Narcotrafficking and Land Control in Guatemala and Honduras

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On frontiers dominated by illicit activities such as narcotrafficking, criminal organizations’ usurpation of land and resources is profoundly changing rural livelihoods and prospects for biodiversity conservation. Prior work has demonstrated how drug trafficking catalyzes forest loss and smallholder dispossession but does not make clear the extent to which the long-term control of land is moved from state, Indigenous, or smallholders to criminal or other actors. This study attempts to describe those shifts. Specifically: we develop a typology of land control, and use it to track how drug trafficking initiates shifts from public lands and Indigenous territories to private large holdings. We examine an array of secondary sources indicating shifts in land control related to narcotrafficking, including illegal land seizure documents, news media, and surveys of land managers. In absence of formal land registries, frontier actors may signal their control over land through land use change. After establishing where changes in land control have taken place, we analyzed land use and resulting changes in spatial patterns of forest loss. We found that large scale sustained forest losses (over 713,244 ha and 417,329 ha), in Guatemala and Honduras, respectively, from 2000–2019) corresponds with areas undergoing shifts in control towards large landowners, often related to narcotrafficking. Incomplete empirical data on land control prevent comprehensive attribution of all sustained forest loss related to narcotrafficking. Yet the limited evidence gathered here indicates drug trafficking activities initiate widespread and sustained shifts and consolidation of who controls land and resources at the frontier. Our work suggests that in Central America and likely elsewhere, control over land—quite separate from property rights—is the key factor in understanding social and ecological change.

Keywords: land control; narcotrafficking; Guatemala; Honduras; illicit frontiers

Introduction

Changes to land cover are visible from space and ever-easier to quantify in detail with satellite data. Changes in land-use, the purpose to which land is employed, can be quantified by supplementing satellite data analyses with social data or insights (Kugler et al. 2019). However, changes in land tenure, ownership, and control—the ability to exclude others from access land and its resources—are social processes difficult to detect at a distance, and thus remain poorly understood and unquantified across the globe (McSweeney & Coomes 2020). Land system science has recently called for greater attention to land control as a key factor in shaping land cover and resource use (Ashwood et al. 2020; McSweeney & Coomes 2020), and others have noted the methodological challenges of ‘seeing’ land control using conventional approaches such as satellite imagery analysis (Marinaro et al. 2020; Tellman, et al. 2020a). Others point to the difficulties of assessing
land control where land registries and cadasters are not publicly available, or are underfunded, corrupted, or seldom updated—all of which render legal titles an inadequate representation of who controls land and its use (Anseeuw & Baldinelli 2020).

Understanding land control is particularly challenging in dynamic frontier landscapes dominated by forms of criminal activity that simultaneously involve use, transformation, and investment in land (McSweeney et al. 2017). In fact, drug traffickers are drawn to frontier landscapes, or those with relative land abundance such as in Indigenous territories and protected areas, precisely because land tenure regimes are weak and political authority or the rule of law is already in question (Ballvé 2018; McSweeney et al. 2017; PRISMA 2014). With this study, we examine how expanded drug trafficking networks lead to narco-driven change in land ownership and control (hereafter, using the acronym NARC-LOC), and the implications of subsequent land use changes for biodiversity conservation in Central America.

Ample research has demonstrated that drug production and trafficking intensity over the last two decades has changed land cover and land use in South and Central America. This region has long been a conduit for South American cocaine heading to northern markets. Cocaine trafficking first spiked in the 1980s as DTOs re-routed cocaine through Central America in response to interdiction in the Caribbean (Bunck & Fowler 2012). By the early 1990s, 15–25% of cocaine bound for the US passed through Central America (Brockett 2019). The volume of cocaine moving through Central America increased significantly again after 2000, as traffickers responded to US-led drug war interdictions in Mexico (Bunck & Fowler 2012; Dudley 2011; Unodc 2012). Today, an estimated 90% of cocaine destined for North America passes through the region (United States Department of State Bureau for International Narcotics and Law and Affairs 2016). Cocaine rents are increasingly captured by regional (e.g., Guatemalan and Honduran) criminal groups and part-time narcotraffickers (known as transportistas) (not just Colombian and Mexican cartels, which dominated pre-2005) (Blume 2021).

The dynamic frontiers of northern Guatemala and eastern Honduras provide the remoteness, maritime and border access, and weak governance systems that drug traffickers prize. The dynamic nature of drug trafficking nodes (N. Magliocca et al. 2019), and the accumulation of excess illicit capital at these locations generates at least five mechanisms that may lead to changes in land control and long-term land use trajectories. Specifically, Drug Trafficking Organizations (DTOs) use land to launder illicit capital, move drugs north (e.g., through clandestine airstrips), acquire land to establish territorial control for smuggling, consolidate land in agri-business landscapes, and enrich local elites operating in frontier regions who secure land near trafficking nodes (Devine et al. 2020, 2018; McSweeney et al. 2017, 2018; Tellman et al. 2020a).

As a result, the intensity with which an area is enrolled in drug transshipment correlates with satellite observed land cover changes, such as forest loss (Sesnie et al. 2017). However, drug trafficking does not inevitably lead to land cover change, because traffickers also launder money in real estate and in mobile assets (Maingot & Anthony 1988). While Central American forest loss is not only caused by narcotrafficking, it is nevertheless a significant cause of forest loss, even when accounting for other factors (Tellman et al. 2020b).

There are thus well-established links between narcotrafficking and resulting land use and land cover changes in Central America. But less is known about a key prior moment: just how, when, and where the business of narcotrafficking creates shifts in land control. As researchers who have previously contributed to understanding the links between drug trafficking and land cover change (Darién 2021; Devine et al. 2021; McSweeney et al. 2017; Wrathall et al. 2020), we realized that we had paid insufficient attention to the underlying shifts in land control. Without clarifying land control dynamics, it became clear that there was a gap in our understanding of the key process by which drug trafficking ultimately precipitates land use change. Land control change is important to understand because it can lead to a larger array of socio-environmental degradation beyond land use change, including illegal logging, wildlife trafficking, declining conservation governance, economic inequality, and violence. Previous work estimated forest loss patterns in protected areas (Sesnie et al. 2017; Wrathall et al. 2020), but did not comprehensively compare land change patterns across the contested, changing, or informal land tenures or forms of ownership, such as Indigenous territories or community concessions. This paper synthesizes novel data on land controlled by narcotraffickers across nine disparate datasets identifying where and when narcotraffickers built airstrips, developed agribusiness, and usurped land from smallholders, cooperatives, and the state. While these data are insufficient to attribute every hectare of land controlled by narcotraffickers, it represents the most comprehensive attempt to spatialize evidence of land control by narcotraffickers on Central America’s frontier.
The purpose of this paper is to identify how the intensification of narcotrafficking is changing the ways in which land is controlled and its effect on land use change in Central America’s forested frontiers. Specifically, we ask: i) in frontier economies increasingly dominated by narcotrafficking activities in Guatemala and Honduras, what dominant shifts in land control have been observed? and, ii) As we see changes in land control, use, and cover, what are the long-term implications for conservation management? We answer these questions by linking spatio-temporal data on land control obtained by consolidating news media, land seizures, assets of convicted narcotraffickers, clandestine airstrips, and surveys of members of land-based NGOs to data on spatial rates of forest loss. After establishing where shifts in land control may be taking place, we quantified where and when patterns of slow, dispersed forest loss are replaced by new patterns of large, rapid clearings rates sustained over many years. In regions with established shifts in land control towards large landowners, we assume actors with large amounts of capital are largely responsible for the shifts towards rapid deforestation. While rapid deforestation and shifts in land control can be caused by many factors, here we focus on change in land use and control associated with narcotrafficking. Results estimate where narcotrafficking-related land control and land cover changes across tenure and property regimes in Guatemala and Honduras.

**Conceptual Framework of Land Control and Land Use Change**

**Defining Land Control**

Land control is the sustained power to exclude others from accessing land and resources, and to deny others’ mobility in and through a given space (Peluso & Lund 2011). Land control includes the power to draw boundaries, restrict access (Ribot & Peluso 2003), and control points of entry and egress (Sikor & Lund 2009). Thus land control is the ability to exclude others from access, in contrast to property rights, defined by the mere right to exclude others (Cole & Ostrom 2012). We define frontiers as an area with high perceived land and resource abundance (relative to the rest of the country) and only partially enrolled in capitalist social relations, i.e., it is considered by outsiders to be ‘underproductive’ and ‘undercapitalized.’ In frontier landscapes where criminal actors wield authority, property rights often do not define land access. Official (or de jure) rights differ from de facto processes typically legitimized by appeals to traditional norms or customary use rights practiced on the ground. In frontiers, actors appeal to overlapping, contested, and constantly changing forms of authority to legitimate rights and ensure land control (Cole & Ostrom 2012; Sikor & Lund 2010). The resulting ambiguities over who controls what in frontiers can be leveraged by new actors (here we focus on narcotraffickers, and thus narco-frontiers) who challenge legitimate sources of authority over land ownership (Hayes 2007).

In the Central American narco-frontiers of Guatemala and Honduras, pre-existing property rights are profoundly impacted and overwhelmed by the influx of money and violence associated with drug trafficking (McSweeney et al. 2017). This happens because traffickers use their financial and physical power to destroy or co-opt pre-existing sources of legitimate authority over property rights and land control. For example, traffickers can force Indigenous peoples to ‘sell’ communal lands, undermining the authority of traditional land regimes. The fact that Indigenous lands are formally inalienable does not matter; narcos routinely co-opt state authority by bribing political officials into legitimizing stolen land through fraudulent land titles (McSweeney et al. 2018). In effect, they create a new source of authority for asserting control over land and resources—one based not on law or precedent but on violence, financial coercion, and state cooptation leading to impunity. While wholly illegitimate and illegal it is no less authoritative (Wrathall et al. 2020).

Distinguishing land ownership from land control is essential in narco-frontiers, where the drug trade contests the rule of law, reshapes political authority, and injects economic relations with illicit capital and violence (Ballvé 2018, 2012). However, narco-frontiers are hardly unique as landscapes in which land control is distinct from ownership. In South African National Parks, for example, state actors have achieved control over de jure private conservation lands in Mozambique (Massé & Lunstrum 2016). Commodity crop booms from Southeast Asia to Guatemala precipitate elite and corporate control of land that is officially held by communities (Alonso-Fradejas 2012; Hall 2011). New urban residents in informally urbanized settlements across Latin America frequently control urban parcels despite not holding legal title (Salazar 2012; Tellman et al. 2021). Sometimes land control leads to changes in de jure land ownership. In Colombia, violent land

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1 We define frontier as an area that relative to the rest of the country has relatively high perceived land and resource abundance, and is only partially enrolled in capitalist social relations, i.e., it is considered by outsiders to be ‘underproductive’ and ‘undercapitalized.’
grabs first involve control of land by criminals, and sometimes, subsequent legalization of their rights to that land (Grajales 2015).

Shifting land control can lead to material changes in land use and land cover, often with negative consequences for smallholders’ rights and Indigenous peoples’ sovereignty, territorial futures, inequality, rural livelihoods, food security (Tamariz 2020), biodiversity conservation, ecosystem services (Ceddia 2019) and Indigenous women’s security (Hernández Castillo 2019). For example, changes in who controls access to the Colombian forest after the Peace Accords—absent any changes in ownership per se, transformed patterns of land use and accelerated deforestation in and around protected areas (Clerici et al. 2020; Murillo-Sandoval et al. 2020) and continued violent displacement of Indigenous peoples (‘Guerra en el paraíso,’ 2020). Understanding changes in land control can predict where land use will, or already has, changed.

**Land Control Change Scenarios**

Land control is shaped by actors with different levels of power in an ‘action arena’, defined as the space encompassing the role of actors, their sets of choices, access to information, and control over the rules of land access (Figure 1). Powerful actors use their ability to exclude to exercise control through political, economic, or social capital, or violence (Knight 1992; Tellman et al. 2021). In illicit land transactions, or exchanges that are intentionally hidden because they violate legal rules or social norms, violence, intimidation or bribes to politicians are often used to enforce the ability to exclude. There may be a large power differential between who previously controlled land in time 1 and who becomes the new controller in time 2 (Tellman et al. 2020a).

Changes in land control may lead to changes in land cover and land use. When control by actors is maintained, land cover change is steady outside of exogenous factors (market shifts, climatic change, environmental change, or others) (Lambin et al. 2001; Meyfroidt et al. 2018). However, since land cover is observable by satellite (and land control is not), large shifts in land cover patterns can be used to infer when a change in control has occurred between two time periods. For example, accelerated land change can indicate a shift in control from type I to a new arrangement of actors in power in a new control type II (e.g., deforestation with new foreign actors in Indonesian palm oil markets) (Hall 2011). Decelerated land change can also indicate a change in control, for example, when a military group, such as the FARC in Colombia, controls a forested region and prevents access (see Murillo-Sandoval 2020).

We use the simplified framework in Figure 1 to identify potential land control transitions and quantify their land use outcomes, or how change in control type I shifts to new types in Central America’s narco-frontiers. Control types include commonly held to private forms of ownership, formal state control to territories controlled by criminal groups, local to extra-local actor control with net dispossession of residents, or other

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**Figure 1:** Hypothetical land control and change scenarios. T1 = time period one, and T2 = time period two at a specified later point in time. When control is maintained, and the actors with different levels of power (size of black dots), in the action area are constant, land change remains relatively constant (same rate, pattern of change). When control changes from type I to type II or III at time 2 (T2), and the action arena shifts who controls land, change might accelerate or decelerate. Changing land uses can feedback into the action arena, influencing who controls land and new land patterns emerge.
combinations (see land control types column in Table 1). Changes in control do not always lead to change in land use outcomes, likewise rapid shift in land cover patterns are not always an indicator of changes in control (e.g., fire regimes, hurricane damage, and other environmental hazards can drastically change land cover). Understanding if, where, and how, land changes signals a shift in control requires linking known

Table 1: Forms of land control in Central America across commonly held, state owned, and privately held land.

| Ownership type | Land control type | Land access controlled by | Principle sources of authority(1) | Spatio-temporal attributes signaling effective land control |
|----------------|------------------|--------------------------|------------------------------------|----------------------------------------------------------|
| Commons        | Indigenous lands | Indigenous communities   | Use precedent (ancestral history), moral claims, customary law; state recognition; collective titles | Clustered settlements surrounded by dynamic patch mosaic of small agricultural plots and forest, typically organized along bodies of water* |
|                | Forestry or agricultural concessions | Campesino organizations or communities | State via land reform laws; moral claims | Clustered settlements surrounded by defined/ fixed parcels dominated by mixed-use agriculture, organized along state-supported road infrastructure |
| State/Public   | Heritage or conservation set-asides | State actors (e.g., forestry service); citizen brigades | State and international biodiversity or heritage preservation commitments; military might | Dominance of forest or other relatively undisturbed land covers (e.g., open pine savannah). Absence of sustained recent human activity, enforced borders |
| National Lands | State actors | State, land ministries, forestry concessions, political power | Lands that have not been titled, developed or ‘improved’, e.g., baldíos, (see Kneas 2020). |
| Private        | Smallholder, resident | Individuals or families | Moral authority; state-sanctioned legal title; land reform decrees; use precedent (settlement history); other forms of power (e.g., patronage by powerful private actors; threat of violence). | Bounded clearings with low or temporary pace of expansion (varies by region), typically emerging along roads or waterways; scattered homesteads; fences; smaller cattle ranches |
|                | Large holder, resident | Individuals or families; employees | Legal property titles, whether legitimate or fraudulent; use or threat of violence; external patronage relationships with political, business, or military elites | Bounded clearings with rapid or sustained pace of expansion (varies by region) can be near or distant from infrastructure; fences and permanent establishment of pasture or plantation |
|                | Absentee | Employees of individuals or corporations | Property titles, whether legitimate or fraudulent; use or threat of violence; external patronage relationships with political, business, or military elites | Sustained presence of large clearings over 5 ha annually; productive uses may be hard to detect; pasture or plantations may be present |

(3) For discussion of sources of authority: see Sikor and Lund (2009).
* Mainly applies in Honduras and Nicaragua.
or underlying land use process to observed spatial patterns (known as 'socializing the pixel' in land system science) (Tellman et al. 2020a).

Land Use Patterns and Control Types Influenced by Narcotrafficking in Guatemala and Honduras

**Typologies of Land Control**

We summarize the most common types of land control and their spatial patterns in Central America in Table 1, followed by a description of how these types emerged and influence narcotrafficking land control dynamics (post 2000). The table disaggregates standard categories of property ownership (commons/public/private) into specific control types, who controls it, by what the authority, and its typical land cover/land use pattern. Land control types describes de facto land access which may not equate to de jure property rights. For example, persistent smallholder inholdings within the borders of a biosphere reserve represent an instance of effective private land control, in which settlers have demonstrated the power to exclude others who might displace them (e.g., Hayes 2007). Land control by smallholders on state land may be legitimized by appeals to morality—that is, the right of the poor to use available land or to maintain inholdings preceding protected area designations. In contrast, large holder resident or absentee land control may achieve legal ownership, especially when legal title increases the speculative value of land (Gilbert 2002). Ascribing specific actors to land control types, however, is challenging (cf. le Polain de Waroux et al. 2018). While drug trafficking catalyzes changes in land control, outsider ‘narcos’ do not necessarily come to control all lands changed under a narco-regime. The social complexity of these regimes makes distinctions between ‘narcos’ versus Indigenous peoples or others untenable (McSweeney et al. 2018). Emergent land control types and authority, and change trajectories are rooted in Guatemalan and Honduran land history that pre-date increased drug trafficking intensity.

**Histories of Frontier Change in Guatemala and Honduras**

The shared histories of agrarian reform, colonization, conservation, and neo-liberal structural adjustment define Guatemalan and Honduran frontier landscapes, and render them susceptible to NARC-LOC (narcodriven change in land ownership and control). The two dominant NARC-LOC dynamics include: 1) direct control over protected areas for territorial operations such as roads and clandestine landing strips, border crossings and money laundering, and 2) trafficking operations and money laundering embedding in private lands (territorial control and cattle ranching) at different times leading to land consolidation and dislocation of capitalized peasants and ranchers further into the forest frontier. These two dynamics precipitate a shift in control from vulnerable conservation set-asides, concessions, and smallholder residents to large holdings held by local elites or absentee owners. Below, we describe key moments in the history of the countries’ frontiers, and the acceleration of land control changes as drug traffickers increasingly operated in the region.

During the 1950s–1980s, public national lands were transferred to private smallholder residents or commonly held land in forest/agricultural concessions. Agrarian and counter agrarian reforms in rural and forested landscapes of Guatemala and Honduras set in motion dynamics of peasant colonization that legitimized de facto land control as means of acquiring formal land rights. State agencies identified forest and scarcely populated rural areas as escape valves for agrarian pressures elsewhere, creating national imaginaries of these frontiers as spaces ripe for colonization. In Guatemala, decades of state-sponsored colonization created a national imaginary of the Petén department as an unpopulated space with available land that endures today (Grandia 2012; Schwartz 1990). In Honduras, agricultural valleys along the frontier in Olancho and Colón departments were targeted for agrarian reform that promoted the occupation of idle public lands considered ‘baldios’ (empty or vacant spaces) and redistributed them to peasant organizations under usufructuary rights (dominio util) (Nelson 2003). In both countries these efforts established informal land occupation and control as mechanisms for formalizing ownership—creating the occupy-then-title practice defining NARC-LOC today.

Heritage or conservation set asides emerged as a key land conservation strategy and form of land control in Guatemala and Honduras in the 1980s and 1990s. Protected areas (PA) were delineated to conserve relatively intact forest and advance sustainable rural development and biodiversity conservation on state owned lands. During Guatemala’s peace process (1985–1996), the state created the National System of Protected Areas in 1989, and the 22,000 km² Maya Biosphere Reserve (MBR) in 1990 in the Petén. In 1991, the Honduras state created the Department of Protected Areas and Wildlife, and within a few years established 22 national parks and two biosphere reserves, including the Tawahka-Asagni and expansion of the Río Plátano in eastern Honduras. These PAs include zoning schemes that allow for non-consumptive uses in core
zones, regulated sustainable uses in buffer zones where private property and cattle ranching are permitted, and mixed use or cultural zones that recognize existing Indigenous settlements and permit sustainable land uses (Herlihy 1997; Nations 2006).

Unfortunately, the creation of protected areas occurred alongside neo-liberal austerity programs in Guatemala and Honduras that resulted in insufficient funding and understaffing of state agencies charged with their stewardship (Bovarnick et al. 2010). These structural adjustment policies undermined the ability of state agencies to control PA access, creating ‘paper parks’ without mechanisms for land control or law enforcement. Nowhere is the paper parks phenomenon more evident than in the frontier regions of northern Guatemala and eastern Honduras. Lack of institutional control and the presence of illicit logging, road building, and illegal settlements led to UNESCO placing the Río Plátano on the list of World Heritage Sites in Danger in 1996 (UNESCO 1996).

In some cases, public heritage or conservation set asides shifted to commonly held land in forest concessions. In mixed use and buffer zones, community forestry concessions represent a unique conservation strategy whereby communities receive long term leases on public lands embedded in protected areas to engage in productive forest enterprises under a state approved management plan (Del Gatto 2013; Nations 2006). Guatemala’s MBR concessions are a global success story and demonstrate that with financial investment, high social capital, and strong state support, community forest concessions are capable of exerting control and reducing deforestation in comparison to non-concession forests (Blackman 2015; Del Gatto 2013).

Neo-liberal market-assisted land reform (MALR) in the 1990s–present has shifted land control from public lands, concessions, and smallholder residents to large holder residents and even absentee landowners. In Guatemala, the national imaginary of the Petén combined with the failure of MALR, drove landless and land poor peasants to the Petén and into the MBR. Poverty, debt, and the poor quality of program lands resulted in many ‘beneficiaries’ selling their lands and moving north to seek alternatives (Alonso-Fradejas 2012). In Honduras, the neo-liberal Agricultural Modernization Law (AML) (1992) allowed for the sale of agrarian reform lands and the titling of up to 200 hectares of national or public lands that had not been deforested (AML 1992). These dynamics led to a new round of land consolidated by large cattle and african palm land owners and displaced smallholder beneficiaries of land reform deeper into the frontier forests (Herlihy 1997; Stonich 1993; Sunderlin & Rodriguez 1996).

Neo-liberal market-assisted land reform in Honduras also shifted control from public land toward commonly held Indigenous lands due to significant Indigenous political mobilization to include Indigenous protections and provisions in the 2004 Property Law and the 2007 Forestry Law. In response, the World Bank’s Land Administration Program titled 14 Indigenous territories encompassing 1.5 M hectares in Gracias a Dios (Galeana & Pantoja 2013; Herlihy & Tappan 2019). These titles are legally indivisible, indefeasible, inalienable and imprescriptible (ICF 2016). However, in the absence of social control, collective management capacities and state support, Indigenous territorial councils have struggled to exclude narcotraffickers and other colonists (Hale 2011; Larson et al. 2013; McSweeney et al. 2017; PRISMA 2014).

**Frontier Change Under Accelerated Drug Trafficking (> ca. 2000)**

The intensification of drug trafficking through Guatemala and Honduras in the 2000s (see UNODC 2012; Brockett 2019) had a variety of impacts on their land control trajectories.

First, remoteness and weak enforcement in National Parks over time has left them vulnerable to control change enacted by narcotraffickers, or as Guatemalan conservation officers describe them, as ‘ungovernable’ (Wrathall et al. 2020). For example, the isolated MBR shares 50% of Guatemala’s border with Mexico, and its largest national park, Laguna del Tigre, was declared a ‘Narco’s Paradise’ in 2004 by the national press. This moniker was given due to the hundreds of clandestine airstrips dotting the park, and the impunity characterizing cartel trafficking activities, illegal land grabs, and territorial occupation (‘Laguna del Tigre, tierra sin ley,’ 2004). Smallholder residents practicing subsistence agriculture in national parks such as Laguna del Tigre have been displaced by narcotraffickers directly, or indirectly through state eviction claiming communities work with narcotraffickers, which may not be true (Lunstrum & Ybarra 2018).

Second, narcotrafficking has also caused a shift in control from concessionaires (residents who manage the concession) to absentee landowners in several cases. Narcotrafficking activity has been linked to canceled or indefinitely suspended concessions in Guatemala’s Petén (La Pasadita, San Miguel, La Colorado).\(^2\) In Cruce a

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\(^2\) The factors leading to concession cancellation are nuanced at the level of the individual concessions. San Miguel la Palotada, for example, failed due to the concession’s small size, lack of commercial forest products, and mismanagement, alongside narco-traf-
la Colorada, the concession was nearly canceled after narco-ranchers cleared forest. Narco-ranchers assassinated the concession leader, David Salguero, who filed a land seizure complaint to Guatemala’s Commission on National Protected Areas (CONAP) (see Devine et al. 2020).

Finally, narco-traffickers have also benefited from market-assisted land reforms. In Guatemala, for example, ten members of the Mendoza trafficking cartel used economic coercion and violence to acquire 28 farms using testaferros, or frontmen, to launder US $3.2 million through land sales and oil palm production (CICIG 2019). In Olancho, Honduras, DTOs extended clandestine roads towards the Nicaraguan border and laundered money through cattle ranching (‘Asequeran mas propiedad de “Los Cachiros” en Olancho,’ 2015), meat processing (Mackey 2017) and logging operations (Avalos 2020). These investments led to a consolidation of control over private lands, the displacement of cattle ranchers into the forest frontier, and opened up new settler access to protected area lands; cattle ranching is a preferred means of money laundering and establishing territorial control for DTOs (Devine et al. 2020, McSweeney et al. 2017). ‘Narco-cattle ranchers’ in Guatemala in the MBR pay peasants meager wages to clear forests or savannahs to plant pasture and ranch cattle, while land speculators of means clear areas near the Mexican border in hopes of selling the ‘improved’ lands to ranchers (Devine et al. 2020). Further, land titling in indigenous territories has also been undermined by narcotrafficking, who can increase land consolidation for absentee owners as they seize on unsure or contested tenure and property relations to seize more land (PRISMA 2014). In the case of Honduras, the state’s recent granting of territorial rights to indigenous Miskitu is a triumph in theory. In practice, the weak and narco-corrupted state cannot support Miskitu efforts to enforce those rights, and the invasion of narco-enriched outsiders into Miskitu territory has even accelerated since (Galeana 2020; Rayo 2021).

Materials and Methods

Our approach is based on the conceptual framework presented in Figure 1. Our first challenge was to empirically demonstrate when and where narcotrafficking catalyzed shifts in land control. We were greatly aided in this respect by a US government dataset that reliably tracks where and when cocaine is delivered into Central America (see ‘drug flows,’ below). But while we could track the location and popularity of drug trafficking hubs, we needed a different approach for analytically linking those trafficking activities to specific sites in which narco were asserting their control over land. This was difficult for obvious reasons: criminals do not typically seek to make visible the ways in which they acquire, hold, and accumulate land. We therefore turned to a multi-method approach that involved gathering nine different forms of evidence of narco-holdings, including public records, news media, in-situ knowledge based on our prior fieldwork, and a survey of land managers in specific conservation areas. Each data source is limited in unique ways, but in combination tell a compelling and fairly coherent picture of the extent and nature of drug traffickers’ control over land. We discuss the sources we used for Guatemala and Honduras, respectively, below.

Our second challenge was to relate those changes in land control to conservation-relevant changes in land cover/land use, specifically in terms of forest loss. We therefore estimate annual forest loss rates of large and rapid, consolidated versus slower, dispersed land clearing for three land ownership types (commons, public, and private from Table 1). To assess when and where land control type change (e.g., from type I to type II) lead to a change in land outcomes, we compare annual graphs and maps of land control and spatial rates of land change at the department and municipal scales. We describe this process in detail at the end of this section.

Data on Drug Flows

Our analysis of the spatial-temporal dynamics of drug trafficking intensity relies on two sources, official records and news media reports (Table 2). The official data relies on the CCDB (Consolidated Counterdrug Database), widely recognized to be the authoritative official data on cocaine flows seized by law enforcement, lost (not delivered to its intended location), or delivered (see McSweeney 2020, for a detailed description). However, CCDB is not available for all departments in Central America, and have a known bias of delayed recording of narco-trafficking intensity increases of up to several years, depending on the country (Tellman et al. 2020b). We supplement drug flow data with media reported events of narco-trafficking, which are spatially complete across Central America and more temporally accurate (see Tellman et al. 2020b, for a detailed description).
The presence of drug trafficking influenced land control was established in five ways (Table 3).

1. Land held by organized crime was identified via registered private lands under names of DTO members identified in a 2011 anonymous report published by InSight Crime (2011); we digitized and georeferenced these data.

2. Thirty farms controlled by DTOs were identified by the International Commission against Impunity in Guatemala (CICIG). One DTO forced peasants to abandon their parcels, which were retitled to DTO members in the Guatemalan National Property Register. While the exact polygons of the properties were not available, the total area by municipality and land use were reported, which we digitized and collated.

3. Reports of illegal land seizures were obtained by request to the Public Ministry under Guatemalan Transparency of Information Laws. The reported timing, and area of seizures was summarized by location and year. These data represent accusations of ‘usurpación’ or illegal land seizures or grabs in protected areas; some of these holdings were corroborated as narco-owned through interviews with the Guatemalan National Commission of Protected Areas (CONAP) (Supplementary Table 1).

4. Clandestine airstrips are built by traffickers to move product, some of which are recorded in the Guatemalan military’s records of unauthorized airstrips. The data were obtained by freedom of information request in June 2020 by the authors.

5. In three community concessions, traffickers cut forest and established cattle ranches. The concessions were canceled as a result in 2009.
**Narcotrafficking Land Control Data for Honduras**

Data on land control by narcotrafficking specific to Honduras were collected in four ways (Table 4).

1. Landed assets from narcotraffickers were identified through the Foreign Narcotics Kingpin Designation Act (Office of Foreign Assets Control 2014). We searched the list of Kingpins (US Department of Treasury 2020) for DTOs. We found no rural landed assets in Guatemala, but in Honduras, three organizations (Los Cachiros, Los Rosenthals, and Los Valle Valle) and recorded the business type and location of each for the 13 assets mentioned.

2. Clandestine airstrip data in Honduras include data from the Honduran military in interdiction efforts called ‘Operation Armadillo’ in 2012 and those identified by authors in Honduras via Landsat Satellite imagery in Google Timelapse and high spatial resolution imagery from WorldView-2 accessed via the Digital Globe (www.digitalglobe.com/products/enhancedview-web-hosting) from 2010–2020. Of the 169 airstrips identified, 140 have been visibly decommissioned (e.g., temporarily disrupted or bombed) during interdiction efforts. Identified airstrips are not connected to municipal airports or official roads. The year each airstrip was built was estimated via satellite data. These data likely underestimate the number of airstrips because strips established on pasture and other agricultural lands can evade detection.

3. News media articles identify where landed property was seized from DTOs and where they operated ($n=1,966$ at department scale and $n=919$ at municipal scales). Geographic coordinates derived from these media sources where then mapped, yielding 659 articles within 15km of protected area boundaries.

4. To understand how narcotrafficking influenced land control, we rely on a 2020 survey of 144 NGOs working in sustainable development. Using purposive chain-referral sampling; we first called 42 randomly selected organizations from the initial list of 144 NGOs. A total of 17 were interviewed. All interviews with managers were recorded, transcribed, and analyzed using NVivo 10 qualitative data analysis software (‘NVivo,’ 2014) through systematic theming and categorization. Two questions were asked: ‘How has your organization been affected by the presence of illegal activities?’ and ‘How has your organization responded or adapted to these activities?’ Preliminary themes illustrated types of illicit resource-based activities in the locations where NGOs reported working, and how the organization has responded to these activities. These themes were utilized to develop the online questionnaire and provide contextual richness for interpreting survey results.

| Data | Explanation | Sample size | Temporal Scale, Resolution, Unit | Source |
|------|-------------|-------------|----------------------------------|--------|
| Cartel territorial control reported by media | Media reports with department specific narcotrafficking activity events related to land and named cartels and within 15km of a protected area | 1,206 events, 283 with named cartels, 659 in protected areas | 2000–2019, annual, Honduran municipalities, events | Coded newspaper articles from major media outlets |
| Perceptions of the effects of illicitness, survey data | Survey participants' valuation of how severe the effect of illicit resource-based activities is on their organization's efforts in conservation and sustainable development initiatives. | 82 survey participants and 17 interviewees | 2020, Honduran Departments, interviewee/respondent | Survey and interviews with 144 non-governmental organizations |
| Clandestine airstrips | Location of clandestine airstrips related to narcotrafficking identified by US & Honduran governments and research team | 196 airstrips | 2017–2020, annual, coordinates | Operación Armadillo, Worldview-2, US army southcom. |
| Kingpin | Assets seized by US treasury under the Foreign Narcotics Kingpin Designation Act | 11 assets from 3 cartels in Honduras (Rosenthals, Valle Valle, and los Cachiros) | 2002–2020, assets are reported as legally registered business for each cartel and country | Office of Foreign Assets Control, (US Department of Treasury, 2020) |
For the subsequent online questionnaire, we identified 392 emails of employees working for the 144 NGOs identified in Honduran directories from 26 municipalities (in 12 departments), yielding 82 complete responses. The online Spanish survey focused on participants’ assessment of how illicit activities (including wildlife poaching, violence, and narcotrafficking) influenced conservation and sustainable development initiatives. The online survey asked respondents to indicate the degree to which (on a 1–4 Likert scale) illegal activities influence 17 challenges (including governance, economic, and land dimensions) related to the success of their organization. We followed Dillman, Smyth and Christian (2014) for enhancing response rates for internet surveys.

Interview and survey questions and methods, including participant consent forms were approved by NAU’s IRB (#1466302-3). Due to the sensitive nature of the topic, the survey was targeted at organizational experiences and not individual experiences. The cover letter attempted to establish the credentials of the research team and make it clear that responses would be anonymous, confidential, and that no identifying information would be requested in the survey. A response rate (29%) prompted a non-response bias check based on the type of organizational conservation or sustainable development work associated with the NGOs in our initial list versus those that responded. We found similar percentages of each in our responses. Additionally, we assessed the geographic areas of work for each NGO participant invited to participate and found no bias in geographic representation.

**Data on Forest Loss and Land Ownership**

Data on forest loss and land ownership are summarized in Table 5. To measure forest loss we used annual, spatially explicit, high resolution (30 m grid cells), and validated forest loss data consistent over the Central American region, obtained from the University of Maryland Department of Geographical Sciences Global Forest Change version 1.7 (see: https://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.7.html accessed 10/8/2020) (Hansen et al. 2013). Continuous forest patches measuring ≤2 ha, representing minor areas of forest loss or potential noise (Sesnie et al. 2017), were removed from the analysis. While not all forest loss signals shift in land control, previous studies indicate that narcotrafficking causes forest loss, explain an additional 5–9% variation (Tellman et al. 2020b) particularly inside protected areas (Sesnie et al. 2017; Wrathall et al. 2020). Statistically anomalous patches of forest loss (representing 30–60% of all forest loss from 2000–2016, according to Sesnie et al. 2017) were cleared at high rates (>5 ha average annual rates in recent decades) and correlated with drug trafficking. The location of forest loss and hectares loss per year are summarized in Figure 2.

To identify the bounds of de jure public lands, we used the World Protected Areas database, focusing on protected areas with ‘strict’ protection, in national parks or regions where, in theory, forest loss and land use change are not permitted. These include IUCN governance category I and II, strict nature reserves and national parks, and exclude multiple use or buffer zones where PA residents and neighbors practice community forestry. We hereafter use the term protected areas, but only refer to these regions with strict protection in this paper (Figure 3).

**Table 5:** Consolidated data on forest loss, protected areas, and Indigenous territories in for Guatemala and Honduras.

| Variable | Description | Temporal Scale, Resolution, N | Source |
|----------|-------------|-------------------------------|--------|
| Forest loss | Annual forest loss at 30 m | 2000–2019, 30 m | Hansen et al. 2013 |
| Protected areas | Polygons of protected areas with designation | 257 for Guatemala and 95 for Honduras | World Protected Areas Database (2016) |
| Community concessions/community managed areas | Polygons of active and canceled community concessions (Guatemala), and areas of community management (Honduras) | 9 active 25-year concessions and 3 canceled in 2009 in Petén; 50 areas of community management in Honduras from 1996–2015 | CEMEC Guatemala, 2016; Honduras: Instituto de Conservation Forestal (ICF), 2019 |
| Indigenous Territories | Polygons of Central American Indigenous Territories (titled and untitled) and recent Indigenous collective titles in Gracias a Dios, Honduras. | 36 in Guatemala and 25 in Honduras, plus 14 titled territories in La Mosquitia | Central America (IUCN) and Mosquitia (Herlihy 2019) |
For an imperfect initial measure of lands held in de facto community commons, we used the IUCN 2016 map of Indigenous peoples’ territories in Central America. In some cases, legal titles transferred state land ownership to Indigenous territories in Honduras from 2012 to 2016 (Figure 3). Finally, community concessions, or regions where the State has long-term leases of community managed forest, were obtained for Guatemala (from CEMEC 2016) and Honduras from The Instituto de Conservación Forestal (ICF 2019) (Supplementary Figure 1).

**Data Analysis Methods**

Our methods aimed to document the spatio-temporal dynamics of land control and the role of narcotrafficking, and to relate those shifts in land control to forest loss. We employed a mixed-methods analytical approach drawing from cross-site comparison techniques (Magliocca et al. 2014). Cross-site comparison
between Guatemala and Honduras is used to both quantify and understand common processes of land control change. We examine the number and location of clandestine airstrips, public documents of known narcotraffickers’ assets and land seizures, number and location of media events, and NGO perceptions of narcotrafficking related land control. We then map or graph these secondary sources of land control data at the department or municipality at annual time steps, and interpret corroboration (and disagreement) across datasets. Interviews and surveys are used to understand how narcotrafficking versus other types of illicit activity might influence land control. We compared survey data responses regarding the impact of illicit activity versus narcotrafficking across 17 socio-economic impacts grouped into three categories ‘Governance’, ‘Economy’, and ‘Land’ with a nonparametric Independent Samples Mann-Whitney U Kruskal-Wallis test (R v. 3.6.2, [R Core Team 2019]).

We then analyze two types of forest loss patterns, which we hypothesize are outcomes of two distinct types of land control. First, we define ‘incremental’ forest loss as slow, small, dispersed clearings, likely related to natural disturbance or subsistence agriculture, and a typical forest pattern in the region.

Second, we define ‘sustained’ forest loss when average clearing rates per patch increase above the threshold observed to be anomalous in previous studies and require significant capital to clear in each country (see Sesnie et al. 2017). To identify incremental versus sustain forest loss patterns, we calculated average annual clearing rates for each contiguous forest loss patch (2000–2019) in Honduras and Guatemala. Incremental clearing rates were defined as <5ha/yr in Guatemala or <3ha/yr in Honduras, and sustained clearing rates >5ha/yr in Guatemala or >3ha/yr in Honduras. We summarize the total amount and percentage of forest loss in these two patterns for three de jure land categories, Common, Public, and Private (Table 1) for the active deforestation frontier region in each country. Active deforestation frontiers are defined as departments with average forest loss rates of >1% loss per year or >50,000 total forest loss from 2000–2019.

We hypothesize incremental forest loss is related to business-as-usual smallholder agriculture or resource extraction and represent steady land change (control type I), and a shift in pattern to sustained loss indicates large landholders have gained control (control type II, Figure 1). Not all large landholders are narcotraffickers; frontiers are dynamics spaces with many actors clearing land, some with licit capital. Land dispossession caused by narcotraffickers or other armed actors can be followed by corporate actors who rapidly clear land (Ballvé 2018; Darién 2021; Murillo-Sandoval et al. 2021). Incomplete empirical data on land control prevent straightforward quantification of the amount of sustained forest loss directly or indirectly attributable to narcotrafficking. Instead we use cross site comparison techniques (Magliocca et al. 2014) to corroborate where and when changes in narco-influenced land control shifts likely precipitate change in forest loss patterns from incremental to sustained. To do so, we interpret the spatio-temporal patterns of land control and land change in tandem.

Results
Narco-influenced Land Control in Guatemala
In Guatemala, secondary evidence indicates significant land control by narcotraffickers in Northern Guatemala and along the Pacific Coast. Drug trafficking data from media (Figure 4A) and counterdrug interdiction (Figure 4B) indicate high trafficking intensity in Northern Guatemala (Petén, Izabal, and Alta Verapaz departments) and the Pacific Coast (Escuintla and San Marcos departments in particular). Land control indicators of seizure accusations in protected areas (n = 1190) and clandestine airstrips (n = 217) were concentrated in Izabal (n = 130 and 29, respectively) and the Petén (n = 954 and 120, respectively) (Figure 4C and 4D).

Detailed spatial data on land control by narcotraffickers available in the Petén (Figure 4) indicate a shift in control from small holders to large, absentee landowners in legally held private lands. The data also indicate a shift in control from publicly held land (e.g., Lacandon National Park) to privately held land. Land seizure data from Caso Genesis indicates DTOs developed cattle ranches operated illegally inside protected areas (e.g., Sierra Lacandon). DTOs seized land from peasants by force (over 30,000 ha documented), also converting territories to cattle ranches. Legally owned DTO territories were cleared of forest for oil palm (Furumo & Aide 2017) and cattle ranching in the early and mid 2000s (Figure 5A) on over 80,000 ha which were previously forest.

Sufficient annual data were available and distinct trends evident in Guatemala in two departments, the Petén and Izabal. In the Petén, land seizures rise in 2003 and are highest from 2005–2009 (Figure 6A), the same period when media and CCDB data indicate high narcotrafficking activity intensity. Likewise, forest loss in the Petén in ~2003–2009, decreased for several years (~2010–2015), and increased in a second wave in about 2016–present. In contrast, in Izabal, land seizures begin to rise in 2008 and peak in 2015, about five years following the peak activity in narcotrafficking identified in the Petén (Figure 6B). Likewise, Izabal forest loss increased in the mid 2000s and peaked in 2016.
The shift in narcotrafficking influenced land control from the Petén to Izabal around 2010 coincides with the Guatemalan government’s ‘zero-cattle’ policy instituted by President Colom in 2009. This policy seized many narco-cattle ranches in the Petén (Devine 2014), causing some narcotraffickers to lose control (note decreased media events, forest lost, and land seizures in Figure 6a after 2009). Narcotraffickers responded by subsequently moving trafficking operations to Izabal (Wrathall et al. 2020) (note increased media events and land seizures around 2010, Figure 6b). Once Colom left office in 2012, many traffickers re- resumes operations again in the Petén (increased forest loss, media, and land seizures by 2015 Figure 6a).
Incremental and Sustained Forest Loss Patterns in Guatemala

An estimated 1,190,500 ha of forest was lost in Guatemala from 2000–2019 (see Supplementary Table 2 for loss rates per department), with 60% of this loss of the sustained forest loss pattern (713,244 ha). Much of the forest loss in Guatemala occurred prior to 2010, with another recent spike between 2016 and 2019. In Guatemala, 10% of forest lost (151,220 ha) occurred in protected areas, where no forest clearing is legally permitted. Of all forest lost in protected areas, 78% was of the sustained forest loss pattern (114,580 ha). Laguna del Tigre and Sierra del Lacandon National Parks stand out for both the large area of forest lost and dominance of control type II patterns (Figure 7A). Forest loss was more pervasive in protected areas than concessions where non-timber forest products of selective logging are practiced (Supplementary data Figure 1). Forest loss (14,875 ha) in canceled or indefinitely suspended concessions (La Pasadita, San Miguel, La Colorada) was dominated by the sustained forest loss type (90% of all forest loss). (Figure 7C). While 4,295 ha of forest was lost from 2000 to 2019 in the six active community concessions, almost all (94%) of the sustained forest loss occurred in Cruce a la Colorada, a concession nearly canceled after narco-ranchers cleared forest. Sustained forest loss is most prevalent in departments with high rates of narcotrafficking and clandestine airstrips (Petén, Izabal, Escuintla, and Retalhuleu—see Figure 7A,C) with 1,026,526 ha of forest lost (633,891 ha of the sustained loss pattern) over the past two decades at an average annual rate of forest cover change of −1.49. Forest lost in private lands was predominantly of the sustained forest loss pattern (394,067 ha, 78% of all forest loss), compared to Indigenous territories, where sustained forest loss only represented about half of all forest loss patterns (376,982 ha, 52%).

The factors leading to concession cancellation are nuanced at the level of the individual concessions. San Miguel la Palotada, for example, failed due to the concessions small size, lack of commercial forest products, and mismanagement, alongside narco-trafficking and narco-cattle ranching activities. In La Pasadita, La Colorada, and Cruce a la Colorada, narco land grabs and narco-cattle ranching played a clear, more prominent role in cancellation (Devine et al. 2020, 2018).

Figure 6: Land control indicators (land seizure accusations in protected areas in Guatemala, and narcotrafficking airstrip construction in Honduras and Guatemala), narcotrafficking measured media events, and cocaine (kilos) seized, lost, and delivered from the Consolidated Counterdrug Database (CCDB), and forest loss in A) Petén, Guatemala, B) Izabal, Honduras, and C) Gracias a Dios, Honduras. Land control indicators tend to increase together with drug flow and forest loss.
In Petén and Izabal, sustained forest loss patterns increase with changes in land control in different years. Izabal exhibits increasing sustained forest loss in the mid 2000s, and then declines after 2016. Petén, on the other hand, demonstrated large sustained forest loss in the early to mid 2000s, declines from 2007–2015, and has a second increase from 2016 to 2019. Notably, these shifts in sustained forest loss patterns are more prevalent in protected areas and in private lands (compared to Indigenous territories). The changes in sustained forest loss patterns co-occur with secondary evidence documenting shifts in control from the State to large landholders in protected areas and from small landholders to larger landholders in private lands. In canceled concessions land was returned to the State after seizure by narcotraffickers (see Supplementary Figure 1).

**Narco-influenced Land Control in Honduras**

Secondary sources indicate narcotrafficking land control is widespread but concentrated along coastal and eastern Honduras in Olancho, Colón, and Gracias a Dios. Evidence of narcotrafficking influenced land control in Honduras begins around 2009 and continued until 2017. Land control shifts are evident in and outside of protected areas. Hundreds of clandestine airstrips in Honduras are concentrated (70%) in designated protected areas (Figure 8). The increased number of clandestine airstrips appearing in publicly held land beginning in 2010 and ending in 2017 indicates a shift in land control towards narcotraffickers in Gracias a Dios that coincides with trends in media records (Figure 6C). Media data (n = 138) indicate the land control and influence in Honduras of large absentee land holdings via agribusiness outside protected areas (Figure 9B). Media events indicated DTOs use land for operations and money laundering most frequently in Olancho, Gracias a Dios, and Colón (n = 268). Kingpin documents show that land investments varied by region. Los Valle in western Honduras, owned coffee farms and cattle ranches (Figure 9D). In eastern Honduras, oil palm and cattle ranching were common investments for the Cachiros and the Atlantic cartel (Figure 9C).

Interview responses indicated narcotrafficking shifts land control from the state to other actors resulting in deforestation, ‘illegal activity is affecting the forest, and fragmentation of forest ecosystems. These activities occur with settlements and taking illegal possession of national territory.’ One response described how absentee landowners displaced smallholder residents ‘people have left their lands or sold them in low lying areas to those wishing to establish plantations of oil palm and have migrated to protected areas in higher elevations.’ Another respondent explained how land control is lost in commonly held or Indigenous areas,
Figure 8: The mapped location of 196 clandestine airstrips in eastern Honduras that were constructed and decommissioned using explosives during interdiction efforts from 2010 to 2019. A total of 139 airstrips and decommission dates were verified by high resolution satellite imagery (WorldView-2), and 57 identified by US Army Southcom (but not verified in WorldView-2 imagery) to interdict in Operación Armadillo in 2012. Clandestine airstrips in protected areas indicate a shift in control from the state towards private control from narcotraffickers.

Figure 9: Known drug trafficking organizations land control documented in media events from 2000 to 2019 (n = 268) in Honduras and seized assets by the US treasury under the Kingpin Act from the two largest cartels. A) DTO influence per department, with circle size proportional to number of media events (ranging from 1–33) for largest DTOs in Honduras. B) Total number of media events reporting land related activity from DTOs (n = 168). C) Seized assets from the Cachiros include palm oil, zoos, cattle ranches, and a mine. D) Seized assets from the Valle Valle include three coffee farms and a cattle ranch.
third parties accumulate land, deforest it (according to the law that is a land improvement), and afterwards they legalize it in the municipality, they don’t respect the law if it’s a protected area or meant for forest uses—they always give the land title to these third parties, because of bribes in a corrupt system. These responses the mechanisms by which narcotrafficking changes land control, displacing small landholders with absentee and large holders and increasing illegal settlements.

Surveys of sustainable development NGOs in Honduras indicated narcotrafficking influences land control more than other types of illicit activities (e.g., poaching). Survey results (Table 6) show narcotrafficking had a large effect (over 3 on average on a 1–4 Likert scale) on illicit cattle ranching, crop cultivation, land speculation, mining, selling land, and timber extraction. Narcotrafficking was reported to have a high impact on governance, economy, and land challenges, and a significantly higher impact than other kinds of illicit activities (Mann Whitney U, W = 15347, 4911, and 2978.5 for governance, economy, and land, respectively; p < 0.001 for all three). Notably, the difference between impacts of narcotrafficking and other illicit activities was greatest in the land category, increasing consolidation of land, land price, illegal settlements, insecurity, and displacement. In contrast, illicit activity not related to narcotrafficking was reported to have only a small effect on these land challenges. Narcotrafficking specifically impacts land challenges in ways general illicit activity does not.

### Incremental and sustained forest loss patterns in Honduras

An estimated 754,500 ha of forest was lost in Honduras between 2000 and 2019. Loss rates per department and forest loss totals are summarized in Table 3 in the Supplementary Data. In Honduras, forest loss appears to be increasing over time. In 2014 and 2015, major droughts (FAO 2016) likely increased access to forest and susceptibility to fires in 2016 (Bullock et al. 2019; Valdez et al. 2017). Narcotraffickers are among the actors who burn forest in dry periods to claim land (‘Why are drug cartels starting forest fires in Guatemala,’ 2016). Over 55% of all forest loss in Honduras (417,329 ha) was sustained forest loss.

### Table 6: Results from perceived effects by 17 impacts (grouped into governance, economic, and land aspects) between respondents (N = 76) who indicated that other illicit activities are present where they work (N = 28) and participants who said narcotrafficking activities are present (N = 48). All items were measured on a 4-point Likert-type scale where 1 = No effect 2 = A little effect 3 = Some effect and 4 = A lot of effect.

| Challenge Category | Challenges                                                                 | Other Illicit Activities mean (median)* | Narcotrafficking Activities mean (median)** | Difference | Mann-Whitney U Statistic | Sig. (2-tailed) |
|--------------------|---------------------------------------------------------------------------|----------------------------------------|---------------------------------------------|------------|-------------------------|----------------|
| Governance         | Intimidation, Corruption, Bribe, Violence, Robbery, Conflict with Gov. Leaders, Conflict with local leaders | 2.41 (2)                               | 3.07 (3)                                    | .66 (1)    | W = 15347               | p-value = 3.509e–10 |
| Economy            | Lost jobs due to security, Increased hiring costs, Weakened civil society, Decreased economic resources for the community | 2.46 (3)                               | 3.09 (3)                                    | .65 (0)    | W = 4911                | p-value = 3.014e–6  |
| Land               | Consolidation of land, Increased value of lands, Illegal settlements, Land insecurity, Displaced landowners | 1.75 (1.625)                         | 3.03 (3.25)                                 | 1.32 (1.625) | W = 2978.5               | p-value = 2.067e–11 |

* Kruskall-Wallis tests for differences across groups chi-squared = 10.972, p < 0.01.
** Kruskall-Wallis tests for differences across groups chi-squared = 0.54218, p = 0.76.
More than 63% of forest loss in protected areas (112,547 ha), 51% of forest loss in Indigenous territories (97,674 ha), 43% of forest loss in 68 community managed areas (12,221 ha), and only 22% of forest loss in private land (369,206 ha) is of the sustained loss pattern. Sustained loss patterns dominated in community managed areas of Horconcitos, El Socoron, and Tronconces, the Tawahka Indigenous territories, and Patuca National park in Honduras (Figure 10 A, B, C, E). Some the land in the Río Plátano and the Patauca, for example, are known agricultural frontiers where land is cleared by large owners whose capital is unrelated to narcotrafficking.

Sustained loss is most prevalent in Olancho, Gracias a Dios, and Colón Honduras (Figure 10D) where 661,526 ha of forest were lost (329,106 ha of which was sustained loss) at an average annual rate of forest cover change of –1.22. Sustained forest loss (save 2016) increased in Olancho from 2004 to 2010, and maintained until 2020. In Gracias a Dios, sustained forest loss appears around 2004, and increases over time, with marked growth from 2015 to 2019. In Colón, sustained forest loss occurs over the 2000s, plateauing in 2016.

Discussion
Narcotraffickers profoundly change the nature of land control in both cocaine production zones (Armenteras et al. 2013; Clerici et al. 2020), and as we show here, cocaine transit zones. Along the entire cocaine commodity chain, land tenure, and titles or rights to land, are not meaningful unless the actors with titles can effectively control that landscape (by excluding others from access). In general, we find that land control changes related to narco trafficking tend to occur in places and at times that sustained forest loss patterns increase or begin to dominate in both Guatemala and Honduras. In frontier regions where forest loss continues an incremental pattern (Jutiapa and Quiche, Guatemala and Choluteca, Honduras), we found little evidence of land control by narcotraffickers. Not all changes in land control led to changes in land cover; in Santa Barbara and Copan, Honduras, DTOs invest in coffee farming, which may not result in land cover changes.

We summarize the evidence of changes in land control and sustained forest loss patterns in Table 7 across commonly held, public, and private land ownership categories and control types from Table 1. Across all ownership types, there is a total of 417,329 ha and 713,244 ha of sustained forest loss in Honduras and Guatemala, respectively from 2000–2019. This area, over half of forest loss in each country, represents a
Table 7: Summary of types of changing land control from type I to type II directly related to narcotrafficking based on above evidence.

| Ownership type       | Form of land control                  | Previous to narcotrafficking-land access controlled | Sustained forest loss in ha (as a % of total forest loss) | Evidence of change in land control towards narcotrafickers (based on incomplete, available data) |
|----------------------|---------------------------------------|-----------------------------------------------------|----------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| Commons              | Indigenous lands                       | Indigenous communities                               | Guatemala: 376,982 (52%)                                 | Honduras: 176 airstrips, qualitative evidence from the survey                                    |
|                      |                                       |                                                     | Honduras: 97,674 (51%)                                   |                                                                                                  |
|                      | Forestry or agricultural concessions   | Campesino organizations or communities              | Guatemala: 3 canceled concessions: 15,875 (94%), 6 active*: 4,295 (64%*) | Guatemala: 15,914 ha of sustained forest loss in 3 canceled concessions and one nearly canceled   |
|                      |                                       |                                                     | Honduras: 12,221 (68%)                                   |                                                                                                  |
|                      | State/Public                           | State actors (e.g., forestry service); citizen      | Guatemala: 114,580 (78%)                                 | Guatemala: 149 airstrips across Petén and Izabal, much of which are covered by protected areas in |
|                      |                                       |            brigades                                   | Honduras: 112,547 (63%)                                  | Guatemala, 954 reported land seizures in protected areas in Petén and 130 in Izabal             |
|                      | Heritage or conservation set-asides    |                                                     |                                                         | Honduras: 159 airstrips; 71% of protected areas >1 media-reported narcotrafficking event within   |
|                      |                                       |                                                     |                                                         | 15km of boundary                                                                                  |
|                      | Private                                | Individuals or families                             | Guatemala: 394,067 (78%)                                 | Guatemala: nearly 30,000 ha land usurped from peasants by Mendoza cartel                         |
|                      | Smallholder, resident                  |                                                     | Honduras: 369,206 (22%)                                  | Honduras: survey evidence indicates narcotraffickers displace small holders                      |
|                      |                                        |                                                     |                                                           | * Data cannot distinguish absentee vs. largerholder resident actors                              |
|                      | Large holder, resident                 | Individuals or families; employees                  |                                                           | Guatemala: 80,000 ha held by cartels for cattle ranching, oil palm or landing strips in the Péten |
|                      |                                        |                                                     |                                                           | Honduras: oil palm, zoo, and coffee plantations for money laundering, Cachiros, Los Valle Valle, |
|                      | Absentee                               | Employees of individuals or corporations             |                                                           | and Atlantic Cartels for control land for agro-industries in Eastern Honduras                   |
|                      | Total for country, across all ownership types** |                                                     | Guatemala: 713,244 (60%)                                 | Guatemala: 95,914 ha of forest loss directly attributable to cartels; up to 633,891 ha of       |
|                      |                                        |                                                     | Honduras: 417,329 (55%)                                  | sustained forest loss in regions with high narcotrafficking potentially attributable, 217 airstrips, 1,171 |
|                      |                                        |                                                     |                                                           | land seizures in regions with high narcotrafficking                                             |
|                      |                                        |                                                     |                                                           | Honduras: up to 329,106 ha of sustained forest loss in regions with high narcotrafficking        |
|                      |                                        |                                                     |                                                           | potentially attributable, 196 airstrips                                                        |

* 94% of all sustained forest loss in active concessions was concentrated in one concession, Cruce a la Colorado, which was nearly canceled after narco-ranchers cleared forest.  
** Ownership types overlap (see Figure 2), and thus forest loss in individual ownership types do not equal the sum of forest loss at the country scale.
possible upper areal estimate of land cleared by large holders that could be attributable to narcotrafficking directly or indirectly. In regions with evidence of both high narcotrafficking intensity and land control (eastern Honduras—Colon, Olancho, and Gracias a Dios departments, and northern/pacific Guatemala—Izabal, Petén, Retalhuleu, and Escuintla), 329,106 ha and 633,891 ha of sustained forest loss occurred in Honduras and Guatemala, respectively. In Guatemala, at least 15% of sustained forest loss (95,914 ha) are directly attributable to narcotraffickers based on spatially explicit data of cartel land holdings and community forest concessions canceled due to narcotrafficking. However, directly attributing the vast majority of forest loss in Guatemala (85%) and all forest loss in Honduras remains elusive due in inadequate spatial information (e.g., exact polygons) associated with documented money laundering operations, land seizures, and airstrips. Spatial and temporal patterns of land control by narcotraffickers at municipal and departmental spatial scales, however, provide strong evidence that a large yet unquantifiable portion of land change occurred due to narco control.

Sustained forest loss patterns, an indicator of large holders clearing land, were uneven across land ownership type. Contrary to research claiming ‘unpeopled’ protected areas are the most preserved (Jones et al. 2018), we find sparsely populated publicly held lands, such as protected areas, have the highest proportion of sustained forest loss (>60% and >70% in Honduras and Guatemala, respectively). This means protected areas in strategic narcotrafficking regions are the most vulnerable land tenure type to forest loss. Sustained forest loss in commonly held land in Indigenous territories is near 50%, and 64% and 43% of total forest loss in Guatemala’s community concessions and Honduras’s community managed areas respectively. Previous research in Central America and Colombia also indicates cocaine influences forest loss more in protected areas than other regions (Bonilla-Mejía & Higuera-Mendieta 2019; Clerici et al. 2020; Sesnie et al. 2017). Our findings align with research in the Amazon showing that in Indigenous territories where control is maintained, deforestation and large fire occurrence are lessened (Baragwanath & Bayi 2020; Nepstad et al. 2006; Ricketts et al. 2010). Even in the Amazon, however, land titles for Indigenous communities does not ensure land control, and titles are not universally effective in limiting illicit forest loss (BenYishay et al. 2017).

How land is controlled ultimately determines the ways that it can be and is used. In the three canceled community concessions (and one active concession) in Guatemala, narcotraffickers disrupted community control. The remaining community concessions continue to resist incursions from narcotrafficking and forest loss, even as nearby protected areas are rapidly deforested. Importantly, Guatemala’s community concession model is supported by years of international investment and a protracted social struggle (Devine 2018). By contrast, in Honduras, the recently titled Indigenous territories received little international and state support to maintain land control, rendering them vulnerable to lose control to narcotraffickers or other colonists (Hale 2011; PRISMA 2014). What impact could large and sustained investments in land control mechanisms (such as those in Guatemala’s concessions) in other protected areas or Indigenous lands in Central America have?

Ensuring the continued success of Guatemala’s sustainable forest management concessions (Gnych et al. 2020) requires more than just continued financial and political support required to maintain land control. US interdiction policies that push narcotraffickers into forested regions in Guatemala and elsewhere in Central America (N. Magliocca et al. 2019; Mcsweeney 2020) threatens the success of community, Indigenous, and State conservation initiatives. Interdiction has negative environmental consequences that often go unacknowledged in both drug and conservation policy (McSweeney et al. 2014).

The sustained forest loss rates and clandestine airstrips in protected areas, in conjunction with canceled forest concessions in Guatemala, are evidence that land control supersedes land tenure or property rights. Similar to Colombia’s narco-frontiers, insecure land tenure or property rights are unlikely to prevent changes in land control and use (Grajales 2011) particularly where land access and control is maintained externally. Narcotrafficking creates territories of impunity (Devine et al. 2021), exempt from laws restricting violence or land use changes. Narcotrafficking organizations coopt the land use process for private, public, and commonly held lands with strong incentive to reduce risks to capital investments. At the same time, state agencies and political leaders criminalize and scapegoat Indigenous and peasant residents in areas of NARC-LOC (Devine et al. 2020) and members of organized crime murder environmental defenders, like Berta Caceres of Honduras and David Salguero of Guatemala, often with impunity (Glazebrook & Opoku 2018).

Narcotraffickers have no monopoly on violence. Shifts in land control are often achieved through violence, when conservation edicts require displacement of residents (West et al. 2006) or cattle ranchers assert control on the Amazonian frontier (Damasceno et al. 2017). However, the extreme physical and financial violence of the drug business typically far exceeds that used otherwise to exclude others from land. For example, Caso Genesis showed that social elites and DTOs with financial means use violence to co-opt the land titling process, dispossess occupants, and expand agricultural lands at a greater rate than small-share farmers.
Some changes in land control, especially outside of protected areas, do not occur violently, and are legally accumulating assets in agribusinesses by narcotraffickers, other elites, and high-ranking politicians. Political leaders, including the 2014–present (as of this writing in 2021) President of Honduras, Juan Orlando Hernández, have been accused of accepting bribes from narcotraffickers to fund political campaigns in exchanging for protecting trafficking routes (Asmann et al. 2021; ‘Convicted drug trafficker testifies that he bribed Honduran president,’ 2021; Palmer & Semple 2021). Historic lack of support for Indigenous communities to control territory, defend sovereignty, and invest in development combined with high levels of poverty predispose locals to sell land to narcotraffickers under duress. Narcotrafficking can indirectly shape landscapes: NGOs reported in Honduras that narcotrafficking increased land consolidation, displacement, and illegal settlements by third parties.

Narcotrafficking embeds in and accelerates existing processing already consolidating land towards large holders in public and common land. Prior to the arrival of narcotraffickers, the arrival of non-indigenous settler campesinos transformed lands under state and Indigenous control to smallholding private control eventually legitimized by the state (e.g., Hayes 2008). After the arrival of narco-traffickers, the process of enclosure and privatization (Blomley 2007; Humphrey & Verdery 2020; Mansfield 2007) started decades before by settlers accelerated and expanded. These transitions did not occur everywhere simultaneously, or over the same number of years; the dates of traffickers’ arrival and intensity of trafficking on Central American frontiers varies by country and sub-region. Our data indicate the transition in control began near 2010 in Gracias a Dios, Honduras, around 2003 in Petén, Guatemala, and near 2008 in Izabal Guatemala. Variance in NARC-LOC across regions that could be due to DTOs adapting to interdiction efforts, e.g., in Guatemala zero-cattle policies in the Petén displacing DTOs to Izabal (N. Magliocca et al. 2019).

Land control transitions are not permanent or linear. In some cases, the state re-assumed its effective control over community concessions that were overtaken by private interests (including DTOs). Multiple actors may create alliances (e.g., peasants in Laguna del Tigre, Guatemala with politicians or narcotraffickers) that transform de facto land control into legal land rights. These relations are observed in other narco-frontiers (Ballvé 2018; Grajales 2011) and non-narco frontiers (N. R. Magliocca et al. 2019; Springer 2013).

Our evidence strongly suggests that narcotrafficking directly and indirectly accelerates the privatization of publicly and commonly held land, as well as the consolidation of private lands into fewer hands. These shifts in land control type are ultimately what cause the deforestation observed in this region (McSweeney et al. 2014; Sesnie et al. 2017; Tellman et al. 2020b) and elsewhere. Privatization of commonly held property in Yucatan Mexico, for example, is linked to increased deforestation (Lawrence et al. 2019). Absentee land control on the Central American frontier typifies a global trend in which corporate financial and agribusiness entities seek land for financial speculation and investment (Ashwood et al. 2020; Borras et al. 2012).

Further investigation is required to better understand not just the form of land control transition but also its pace. The speed of narco-land-grabbing and the saturation of the violent authority of narcotraffickers over landed property regimes makes resisting control difficult. The way narcotrafficking capital opens and shapes informal frontier land markets that continue to accelerate with new actors even after drug flows shift is also not well known. We found narcotrafficking foments land consolidation, displacement of owners, and illegal settlements in private, commonly held, and protected areas previously protected from accelerated forest loss. Future research could compare how land control in narco-frontiers might shape land change outcomes differently than frontiers where drugs are not involved, or how interdiction influences these dynamics. For example, in the Brazilian Amazon, organized crime and lack of governance wrestled land control from Indigenous forest defenders (Acebes et al. 2019), increasing illegal logging and reversing a trend of reduced forest loss.

Ultimately, we acknowledge that drug traffickers and other illicit actors are enabled by a prohibitionary drug control regime that has historically served the interests of landed elites and investors from the Global North (Paley 2014). In effect, narco-traffickers act as an advance front in the extension of capitalist social relations into the most relatively under-capitalized spaces of Central America: Indigenous lands and conservation set-asides (McSweeney et al. 2017). These processes of accumulation do not require drug traffickers, but, as we show here, in Honduras and Guatemala, narco-trafficking greatly accelerated the rate at which control over these frontier landscapes was transferred from many smallholding peasants and Indigenous peoples, or from state-held commons, to privatized enclosures held by a relatively small number of local elites and absentee landowners.
Conclusion
Changes in land control can represent an abrupt departure from land stewardship, biodiversity protection, and sustainable socioeconomic development within protected areas or community forest concessions. Drug trafficking can change the social relations around land, causing dispossession and transfers of land control. In this paper we conceptualize how land control and the ability to access land changes land use when Central America’s frontiers become enrolled in the drug trafficking business. The incomplete spatial precision outlining where narcotraffickers control land obfuscates attributing each hectare of land use change caused by narcotrafficking. Despite these limitations, we marshal evidence demonstrating that narcotrafficking activities initiate profound shifts in how and where land is controlled, resulting in sustained forest loss patterns. Forest loss associated with changes in land control significantly threatens the conservation and protection of increasingly scarce forested landscapes.

These findings suggest that significant prior international investment in land rights and land tenure regularization in Central America—from protected areas to community concessions—are at considerable risk unless NARC-LOC can be addressed. To reduce the ways in which drug trafficking activities lead to widespread land privatization, it is essential for Central American governments, with the support of bilateral and multi-lateral partnerships to: a) promptly investigate accusations of land seize that Indigenous and peasant groups continue to file with state prosecutors; b) champion the communal land regimes of Indigenous peoples by supporting their efforts at land management sovereignty, including saneamiento (clearing territory of invaders), and c) calling out elite abuses of power in protected areas as part of broader anti-corruption efforts. Absent these initiatives—ideally implemented simultaneously—the existing, pervasive and pronounced role of narcotrafficking further concentrates territorial and economic wealth in Central America. Absent aggressive action, illegal economies can be expected to play a significant role in further concentrating land, increasing rural inequality, and delivering land to absentee actors with little incentive to invest in the long-term well-being of local peoples and ecosystems.

Additional File
The additional file for this article can be found as follows:

• Supplementary figures and tables. Supplementary figure 1 map of forest loss in concessions (and canceled concessions) or community managed areas. Supplementary tables 1 includes emblematic cases of narcotraffickers seizing land in protected areas in the Petén. Supplementary Tables 2 and 3 include forest loss totals and rates from 2000-2019 for Honduras and Guatemala, respectively. DOI: https://doi.org/10.31389/jied.83.s1

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Competing Interests
The authors have no competing interests to declare.

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