Indonesia from 2000 to 2014. In Indonesia, regulatory dispersal has increased the density of regulatory units, but contemporary research has not yet investigated the impact of regulatory dispersal on forest cover change. This chapter demonstrates that periods following the proliferation of new administrative units increases forest cover loss, but the type of regulatory dispersal and when it occurs influences this effect.

Chapter 4 assesses how a legacy from international conservation funding affects local livelihoods and village-level development surrounding Indonesia's second largest, terrestrial protected area. The largest conservation and development project of its time, the Kerinci-Seblat Integrated Conservation and Development project (KS-ICDP), initiated the transfer of direct conservation payments to villages across central Sumatra in the early 2000s (World Bank 2003). Chapter 4 assesses the legacy of this conservation funding, using primary survey data (n=1,304), village-level development indicators, and forest cover data. It concludes that villages which received KS-ICDP funding demonstrate forest cover trends in direct contrast to the project's stated objectives, and households within villages that received direct funding report livelihood strategies that preference greater and more informal land ownsership. Failures of the project during its time of operation, coupled with how it may haved crowded out conservation motivations, help explain this legacy.

Chapter 5 provides a set of conclusions about how forest cover and livelihoods in Indonesia have been shaped by the overarching political institutions that result from its transition to democracy. Policy change, regulatory dispersal, and conservation finance provide windows through which to examine institutional transitions related to formalization, decentralization, and globalized governance. To study institutional drivers of social-ecological outcomes, research must pay careful attention to the time, the sequence, and the space over which the institution operates. This dissertation concludes by reiterating the role political change played in affecting forest cover change across the archipelago through specific policy, regulatory, and conservation practices, discussing limitations of studying institutional transitions and social-ecological outcomes, and identifying areas for further study.

Chapter 2

Assessing, analyzing, and visualizing change in Indonesian forest-related policy content from 1999 to 2016

Abstract:

Despite numerous pledges by Indonesian authorities to reduce emissions from deforestation and forest degradation, Indonesian forest cover loss has consistently increased over the past two decades. To determine if forest-related policy demonstrates a paradigm shift toward forest protection, we identify and code a set of 218 national forest-related policies passed between 1999 and 2016. We assess the type of forest-related content, whether a change in policy has occurred, and the mechanism by which change has or has not taken place through the interpretation of policy citation networks and statistical analysis of temporal relationships between forest-related policy content and change over time. We find there has been a significant increase in the amount of Indonesian forest-related policy and that this increase is largely comprised of content that promotes forest protection and redefines the structure and funding for forest-related organizations. However, these content changes have primarily occurred through the process of policy layering, when new policy does not amend or repeal old policy and regulation. We examine current trends in the regulation of forest territory and flow in Indonesia and find further evidence of policy layering. Thus, although national forest-related policy in Indonesia has changed to promote increased forest protection and monitoring, policy layering promotes interpretable flexibility, which can enable continued forest cover loss.

2.1 Introduction

Growing recognition of tropical forest conservation as a low-cost option for mitigating climate change has motivated international efforts to reduce forest degradation and deforestation. Actors, organizations, and states that promote international forest conservation, sometimes referred to as the International Forests Regime (IFR), often seek to reduce forest cover loss by promoting cooperative agreements and good forest governance (Giessen 2013; Smouts 2008). Through different pathways, international governance can influence domestic governments to produce formal laws and regulations that deliver policy instruments to achieve these goals (Bernstein and Cashore 2012; Cashore et al. 2007; Maryudi 2016). States that contain large tracts of tropical forest and ascribe to the objectives of the IFR should demonstrate an increase in national-level policy that promotes reduced emissions from forest cover change as well as good forest governance. However, little empirical evidence on forest-related policy content exists to document and understand whether and how this policy trend occurs.

Political leaders in Indonesia have voiced significant support for Reducing Emissions from Deforestation and Forest Degradation (REDD+) as well as sustainable forest governance. However, studies conclude that primary forest loss in Indonesia increased consistently from 2000 to 2012 (Margono et al. 2014), and over the same period Indonesian forest cover loss has accelerated at a greater rate than any other nation (Hansen et al. 2013). The reality of forest loss despite the Indonesian state’s purported dedication to REDD+ and sustainable forest governance present a puzzle: has Indonesian forest-related policy changed? If it has, what type of forest-related policy content best summarizes this change, and through what mechanism of policy change has it occurred? This research examines whether and how national forest-related policy change occurred in Indonesia between 1999 and 2016.

2.2 Theories of policy change

Identifying change in policy content requires an analysis of what content is changing, over what period, and how new and old policies relate to one another. These analytical focuses can be considered the “what,” “when,” and “how” of policy content change, and they are referred to, respectively, as directionality, tempo, and mode of policy content change (Cashore et al. 2007; Howlett and Cashore 2009; Mahoney and Thelen 2010; Thelen 2004).

The directionality of policy content describes the way in which it shifts over time toward different objectives (Nisbet 1972). Cumulative policy change exists when there is a concerted shift in policy content objectives. Policy content change that remains in equilibrium is characterized by new policy that, over the period in question, does not shift toward different objectives. This occurs when a set of subsequent policies promote the same set of objectives or a set of different objectives that consistently offset one another. Considering the directionality of policy content change alongside tempo provides a method for assessing when policy content changes (Table 2.1).

Policy content change is often considered a long, stochastic process of “muddling through” (Lindblom 1964). This “classic incremental” pattern of policy change does not demonstrate a cumulative directionality toward different policy objectives over the short-term. Rather, it defines a set of policy content that may differ in objective and purpose from baseline

Table 2.1: Policy Change (adapted from Cashore and Howlett 2007)

	Tempo	
Directionality	Fast	Slow
Cumulative	Classic Paradigm	Progressive Incremental
In Equilibrium	Faux Paradigmatic	Classic Incremental

content but in aggregate and over long time horizons. Therefore, it is not unusual for research to examine changes in policy content over many decades.

However, policy change can also occur within shorter timeframes. Policy change that occurs quickly in response to an exogenous cause is referred to as a “classic” paradigm shift or “punctuated equilibrium” (True, Jones, and Baumgartner 1999). A fast shift in policy directionality that changes objectives but is subsequently offset by another set of policies is referred to as “faux paradigmatic.” Analyzing policies for evidence of policy change requires the definition of timescales appropriate to the political systems and histories from which they come.

The mode or type of policy change identifies the process through which policy content aggregates. In conjunction with directionality and tempo, the mode of policy content change establishes the political practices upon which policy content is predicated and how policy implementation unfolds. Different modes of policy change represent contrasts in creation and the implementation of policy content (Table 2.2). Policy displacement or layering occurs when new content is created. Displacement refers to when new policy replaces old rules. Layering, when new policy content does not replace existing content. Drift and conversion represent two scenarios where existing rules persist, new rules are not introduced, but the implementation or impact or existing rules changes. Thus, displacement and layering are relevant when cumulative policy change has occurred, whereas drift and conversion pertain to policy content change that is in equilibrium (Table 2.1).

To assess the directionality, tempo, and mode of policy content, analysis must be based on strong rationale for the timeframe under study and the scope of policy being examined.

Table 2.2: Mode of Policy Change (adapted from Mahoney and Thelen 2010)

Mode of Change	Characteristics
Displacement	Removal of existing rules, introduction of new rules
Layering	No removal of old rules, introduction of new rules along with maintenance of old rules
Drift	No removal of old rules, no introduction of new rules, changed enactment of old rules due to environmental change (not strategic)
Conversion	No removal of old rules, no introduction of new rules, intentional redeployment of old rules

Sections 2.3 and 2.4 present information on the period under study, types of policy, and identification as well as coding protocols that comprise the present study.

2.3 Forest-related policy in Indonesia

Forest-related policy in democratic Indonesia represents a stark break from forest-related policy before the democratic transition. Before the democratic transition, Indonesian forest-related policy was based in the 1967 Basic Forestry Law. This law, which characterizes Indonesian forest-related policy before the democratic transition, granted central authority over 143 Mha of "forest land," which covered over three fourths of Indonesian land area. The Basic Forestry Law of 1967 allowed the New Order regime to implement an insular patronage system through the forestry sector that dominated forest-related policy until 1998 (Obidzinski and Kusters 2015). However, with the fall of Suharto's New Order government came a series of new forest-related policies. These policies respond to the decades of centralized control the New Order regime practiced, and they inculcate international influence and funding (Roberts, Habir, and Sebastian 2015).

The years between 1999 to 2016 provide an ideal time in which to study if and how national forest-related policy changed as Indonesia transitioned to full democracy. As a

Table 2.3: Executive and legislative changes in post-transition periods of Indonesian democracy

	Executive Changes	Legislative Changes
Period One: Transition to full democracy (1999-2004)	President elected by Parliament	First free election since 1955
	Amendment to elect president through direct elections (2002)	Reorganization of legislatureinto two houses without military appointees (2002)
	First direct presidential election (7 and 9/ 2004)	Second free legislative election (4/2004)
Period Two: First period of full democracty (2005-2010)	First term of directly elected president (10/2004-10/2009)	First term of reorganized legislature (10/2004-9/2009)
	Second direct presidential election (7/2009)	Third free legislative election (4/2009)
Period Three: Second period of full democracy (2011-2016)	Second term of directly elected president (10/2009-10/2014)	Second term of reorganized legislature (10/2009-9/2014)
	Third direct presidential election (7/2014)	Third free legislative election (4/2009)

democratic nation, Indonesia welcomed a number of actors, organizations, and states who sought to promote general concepts related to the IFR, including REDD+ and sustainable forest governance (Bernstein and Cashore 2012; Sahide, Maryudi, et al. 2016), which represents a clear break from previous forest-related policy during the New Order. For purposes of analysis, we divide the 18 years including and between 1999 and 2016 into three periods, each of which contains unique events in the democratic evolution of the Indonesian political system (Table 2.3). Within these periods, and across 18 years of Indonesian democracy, we examine trends in forest-related policy.

Indonesian legislative structures extend to province and district levels, but we limit the present study to national forest-related policy. We focus on national-level policy content because of data constraints: a database or centralized system for province and district policy does not yet exist. Within national policy content, we examine five types of policy (Table 2.4). These policy

Table 2.4 National policy types and information (Sources: Laws 10/2004 and 12/2011)

Policy Type	Political Actor/s	Method of Passage	Notes
Law (*Undang-Undang)*	People's Representative Assembly (DPR)	Drafted by People's Representative Assembly with presidential consent. Subjected to review via Constitional Court	Legislated regulation planned, prepared, and ratified by legislature and President
Government Regulation (*Peraturan Pemerintah*)	People's Representative Assembly (DPR)	Enacted by the President	Prepared and enacted by President to implement law
Presidential Regulation (*Peraturan Presiden*)	President of Indonesia	Enacted by the President	Regulation prepared and enacted by president
Presidential Decree (*Keputusan Presiden*)	President of Indonesia	Enacted by the President	Often a set of instructions, specifying an action to be completed
Presidential Instruction (*Instruksi Presiden*)	President of Indonesia	Enacted by the President	Orders or instructions from the President's office, often to ministers and ministeries

types include laws, government regulations (GRs), presidential regulations (PRs), presidential decrees (PDs), and presidential instructions (PIs). The following section describes the steps we took to identify and code national forest-related policy passed in Indonesia between 1999 and 2016.

2.4 Methods

Our analysis of policy content proceeded in three steps. First, we searched for and identified forest-related policy. Second, we read and coded forest-related policy according to a set of formal criteria. And third, we visualized, analyzed, and tested hypotheses about forest-related policy change in Indonesia.

2.4.1 Defining the policy set

To identify forest-related policy, we used a two-step search protocol. First, we conduct a search of two Indonesian policy databases (Hukum Online 2018; Produk Hukum 2018) using a set of terms common within forest-related policy identified in current literature (Ardiansyah, Marthen, and Amalia 2015; Brockhaus et al. 2012; Sahide, Supratman, et al. 2016; Singer, Elated, and In 2009). These terms include:

> "plantation" OR "forestry" OR "garden" OR "forest" OR "natural resources" OR "environment" OR "tree" OR "wood" OR "palm" OR "rubber" OR "coffee" OR "food sovereignty" OR "food security" OR "food safety[1]"

Any policy that contained at least one of the key terms was identified for further review. We also used legal product databases to determine total yearly counts for all categories of national policy considered in this research. Following this database search, we identified relevant white and gray literature that focuses on Indonesian forest-related policy to complement the hits from our database search. Appendix D lists additional sources that identified Indonesian forest-related policy.

2.4.2 Coding policy documents

We coded policy documents according to a set of eight forest-related categories. These categories include: "Ecosystem Services/Biodiversity," "Allowable Harvest," "Reforestation," "Road Building," "Forest Protection and Monitoring," "Riparian or Coastal Zones." Table 2.5 contains the definitions for these categories. We selected these categories based on precedent in forest-related policy literature (Cashore and Howlett, 2007; McDermott et al. 2010; McDermott et al., 2012). In addition to these categories, we added "Financial Mechanisms for Forest Regulation" and "Organizational Mechanisms for Forest Regulation" content categories, based on current literature that emphasizes changes in forest-related organizations and administrations (Nurrochmat *et al.*, 2014; Nurfatriani *et al.*, 2015; Sahide and Giessen, 2015). We coded each policy document based on all the forest-related policy content it contained as well as the

[1] Indonesian translation: "perkebunan" OR "kehutanan" OR "kebun" OR "hutan" or "sumber daya alam" OR "lingkungan hidup" OR "pohon" OR "kayu" OR "sawit" OR "karet" OR "kopi" or "kedaulatan makan" OR "ketahanan pangan" OR "keamanan makanan"

Table 2.5: Forest policy content categories

Content Name	Definition
Ecosystem Service and Biodiversity	Regulation related to management, protection, or evaluation of ecosystem services or biodiversity
Allowable Harvest	Regulation related to management or evaluation of forest products (e.g. wood, non-timber forest products, eco-tourism, and etc.)
Road Building	Regulation related to the management and construction of roads within or surrounding forest areas
Reforestation	Regulation related to the management, location, funding, or implementation of reforestation activities
Forest Protection or Monitoring	Regulation related to the the management, protection, conservation, and/or evaluation of forest areas
Riparian or Coastal Zones	Regulation related to the management, protection, evaluation, or use of forest areas that are in riparian or coastal zones
Funding or Financing for Forest Organizations	Regulation related to the funding, financing, or taxation of forest-related organizations
Structure or Organization of Forest Organizations	Regulation related to the structure or organization of forest-related organizations (e.g. ministries, agencies, special cabinets, etc.)

"majority" content type for each document. Two coders read and coded all policy documents in Bahasa Indonesia, and they dual-coded a 10% (n= 22) sample of to ensure inter-coder reliability.

In addition to policy-content, we identified the references contained within each policy document. Indonesian policy documents provide clear references to the policy they cite and/or modify. We determined if the policy document in question directly amended or repealed a previous policy, the name of the policy it amended, and the name of all policies referenced in the document. Appendix D includes a complete list of all forest-related policies included in this study.

2.4.3 Analyzing forest-related policy

To analyze forest-related policy, we assessed the relationship between policy-content themes, the years or periods in which they were passed, and the amendments each document contains. To confirm our coding themes and assess their salient relationships, we created and analyzed citation networks. Then, we conducted statistical tests to determine the relationships between time and the rates of forest-related policy, content, and amendments.

We examined policy citation networks to confirm and guide policy change hypotheses. Using Gephi visualization software, we visualized policies as nodes, connected to one another through in-text citations (edges). Citations in these networks are of two types: policy reference or amendment. We assumed that different policy-content themes would create distinguishable clusters based on high levels of cross-policy references. Identifying these distinguishable clusters resembles community-detection in network analysis, which identifies groups of nodes that are more densely connected to one another through edges than to other nodes (Meerow and Newell 2015; Newman 2006). In addition to providing broad insight into policy citation communities, we use policy citation networks to examine how content types changed across our different study periods by visualizing the network during the first (1999-2004), second (2005-2010) and third (2011-2016) period. Using policy network visualization to guide hypotheses about policy content change, we proceeded to statistical analysis.

We used several statistical tests to analyze if the amount and type of forest-related policy changed between 1999 and 2016. Following interpretation of policy-citation networks, we tested null hypotheses of whether policy type, content, and references are independent of the period in which they were passed using chi-squared tests of independence and Kendall's rank correlation (Kendall's tau) statistics. First, we assessed whether the rate of forest-related policy is correlated across time and if it is significantly dependent upon the period in which it was passed. We conduct these tests on the proportion of forest-related policy to total national policy, to control for the potential confounding relationship of overall national policy passage over time. Second, after identifying general trends within the policy citation networks, we tested whether specific forest-related policy content (identified from the policy citation networks) is independent of the period in which policy is passed. We tested whether different time periods contain significantly different rates of policies that focus on a forest-related policy type using chi-square tests of independence, since real 0s in the data made Kendall's tau tests unreliable.

To direct our interpretation of the mode of policy change, we assessed the rate of forest-related policy amendments. We first examined the relationship between the number of forest-related policies with amendments to total forest-related policies using a Kendall's tau correlation test and chi-square tests of independence. We repeated these tests using the rate of forest-related amendments to total policy per year. A significant and positive relationship between year, the rate of new forest-related policy, and the rate of forest-related amendments indicates that new policy displaced pre-existing policy (Table 2.2). A significant relationship between year and the rate of new forest-related policy, but no significant relationship between year and forest-related amendments indicates new policy is layered over pre-existing policy. And, should no significant relationships exist between year and forest-related policy, drift or conversion may best explain forest-related policy change in Indonesia.

Coding, visualizing, and testing policy-content rates over time can establish if change occurred, but sector-specific insight is necessary to reconcile how content and implementation occur together. We used empirical results to inform a discussion of major trends in the regulation Indonesian forest territory and forest product flow from 1999 to 2016.

2.5 Results

The search criteria returned 289 policy documents. 254 of these documents were relevant to the timeframe of this study, and 218 contained policy content related to the set of categories we used to define forest-related policy. No small set of categories represented the content within the policies our search found that we determined to be unrelated to forest management.

2.5.1 Visualizing and interpreting Indonesian forest-related policy citation networks

Visualizing the policy citation network illustrates addition of forest-related policy over time. Panels A through C (Figure 2.1) highlight the addition of new forest-related policy between periods. The 218 forest-related policies contain 1,289 references. Of these, 6.9% are amendments and 93.1% are references. Policy citation networks also highlight dominant categories of forest-related policy content.

National forest-related policy in Indonesia, from 1999-2016, is dominated by three overall categories. Policy-content coded as primarily addressing “Forest Protection and Monitoring” comprises 24% of the final citation network, “Financial Mechanisms for Forest Regulation” comprises 22.9%, and “Organizational Mechanisms for Forest Regulation” comprises 22.4%. Policy citation networks illustrate the dominance of these three content categories within the overall network (Panel D, Figure 2.1). All other major content categories comprise 10.1% or less of the total citation network. Across policy citation communities, there is a strong co-occurrence of “Forest Protection and Monitoring” and “Ecosystem Services/Biodiversity.” This co-occurrence is the strongest within the citation network, with two thirds of all “Ecosystem Services/Biodiversity” majority policy references citing “Forest Protection and Monitoring” policies. This citation co-occurrence is double the amount of the second highest co-occurring categories (“Reforestation” and “Forest Protection and Monitoring”). We use the trends illustrated by the policy citation networks to inform our statistical analyses.

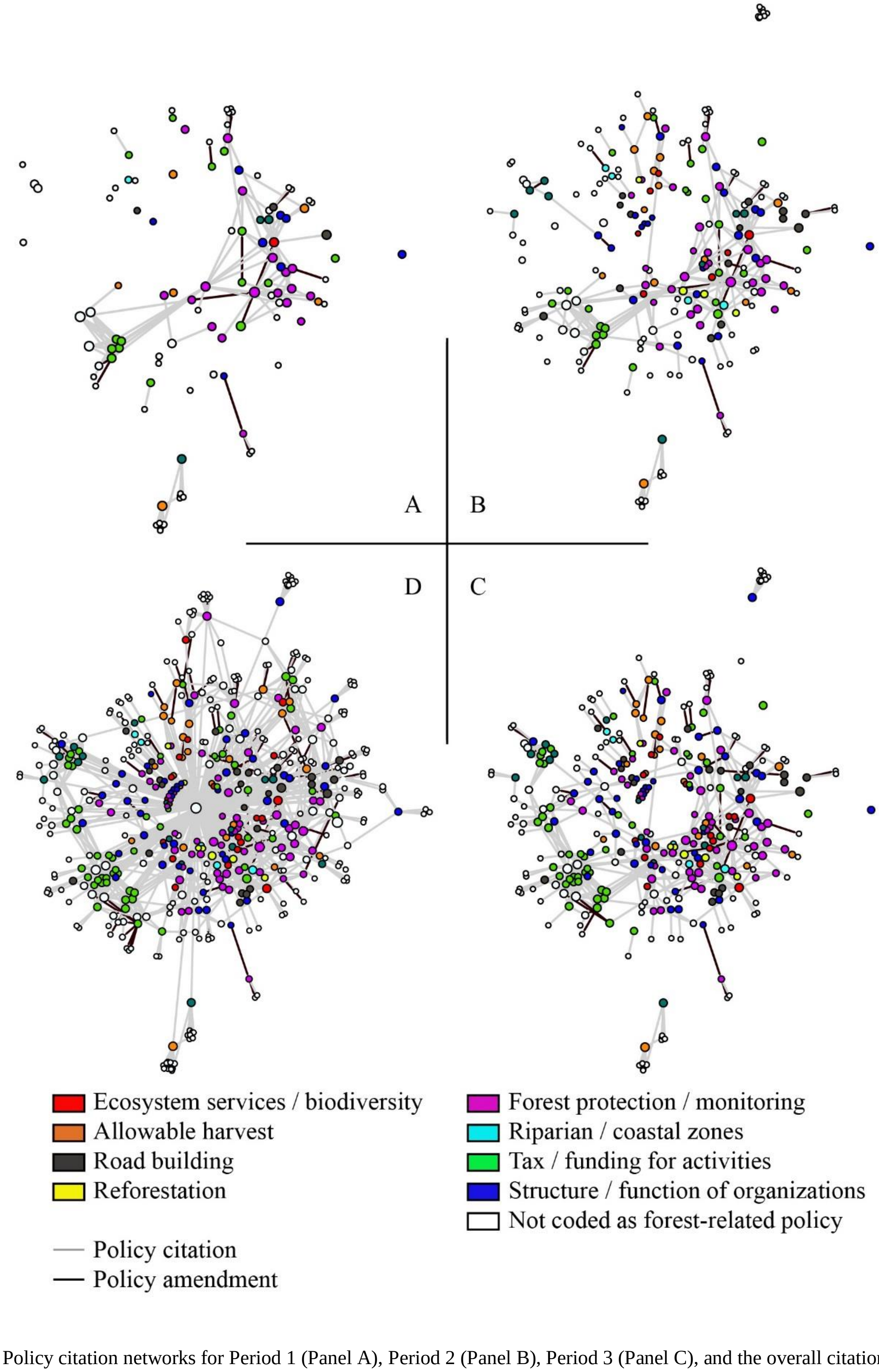


Figure 2.1: Policy citation networks for Period 1 (Panel A), Period 2 (Panel B), Period 3 (Panel C), and the overall citation network with non-forest and forest-related policies (Panel D). Nodes with color indicate forest-related policy. Nodes without color indicate policy-content referenced by forest-related policy.

Although the policy citation network demonstrates changes in counts, it does not control for the rate of all national-level policy creation. Our statistical analyses formally test whether the proportion of forest-related policy to total policy, as well as the number of forest-related amendments to total policy, significantly change over time and across periods to control for increases in overall policy-content generation that may influence results.

We used findings from the policy citation network to focus statistical analysis. We tested the following hypotheses to examine the tempo, directionality, and mode of Indonesian forest-related policy:

1. Forest-related policy has increased in amount from 1999 to 2016
2. Forest-related policy content increasingly focused on:
   a. Forest protection and monitoring
   b. Financial mechanisms for forest regulation
   c. Organizational mechanisms for forest regulation
3. Forest-related policy demonstrates an increase in direct policy amendments

2.5.2 Analysis of forest-related policy trends

From 1999 to 2016, the People's Representative Assembly and the President of Indonesia passed an increasing amount of forest-related policy (Table 2.6). Period 1 (1999-2004) contained 55 forest-related policies (25.2% of all forest-related policies), Period 2 (2005-2010) contained 65 (29.8%), and Period 3 (2011-2016) contained 98 (45.0%). A Mantel-Haenszel chi-squared test demonstrates that this change is significantly different from the null hypothesis of independence between year and number of forest-related policies as a proportion of overall national policies (Table 2.6). Further, Kendall's Tau Correlation demonstrates that this significant relationship is moderately positive (Figure 2.2).

Table 2.6: Forest-related policy, content, and amendment rates and significance from Mantel-Haenzel chi-squared test by period

	Total		Period 1 ('99 - '04)		Period 2 ('05 - '10)		Period 3 ('11 - '16)			
	N	%	N	%	N	%	N	%	χ^2	p-value
Total National Policies	5,149	----	1905	----	1472	----	1775	----	----	----
Total Forest-Related Policies (FRPs)	218	4.23	55	2.89	65	4.42	98	5.52	15.90	<.01
FRPs with Amendments	67	1.30	19	1.15	20	1.36	25	1.41	0.73	0.69
FRPs with Protection and Monitoring Content	85	1.65	24	1.26	24	1.63	37	2.08	3.86	0.15
FRPs with Protection and Monitoring & Ecosystem Services and Biodiveristy Content	103	2.00	27	1.42	32	2.17	44	2.48	5.59	0.06
FRPs with Funding and financing Content	77	1.50	22	1.15	17	1.16	38	2.14	7.68	<.05
FRPs with Forest-Related Organization and Structure Content	60	1.17	19	1.00	19	1.29	36	2.03	7.19	<.05

Descriptive analysis demonstrates an increase in "Forest protection and monitoring & ecosystem services and biodiversity," "Structure and organization," and "Funding and financing" content over the three periods of analysis. These counts represent the total number of policies that included content related to categories, rather than the number of policies primarily defined by one category. "Protection and Monitoring & Ecosystem Services and Biodiversity" has the highest overall proportion of overall policy content (2%), consistently increases from Period 1 to Period 3, and is the greatest percentage of forest-related policy passed in Period 3 (44.9%). "Structure and Organization" of forest-related organizations also demonstrates consistent increases and is included in 36.7% of national forest-related policies from Period 3. Policy that addresses "Funding and Financing" of forest-related organizations also increases from Periods 1 to 3 and is referenced in 38.7% of all policy from Period 3. The increasing amount of policy that

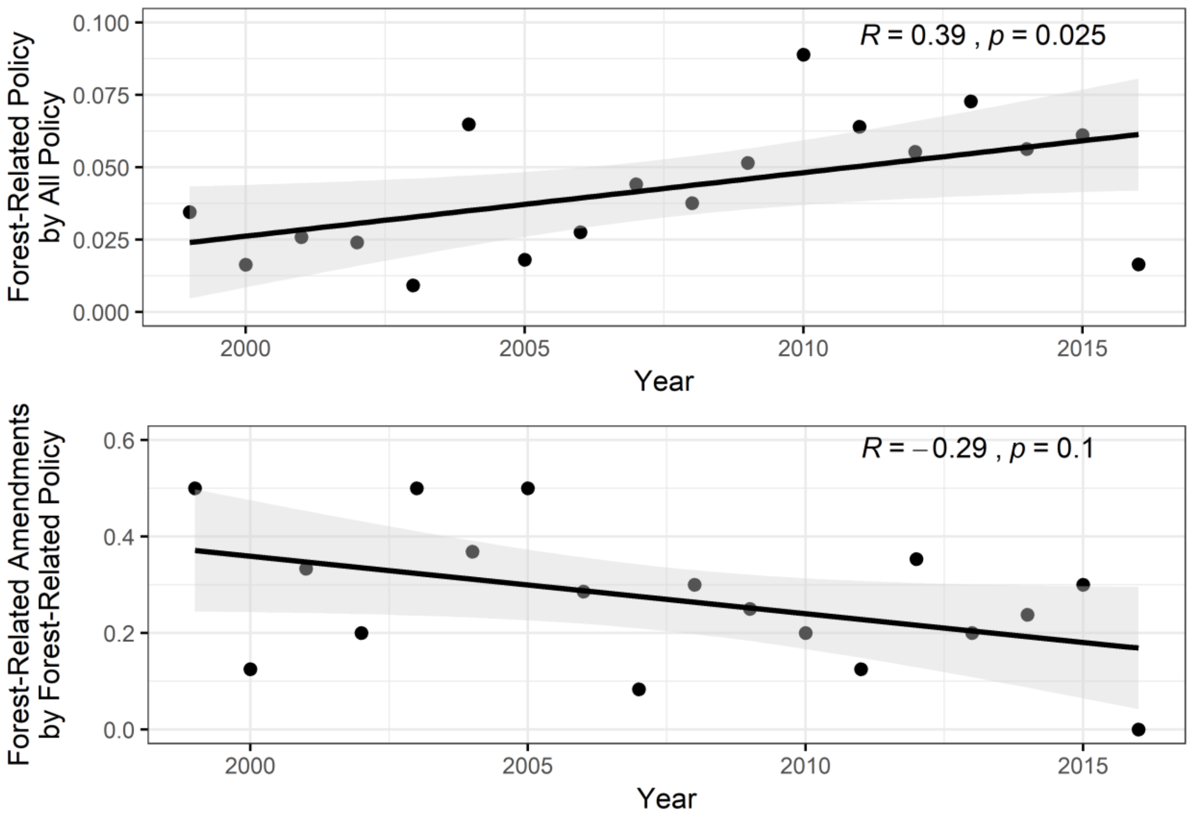


Figure 2.2: Kendall's tau correlation results for year (x-axis) by proportion of forest-related policy of total policy (top) and forest-related amendements by total forest-related policy (bottom)

contains "Forest protection and monitoring & ecosystem services and biodiversity," "Structure and organization," and "Funding and financing" content is in contrast with the proportion of forest-related policies that introduce amendments over the same period.

The proportion of forest-related policy amendments over time demonstrates significant decrease. A Mantel-Haenzel chi-squared test of the proportion of forest-related amendments from overall policy cannot reject the independence between time periods (Table 2.6). However, testing the proportion of forest-related amendments of only forest-related policy with a Kendall's tau correlation indicates that the rate of forest-related amendments per forest-related policy decreases over time (tau = -0.29, p=0.1).

2.6 Discussion

National forest-related policy in Indonesia demonstrated significant change between 1999 and 2016. This change is best described as a classic paradigm shift toward forest protection and monitoring, which occurred through a layering process. This discussion examines the trend of policy change and then considers how Indonesian governance of forest territory and the flow of forest products reflects policy layering.

2.6.1 The classic paradigm shift in Indonesian forest-related policy

Between 1999 and 2016, Indonesia passed more forest-related policy that emphasizes forest protection and focuses on restructuring forest-related organizations. Classic paradigm shifts occur when the tempo of policy change is relatively fast and the directionality is consistent (Cashore and Howlett 2007). This often occurs through an exogenous pressure, and is referred to as a "punctuated equilibrium" that overwhelms standard incremental change of policy content (Nisbet 1972). The significant increase of forest-related policy over time demonstrates a continuous change in policy-content focus. The marked increase in financing, organizational restructuring, and forest protection support the classic paradigm shift hypothesis of forest-related policy change.

Since *reformasi,* the amount of forest-related policy that addresses forest protection, monitoring, biodiversity, and ecosystem services has increased significantly. International rules, norms/discourse, market intervention, and access to domestic policy comprise four pathways through which international regimes—including uncomprehensive regimes, like the IFR—can influence domestic policy (Bernstein and Cashore 2012). Increasing trade restrictions, notably those related to CITES, the Lacey Act, and the EU Forest Legality, Governance, and Trade Voluntary Partnership Agreements (FLEGT VPAs) for verified legal timber, seek to constrain the market for illegal timber and timber products (Lesniewska and McDermott 2014). These restrictions, coupled with market incentives for forest certification and legality verification, and international norms, such as committing to carbon emissions reductions, have increased the importance of protecting and monitoring Indonesian forests for the Indonesain state. The emphasis on forest monitoring and protection is observable in policy content that addresses how forest concessions are issued (GR 34/2002, GR 38/2007, GR 3/2008, Law 32/2009, GR 24/2010, GR 72/2010, GR 61/2012, Law 23/2014, GR 57/2016), how forests are monitored and by whom (Law 32/2009, Law 18/2013, Law 23/2014, PR 16/2015), in policy that addresses timber trade (GR 34/2002, GR 6/2007, PR 21/2014), and ratifies international commitments (Law 17/2004, GR 21/2014).

International financial commitments and contributions that promote forest protection and monitoring provide another example of how international pressures have promoted forest conservation agendas in Indonesia. Commitments include the 2010 Letter of Intent between the Norwegian and Indonesian governments, which pledged $1 billion for evidence of REDD impacts, as well as the hundreds of millions of dollars provided through organizations such as the World Bank, the UK Department for International Development, and others that focus on "good forest governance" in Indonesia. Specifically, international funding has promoted the One Map Policy to harmonize ministerial land claims, improved governance of forest management units (Sahide *et al.*, 2016), and others. As policy content that focuses on protection and monitoring of Indonesian forests increased, forest-related organizations in Indonesia were restructured.

Between 2011 and 2016, three major changes altered forest-related organizations. First, presidents established two ad hoc agencies that report directly to the president. In 2013 President Susilo Bambang Yudhyono formed a special agency to implement activities and funding associated with reducing emissions from deforestation and forest degradation (PR 62/2013)[2]. Then, President Widodo established the Peatland Restoration Agency (PR 57/2016). Both of these special agencies were established outside the Ministry of Environment and/or Forestry to report directly to the president in order to facilitate President Yudohoyo's 2009 pledge to reduce carbon emissions between 26% and 41% by 2020, and President Widodo's 2015 pledge and Paris Agreement commitment to reduce carbon emissions between 29% and 41% by 2030 (Alisjahbana and Busch 2017).

Second, President Joko Widodo combined the Ministry of Forestry with the Ministry of Environment to create the Ministry of Environment and Forestry in 2015 (PD 16/2015). The combination of these ministries created a "mega ministry," charged with overseeing forestry management and conservation activities of the state's forest areas. Within it, PD 16/2015 gives powers over REDD+ to the newly formed Secretariat of Climate Change. Additionally, a new Secretariat of Social Forestry and Environmental Partnerships is charged with the allocation of 12.7 Mha of forest area to communities (Afiff 2016).

Third, two different laws redistributed rights to control of forest resources in 2014. The Village Law (6/2014) extended more authority over natural resources to villages than ever before in Indonesian history (Antlöv, Wetterberg, and Dharmawan 2016). Meanwhile, the Province Law (23/2014) increased control over forest resources and administration at the province level, and established a greater administrative role for forest management units (Sahide, Supratman, et al. 2016). The Village Law, in combination with the pledge to allocate 12.7 Mha to communities across Indonesia, aims to promote community conservation and natural resource management (Myers, Intarini, Sirait, et al. 2017). The Regional Governance Law increases the power of

[2] This agency was not appointed until near President Yudhoyono's term and its mechanism for finance was never clarified. In 2015, President Widodo dissolved this agency (Presidential Regulation 16/2015).

province governments, clarifying their role in overseeing forest management units, and specifying how concession rights to national forest lands are to be allocated (Afiff 2016; Sahide, Supratman, et al. 2016).

International rules, norms, and market incentives represent the pathways through which external actors influenced the incentive for Indonesian political actors to legislate in favor of forest protection (Bernstein and Cashore 2012). Thus, the People's Consultative Assembly (DPR and DPD) and the President of Indonesia have dedicated increased attention to promote forest protection through policy creation that focuses on forest protection and monitoring as well as administrative reorganization. The mechanism through which this shift has occurred, however, leaves room for contradictory laws, regulatory mis- or re-interpretation, and jurisdictional differences in forest-related enforcement.

2.6.2 Forest-related policy layering and the limits of institutional reform

Although the amount of forest-related policy content that focused on protection and monitoring significantly increased from 1999 to 2016, total forest cover loss across the Indonesian archipelago consistently increased over the same time period (Hansen et al. 2013; Margono et al. 2012, 2014). This points to a discrepancy between new policy content and implementation. Policy layering within national-level policy and across different policy levels provides a possible explanation as to why this discrepancy persists.

Through the analysis of policy-content change using citation networks, we identified a decrease in policy amendments from 1999 to 2016. As political actors passed more policy focused on forest protection and monitoring, they did not displace previous regulation. 30.1% of forest-related policy passed between 1999 and 2016 includes policy amendment or repeal. Examining current trends in the regulation of forest territory and forest product flow (Sikor et al.

2013) illustrates the relationship between policy layering, forest governance, and interpretable ambiguity.

Though related, forest-related policy and forest governance are not synonymous (Rhodes 2007). Mandates for forest governance are often found within forest-related policy, but the intermingling of rules, practice, and context are what generate outcomes for forests and people. In general, forest governance focuses on the regulation of forest territory and the flow of forest products (Sikor, He, and Lestrelin 2017). Generating and analyzing data on forest-related policy identifies patterns in the policy itself, but it does not provide insight into how policy is implemented through practices of the state (Foucault 1978; Scott 1998). To connect forest-related policy and governance in contemporary Indonesia, we discuss the role of forest-related policy change and layering in the regulation of forest territory and the flow of forest products.

Regulating forest territory

The shift to increased forest protection via the layering of forest-related policy has significant consequences for how, and through what organizations, the Indonesian state manages forest territory. The structure of government organizations imbued with the authority to manage and regulate state forests in Indonesia changed more between 1999 to 2016 than in the 30 years preceding this period (Barr et al. 2006; Moeliono, Wollenberg, and Limberg 2010). In addition, recent policy changes indicate a strong push for the conservation of primary and peatland forests. However, overlapping land use claims and layered authority of different ministries and sub-national jurisdictions challenge the enforcement of national policy and promote local forms of tenure and planning.

Recent forest concession moratoria exemplify policy layering that promotes forest protection. With the first moratoria (IP 10/2011), President Yudhoyono signaled to the international community that Indonesia would no longer sell the right to convert primary or peat forests. Since this initial passage, three additional moratoria have been passed that maintain the prohibition of new concessions in primary and peatland forest. Empirical research finds that, were a moratorium on new concessions in place from 2000 to 2010, forest cover loss would have been between 2.5 to 7.2% lower (Busch et al. 2014). Assuming consistent trends, this predicts a significant effect of moratoria for reducing forest cover loss, but the loss of forest cover on areas outside concessions remains high. Additionally, the concession moratoria are neither permanent nor are they able to fully prohibit the conversion of land cover in primary and peatland forests within primary and peatland forests, due to pre-existing concession claims, competing ministerial jurisdictions, and layered policy related to land use planning.

Indonesian land use planning influences the protection and monitoring of forest territory because the authority to govern Indonesian land rests in ministerial jurisdiction and spatial planning. The Geospatial Law (4/2011) provides authority to the National Mapping Agency (*Badan Informasi Geospasial*—BIG) to unify information on natural resources and land across the country. Despite this mandate, spatial planning remains subject to horizontal and vertical layering. Horizontal layering refers to the overlap between different policies as well as ministerial land claims. Indonesian ministries, including the Ministries of Environment and Forestry, Agriculture, Energy and Mineral Resources, and Public Works and Housing have spatially determined authority. Historically, these ministries used their own maps to determine where they were authorized to regulate land use (Wibowo and Giessen 2015). The One Map Initiative is a national effort to harmonize different ministerial claims across Indonesia. Although this initiatives has improved transparency between many ministries, it has yet to produce a fully harmonized map of ministerial territory (Mulyani and Jepson 2017) and is not charged with making the one map available to the public (Wibowo and Giessen 2015).

Vertical overlap in territory demarcation and determination occurs through the process of land use planning. In Indonesia, spatial planning relies on the communication and approval between district, province, and national governments. Districts generate spatial plans which are approved both by province and national governments. These district-level plans determine where certain activities can take place, and they can reclassify land cover categories through legal means. However, spatial plans do not necessarily represent the tangle of local, corporate, and governmental claims to land. Recent scholarship demonstrates how smallholder and industrial agriculture demonstrate mutual encroachment (Gaveau et al. 2017), and how ministerial and district-level land-claims intersect with community territories to disenfranchise local communities (Myers, Intarini, Sirait, et al. 2017). Although Law 4/2011 gives BIG the authority to harmonize Indonesian land tenure, ministries are reluctant to compromise jurisdiction, districts and provinces retain some control over spatial planning, and local realities do not necessarily reflect government maps.

Despite the challenges policy, ministerial, and administrative overlap pose, significant progress toward forest protection and harmonized land-management has occurred across Indonesia since its transition to democracy. Recent pledges have indicated that, in addition to reforming land-tenure and spatial planning, the national government is dedicated to recognizing local authority over community forests (Myers, Intarini, Thomas, et al. 2017; Santika et al. 2017). Although the pledged redistribution of 12.7 MHa of state forest to local communities represents a drastic change in land-tenure, and may generate additional layering, it recognizes indigenous and local rights to land. Indonesia is not alone in its struggle to provide clear tenure and protect forest areas; eleven other countries with emerging economies demonstrate similar patterns of overlapping land claims (De et al. 2013). As Indonesia enters its third decade of democracy, forest protection and land use planning are positioned to remain important topics.

Regulating the flow of forest products

Greater attention to forest protection and the structure of forest-related organizations has also influenced how forest products are regulated. Specifically, Indonesian forestry governance shifted to provincial oversight of forest management units and implemented a new system of internationally recognized timber legality verification (*Sistem Verifikasi Legalitas Kayu*—SVLK). Both developments reflect change in forest-related policy and were implemented through layering.

Although forest management units have long been part of Indonesian forest governance, they have recently risen to prominence as the key bureaucratic technology for implementing regulation and monitoring on behalf of the Ministry of Environment and Forestry and province administrations. The ability to issue concessions on state forest land and monitor timber production was, in the early 2000s, the right of district administrations. Over time, this authority has shifted, and is now held by the Ministry of Environment and Forestry and province governments. A series of laws, issued between 2003 and 2016, ushered in these changes, which reflect a relative recentralization of state authority over forest resources (Sahide and Giessen, 2015; Sahide *et al.*, 2016). Although the 1999 to 2004 period included a large amount of policy layering, resulting in heightened forest cover change from district-level decentralization (Burgess and Olken 2012), more recent administrative changes directly amended previous laws. However, this displacement remains partial. Implementing Law 23/2014, depends upon older fiscal balance laws (32/2004 and 28/2009). Thus, district, province, and national government administration have been charged with implementing forest regulation and monitoring through Law 23/2014 but must share tax and non-tax revenues as determined by outdated fiscal balance laws and procedures. During this same period, district-level forestry offices have either been closed or integrated with new offices for forest management units, without clear instructions on how to complete this transition (Sahide *et al.*, 2016).

Timber legality verification demonstrates how, over time, policy layering can transition to displacement. Initiated by a Voluntary Partnership Agreement (VPA) between Indonesia and the European Union in 2010, Indonesia implemented mandatory third-party legality verification for all timber and timber products (Lesniewska and McDermott 2014). Intended to reduce illegal logging, and assist the government ministries and administrations capture full value of timber and timber products (Maryudi 2016), the legality verification system mandates third party auditing for timber production. International funding for timber legality verification has increased through different international initiatives, including the European Commission Directorate General for International Cooperation and Development and the UK Department for International Development (European Union 2017; Sahide and Giessen 2015). Early in Period 3 (2011-2016), there was significant confusion with regard to what types of enterprises needed to be certified, by whom, and by when (Lesniewska and McDermott 2014; Obidzinski et al. 2014). Significant confusion and barriers still exist for small and medium sized enterprises, as well as for timber that comes from private or community forests (Nurrochmat *et al.*, 2014; Erbaugh, Nurrochmat and Purnomo, 2017). However, the EU FLEGT Facility reports that by 2016, 100% of natural and plantation concessions were certified legal (European Union 2017) and the majority of Indonesian timber for export is certified legal. Although certified legal timber represents a specific "commoditization of legality," and does not necessarily address issues of land use and planning, indigenous/local peoples' rights, or sustainable forestry (Setyowati and McDermott 2017), it does represent the integration of third party auditing and transparency in governance, important qualities of good forest governance (Cashore et al. 2007; Lesniewska and McDermott 2014). It further demonstrates how, over time, layered policies can lead to displacement and clearer implementation guidelines.

The limits of institutional reform

In many ways, layering national forest-related policy is an optimal solution for national politicians. Passing an increasing amount of policy focused on forest protection and monitoring signals a willingness of the Indonesian state to modernize in accordance with the wishes of the IFR (Andrews 2013). Layering new forest-related policy on top of older policy, in contrast to displacing older policy, maintains space for jurisdictions, sub-national administrations, and corporations to continue current extractive activities and anonymizes illegal or extra-legal land cover change (Gaveau et al. 2017).

Indonesian political actors often rely upon extractive industries (Berenschot 2018). Ambitious economic growth targets set by the president, high campaign costs, and economies dominated by specific agricultural commodities connect sub-national political actors and land cover change (McCarthy 2004; McCarthy and Cramb 2016). There is empirical evidence that, between 2000 and 2007, Indonesian forest cover loss associated with concession rights increased during election years (Burgess and Olken 2012). National policy layering thus balances international demands for sustainable forest management and improved protection and monitoring with maintain a status quo where political power and land use are intertwined.

New policy is not sufficient to realize institutional change. Increasing levels of forest cover loss in Indonesia occurred as national policy shifted to promoted forest protection and monitoring. Although it may be necessary for institutional change, new policy creation should not be a goal in itself (Andrews 2013). Rather, policy coupled with transparent and efficient systems to for implementation and regulation are necessary to realize changes in Indonesian forest outcomes. Future research would do well to examine the relationship between policy layering, political power, and Indonesian land cover change.

2.7 Conclusion

The proportion of total forest policies to all national policy demonstrates a significant increase over time. From 1999 to 2016, we identified 269 national, forest-related policies. Among them, the amount of content that focused primarily on increasing forest protection and monitoring/ecosystem service and biodiversity conservation, determine financial policies for forest-related activities, and restructure forest-related organizations (24%) also demonstrated significant increases over time. These changes in policy content occurred alongside new international rules that restrict illegal timber, international norms that promote climate pledges and agreements to reduce carbon emissions, as well as international market incentives that provide conditional aid for REDD+ activities (Angelsen 2017) and sustainable forest management (Bernstein and Cashore 2012). Thus, this research supports the conclusion that national forest-related policy in Indonesia demonstrates a classic paradigm shift, whereby exogenous influences have promoted a relatively rapid change in policy content. Although national policy demonstrates a classic paradigm shift toward the protection and management of Indonesian forest areas, we find that policy changes have not occurred alongside a significant increase in policy amendments. Thus, as new policies are passed, older policies are not necessarily amended or repealed. This process of policy change, referred to as layering

(Mahoney and Thelen 2010), generates ambiguity in regulation and enforcement. Policy layering has impacts for the regulation of forest territory and the flow of forest products.

Current developments in Indonesian forest governance illustrate how an increase in forest-related policy focused on protection and monitoring and consistent forest cover loss can co-exist. Land use and planning in Indonesia are subject to significant jurisdictional turf wars. Overlapping claims between ministries and local actors exist across the archipelago. Although Law 4/2011 provides the legal framework for resolving these overlaps, it neither guides the process to integrate different ministerial jurisdictions, nor does it help resolve conflict between different national, provincial, and district land agencies that are key in issuing and holding land rights (Harahap, Silveira, and Khatiwada 2017). Further, different administrative levels can change land use plans. Thus, with unclear ministerial tenure and changing land use plans, the implementation and enforcement of new policy that supports forest protection and monitoring remains difficult. Additionally, policy layering affects the regulation of forest products. Empowering forest management units and timber legality verification have recentralized forest governance in the name of transparency and legitimacy. These same policies fail to directly modify previous systems of regulation and accountability. However, timber legality verification provides an example of how layering can lead to displacement. Since 2010, timber legality verification has become increasingly formalized, covering all natural and plantation concession areas, and a rising number of small and medium enterprises (European Union 2017). This, perhaps, provides insight into the functionality of layered policy: it provides an initial step that, over time, generates changes in forest governance.

The passage of forest-related policy has impacts beyond its operationalization. By signaling a willingness to modernize through new policy, the Indonesian state continues to represent itself as modern, open to reform, and willing to engage international actors and foreign states (Andrews 2018). A growing literature identifies the way in which national and sub-national governments and actors in Indonesia pursue multiple agendas through international funding for forest protection and monitoring. The Ministry of Environment and Forestry seeks to gain power and authority both through forest protection and through forest harvest (A. Wibowo and Giessen 2015); local bureaucracies are able to extend their authority through the promotion of forest management units (Sahide, Maryudi, et al. 2016); and companies that conduct third party audits benefit from mandating independent legality verification of timber products (Setyowati and McDermott 2017). Meanwhile, converting forest areas to plantations, intensive agriculture, or urban development curries political favor with the communities and corporations that benefit from infrastructure and development projects and it helps Indonesia progress toward annual development goals. Neither nations, sub-national bureaucracies, nor local people are passive recipients of international conservation funding (Myers, Intarini, Sirait, et al. 2017; Singer 2009). The passage of more forest-related policy and more forest protection and monitoring content should not be considered goals in themselves. Rather, the passage of these policies must engender change within forestry and conservation sectors across Indonesia to promote the goals which they reflect.

Chapter 3

The impact of regulatory dispersal on Indonesian forest cover, 2000-2014

Abstract:

Countries that contain some of the largest tracts of tropical forest experienced rapid decentralization over the past two decades. The creation of new local administrations often follows decentralization reforms, which seek to delegate political, economic, or administrative powers to lower levels of government. When new local administrations are created, regulation is dispersed across a greater number of units. Despite the prevalence of regulatory dispersal across the tropics, its effect on forest cover is often overlooked. We measure the effect of regulatory dispersal on forest cover in Indonesia from 2000 to 2014 using two-way fixed effect models and statistical matching. We find that dispersal of village and district regulation results in higher rates of forest cover loss in the period after regulatory dispersal begins. However, the effect of regulatory dispersal on Indonesian forest cover attenuates over time and depends on the administrative level of dispersal. Our findings highlight the importance of considering scale and timing of regulatory dispersal in future analyses of land change or natural resource management.

3.1 Introduction

Conserving and sustainably managing tropical forests are two of the most cost effective methods for reducing global carbon emissions to mitigate climate change (Houghton, 2005; Gullison *et al.*, 2007). However, consistent tropical forest loss and fragmentation has continued over the past two decades (Brinck et al. 2017; Haddad et al. 2015; Hansen et al. 2013; Potapov et al. 2017b). Social-ecological scholarship on land cover change finds that community-based management, protected areas, moratoria, and formalized land ownership tend to reduce forest cover loss (Andam et al. 2008; Blackman et al. 2017; Chhatre and Agrawal 2009; Ferraro et al. 2015; Ferraro and Hanauer 2014b; Gaveau, Epting, et al. 2009; Persha, Agrawal, and Chhatre 2011; Wright et al. 2016), despite improved transportation networks, unclear and overlapping land rights, as well as increased demand for agricultural products that often combine to increase it (Cropper, Griffiths, and Mani 1999; Gaveau et al. 2017; Lambin, Geist, and Lambin 2002; Lambin and Meyfroidt 2011; Meyfroidt and Lambin 2009). Although these insights are crucial for understanding collectivism, management of the commons, incentives for sustainable common-pool resource use, and deforestation “drivers,” they do not address the widespread phenomenon of regulatory dispersal.

Regulatory dispersal often occurs when states decentralize rights and responsibilities for natural resource management (Agrawal 2005). Countries that contain the world’s most biologically diverse and carbon rich forests, spanning sub-Saharan Africa, Southeast Asia, and Latin America, have undergone extensive decentralization over the past two decades (Agrawal, Chhatre, and Hardin 2008; Manor 1999; Ribot, Agrawal, and Larson 2006). Decentralization is often associated with a suite of benefits, including higher accountability between representatives and electors, greater transparency, improved service provision, and democratizing resource use

(Blair 2000; Faguet 2014; Larson and Soto 2008; Lund, Rutt, and Ribot 2018). However, empirical research demonstrates that, without appropriate safeguards and incentives, decentralization can promote outcomes often considered negative (Agrawal and Ostrom 2001; Andersson, Gibson, and Lehoucq 2004; Bardhan 2002; Tacconi 2007). Some of these "perverse outcomes" include elite or political capture (Andersson, Gibson, and Lehoucq 2006; Wilfahrt 2018), reduced financial disbursement and service provision (Adam and Eltayeb 2016), and unintented recentralization (Phelps, Webb, and Agrawal 2010; Ribot, Agrawal, and Larson 2006). Following decentralization reforms, many countries experience rapid administrative proliferation.

Administrative proliferation refers to the creation of new local governments. Devolving authority to local governments, as through decentralization reforms, increases their value to local elites and citizens. As value increases, demand for local governments increases as well (Grossman and Lewis 2014). Despite the rapid proliferation of administrative units across much of the Global South (Dickovick 2011; Grossman and Lewis 2014; Malesky 2009; Pierskalla 2016), social-ecological impact studies rarely consider how new administrative units affect resource outcomes. It is common practice to control for the administrative unit at a temporal baseline and overlook subsequent administrative changes through weighting of population and land-area, in order to compare land cover and/or socioeconomic indicators over time. However, changing local administrative boundaries represents a social process that disperses resource regulation across more units (Agrawal 2005) and alters formal or informal regulations that structure how people interact with one another to use natural resources (North 1990; Ostrom 1990).

Regulatory dispersal is a process that occurs in time and over space. We distinguish three key elements for analyzing the role of regulatory dispersal on resource use and/or land cover change.

1. **Regulatory type.** Rules, norms, and behaviors are generally categorized as formal and informal (e.g. Ostrom, 2005). We extend this categorization to identify formal and informal regulatory dispersal in relation to natural resource management. Regulatory dispersal that affects formal institutions occurs when units proliferate that have codified or otherwise formal rights to regulating natural resource use. Regulatory dispersal that affects informal institutions occurs when units proliferate that affect norms or behaviors of resource use, but do not have legal rights to resource use. Table 3.1 provides a typology of land cover change related to the types of regulatory dispersal. In studying regulatory dispersal and resource use, it is important to identify the scale of dispersed regulation, in addition to the formal or informal authority it claims.

Table 3.1: Formal and informal mechanisms of land cover change

	In accordance with formal institutions (legal)	In violation of formal institutions (illegall)
In accordange with informal institutions (customary)	Land converted by actors with use/control rights in accordance with local custom E.g., Legal and customary agricultural conversion	Land covcerted by actors without use/control rights in accordance with local ustom E.g. Intentional forebearance of formal land regulations
In violation of informal institutions (uncustomary)	Land converted by those with use or control rights in violation of local customs E.g., Rapid territorialization or exclusion and conversion	Land converted by actors without use/control rights in violation of local custom. E.g., Ungovernable spaces; periods of limited regulation

2. **Sequence and time.** The moment when regulatory dispersal occurs may affect resource outcomes, and the resource outcomes that result may change over time. Policy, national stability, and international influence may vary over time to influence local governments. Understanding regulatory dispersal as an institutional transition that may be influenced by the sequence of preceding institutional changes is crucial for assessing outcomes (Pierson 2000). Further, outcomes from regulatory dispersal may change over time. These longitudinal effects may be the result of outside exogenous changes, or it may result from endogenous changes within the administrative unit. During the transition from one administration to another, the formal and informal institutions that previously guided resource use are in flux, the administration that regulates or promotes formal or informal institutions is changing, or both institutions and the administration are in transition.
3. **Spatial variation.** Regulatory dispersal is a process that occurs over time and space. It may result in the increase of regulated territory or through the densification of regulatory units within the same area. Although historical examples of regulatory dispersal that expands administrative control are many, contemporary trends in regulatory dispersal are connected to the process of densification. For example, across the Global South an increasing number of administrative units are proliferating to serve and regulate the same area (Grossman and Lewis 2014).

Using administrative proliferation as the signal, this research examines regulatory dispersal on Indonesian forest cover.

Indonesia is an ideal country in which to study the effect of regulatory dispersal on forest cover change. In the beginning of the 21st century, Indonesia transitioned from the *reformasi* era

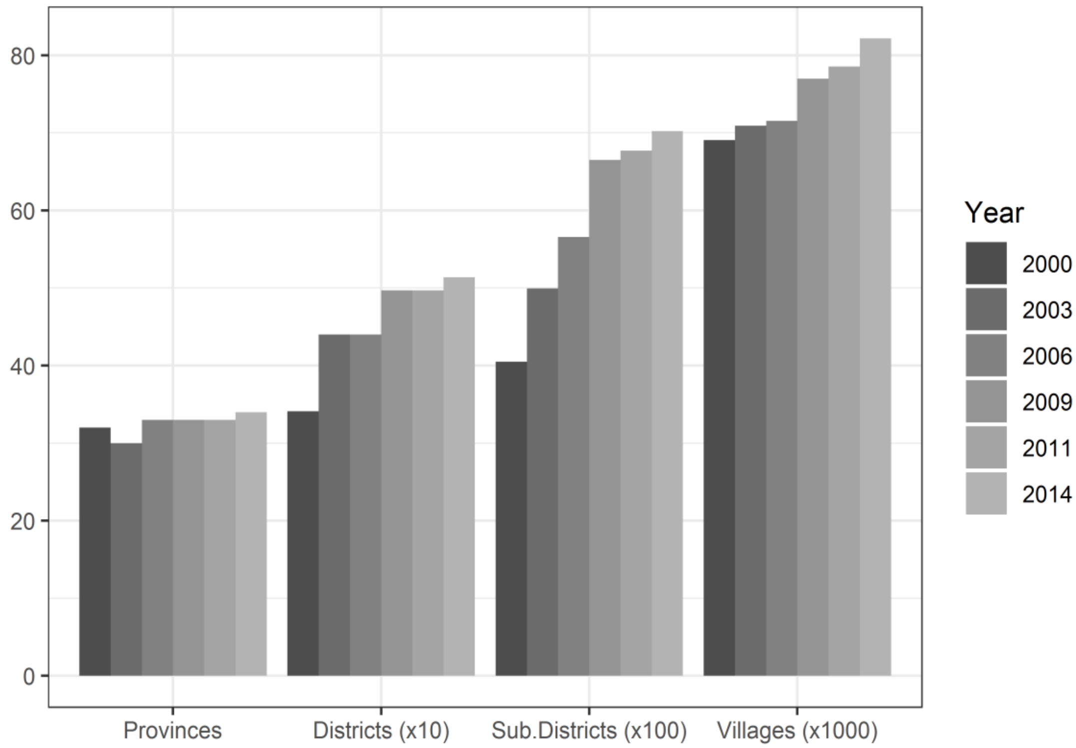


Figure 3.1: Administrative unit (x-axis) by count frequency (y-axis) by year (legend) (BPS 2006, 2011, 2016)

that marked the end of authoritarian rule, to the world's third largest democracy. Key to this process was the proliferation of new provinces, districts, and villages (SI: Background). For example, as Indonesia democratized and decentralized between 2000 and 2014, the number of district-level administrations increased by 62% and the number of villages increased by 21% (Figure 3.1). During this same period, Indonesia also experienced one of the greatest changes in contemporary forest cover change (Hansen et al. 2013; Margono et al. 2014). Thus, studying the relationship between regulatory dispersal and Indonesian forest cover change can provide insight into one of the most significant changes in contemporary and contribute to better understanding how institutional transitions impact land cover change.

To test and measure the effect of regulatory dispersal on natural resource use, we construct an original dataset with information on land cover, geophysical attributes, socioeconomic village indicators, and administrative changes in Indonesia from 2000 to 2014. This dataset allows us to test three hypotheses related to how timing, regulatory type, and sequencing of regulatory dispersal affect forest cover change in Indonesia from 2000 to 2014.

First, we hypothesize that regulatory dispersal will affect forest cover change in the first period following dispersal. If regulatory dispersal affects forest cover change, it will do so either during the period in which dispersal is occurring, in the periods following dispersal, or both. Since periods following dispersal represent moments when actors have adjusted and are reacting to new formal and informal types of regulation, we hypothesize that regulatory dispersal will demonstrate a temporal lag effect. That is, the effect of regulatory dispersal on forest cover change will be most pronounced in the period following dispersal, rather than the same period of dispersal or the period before (reverse causation).

Second, we hypothesize that the affect of regulatory dispersal on forest cover change will attenuate over time. The formalization if Indonesian forest regulation and management has increased since its transition to democracy in 1998 (Obidzinski and Kusters 2015). This formalization has occurred primarily through a series of reforms that increased the recentralization of forest management through policy that gave increasing authority over forest lands to ministries and provinces, and reduced the authority of district administrations (Barr et al. 2006; Sahide, Maryudi, et al. 2016). Although the marginal increase of administrative units over time is positive, this trend is in line with the recentralization of power in Indonesia and in other national contexts (Grossman, Pierskalla, and Dean 2017; Ribot, Agrawal, and Larson 2006; Sahide, Supratman, et al. 2016). Thus, we hypothesize that the effect of regulatory dispersal on forest cover change attenuates over time, responding to the increased formalization and recentralization of forest management. We test this hypothesis using a series of matching analyses.

Third, we hypothesize that the effect of regulatory dispersal will vary across regulatory type. Given the difference in power and authority over forest resources held by different levels of government, we anticipate the dispersal of units with formal authority will differ in its effect on forest cover than the dispersal of units without formal authority over forest areas. To examine differences in regulatory dispersal type, we focus on village- and district-level dispersal. Village administrations represent informal regulatory dispersal since they have no formal authority to manage forest areas; district administrations represent formal regulatoy dispersal, since between 1999 and 2014 they were the primary administrative level through which forest management decisions were made (2000-2003) or implemented (2004-2014). We test the hypothesis by examining the affect of village- and district-level regulatory dispersal separately in the fixed-effect models and matching analyses, as well as examining how land cover changes in villages affected by village-level regulatory dispersal, village- and district-level dispersal, and district-level dispersal.

3.2 Materials and Methods:

3.2.1 Data

To conduct our analysis, we combined datasets containing socioeconomic, boundary, land cover, and physical data. We obtained data on village-level, socioeconomic indicators as well as jurisdictional boundaries from the Central Statistics Agency of Indonesia (*Badan Pusat Statistik* - BPS). Village-level indicators are measured every three years through the Indonesian Village Census (PODES), which Village Heads complete with direction and oversight from BPS enumerators[3] (BPS 2001, 2003, 2006b, 2008, 2011b, 2015c). Village, sub-district, district, and province boundaries are updated twice a year (BPS 2015b). We obtained land cover data from the Indonesian Ministry of Environment and Forestry (KLHK, 2016). Before 2010, the Ministry of Environment and Forestry generated land cover data using supervised classification of Landsat Satellite Imagery; it now generates land cover data annually (KLHK - Kementerian Lingkungan Hidup dan Kehutanan 2015). From the 22 land cover categories specified by KLHK, we combined "primary forest" and "secondary forest" to assess forest cover change. This land cover combination has demonstrated 90.2% agreement of forest cover identification (Kappa=0.8) with other land cover products generated from Landsat Imagery (Margono et al. 2014).

We obtained data on Indonesian road networks from the GROADS dataset and the Indonesian Geographic Information Agency (BIG) for the years 2000 and 2015, respectively (CIESIN, 2013; Badan Informasi Geospasial, 2014), and assumed a linear relationship to estimate distance to road values between 2000 and 2014. We obtained data on slope and elevation from the Shuttle Radar Topography Mission (SRTM), 90m resolution dataset (Jarvis, Reuter, and Nelson, 2008) and precipitation data from the Tropical Rainfall Measuring Mission (TRMM). Precipitation data is the spatial average (mm/day) for two years before and the year of each time point (Huffman et al. 2007). Additional information on land cover and biophysical variables is in Appendix A.

Combining boundary, Village Census, and land cover data resulted in the identification of 51,800 villages with complete data in 2000, 57,824 in 2003, 58,358 in 2006, 67,518 in 2008, and 74,790 in 2011. These totals are similar to other studies that combined border and Village Census data (Martinez-bravo 2013) as well as studies that have combined border, Village

[3] Oversight of Village Census completion began in 2008. Before 2008, Village Heads completed the Village Census questionnaire independently.

Census, and land cover data (Ferraro et al. 2013, 2015; Miteva, Loucks, and Pattanayak 2015). Villages with incomplete data demonstrated no distributional differences from villages with complete data. Further, statistical matching, which utilizes a set of cross-sectional analyses anchored to a "moving baseline" incorporates improvements in connecting border and Village Census datasets and provides a robustness check against our panel models, which are anchored to a year 2000 baseline.

3.2.2 Methods

To estimate the effect of regulatory dispersal on forest cover, we used a combination of forest cover measurements and analytical approaches. We tested the effect of regulatory dispersal on forest area change using two-way fixed effect models. We also assessed the difference in forest change between villages that experienced regulatory dispersal ("dispersed villages") and villages that did not ("undispersed villages") using statistical matching analyses. Together, these analytical techniques provide a robust method for measuring the effect of regulatory dispersal on forest cover change over time and across administrative scales.

We examined forest cover using two outcome variables. First, we examined the effect of regulatory dispersal on village-level forest area. To normalize variable distribution and model real zeros (i.e. villages without forest area), we transformed the number of forested hectares per village using the inverse hyperbolic sine (IHS) function (Burbidge, Magee, and Robb 1988). The inverse hyperbolic sine transformation is defined as:

$$\bar{y}_{it} = \ln(y_{it} + ({y_{it}}^2 + 1)^{0.5} \qquad \text{[Equation 3.1]}$$

Where *i* indexes a village, *t* indexes a period of time, and *y* is the number of forest hectares (ha).

Second, we examined the effect of regulatory dispersal on the compounded annual rate (CAR) of forest cover change. We calculate the CAR of forest cover change as:

$$\bar{y}_{it} = \frac{A_{i2} - A_{i1}}{T_2 - T_1} \frac{2}{A_{i1} + A_{i2}}$$ [Equation 3.2]

Where *i* indexes an indexes a village, *t* indexes a period of time, *1* and *2* index the beginning and ending of the period, *A* is the forested area (ha) at year *T* (Puyravaud 2003). We refer to these variables together as "forest cover," and identify them individually as "forest area" and "rate of forest change."

To examine the effect of regulatory dispersal on forest cover, we used two-way fixed effect models. Two-way fixed effect models control for time effects and endogenous individual effects at the village-level (Angrist and Pischke 2009). Further, these models provide the ability to analyze the relationship between regulatory dispersal variables and forest area change during different periods of regulatory dispersal and forest cover change (Finkel 1995). In our research, these models take the form:

$$Y_{it} = \gamma_i + \delta_i + D_{it-z}\beta_1 + X_{it-z}\beta_2 + \varepsilon_{it}$$ [Equation 3.3]

Where *i* indexes the village, *t* indexes year, *z* indexes time lags/leads, *Y* is the forest change variable, γ are village fixed effects, δ are time fixed-effects, *D* is a vector of regulatory dispersal dummy variables, *X* is a vector of time varying covariates, β_1 and β_2 are coefficient estimates, and ε is the error term. Due to data constraints, and in order to control for different levels of regulatory dispersal, we imposed a hierarchical assumption on regulatory dispersal. We coded villages that experienced two or more administrative changes in one period as only having the highest-level of administrative change. For example, a village that experienced a sub-district change and a village change in Period 1 (2000 to 2003) is coded as having sub-district change from 2000 to 2003. We imposed this assumption because higher-level changes can affect the information that identifies lower-level changes. Thus, coding for multiple administrative changes within one period could lead to the false identification of lower-level regulatory dispersal. However, identifying a lower-level administrative change cannot falsely identify a higher-level change. The results we provide control for the effect of higher-level changes, but they do not lend insight into the interaction between multiple levels of regulatory dispersal. We check the robustness of this assumption by examining patterns in land cover change in differently dispersed villages (see “3.2.3 Robustness checks”).

In addition to regulatory dispersal variables, we regressed forest cover change over a set of covariates common to analyses of deforestation. Following previous studies on forest cover change (Brandt et al. 2014; Ferraro et al. 2015; Honey-Rosés, Baylis, and Ramírez 2011; C. Nolte et al. 2013) and administrative proliferation (Grossman and Lewis 2014; Grossman, Pierskalla, and Dean 2017; Pierskalla 2016), we controlled for a combination of static and time-variant covariates. We controlled for static variables that influence forest cover change (i.e., elevation and slope) through village-level fixed effects. Variables that vary over time within village units, and are associated with forest cover change, include baseline forest cover, paddy agriculture, field agriculture, mixed field and tree agriculture, timber plantations, agricultural plantations, settlement, protected area (i.e. national parks and strict conservation areas), as well as presence of village council, average Euclidean distance to nearest road, household population, and multidimensional village development (i.e. development and infrastructure). Appendix A includes further variable descriptions and Appendix B includes a discussion of the multidimensional village deprivation indicator (MDVDI) we used to control for multidimensional village development in this research. We combined insights from the two-way fixed effect models with statistical matching analyses to check and further investigate the direction, magnitude, and significance of the effect of regulatory dispersal on forest cover change.

Pre-processing data using statistical matching provides a non-parametric alternative for assessing the effect of regulatory dispersal on forest change. We paired each dispersed village with the most similar undispersed village/s, based on a set of covariates that influence forest cover change and regulatory dispersal. Matching dispersed and undispersed villages controls for selection biases from identified variables that influence which villages experience regulatory dispersal in addition to the rate of forest cover change (Morgan and Winship 2014), assuming no omitted variable bias (Woolderidge 2010). We match villages using the set of covariates within our fixed-effect models, including time-invariant covariates (elevation and area of village over 12% slope), as well as the rate of forest cover change from the previous period. We include the lagged rate of forest cover change to ensure that forest cover change between dispersed and non-dispersed villages does not vary significantly leading up to regulatory dispersal. We do not include average precipitation and province in our matching criteria because they demonstrate strong correlation with other covariates.

To leverage our time-series data in a matching framework, we generate a total of 15 matched datasets, matching groups of dispersed versus undispersed villages based on the period in which they proliferated, across subsequent time periods. For example, we matched villages that experienced regulatory dispersal in the 2000 to 2003 period with undispersed villages during this period and calculated the average difference in their rate of forest change. We then re-matched this same group of villages with the most similar undispersed villages in 2003, to assess CAR of forest cover change over the 2003 to 2006 period. We repeated this procedure for each subsequent period (in this example, 2006 to 2009, 2009 to 2011, and 2011 to 2014), and repeated it again for each period of regulatory dispersal.

After matching, we ran a weighted least squares (WLS) regressions to calculate point estimates of the difference in annual forest cover loss between villages that experienced province, district, and village dispersal and those that did not. Using WLS on pre-matched data provides a "doubly robust" effect estimation for administrative proliferation by controlling for potential confounding variables within the matching pre-processing step and in the WLS regression (Ho et al. 2007). We calculate all effects with robust standard errors.

To examine variation in regulatory dispersal type, we examine data on how land cover changed in villages during the first and second periods following regulatory dispersal. From 2000 to 2014, less than 1% of Indonesia's forest estate was managed by village administrations (Lee, Rianti, and Park 2017). Meanwhile, districts were the primary administrive level at which forest management occurred, first as determined by district administrations, and later as determined by the national government. Thus, we assess the percentage change in forest, agricultural plantations, timber plantations, field agriculture, mixed agriculture, and paddy agriculture across villages that experienced no regulatory dispersal, villages that experienced only village-level dispersal, villages that experienced village- and district-level dispersal, and villages that experienced only district-level dispersal. In our analyses and discussion, we thus focus on the effects of village and district dispersal.

Examining village- and district-level dispersal provides several advantages in addition to providing information on how informal and formal regulatory dispersal varies in its effect on forest cover change. Village-level and district-level regulatory dispersal are common occurrences across Indonesia, unlike province-level change that occurs far less frequently (Figure 3.1), rendering them more amenable to statistical analysis over time. Further, villages and districts are autonomous administrative units, unlike sub-districts, which districts manage. This means that the effect of regulatory dispersal in these units is more likely driven by political causes, rather than bureaucratic planning. Although we do not explicitly address results from province or sub-district regulatory dispersal, our methods control for them, and our models summarize them.

3.2.3 Robustness checks

To determine the most appropriate model, we used a Lagrange Multiplier test to determine the need to control for villages and time periods, and a Hausman test to assess the suitability of a mixed model with random intercepts (Hausman, 1978; Gourieroux, Holly and Monfort, 1982). The results of these tests demonstrated the need to control for endogenous variation within the villages and time-periods. This directed our choice to use two-way fixed effect models (Woolderidge 2010). In order to assess the robustness of the two-way fixed effect model restults, we used the same set of covariates on alternate forest cover variables and transformations. In Appendix E, Table E.2 provides values for the log of village forest area plus 0.01, and Table E.3 provides values for CAR of forest change per village. We assessed multicollinearity by examining correlations between variables and assessing variable inflation factors within pooled models for each variable and model type combination. We calculated all two-way fixed effect models using "xtreg" command in Stata, as well as in R with the plm package (Croissant and Millo 2008).

We accounted for different theories of village-level autonomy by providing different clustered robust standard errors. Clustering robust standard errors at the village-level maintains the assumption that individual villages function as independent entities, and thus there is no need to correct for design or treatment issues within the models (Abadie et al. 2017). Clustering robust standard errors at the district-level maintains that village-level variables should be interpreted as district-level clusters in order to correct for treatment issues and spatial correlation within land cover variables. For all models, we provide village- and district-level clustered robust standard errors.

To assess the robustness of our matching results, we re-matched our data using two alternative matching techniques, and we examine the balance of our 15 matching results across all covariates. The type and specification of matching procedures can significantly affect the resulting dataset (Stuart, 2010; King and Nielsen, 2016). We compared outcomes from one to many propensity score matching, one to one propensity score matching, and full matching (Appendix E: Robustness checks). In each, we dropped a village if a match was not found within 0.25 standard deviations of the propensity score for selection into administrative change. For the one to many propensity score matching, we matched each dispersed village with non-dispersed villages according to the ratio of dispersed to non-dispersed villages within the dataset. For example, the period 2000 to 2003 contained approximately 10,000 "treatment" villages and 50,000 "control" villages, so we matched each treatment village with the best five control matches, with replacement. Including multiple controls for each matched treatment provides additional assurance that matched groups better reflect qualities in the population and control for confounding variables (Stuart, 2010). We conducted statistical matching using the "Matchit" and "optmatch" packages in R, and ran weighted regressions to provide point estimates in base R. We provide information on the number of villages available for each match (SI: Results) as well as alternative matching approaches and covariate balance results in Appendix E.

We assess whether our "hierarchical assumption" of regulatory dispersal is tractable by examining the patterns of land cover change between village- and district-level dispersal. If patterns of land cover change between villages that experienced village- and district-level dispersal demonstrate outcomes that strongly resemble either village-level only dispersal or district-level only dispersal, we assert that it is unlikely the assumption has effectively isolated village- and district-level dispersal. If there exists no distinction in land change patterns between villages that experienced the three types of dispersal, we assert that the analysis provides no additional information about the hierarchical assumption. And, if land change patterns in village- and district-level dispersal resemble a middle-ground between village-level only and district-level only land change patterns, we assert it is more likely that our hierarchical assumption has effectively isolated different dispersal types that create different land cover patterns. Although this analysis represents a post-hoc test of robustness, the structure of our data is such that other robustness checks are not possible.

3.3 Results

From 2000 to 2014, we estimate that 11.4% of the primary and secondary terrestrial forest in Indonesia was deforested (KLHK, 2016b). This sum resembles forest-loss findings from others studies that look at total loss of natural and plantation tree cover loss (Hansen *et al.*, 2013) and primary forest-loss (Margono et al. 2014). Aggregating forest loss within villages that did and did not experience any administrative change between 2000 and 2014 demonstrates that the majority of Indonesian forest cover loss occurred in villages that experienced some form of regulatory dispersal. Further, the annual rate of forest cover change in dispersed villages increases over time as compared to undispersed villages (Figure 3.2). Although these trends indicate that regulatory dispersal may increase forest cover loss, it does not control for important confounding variables that may account for a village’s propensity to undergo regulatory dispersal as well as forest cover change. To control for these variables and examine the effect of

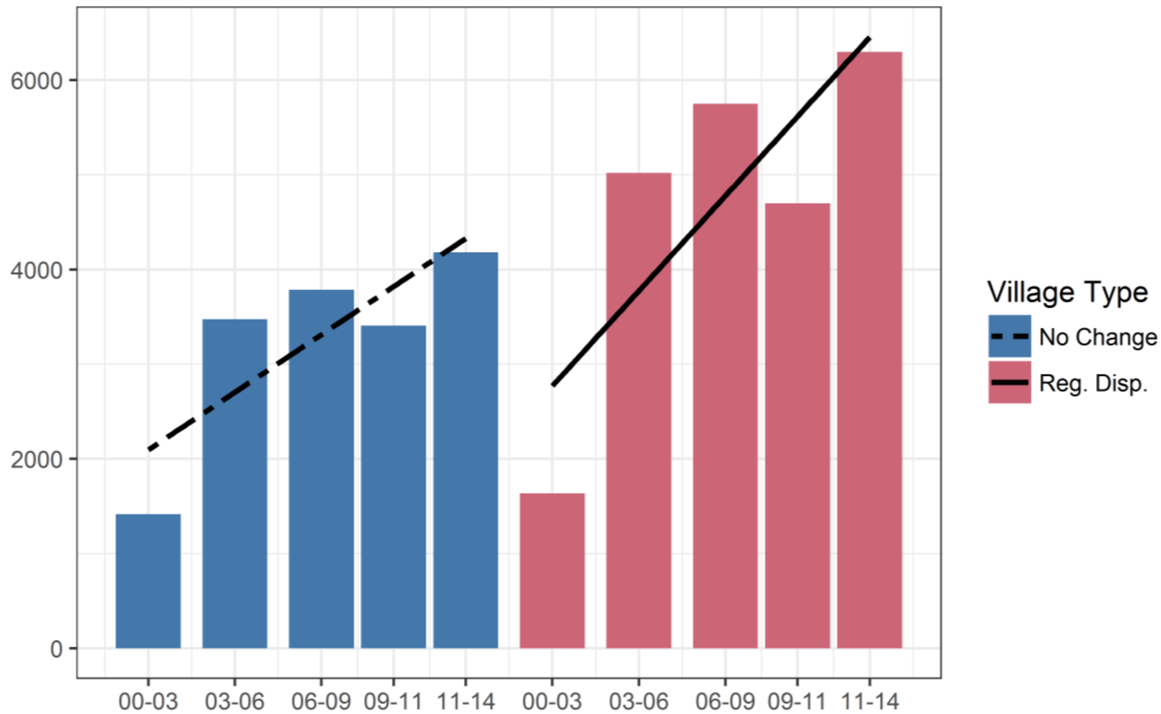


Figure 3.2 Period of analysis (x-axis) by average km^2 of forest cover loss per year (y-axis). Colors represent different average estimates for villages that did not experience any regulatory dispersal (blue color, dotted trend line) and villages that did experience regulatory dispersal (red color, solid trend line)

regulatory dispersal on forest cover over time, we model forest area over time and use matching analysis to test differences in dispersed and undispersed villages' compounded annual rate (CAR) of forest cover change.

3.3.1 Fixed effect model analysis

After controlling for individual-level variation, variation over time, and time-variant land cover and socioeconomic variables, we find that regulatory dispersal significantly reduces forest cover (SI Results: Table 3.3). Figure 3.3 illustrates the effect of village- and district-level dispersal over time, with standard errors clustered at the village-level. Examining the effect of future regulatory dispersal on forest area predicts more forest cover in villages that experienced village-level dispersal (β = 0.014, SE = 0.01) and district-level dispersal (β = 0.011, SE = 0.004). However, examining the effect of regulatory dispersal on forest cover in the first period after

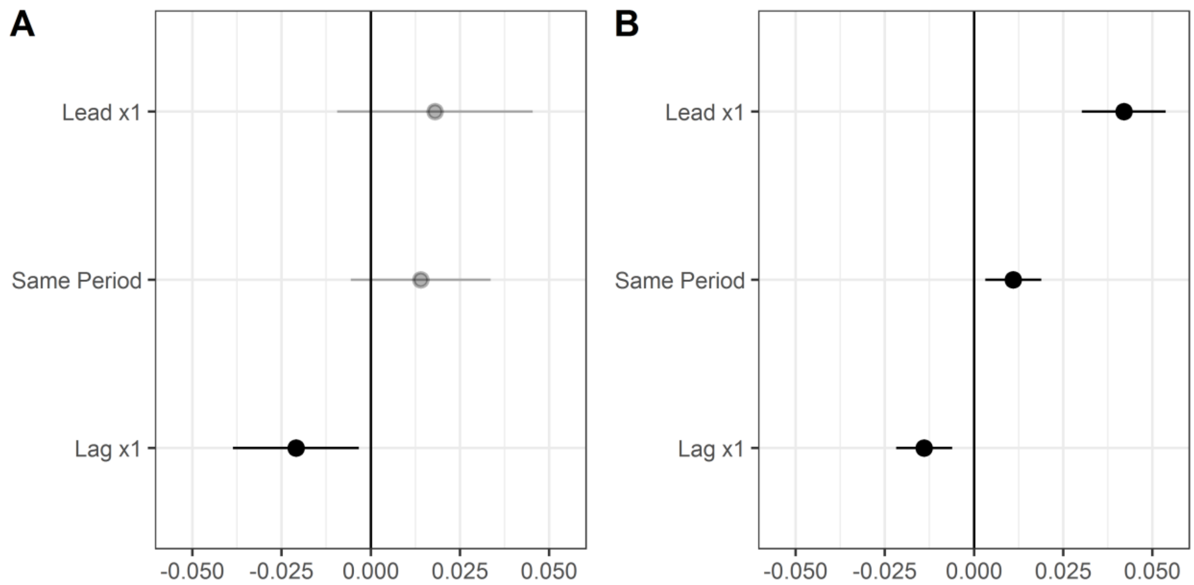


Figure 3.3: Coefficient estimates of forest cover area transformed by the inverse hyperbolic sine function (x-axis) by time effect of village-level dispersal (Panel A) and district-level dispersal (Panel B). "Same Period" estimates the effect of regulatory dispersal on forest cover area in the same time period. “Lead x1” estimates the effect of regulatory dispersal on forest cover area in the first period before the dispersal occurs (i.e. reverse causation). “Lag x1” estimates the effect of regulatory dispersal on forest cover area in the first period following dispersal. All coefficients are estimated from two-way fixed effect first difference models that control for relevant covariates with cluster robust standard errors at the village-level.

dispersal occurred demonstrates a negative effect on forest cover in villages that experienced village-level dispersal (=- 0.021, SE = 0.009) and district-level dispersal (β = -0.014, SE = 0.004). These findings are robust to a logged transformation of forest area and they mirror results from two-way fixed effect models of CAR of forest change (Appendix E: Robustness checks). Thus, we support our hypothesis that regulatory dispersal affects forest cover change in the first subsequent period.

Subsetting the data to examine only villages that experienced dispersal shows that baseline forest cover, agricultural area, average distance to roads, presence of village council, and MDVDI significantly predict forest cover change (SI Results: Table 3.4). Increasing the amount of agriculture across all agricultural variables predicts greater declines in forest cover in the first period following dispersal for villages that experienced regulatory dispersal. Increasing the amount of development deprivations (MDVDI) and the average distance to roads reduced the

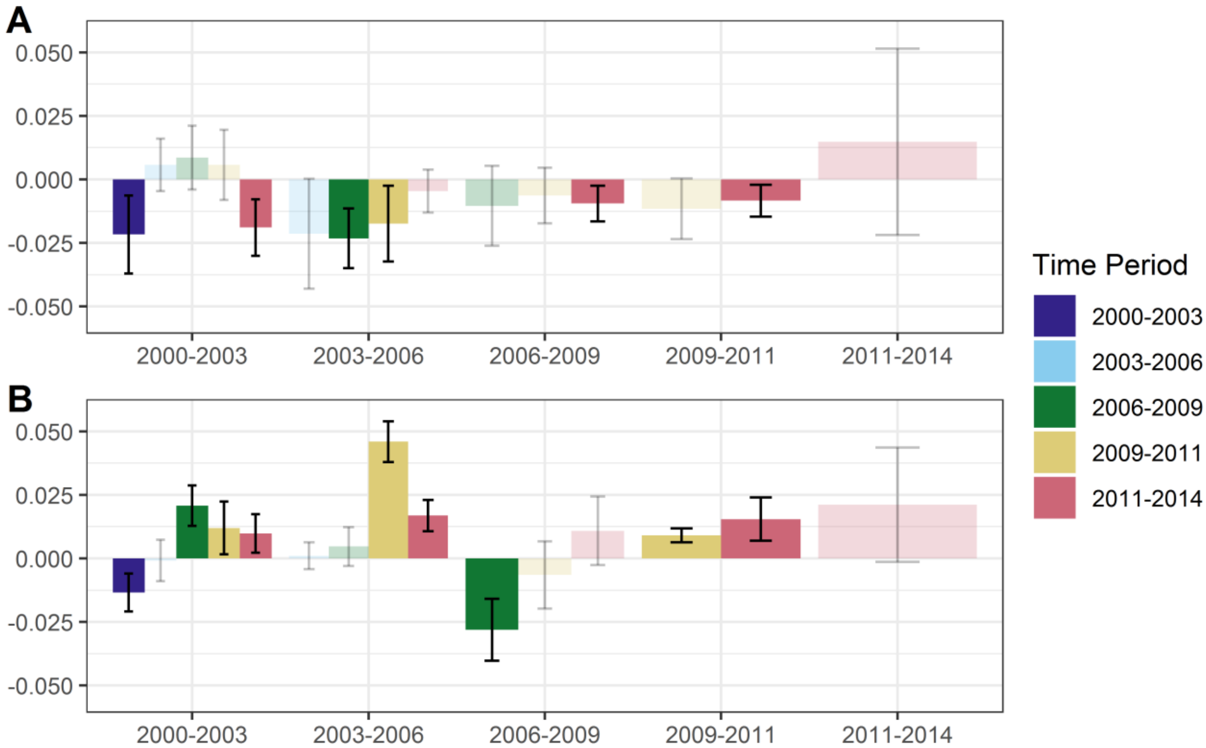


Figure 3.4: Matched differences in compounded annual rate of forest cover loss between villages with village-level regulatory dispersal (Panel A) and district-level regulatory dispersal (Panel B). Shading represents nonsignificant differences (p>0.05).

overall amount of forest cover loss. Statistical matching provides a robustness check of these findings, and it provides additional information on the time-trends of regulatory dispersal.

3.3.2 Matching analysis

Matching results confirm consistent and significant negative effects of village-level changes on CAR of forest change over time. One-to-many propensity score matching provided the best balance, compared to one-to-one and full matching. Matching analysis shows that, over time, the effects from village- and district-level dispersal decreases in magnitude and becomes less significant (Figure 3.4). This finding supports our second hypothesis, that the effect of regulatory dispersal on forest cover change in Indonesia attenuates over time.

In contrast to fixed effect models, matching analysis demonstrates a varied effect of district-level regulatory dispersal on village-level CAR of forest change. Although certain periods of district-level dispersal demonstrate negative effects on annual forest cover change, most of these effects are positive or non-significant. This is especially true in the periods after 2008. This supports our third hypothesis that different types of regulatory dispersal demonstrate different effects on forest cover. Matching analysis supports the overall negative effect of regulatory dispersal on forest cover from the fixed effect models during the period of 2000-2003, and 2006-2008. Findings from matching analyses are robust to alternative matching techniques (Appendix E: Robustness checks). In the following section we discuss how the consistently negative effect of village-level dispersal and the varied effect of district-level dispersal on forest cover change contribute to understanding the type, timing, and variation of regulatory dispersal.

3.3.3 Land cover change

Villages that experienced only village or only district dispersal demonstrate different land cover change patterns, and villages that experienced both village- and district-level dispersal depict a combination of these results (Figure 3.5). Villages that experienced only district-level dispersal show an increase in field agriculture cover (3.5%) and a decrease in mixed agriculture cover (-1%) over the first two periods (5 to 6 years) after regulatory dispersal. Villages that experienced only village-level dispersal see a smaller gain in field agriculture (0.8%) as well as a gain in mixed agriculture (0.6%). Villages that underwent village-level and and district-level dispersal represent a middleground, with an increase in field agriculture (1.8%) and mixed agricultural (0.2%). These findings further support our third hypothesis, that regulatory type demonstrates a varied effect on forest cover change. These findings also provide reason to believe that our hierarchical assumption is likely to have identified different dispersal types that generate different outcomes for land cover change.

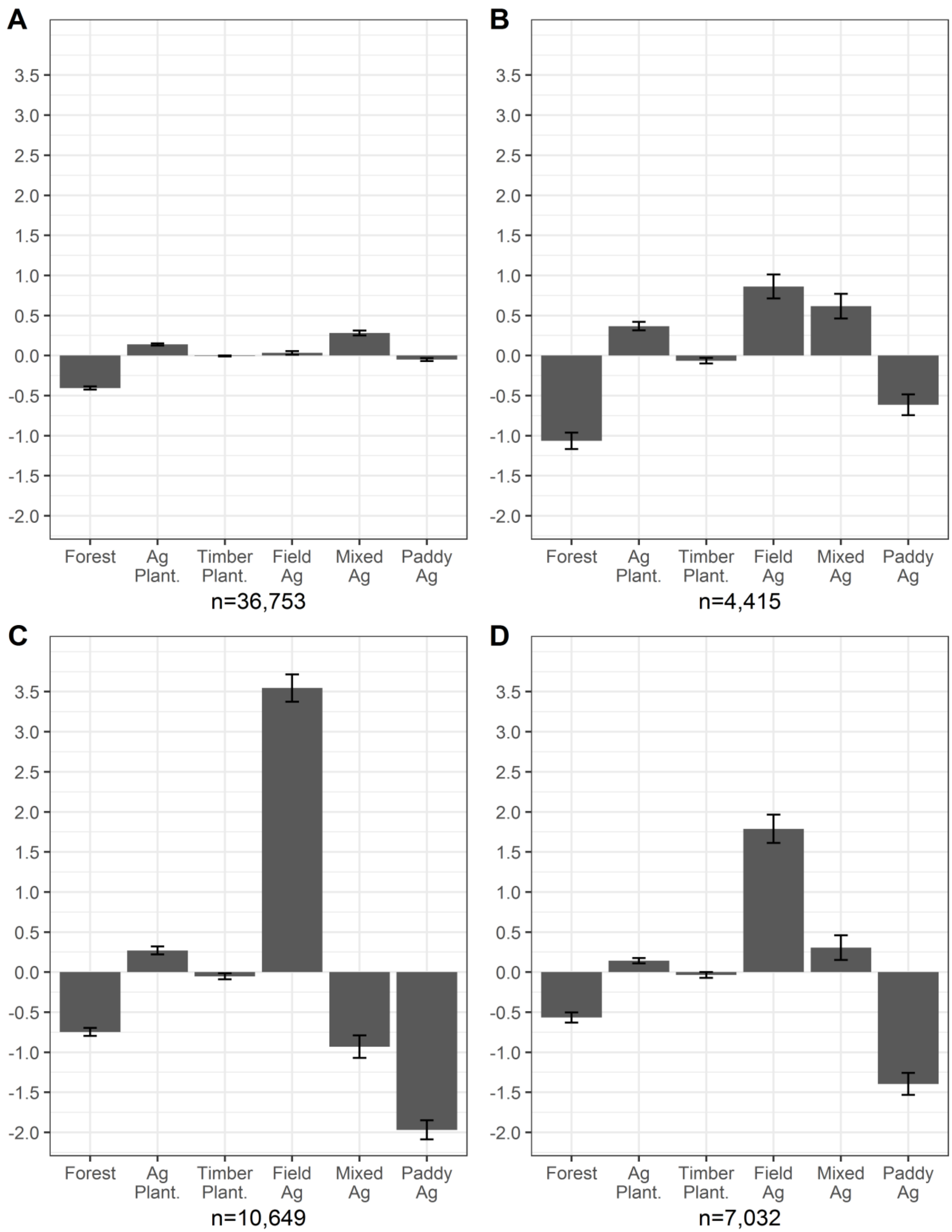


Figure 3.5: Land cover type (x-axis) by mean area change within village (y-axis). Panels refer to villages without regulatory dispersal (A), villages with only village-level dispersal (B), villages with only district-level dispersal (C), and villages with district-level and village-level dispersal (D).

3.4 Discussion

Between 2000 and 2014, regulatory dispersal across Indonesia increased forest cover loss. However, our analyses demonstrate that the impact of regulatory dispersal on forest cover change depends upon the time, sequencing, and type of regulatory dispersal. Regardless of type, between 2000 and 2014 Indonesian regulatory dispersal generates forest cover loss in the period immediately following dispersal (two to three years), an effect which attenuates over time. However, the effect of regulatory dispersal on forest cover change is markedly different between village-level and district-level dispersal. Village-level regulatory dispersal demonstrates a consistently negative effect on forest area and rate of forest change, while district-level dispersal does not. After discussing results for village-level dispersal and district-level dispersal individually, we consider the difference in these effects through the different forest use rights village and district administrations hold.

3.4.1 Village-level regulatory dispersal

Villages are legally defined as autonomous communities that maintain the right to raise funds and, in certain circumstances, reject higher-level policy (Antlöv 2003). A village head, often democratically elected (within this study period), and a village council, either appointed by consensus of village members (2004-2014), or elected (2000-2004 and 2014-present) comprise village government (Antlöv, Wetterberg, and Dharmawan 2016). Although a small number of villages have rights to community, village, or *adat* forests, such community-based forests are roughly 1% of the national forest estate (Lee, Rianti, and Park 2017). Dispersing regulation at the village-level thus imparts no formal changes of forest use, at the population level. However, we find a significant and negative effect of village-level regulatory dispersal and forest cover immediately after a village-level change.

Village-level regulatory dispersal shows a consistent negative effect on forest cover in the fixed-effect and matching analyses. Matching analysis finds that from 2000 to 2011, villages that experienced village-level dispersal experienced at least one period with significantly great CAR of forest loss. Fixed effect analysis demonstrates that the period after village-level regulatory dispersal contains the highest level of forest cover change with the smallest standard error. The lack of formal rights village administrations hold over forest management in Indonesia, and the consistently negative effect of village dispersal on forest cover in the periods following dispersal point to an informal mechanism of land conversion.

3.4.2 District-level regulatory dispersal

Districts are sub-national units that, over the study period, had changing authority over the sale and management of forest land. When the district-level regulatory dispersal occurs changes its effect on forest cover. We estimate 8,000 villages experienced district-level dispersal between 2000 and 2003, compared with half that many between 2003 to 2006 and 2006 to 2009. Even fewer villages experienced district-level dispersal from 2009 to 2014 (SI Results: Table 3.5). This contributes to the attenuated significance of district-level regulatory dispersal, but it does not explain the variation in the magnitude and sign of the difference district-level regulatory dispersal displays over time. We attribute this variation to policy-level changes that shifted administrative authority over forest resources.

At the turn of the 21st century, new districts formed at an accelerated rate, and district leaders were able to issue forest concessions as a way to increase district revenues and personal income (Barr et al. 2006). The fixed effect models we use, as well as previous findings on district-level changes and their effects on forest cover, are likely largely determined by these early periods of district dispersal (Barr et al. 2006; Burgess et al. 2012). Villages that experienced district-level dispersal between 2003 and 2006, however, demonstrate different trends in forest cover. A 2002 Government Regulation revoked the right for district leaders to issue forest use concessions, and in 2004 new Local Government and Fiscal Balance laws (UU 32/2004 and 33/2004) recentralized forest use and concession rights. Further, a moratorium on district-level splits from 2004 to 2006, the 2008 Financial Crisis, and a significant restructuring of forest management and forest management units over the same period, help interpret district-level changes after 2003 and the effect of district-level change on forest cover (Nurfatriani et al. 2015). Given the moratoria on district splits and the revocation of concessionary rights, district leaders were not able to raise revenue from timber as in previous periods, and they likely began to focus on alternative sources of district revenue.

In contrast to villages that experienced district-level dispersal in the 2003-2006 period, villages that experienced district-level dispersal between 2006 and 2009, after the moratoria on district splits ended, liquidated substantial forest assets compared to similar villages that did not experience regulatory dispersal. This trend echoes the Indonesian Ministry of Forestry's 2007 initiative to revitalize the forestry sector, and may have been exacerbated by declining export prices for timber and timber products, forcing districts to liquidate more forest cover to raise the same amount of revenue (Blaser et al. 2011; Masiero, Pettenella, and Cerutti 2015). The 2006-2009 period marks the end of strong negative effects on forest cover change from district-level changes. Post-2009 policy trends indicate increasing formalization of Indonesian timber production propelled by mandatory timber legality verification (Erbaugh, Nurrochmat, and Purnomo 2017; Lesniewska and McDermott 2014), as series of moratoria that prohibit new concessions in primary and peatland forests (Busch et al. 2014), and continued emphasis of regulation within forest management units (Sahide, Maryudi, et al. 2016). Villages that experienced district-level transitions from 2009 to 2014 show a positive or non-significant effect of administrative change on annual forest cover change.

3.4.3 Institutional formality, regulatory dispersal, and forest change

The effects of village- and district-level regulatory dispersal are similar in aggregate, but they differ in the importance of sequencing and land change patterns. This contrast resembles the way in which formal powers over forest management have, or have not, changed within these different levels of administration. From 2000 to 2014, less than 1% of the Indonesian forest estate was managed at the village-level (Lee, Rianti, and Park 2017). Over the same time period, district administrations first enjoyed transfer rights over forest areas, followed by the responsibility to design and execute forest management plans and the ability to receive revenue from forest products (Nurfatriani et al. 2015). This variation in the relationship between the sequence of policy change and the effect of regulatory dispersal on forest cover change indicates that village-level dispersal is likely to have occurred in contrast to formal rules, and district-level dispersal is likely to have occurred in accordance with formal rules (Table 3.1). This conclusion is further supported by the patterns of land cover change that define village- and district-level dispersal.

Village-level dispersal is characterized by the greatest comparative increase in mixed agriculture, and district-level dispersal by field agriculture. Mixed agriculture is representative of agricultural mosaics that include trees and field crops (Ministry of Environment and Forestry 2018), which are more characteristic of smallholder agriculture (Cohn et al. 2017; Perfecto and Vandermeer 2010). Thus, for villages that underwent village-level dispersal, smaller-scale and “bottom-up” land cover change is more likely, with local actors converting land for smallholder agriculture or economic advantage. In contrast, large increases in field agriculture require a greater amount of time, money, and/or labor. These larger investments are more characteristic of “top-down” land cover change, when government and corporate actors drive the conversion of forest area to intensive agriculture in line with formal institutions (White et al. 2012). Thus, taken together village-level dispersal seems to occur through decentralized clearing in contrast with formal rules, and district-level dispersal in accordance with formal rules through actors or organizations capable of large investments.

Regulatory dispersal affects forest cover change, and its relationship with formal institutions shapes the land change patterns through which the effect is generated. Assuming only formal rules matter, one could dismiss village-level regulatory dispersal when considering forest cover change. Our analyses show, however, that village-level regulatory dispersal is more consistent and significant than district-level dispersal. Though it is beyond the scope of this study, future research would do well to understand how the type of regulatory dispersal and land cover change interacts with customary institutions. For example, is forest cover loss that occurs following village-level dispersal a result of regulatory forebearance (Holland 2016), or does it occur against the wishes of village leaders as a result of insufficient training or capacity (Grossman and Lewis 2014)? Case-specific and field-based research that augments this research is necessary to confirm the connections between forest cover loss, land cover change, and institutional mechanisms within Indonesian villages.

3.5 Conclusion

Regulatory dispersal generates change in Indonesian forests. However, the timing and nature of these effects varies. As Indonesia transitioned to become the third largest democracy in the world, the state pursued a strategy of alternating the rights districts and provinces had to state-managed forest areas (Kimura 2013). Additionally, international agencies and foreign governments began making significant financial contributions and loans for reduced deforestation and forest degradation, support for mandatory timber legality verification, and improved governance of forest management units (Busch *et al.*, 2011, 2014; Nurrochmat *et al.*, 2014; Luttrell *et al.*, 2014; Sahide, Maryudi, *et al.*, 2016). As the governance of Indonesia's forests increased in formalization, the impact of regulatory dispersal at the district-level has become positive or non-significant; however, the effect of regulatory dispersal at the village-level remains consistent.

The difference in formal and informal rights to forest management best explains differences in the effect of village- and district-level regulatory dispersal on forest change. Between 2000 and 2014, the vast majority of Indonesian villages had no formal right to manage forest areas. The consistent and negative effect of village-level regulatory dispersal on forest cover and rate of forest change mirror the consistent lack of forest management rights and point to an informal mechanism of land conversion. Similarly, the inconsistently negative effect of district-level dispersal mirrors changing policy over district rights to sell and manage state-owned forest area. Assessing average land conversion five to six years following district only and village only regulatory dispersal lends additional support to this argument. Land conversion in villages that only experienced village-dispersal was defined by lower rates of field agriculture and higher rates of mixed field and tree agriculture when compared to villages that experienced only district-level dispersal. There is a strong association between mixed agriculture and informal, smallholder clearing in Indonesia (Gaveau, Linkie, *et al.*, 2009; Levang, Sitorus, Gaveau, *et al.*, 2012; Clough *et al.*, 2016; Gaveau *et al.*, 2017). Thus, it seems likely that the district-level effect of regulatory dispersal is driven by larger scale agriculture, in line with formal institutions, whereas village-level dispersal is more likely driven by smallholder agriculture, in opposition to formal institutions.

Our findings are particularly relevant to the current agenda for village-level decentralization. The 2014 Village Law increases village budgets, mandates democratically elected councils, and provides an increasing amount of natural resource rights to village governments (Antlöv, Wetterberg, and Dharmawan 2016) and the current presidential administration has pledged 12.7 Mha of forest land for new community, village, village plantation, and customary forests (Myers, Intarini, Sirait, et al. 2017; Santika et al. 2017). Further research that combines field-based methods with remotely sensed imagery to monitor and assess how regulatory dispersal affects Indonesian forest cover will remain essential for conservation and development agendas.

Beyond Indonesia, institutional transitions that increase the density of regulatory units have accompanied drastic changes in tropical forest cover over the past two decades. Further analysis of the impact and causal mechanisms of regulatory dispersal on resource use can help inform scholarship on institutions and resource management. Our findings emphasize the need for analyses of land cover change and environmental outcomes to more rigorously engage with changing political institutions.

3.7 Supplemental information

3.7.1 Regulatory dispersal in Indonesia

In Indonesia, regulatory dispersal occurs after the approval of administrative proliferation. The proliferation of provinces, districts, sub-districts, and villages requires approval from different levels of government, depending on the level of administration seeking to proliferate. For villages, the process of administrative proliferation begins with local support, and proceeds through the submission of village regulation reports; meetings between village, sub-district, and district officials; and approval from the regional legislature and executive offices. For the period of study in this research, Ministry of Internal Affairs Regulation 27/2006 and 28/2006 outlined requirements and processes for village-level proliferation. Ministry of Internal Affairs Regulation 45/2016 has since altered some of the regulations for official changes to village units. The number of villages in Indonesia rose from 69,050 in 2000 to 82,190 in 2014 (BPS 2006a, 2011a, 2016).

The creation of new sub-districts requires approval from village-level authorities (village councils and/or village heads) and province-level approval from the governor. This process is implemented by district governments, in order to facilitate the allocation of administrative services or resources. The process of sub-district change in this research is outlined in Government Regulation 19/2008. The number of new sub-districts rose from 4,049 in 2000 to 7,024 in 2014.

District and province creation require approval from district to national government authorities, with legal procedures outlined in Laws 22/1999, 32/2004, and 78/2007. The process of new district creation begins with citizens lobbying the current district legislature and executive authority for approval. After receiving district approval, province authorities (legislative and executive) must approve the district fracture, which requires further approval from the president and the People's Consultative Assembly (MPR) (Law 78/2007). Provincial proliferation follows a similar process, though without approval from district-level authorities. Research on the motivations behind district dispersal point to the role that local elites play in leading campaigns, and the important role ethnicity, identity, and perceived marginalization play in district creation (Choi 2011; Kimura 2013; Pierskalla 2016). From 2000 to 2014 the number of districts/cities in Indonesia increased from 341 to 514. Compared to the number of new villages, sub-districts, and districts, the number of new provinces created over this period is much smaller, growing from 32 to 34[4] (Figure 3.6).

Scholarship that examines the drivers of administrative proliferation focus on material, political, and symbolic marginalization (Grossman and Lewis 2014; Kimura 2010). Material marginalization occurs when a sub-group perceives the distribution of goods and services, including natural resources, as allocated disproportionately within the administrative unit. Political marginalization, when a group within an existing administrative unit feels underrepresented in current ruling structures. And symbolic marginalization occurs when individuals identify differently than other members within the administrative unit. Scholarship that focuses on administrative proliferation in Indonesia emphasizes the important role of symbolic marginalization with reference to provincial proliferation (Kimura 2013) and material marginalization at the district-level (Barr et al. 2006; Burgess and Olken 2012; Pierskalla 2016). Research is yet to address drivers of village-level proliferation in Indonesia.

[4] This number does not include the five provinces that were formed leading up to and in the first half of the year 2000.

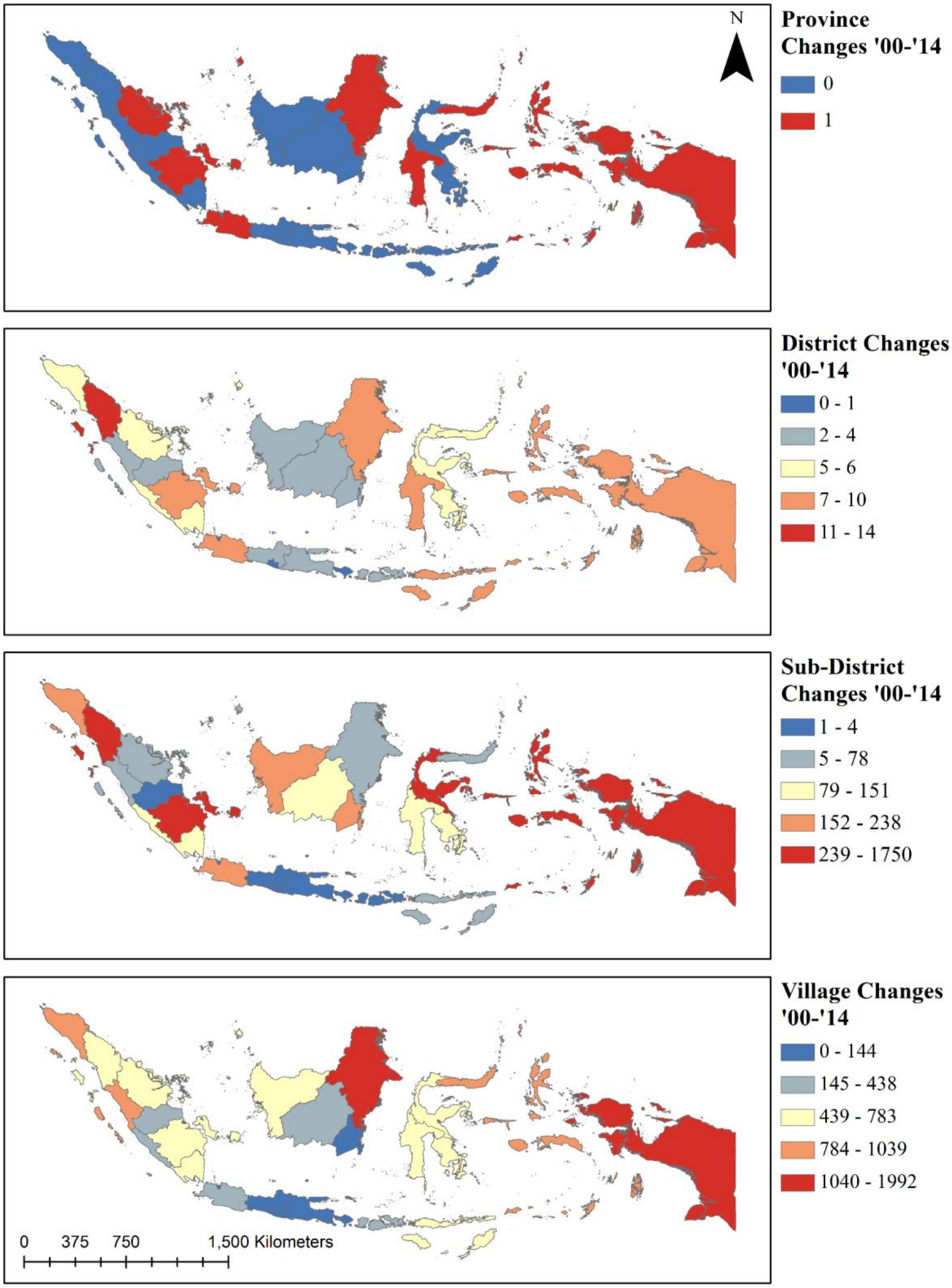


Figure 3.6: Year 2000 province boundaries by number of regulatory dispersal (BPS 2015)

3.7.2 Results

3.7.2.1 Variable summaries, model summaries, and interpretation

Table 3.2: Variable summaries

Variable	Abbreviation	Mean	Standard Deviation
Percent forest cover	Forest	0.13	0.26
Percent paddy agriculture	Paddy ag.	0.22	0.32
Percent field agriculture	Field ag.	0.12	0.25
Percent mixed agriculture	Mixed field/tree ag.	0.21	0.32
Percent timber plantation	Timber plant.	0.04	0.14
Percent agricultural tree plantation	Ag. tree plant.	0.04	0.14
Percent settlement	Settlement	0.11	0.22
Percent protected area	Protected area	0.03	0.13
Village council	Village council	0.91	0.52
Distance to nearest road (m)	Distance to roads	4161	11053
Number of households	Household pop.	851.48	1205.44
Multidimensional development index	MDVDI	0.22	0.18

All models in this text include standardized independent variables. Standardizing independent variables provides uniform unit measurements. A one unit increase in each model variable refers to an increase in one variable standard deviation. Table 3.2 includes variable summaries to aid in the interpretation of all fixed-effect models. Table 3.3 provides summaries for the two-way fixed effect models whose estimates are plotted by Figure 3.3. Models 1.1 through 1.4 in Table 3.3 provide estimates for the two-way fixed effect model that explained the greatest variation in village-level forest area. Appendix E presents models that use an alternative variable transformation for village-level forest area (Table B.2) and that regress CAR of forest cover change on the same set of covariates in a two-way fixed-effect framework (Table B.3). These models affirm the robustness of our results, demonstrating significant negative effects of village- and district-level dispersal on forest area and CAR of forest change in periods following the dispersal. Table 3.4 presents model summaries of forest cover change in data subset to only include villages that underwent regulatory dispersal. These models demonstrate similar signs and significance to models of forest change for all villages, but coefficient estimates are often of slightly larger magnitude. Model summares in Table 3.4 contain values for three alternative dependent variables: the IHS of forest area (Model 2.1), the natural log of forest area +.01 (Model 2.2), and the CAR of forest cover change (Model 2.3).

3.7.2.2 Matching data

We assessed matched villages for difference in mean CAR of forest cover change for fifteen different combinations of village fracture periods and time periods. This “moving window” approach to longitudinal analysis enables an assessment of immediate and eventual impacts from regulatory dispersal on forest cover change. It makes best use of a dataset that improves over time, as the baseline year for comparison is not limited to the earliest time point. However, each “window” of time contains different numbers of “dispersed” and “undispersed” villages, and estimates from that window are subject to the quality of data within that time period. Thus, although matching analysis provides for rigorous estimation of the differences in CAR of forest change between villages that did and did not experience regulatory dispersal, these estimates are constrained by data quality. In Table 3.5 (A) we provide the total number of villages within each category of administrative change and within each time period. Table 3.5 (B) presents the percentage of the total number of dispersed villages in each administrative category, within each period.

Table 3.3 Two-way fixed effect models for village-level forest area. Coefficient estimates are transformed by the inverse hyperbolic sine function. Models 1.1 through 1.4 include different time effects for regulatory dispersal. Land cover and sociopolitical variables remain anchored to the period of forest area measurement. SEs are robust and clustered at both village-level (Std Err) and district-level (Clst. Std Err).

	Model 1.1: Same Period regulatory dispersal			Model 1.2: One lagged period regulatory dispersal			Model 1.3: Two lagged periods regulatory dispersal			Model 1.4: One lead period regulatory dispersal		
	Coef.	Std Err	Clst. Std Err	Coef.	Std Err	Clst. Std Err	Coef.	Std Err	Clst. Std Err	Coef.	Std Err	Clst. Std Err
Same period dispersal level												
Village	0.014	0.01	0.016	-0.021	0.009 **	0.017	-0.031	0.011 ***	0.029	0.018	0.014	0.039
Sub-district	0.048	0.006 ***	0.017 ***	-0.002	0.005	0.011	-0.034	0.006 ***	0.018 *	0.035	0.006 ***	0.022 *
District	0.011	0.004 ***	0.013	-0.014	0.004 ***	0.011	0.012	0.004 ***	0.01	0.042	0.006 ***	0.025
Province	0.033	0.009 ***	0.028	-0.105	0.008 ***	0.034 ***	-0.006	0.004	0.011	0.052	0.017 ***	0.041
Land-cover												
Forest	1.306	0.026 ***	0.064 ***	1.309	0.026 ***	0.064 ***	1.14	0.027 ***	0.07 ***	1.055	0.035 ***	0.121 ***
Paddy ag.	-0.068	0.015 ***	0.033 **	-0.066	0.015 ***	0.033 **	-0.074	0.016 ***	0.041 *	-0.018	0.014	0.042 *
Field ag.	-0.049	0.011 ***	0.026 *	-0.05	0.011 ***	0.026 *	-0.056	0.012 ***	0.032 *	-0.008	0.01	0.033 *
Mixed field/tree ag.	-0.056	0.015 ***	0.037	-0.057	0.015 ***	0.037	-0.071	0.017 ***	0.045	0.008	0.014	0.046
Timber plant.	-0.033	0.01 ***	0.018 *	-0.032	0.01 ***	0.018 *	-0.009	0.01	0.02	-0.019	0.01	0.033
Ag. tree plant.	-0.121	0.016 ***	0.034 ***	-0.12	0.016 ***	0.034 ***	-0.105	0.016 ***	0.036 ***	-0.069	0.017 ***	0.044 ***
Settlement	-0.027	0.01 ***	0.022	-0.031	0.01 ***	0.022	-0.034	0.011 ***	0.027	0.002	0.009	0.028
Protected area	0.004	0.004	0.007	0.003	0.004	0.007	0.013	0.003 ***	0.005 **	0	0.004	0.011 **
Sociopolitical variables												
Village council	-0.025	0.004 ***	0.01 **	-0.028	0.004 ***	0.01 ***	-0.049	0.005 ***	0.013 ***	-0.016	0.004 ***	0.007 ***
Distance to roads	0.043	0.005 ***	0.021 **	0.053	0.005 ***	0.02 ***	0.025	0.004 ***	0.019	0.092	0.006 ***	0.054
Household pop.	-0.018	0.003 ***	0.005 ***	-0.021	0.004 ***	0.006 ***	-0.02	0.004 ***	0.006 ***	-0.008	0.003 **	0.005 ***
MDVDI	0.032	0.002 ***	0.006 ***	0.034	0.002 ***	0.006 ***	0.036	0.002 ***	0.007 ***	0.02	0.002 ***	0.009 ***
Constant	1.883	0.004 ***	0.009 ***	1.892	0.004 ***	0.009 ***	1.936	0.004 ***	0.012 ***	1.84	0.004 ***	0.009 ***
Number of obs		311,232			311,232			254,324			244,049	
Within R^2		0.179			0.179			0.15			0.08	

**p<0.1; **p<0.05; ***p<0.01*

Table 3.4: Two-way fixed effect models of forest area (Models 2.1 and 2.2) and CAR of forest cover change (Model 2.3) for villages that experienced regulatory dispersal between 2000 and 2014. Models 2.1 to 2.3 include lagged effects of regulatory dispersal. Standard errors are robust and clustered at the village- and district-level.

	Model 2.1: One lagged period regulatory dispersal: Inverse hyperbolic sine of forest cover					Model 2.2: One lagged period regulatory dispersal: Logged ha + 0.01 of forest cover					Model 2.3: One lagged period regulatory dispersal: CAR forest change				
	Coef.	Std Err		Clst. Std Err		Coef.	Std Err		Clst. Std Err		Coef.	Std Err		Clst. Std Err	
Same period dispersal level															
Village	-0.022	0.009	**	0.0170		-0.037	0.014	***	0.028		-0.011	0.004	***	0.007	*
Sub-district	-0.003	0.005		0.0110		-0.002	0.008		0.017		0.000	0.002		0.005	
District	-0.014	0.004	***	0.0110		-0.022	0.006	***	0.018		-0.010	0.002	***	0.005	*
Province	-0.094	0.009	***	0.0320	***	-0.136	0.013	***	0.048	***	-0.025	0.002	***	0.008	***
Land-cover															
Forest	1.291	0.034	***	0.0850	***	1.816	0.053	***	0.125	***	-0.039	0.006	***	0.014	***
Paddy ag.	-0.059	0.019	***	0.0470		-0.103	0.030	***	0.071		-0.036	0.012	***	0.021	*
Field ag.	-0.045	0.015	***	0.0360		-0.078	0.023	***	0.055		-0.037	0.007	***	0.017	**
Mixed ag.	-0.048	0.020	**	0.0510		-0.082	0.032	**	0.078		-0.007	0.007		0.017	
Timber plant.	-0.053	0.018	***	0.0390		-0.072	0.029	**	0.059		-0.002	0.006		0.011	
Ag. tree plant.	-0.129	0.021	***	0.0370	***	-0.184	0.032	***	0.054	***	-0.029	0.006	***	0.008	***
Settlement	-0.027	0.013	**	0.0320		-0.050	0.021	**	0.049		-0.034	0.024		0.027	
Protected area	0.009	0.004	**	0.0070		0.018	0.007	***	0.011	*	0.001	0.001		0.002	
Sociopolitical variables															
Village council	-0.030	0.005	***	0.0120	**	-0.051	0.009	***	0.019	***	-0.008	0.002	***	0.005	*
Distance to roads	0.039	0.006	***	0.0210	*	0.052	0.009	***	0.032	*	0.010	0.001	***	0.005	**
Household pop.	-0.021	0.007	***	0.0080	***	-0.032	0.010	***	0.012	***	-0.006	0.004		0.004	
MDVDI	0.036	0.003	***	0.0060	***	0.055	0.004	***	0.009	***	0.011	0.001	***	0.002	***
Constant	2.357	0.008	***	0.0210	***	-0.976	0.012	***	0.032	***	-0.039	0.015	***	0.029	
Number of obs		150,210					150,210					52,824			
Within R^2		0.178					0.142					0.017			

**p<0.1; **p<0.05; ***p<0.01*

Table 3.5 Matching data village frequencies by the number of changes (Table A) and by the number of changes per the total number of villages with complete data (Table B)

A

		Period of Forest Loss (Compounded Annual Rate)				
		2000-2003	2003-2006	2006-2009	2009-2011	2011-2014
Year of Village Change	2000-2003	302	344	569	775	1085
	2003-2006		222	838	1017	1424
	2006-2008			384	1567	1967
	2008-2011				422	2101
	2011-2014					58
Year of Sub-District Change	2000-2003	1286	1616	1661	1802	1995
	2003-2006		1381	1408	1748	1771
	2006-2008			1360	1838	1970
	2008-2011				667	1676
	2011-2014					494
Year of District Change	2000-2003	1611	1720	1695	1852	1962
	2003-2006		1750	1575	2064	2551
	2006-2008			675	735	764
	2008-2011				957	1046
	2011-2014					297

B

		Period of Forest Loss (Compounded Annual Rate)				
		2000-2003	2003-2006	2006-2009	2009-2011	2011-2014
Year of Village Change	2000-2003	0.030	0.024	0.039	0.043	0.052
	2003-2006		0.016	0.058	0.057	0.068
	2006-2009			0.026	0.088	0.094
	2009-2011				0.024	0.101
	2011-2014					0.003
Year of Sub-District Change	2000-2003	0.129	0.116	0.114	0.101	0.095
	2003-2006		0.099	0.097	0.098	0.085
	2006-2009			0.093	0.103	0.094
	2009-2011				0.037	0.080
	2011-2014					0.024
Year of District Change	2000-2003	0.161	0.123	0.116	0.104	0.094
	2003-2006		0.126	0.108	0.116	0.122
	2006-2009			0.046	0.041	0.037
	2009-2011				0.054	0.050
	2011-2014					0.014

Chapter 4

Green handcuffs or head-starts? The legacy of sustainable conservation, forest cover change, and household well-being in the Kerinci Valley

Abstract:

Empirical evidence of the long-term impacts from international conservation funding is limited. We examine the conservation legacy of Indonesia's most ambitious Integrated Conservation and Development Project (ICDP). The Kerinci-Seblat ICDP operated from 1997 to 2002, provided $19 million in funding to integrate management of Kerinci-Seblat National Park (KSNP) with local development, and distributed $1.5 million in local development grants to support village conservation agreements (VCAs). We assess forest cover change across the entire KSNP landscape from 2003 to 2016 and analyze household survey data (n=1,303) from a subset of villages (n=51) surrounding KSNP. Using statistical matching, linear and generalized linear models, we conclude that forest cover loss within KSNP is higher in villages that received direct ICDP funding; households in directly funded villages are more likely to own land without a formal title, farm high-value tree crops (coffee, cinnamon, rubber, and oil palm), and have lower incomes. We discuss how the project may have devalued conservation motivations and bolstered interest in agricultural expansion. The stakes for conservation funding are high. Failures can engender long-term outcomes opposite the very goals they aim to achieve.

4.1 Introduction

Protecting high conservation value tropical forests promotes the dual goals of reducing emissions from deforestation and forest degradation and conserving biodiversity. This low-cost option for multiple environmental benefits attracted significant international funding for conservation in the Global South, with a focus on tropical forests and biodiversity conservation (Miller, Agrawal, and Roberts 2013). In addition to providing environmental benefits, international conservation funding is often charged with ensuring local communities benefit from project implementation (Garnett, Sayer, and Du Toit 2007; Tallis et al. 2008). However, few studies examine how conservation legacies, established through international funding, generate long term social-ecological outcomes across conservation landscapes.

Establishing, enforcing, and monitoring the protection of high-value conservation areas is one of the most widespread methods for protecting tropical forests (Jones et al. 2018; Miller and Nakamura 2018; Watson et al. 2016). Protected areas (PAs) protect land through territorialization, which is a specific of practices that render spaces governable by an authority (Sack 1986). For a PA, these practices include the establishment of boundaries, creation of monitoring protocols, and enforcement of sanctions, among others (Peluso and Vandergeest 2001; Vandergeest and Peluso 1995). PA conservation has provided immense environmental benefits, conserving more forest area and biodiversity than the most similar unprotected areas (Andam *et al.*, 2008; Gaveau, Epting, *et al.*, 2009; Nolte *et al.*, 2013). However, separating PAs from proximate communities that depend on land for their livelihood and well-being, and whose presence may even predate the establishment of the PA itself, raises significant concerns over the fairness and justice of PAs (West, Igoe, and Brockington 2006). To address this concern, conservation funding that aims to improve PA effectiveness often incorporates a "social dimension" that seeks to enhance the livelihoods and well-being of nearby communities (Adams et al. 2004; Herren et al. 2018; Watson et al. 2014).

Communities can benefit from conservation, including PAs, through direct and indirect pathways (Erbaugh and Oldekop 2018). First, "direct investment" refers to when PAs provide incentives that are directly disbursed to communities or individuals near the PA in return for specific, conservation-based activities. Second, communities may receive "indirect benefits" from PAs from infrastructure development, increased employment opportunities, and enhanced ecosystem services (Ferraro and Hanauer 2014b). There is a growing body of evidence that, on average, communities near PAs enjoy more development benefits than do similar communities that are further away (Ferraro et al. 2015). However, research into the specific mechanisms that provide community benefits remain limited (Agrawal 2014). Studies that examine joint social-ecological impacts of international conservation over space and time, also known as "conservation legacies" (Miller 2013), are fewer still. To investigate long-term social-ecological outcomes of reduced forest cover and community well-being from international conservation funding, we examine social-ecological outcomes in and surrounding Kerinci-Seblat National Park (KSNP) associated with direct investment from the Kerinci-Seblat Integrated Conservation and Development Project (KS-ICDP).

4.2 Kerinci-Seblat National Park (KSNP) and Direct Conservation Investment

KSNP is Indonesia's second largest, terrestrial national park (Figure 4.1). It covers an area of over 1.375 Mha, extends 345 km along the Bukuit Barisan Mountains, and contains territory within four provinces and 15 districts/cities in central Sumatra. The Dutch Colonial Government protected forest area now within KSNP boundaries in 1929 (Aumeeruddy 1994).

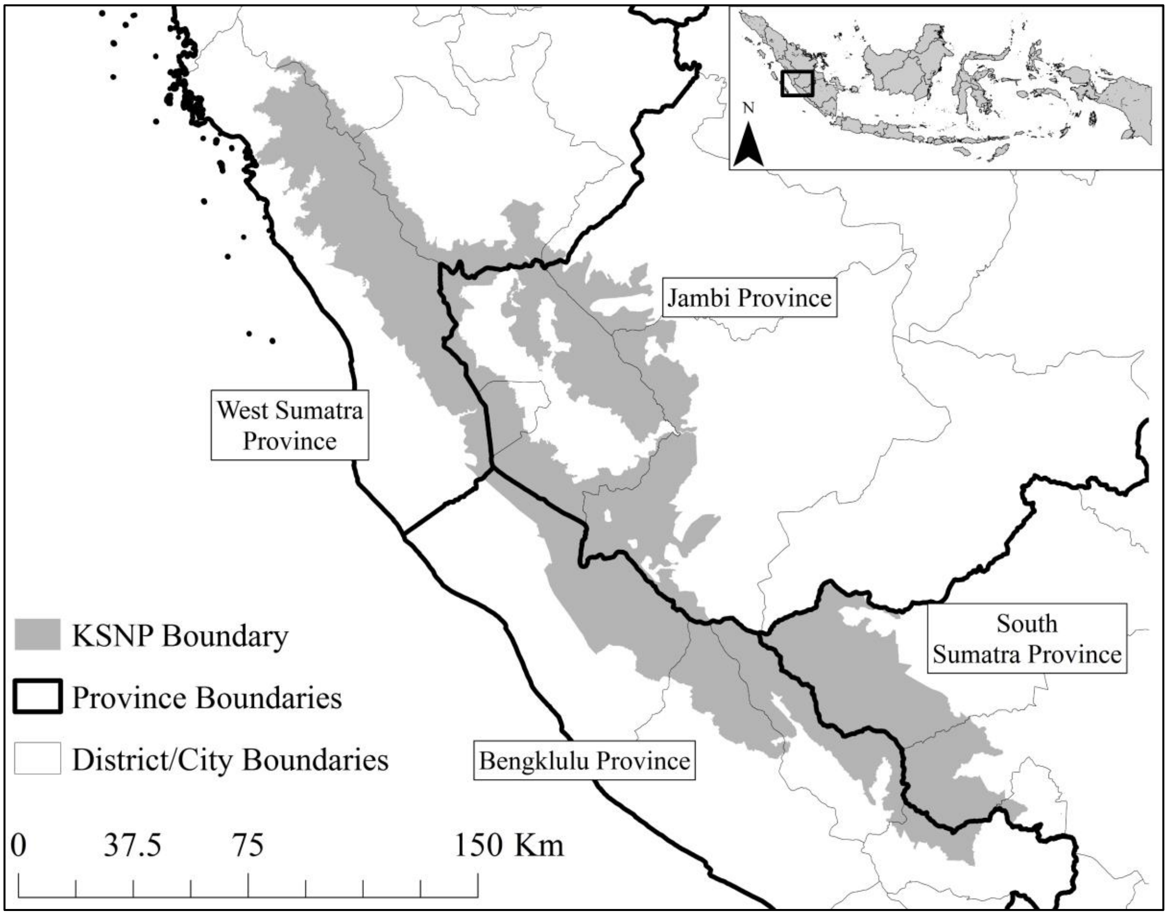


Figure 4.1: Kerinci-Seblat National Park and surrounds

The Indonesian government combined a set of 15 pre-existing conservation areas, adding approximately 100,000 additional ha (Bettinger 2015), to declare the Kerinci-Seblat area a national park in 1982 (Minister of Agriculture Decree No. 736/Mentan/X/1982). Disputes over the size of KSNP marked the beginning of the park's history, but in 1993 the Ministry of Forestry and relevant district and provincial governments reached a boundary agreement to finalize the size of KSNP (D. Wibowo 1999), although it was not officially gazetted until 1999, through the KS-ICDP.

The KS-ICDP operated from 1997 to 2002 and allocated $19 million to gazette the 1.375 Mha national park, improve park management and service delivery, and promote sustainable development within proximate communities (World Bank 1996). This research focuses on the methods KS-ICDP used to promote sustainable development and the long-term outcomes from the project in villages surrounding the national park.

The KS-ICDP implemented sustainable development through voluntary conservation agreements (VCAs) that provided development grants to improve local livelihoods, reduce local reliance on forest resources, and ensure villagers did not deforest traditional or national park forest areas (World Bank 1996, 2003). Trained and local facilitators drafted the VCAs, which village councils and village head supported and signed. According to facilitation standards, all adult members of VCA villages should have been aware of how the VCA was drafted and what it stipulated (Wood et al. 2014). Of the 425 villages available for selection among in the KSNP landscape, and the 134 villages in the "park buffer zone," project managers and the Indonesian Government selected 75 villages to sign VCAs (Linkie et al. 2007). The 72 villages that reached and signed a VCA were promised $25,000 in development grant money ($34,069.10 AFI), to be applied toward "income generating" as well as "physical and infrastructure" activities. Upon signing the VCA, villages were supposed to receive the initial grant disbursement ($12,500), with the final tranche disbursed upon initiation of conservation activities. Due to problems with project implementation, administration, and project timelines, only 19 of 72 villages received the second tranche of funding, with 64% of VCA villages recieved their first disbursement in the KS-ICDP's final year of operation (World Bank, 2003, 23).

This study examines how forest cover and household livelihoods surrounding KSNP vary between villages that did and did not receive direct investment from the KS-ICDP. A growing body of literature examines how payments for ecosystem services affect conservation motivations. "Crowding-in" refers to when pre-existing motivation for conservation activities are reinforced through direct payments; "crowding-out" refers to when direct payments erode the intrinsic motivation to conserve (Rode, Gómez-Baggethun, and Krause 2015). Examining the conservation legacy of KS-ICDP can contribute to this literature by determining whether activities representative of crowding-in or crowding-out best characterize forest cover change from 2003 to 2016. Combining information on forest cover change with household livelihood strategies provides further evidence of how forest cover change may have occurred, and how findings support current literature on conservation motivations.

Although previous studies have examined the outcomes of conservation across the KSNP landscape, the current research is novel in its temporal and methodological scope. Previous research has examined drivers of deforestation in KSNP (Bettinger 2014, 2015; Linkie et al. 2003; Linkie, Smith, and Leader-Williams 2004), including an analysis of forest cover change between VCA villages before and during the KS-ICDP implementation that found no difference in rates of forest loss (Linkie et al. 2008). Other research has examined traditional livelihood strategies surrounding KSNP (Hariyadi and Ticktin 2012; D. Wibowo 1999), with one study finding that 43% of VCA activities continued five years after the KS-ICDP finished (Wood et al 2014). The current research is the first to examine the legacy of conservation, and its relationship to motivation, within and adjacent to KSNP through empirical research on forest cover change and household livelihood in villages surrounding the national park.

4.3 Methods

To determine the relationship between conservation funding from the KS-ICDP and forest cover as well as household livelihood and well-being, we combine remotely sensed land cover data, the village census (*Sensus Potensi Desa*) from 2003 to 2014, and a novel survey that collected data from households within three km of KSNP in Jambi province. This research thus represents a mixed-methods approach, using a combination of data types to provide insights into forest cover change, village development, and household well-being (Ostrom and Nagendra 2006). The following two sub-sections explain data sources and the final subsection describes empirical methods.

4.3.1 Forest cover change

To determine where and when forest cover loss occurs in KSNP, we combine tree cover loss data (Hansen et al. 2013) with land cover data from the Indonesian Ministry of Environment and Forestry (Kementerian Lingkungan Hidup dan Kehutanan 2016a) and administrative boundary data from the Central Statistics Agency (Badan Pusat Statistik, 2015). Combining these datasets enables us to investigate temporal trends of when forest cover loss has occurred, in what type of land cover category, and if forest cover loss occurred within the KSNP boundaries.

To examine differences between villages that signed a VCA (VCA villages) and villages that did not sign a VCA (non-VCA villages), we extracted information from the World Bank KS-ICDP project narratives (WWF Indonesia, n.d.). Using village and district names, we combined narrative information with data from the Central Statistics Agency to identify VCA village boundaries. We matched 59 of the villages listed in KS-ICDP project narratives with villages directly adjacent to KSNP in 2003. Two villages were not directly adjacent, and thus not included in our analysis, and we could not reconcile 13 villages with official records from the Central Statistics Agency (*Badan Pusat Statistik*—BPS).

4.3.2 Survey design and household indicators

Our household survey provides cross-sectional information on differences between household livelihood strategies and well-being across a segment of the KSNP landscape. The primary unit of analysis for this survey was the household, and the sample population included all households within three km of KSNP in the districts of Sungai Penuh, Kerinci, and Merangin.

We sampled households using a stratified cluster design that maximized the proportionate representation and minimized survey costs through clustering (Groves, R.M. et al. 2009; Kish 1965). We stratified our sample based on district population, and we clustered our sample within 51 randomly selected villages (Appendix C). Within each village, we selected approximately 25 households at random, adjusting the number of households selected based on the proportionate size of the population at the time of surveying (Kish 1965). We generated our random household selection using household rosters from village heads (*kepala desa*) and village maps we obtained from district statistic agencies (Appendix C). Developed through the Forest and Livelihoods: Assessment, Research, and Engagement research community (FLARE Network 2016), our survey instrument contained modules on household demographics, livelihood, health, forest-use, finances, and public participation. We translated the survey instrument into Bahasa Indonesia and trained eight local enumerators to conduct survey interviews. Enumerators piloted the survey instrument for two days before our three-month period of survey dissemination. We completed survey data collection in January 2017.

4.3.3 Analytical techniques

Our analytical approach contains three steps. First, we use land cover and village census data to test forest cover differences between VCA and non-VCA villages. Second, we visualize and test differences in livelihood and well-being between VCA and non-VCA households within our sample. And third, we test the relationship between household income and demographic, economic, and village-level indicators, including VCA participation. Together, these analyses provide insight into how legacies of conservation investment affect conservation and development outcomes in and surrounding KSNP.

We used matching—a non-parametric pre-processing step in data analysis—to control for selection bias among VCA villages when measuring differences in forest cover loss from 2003 to 2016. Selection bias refers to consistent similarities between units within a "treatment" group that may confound comparisons with "control" group members. For example, VCA villages demonstrate more village-level deprivations in access to education, health, and infrastructure than non-VCA villages. These differences, if they are not controlled for using empirical methods, can drive the differences in average forest cover loss between VCA and non-VCA villages. Using statistical matching to compare villages with similar indicators for multidimensional village deprivation can controls for these differences, leading to more robust estimates of the difference between VCA and non-VCA houses[5].

In addition to multidimensional village deprivation, we matched villages based on 2003 values for: village area, average elevation, percent of area over 12% slope, distance to roads, distance to nearest district capital, percent of village are dedicated to paddy or field agriculture, percent of village area dedicated to agricultural or timber plantations, percent of village area dedicated to settlement areas, number of households, and mean precipitation (2000 to 2003). We also matched on year 2000 mean forest cover, to control for parallel trends before the baseline period of analysis. We then re-matched without year 2000 mean forest cover to assess robustness of our matching to alternative specification (Appendix F). Other studies use a similar set of covariates to control for deforestation pressure (Andam et al. 2008; Blackman et al. 2017; Brandt, Nolte, and Agrawal 2016; C. Nolte et al. 2013; Santika et al. 2017). We used two different matching algorithms—full matching and nearest-neighbor (1:4) propensity score matching—to test the robustness of our results, and ensure that covariance balance is below 0.25

[5] For further information on the multidimensional village deprivation indicator (MDVDI), as well as the multidimensional deprivation index (MDI), please see Appendix A.

in standardized difference (Stuart, 2010). We further controlled for confounders by including the matched covariates in a weighted least-squares (WLS) regression to generate point estimates for the differences in forest cover loss within KSNP between villages that did and did not receive direct ICDP funding (Imbens and Wooldridge 2009).

We combined visualization, statistical tests of independence, and generalized linear models to examine livelihood strategies in VCA and non-VCA villages within our survey sample. First, we identified and tested general proportional differences between household occupation, land ownership, land titles, income, and multidimensional poverty. The household multidimensional deprivation indicator (MDI) equally weights education, health, and livelihood indicators to provide a general and widely comparable measurement of household welfare (Alkire and Santos 2014). To test if VCA and non-VCA households significantly differ, controlling for other household variables, we ran generalized linear models on outcome variables that demonstrated significant differences in means or proportions from the previous step. The differences between VCA and non-VCA households inform our models within the third analytical step.

Regressing logged yearly income over demographic, economic, and village-level indicators tests for differences between VCA and non-VCA household economies. Studies show that yearly income varies more than other economic indicators, such as consumption indices (Coudouel, Hentschel, and Wodon 2002). Thus, we included the household MDI as a covariate to control for longer term household well-being. For all the models included in our analysis, we include selection criteria in Appendix F. Each covariate in every model was assessed for multicollinearity and removed if it had a variable inflation factor over three. We controlled for

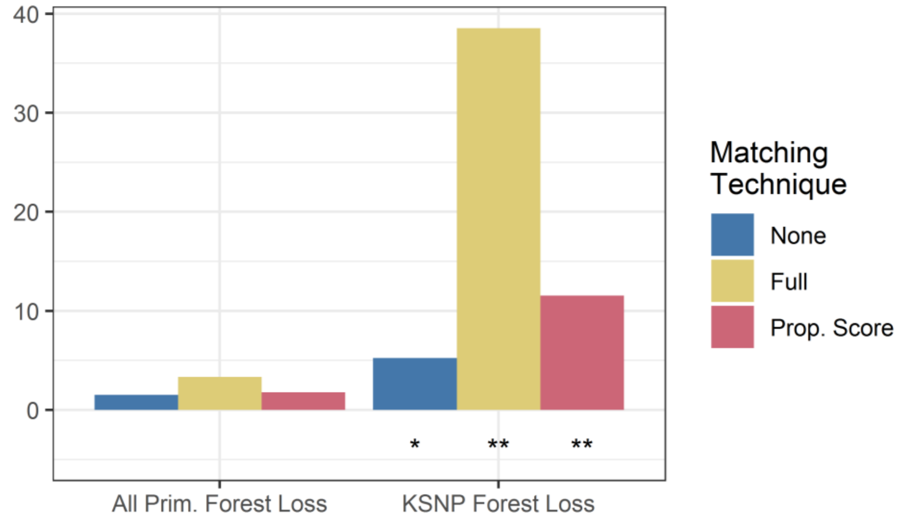


Figure 4.2: Forest type (x-axis) by difference in average forest cover change (ha) between VCA and non-VCA villages (y-axis), by different matching techniques

potential heteroskedactisity as well as inter-cluster correlation resulting from our clustered sample design using clustered robust standard errors (Abadie et al. 2017).

4.4 Results

4.4.1 Forest cover change

Comparing VCA and non-VCA villages matched on covariates linked to forest cover loss demonstrates forest-loss in VCA villages was greater in VCA villages. We examine the difference between primary forest cover loss as well as primary forest cover loss within KSNP (Figure 4.2). When we correct for village-level attributes often tied to forest cover loss, we find that the difference in 2003-2016 forest cover loss within KSNP is significantly higher in villages that received VCA funding. Although overall primary forest loss is also higher in non-VCA villages, the difference is not significant. VCA villages lost an average 38.6 ha of KSNP forest area more than non-VCA villages ($p<0.1$), according to our full matching result, which provided the best covariate balance between VCA and non-VCA villages (Appendix F). However, the 1:4 Propensity Score Matching dataset, which generated only slightly less balanced results, estimates

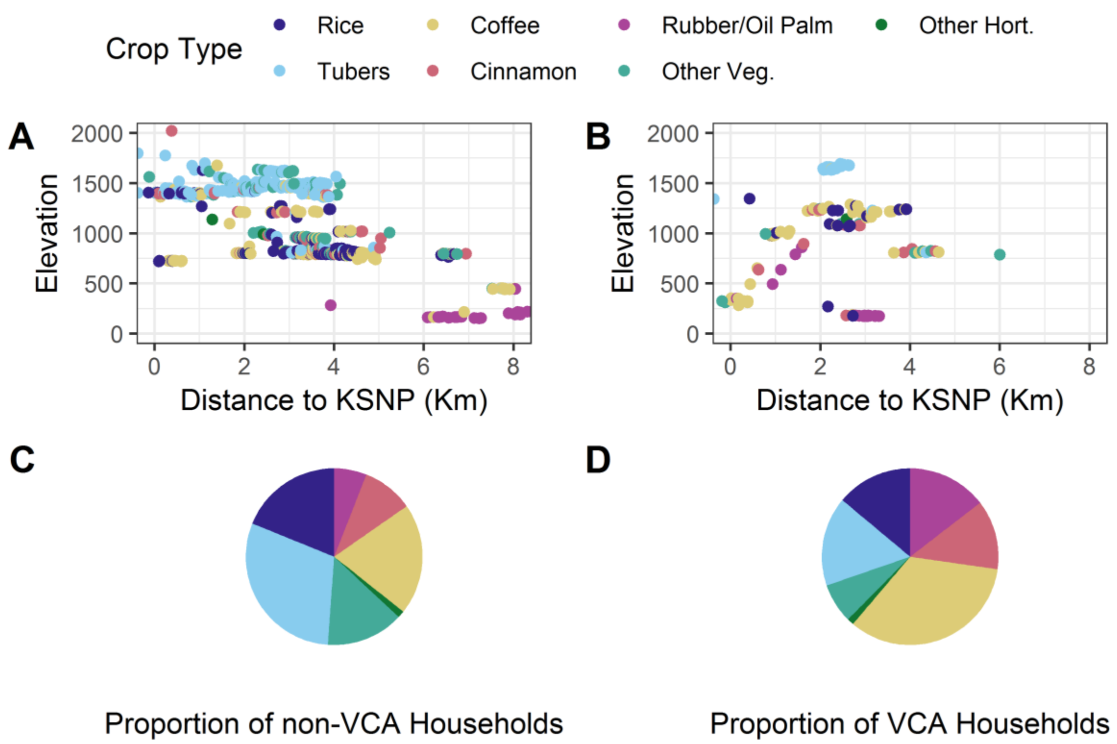


Figure 4.3: Primary commercial crop among farming households for non-VCA households (Panels A and C) and VCA households (Panels B and D).

that VCA villages lost 10.5 ha more than non-VCA villages between 2003 and 2016. The 10.5 ha estimate more closely resembles matching estimates that do not include pre-2003 average forest cover as a matched covariate. With estimates of KSNP forest cover loss in VCA villages between 10.5 and 38.6 ha, VCA villages lost significantly more forest cover within KSNP boundaries as compared to the most similar non-VCA villages.

4.4.2 Household livelihood

1,304 respondents living in 51 villages across three districts in Jambi Province contributed responses, with a response rate of 0.99. Of the 1,304 randomly selected respondents, 180 lived in seven villages that signed VCAs. The proportion of VCA to non-VCA villages in our random sample (0.137) does not significantly differ from the proportion of VCA villages across all four provinces (0.186) in a two-sample test for equality of proportions (p-value = 0.51).

The most pronounced cropping patterns occur across the elevation gradient and between VCA and non-VCA households. Figure 4.3 illustrates VCA and non-VCA households' most important commercial crops by distance to the park and elevation. Rubber and oil palm are farmed at lower elevations (<500 m), tubers at higher elevations (>1,250 m), with coffee, cinnamon, other vegetables and horticultural crops more prevalent between these extremes. To determine differences in environmental factors and livelihood variables between VCA and non-VCA households, we use clustered Wilcoxon rank tests (Rosner-Glynn-Lee method) for continuous variables and clustered t-tests for nominal variables. Both of these tests account for our clustered survey design. VCA and non-VCA households do not differ in average distance to KSNP border ($Z = -1.67$, $p > .05$, $n = 1,276$), average elevation ($Z = -0.28$, $p > .05$, $n = 1,276$), total income ($Z = 1.61$, $p > .05$, $n = 1,267$), or MDI ($Z = 0.19$, $p > .05$, $n = 1,285$). However, VCA households own significantly more land than non-VCA households ($Z = 2.2358$, $p<.05$, $n=1,290$), fewer official land titles ($Z=-1.18$, $p<.1$, $n=1,290$), report more coffee farming ($Z = 2.17$, $p < .01$, $n = 1,290$), cinnamon farming ($Z = 2.67$, $p < .01$, $n = 1,290$), and rubber or oil palm farming ($Z = 2.11$, $p < .05$, $n = 1,290$). To control for potential confounding within the clustered Wilcoxon rank and t-tests, we model total land area and high-value tree crops (Table 4.1).

Table 4.1: Models of the propensity to use a livelihood strategy, accounting for demographic, economic, and village-level indicators

	Model 1: Logistic regression of any land owned				Model 2: Linear regression of logged hectares of land owned			Model 3: Logistic regression of farmed high-value tree crops			
	Coef.	Log Odds	SE		Coef.	SE		Coef.	Log Odds	SE	
Intercept	-9.625	NA	2.236	***	-7.000	0.846	***	2.257	NA	0.209	
Female head of house	0.258	1.295	0.197		0.007	0.112		-0.262	0.770	0.221	
Head of house age	0.025	1.025	0.007	***	0.005	0.004		0.004	1.004	0.543	
Head of house ed. years	0.055	1.057	0.026	**	0.022	0.007	***	-0.014	0.986	0.514	
Number of adults	0.184	1.202	0.163		-0.003	0.052		0.005	1.005	0.954	
Ag. primary occupation	1.512	4.538	0.248	***	0.325	0.157	**	0.050	1.051	0.821	
Ethnicity: Jambi	0.930	2.535	0.484	*	-0.471	0.251	*	-1.117	0.327	0.071	*
Ethnicity: Javanese	1.030	2.802	0.625	*	0.144	0.212		0.552	1.737	0.283	
Ethnicity: Kerinci	0.536	1.709	0.355		-0.276	0.217		-0.609	0.544	0.141	
Farms high value tree crop	2.720	15.181	0.448	***	0.596	0.149	***				NA
Total land owned (ha)				NA			NA	0.391	1.478	0.009	**
Ln(total income (IDR))	0.313	1.367	0.146	**	0.368	0.057	***	-0.093	0.911	0.346	
MDI	-2.050	0.129	1.100	*	-0.807	1.012		-0.671	0.511	0.555	*
Holds formal land title				NA	0.130	0.114		-0.501	0.606	0.133	
VCA village	0.952	2.591	0.451	**	0.226	0.206		1.071	2.919	0.000	***
Elevation	0.119	1.126	0.057	**	-0.015	0.022		-0.184	0.832	0.000	***
Distance to KSNP (km)	0.112	1.118	0.077		-0.029	0.042		0.057	1.059	0.381	
KSNP forest-loss (ha)	0.000	1.000	0.001		0.000	0.000		0.000	1.000	0.866	
AIC		1010				NA			1147.9		
R-Squared, Adj. R-Squared		NA				0.201, 0.187			NA		

**p<0.1; **p<0.05; ***p<0.01*

Controlling for economic, demographic, as well as village factors indicates that VCA households are more likely to own land and farm high-value tree crops. Using a nested model selection process (Appendix F) we find that accounting for economic, demographic, and village indicators best predicts a household's propensity to farm high-value tree crops, own land, as well as the amount of land a household owns. Table 4.1 presents the best-fit models from model selection. Model 1 demonstrates that the odds a household residing in a VCA village owns land is 2.59 times greater than a household in a non-VCA village (β = 0.952, SE = 0.451). Although the effect is nonsignificant, residing in a VCA village predicts owning 25% more land (β = 0.226, SE = 0.206), and the significant effect of farming high-value tree crops predicts an 81%

increase in the amount of land a household owns (β = 0.596, SE = 0.149). Finally, households in VCA villages are 2.9 times more likely to farm high-value tree crops (β = 1.071, SE = 0.000).

Table 4.2: Model of income among KSNP proximate households. SEs are robust and clustered at the village-level.

Model 4: Linear regression of log (total income (IDR))	Coef.	SE	
Intercept	17.192	0.354	***
Female head of house	-0.098	0.058	*
Head of house age	-0.007	0.002	**
Head of house ed. years	0.015	0.012	
Number of adults	0.098	0.035	**
Ag. primary occupation	-0.097	0.065	
Ethnicity: Jambi	-0.212	0.151	
Ethnicity: Javanese	-0.029	0.124	
Ethnicity: Kerinci	-0.123	0.129	
Farms high-value tree crop	-0.048	0.067	
MDI	-2.946	0.446	***
Holds formal land title	0.055	0.060	
Total land owned (ha)	0.137	0.042	**
VCA village	0.114	0.140	
Elevation	0.028	0.013	**
Distance to KSNP (km)	-0.006	0.027	
KSNP forest-loss (ha)	0.000	0.000	
Land Owned * VCA Village	-0.115	0.059	**
R-Squared, Adj. R-Squared	0.1997, 0.1884		

$^*p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Modeling income shows small yet significant differences between VCA and non-VCA households (Table 4.2). The income model that included economic, demographic, and village-level indicators with an interaction between VCA-treatment and hectares of agricultural land owned performed best (Appendix F). This model demonstrates that the predicted increase in income from owning more land is attenuated for VCA households. Our model predicts a 14% increase in total income for non-VCA households that own one hectare of land, and a 2% increase for VCA households that own one hectare of land.

4.5 Discussion

Our findings explain heterogeneity in social-ecological outcomes within and surrounding Indonesia's second largest terrestrial PA. Many studies indicate that, compared to similar unprotected areas, PAs significantly reduce forest cover loss in Indonesia (Ferraro et al. 2013, 2015), Sumatra (Gaveau et al. 2012; Gaveau, Epting, et al. 2009), and across KSNP (Linkie, Rood, and Smith 2010; Linkie, Smith, and Leader-Williams 2004; Shah and Baylis 2015). However, this research often focuses on the average effect of protected areas, rather than attending to heterogeneity over space and time within PAs. Notable exceptions document how PAs, such as KSNP, contain considerable spatial variation of marginal forest cover loss (Shah and Baylis 2015), how park enforcement and management contribute to biodiversity conservation and reduced forest cover loss (Linkie et al. 2015; Linkie, Rood, and Smith 2010) and how local and international commodity prices affect Indonesian forest cover (Gaveau, Linkie, et al. 2009; Wheeler et al. 2013). In our study, heterogeneity of social-ecological outcomes is predicated upon institutional changes from the KS-ICDP. Significant differences divide villages that signed VCAs and those that did not. First, VCA villages contain greater levels of forest cover loss in KSNP than non-VCA villages. Second, households in VCA villages are more likely to own land and farm high-value cash-crops. And third, VCA households have overall lower incomes and demonstrate a smaller increase in yearly income as land ownership increases. These findings indicate that VCA villages own more land, plant high-value tree crops, but do not report higher incomes. KS-ICDP funding may have engendered these differences by crowding out conservation motivations.

By monetizing conservation and failing to pay villages the full amount for their conservation activities, the KS-ICDP may have crowded out intrinsic motivations and decreased extrinsic motivation for forest conservation. Recent literature demonstrates that providing material benefits can “crowd out” intrinsic motivations (Gneezy and Rustichini 2000), including those related to conservation values (Agrawal, Chhatre, and Gerber 2015; Börner et al. 2017; Chervier, Le Velly, and Ezzine-de-Blas 2016). Although the KS-ICDP sought to promote local development and conservation through a variety of livelihood and infrastructure activities, only

19 of 72 villages received all of the grant money the VCAs promised (World Bank 2003). Offering $25,000 for signing and implementing a VCA monetizes conservation, potentially crowding out intrinsic motivations to conserve forest area. Paying half of the agreed upon amount to 53 villages reduces the extrinsic motivation to maintain VCA activities, including the pledge not to convert KSNP forest area into agricultural land cover. Time series data that provides information on land-ownership type, amount of land owned, and VCA participation does not exist; without it, research cannot definitively claim that KS-ICDP funding caused higher rates of forest cover loss and informal land ownership in VCA villages. However, our findings provide substantial evidence that the the conservation legacy of KS-ICDP is opposite its intended objectives. The significant differences between VCA and non-VCA villages and households indicate that the legacy of KS-ICDP promoted agricultural expansion rather than forest conservation.

The increased likelihood of VCA households to own land without a formal title and farm high-value tree crops points to potential problems for future conservation activities in these same villages. High-value tree crops require longer time to harvest than standard field crops, such as tubers and other vegetables common among our household sample. Coffee (*C. arabica* and *C. canephora*), the high-value tree crop with the shortest time to harvest, takes approximately three to four years before first harvest; cinnamon (*Cinnamomum burmanni*), the crop with the longest time to first harvest, requires approximately 10 years. If KSNP forest loss within VCA villages is primarily from planting high-value tree crops, as our surveys indicate is likely, then households have invested time and money into land conversion that will provide returns over over ten-year time horizons, at a minimum; reclamation of such territory is unlikely to occur through voluntary abandonment. Further, 40% of VCA households that farm coffee as their main commercial crop reported an increase in production over the past five years, as compared to 31% non-VCA coffee farmers. It is possible that these farmers are taking advantage of government support for coffee farming, harvest, and production in Jambi province and in Kerinci district (Saputra 2018; Wintani 2017). Literature on commodity production, coffee prices, and forest cover change surrounding KSNP remains wanting, but other studies have documented how coffee demand and PA encroachment are related elsewhere in Sumatra (Scholz, 1983; Gaveau, Linkie, *et al.*, 2009; Levang, Sitorus, Gaveau, *et al.*, 2012). Heavy investment in high-value tree crops within VCA villages may mean increasing re-investment and expansion. Future research should focus on the relationship between increased production of high-value tree crops and forest cover change across the KSNP landscape.

4.6 Conclusion

Conservation legacies can last long after project funding and activities cease. We find that the legacy of KS-ICDP generated long-term, village-level outcomes in contrast to project goals and objectives. Villages that signed the VCA to implement conservation activities and receive $25,000 ($34,068.10 AFI) show higher levels of forest loss within KSNP than villages that did not sign VCAs. Households within VCA and non-VCA villages in Jambi province demonstrate little difference in total income but are more likely to own land without a formal title and grow high-value tree crops, including coffee, cinnamon, oil palm, and rubber. We argue that differences between VCA and non-VCA villages may be motivated by the way in which KS-ICDP monetized and did not pay most VCA villages the agreed upon amount. Over 70% of VCA villages received half the agreed upon funding for signing VCAs and implementing conservation activities. Thus, the KS-ICDP may have simultaneously devalued intrinsic and extrinsic motivations for conservation. This, in turn, may have led households within VCA villages to increase informal land ownership and invest in high-value tree crops. With more support and incentives to plant and sell coffee, and a history of land cover change related to high-value tree crop expansion in other Sumatran PAs, future research should investigate the role of land-ownership, agricultural expansion, and international conservation aid across the KSNP landscape.

Over a decade after its implementation, the conservation legacy of KS-ICDP persists. This points to the significance of investigating heterogeneity surrounding PA efficacy, in addition to the importance of considered and fair engagement with local communities. International funding that seeks to promote conservation and local development is becoming more common in countries with tropical forests. Those who implement conservation projects that aim to provide direct livelihood benefits for conservation activities would do well to ensure the communities they work with receive promised benefits, and fully understand their rights and responsibilities with regard to conservation activities. The stakes for such funding are high. Long-term failure is a real possibility.

Chapter 5

Conclusions

Institutional changes, forest cover, and rural livelihoods are intertwined across Indonesia. This dissertation finds that over the first two decades of Indonesian democracy, political transitions generate specific outcomes for people and forests. Together, these findings support understanding institutional change as a series of institutional transitions. As defined in the introduction, analysis of institutional transitions centers on recognition of how the timing or sequencing of an institutional change is embedded in place-based histories; how an institutional change can generate varying effects over time; and how an institutional change can generate varying effects over space. The results of this dissertation contain conclusions relevant to the relationship between political transitions, forests, and people in Indonesia. In studying Indonesia, this dissertation motivates a "geographical turn" in the institutional analysis of social-ecological outcomes.

5.1 Institutional transitions and Indonesian forest landscapes, 1999 to 2016

Previous scholarship on Indonesian politics and forest cover change provide precedent for understanding Indonesian forest change as created within and through processes of political transition. During the New Order, government claimed authority over forest lands through policy based in Dutch colonial law (Peluso 1992). This translated to state control over specific forms of forest labor and complete control over forest lands and trade in certain timber species. Through the Basic Forestry Law (41/1999), the Indonesian state retains authority of the Indonesian forest estate, which accounts for approximately 60% of Indonesia's total land area. Scholarship that examines the causes of forest cover change in Indonesia post-*reformasi* point to land conversion related to global commodity demand (McCarthy and Cramb 2016; Mccarthy and Robinson 2016; Tsing 2005). However, contemporary and empirical institutional analyses often seek to separate analytical methods from overarching political change. Accounting for space and time in empirical method can be challenging, and social-ecological data may not be available at appropriate temporal or spatial resolution. As this dissertation shows, when data is available that enables deeper consideration of institutional change as transitional processes, examining some combination of sequence, longitudinal effects, and spatial variation can assist in the identification and explanation of causes that drive institutional effects related to social-ecological outcomes.

Chapter 2 examines a puzzle: From 1999 to 2016, political support for forest conservation has increased but there was not a concomitant decrease in forest cover loss. Results from Chapter 2 show that, in line with pledges and vocal support, Indonesian political actors have passed an increased number of national, forest-related policies (n=269), with the most significant increase in policy content that addresses forest protection, monitoring, ecosystem services, and biodiversity conservation. Between 1999 and 2016, there has also been a significant increase in policy that reorganizes forest-related administrations in Indonesia. Significant international pressures, including changes in trade laws, norms surrounding climate change and carbon emission, as well as market incentives for evidenced-based conservation likely motivate these policy changes. The combination of this significant change in policy content, coupled with significant international motivation and pathways of influence (Bernstein and Cashore 2012), indicate that Indonesian forest-related policy has undergone a "classic paradigm shift" from 1999 to 2016 (Cashore and Howlett 2007). However, these increases in policy change do not demonstrate an associated increase in forest-related policy amendments. Thus, national forest-related policy in Indonesia has changed through the process of policy layering (Mahoney and Thelen 2010).

Policy layering indicates that new policy and old policy co-exist, potentially generating ambiguity around implementation and regulatory enforcement. Through a discussion of current trends in Indonesian forest governance, Chapter 2 provides evidence of considerable ambiguity surrounding the regulation of forest territories and the flow of forest products. Regulation of forest territory is subject to horizontal layering, or the ambiguity surrounding new regulatory policies at the national level. It is also subject to vertical layering, when provinces and administrations pass overlapping and sometimes contradictory policies. However, the regulation of forest products provides an example of how policy layering can translate into regulatory change. Over the past decade, timber legality verification has increased the formalization of Indonesian timber production (Obidzinski and Kusters 2015; Setyowati and McDermott 2017). This process began through policy layering, but has since become less ambiguous through ministerial enforcement and legal clarification (Nurrochmat *et al.*, 2014; Erbaugh, Nurrochmat and Purnomo, 2017).

The results from Chapter 2 demonstrate the need to consider sequencing and spatial variation when measuring the relationship between institutional change and social-ecological outcomes in Indonesia. Forest-related policy content typically seeks to codify, and thus formalize, processes of forest management. Formalization increases as social and economic activities become more entangled in official state technologies, and as the structure and pattern of these processes becomes more predictable (Guha-Khasnobis, Kanbur, and Ostrom 2006).

From 1999 to 2016, Indonesian political actors passed a series of policies that sought to increase the role, scope, and reach of government in controlling forest resources. The fast tempo of policy content change in Indonesia indicates that when a social-ecological outcome is measured against a policy instrument or institutional change can drastically effect the relationship under study. For example, the influence of Indonesian timber legality and certification on smallholder timber production has changed drastically from when Indonesia and the EU first signed the voluntary partnership agreement (VPA), to the present (Obidzinski et al. 2014; Purnomo et al. 2016). Research that measures the impact of smallholder timber production on forest cover or livelihoods must carefully select timeframes that account and include the diversity of legal ambiguity and enforcement that has accompanied timber legality verification in Indonesia, or else risk finding incomplete and/or spurious relationships between smallholder timber production and social-ecological outcomes. Further, due to policy layering, the increased amount of forest-related policy that sought to extend the function of government may not have increased the predictability of interactions surrounding forest use. Ambiguity surrounding layered policy and regional implementation emphasize the need to focus on local-level drivers and spatial variation when studying social-ecological outcomes in Indonesia.

Chapter 3 focuses on how village- and district-level regulatory dispersal affect Indonesian forest cover from 2000 to 2014. Regulatory dispersal is the process by which regulatory powers are dispersed across a greater number of administrative units (Agrawal 2005). In the period following administrative proliferation, village-level regulatory dispersal generates an overall and consistently negative effect on forest cover change. District-level regulatory dispersal decreases forest cover but demonstrates a heterogeneous effect that depends on when a district proliferated between 2000 and 2014. Over this time period, a variety of forest-related policies sought to reduce the powers that district-level authorities have over forest management (Barr et al. 2006; Kimura 2010), while village-level natural resource management rights remained nonexistent (Antlöv, Wetterberg, and Dharmawan 2016). These findings suggest that the effect of regulatory dispersal is generally negative, but that formal policy that addresses incentives for administrative proliferation and natural resource management can attenuate this trend.

Chapter 3 also investigates drivers of forest cover change as a result of regulatory dispersal. Villages that only underwent district-level dispersal demonstrated significantly greater conversion of land cover to field agriculture in the first and second periods after administrative proliferation (+3.5%). In contrast, villages that only underwent village-level dispersal show similar increases in conversion to field agriculture (+0.8%) and mixed field and tree agriculture (+0.6%). Since few villages claim any formal land use rights, it is surprising that any relationship exists between regulatory dispersal and land conversion at all. The difference between district-level and village-level land conversion elucidates conversion trends. This difference suggests that, following regulatory dispersal, district-level conversion occurs through more formal processes of land clearing that result in an increase of large-scale monocropped field agriculture; village-level dispersal, however, seems to promote the conversion of smallholder agriculture, detectable through and increased amount of mixed field and tree agricultural mosaics.

Through longitudinal and multi-scalar analysis of regulatory dispersal, Chapter 3 demonstrates the importance of attending to sequencing and longitudinal effects when studying decentralization. The period when villages experienced district-level regulatory dispersal shifted how dispersal effected forest cover change. Understanding overarching policy trends help explain these differences and emphasize the importance of timing and sequencing. Comparing the effect of district-level dispersal to village-level dispersal show that multi-scalar analysis can identify important relationships between institutional change and social-ecological outcomes. Chapter 4 retains a similar focus on village-level outcomes and examines how international conservation finance generates legacies surrounding Kerinci-Seblat National Park (KSNP).

Chapter 4 examines the conservation legacy of Indonesia's largest Integrated Conservation and Development Project (ICDP). From 2000 to 2016, Indonesia received increasing amounts of international environmental aid; the Kerinci-Seblat ICDP was a flagship project, operating between 1999 and 2003. One of the ICDP objectives was to incent conservation and development activities in proximate populations by paying villages to sign voluntary conservation agreements (VCAs) in the early 2000s. In return for two disbursements of $12,500 betwene 2000 and 2003, villages agreed to pursue specific development projects and pledge not to convert forestland within the recently gazetted KSNP. Of the 72 villages that signed VCAs, only 19 received the full disbursement of funding. Chapter 4 shows that, a decade later, villages that signed a VCA demonstrate significantly higher rates of deforestation within KSNP boundaries. Further, households in VCA villages are more likely to own land that is held informally (i.e. no formal title), farm high-value tree crop, and the direct relationship between land ownership and income is significantly attentuated in VCA households. The differences between VCA and non-VCA villages suggest that households in VCA villages have pursued agricultural expansion instead of conservation activities specified in their VCA.

The significant differences between VCA and non-VCA villages may be attributable to the monetization of conservation land that was immediately devalued. Chapter 4 discusses how, by paying villages to sign and pursue activities outlined in the VCA, the KS-ICDP may have crowded out intrinsic motivations for conservation. When the KS-ICDP failed to pay the full amount to villages, as specified in the VCA, they may have further crowded out extrinsic motivation to conserve forest area in KSNP. The chapter thus concludes that, as conservation aid continues to affect landscapes across Indonesia, it will be crucial to study the long-term and potentially heterogeneous effects born by international funding and that it is crucial to study heterogeneity of conservation efficacy, as related to space and institutional change.

Chapter 4 provides an example of how considering sequencing and spatial variation can provide understanding of potential causal mechanisms that generate social-ecological outcomes. In payments for ecosystem service projects, payments matter. Differences in VCA and non-VCA villages suggest that international conservation aid, though a manifestation of globalized diplomacy and development assistance, mixes with logistical, economic, and political realities to produce place-based transitions. Through the consideration of varying social-ecological outcomes across a conservation landscape, Chapter 4 shows that the legacy of the largest ICDP in Indonesia is largely opposite project goals and ambitions, within villages that received direct benefits from project activities. Considering spatial variation, especially spatial variation over time, can improve research on conservation and conservation legacies.

5.2 Institutional transition and Indonesian forest landscapes, 1999 to 2016

Individual chapters of this dissertation investigate the temporal and/or spatial processes of political change in Indonesia, and its relationship to forests and people. Analyses in this dissertation have been built upon baselines relevant to overarching institutional change, assess periods of time that encapsulates longitudinal variation relevant to individual research questions, and examine variation across and within political spaces. In sum, these findings promote greater consideration of how processes of institutional change "stretch" across space and time to affect and generate social-ecological outcomes.

General processes of formalization, decentralization, and globalized governance affect outcomes for forests and people in Indonesia. Chapter 2 examines the process of increasing formalization through policy content change, and how it has engendered ambiguity. As Indonesia has progressed to become the world's third largest democracy, significant policy change occurred alongside natural resource management. Chapter 3 examines the sequence, longitudinal effect, and scalar variation of decentralization. It finds a significant and time-sensitive effect of village-level regulatory dispersal, which encourages other institutionalist studies of land cover change to more rigorously engage with changes in administrative boundaries. Chapter 4 examines how the international conservation funding, implemented through the globalization of NGOs, combines with international commodity demand to generate conservation legacies surrounding an Indonesia's second largest terrestrial PA. It supports analysis of how conservation efficacy varies through political and financial drivers of heterogeneous conservation outcomes. However, these examples are not exhaustive. Continued research of institutional transitions and forest outcomes in Indonesia can examine different aspects of formalization, decentralization, and globalized governance. Extending insights from this dissertation beyond Indonesia requires further analysis of how institutional transitions affect social-ecological outcomes.

Many barriers exist to studying institutional transitions. Within this dissertation, individual chapters focus more on one or two aspects of institutional transition, often at the expense of analyzing and discussing the rest. Chapter 2 engages with temporal elements but is unable to assess spatial variation in policy content change. Chapter 3 examines sequencing, longitudinal effects, and variation across political space, but it does not engage with the heterogeneity of regulatory dispersal's effect across geographical space. Chapter 4 examines variation across administrative space, but it controls for sequencing effects through matching analysis and does not engage with longitudinal effects within the study period. If a dissertation dedicated to understanding institutional change as spatiotemporal transitions can only perform analysis in part, what hope is there for other research? This dissertation represents a small step on the path toward the scholarship on institutional transitions and social-ecological outcomes. Along with the growing number of studies that seek to understand institutional and social-ecological change in tandem, it is one step in a larger movement.

Studies at the interstices of institutional analysis and land systems science have already started to more comprehensively engage with the analysis of institutional transitions. Among others, these studies examine the heterogeneous effects of conservation rules over space (den Braber, Evans, and Oldekop 2018; Shah and Baylis 2015), elevation and slope gradients (Ferraro et al. 2015; Santika et al. 2017), as well as the longitudinal effects of environmental policy on human-environmental relationships (Allington, Li, and Brown 2017; Sylvester, Gutmann, and Brown 2016; Waroux et al. 2017). As with individual chapters in this dissertation, most of this research is able to focus on one or two elements of institutional transition. The ongoing quest for better data, especially social data of high temporal and spatial resolution (Erbaugh and Agrawal 2017), is related to improving analyses of institutional change and social-ecological outcomes.

As improvements in data and computing capacity permit more rigorous operationalization of space and time within empirical research, institutional analysis and land systems science will be able to more fully operationalize institutional change as transitional processes. Future research related to this dissertation can examine if and/or how vertical policy layering generates heterogeneous outcomes for forest cover and rural livelihoods; whether forest cover change following regulatory dispersal demonstrates unique land change patterns; and how international conservation projects that provide economic inventives differ across geographical contexts. Each of these future directions examines timing, longitudinal effects, and spatial variation, of institutional change in a new way. Like institutional change, research is a social process that occurs in space and time. Analyzing institutional transitions through successive research iterations will be crucial for advancing understanding of social-ecological outcomes in a world of institutional change.

The beginning of the 21^{st} century has witnessed rapid environmental, social, political, and economic changes. Living in the Anthropocene, we are aware as never before of interconnections within social and ecological systems. Institutions shape the way in which people engage with one another, and they structure human-environmental interaction. Communities and the institutions they create and enact are capable of limitless change; however, the natural resources upon which they depend are limited in amount or in their regenerative capacity. If the sustainable use of resources for present and future generations is the goal, institutional transitions that promote such sustainability is the means. Studying how changes in rules, norms, and behaviors influence outcomes within social-ecological systems promises to improve our capacity for institutional design, how we understand the world around us, and our place in it.

Appendices

Appendix A

Spatial Data

A.1 Land cover data

Data on land cover categories come from the Indonesian Ministry of Environment and Forestry (*Kementerian Lingkungan Hidup dan Kehutanan*—KLHK). KLHK generated this dataset using manual classification of Landsat and MODIS imagery from 2000 to 2008, and a combination of manual and automatic classification of exclusively Landsat imagery from 2008 to 2014 (KLHK, 2016). From 2000 to 2010, KLHK produced land cover data at three year intervals (2000, 2003, 2006, 2009). After 2009, KLHK produced land cover data annually. There are 22 categories of land cover within the KLHK dataset (KLHK, 2015). To measure the change in overall forest cover, this dissertation combines the following categories: "primary forest," "primary peat forest," "secondary forest," and "secondary peat forest" following other studies that find the combination of these forest areas in best agreement with other remotely sensed forest products (Hansen et al. 2013; Margono et al. 2014). Overall forest cover explicitly excludes "primary mangrove forest" and "secondary mangrove forest" from analyses, because these forests are subject to different deforestation drivers than terrestrial forests (Richards and Friess 2016). Table A.1 contains further information on all land cover variables contained in this dissertation that derive from the KLHK land cover product.

Table A.1: Spatial data variables, definition, treatment, and source

Variable	Original variable name/s	Definition	Treatment	Source
Forest	Hutan lahan kering primer; hutan lahan kering sekonder, hutan rawa primer; hutan rawa sekonder	Terrestrial forest	Combined primary and secondary forest land cover	KLHK 2016
Paddy agriculture	Sawah	Wet agriculture	None	KLHK 2016
Field agriculture	Pertanian lahan kering	Dryland agriculture	None	KLHK 2016
Mixed agriculture	Pertanian lahang kering campur	Mixed field and tree agriculture mosaics	None	KLHK 2016
Timber plantation	Hutan tanaman	Forest plantation	None	KLHK 2016
Agricultural plantation	Perkebunan	Agricultural tree plantation	None	KLHK 2016
Settlement area	Pemukiman	Settlement	None	KLHK 2016
Distance to roads	Roads	Euclidean distance to roads within an administrative unit or from a specific point	Measured Euclidean distance to roads (2000 and 2015) in ArcGIS 10.5 and calculated a weighted average of distances based on intervening year	BIG 2016, CIESIN 2013
Elevation	Elevation	Meters above sea-level	Cubic interpolation of NAs	SRTM 2008
Slope over 12%	Slope	Land over 12% slope	Created slope raster and identified all pixels (90m resolution) greater than or equal to 12% slope	SRTM 2008
Precipitation	Average mm/day	Precipitation in mm/day	Averaged over a three year period, including the year of analysis. For example, average precipitation for 2003 includes 2001, 2002, and 2003	Huffman et al. 2017
Protected area	IUCN Protected area categories I-IV	Strictly protected areas	Subsetted protected area shapefiles to Indonesia, dropped marine protected areas, dropped protected areas established after a given year in analysis, dropped less strictly protected areas and multiple use areas	UNEP-WCMC and IUCN 2016

A.2 Additional spatial data

In addition to KLHK land cover data, this dissertation incorporates elevation, slope, precipitation, and road network data from different sources. Values for elevation and slope derive from the SRTM digital elevation model (Jarvis, Reuter, and Nelson, 2008). To generate the slope raster, this dissertation uses the SRTM digital elevation model processed with ArcGIS 10.5. Instead of using average village slope, analyses in this dissertation use the average amount of village area with slope greater than 12%, following other studies that seek to more accurately control for agricultural suitability (Blackman et al. 2017).

To calculate relevant precipitation values, this dissertation incorporates data from the Tropical Rainfall Measurement Mission (TRMM), calculating average precipitation for two years preceding and including each year within the panel data (Huffman et al. 2007). Three year precipitation averages in Indonesia demonstrate strong, positive correlation with field agriculture, paddy agriculture, and elevation. Analyses in Chapter 3 drop the measurement of average precipitation due to strong positive associations. However, matching pre-processing in Chapter 4 controls for average precipitation, as the association between it and agricultural variable and elevation did not make it redundant.

Spatially explicit road network data comes from two sources that enable interpolation of average distance to road values between 2000 and 2014. As with many spatially-explicit analyses, finding and incorporating accurate and time-varying road data into analyses proved challenging (Frizzelle et al. 2009). The GROADS database (CIESIN, 2013) provides road information for Indonesia, at the national level, for the year 2000. The Geographical Information Agency (*Badan Informasi Geospasial*—BIG) provided public data on Indonesian road networks for the year 2014 (BIG, 2014). To calculate average distance to roads for intervening years in our analyses (2003, 2006, 2009, 2011), we assume road growth is linear. Although this method does not model average distance to roads using population or land cover changes, it improves on the current state of incorporating road network data within institutional studies of social-ecological outcomes in Indonesia. Leading studies that incorporate rigorous causal inference to assess institutional drivers of land or forest cover change treat distance to roads as a time-invariant variable, either matching on road data once or by holding the average distance to roads or cities as constant in an analysis of panel data (Ferraro et al. 2015; Miteva, Loucks, and Pattanayak 2015; Santika et al. 2017; Shah and Baylis 2015). By interpolating road data, even using a basic assumption of linear growth, analyses in this dissertation more accurately consider distance to roads as time-variant. Future research can build upon this small step forward in combining insights from land-change science into institutional analyses to develop more accurate models of road-network growth in Indonesia and include more accurate interpolation of road data.

Analyses include data on protected areas from the International Union for Conservation of Nature and Natural Resources World Database for Protected Areas (UNEP-WCMC and IUCN 2016). This dataset has been used extensively in other studies that investigate the efficacy of protected area networks (den Braber, Evans, and Oldekop 2018; Miller and Nakamura 2018; Christoph Nolte et al. 2013). Since this dissertation focuses on terrestrial forests (excluding mangrove forests), it limits the dataset to terrestrial protected areas.

Appendix B

Multidimensional deprivation indicators

B.1 Background

Multidimensional measurements of livelihoods and well-being combine health, education, and livelihood data to generate a more accurate picture of human well-being than unidimensional measurements. Although economic measurements of income or consumption provide valid and easily quantifiable data on national or sub-national economic well-being, these measurements have been critiqued as unrepresentative and subject to temporary and drastic fluctuations that are unrepresentative of human well-being. Multidimensional measurements that combine economic well-being with measurements of health and education can provide more comprehensive insight into poverty and well-being (Alkire and Foster 2011b; UNDP 1997; World Bank 2000). The United Nations Development Programme (UNDP) reports the Human Development Index (HDI) as well as the Multidimensional Poverty Index (MPI). The HDI draws on national statistics of average life expectancy at birth, expected years of schooling, mean years of schooling, and Gross National Income (GNI) per capita to provide a multidimensional development measurement. The MPI borrows from the theory and logic of the HDI, and applies the multidimensional well-being framework to the household level.

Using nationally representative surveys, the Alkire-Foster method calculates the MPI based on household data for health, education, and assets. Using a set of variables common among nationally representative household surveys, the Alkire-Foster method first calculates a deprivation matrix (Table B.1). The deprivation matrix contains information on which households are deprived in what indicators that comprise the more general categories of health, education, and livelihood (Alkire and Foster 2011a; Alkire and Santos 2014). Equally weighting health, education, and asset deprivation categories, the Alkire-Foster method estimates the incidence of multidimensional poverty as the proportion of households with an overall deprivation indicator score of 0.33 or lower. This cut-point reflects a household that is completely deprived in one of the three categories. Analyses in this dissertation use the logic and

Table B.1: Deprivation categories, variables, and weight for MPI (Alkire & Santos 2014)

Deprivation Category	Variable Description	Overall Weight (Category Weight)
Health	Nutrition: If the household had to skip a meal, ran out of all food, or went an entire day without eating during the past four weeks	16.67% (50.0%)
	Child mortality: If any child (household member less than 15 years old) died in the past year	16.67% (50.0%)
Education	Educational attainment: If no household member completed over five years of schooling	16.67% (50.0%)
	Educational attendance: If any child (household member less than 15 years old) does not attend school	16.67% (50.0%)
Livelihood	Fuel Deprivation: If the household reports dung, wood, or carbon (charcoal or coal) as their primary cooking fuel	5.56% (16.67%)
	Sanitation Deprivation: If the household does not have a private and improved toilet	5.56% (16.67%)
	Flooring: If the household has dirt, sand, or dung floor	5.56% (16.67%)
	Drinking Water Deprivation: If the household does not have protected drinking water (i.e. piped, public tap, borehole/pump, protected spring or rainwater)	5.56% (16.67%)
	Electricity Deprivation: If the household does not have electricity	5.56% (16.67%)
	Assets: If the household does not own a radio, TV, telephone, bicycle, motorbike, or refrigerator and does not own a car or truck	5.56% (16.67%)

theory of MPI to generate multidimensional deprivation indicators (MDI) that assist with the examination of multidimensional deprivations at the household and village level.

B.2 Household MDI

It is essential to control for household or regional development when assessing the effect of institutional change on land cover change or social-ecological outcomes. The relationship between development, poverty, and land cover change is contextual and dependent, but controlling for multidimensional well-being in the empirical examination of institutions and land cover change is crucial. Failing to control for multidimensional well-being risks identification of a spurious relationship between the institution under examination and the land cover outcome. Thus, analyses in Chapter 3, which examine differences in household livelihood strategies and income in villages that did and did not sign a Voluntary Conservation Agreement (VCA), control for multidimensional household deprivations.

The multidimensional deprivation indicator in this dissertation combines health, education, and asset data collected through a household survey disseminated in Jambi province (Appendix C). Table B.2 provides information on how the different categories of deprivation are calculated and weighted to produce the overall multidimensional deprivation indicator. This value follows the first step of the MPI protocol, where a “deprivation matrix” is calculated. Subsequent steps for generating the MPI include censoring the deprivation matrix to focus only on multidimensionally poor households (incidence, or H), calculating the average deprivation index score per multidimensionally poor household (intensity, A), and taking the product of H and A to generate M_0, which is the adjusted headcount ratio that is reported as the MPI. These steps focus on the identification of multidimensionally poor households and accounting for the intensity of poverty among them. Instead of limiting consideration of the deprivation matrix to

Table B.2: Multidimensional village deprivation indicator (MDVDI) by deprivation category, variable, and weighting strategy

Deprivation Category	Variable Description	w_1 Overall Weight (Category Weight)	w_2 Overall Weight (Category Weight)	w_3 Overall Weight (Category Weight)
Health	Nutrition Deprivation: If anyone in the village was reported to suffer from malnutrition over the past year	16.67% (50.0%)	16.67% (50.0%)	16.67% (50.0%)
	Hospital Access Deprivation: If a Hospital is over approximately 60 minutes away	8.33% (25%)	0	16.67% (50.0%)
	Treatment Deprivation: If anyone in the village has died from the following treatable illnesses: Diarrhea/Vomiting, Measles, Dengue Fever, Malaria, Respiratory Infection,	8.33% (25%)	16.67% (50.0%)	0
Education	Overall School Access Deprivation: If the average distance to the nearest Kindergarten, primary, Middle, High, or Private Religious School is over 9 km away (approximately 2-3 hours walking distance)	16.67% (50.0%)	0	33.33% (100%)
	Leadership Education Deprivation: If the Current Village Leader (if not Village Head, then Village Secretary) has less than High School Education	16.67% (50.0%)	33.3% (100%)	0
Livelihood	Fuel Deprivation: If the majority of HHs in a village use wood, charcoal, or dung as their primary fuel type	5.56% (16.67%)	8.33% (25.0%)	5.56% (16.67%)
	Sanitation Deprivation: If the majority of HHs in a village use shared toilets or rivers/open land	5.56% (16.67%)	8.33% (25.0%)	5.56% (16.67%)
	Road Material Deprivation: If the major road in town is not paved (asphault)	5.56% (16.67%)	0	5.56% (16.67%)
	Drinking Water Deprivation: If majority of HHs receive water from an unimproved and insecure source (river/lake or rain water)	5.56% (16.67%)	8.33% (25.0%)	5.56% (16.67%)
	Electricity Deprivation: If over 10% of households in the village do not have electrictiy	5.56% (16.67%)	8.33% (25.0%)	5.56% (16.67%)
	Overall Village Asset Deprivation: If the major road in the village is not passable all year AND the mobile phone signal is weak or does not exist	5.56% (16.67%)	0	5.56% (16.67%)

identify and measure poverty within poor households alone, this dissertation uses the deprivation matrix to calculate a multidimensional deprivation indicator (MDI) that provides information for households that are and are not multidimensionally poor.

B.3 Village MDI

Developing a multidimensional deprivation indicator at the village-level holds great promise for empirical analysis of social-ecological outcomes at small spatial scales. Previous studies have generated small-scale poverty indices by aggregating household data (Bedi, Coudouel, and Simler 2007) or through the use of remotely sensed land cover data that is associated with livelihoods and well-being (Watmough et al. 2016). Although aggregating household-level information can provide detailed and robust data on poverty and well-being at smaller jurisdictional levels, such data collection is expensive, time consuming, and requires explicit sampling protocols to ensure a representative sample is collected. Alternatively, predicting poverty and well-being across small jurisdictional units using remotely sensed land cover imagery costs little, but requires strong assumptions about the connections between land cover, livelihood, and well-being. Surveying regional officials about infrastructure, livelihood, and well-being can provide a compromise on data quality and cost for estimating small-area poverty and well-being. The Indonesian Village Census (*Sesus Potensi Desa*—PODES), completed by Village Heads every three years, provides a dataset rich in village-level information that this dissertation uses to generate a multidimensional village deprivation index (MDVDI).

MDVDI measurements using PODES provide multidimensional deprivation data at a significantly smaller jurisdictional scale than other available data sources. However, other Indonesian surveys have higher temporal resolution, such as the National Socioeconomic Survey (*Sensus Sosioekonomi Nasional*—SUSENAS). Future research can improve on the MDVDI presented here by combining PODES data with SUSENAS data to generate low-cost, small-area, multidimensional well-being information with high spatial as well as temporal resolution.

Table B.3: Kendall's tau correlations of multidimensional village deprivation indicator weighting scenarios by year

Ranking pair	2000	2003	2006	2008	2011	2014
$\tau_B(w_1,w_2)$	0.76	0.74	0.75	0.69	0.83	0.86
$\tau_B(w_1,w_3)$	0.81	0.71	0.79	0.60	0.82	0.84
$\tau_B(w_2,w_3)$	0.58	0.53	0.51	0.59	0.63	0.69

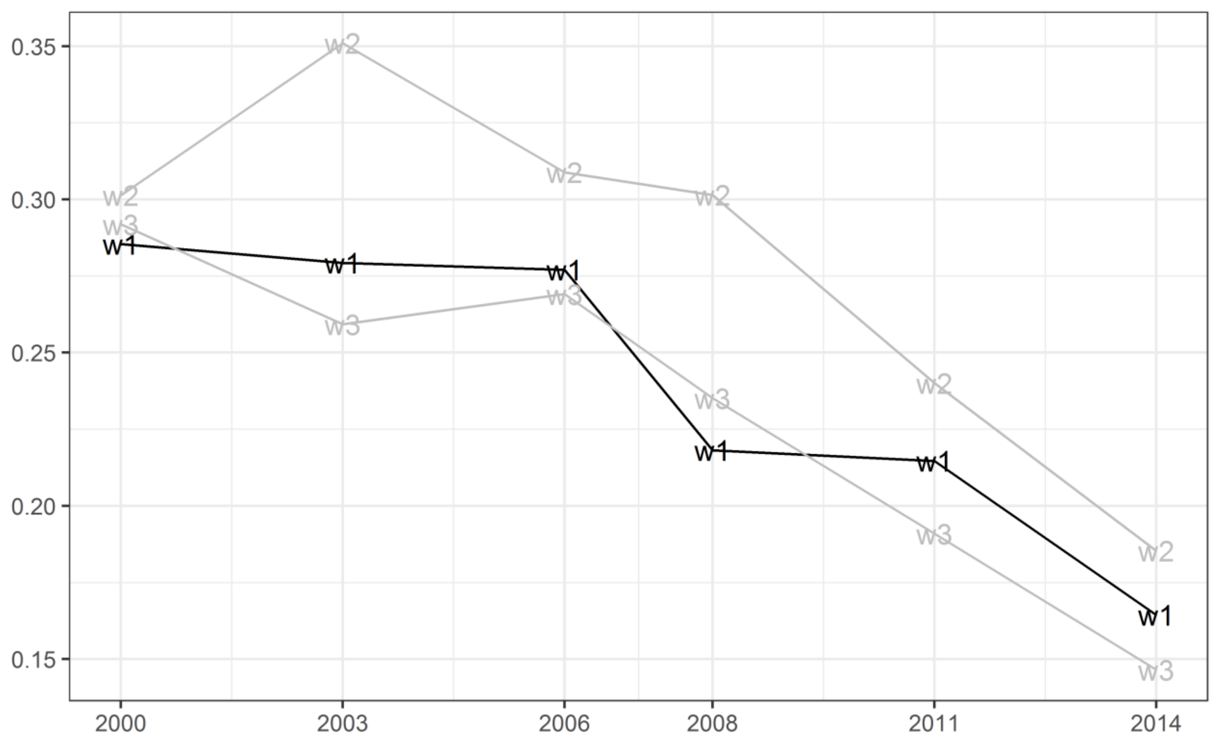


Figure B.1: Year of Indonesian village census (PODES) data collection (x-axis) by MDVDI (y-axis) by weighting strategy

Appendix C

Survey design and dissemination

C.1 Sample size and precision

This survey aims to collect data representative of the population of households living in close proximity to Kerinci-Seblat National park (KSNP). To maximize precision and minimize survey costs, the sample is selected from a stratified cluster sample (Groves *et al.*, 2009). To define the sample population, households in villages within 3 km of the KSNP border are considered “proximate” (Figure C.1), following methods that define intact forest landscapes through 3 km buffers of human impact (Potapov et al. 2008, 2017a). These three districts (Table C.1) contain the largest proportion of KSNP and primary forest cover within their administrative boundaries. Two additional districts within Jambi province contain villages within 3 km of the KSNP boundary. However, due to budgetary constraints and a lack of official research approval, Bungo and Sarolangun districts were not included in the survey sample.

Table C.1: Sample population

Note: Three boundaries were dropped from the village population, including two lake boundaries and one village boundary. The lakes were dropped because they contain only water bodies. The village was dropped because it did not reconcile with PODES data, and thus could not be verified. All dropped boundaries were inside Kerinci district.

District/City	Sub-District	Village	Households
Kerinci	16	143	48,151
Merangin	7	37	9,699
Sungai Penuh	5	15	4,979
Totals	28	195	62,829

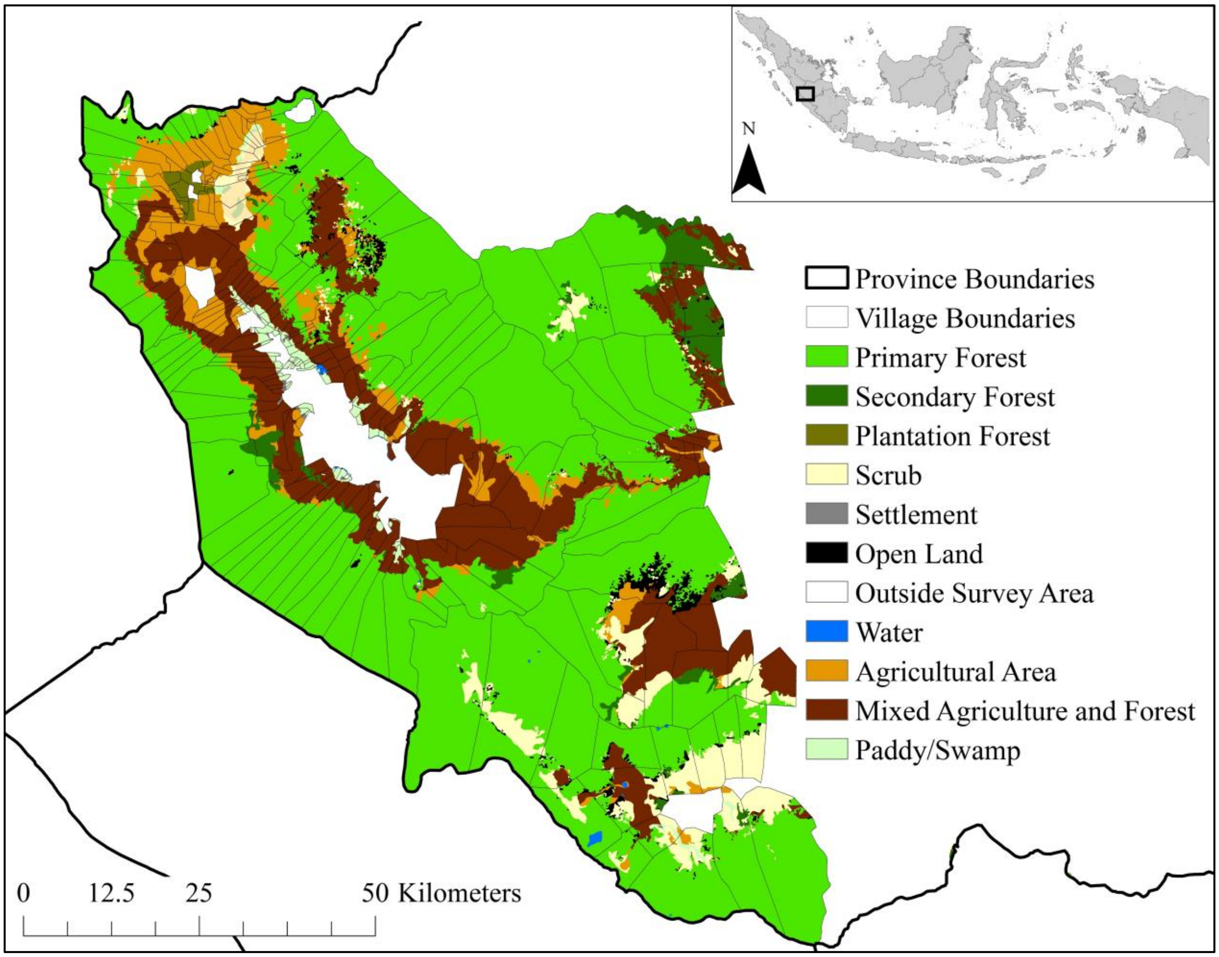


Figure C.1: Villages in Kerinci, Merangin, and Sungai Penuh districts within 3 km of Kerinci-Seblat National Park (KSNP)

Equation C.1 calculates the optimal number of primary sampling units (PSUs) and secondary sampling units (SSUs) in order to maximize the representation and precision of the survey sample based on a budget of $11,200.00.

$$b_{opt} = \sqrt{\left(\frac{c_a}{c_b}\right) * \frac{1 - roh_y}{roh_y}} \qquad \text{[Equation C.1]}$$

Where *c* is cost, *a* is the primary sampling unit (villages), *b* is the secondary sampling unit (households), roh_y is the rate of homogeneity within clusters, and b_{opt} is the optimal number of households sampled per village. The rate of homogeneity (*roh*) is calculated by:

$$roh = \frac{(d_{eff} - 1)}{b - 1} \qquad \text{[Equation C.2]}$$

Where d_{eff} is the design effect and b refers to SSUs (villages). Previous to this study, a sample design that focuses on the Jambi Highlands did not exist. In interviews, local NGO leaders and government officials estimated the marginal cost of each village (c_a) to be between \$70.00 and \$85.20, and the marginal cost of each survey (c_b) as \$6.08. Due to a lack of data survey design information for the Jambi Highlands, we use the Indonesian Demographic Health Survey (DHS) collected in 2012 (BPS, 2013) to estimate *roh*. However, the Indonesian DHS contains significant differences in focus and aim from this research. First, it collects data to be representative at the province level; this study seeks to collect data representative of households that live within 3 km of KSNP in Kerinci, Merangin, and Sungai Penuh districts. Second, the Indonesian DHS uses selects census blocks as the PSU; this study uses villages. And finally, the Indonesian DHS selected a representative sample across Jambi province in order to measure individual and household health. This study seeks to calculate health, livelihood, and environmental statistics at the household level. Despite these differences, some of the measures provided by the Indonesian DHS are similar to measures of interest in this study and it is the only rigorous, publically available survey to provide survey design information relevant to Jambi province.

Table C.2: Cost and sample design scenarios

c_a	b_{opt}	c_b/village	Village Cost ($c_a + c_b$)	Total Villages	Total surveys
42.6	17.06	103.74	146.34	76	1292
70	21.87	132.99	202.99	55	1155
85.2	24.13	146.71	231.91	48	1152
100	26.14	158.95	258.95	43	1118

Calculating *roh* from the design effect of clustered survey sampling informs our calculation of optimal sub-sample size (b_{opt}). The average *roh* for relevant indicators, including literacy rates, morbidity, mortality, and educational attainment in Jambi province, is of 0.012, with an average d_{eff} of 1.31. Using the cost estimates (c_a and c_b) as well as average *roh* for Indonesian DHS data from Jambi province, Table C.2 presents a series of optimal cluster size scenarios.

Using this information, we decided to draw a sample of 60 villages with the aim to complete 25 household surveys within 50 to 56 of the sampled villages. This sample target represents a balance between feasibility and ambition, given the survey budget and dearth of cost information. Since no prior estimates of actual enumerator travel times and marginal village cost exist, we selected to sample 25 households per village, in the event that c_a approached $85.20. However, randomly selecting 60 villages represents a best-case scenario where both c_a and c_b are lower than the estimates calculated at the beginning of this survey design. Completion of 25 surveys within 60 villages represents the best-case scenario, completion of 25 surveys within 50 to 55 villages represents the survey target, and the completion of 25 surveys within 48 represents the worst-case scenario. Since the study target was to complete 25 surveys within at least 50 villages, precision estimates were calculated using 50 clusters of 25 subsamples. Table C.3 illustrates the proportionate stratum totals for primary and secondary sampling units within Kerinci, Merangin, and Sungai Penuh districts.

Table C.3: Stratum, cluster, and survey totals based on b_{opt}

Stratum	Households	Weighted Cluster Totals	HH Total per Stratum
Kerinci	37,104	37	925
Sungai Penuh	4,118	4	100
Merangin	9,699	9	225
Total Sample	50,921	50	1250

C.2 First stage selection

All villages with boundaries within 3km of the Kerinci Seblat National Park, in Kerinci, Merangin, and Sungai Penuh were possible primary sampling units (PSUs) for this study (n=195). Three boundary areas were dropped—two were water body areas and one village boundary was recorded twice. We selected villages systematically, based on probability proportionate to estimated size (PPeS), using the number of households within each village as recorded by 2015 BPS estimates from each district (Kish 1965). Village and household totals were collected from district-level BPS offices between April and May 2016. Each village was ordered according to its province, district, and sub-district identification number. Then, villages were selected using the sampling fraction of 52,423/1,250 and a random start of 18,489. Table C.4 presents the list of 51 villages that comprise the final village sample.

Table C.4: List of villages selected for survey dissemination (continued on next page)

ID 2013	District/City	Sub-District	Village
1501010003	KERINCI	GUNUNG RAYA	LEMPUR TENGAH
1501010017	KERINCI	GUNUNG RAYA	MANJUNTO LEMPUR
1501020001	KERINCI	BATANG MERANGIN	MUARA HEMAT
1501020004	KERINCI	BATANG MERANGIN	TAMIAI
1501020009	KERINCI	BATANG MERANGIN	DUSUN BARU PULAU SANG
1501030011	KERINCI	KELILING DANAU	DUSUN BARU PULAU TENG
1501030022	KERINCI	KELILING DANAU	PULAU TENGAH
1501040005	KERINCI	DANAU KERINCI	KOTO TENGAH
1501040012	KERINCI	DANAU KERINCI	CUPAK
1501050022	KERINCI	SITINJAU LAUT	AMBAI ATAS
1501070040	KERINCI	AIR HANGAT	PENDUNG HILIR
1501071007	KERINCI	AIR HANGAT TIMUR	PUNGUT MUDIK
1501071013	KERINCI	AIR HANGAT TIMUR	AIR HANGAT
1501071016	KERINCI	AIR HANGAT TIMUR	KEMANTAN KEBALAI
1501072004	KERINCI	DEPATI VII	DUSUN BARU KUBANG
1501072017	KERINCI	DEPATI VII	TAMBAK TINGGI
1501080024	KERINCI	GUNUNG KERINCI	SIMPANG TUTUP
1501080027	KERINCI	GUNUNG KERINCI	DANAU TINGGI
1501080034	KERINCI	GUNUNG KERINCI	BARU SUNGAI BETUNG MUDIK

ID 2013	District/City	Sub-District	Village
1501081024	KERINCI	SIULAK	SUNGAI PEGEH
1501082001	KERINCI	SIULAK MUKAI	MUKAI HILIR
1501082008	KERINCI	SIULAK MUKAI	TEBING TINGGI MUKAI M
1501090003	KERINCI	KAYU ARO	SUNGAI DALAM
1501090016	KERINCI	KAYU ARO	KOTO PANJANG
1501090024	KERINCI	KAYU ARO	BATANG SANGIR
1501090025	KERINCI	KAYU ARO	KERSIK TUO
1501090040	KERINCI	KAYU ARO	MEKAR SARI
1501090043	KERINCI	KAYU ARO	MEKAR JAYA
1501091002	KERINCI	GUNUNG TUJUH	BENGKOLAN DUA
1501091004	KERINCI	GUNUNG TUJUH	TANGKIL
1501091007	KERINCI	GUNUNG TUJUH	LUBUK PAUH
1501091010	KERINCI	GUNUNG TUJUH	SUNGAIJERNIH
1501092001	KERINCI	KAYU ARO BARAT	BATU HAMPAR
1501092005	KERINCI	KAYU ARO BARAT	SAKO DUA
1501092008	KERINCI	KAYU ARO BARAT	PATOK EMPAT
1501092011	KERINCI	KAYU ARO BARAT	GIRI MULYO
1501092014	KERINCI	KAYU ARO BARAT	KEBUN BARU
1501092016	KERINCI	KAYU ARO BARAT	PASAR MINGGU
1502010015	MERANGIN	JANGKAT	MUARA MADRAS
1502010017	MERANGIN	JANGKAT	PULAU TENGAH
1502010022	MERANGIN	JANGKAT	RENAH KEMUMU
1502020004	MERANGIN	MUARA SIAU	DURIAN RAMBUN
1502021006	MERANGIN	LEMBAH MASURAI	DUSUN TUO
1502021011	MERANGIN	LEMBAH MASURAI	SUNGAI LALANG
1502052001	MERANGIN	PANGKALAN JAMBU	BUKIT PERENTAK
1502052007	MERANGIN	PANGKALAN JAMBU	KAMPUNG LIMO
1502067003	MERANGIN	TABIR BARAT	TELENTAM
1572020001	SUNGAI PENUH	KUMUN DEBAI	RENAH KAYU EMBUN
1572031001	SUNGAI PENUH	PONDOK TINGGGI	SUNGAI JERNIH
1572031002	SUNGAI PENUH	PONDOK TINGGGI	KOTO LEBU
1572040012	SUNGAI PENUH	HAMPARAN RAWANG	LARIK KEMAHAN

C.3 Second stage selection

After first stage selection, we received permission to survey in each village from village heads (*kepala desa*), and we acquired address and household location information from district-level BPS offices (Figure C.2 and Figure C.3). From BPS maps, we randomly selected households. To account for any new addresses added after BPS maps were made, we disseminated surveys with a half-open interval technique. Sampling with half-open intervals requires that every address starting with the selected household until the next listed address be sampled for survey completion. If no address exists between the selected address and the next address in the list, no additional households are sampled. Further, if a selected household was at the end of a road, all addresses before the first listed address for that road are included in the sample.

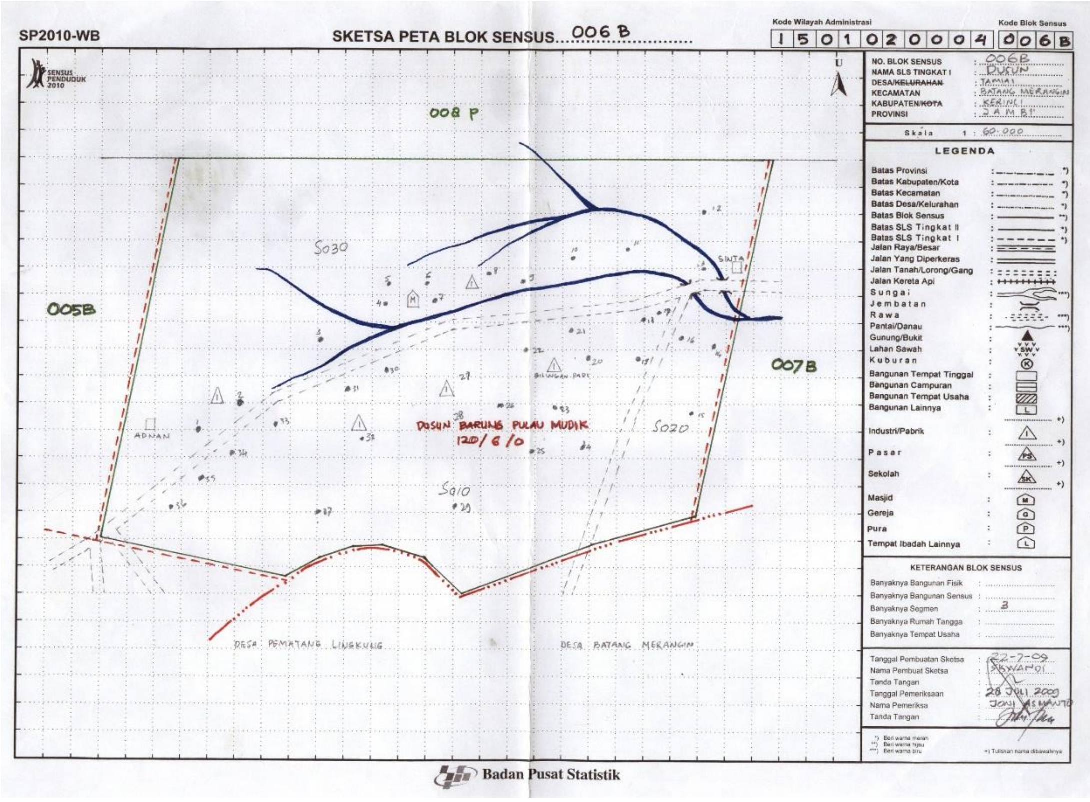


Figure C.2: Example map from which random household samples were drawn

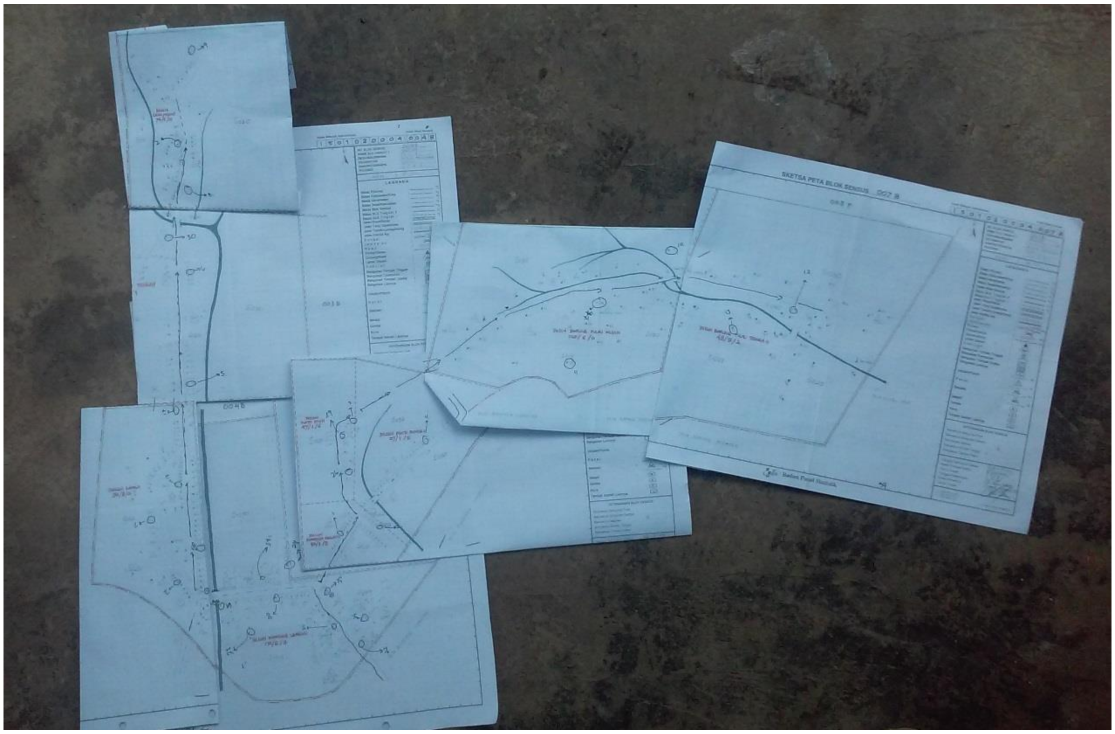


Figure C.3: Example of BPS Census Block maps that combine to make a village. Figure C.2 is the second map from the right.

C.4 Survey dissemination

Survey enumeration ran between October 2016 and January 2017. Enumerators used electronic tablets and entered survey data using the Qualtrics electronic survey platform. At the end of each every week, each enumerator uploaded their surveys. To ensure quality data collection, surveys were assessed for completion and errors every two weeks. Eight enumerators conducted interviews with 1,304 households within the 51 sampled villages. This total number includes households that comprised the survey pilot, conducted in Sungai Jernih village (Sungai Penuh city). The response rate was 0.98. Figure C.4 plots household survey locations on the sample population map.

In addition to household surveys, enumerators disseminated a unique survey to each Village Head (n=51). In contrast to the household survey, the Village Head survey elicited information on village history, demographics, economy, forest-use, and interaction with political figures as well as NGOs. The response rate for the Village Head survey was 100%.

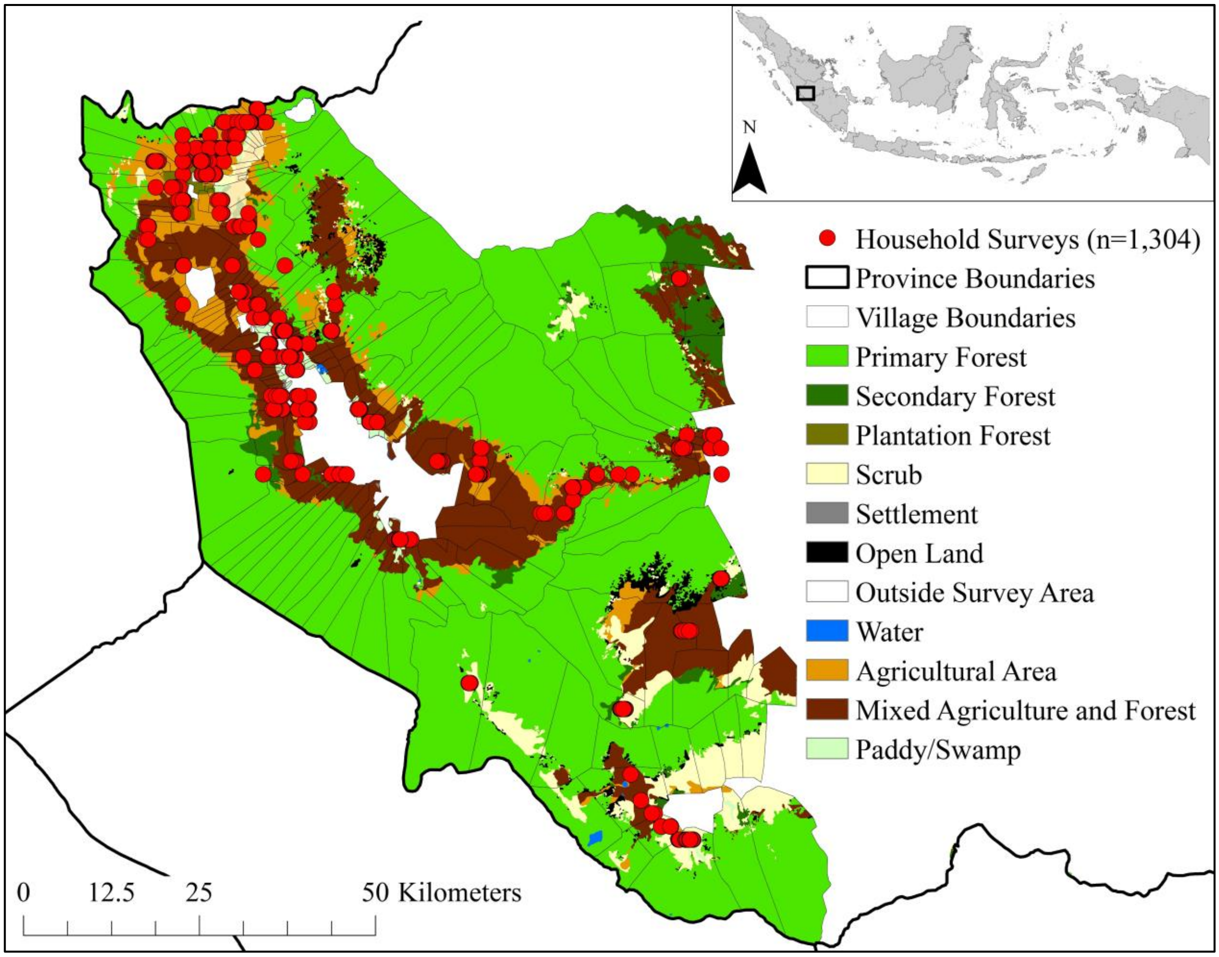


Figure C.4: Household survey location within the village sample population

Appendix D

Supplemental material for Chapter 2

Table D.1: Additional sources used to identify national forest-related policy

Citation	Peer-Reviewed
Sahide, M. A. K. and Giessen, L. (2015) 'The fragmented land use administration in Indonesia - Analysing bureaucratic responsibilities influencing tropical rainforest transformation systems', Land Use Policy. Elsevier Ltd, 43, pp. 96–110. doi: 10.1016/j.landusepol.2014.11.005.	Yes
Brockhaus, M. *et al.* (2012) 'An overview of forest and land allocation policies in Indonesia: Is the current framework sufficient to meet the needs of REDD+?', *Forest Policy and Economics*. Elsevier B.V., 18, pp. 30–37. doi: 10.1016/j.forpol.2011.09.004.	Yes
Nurfatriani, F. *et al.* (2015) 'Redesigning Indonesian forest fiscal policy to support forest conservation', *Forest Policy and Economics*. Elsevier B.V., 61, pp. 39–50. doi: 10.1016/j.forpol.2015.07.006.	Yes
Harahap, F., Silveira, S. and Khatiwada, D. (2017) 'Land allocation to meet sectoral goals in Indonesia—An analysis of policy coherence', *Land Use Policy*. Elsevier Ltd, 61, pp. 451–465. doi: 10.1016/j.landusepol.2016.11.033.	Yes
Nurrochmat, D. N. et al. (2015) 'Changing policies over timber supply and its potential impacts to the furniture industries of Jepara, Indonesia', Jurnal Manajemen Hutan Tropika (Journal of Tropical Forest Management), 21(1), pp. 36–44. doi: 10.7226/jtfm.21.1.36.	Yes
Ardiansyah, F., Marthen, A. A. and Amalia, N. (2015) 'Forest and land-use governance in a decentralized Indonesia: A legal and policy review', *CIFOR Working Paper*, 132, p. 114. doi: 10.17528/cifor/005695 Ardiansyah.	No
Indonesia. Forest Legality Initiative. WRI. 2017. 15 June 2018 https://forestlegality.org/risk-tool/country/indonesia	No
Indonesia: Plans and Policies. The REDD Desk. 2018. 15 June 2018 https://theredddesk.org/	No

Table D.2: List of all national forest related policies from analysis (continued next seven pages)

Type	No.	Year	Name
Law	22	1999	Tentang Pementahan Daerah
Law	25	1999	Tentang Pembangan Keuangan Antara Pementah Pusat Dan Daerah
Law	41	1999	Tentang Kehutanan
Law	17	2000	Tentang Perubahan Ketiga UU7-1983 : Tentang Pajak Penhasilan
Law	29	2000	Tentang Perlindungan Varietas Tanaman
Law	22	2001	Tentang Minyak Dan Gas Bumi
Law	27	2003	Tentang Panas Bumi
Law	7	2004	Tentang Sumber Daya Air
Law	17	2004	Tentang Pengesahan Protokol Kyoto Atas Konvensi Kerangka Kerja Persekatan Bangsa-Bangsa Tentang Perubahan Iklim
Law	18	2004	Tentang Perkebunan
Law	19	2004	Tentang Penetapan PerPem Pengganti UU 1/2004: Tentang Perubahan Atas UU 41/1999: Tentang Kehutanan
Law	25	2004	Tentang Sistem Perencanaan Pembangunan Nasional
Law	32	2004	Tentang Pemerintahan Daerah
Law	33	2004	Tentang Pembangan Keuangan Antara Pementah Pusat Dan Daerah
Law	38	2004	Tentang Jalan
Law	4	2006	Tentang Perjanjian Mengenai Sumber Daya Genetik Tanaman Untuk Pangan Dan Pertanian
Law	16	2006	Tentang Penyuluhan Pertanian Pekanan Dan Kehutanan
Law	24	2007	Tentang Penanggulangan Bencana
Law	17	2007	Tentang Rencana Pembangunan Jangka Panjang Nasional Tahun 2005-2025
Law	26	2007	Tentang Penataan Ruang
Law	27	2007	Tentang Pengelolaan Wilayah Pesisir Dan Pulau-Pulau Kecil
Law	30	2007	Tentang Energi
Law	4	2009	Tentang Pertambangan Mineral Dan Batu Bara
Law	28	2009	Tentang Pajak Daerah Dan Retbusi Daerah
Law	32	2009	Tentang Perlindungan Dan Pengelolaan Lingkungan Hidup
Law	39	2009	Tentang Kawasan Ekonomi Khusus
Law	41	2009	Tentang Perlindungan Lahan Pertanian Berkelanjutan
Law	13	2010	Tentang Hortikultura
Law	4	2011	Tentang Informasi Geospasial
Law	2	2012	Tentang Pengadaan Tanah Bagi Pembangunan Dan Kepentingan Umum
Law	18	2012	Tentang Pangan
Law	11	2013	Tentang Protokol Nagoya Tentang Akses Pada Sumberdaya Genetik Dan Pembagian Keuntungan Yang Adil Pada Konverensi Keanekaragaman Hayati
Law	18	2013	Tentang Pencegahan Dan Pemberantasan Pengrusakan Hutan
Law	19	2013	Tentang Perlindungan Dan Pemberdayaan Petani
Law	1	2014	Tentang Perubahan Atas UU 27/2007: Tentang Pengelolaan Wilayah Pesisir Dan Pulau-Pulau Kecil
Law	6	2014	Tentang Desa
Law	21	2014	Tentang Panas Bumi

Type	No.	Year	Name
Law	23	2014	Tentang Pemerintahan Daerah
Law	26	2014	Tentang Pengesahan Persutujuan Asean Tentang Pencemaran Asap Lintas Batas
Law	37	2014	Tentang Konservasi Tanah Dan Air
Law	39	2014	Tentang Perkebunan
Law	12	2016	Tentang Prubahan Atas UU 14/2015: Tentang Anggaran Pendapatan Dan Belanja Negara Tahun Anggaran 2016
GR	6	1999	Tentang Pengusahaan Hutan Dan Pemungutan Hasil Hutan Pada Hutan Produksi.
GR	27	1999	Tentang Analisis Mengenai Dampak Lingkungan Hidup
GR	53	1999	Tentang Perusahaan Umum Kehutanan Negara (Perum Perhutani)
GR	74	1999	Tentang Perubahan Atas Peraturan Pemerintah No 59 Tahun 1998 Tentang Tarif Atas Penerimaan Negara Bukan Pajak Yang Berlaku Pada Departemen Kehutanan Dan Perlkebunan
GR	83	1999	Tentang Kerjasama Antar Pemerintah Dan Bank Umum Dalam Rangka Pembiayaan Kredit Usaha Tani
GR	92	1999	Tentang Perubahan Kedua Atas Peraturan Pemerintah No 59 Tahun 1998 Tentang Tarif Atas Jenis Penerimaan Negara Bukan Pajak Yang Berlaku Pada Departemen Kehutanan Dan Perkebunan
GR	25	2000	Tentang Kewenangan Pemerintah Dan Kewenangan Propinsi Sebagai Otonom
GR	57	2000	Tentang Penambahan Penyertaan Modal Negara Republik Indonesia Ke Dalam Modal Saham Perusahaan Perseroan (Persero) Pt Perkebunan Nusantara Iv
GR	95	2000	Tentang Perusahaan Umum (Perum)Sarana Pengembangan Usaha
GR	150	2000	Tentang Pengendalian Kerusakan Tanah Untuk Produksi Biomassa
GR	4	2001	Tentang Pengendalian Kerusakan Atau Pencemaran Lingkungan Hidup Yang Berkaitan Dengan Kerusakan Lingkungan Hidup Dan Lahan
GR	14	2001	Tentang Pengalihan Bentuk Perusahaan Umum (Perum) Kehutanan Negara Menjadi Perusahaan Perseroan
GR	75	2001	Tentang Perubahan Kedua Atas Peraturan Pemerintah No 32 Tahun 1969 Tentang Pelaksanaan Uu No 11 Tahun 1967 Tentang Ketentuan Pokok Pertambangan
GR	34	2002	Tentang Tata Hutan Dan Penyusunan Rencana Pengelolaan Hutan Pemanfaatan Hutan Dan Penggunaan Kawasan Hutan
GR	35	2002	Tentang Reboisasi
GR	38	2002	Tentang Daftar Koordinat Titik Pangkal Kepulauan Indonesia
GR	63	2002	Tentang Hutan Kota
GR	68	2002	Tentang Ketahanan Pangan
GR	4	2001	Tentang Pengendalian Kerusakan Dan Pencemaran Lingkungan Hidup Yang Berkaitan Dengan Kebakaran Hutan Dan Lahan
GR	7	2004	Tentang Perubahan Atas Peraturan Pemerintah No 49 Tahun 2002 Tentang Tarif Atas Jenis Penerimaan Negara Bukan Pajak Yang Berlaku Pada Departemen Pertanian
GR	15	2004	Tentang Perusahaan Umum (Perum) Pembangunan Perumahan Nasional
GR	16	2004	Tentang Penatagunaan Tanah
GR	44	2004	Tentang Perencanaan Kehutanan
GR	45	2004	Tentang Perlindungan Hutan
GR	48	2004	Tentang Penambahan Penyertaan Modal Negara Ri Kedalam Modal Saham Perusahaan Perseroan (Persero) Pt Eksploitasi Dan Industri Hutan I (Inhutani I)
GR	49	2004	Tentang Penambahan Penyertaan Modal Negara Ri Kedalam Modal Saham Perusahaan Perseroan (Persero) Pt Eksploitasi Dan Industri Hutan Ii (Inhutani Ii)

Type	No.	Year	Name
GR	50	2004	Tentang Penambahan Penyertaan Modal Negara Ri Kedalam Modal Saham Perusahaan Perseroan (Persero) Pt Eksploitasi Dan Industri Hutan Iii (Inhutani Iii)
GR	52	2004	Tentang Penambahan Penyertaan Modal Negara Ri Kedalam Modal Saham Perusahaan Persero Pt Eksploitasi Industri Hutan V (Pt Inhutani V)
GR	53	2004	Tentang Pengurangan Penyertaan Modal Negara Republik Indonesia Pada Modal Saham Perusahaan Perseroan (Pt Persero) Pt Eksploitasi Dan Industri Hutan Ii Dan Penambahan Penyertaan Modal Negara Dalam Modal Saham Perusahaan Pt Persero Pt Eksploitasi Dan Industri Hutan V (Pt Inhutani V)
GR	22	2005	Tentang Pemeriksaan Penerimaan Negara Bukan Pajak
GR	6	2007	Tentang Tata Hutan Dan Penyusunan Rencana Pengelolaan Hutan Serta Pemanfaatan Hutan
GR	59	2007	Tentang Kegiatan Usaha Panas Bumi
GR	68	2007	Tentang Penyertaan Modal Negara Ri Ke Dalam Modal Perusahaan Pt Perseroan (Persero) Pt Perkebunan Nusantara Xiv
GR	2	2008	Tentang Jenis Dan Tarif Atas Penerimaan Negara Bukan Pajak Yang Berasal Dari Penggunaan Kawasan Hutan Untuk Kepentingan Pembangunan Diluar Kegiatan Kehutanan
GR	3	2008	Tentang Perubahan Atas Aturan Pemerintah No 6 Tahun 2007 Tentang Tata Hutan Dan Penyususnan Rencana Pengelolaan Hutan Serta Pemanfaatan Hutan
GR	26	2008	Tentang Rencana Tata Ruang Wilayah Nasional
GR	37	2008	Tentang Perubahan Atas Peratuan Pemerintah No 38 Tahun 2002 Tentang Daftar Koordinat Geografis Titik Pangkal Kepulauan Indonesia
GR	51	2008	Tentang Provisi Sumberdaya Hutan
GR	76	2008	Tentang Rehabilitasi Hutan Dan Lahan
GR	29	2009	Tentang Tata Cara Penentuan Jumlah Pembayaran Dan Penyetoran Penerimaan Negara Bukan Pajak
GR	31	2009	Tentang Perlindungan Wilayah Geografis Penghasil Produk Perkebunan Spesifikasi Lokal
GR	43	2009	Tentang Pembiayaan, Pembinaan , Pengawasan Penyuluhan Pertanian Perikanan Dan Kehutanan
GR	60	2009	Tentang Perubahan Atas Peraturan Pemerintah No.45 Tahun 2004 Tentang Perlindungan Hutan
GR	69	2009	Tentang Penambahan Penyertaan Modal Negara Ke Dalam Pt Perkebunan Nusantara V
GR	78	2009	Tentang Penambahan Penyertaan Modal Negara Ke Dalam Modal Saham Perusahaa Perseroan Pt Persero Ptpn Ii
GR	5	2010	Tentang Pembangunan Jangka Menengah Nasional Tahun 2010-2014
GR	10	2010	Tentang Cara Perubahan Peruntukan Dan Fungsi Kawasan
GR	11	2010	Tentang Penerniban Dan Pendayagunaan Tanah Terlantar
GR	12	2010	Tentang Penelitian, Pengembangan Seta Pendidikan Dan Pelatihan Kehutanan
GR	15	2010	Tentang Penyelenggaraan Penaatan Ruang
GR	22	2010	Tentang Wilayah Pertambangan
GR	23	2010	Tentang Pelaksanaan Kegiatan Usaha Pertambangan Mineral Dan Batu Bara
GR	24	2010	Tentang Penggunaan Kawasan Hutan
GR	36	2010	Tentang Pengusahaan Pariwisata Alam Di Suaka Marga Satwa Taman Nasional Taman Hutan Raya Dan Taman Wisata Alam
GR	55	2010	Tentang Pembinaan Dan Pengawasan Penyelenggaraan Pengelolaan Usaha Pertambangan Mineral Batu Bara
GR	68	2010	Tentang Bentuk Dan Tata Cara Peran Masyarakat Dalam Penataan Ruang

Type	No.	Year	Name
GR	70	2010	Tentang Perubahan Atas Peraturan Pemerintah No 59 Tahun 2007 Tentang Usaha Panas Bumi
GR	72	2010	Tentang Perusahaan Umum (Perum) Kehutanan
GR	78	2010	Tentang Reklamasi Dan Pasca Tambang
GR	1	2011	Tentang Penetapan Dan Alih Fungsi Lahan Pertanian Pangan Berkelanjutan
GR	28	2011	Tentang Pengelolaan Kawasan Suaka Alam Dan Kawasan Pelestarian Alam
GR	72	2011	Tentang Penyertaan Modal Negara Ke Dalam Modal Saham Perusahaan Perseroan Pt Inhutai I
GR	12	2012	Tentang Insentif Perlindungan Lahan Pertanian Pangan Berkelanjutan
GR	24	2012	Tentang Perubahan Atas Peraturan No 23 Tahun 2010 Mengenai Pelaksanaan Kegiatan Pertambangan Batu Bara Dan Mineral
GR	25	2012	Tentang Sistem Informasi Lahan Pertanian Berkelanjutan.
GR	27	2012	Tentang Izin Lingkungan
GR	30	2012	Tentang Pembiayaan Perlindungan Lahan Pertanian Pangan Berkelanjutan
GR	37	2012	Tentang Pengelolaan Aerah Aliran Sungai
GR	60	2012	Tentang Perubahan Atas Peraturan Pemerintah No. 10 Tahun 2010 Tentang Tata Cara Perubahan Peruntukan Dan Fungsi Kawasan Hutan
GR	61	2012	Tentang Penggunaan Kawasn Hutan
GR	10	2013	Tentang Penambahan Penyertaan Modal Negara Ri Kedalam Modal Saham Perusahhan Persero Pt Perkebunan Nusantara I
GR	11	2013	Tentang Penambahan Penyertaan Modal Negara Ri Ke Dalam Modal Perusahaan Persero Pt Perkebunan Nusantara Ii
GR	12	2013	Tentang Penambahan Penyertaan Modal Negara Republik Indonesia Kedalam Modal Saham Perusahaan Perseroan (Persero) Pt Perkebunan Nusantara Iii
GR	13	2013	Tentang Penambahan Penyertaan Modal Negara Ke Dalam Saham Perusahaan Perseroan (Persero) Pt Perkebunan Nusantara Ix
GR	19	2013	Tentang Tunjangan Jabatan Fungsional Penyuluh Kehutanan
GR	63	2013	Tentang Badan Pertanahan Nasional Republik Indonesia
GR	73	2013	Tentang Rawa
GR	79	2013	Tentang Jaringan Lalu Lintas Dan Angkutan Jalan
GR	1	2014	Tentang Perubahan Kedua Atas Peraturan Pemerintah No 23 Tahun 2010 Tentang Pelaksanaan Kegiatan Usaha Pertambangan Batu Bara Dan Mneral
GR	12	2014	Tentang Jenis Dan Tarif Atas Penerimaan Negara Bukan Pajak Yang Berlakku Pada Kementerian Kehutanan
GR	33	2014	Tentang Jenis Dan Tarif Atas Jenis Penerimaan Negara Bukanpajak Yang Berasal Dari Penggunaan Kawasan Hutan Untuk Kepentingan Pembangunan Di Luar Kegiatan Kehutanan Yang Berlaku Pada Kementerian Kehutanan
GR	71	2014	Tentang Pengelolaan Ekosistem Gambut
GR	72	2014	Tentang Penambahan Penyertaan Modal Negara Ri Kedalam Modal Saham Perusahaan Saham Perusahaan Persero Pt Perkebunan Nusantara Iii
GR	73	2014	Tentang Penambahan Penyertaan Modal Negara Republik Indonesia Kedalam Modal Perusahaan Umum (Perum)
GR	165	2014	Tentang Penataan Tugas Dan Fungsi Kabinet Kerja
GR	86	2015	Tentang Penambahan Penyertaan Modal Negara Republik Indonesia Ke Dalam Modal Saham Perusahaan Perseroan (Persero) Pt Pertani
GR	104	2015	Tentang Tata Cara Peruntukan Fungsi Kawasan Hutan
Type	No.	Year	Name

GR	105	2015	Tentang Perubahan Kedua Atas Peraturan Pemerintah No.24 Tahun 2010 Tentang Penggunaan Kawasan Hutan
GR	108	2015	Tentang Perubahan Atas Peraturan Pemerintah No 28 Tahun 2011 Tentang Pengolaan Kawasan Pelestarian Alam
GR	109	2015	Tentang Pembiayaan Hortikultura
GR	128	2015	Tentang Jenis Dan Tarif Atas Penerimaan Negara Bukan Pajak Yang Berlaku Pada Kementerian Agraria Dan Dan Tata Ruang Badan Pertanahan Nasional
GR	135	2015	Tentang Penambahan Penyertaan Modal Negara Republik Indonesia Ke Dalam Modal Saham Perusahaan Perseroan Pt Perkebunan Nusantara Iii
GR	136	2015	Tentang Penambahan Penyertaan Modal Negara Republik Indonesia Ke Dalam Saham Pt Perkebunan Nusantara Vii
GR	137	2015	Tentang Penyertaan Modal Negara Ri Kedalam Pt Perkebunan Nusantara Ix
GR	139	2015	Tentang Penambahan Penyertaan Modal Negara Ri Kedalam Modal Saham Pt Perkebunan Nusantara Ix
GR	140	2015	Tentang Penambahan Penyertaan Modal Negara Republik Indonesia Ke Dalam Modal Saham Pt Perkebunan Nusantara Xii
GR	55	2016	Tentang Penambahan Penyertaan Modal Negara Republik Indonesia Kedalam Modal Saham Perseroan Pt Pertani
PR	36	2005	Tentang Pengadaan Tanah Bagi Pembangunan Untuk Kepentingan Umum
PR	42	2005	Tentang Komite Percepatan Kebijakan Percepatan Infrastruktur
PR	5	2006	Tentang Kebijakan Energi Nasional
PR	10	2006	Tentang Badan Pertanahan Nasional
PR	65	2006	Tentang Perubahan Peraturan No 36 Tahun 2005 Tentang Pengadaan Tanah Bagi Pelaksanaan Kepentingan Umum.
PR	89	2007	Tentang Gerakan Nasional Rehabilitasi Hutan Dan Lahan
PR	109	2007	Tentang Pengesahan Confention For The Conservation Of Southern Bluefin Tuna (Konvensi Tentang Konservasi Tuna Sirip Biru Selatan)
PR	3	2008	Peraturan Pemerintah Republik Indonesia No.3 Tahun 2008 Tentang Perubahan Atas Tentang Tata Hutan Penyusunan Rencana Pengelolaan Hutan Serta Pemanfaatan Hutan
PR	26	2008	Tentang Pembentukan Dewan Energi Nasional
PR	46	2008	Tentang Dewan Nasional Perubahan Iklim
PR	78	2008	Tentang Pengesahan International Tropical Timber Agreement 2006
PR	10	2010	Tentang Tata Cara Perubahan Peruntukan Dan Fungsi Kawasan Hutan
PR	55	2010	Tentang Perpanjangan Batas Usia Pensiun Bagi Pegawai Negeri Sipil Yang Menduduki Jabatan Fungsional, Penyuluhan Pertanian, Perikanna Dan Kehutanan
PR	78	2010	Tentang Penjaminan Infrastruktur dalam Proyek Kerjasma Pemerintah dengan Badan Usaha yang dilakukan melalui Badan Usaha Penjaminan Infrastruktur
PR	10	2011	Tentang Badan Koordinasi Nasional Penyuluh Pertanian Perikanan Dan Kehutanan
PR	12	2011	Tentang Perubahan Atas Peraturan Presiden No 42 Tahun 2005 Tentang Komite Kebijakan Percepatan Penyediaan Infrastruktur
PR	28	2011	Tentang Penggunaan Kawasan Lindung Untuk Penambangan Bawah Tanah
PR	32	2011	Tentang Master Plan Percepatan Dan Perluasan Pembangunan Ekonomi Indonesia 2011-2025
PR	61	2011	Tentang Rencana Aksi Nasional Penurunan Emisi Gas Rumah Kaca
PR	71	2011	Tentang Penyelenggaraan Inventarisasi Gas Rumah Kaca Nasional
PR	80	2011	Tentang Dana Perwalian

Type	No.	Year	Name
PR	3	2012	Tentang Rencana Tata Ruang Pulau Kalimantan
PR	13	2012	Tentanng Rencanan Tata Ruang Pulau Sumatera
PR	71	2012	Tentang Penyelenggaraan Pengadaan Tanah Bagi Pembangunan Untuk Kepentingan Umum
PR	73	2012	Tentang Strategi Nasional Pengelolaan Ekosistem Mangroove
PR	103	2012	Tentang Tunjangan Kinerja Pegawai Di Lingkungan Kementerian Pertanian
PR	121	2012	Tentang Rehabilitasi Wilayah Pesisir Dan Pulau-Pulau Kecil
PR	122	2012	Tentang Reklamasi Di Wilayah Pesisir Dan Pulau Pulau Kecil
PR	16	2013	Tentang Tunjangan Jabatan Fungsional Penyuluh Pertanian Pengendali Organisme, Pengawas Bibit Tanaman Pengawas Bibit Ternak Medik Veteriner, Paramedik Veteriner Dan Pengawas Mutu Pangan
PR	18	2013	Tentang Tunjangan Fungsional Polisi Kehutanan
PR	19	2013	Tentang Tunjangan Jabatan Fungsional Penyuluh Kehutanan
PR	23	2013	Tentang Pengesahan Agreement Between The Governments Of The Member States Of Assosiation Of Southeast Asian Nations And The Republic Of Korea On Forest Cooperation
PR	61	2013	Tentang Pengesahan Convention On The Conservation And Management Of Highly Migratory Fish Stocks In The Western And Central Pacifik Ocean (Konvensi Tentang Konservasi Dan Pengelolaan Sdiaan Ikan Beruaya Jauh Di Samudera Pasifik Barat Dan Tengah
PR	62	2013	Tentang Badan Pengelola Penurunan Emisi Gas Rumah Kaca Dari Deforestasi Degradasi Hutan Dan Lahan Gambut
PR	63	2013	Tentang Badan Pertanahan Nasional Ri
PR	79	2013	Tentang Tunjangan Kinerja Pegawai Di Lingkungan Kementrian Kehutanan
PR	6	2014	Tentang Tunjangan Jabatan Analisis Pasar Hasil Pertanian
PR	19	2014	Tentang Pengesahan Persetujuan Mengenai Pembentukan Sekretariat Pemrakarsa Segitiga Krang, Terumbu Krang, Perikanan Dan Ketahanan Pangan.
PR	21	2014	Tentang Persetujuan Kemiteraan Sukarela Antar Republik Indonesia Dan Uni Eropa Tentang Penegakan Hukum Indonesia Tentang Penegakan Hukum Kehutanan
PR	154	2014	Tentang Kelembagaan Penyuluhan Pertanian, Perikanan Dan Kehutanan
PR	170	2014	Tunjangan Jabatan Fungsional Pengendalian Ekosistem Hutan
PR	171	2014	Tentang Tunjangan Jabatan Fungsional Penyuluh Kehutanan
PR	16	2015	Tentang Kementerian Lingkungan Hidup Dan Kehutanan
PR	17	2015	Tentang Kementerian Agraria Dan Tata Ruang
PR	45	2015	Tentang Kementerian Pertanian
PR	61	2015	Tentang Penghimpunan Dan Penggunaan Dana Perkebunan Kelapa Sawit
PR	134	2015	Tentang Tunjangan Kinerja Pegawai Di Lingkungan Kementerian Pertanian
PR	139	2015	Tentang Tunjangan Kinerja Pegawai Di Lingkungan Kementerian Lingkungan Hidup Dan Kehutanan
PR	140	2015	Tentang Tunjangan Kinerja Pegawai Negeri Sipil Di Lingkungan Kementerian Agraria Dan Tata Ruang Pertanian Nasional
PR	1	2016	Tentang Badan Restorasi Gambut
PR	53	2016	Tentang Pengesahan Perjanjian Negara Tuan Rumah Antara Pemerintah Republik Indonesia Dan Dana Internasional Untuk Pembangunan Pertanian (Fad) Tentang Pendirian Kantor Ifad Di Indonesia
PP	10	2006	Tentang Badan Pertanahan Nasional
Type	No.	Year	Name

PP	65	2006	Tentang Perubahan Atas Peraturan Presiden No 36 Tahun 2005 Tentang Pengadaan Tanah Bagi Pelaksanaan Pembangunan Untuk Kepentingan Umum.
PP	59	2007	Peraturan Presiden Ri No 59 Tahun 2007 Mengenai Kegiatan Usaha Panas Bumi
PP	32	2011	Tentang Master Plan Percepatan Dan Perluasan Pembangunan Ekonomi Indonesia 2011-2025
PP	165	2014	Tentang Penataan Tugas Dan Fungsi Kabinet Kerja
KP	80	1999	Tentang Pedoman Umum Perencanaan Dan Pengelolaan Kawasan Pengembangan Lahan Gambut Di Kalimantan Tengah
KP	172	1999	Tentang Penataan Kembali Fungsi Depatemen Pertanian Departemen Kehutanan Dan Departemen Perkebunan
KP	175	1999	Tentang Pencabutan Keputusan Presiden No 172 Tahun 1999 Tentang Penataan Kembali Tugas Dan Fungsi Departemen Pertanian Kehutanan Dan Perkebunan
KP	80	2000	Tentang Komite Antar Departemen Bidang Kehutanan
KP	95	2000	Tentang Bdan Pertahanan Nasional
KP	10	2001	Tentang Pelaksanaan Otonomi Daerah Dibidang Pertanahan
KP	25	2001	Tentang Tim Koordinasi Penanggulangan Pertambangan Tanpa Izin , Penyalahgunaan Bahan Bakar Minyak Serta Perusakan Instalasi Ketenaga Listrikan Dan Pencurian Aliran Listrik
KP	81	2001	Tentang Komite Kebijakan Pembangunan Infrastruktur
KP	34	2003	Tentang Kebijakan Nasional Dibidang Pertanahan
KP	41	2004	Tentang Perizinan Atau Perjanjian Dibidang Pertambangan Yang Berada Di Kawasan Hutan
KP	19	2010	Tentang Satuan Tugas Persiapan Pembentuakan Kelembagaan Redd+
KP	25	2011	Tentang Satuan Tugas Persiapan Kelembagaan Reducing Emission From Deforestastion And Degradation (Redd+)
KP	32	2011	Tentang Rincian Anggaran Belanja Pemerintah Pusat Tahun Anggaran 2012
IP	5	2001	Tentang Pemberantasan Penebangan Kayu Illegal Dan Peredaran Hasil Hutan Di Kawasan Ekosistem Leuser Dan Taman Nasional Tanjung Putting
IP	4	2005	Tentang Pemberantasan Penebangan Kayu Secara Illegal Dikawasan Hutan Dan Peredarannya Di Seluruh Wilayah Indonesia
IP	1	2006	Tentang Penyediaan Dan Pemanfaatan Bahan Bakar Nabati Sebagai Bahan Bakar Lain
IP	2	2006	Tentang Penyediaan Dan Pemanfaatan Batu Bara Yang Dicairkan Sebagai Bahan Bakar Lain
IP	2	2007	Tentang Rehabilitasi Dan Revitalisasi Pengembangan Lahan Gambut Di Kalimantan Tengah
IP	3	2009	Tentang Pengembangan Infrastruktur Istana Kepresidenan Kebun Raya Dan Cagar Alam Budaya
IP	1	2010	Tentang Percepatan Pelaksanaan Prioritas Pembangunan Tahun 2010
IP	5	2011	Tentang Pengamanan Produksi Beras Nasional Dalam Menghadapi Kondisi Ekstrim
IP	10	2011	Tentang Penundaan Pemberian Izin Baru Hutan Alam Primer Dan Lahan Gambut
IP	16	2011	Tentang Peningkatan Pengendalian Kebakaran Hutan Dan Lahan
IP	6	2013	Tentang Penundaan Pemberian Izin Baru Dan Penyempurnaan Tata Kelola Hutan Alam Primer Dan Lahan Gambut
IP	8	2015	Tentang Penundaan Pemberian Izin Baru Dan Penyempurnaan Tata Kelola Hutan Alam Primer Dan Lahan Gambut
IP	11	2015	Tentang Peningkatan Pengendalian Kebakaran Hutan Dan Lahan

Appendix E

Supplemental material for Chapter 3

E.1 Robustness tests: Linear fixed effect models

To assess the need to control for time-period and village-level trends, we conduct Lagrange Multiplier Tests: Gourieroux, Holly, and Monfort to assess the need to control for cross-sectional and time effects (Baltagi, Chang, and Li 1992). We run Hausman Tests to assess the consistency of random intercept estimators (Hausman, 1978). For each model in our analysis, we determine the need to use two-way fixed effects to provide consistent estimators (Table E.1).

Table E.1 Diagnostic tests for serial correlation and consistent village-level estimators

Dependent Var.	Test	Lead model (x^2)	No time effect (x^2)	Lag 1 model (x^2)	Lag 2 model (x^2)	df (w)	p	Interpretation
Log of forest area	Lagrange Multiplier (GHM)	242570	402390	402360	256940	0/1/2 (0.25/0.5/0.25)	< .001	Control for time and individual effects
	Hausman Test	25664.76	14270.78	14226.22	14452.76	16	< .001	Control for individual effects with fixed effects
CAR of forest cover change	Lagrange Multiplier (GHM)	9780.1,	8866.2	10940	857.75	0/1/2 (0.25/0.5/0.25)	< .001	Control for time and individual effects
	Hausman Test	764.22	659.76	474.08	394.14	16	< .001	Control for individual effects with fixed effects

We present findings from the inverse hyperbolic sine (IHS) transformation of village-level forest area in the main text but check the robustness of our results by running the same models on the natural log of forest area plus 0.01 as well as on the CAR of forest change. We re-run our models with an alternate transformation (Table E.2) and with alternate dependent variables (Table E.3) to ensure that results are not driven by variable specification and are the result of robust patterns within the data. We find that coefficient direction and relative magnitude are consistent between specifying Y_{it} as CAR of forest change (Equation 3.2), the IHS of forest area (Equation 3.1) or as ln(forest area + 0.01).

To ensure our results are robust to reverse causation, we run all models with lead effects for regulatory dispersal. We find that the coefficient for village- and district-level regulatory dispersal in the period before forest cover change is either non-significant and positively related to forest cover change (as for village-level dispersal) or significant and positively related to forest cover (as with district-level dispersal). Models 1.4 (Table 3.3), 3.4 (Table E.2), and 4.4 and 2.4 (Table E.3) provide estimates. This demonstrates that reverse causation—change in forest cover drives regulatory dispersal—is unlikely.

To examine the relationship between clustering and outcomes, we provide village-level and district-level cluster robust standard errors for all models. Clustered robust standard errors help solve design issues, as when survey samples are clustered at a geographic unit for ease of dissemination, or for experimental problems, for when a treatment is assigned to a higher-level unit (Abadie et al. 2017). Although regulatory dispersal from sub-district, district, and province proliferation is clustered at those levels of administration, village-level dispersal is not. Thus, we interpret village-level regulatory dispersal with village-level clustered robust standard errors, and district-level regulatory dispersal with district-level clustered robust standard errors.

Table E.2: Two-way fixed effect models of forest area transformed by: ln(ha forest cover + 0.01). Covariates include regulatory dispersal dummy variables, mean village land cover change, and sociopolitical variables. Models 3.1 through 3.4 include different time effects for regulatory dispersal. Land cover and sociopolitical variables remain anchored to the period of CAR of forest cover change. Standard errors are robust and clustered at both the village-level (Std Err) and the district-level (Clst. Std Err).

	Model 3.1: Same Period regulatory dispersal			Model 3.2: One lagged period regulatory dispersal			Model 3.3: Two lagged periods regulatory dispersal			Model 3.4: One lead period regulatory dispersal		
	Coef.	Std Err	Clst. Std Err	Coef.	Std Err	Clst. Std Err	Coef.	Std Err	Clst. Std Err	Coef.	Std Err	Clst. Std Err
Same period dispersal level												
Village	0.025	0.016	0.025	-0.036	0.014 **	0.028	-0.047	0.017 ***	0.045	0.033	0.022	0.039
Sub-district	0.072	0.01 ***	0.026 ***	-0.002	0.008	0.016	-0.052	0.01 ***	0.027 *	0.051	0.01 ***	0.022 **
District	0.019	0.007 ***	0.02	-0.022	0.006 ***	0.018	0.018	0.006 ***	0.016	0.066	0.01 ***	0.025 ***
Province	0.059	0.015 ***	0.046	-0.151	0.013 ***	0.049 ***	-0.012	0.006 **	0.016	0.08	0.028 ***	0.04 **
Land-cover												
Forest	1.835	0.042 ***	0.098 ***	1.84	0.042 ***	0.097 ***	1.601	0.042 ***	0.106 ***	1.491	0.055 ***	0.121 ***
Paddy ag.	-0.119	0.023 ***	0.053 **	-0.117	0.023 ***	0.053 **	-0.13	0.025 ***	0.065 **	-0.028	0.022	0.042
Field ag.	-0.087	0.018 ***	0.041 **	-0.088	0.018 ***	0.042 **	-0.098	0.02 ***	0.05 *	-0.013	0.017	0.033
Mixed field/tree ag.	-0.099	0.024 ***	0.059 *	-0.102	0.024 ***	0.058 *	-0.123	0.026 ***	0.071 *	0.014	0.022	0.046
Timber plant.	-0.044	0.016 ***	0.028	-0.043	0.016 ***	0.028	-0.01	0.017	0.033	-0.021	0.016	0.033
Ag. tree plant.	-0.168	0.025 ***	0.049 ***	-0.167	0.025 ***	0.048 ***	-0.147	0.025 ***	0.055 ***	-0.083	0.026 ***	0.044 *
Settlement	-0.053	0.016 ***	0.036	-0.059	0.016 ***	0.035 *	-0.062	0.017 ***	0.043	0.002	0.014	0.028
Protected area	0.01	0.006	0.011	0.008	0.006	0.011	0.023	0.006 ***	0.009 **	0.003	0.006	0.011
Sociopolitical variables												
Village council	-0.041	0.006 ***	0.015 ***	-0.045	0.006 ***	0.015 ***	-0.079	0.008 ***	0.01 ***	-0.026	0.006 ***	0.015 *
Distance to roads	0.056	0.008 ***	0.031 *	0.071	0.008 ***	0.031 **	0.031	0.007 ***	0.025	0.132	0.01 ***	0.054 **
Household pop.	-0.026	0.005 ***	0.008 ***	-0.03	0.005 ***	0.008 ***	-0.029	0.006 ***	0.007 ***	-0.011	0.004 ***	0.005 **
MDVDI	0.049	0.003 ***	0.009 ***	0.051	0.003 ***	0.009 ***	0.053	0.004 ***	0.01 ***	0.03	0.003 ***	0.01 ***
Constant	-1.713	0.006 ***	0.014 ***	-1.7	0.006 ***	0.014 ***	-1.631	0.007 ***	0.006 ***	-1.776	0.006 ***	0.015 ***
Number of obs		311,232			311,232			254,324			244,049	
Within R^2		0.144			0.144			0.122			0.08	

**p<0.1; **p<0.05; ***p<0.01*

Table E.3: Two-way fixed effect models of the CAR of forest cover change. Models 4.1 through 4.4 include different time effects for regulatory dispersal. Land cover and sociopolitical variables remain anchored to the period of CAR of forest cover change. Standard errors are robust and clustered at both the village-level (Std Err) and the district-level (Clst. Std Err).

	Model 4.1: Same Period regulatory dispersal			Model 4.2: One lagged period regulatory dispersal			Model 4.3: Two lagged period regulatory dispersal			Model 4.4: One lead period regulatory dispersal		
	Coef.	Std Err	Clst. Std Err	Coef.	Std Err	Clst. Std Err	Coef.	Std Err	Clst. Std Err	Coef.	Std Err	Clst. Std Err
Same period dispersal level												
Village	0.01	0.003 ***	0.005 *	-0.011	0.004 ***	0.007 *	-0.004	0.004	0.008	0.006	0.004	0.008
Sub-district	0.022	0.002 ***	0.006 ***	0	0.002	0.005	-0.016	0.003 ***	0.007 **	0.014	0.002 ***	0.006 **
District	0.006	0.002 ***	0.006	-0.011	0.002 ***	0.005 **	0.007	0.002 ***	0.006	0.016	0.002 ***	0.006 ***
Province	0.007	0.003 ***	0.01	-0.03	0.002 ***	0.007 ***	-0.009	0.002 ***	0.004 **	0.004	0.004	0.006
Land-cover												
Forest	-0.047	0.005 ***	0.012 ***	-0.046	0.005 ***	0.012 ***	-0.069	0.005 ***	0.012 ***	-0.075	0.007 ***	0.016 ***
Paddy ag.	-0.028	0.008 ***	0.014 **	-0.028	0.008 ***	0.014 **	-0.021	0.008 ***	0.015	-0.033	0.012 ***	0.019 *
Field ag.	-0.027	0.005 ***	0.012 **	-0.028	0.005 ***	0.012 **	-0.027	0.005 ***	0.012 **	-0.02	0.007 ***	0.014
Mixed field/tree ag.	-0.014	0.005 ***	0.013	-0.016	0.005 ***	0.013	-0.021	0.006 ***	0.014	0.011	0.006 *	0.01
Timber plant.	-0.003	0.005	0.008	-0.002	0.005	0.007	0.008	0.006	0.008	0	0.007	0.01
Ag. tree plant.	-0.028	0.004 ***	0.007 ***	-0.027	0.004 ***	0.007 ***	-0.019	0.005 ***	0.009 **	-0.015	0.005 ***	0.009 *
Settlement	-0.045	0.022 **	0.027 *	-0.051	0.023 **	0.027 *	-0.056	0.029 *	0.033 *	0.022	0.022	0.022
Protected area	0.001	0.001	0.002	0	0.001	0.002	0.004	0.001 ***	0.002 **	0	0.001	0.002
Sociopolitical variables												
Village council	-0.008	0.002 ***	0.004 *	-0.011	0.002 ***	0.004 **	-0.022	0.002 ***	0.006 ***	-0.005	0.002 ***	0.005
Distance to roads	0.009	0.001 ***	0.005 *	0.013	0.001 ***	0.005 ***	0.004	0.001 ***	0.004	0.021	0.001 ***	0.01 **
Household pop.	-0.009	0.005 *	0.006 *	-0.01	0.006 *	0.006 *	-0.009	0.006	0.006	-0.005	0.003	0.003
MDVDI	0.012	0.001 ***	0.002 ***	0.013	0.001 ***	0.002 ***	0.015	0.001 ***	0.003 ***	0.01	0.001 ***	0.003 ***
Constant	-0.037	0.012 ***	0.021 *	-0.037	0.012 ***	0.021 *	-0.001	0.014	0.021	0.022	0.014	0.024
Number of obs		79,123			79,123			66,570			61,312	
Within R^2		0.017			0.018			0.023			0.021	

**p<0.1; **p<0.05; ***p<0.01*

E.2 Robustness tests: Matching analysis

Dispersed and non-dispersed villages demonstrate significant overlap across variables that best predict CAR of forest cover change as well as variables that best predict CAR of forest cover change and administrative proliferation. Due to this overlap, in addition to the variables we identified in the literature as contributing to either forest cover change or forest cover change and administrative proliferation, we use traditional propensity score matching with replacement to generate our matched sample. We defend against potential biases from this technique by pruning fewer than 3% of the "treatment" villages (villages that experienced regulatory dispersal) in any matched sample and by ensuring that matching with replacement does not result in too few matched control units (Stuart, 2010; King and Nielsen, 2016). We test the robustness of our matched samples with alternative matching techniques and by assessing the standardized difference in means for each the fifteen matched datasets (Ho *et al.*, 2007; Stuart, 2010)

To determine the effect of matching technique on the difference in CAR of forest change means between villages that did and did not experience regulatory dispersal, we rematch the fifteen unique combinations of fracture period and time period using full matching matching with replacement (Ho et al. 2007). We also repeat our original matching technique using a ratio of 1:1 treatment to control. Figures E.1 and E.2 provide the results of these alternative matching methods. Our findings are robust to these alternative specifications.

To measure the balance of matched units, we assess the standardized difference of all the covariates that contributed to generating the propensity score as well as two final measurements (mean precipitation and province number) that we did not include in matching because of their high correlation with other covariates. Figures E.3 through E.18 illustrate the standardized mean differences within our original matched samples (Figure 3.4, Main Text).

Figure E.1: Difference in means between villages that have and have not experienced administrative change. Matching sample generated with nearest neighbor matching with calipers of .25 std of the propensity score and a 1:1 treatment:control ratio.

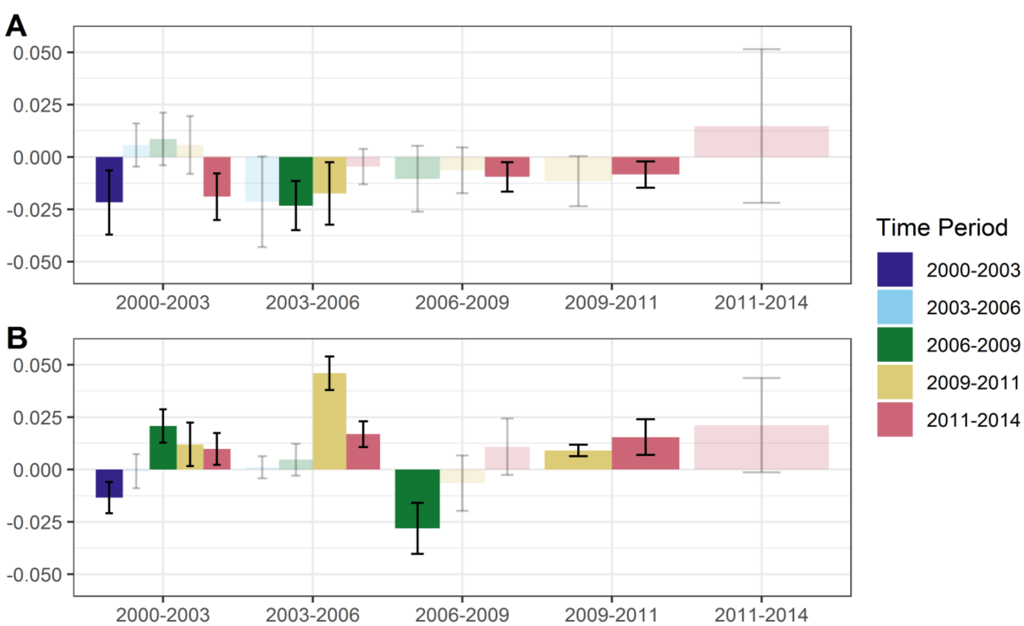
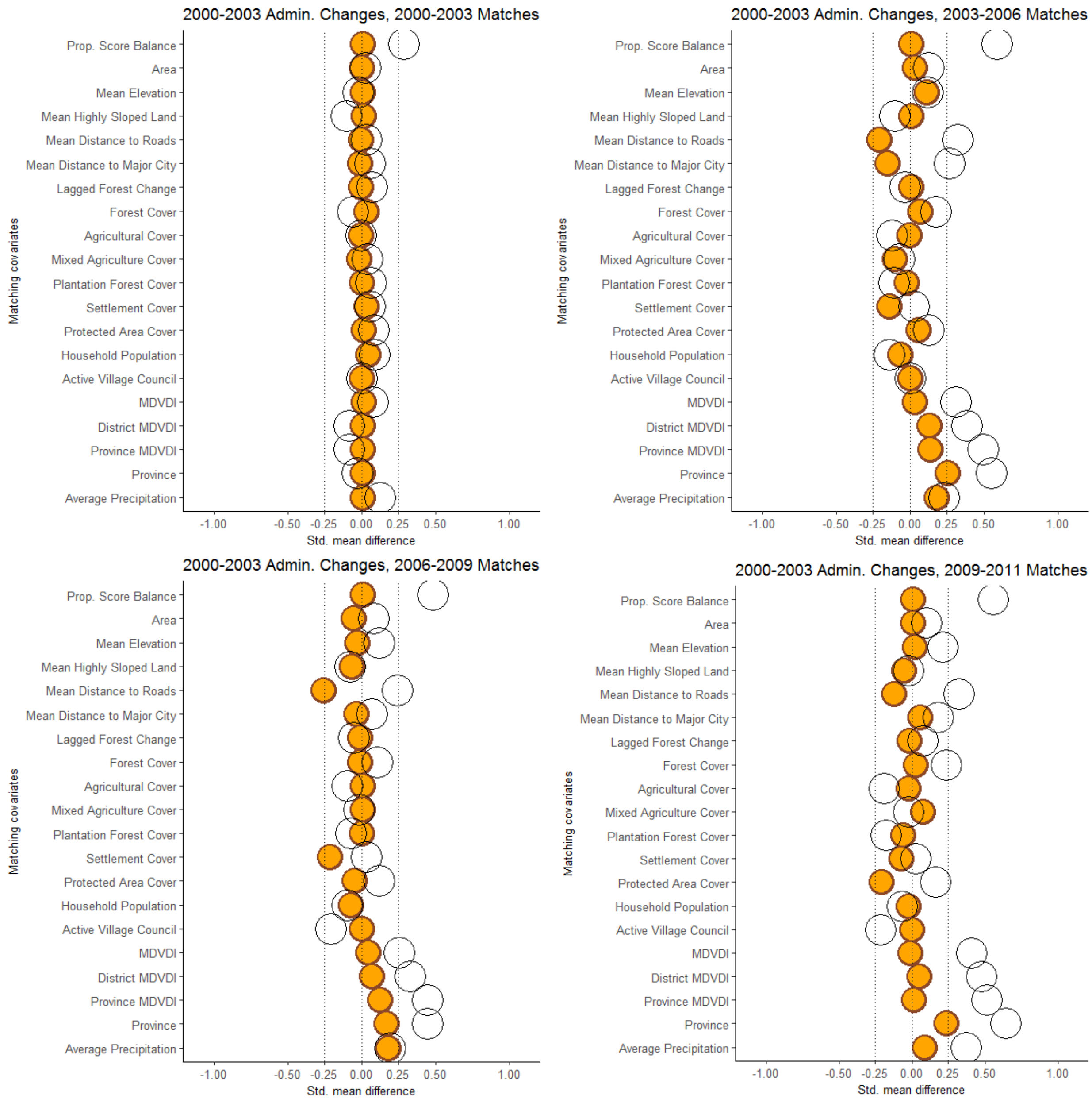
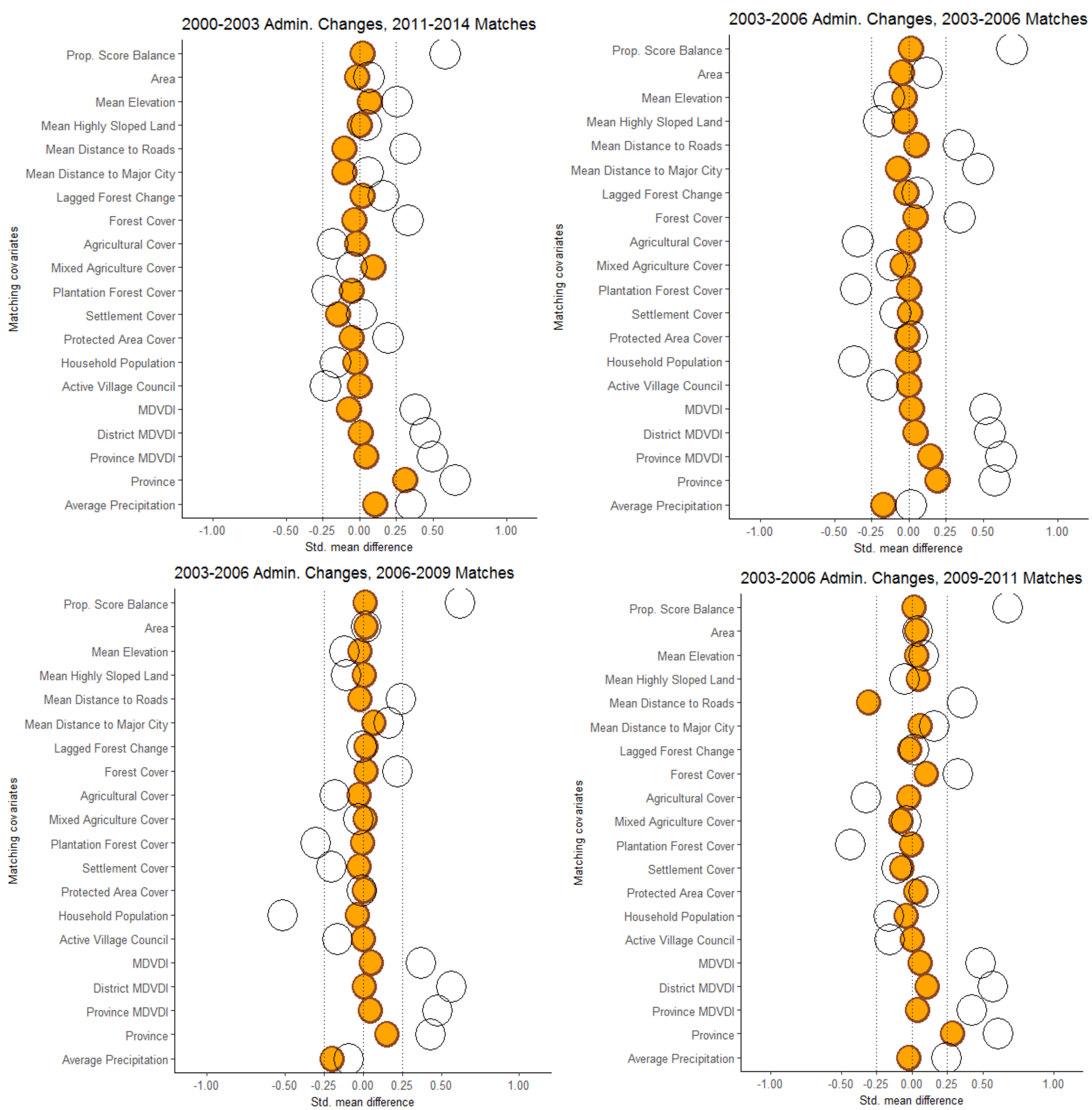


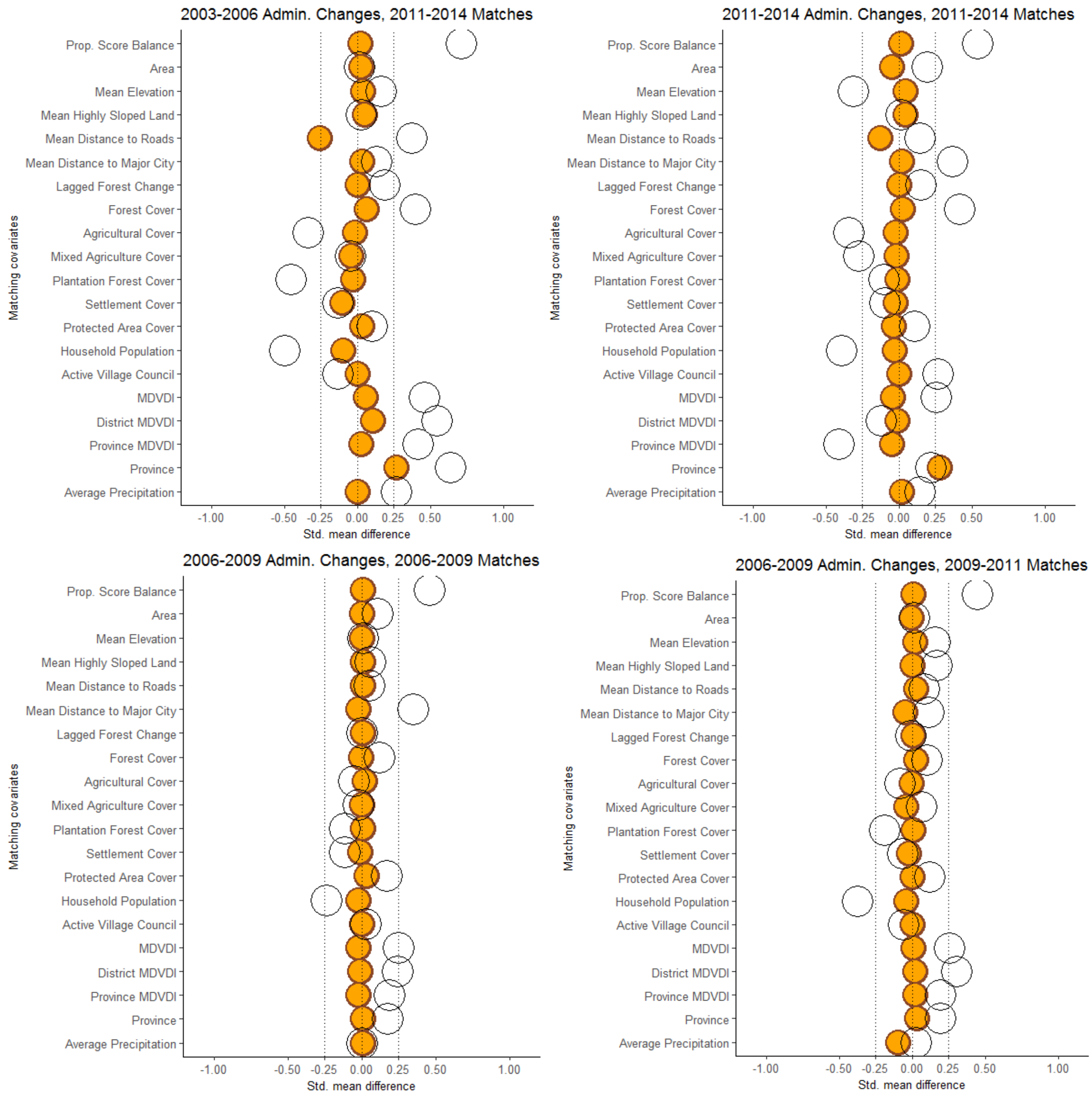
Figure E.2: Difference in means between villages that have and have not experienced administrative change. Matching sample generated with full matching within calipers of .25 std of propensity score.

Figure E.3-E.18: Standardized mean differences by covariate for one-to-many PSM

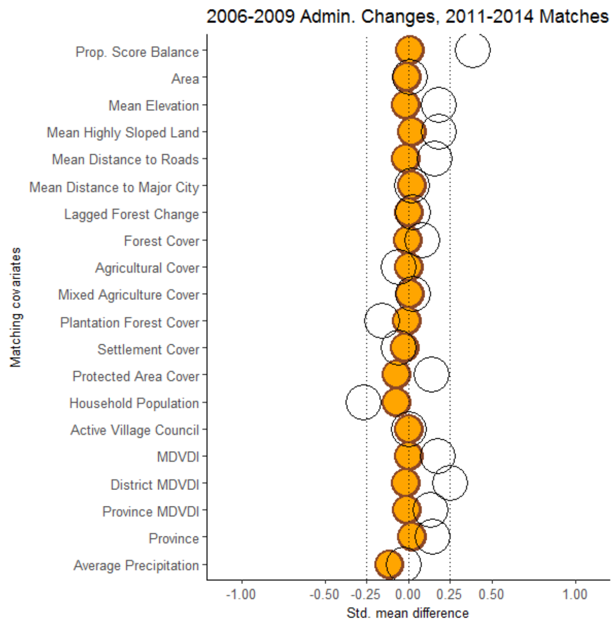
Plots are organized by year of administrative change and year of baseline match

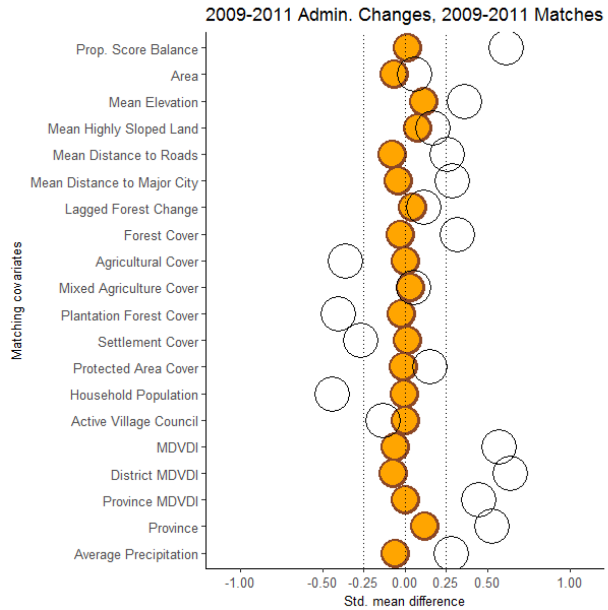


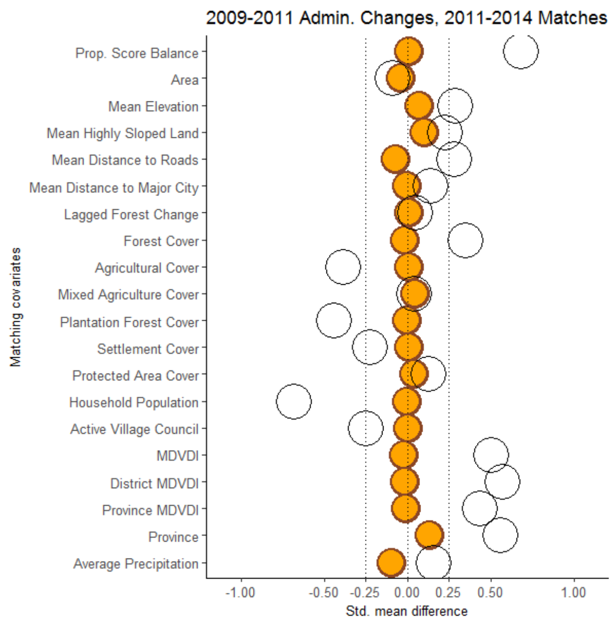

2000-2003 Admin. Changes, 2011-2014 Matches
2003-2006 Admin. Changes, 2003-2006 Matches
2003-2006 Admin. Changes, 2006-2009 Matches
2003-2006 Admin. Changes, 2009-2011 Matches
Matching covariates
Prop. Score Balance
Area
Mean Elevation
Mean Highly Sloped Land
Mean Distance to Roads
Mean Distance to Major City
Lagged Forest Change
Forest Cover
Agricultural Cover
Mixed Agriculture Cover
Plantation Forest Cover
Settlement Cover
Protected Area Cover
Household Population
Active Village Council
MDVDI
District MDVDI
Province MDVDI
Province
Average Precipitation
-1.00 -0.50 -0.25 0.00 0.25 0.50 1.00
Std. mean difference



2003-2006 Admin. Changes, 2011-2014 Matches
2011-2014 Admin. Changes, 2011-2014 Matches
2006-2009 Admin. Changes, 2006-2009 Matches
2006-2009 Admin. Changes, 2009-2011 Matches
Matching covariates
Prop. Score Balance
Area
Mean Elevation
Mean Highly Sloped Land
Mean Distance to Roads
Mean Distance to Major City
Lagged Forest Change
Forest Cover
Agricultural Cover
Mixed Agriculture Cover
Plantation Forest Cover
Settlement Cover
Protected Area Cover
Household Population
Active Village Council
MDVDI
District MDVDI
Province MDVDI
Province
Average Precipitation
-1.00
-0.50
-0.25
0.00
0.25
0.50
1.00
Std. mean difference


2006-2009 Admin. Changes, 2011-2014 Matches
Matching covariates
Prop. Score Balance
Area
Mean Elevation
Mean Highly Sloped Land
Mean Distance to Roads
Mean Distance to Major City
Lagged Forest Change
Forest Cover
Agricultural Cover
Mixed Agriculture Cover
Plantation Forest Cover
Settlement Cover
Protected Area Cover
Household Population
Active Village Council
MDVDI
District MDVDI
Province MDVDI
Province
Average Precipitation
-1.00
-0.50
-0.25
0.00
0.25
0.50
1.00
Std. mean difference


2009-2011 Admin. Changes, 2009-2011 Matches
Matching covariates
Prop. Score Balance
Area
Mean Elevation
Mean Highly Sloped Land
Mean Distance to Roads
Mean Distance to Major City
Lagged Forest Change
Forest Cover
Agricultural Cover
Mixed Agriculture Cover
Plantation Forest Cover
Settlement Cover
Protected Area Cover
Household Population
Active Village Council
MDVDI
District MDVDI
Province MDVDI
Province
Average Precipitation
-1.00
-0.50
-0.25
0.00
0.25
0.50
1.00
Std. mean difference


2009-2011 Admin. Changes, 2011-2014 Matches
Matching covariates
Prop. Score Balance
Area
Mean Elevation
Mean Highly Sloped Land
Mean Distance to Roads
Mean Distance to Major City
Lagged Forest Change
Forest Cover
Agricultural Cover
Mixed Agriculture Cover
Plantation Forest Cover
Settlement Cover
Protected Area Cover
Household Population
Active Village Council
MDVDI
District MDVDI
Province MDVDI
Province
Average Precipitation
-1.00
-0.50
-0.25
0.00
0.25
0.50
1.00
Std. mean difference

Appendix F

Supplemental material for Chapter 4

F.1 Matching and covariate balance

We compare the balance between VCA and non-VCA village covariate means across the original data with datasets pre-processed with one-to-one propensity score matching (1:4 PSM) and full matching (Table F.1). We find that full matching, which reduces the standardized difference between treated and control units based on a dynamic selection of one to many control units per treatment unit, performs the best. All standardized covariate means within the full matching dataset are below 0.25 (Stuart, 2010), and eight out of seven covariates out-perform

Table F.1: Standardized difference between treatment and control covariate means for original data and data pre-processed with one-to-one propensity score matching (1:4 PSM) and full matching.

Covariate	Original Data	Full Matching	1:4 PSM	Best Balance
Prop. Score	0.679	0.004	0.057	Full
Village Area 2003	0.181	0.065	0.071	Full
Mean Elevation	-0.087	0.043	-0.074	Full
Mean Area > 12% Slope	0.524	-0.041	-0.025	PSM
Average Distance to Roads	0.008	-0.009	-0.045	Full
Average Time to Nearest District Capital	0.257	-0.035	0.015	PSM
Mean Forest Cover (2003)	0.379	0.062	0.029	PSM
Mean Forest Cover (2000)	0.381	0.062	0.029	PSM
Mean Field Ag. Cover	0.070	0.003	0.005	Full
Mean Mixed Ag Cover	-0.321	-0.072	-0.038	PSM
Mean Plantation Forest (Timber and Ag)	-0.462	0.029	0.034	Full
Mean Settlement Area	-2.416	0.100	0.115	Full
Number of Households	0.055	-0.001	0.026	Full
MDVDI	0.244	-0.014	0.009	PSM
Mean Precipitation	0.159	0.065	0.037	PSM

covariate balance within the one-to-one matching dataset, including the overall balance, as indicated by the propensity score.

We re-match VCA and non-VCA villages on all covariates, excluding "Mean Forest Cover (2000)," to ensure that our matching results account for parallel trends in year 2000 forest cover between VCA and non-VCA villages, but are not driven by these same trends. We find that eliminating parallel trends produces similar though slightly worse overall balance and similar estimate signs across all matching types. However, full matching estimates are approximately one fourth the average value when accounting for year 2000 forest cover (Figure F.1). Controlling for parallel trends in forest cover before the end of KS-ICDP implementation increases the estimate of average forest cover loss within VCA villages, thus lending greater credence to the overall conclusion that VCA villages lost greater amounts of forest cover between 2003 and 2016.

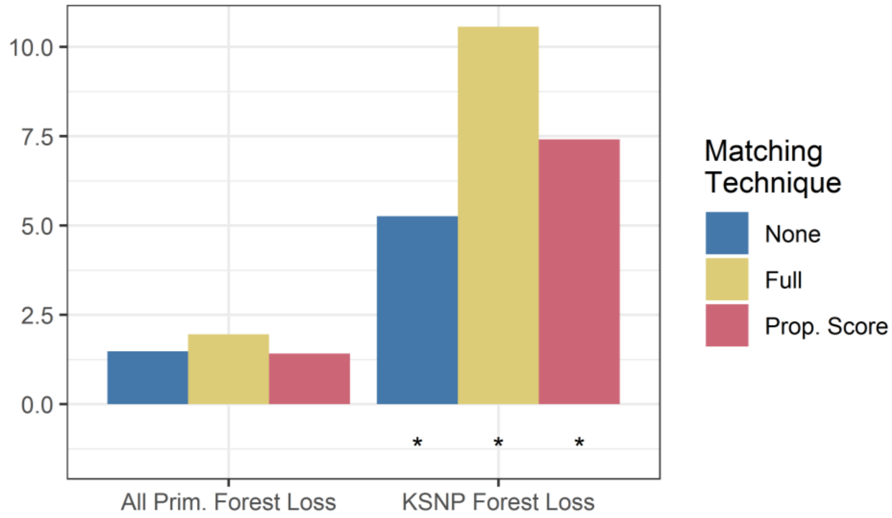


Figure F.1: Forest type (x-axis) by difference in average forest cover change (ha) between VCA and non-VCA villages (y-axis), by different matching techniques without "Mean Forest Cover (2000)"

Table F.2: Standardized difference between treatment and control covariate means for original data and data pre-processed with one-to-one propensity score matching (1:4 PSM) and full matching that does not include "Mean Forest Cover (2000)."

Covariate	Original Data	Full Matching	1:4 PSM	Best Balance
Prop. Score	0.679	0.005	0.066	Full
Village Area 2003	0.181	0.083	0.035	PSM
Mean Elevation	-0.087	0.011	0.027	Full
Mean Area > 12% Slope	0.524	-0.038	-0.024	PSM
Average Distance to Roads	0.008	0.060	-0.058	PSM
Average Time to Nearest District Capital	0.257	-0.036	-0.001	PSM
Mean Forest Cover	0.381	0.080	0.036	Full
Mean Field Ag. Cover	0.070	0.028	0.074	Full
Mean Mixed Ag Cover	-0.321	-0.131	-0.115	PSM
Mean Plantation Forest (Timber and Ag)	-0.462	0.111	0.045	PSM
Mean Settlement Area	-2.416	0.133	0.113	PSM
Number of Households	0.055	0.035	0.039	Full
MDVDI	0.244	0.046	-0.049	Full
Mean Precipitation	0.159	0.073	0.047	PSM

F.2 Model selection

We select the best-fit model using a nested modeling approach and analysis of variance (ANOVA) tests to measure significant differences between models (Montgomery, Peck, and Vining 2012). Each subsequent model number includes an additional covariate category (Table F.2). Models 1 begin with economic covariates, Models 2 include economic and demographic covariates, and Models 3 include economic, demographic, and environmental covariates (Table F.2). Table F.3 provides information on model selection criteria. Models two and three for "Ln(Area Land owned)" were not statistically significant, and included the same Adjusted R^2 values. For consistency, and because Model 3 provided a slightly higher R^2 value due to the inclusion of more variables, we selected it as the best-fit model. For all other variables, Model 3 performed significantly better than Models 1 and 2.

Table F.3: Covariates Category and names

Covariate Category	Covariates
Economic	Primary income from agriculture
	Multidimensional poverty indicator
	Household owns agricultural land
	Area of land owned (Ha)
	Holds formal land title
	Farms high-value tree crop
Demographic	Female head of household
	Head of household age
	Ethnicity: Jambi
	Ethnicity: Javanese
	Ethnicity: Kerinci
Environmental	Household elevation
	Euclidean distance to KSNP
	KSNP forest loss
	VCA village

Table F.4: Model selection criteria

Variable	Model	Residual Dev.	DF	Dev.	Pr(>Chi)	R^2	Adj. R^2	AIC
Land Ownership	1	1139.217	---	---	---	---	---	1149.2
	2	993.073	7	146.144	***	---	---	1017.1
	3	977.967	4	15.107	***	---	---	1010
Ln(Area Land Owned)	1	1397.969	---	---	---	0.152	0.148	---
	2	1322.152	8	75.817	***	0.199	0.187	---
	3	1318.862	3	3.290		0.201	0.187	---
Farms High Value Tree Crop	1	1315.136	---	---	---	---	---	1327.1
	2	1181.543	8	133.593	***	---	---	1209.5
	3	1113.943	3	67.600	***	---	---	1147.9
Household Income	1	809.166	---	---	---	0.153	0.148	---
	2	778.123	7	31.043	***	0.194	0.183	---
	3	764.556	3	13.567	***	0.2	0.188	---

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