The Conservation Paradox:

How Armed Groups and the State Shape Forest Governance and Conservation in Colombia

Abstract

Nearly half of rebel groups worldwide engage in some form of environmental governance. Drawing on an original household survey, satellite measures of forest loss, and qualitative interviews from the Colombian Amazon, we document a paradox: armed-group governance is associated with more rules concerning forest use, but not with reduced forest loss. We argue and show that the effects of environmental rules depend on the economic activities they regulate and on the configuration of actors that creates and enforces them. Forest loss is especially high where armed groups govern alongside local civilian institutions and illegal economies are prevalent, consistent with armed groups co-opting these institutions to promote extraction. By contrast, regional environmental authorities are associated with lower forest loss, especially where extractive pressures are greater. Environmental governance thus cannot be understood independently of the political economy of extraction.

Short title: The Conservation Paradox
Keywords: rebel governance; deforestation; environmental governance; armed groups; Colombian Amazon
Word count: 3,459

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1 Introduction

Armed groups are among the world's most prolific environmental regulators: nearly half engage in environmental governance, from regulating extractive industries to issuing fishing permits (Cunningham et al., 2025). They also often govern alongside others. In conflict zones, governance is typically contested, as state and nonstate actors create and enforce rules governing land and natural resources (Bolte, Yadav and Mukherjee, 2026). Yet this extensive rule-making often fails to produce conservation.

This article examines why. We argue that rules do not automatically produce conservation. Their effects depend on the economic activities they regulate and on *governance configurations*—the combination of actors and institutional arrangements through which a territory is governed. Economic activities shape actors' incentives toward conservation or extraction, while different actors possess institutional resources that may complement one another. Whether environmental rules produce conservation therefore depends on which actors govern, which govern together, and the activities they regulate.

We evaluate this argument in the contemporary Colombian Amazon, where state agencies, rebel successor groups, and local civilian institutions create and enforce overlapping rules governing land use. We draw on an original household survey ($N = 2{,}024$), satellite measures of forest loss, and qualitative evidence from interviews and focus groups. Because territorial control is not randomly assigned, our aim is to describe robust patterns rather than estimate causal effects.

Our findings establish a conservation paradox and point to its source. Rules governing resource use are abundant, more common where armed groups are present, and often supersede state rules. Yet armed-group governance is not associated with lower forest loss. Two further patterns suggest why. Forest loss is especially high where armed groups govern alongside local institutions and illegal economies are prevalent, consistent with armed groups co-opting those institutions to support the illicit activities that drive clearing. By contrast, regional environmental authorities—but not other levels of government—are associated with lower forest loss, especially where extractive pressures are greater. These results suggest that environmental rules fail to produce conservation when those who make and enforce them profit from forest conversion.

Our work contributes to several literatures. First, we add to research on how institutions shape deforestation. Existing studies center on electoral incentives (Sanford, 2023; Xu, 2025). Yet on many deforestation frontiers, those who make and enforce environmental rules are neither elected nor part of the formal state. We show how forest outcomes depend on which state and nonstate actors govern.

Second, our findings extend research on rebel governance. Existing work shows that armed groups with stable territorial control can provide order and public goods, often ruling through preexisting local institutions (Arjona, 2016; Breslawski, 2021; Sánchez de la Sierra, 2020). Recent work asks why they adopt environmental rules (Cunningham et al., 2025). We study fragmented authority, where armed groups, state actors, and community organizations govern together, and show that different governance configurations are associated with distinct environmental outcomes. Armed groups can govern extensively while organizing the very extraction their rules appear to regulate.

Finally, we contribute to research on armed conflict and the natural environment. Prior work shows that conflict can reduce deforestation by restraining economic activity or accelerate it through state withdrawal, illegal economies, and land grabbing (Burgess, Miguel and Stanton, 2015; Castro-Núñez, Mertz and Sosa, 2017; Fergusson, Romero and Vargas, 2014). This work typically treats armed-group presence as a single condition, which may help explain its divergent findings. We show instead that armed groups' environmental consequences depend on the organizations with which they govern and the economic activities they facilitate. More broadly, our findings challenge "governance vacuum" accounts (Ballvé, 2020; Gutiérrez-Sanín, 2019; Gutiérrez-Sanín and Vargas, 2017): deforestation reflects not only the absence of governance, but governance organized around extraction.

2 Armed Governance and Forest Loss in Colombia's Amazon

We focus on Colombia, a country that combines extraordinary biodiversity, high levels of deforestation, and fragmented governance across state institutions, armed groups, and criminal organizations. Annual forest loss nearly doubled between 2015 and 2018, from 124,000 to 197,000 hectares (Furumo and Lambin, 2020). Cattle ranching is the leading driver of deforestation in post-conflict Colombia, ahead of illicit crops (Vanegas-Cubillos et al., 2022). The backdrop for these pressures is a multi-decade, multi-actor armed conflict: 20 percent of the country's remaining closed-canopy forest lies in municipalities affected by violence (Álvarez, 2003).

Governance in our study region has long been contested among state and nonstate actors, each imposing distinct rules on land use and resource extraction. For decades, the FARC rebel group exercised territorial control over large areas and restricted logging, land clearing, and other forms of resource use (International Crisis Group, 2021). These rules served both military and governance purposes, preserving canopy cover while regulating civilian land use. Following the group's demobilization following the 2016 peace agreement, these constraints weakened or collapsed, contributing to an increase in deforestation (Prem, Saavedra and Vargas, 2020).

The FARC's exit marked a critical transition in resource governance as new armed groups and criminal organizations entered the region. These successor groups are more ideologically heterogeneous and generally pursue more extractive strategies. They often permit, tax, direct, and sometimes finance cattle ranching, coca cultivation, and other activities that depend on forest clearing (International Crisis Group, 2021). Deforestation also operates through land markets regulated by armed groups. In the Northwestern Amazon Arc, forest is occupied, cleared, converted to pasture, and incorporated into cattle, coca, and land-speculation circuits (Foundation for Conservation and Sustainable Development, 2023).

At the same time, the Colombian state has maintained only a limited and uneven presence on this frontier. In practice, governance is shared with local and regional institutions. The key local institutions are the *Juntas de Acción Comunal* (JACs)—elected, legally recognized village councils—which often serve as the primary rule-setters for land and forest use.[1] Environmental policy is formally administered by regional autonomous corporations (CARs), which issue permits, monitor land use, and set regulations, although their reach is uneven. Overall, forest governance is divided among armed groups, local institutions, environmental authorities, and other state agencies.

Our study covers eight municipalities in southern Meta and near Chiribiquete National Park (SI Figure A1). We surveyed households in two frontier settings. The first sample comprises *veredas*—rural villages, Colombia's smallest administrative units—around Puerto Rico, Meta, a former FARC stronghold. The second comprises peasant communities along an expanding agricultural frontier in Guaviare and Caquetá, delineated by survey *polygons* rather than administrative boundaries, where cattle ranching dominates, state presence is limited, and armed groups govern.

3 Data and Empirical Strategy

Data sources. The dynamics we study are difficult to observe. De facto governance does not appear in administrative records, and its consequences evolve in remote frontier regions. We therefore combine three sources: a household survey to identify who governs, satellite data to measure forest conservation, and qualitative fieldwork to trace how governance operates on the ground. Between February and April 2023, we surveyed 2,024 households in the Colombian Amazon about household forest use, governing actors (including armed groups and JACs), and enforcement (descriptive statistics appear in Supplementary Information (SI) Tables A1 and A2). We complement the survey with 11 focus group discussions and 54 semi-structured interviews with implementing partners, local authorities, and community leaders (SI Section C). This qualitative evidence documents how governance actors shape land and forest rules and perceptions of conservation efforts.

[1]In parts of Guaviare, armed groups have explicitly delegated environmental authority to JACs (International Crisis Group, 2021).

Forest outcomes come from satellite data and are therefore measured independently of household reports. For each surveyed household, we measure five-year forest loss within a 3-kilometer buffer as a share of the buffer area; results using a 5-kilometer buffer appear in the SI. We calculate geographic covariates over the same buffer and, in robustness checks, use geolocated data on violent events involving armed actors (Osorio et al., 2019).

Measuring Governance Configurations. We measure actor governance using a survey question asking which actors are responsible for forest governance across three roles—rule-making, monitoring, and enforcement. This approach treats governance as a set of functions rather than mere presence. Because co-governance is endemic in these settings, we construct three specifications: how much governance each actor performs (*functions*), how governance is divided among actors (*governance shares*), and which actor dominates (*dominance*).

The *functions* specification counts, for each actor, the number of roles for which it is named, from zero to three, and standardizes the resulting measure. The *governance-shares* specification measures each actor's share of governance across the three roles, assigning equal shares within a role when households name more than one actor. The *dominance* specification classifies households by the actor holding the largest governance share. Households in which two or more actors tie for the largest share form separate co-governance categories, including the armed–JAC dyad examined in Section 5. Households naming no governing actor form the comparison group unless otherwise noted. We use the *functions* specification as our primary specification and the *dominance* specification for the configurational analyses; full results for all three appear in the SI.

Empirical Strategy. We estimate cross-sectional OLS regressions of the form

$$Y_{i,v} = \alpha + \beta_1 \text{Armed}_i + \beta_2 \text{JAC}_i + \beta_3 \text{OtherLocal}_i + \beta_4 \text{NatState}_i + \beta_5 \text{CAR}_i + \beta_6 \text{MuniGov}_i + X_i' \gamma + \varepsilon_{i,v}. \quad (1)$$

where $Y_{i,v}$ is an outcome for household i in vereda v. The six actor variables enter jointly, using one of the three specifications described above: armed groups; community action boards (JACs), the local institutions at the center of our argument; other local organizations; the national government; regional environmental authorities; and municipal governments. Each coefficient is therefore conditional on the governance of the other actors. In the *governance-shares* specification, the armed-group share is omitted and serves as the baseline. Municipal governments and other local organizations enter every regression but are omitted from some figures to reduce clutter.

All models include household controls and, in the combined sample, a sample fixed effect. Models of satellite-measured forest loss also include elevation, slope, precipitation, distances to roads, towns, water, and navigable water, and year-2000 forest cover. Standard errors are clustered by *vereda*. Because our argument implies that the effects of rules depend on the activities they regulate, we interact the actor variables with household tolerance of illegal cattle ranching and coca cultivation. Results from geographic sample splits and robustness checks appear in SI Sections H and I. Because territorial governance is not randomly assigned, these estimates do not identify causal effects.

4 Results

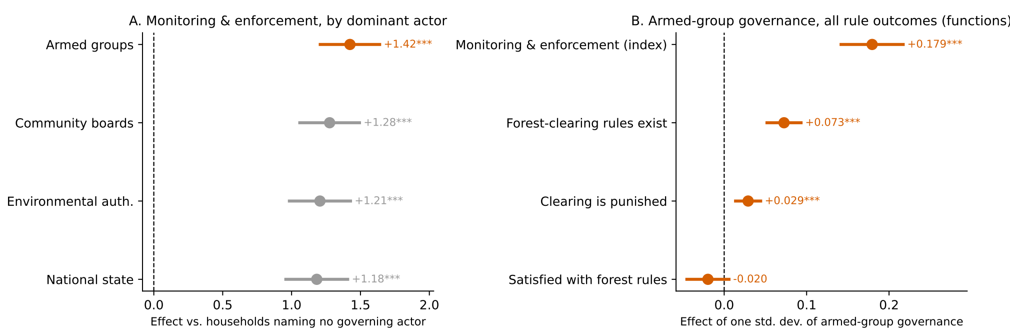
4.1 Armed groups produce the most environmental governance

We first examine who governs the forest. By households' own accounts, armed groups are in charge. Panel A of Figure 1 compares households according to the *dominant* governing actor with households naming no governing actor. The outcome is a standardized index of how effectively rules governing forest use are monitored and enforced. Where armed groups dominate, the index is 1.42 standard deviations higher—the largest estimate for any actor and significantly larger than each of the others ($p \leq .004$). The *governance-shares* specification yields the same pattern: relative to armed groups, a larger governance share for any other actor predicts less monitoring and enforcement (SI Table A7).

Armed groups' advantage also holds when we examine the number of roles they perform (Panel B, *functions* specification). A one-standard-deviation increase in armed-group governance predicts a 0.179-standard-deviation increase in monitoring and enforcement, a 7.3-percentage-point increase in the probability that forest-clearing rules exist, and a 2.9-percentage-point increase in the probability that violations are punished.

Focus group evidence supports these findings: residents and key informants widely describe armed groups as the de facto rulers of the forest. A park ranger in Caquetá called them “the ones who rule the territory.” In Vista Hermosa, a member of a civil society organization explained: “They gave the order that nobody could cut, so let’s say that conservation depends a lot [on them] . . . [the state environmental authority] is not as much in charge as they are.” Others described their role in rule-making: “they [. . .] have [forest management] manuals, they have environmental committees [. . .] there is no representation of the Colombian State” (park ranger, Caquetá). As a farmers’ cooperative leader summarized, in the forest “there are two laws.”

Figure 1: Armed groups produce the most environmental governance



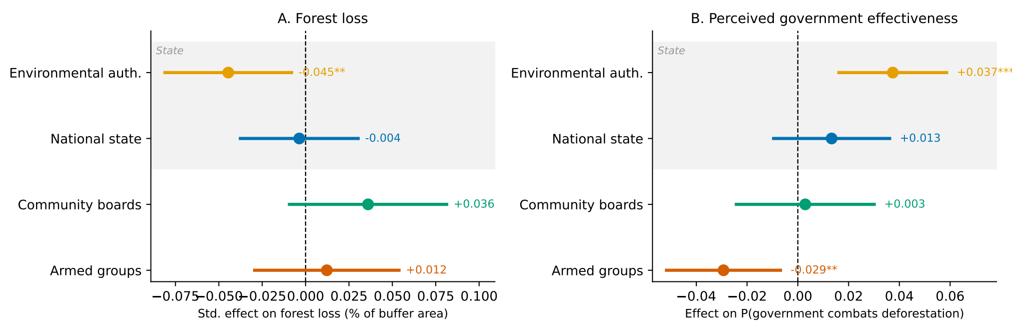
Notes: Panel A: dominance specification. Coefficients are for dominant-actor categories in the six-actor classification, relative to households naming no governing actor, with the standardized monitoring-and-enforcement index as the outcome. Municipal government and other local organizations are estimated but not shown. Panel B: functions specification. Coefficients are for z-scored armed-group governance functions across the four rule outcomes; all six actors enter jointly. The monitoring-and-enforcement index is standardized; the remaining outcomes are binary. The punishment item is asked only where rules exist ($N = 1{,}252$). All models include household controls and a polygon-sample indicator. Standard errors are clustered at the vereda level. Full estimates: SI Tables A6–A8. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.2 Governance does not translate into forest conservation

Does rebel governance conserve the forest? Panel A of Figure 2 suggests not. Armed-group governance—the strongest predictor of rule-making, monitoring, and enforcement—is not associated with lower forest loss. JAC governance is positively but not significantly associated with forest loss, while governance by the national government is unrelated to it. The exception is governance by environmental authorities: a one-standard-deviation increase predicts 0.045 standard deviations lower forest loss ($p = .019$), a 4.1% reduction relative to the average loss rate of 4.6%, or roughly 5.4 hectares over five years. Governance and conservation thus diverge: the actor that governs the forest most extensively does not conserve it, while the actor associated with conservation does not govern it most extensively.

Panel B suggests why. Where environmental authorities govern, residents perceive the government as 3.7 percentage points more effective against deforestation ($p = .001$); where armed groups govern, they perceive it as 2.9 percentage points less effective ($p = .012$).

Figure 2: Forest loss and perceived state effectiveness, by governing actor



Notes: Functions specification, combined sample. All six actors enter jointly; four are shown. All models include household controls; Panel A also includes geographic controls, including year-2000 forest cover. Standard errors are clustered at the vereda level. Panel A shows standardized five-year forest loss as a share of buffer area. Panel B shows perceived government effectiveness in combating deforestation. Full estimates: SI Tables A9–A10. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Our focus-group evidence supports this contrast. Participants in a women's focus group in Puerto Rico reported that "since [environmental authorities] came in, they have not cut again." Armed groups, however, often prevent environmental authorities from reaching communities. A park ranger in Caquetá explained: "The groups outside the law are the ones that have not allowed us to approach the communities and to carry out this prevention process throughout the territory," adding that "since 2018 we have not been able to return to the territory." These interactions can also turn violent: "the [armed groups] killed an [environmental authority] official in November" (civil society organization member, Vista Hermosa). Overall, these patterns are consistent with armed groups not merely failing to conserve, but crowding out the actor that does.

5 Why Rules Do Not Produce Conservation

5.1 Armed cooptation of local institutions

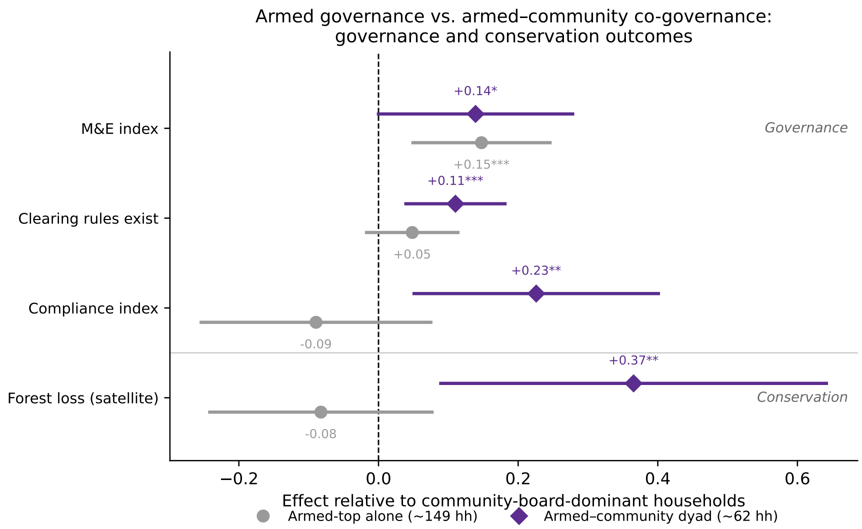
The results so far show that armed-group governance is not associated with conservation and that local institutions (JACs) may also be associated with deforestation. We argue that this pattern reflects a specific governance configuration in which armed groups co-opt local institutions, one associated with greater forest loss. This configuration combines the institutional resources of JACs with the coercive capacity of armed groups. Historically, the FARC governed through JACs, which provided local legitimacy, community monitoring, conflict resolution, and knowledge of land use, while the guerrilla provided coercive enforcement. Successor groups inherited this architecture but repurposed it toward extraction. For instance, recent reports show that JAC-issued certificates of possession facilitate cattle-credit schemes and land transactions involving newly cleared pasture (La Silla Vacía, 2026). Armed groups have also compelled JACs to support illegal road construction (International Crisis Group, 2024). JACs therefore provide armed groups with legal recognition, documentation, and access to administrative processes that can facilitate land clearing.

Figure 3 compares households under armed-group dominance and armed–JAC co-governance with those under JAC dominance. Armed-group dominance alone predicts stronger monitoring but not greater forest loss. By contrast, armed–JAC co-governance predicts more forest-clearing rules, greater compliance, and about 0.4 standard deviations greater satellite-measured forest loss—significantly greater than under either single-actor configuration. This pattern is consistent with institutional complementarity, in which the two actors' resources jointly help organize extraction.

5.2 Regulation and extraction as joint products of territorial control

We contend that the political economy of extraction helps explain this pattern. Armed groups are deeply invested in the extractive economy: they tax, direct, or finance cattle ranching, coca produc-

Figure 3: Armed governance vs. armed–community co-governance: governance and conservation outcomes



Notes: Dominance specification. Armed–community co-governance denotes households in which armed groups and community boards tie for the largest governance share. Coefficients for armed–community co-governance and armed-dominant households are relative to community-board-dominant households. All models include household controls; models with the satellite outcome also include geographic controls. Standard errors are clustered by vereda. Upper rows show governance outcomes: the monitoring and compliance indices are standardized, and the remaining outcomes are binary. Lower rows show conservation outcomes: forest loss is standardized five-year satellite-measured loss as a share of buffer area. On satellite forest loss, co-governance exceeds the armed-dominant configuration (difference $+0.448$, $p = .005$); the two single-actor configurations do not differ from each other ($p = .31$). Full estimates: SI Table A11. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

tion, illegal roads, timber extraction, and land speculation; they reportedly pay farmers $80–90 per hectare to clear forest, tax the resulting cattle operations, and profit from illegal road construction (International Crisis Group, 2021). Land clearing, in turn, converts occupied forest into pasture that can be sold or incorporated into cattle and land markets (Foundation for Conservation and Sustainable Development, 2023). Armed groups thus regulate the same activities from which they profit: their rules support territorial control without producing conservation. An observable implication of this account is that the relationship between governance and forest loss should depend on the local prevalence of extractive activities.

Figure A2 examines this implication by interacting governance by each actor with separate indicators for whether respondents consider illegal cattle ranching and coca cultivation acceptable livelihoods, our proxies for the local prevalence of each activity. The patterns are strongest for coca and consistent with this implication. Where coca cultivation is tolerated, armed-group governance is associated with greater forest loss (interaction $= 0.128$, $p = .019$), whereas environmental-authority governance is associated with lower forest loss (interaction $= -0.101$, $p = .037$). The cattle interactions are weaker, although JAC governance is more strongly associated with forest loss where illegal cattle ranching is tolerated. The armed–JAC co-governance estimates follow the same pattern but are imprecise.[2]

These estimates are associational and might reflect the selection of armed groups into areas already prone to clearing. An exposure analysis based on predetermined coca cultivation and the collapse in coca prices from 2016 to 2022 yields the same pattern: more exposed places experienced greater forest loss (SI Section J).

6 Conclusion

Deforestation reflects not the absence of rules, but who governs and to what end. In the Colombian Amazon, armed groups produce extensive rules, monitoring, and enforcement, yet forest loss does not decline and may rise under their rule. Only regional environmental authorities are associated with conservation. Our findings challenge the view of extractive frontiers as "governance vacuums" (Ballvé, 2020): rules can organize extraction as well as restrict it. They also carry a caution for post-conflict conservation policy, which often works through community institutions and calls for more state presence. In frontier zones, community institutions can be captured, and not all forms of state presence produce conservation. Future research should examine whether community institutions can resist rebel rule in extractive frontiers (Arjona, 2016) and how environmental authorities gain access to armed-group territory.

[2]Full interaction terms appear in SI Table A12; SI Figure A3 plots the fitted relationships for armed groups and environmental authorities.

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Competing interests: The authors declare none.

Use of Artificial Intelligence (AI) Tools: We used Claude Code with Anthropic's Claude Opus 4.8 and Fable to assist with data cleaning and coding. All code, analytical decisions, analyses, and interpretations were reviewed and finalized by the authors. We used OpenAI's ChatGPT to assist with copyediting and stylistic revision.

Supplementary Information:

The Conservation Paradox:

How Armed Groups and the State Shape Forest Governance and Conservation in Post-Conflict Colombia

Contents

A Descriptive statistics

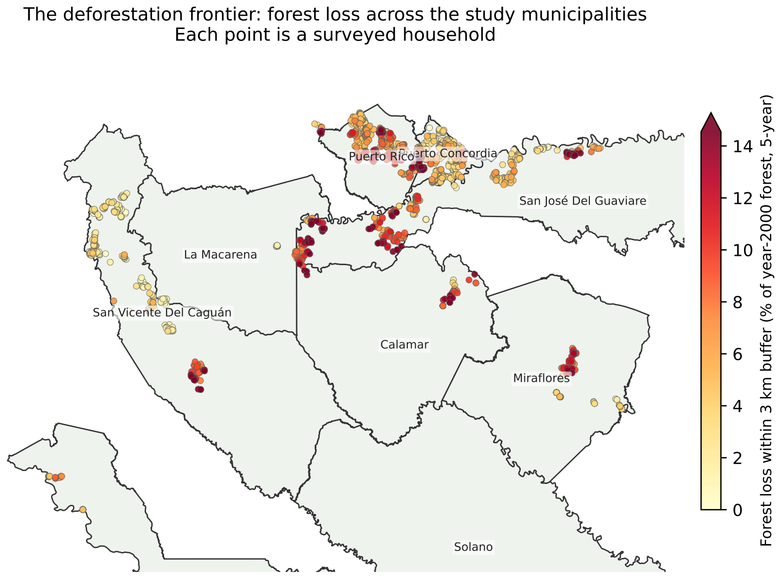


Figure A1: Study area: the deforestation frontier. Each point is a surveyed household, colored by five-year forest loss within a 3-kilometer buffer as a share of year-2000 forest cover. The vereda sample surrounds Puerto Rico (Meta); the polygon sample spans San José del Guaviare, Miraflores, Calamar, San Vicente del Caguán, and Solano (Guaviare and Caquetá departments).

Table A1: Descriptive statistics: outcomes and governance measures

	N	Mean	SD	Min	Max
Panel A: Governance and conservation outcomes					
Monitoring & enforcement index (std.)	1,975	-0.00	1.00	-2.54	0.50
Compliance index (std.)	2,000	-0.00	1.00	-4.55	1.14
Clearing rules exist	1,759	0.78	0.42	0.00	1.00
Rule violations punished	1,354	0.87	0.33	0.00	1.00
Satisfied with forest management	1,992	0.66	0.47	0.00	1.00
Government effective vs. deforestation	1,989	0.56	0.50	0.00	1.00
Cleared virgin land, past 12 months	2,002	0.14	0.35	0.00	1.00
Plans to clear, next 12 months	1,981	0.10	0.31	0.00	1.00
Five-year forest loss (% of buffer area)	2,003	4.6	4.3	0.0	38.2
Five-year forest loss (% of year-2000 forest)	2,003	6.0	4.4	0.0	22.9
Panel B: Governance measures					
Armed groups: governance roles (0–3)	2,003	0.54	0.96	0.00	3.00
Community boards (JAC): governance roles (0–3)	2,003	1.27	1.21	0.00	3.00
Environmental authorities: governance roles (0–3)	2,003	0.92	1.11	0.00	3.00
National government: governance roles (0–3)	2,003	0.53	0.90	0.00	3.00
Municipal government: governance roles (0–3)	2,003	0.48	0.88	0.00	3.00
Other local organizations: governance roles (0–3)	2,003	0.46	0.87	0.00	3.00
Armed groups: governance share (0–1)	1,734	0.13	0.22	0.00	1.00
Community boards (JAC): governance share (0–1)	1,734	0.33	0.31	0.00	1.00
Environmental authorities: governance share (0–1)	1,734	0.22	0.27	0.00	1.00
National government: governance share (0–1)	1,734	0.12	0.20	0.00	1.00
Municipal government: governance share (0–1)	1,734	0.09	0.17	0.00	1.00
Other local organizations: governance share (0–1)	1,734	0.10	0.20	0.00	1.00
Names no governing actor	2,003	0.13	0.34	0.00	1.00
Panel C: Moderators					
Tolerates illegal cattle ranching	1,979	0.40	0.49	0.00	1.00
Tolerates coca cultivation	1,955	0.16	0.37	0.00	1.00

Notes: Analysis sample: the 2,003 consented households; estimation samples vary by outcome. The monitoring-and-enforcement and compliance indices are standardized to mean zero and unit variance. Governance roles count the roles (rule-making, monitoring, enforcement) for which the actor is named (regressions use the z-scored version); governance shares are each actor's average share of named roles. Forest loss as a share of buffer area is the main-text outcome; the year-2000-forest share (winsorized at the 99th percentile) is the SI robustness outcome.

Table A2: Descriptive statistics: household characteristics and geographic covariates

	N	Mean	SD	Min	Max
Panel A: Household characteristics					
Respondent age (years)	1,987	48.8	14.3	6.0	88.0
Respondent female	2,003	0.36	0.48	0.00	1.00
Born in this vereda	2,003	0.26	0.44	0.00	1.00
Household size	2,003	3.3	1.6	1.0	7.0
Owns livestock	2,003	0.56	0.50	0.00	1.00
Holds any land title	2,003	0.10	0.30	0.00	1.00
JAC member	2,003	0.67	0.47	0.00	1.00
Ever forcibly displaced	2,003	0.32	0.47	0.00	1.00
Food insecurity	2,000	0.49	0.50	0.00	1.00
Coca cultivation history	2,003	0.19	0.39	0.00	1.00
High forest dependence	2,003	0.30	0.46	0.00	1.00
Land in protected area	1,944	0.15	0.36	0.00	1.00
Polygon sample	2,003	0.49	0.50	0.00	1.00
Panel B: Geographic covariates (3 km buffer)					
Elevation (m)	2,003	271	156	171	1,361
Slope (degrees)	2,003	3.1	3.7	0.8	24.1
Precipitation (mm)	2,003	2,771	281	1,957	3,529
Distance to road (km)	2,003	0.7	1.3	0.0	11.6
Distance to town (km)	2,003	7.6	8.1	0.0	52.1
Distance to water (km)	2,003	0.6	0.5	0.0	2.3
Distance to navigable water (km)	2,003	4.3	3.9	0.0	19.4
Year-2000 forest cover (%)	2,003	71.7	18.9	17.4	100.0

Notes: Distances are straight-line distances from the household; elevation, slope, precipitation, and forest cover are means over the 3-kilometer buffer.

B Survey data and methods

Soluciones Estratégicas en Información (SEI), a Colombian research firm, conducted the quantitative and qualitative data collection. Household data collection took place from February 26 to April 11, 2023. Enumerators recorded responses directly on Android smartphones using SurveyCTO, a cloud-based mobile data-collection platform.

The University of Pennsylvania Institutional Review Board approved the study in January 2023 (protocol 852855). Before administering the survey, enumerators read each prospective participant a standardized consent statement describing the purpose and content of the research, its anticipated risks and benefits, the expected time commitment, and the measures used to protect confidentiality. Participants provided verbal informed consent, which enumerators recorded in the electronic survey form. Data-quality procedures included direct observation of enumerators, field presence by the SEI field manager, daily remote checks by the research team, and audits and reinterviews of selected respondents.

The household survey took approximately 60 minutes to administer. It measured perceived tenure security, land rights and conflicts; livelihoods, income, and well-being; productive and housing investments and land clearing; and households' knowledge, experiences, and perceptions of land and forest governance.

The study focuses on communities along Colombia's expanding agricultural frontier in Meta, Guaviare, and Caquetá. The sampling frame was originally constructed around two USAID Land for Prosperity activities. In Puerto Rico, Meta, the evaluation team randomly selected 21 *veredas* from communities eligible for the municipal parcel sweep and added 25 communities in the neighboring municipalities of Puerto Concordia, La Macarena, and San José del Guaviare. For the community-level formalization component, the team sampled communities within priority polygons defined by the overlap of deforestation hotspots, ecological-connectivity corridors, settlements with high tenure informality, and areas prioritized for right-of-use contracts. Because the original polygons varied greatly in size and population, 71 polygons were consolidated into 30 "macropolygons." Within each macropolygon, one or more *veredas* were selected based on their geographic coverage of the macropolygon, population, rural character, and forest presence. Thus, the sample was designed to capture communities at the intersection of forest pressure, informal settlement, and overlapping environmental and land-governance institutions. It was designed to represent treatment and control areas for a future program evaluation of the Land for Prosperity activities, not rural Colombia as a whole.

Within the selected *veredas* and polygons, field teams used randomized procedures to select resident households and confirmed household locations by GPS. The design generally targeted at least 20 households per selected *vereda* or macropolygon, with larger samples in the original program areas and more populous or geographically extensive polygons. The resulting sample comprised 2,024 households across Puerto Rico and surrounding areas in Meta, Guaviare, and

Caquetá. Because armed-group activity prevented access to 14 initially selected *veredas* and to Cartagena del Chairá, inaccessible communities were replaced, where possible, with the nearest accessible *veredas*; the sample therefore does not represent communities that could not safely be reached during fieldwork.

C Qualitative data and methods

The qualitative data comprise 11 focus group discussions and 54 semi-structured key-informant interviews conducted between April 14 and May 17, 2023. Focus groups were held in five municipalities, including separate sessions for men and women and one additional session with participants in public–private conservation partnerships (Table A3). Interviewees included community and JAC leaders; municipal, departmental, and national officials; environmental authorities; civil-society and producer organizations; and implementing partners (Table A4).

Focus groups included six to eight participants, lasted about 90 minutes, and were led by a moderator and a notetaker. Interviews followed a semi-structured guide tailored to each informant type. The interviews covered institutional roles and priorities in conservation, land administration, resource protection, enforcement against illegal deforestation, and tenure security. Focus groups followed a structured protocol on land rights, land disputes, land governance, and rules governing forest clearing. Both instruments are included in the replication materials.

Participants provided informed consent through a standardized script. Participation was voluntary. Respondents could decline any question. Names would not be used in reporting, and identifying information would remain confidential. Sessions were conducted in Spanish and recorded with participants' consent. Recordings were destroyed after transcription, and the transcripts were professionally translated into English.

Quotations in the main text come from the translated transcripts. Omissions and clarifications are marked by ellipses and brackets. Table A5 maps each quotation to its source transcript, and speakers are identified only by role and municipality. We do not publicly deposit the transcripts because the interviews concern armed-group governance in an active conflict setting and participants may be identifiable from their roles and locations. Public release would violate the confidentiality terms under which consent was obtained.

Table A3: Focus group discussions

ID	Municipality	Department	Participants
GF_MUJERES_PR	Puerto Rico	Meta	Women
GF_HOMBRES_PR	Puerto Rico	Meta	Men
GF_APP_PR	Puerto Rico	Meta	Public–private partnership participants
GF_MUJERES_PC	Puerto Concordia	Meta	Women
GF_HOMBRES_PC	Puerto Concordia	Meta	Men
GF_MUJERES_SJG	San José del Guaviare	Guaviare	Women
GF_HOMBRES_SJG	San José del Guaviare	Guaviare	Men
GF_MUJERES_MF	Miraflores	Guaviare	Women
GF_HOMBRES_MF	Miraflores	Guaviare	Men
GF_MUJERES_SVC	San Vicente del Caguán	Caquetá	Women
GF_HOMBRES_SVC	San Vicente del Caguán	Caquetá	Men

Notes: Eleven focus group discussions, April–May 2023. Sessions were conducted in Spanish and translated into English.

Table A4: Semi-structured interviews, by informant type and location

Informant type	Meta	Caquetá	Guaviare	Puerto Rico	Polygon communities	Subnational	National	Total
Community and local leaders	0	0	0	1	2	0	0	3
Civil-society and producer organizations	2	3	3	5	2	0	0	15
JAC leaders	0	0	0	1	3	0	0	4
Municipal and departmental government	0	1	1	2	0	1	0	5
Environmental authorities	1	3	3	0	0	0	0	7
National agencies	0	0	0	0	0	0	11	11
Implementing partners and NGOs	0	1	1	1	0	0	6	9
Total	3	8	8	10	7	1	17	54

Notes: Counts are drawn from the baseline evaluation report. Detailed informant types were collapsed into the broader categories shown here. Civil-society and producer organizations include partnership, producer, and community-based organizations; implementing partners and NGOs include LfP implementers and conservation organizations. Location columns are mutually exclusive: Puerto Rico interviews are not also counted under Meta, and interviews identified only as occurring in polygon treatment communities are not assigned to a department. Subnational denotes one interview with a departmental or municipal land authority for which the source table does not identify a specific location. JAC denotes Junta de Acción Comunal.

Table A5: Provenance of quotations used in the main text

Quotation (abridged)	Transcript	Speaker	Location
"those who rule the territory"	EI_GUARDAPARQUES_1	Park ranger	Caquetá
"they gave the order that nobody could cut..."	EI_OSC_VH	CSO member	Vista Hermosa
"internal coexistence manuals... environmental committees"	EI_GUARDAPARQUES_1	Park ranger	Caquetá
"there are two laws"	EI_OSC_VH	CSO member	Vista Hermosa
"since CORMACARENA came in, they have not cut again"	GF_MUJERES_PR	Women's focus group	Puerto Rico
"have not allowed us to approach the communities..."	EI_GUARDAPARQUES_1	Park ranger	Caquetá
"the dissidents killed a CORMACARENA official in November"	EI_OSC_VH	CSO member	Vista Hermosa

Notes: Transcript IDs follow the fieldwork naming convention (EI = individual interview; GF = focus group). Quotations are from the English translations of the transcripts.

D Governance production: full estimates

Table A6: Governance functions and rule outcomes: full estimates (functions specification)

	(1) M&E index	(2) Rules exist	(3) Punished	(4) Satisfied
Armed groups	0.179***	0.073***	0.029***	-0.020
	(0.019)	(0.011)	(0.008)	(0.013)
Community boards (JAC)	0.179***	0.073***	0.013	0.025*
	(0.023)	(0.013)	(0.013)	(0.013)
Environmental authorities	0.168***	0.037***	0.025***	0.009
	(0.024)	(0.012)	(0.009)	(0.011)
National government	0.056***	0.007	0.009	0.033***
	(0.020)	(0.011)	(0.014)	(0.010)
Municipal government	0.013	0.001	-0.005	0.010
	(0.024)	(0.012)	(0.011)	(0.011)
Other local organizations	0.093***	0.027***	-0.008	-0.013
	(0.021)	(0.010)	(0.013)	(0.010)
Observations	1,831	1,628	1,252	1,845

Notes: Functions specification, combined sample: each actor's z-scored count of governance roles (0–3), all six actors estimated jointly. Column (1) is the standardized monitoring-and-enforcement index; columns (2)–(4) are binary. The punishment item is asked only where rules exist. All models include household controls and a polygon-sample indicator. Standard errors, clustered by vereda, in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A7: Governance shares and rule outcomes: full estimates (linear-shares specification)

	(1) M&E index	(2) Rules exist	(3) Punished	(4) Satisfied
Community boards (JAC)	-0.329***	-0.140**	-0.090*	0.161**
	(0.080)	(0.055)	(0.048)	(0.065)
Environmental authorities	-0.290***	-0.234***	-0.047	0.139**
	(0.084)	(0.058)	(0.047)	(0.064)
National government	-0.515***	-0.296***	-0.065	0.233***
	(0.112)	(0.081)	(0.074)	(0.077)
Municipal government	-0.575***	-0.316***	-0.158*	0.158**
	(0.169)	(0.092)	(0.085)	(0.074)
Other local organizations	-0.397***	-0.170***	-0.130	0.087
	(0.124)	(0.061)	(0.089)	(0.079)
Observations	1,596	1,586	1,236	1,602

Notes: Linear-shares specification, combined sample: each actor's governance share, with the armed-group share omitted as the baseline; coefficients are interpreted relative to armed groups. Column (1) is the standardized monitoring-and-enforcement index; columns (2)–(4) are binary. The punishment item is asked only where rules exist. All models include household controls and a polygon-sample indicator. Standard errors, clustered by vereda, in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A8: Dominant governing actor and rule outcomes (dominance specification)

	(1) M&E index	(2) Rules exist	(3) Punished	(4) Satisfied
Armed groups top	1.424***	0.400***	0.213	0.028
	(0.110)	(0.103)	(0.134)	(0.047)
Community boards (JAC) top	1.276***	0.352***	0.196	0.088*
	(0.111)	(0.101)	(0.129)	(0.044)
Environmental authorities top	1.206***	0.285***	0.227*	0.082*
	(0.113)	(0.105)	(0.133)	(0.045)
National government top	1.183***	0.312***	0.234*	0.108**
	(0.115)	(0.112)	(0.132)	(0.046)
Municipal government top	1.019***	0.186	0.093	0.060
	(0.173)	(0.122)	(0.152)	(0.061)
Other local organizations top	1.132***	0.320***	0.179	0.054
	(0.161)	(0.118)	(0.153)	(0.061)
Observations	1,831	1,628	1,252	1,845

Notes: Dominance specification, combined sample: indicators for the actor holding the largest governance share, relative to households naming no governing actor; tied-top (co-governance) categories are estimated but not shown. Column (1) is the standardized monitoring-and-enforcement index; columns (2)–(4) are binary. All models include household controls and a polygon-sample indicator; standard errors, clustered by vereda, in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

E Conservation and perceived effectiveness: full estimates

Table A9: Governance and conservation outcomes: full estimates (functions specification)

	(1) Forest loss (satellite)	(2) Perceived effectiveness
Armed groups	0.012	-0.029**
	(0.021)	(0.011)
Community boards (JAC)	0.036	0.003
	(0.023)	(0.014)
Environmental authorities	-0.045**	0.037***
	(0.019)	(0.011)
National government	-0.004	0.013
	(0.017)	(0.012)
Municipal government	0.027	0.012
	(0.019)	(0.013)
Other local organizations	-0.011	0.009
	(0.018)	(0.013)
Observations	1,853	1,844

Notes: Functions specification, combined sample: each actor's z-scored count of governance roles, all six actors estimated jointly. Column (1) is standardized five-year forest loss as a share of total buffer area within the 3-kilometer household buffer, with year-2000 forest cover among the geographic controls (household controls, polygon-sample indicator, and eight geographic controls). Column (2) is a binary indicator for perceiving government efforts against illegal deforestation as effective (household controls and polygon-sample indicator). Standard errors, clustered by vereda, in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A10: Governance and conservation outcomes: full estimates (linear-shares specification)

	(1) Forest loss (satellite)	(2) Perceived effectiveness
Community boards (JAC)	0.080	0.150**
	(0.109)	(0.062)
Environmental authorities	-0.151	0.266***
	(0.123)	(0.067)
National government	-0.052	0.138*
	(0.117)	(0.078)
Municipal government	0.135	0.199**
	(0.167)	(0.097)
Other local organizations	-0.079	0.198**
	(0.118)	(0.087)
Observations	1,609	1,602

Notes: Linear-shares specification, combined sample: each actor's governance share, with the armed-group share omitted as the baseline; coefficients are interpreted relative to armed groups. Column (1) is standardized five-year forest loss as a share of total buffer area within the 3-kilometer household buffer (household controls, polygon-sample indicator, and eight geographic controls). Column (2) is a binary indicator for perceiving government efforts against illegal deforestation as effective (household controls and polygon-sample indicator). Standard errors, clustered by vereda, in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

F Armed–community co-governance: full estimates

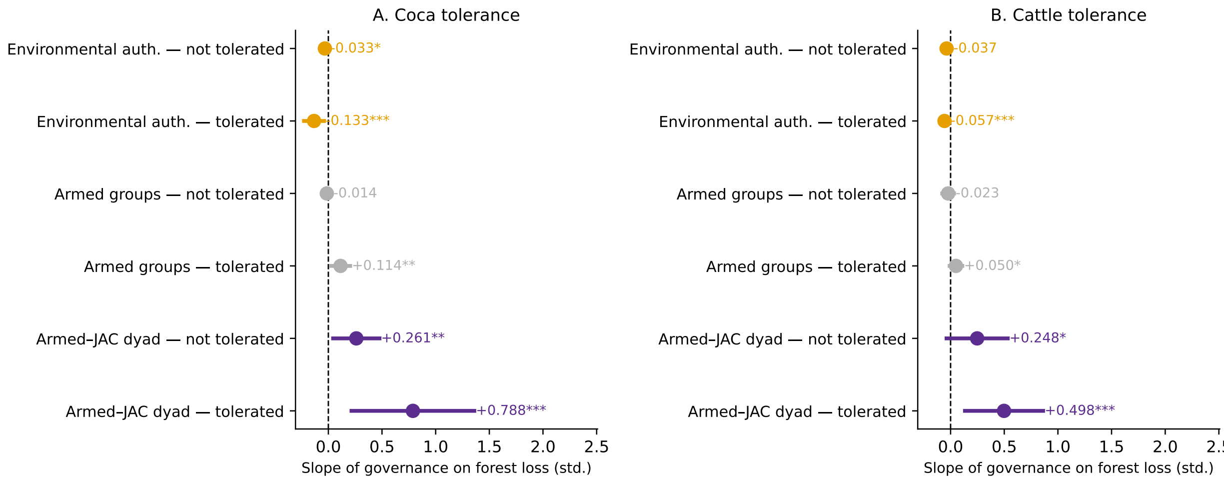
Table A11: Armed governance vs. armed–community co-governance: full estimates

	Armed-dominant	Armed–JAC dyad
M&E index	0.147***	0.139*
	(0.050)	(0.071)
Clearing rules exist	0.048	0.110***
	(0.033)	(0.036)
Punishment exists	0.017	0.066*
	(0.039)	(0.036)
Compliance index	-0.090	0.226**
	(0.084)	(0.089)
Leaders protect forest	-0.096*	0.117*
	(0.050)	(0.065)
Plans to clear	0.051	0.081**
	(0.031)	(0.039)
Forest loss, share of buffer area	-0.082	0.365**
	(0.081)	(0.141)
Forest loss, share of year-2000 forest	-0.097	0.414***
	(0.075)	(0.139)

Notes: On satellite forest loss, co-governance exceeds the armed-dominant configuration (difference $+0.448$, $p = 0.005$); the two single-actor configurations do not differ from each other ($p = 0.31$). Dominance specification: armed-dominant households and armed–JAC co-governance households (armed groups and community boards tied for the largest governance share), each relative to community-board-dominant households ($n = 149$ armed-dominant, $n = 62$ dyad). The monitoring and compliance indices and satellite forest loss are standardized (forest loss is shown both as a share of total buffer area and as a share of year-2000 forest; the main text uses the former); the remaining outcomes are binary. Household controls, with geographic controls for the satellite outcomes; standard errors, clustered by vereda, in parentheses. The figure in the main text displays a subset of these rows. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

G Mechanism interactions: full estimates and fitted lines

Figure A2: Governance and forest loss, by tolerance of coca cultivation and illegal cattle ranching



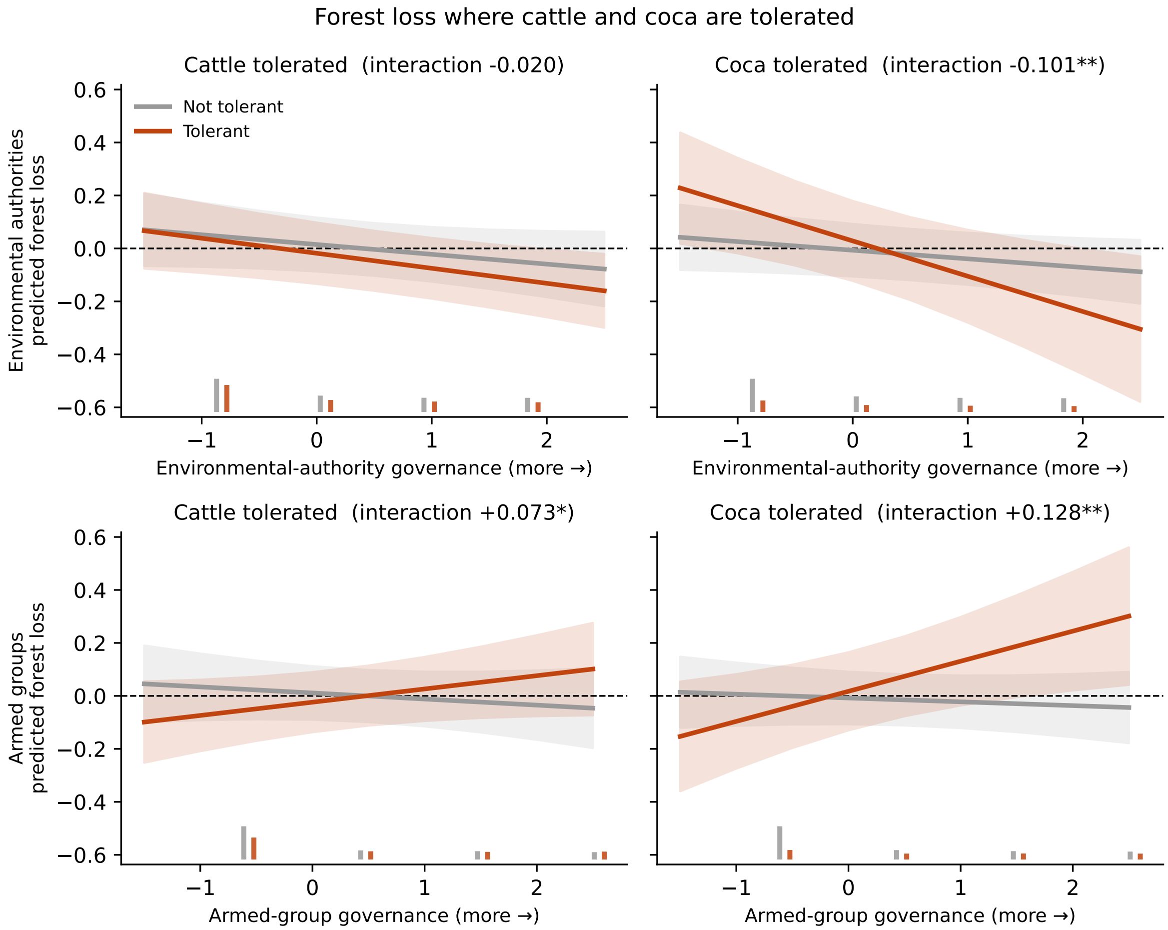
Notes: The figure reports estimates for standardized satellite forest loss. Within each pair, the upper row shows estimates for households that do not tolerate the relevant activity and the lower row for households that do. Panel A considers coca cultivation; Panel B considers illegal cattle ranching. Environmental-authority and armed-group estimates are slopes for z-scored governance functions. Armed–JAC dyad estimates compare households under joint governance with all other households. All models include the same household and geographic controls. Standard errors are clustered by vereda. Full estimates: SI Table A12. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A12: Governance and forest loss, by tolerance of coca cultivation and illegal cattle ranching: full estimates

	Not tolerated	Tolerated	Interaction
Panel A: Coca cultivation			
Environmental authorities	-0.033*	-0.133***	-0.101**
	(0.019)	(0.048)	[$p = 0.037$]
Armed groups	-0.014	0.114**	0.128**
	(0.024)	(0.046)	[$p = 0.019$]
Community boards (JAC)	0.024	0.100**	0.076
	(0.024)	(0.046)	[$p = 0.113$]
Armed–JAC dyad (contrast)	0.261**	0.788***	0.527**
	(0.110)	(0.292)	(0.257)
Panel B: Illegal cattle ranching			
Environmental authorities	-0.037	-0.057***	-0.020
	(0.025)	(0.021)	[$p = 0.505$]
Armed groups	-0.023	0.050*	0.073*
	(0.028)	(0.030)	[$p = 0.077$]
Community boards (JAC)	0.006	0.082**	0.077**
	(0.026)	(0.034)	[$p = 0.045$]
Armed–JAC dyad (contrast)	0.248*	0.498***	0.250
	(0.145)	(0.186)	(0.199)

Notes: Outcome: standardized five-year forest loss (share of total buffer area, 3-kilometer buffer; year-2000 forest cover among the geographic controls). For the three actors, cells are conditional slopes of z-scored governance functions among households that do not tolerate (column 1) and tolerate (column 2) the activity, and the interaction term (column 3; p-value in brackets). For the armed–JAC dyad, cells are conditional contrasts for households in which armed groups and community boards tie for the largest governance share, relative to all other households. Benchmarked against JAC-dominant households (the comparison in Figure 3) rather than all other households, the dyad interactions are 0.377 ($p = 0.231$) for coca and 0.097 ($p = 0.644$) for cattle. All models include household and geographic controls and a polygon-sample indicator ($N = 1{,}853$ for the actor slopes); standard errors, clustered by vereda, in parentheses. Figure A2 displays the environmental-authority, armed-group, and dyad estimates; community-board (JAC) estimates are reported here. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure A3: Environmental-authority and armed-group governance under extractive pressure (fitted lines)



Notes: The figure plots predicted standardized forest loss across levels of environmental-authority governance (top row) and armed-group governance (bottom row). The left column distinguishes households that tolerate and do not tolerate illegal cattle ranching; the right column does the same for coca cultivation. Shaded areas show 95% confidence intervals. Estimates are based on the same regressions as Figure A2. All models include household and geographic controls and a polygon-sample indicator. Standard errors are clustered by vereda. Vertical ticks along the horizontal axis mark the four observed values of the governance measure, with height proportional to the number of households at each value (grey: households not tolerating the activity; red: tolerant households) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

H Results by sample

Table A13: Rule outcomes by sample (functions specification)

	Vereda	Polygon	Combined
Panel A: Monitoring & enforcement index			
Armed groups	0.204***	0.157***	0.179***
	(0.024)	(0.027)	(0.019)
Community boards (JAC)	0.176***	0.181***	0.179***
	(0.035)	(0.034)	(0.023)
Environmental authorities	0.194***	0.150***	0.168***
	(0.039)	(0.029)	(0.024)
National government	0.074**	0.034	0.056***
	(0.030)	(0.028)	(0.020)
Municipal government	0.003	0.029	0.013
	(0.034)	(0.035)	(0.024)
Other local organizations	0.095**	0.085***	0.093***
	(0.044)	(0.025)	(0.021)
Observations	955	876	1,831
Panel B: Clearing rules exist			
Armed groups	0.085***	0.052***	0.073***
	(0.016)	(0.013)	(0.011)
Community boards (JAC)	0.077***	0.059***	0.073***
	(0.018)	(0.018)	(0.013)
Environmental authorities	0.046**	0.033**	0.037***
	(0.020)	(0.014)	(0.012)
National government	0.011	0.005	0.007
	(0.015)	(0.017)	(0.011)
Municipal government	0.029*	-0.030	0.001
	(0.015)	(0.018)	(0.012)
Other local organizations	0.033*	0.019	0.027***
	(0.019)	(0.013)	(0.010)
Observations	839	789	1,628

Notes: Functions specification, estimated separately by sample; all six actors estimated jointly. Household controls; the combined sample adds a polygon indicator. Panel A is standardized; Panel B is binary. Standard errors, clustered by vereda, in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A14: Rule outcomes by sample (functions specification), continued

	Vereda	Polygon	Combined
Panel A: Rule violations punished			
Armed groups	0.033***	0.026**	0.029***
	(0.010)	(0.011)	(0.008)
Community boards (JAC)	0.008	0.010	0.013
	(0.015)	(0.019)	(0.013)
Environmental authorities	0.027**	0.017	0.025***
	(0.012)	(0.013)	(0.009)
National government	0.012	0.009	0.009
	(0.015)	(0.021)	(0.014)
Municipal government	0.018	-0.025	-0.005
	(0.013)	(0.017)	(0.011)
Other local organizations	-0.023	-0.005	-0.008
	(0.020)	(0.016)	(0.013)
Observations	596	656	1,252
Panel B: Satisfied with forest management			
Armed groups	-0.009	-0.024	-0.020
	(0.018)	(0.018)	(0.013)
Community boards (JAC)	0.033*	0.014	0.025*
	(0.018)	(0.018)	(0.013)
Environmental authorities	0.017	-0.003	0.009
	(0.015)	(0.016)	(0.011)
National government	0.042***	0.021	0.033***
	(0.012)	(0.017)	(0.010)
Municipal government	0.015	0.008	0.010
	(0.017)	(0.014)	(0.011)
Other local organizations	-0.006	-0.014	-0.013
	(0.024)	(0.011)	(0.010)
Observations	969	876	1,845

Notes: Functions specification, estimated separately by sample; all six actors estimated jointly. Household controls; the combined sample adds a polygon indicator. Both outcomes are binary; the punishment item is asked only where rules exist. Standard errors, clustered by vereda, in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A15: Conservation outcomes by sample (functions specification)

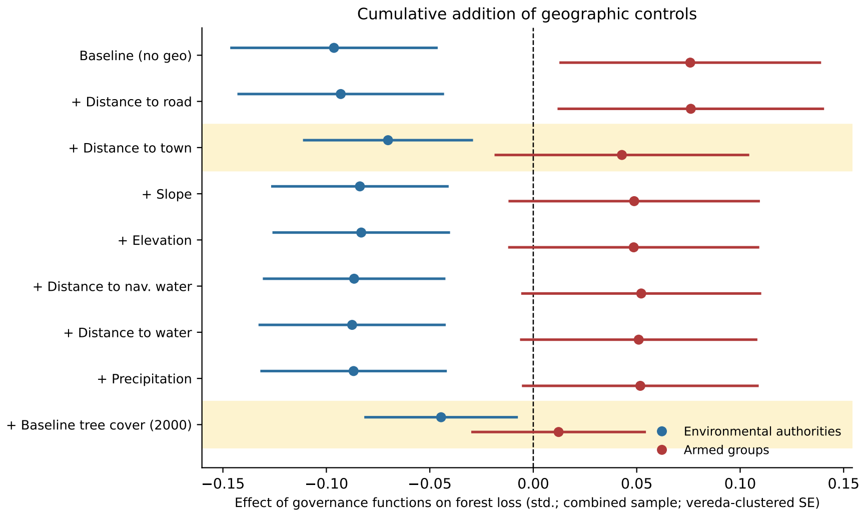
	Vereda	Polygon	Combined
Panel A: Forest loss (satellite)			
Armed groups	0.038	-0.020	0.012
	(0.029)	(0.026)	(0.021)
Community boards (JAC)	0.077***	0.016	0.036
	(0.025)	(0.042)	(0.023)
Environmental authorities	-0.028*	-0.041	-0.045**
	(0.016)	(0.036)	(0.019)
National government	-0.006	0.015	-0.004
	(0.020)	(0.028)	(0.017)
Municipal government	0.000	0.039	0.027
	(0.019)	(0.035)	(0.019)
Other local organizations	0.031	-0.038*	-0.011
	(0.040)	(0.020)	(0.018)
Observations	973	880	1,853
Panel B: Perceived government effectiveness			
Armed groups	-0.027	-0.028*	-0.029**
	(0.019)	(0.015)	(0.011)
Community boards (JAC)	-0.004	0.006	0.003
	(0.021)	(0.017)	(0.014)
Environmental authorities	0.036**	0.029*	0.037***
	(0.014)	(0.016)	(0.011)
National government	0.021	0.001	0.013
	(0.016)	(0.016)	(0.012)
Municipal government	0.022	-0.000	0.012
	(0.016)	(0.021)	(0.013)
Other local organizations	0.005	0.012	0.009
	(0.020)	(0.017)	(0.013)
Observations	968	876	1,844

Notes: Functions specification, estimated separately by sample; all six actors estimated jointly. Panel A is standardized five-year forest loss as a share of total buffer area (3-kilometer buffer; adds eight geographic controls); Panel B is binary. Household controls; the combined sample adds a polygon indicator. Standard errors, clustered by vereda, in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

I Robustness of the conservation results

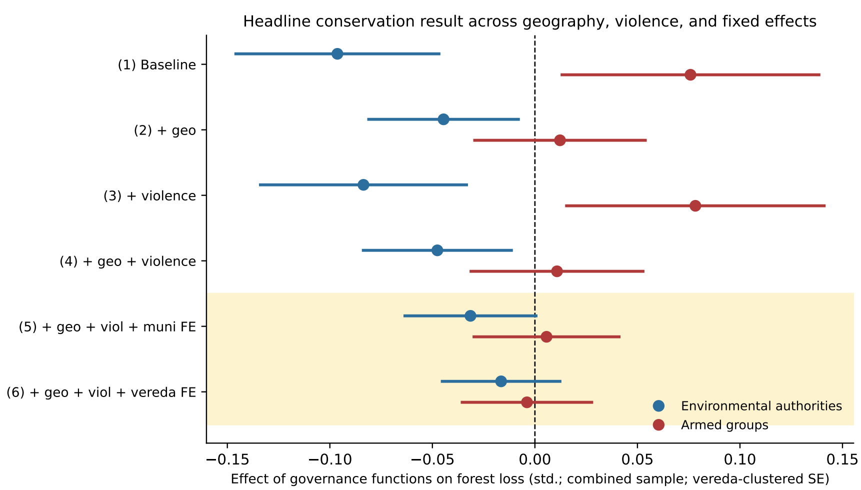
We probe the environmental-authority conservation estimate in several ways. Figure A4 traces the coefficient as the geographic controls are added one at a time, and Figure A5 reports it across alternative specifications. Table A17 reports wild-cluster bootstrap inference (Webb weights, clustered by vereda) for the headline coefficients: the conservation result, the armed-null result, the governance-production result, and the armed–JAC dyad all retain their significance, while the illegal-economy interactions are, as in the main text, more marginal. The environmental-authority estimate is negative in both frontier settings, though estimated precisely only in the pooled sample (Section H).

Figure A4: Forest loss and governance: cumulative addition of geographic controls



Notes: The figure reports coefficients on environmental-authority and armed-group governance functions from regressions of standardized forest loss on household controls and the cumulative addition of eight geographic controls. The armed-group coefficient in the baseline model is 0.076 ($p = .019$) but becomes statistically insignificant once distance to town is added. The environmental-authority coefficient remains negative and statistically significant throughout; adding year-2000 forest cover, the final control, reduces it from -0.096 to -0.045. Standard errors are clustered by vereda; $N = 1{,}853$ in all specifications.

Figure A5: Forest loss and governance under progressively stricter specifications



Notes: The figure reports coefficients on environmental-authority and armed-group governance functions from regressions of standardized forest loss across six specifications: household controls only; geographic controls; violent-event controls; geographic and violent-event controls; municipality fixed effects; and vereda fixed effects. The environmental-authority coefficient remains negative throughout, and statistically significant through the geographic and violent-event specifications; it becomes marginal with municipality fixed effects (-0.031, $p = .057$) and statistically insignificant with vereda fixed effects (-0.016, $p = .26$), which absorb most of the variation in governance. Because violent events may themselves respond to armed-group governance, violence is excluded from the main specification and reported here as a robustness check. Standard errors are clustered by vereda.

Table A16: Conservation results at the 3 km and 5 km buffer radii

	3 km buffer	5 km buffer
Panel A: Forest loss, by actor (functions)		
Armed groups	0.012	0.000
	(0.021)	(0.020)
Community boards (JAC)	0.036	0.032
	(0.023)	(0.022)
Environmental authorities	-0.045**	-0.035*
	(0.019)	(0.018)
National government	-0.004	0.007
	(0.017)	(0.016)
Municipal government	0.027	0.013
	(0.019)	(0.017)
Other local organizations	-0.011	-0.015
	(0.018)	(0.016)
Panel B: Interaction terms		
Environmental authorities × coca	-0.101**	-0.107**
	[$p = 0.037$]	[$p = 0.010$]
Environmental authorities × cattle	-0.020	0.007
	[$p = 0.505$]	[$p = 0.790$]
Armed groups × coca	0.128**	0.107**
	[$p = 0.019$]	[$p = 0.024$]
Armed groups × cattle	0.073*	0.068**
	[$p = 0.077$]	[$p = 0.043$]
Community boards (JAC) × coca	0.076	0.072**
	[$p = 0.113$]	[$p = 0.042$]
Community boards (JAC) × cattle	0.077**	0.043
	[$p = 0.045$]	[$p = 0.219$]
Armed–JAC dyad × coca	0.527**	0.170*
	(0.257)	(0.101)
Armed–JAC dyad × cattle	0.250	0.174*
	(0.199)	(0.095)

Notes: Robustness of the satellite conservation results to the buffer radius. Both the outcome (five-year forest loss as a share of buffer area) and the geographic controls are recomputed at each radius. Panel A: functions-specification coefficients on standardized forest loss, combined sample. Panel B: interaction terms from the mechanism specifications (p-values in brackets for the actor interactions; standard errors in parentheses for the dyad contrasts). Household and geographic controls and a polygon-sample indicator throughout; standard errors clustered by vereda. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A17: Wild-cluster bootstrap inference for the headline coefficients

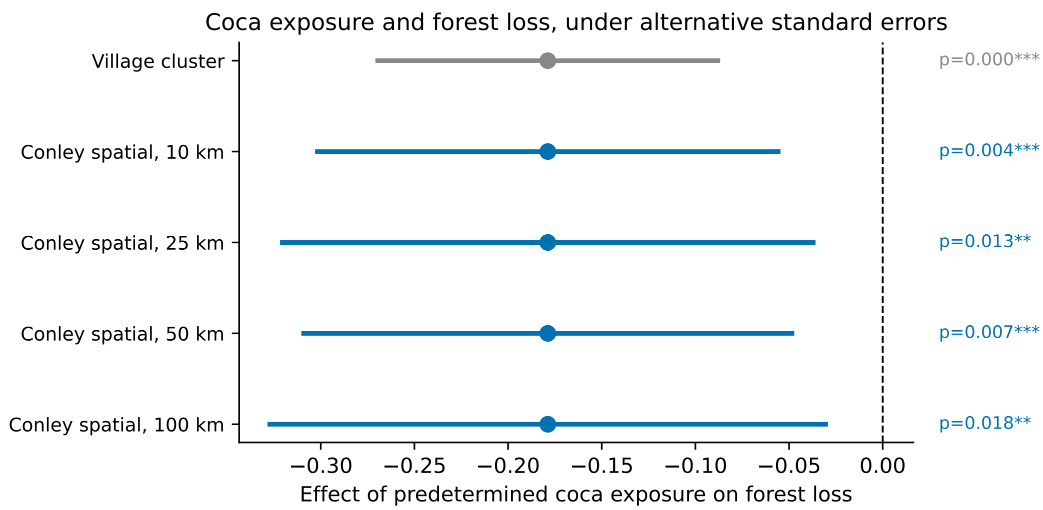
	Coef.	Analytic p	Wild-boot p	N
Env. authorities $\rightarrow$ forest loss	-0.045**	0.019	0.022	1,853
Armed groups $\rightarrow$ forest loss	0.012	0.565	0.586	1,853
Community boards $\rightarrow$ forest loss	0.036	0.123	0.146	1,853
Armed groups $\rightarrow$ M&E index	0.179***	0.000	0.000	1,831
Env. authorities $\rightarrow$ perceived effectiveness	0.037***	0.001	0.001	1,844
Armed–JAC dyad $\rightarrow$ forest loss	0.365**	0.011	0.021	1,853
Armed groups $\times$ coca	0.128**	0.019	0.022	1,853
Env. authorities $\times$ coca	-0.101**	0.037	0.045	1,853
Community boards $\times$ cattle	0.077*	0.045	0.051	1,853

Notes: Wild-cluster bootstrap p-values (Webb weights, 9,999 replications, clustered by vereda; fixed seed) for the headline coefficients, alongside the analytic vereda-clustered p-value. Each block reproduces the corresponding main-text specification (functions specification for the actor rows; the dominance tie-category for the armed–JAC dyad). Stars follow the wild-bootstrap p. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

J Coca-price exposure design (Bartik)

To complement the interaction analyses, we estimate a Bartik-style exposure design that does not rely on reported attitudes or contemporaneous governance measures. Exposure is measured as predetermined coca cultivation (hectares, 2001–2004, SIMCI/UNODC) within the same 3-kilometer household buffer used to measure forest loss. Because this measure predates the peace accords, the emergence of successor organizations, and our survey by nearly two decades, it is predetermined with respect to the outcomes we study. We interact this exposure with the national collapse in coca-leaf prices between 2016 and 2022 ($\Delta \log \text{price} = -0.129$) to construct a standardized shift-share measure. Since the price shock is common to all households, identification comes from cross-sectional differences in predetermined coca exposure. We regress standardized five-year forest loss (measured as a share of the buffer area) on this exposure measure, controlling for the full set of household and geographic controls ($N = 1{,}853$). One standard deviation of predetermined coca exposure predicts 0.18 standard deviations more forest loss following the price collapse (reduced-form coefficient $= -0.179$, SE $= 0.046$, vereda-clustered $p < .001$), consistent with extraction-driven clearing as declining coca profitability shifted land toward cattle ranching and speculation. Because the price shock is a single national scalar, the identifying variation is cross-sectional—predetermined household coca exposure—so we report Conley spatial HAC standard errors that account for spatial correlation in exposure; the estimate remains significant at distance cutoffs between 10 and 100 kilometers (all $p < .02$; Figure A6). Results using forest loss measured as a share of year-2000 forest cover are stronger. We report the reduced-form estimates only and do not pursue an instrumental-variables strategy.

Figure A6: Coca-price exposure and forest loss, under alternative standard errors



Notes: Reduced-form coefficient on the standardized shift-share variable (predetermined 2001–2004 coca cultivation within the 3-kilometer household buffer × national 2016–2022 change in coca-leaf prices), with standardized five-year forest loss as the outcome; household and geographic controls and a polygon-sample indicator; $N = 1{,}853$. Each row re-estimates the standard error: village (vereda) clustering and Conley spatial HAC at 10–100 km. The coefficient is negative because the price shock is a decline: households more exposed to the collapse experienced more forest loss. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

K Variable definitions and survey items

Governance measures

Governance actor identification: All actor measures derive from three survey questions, one per governance role (E3–E5): "Who are the three most important actors for making rules about forest use and access in this vereda?"; "Who are the three most important actors for monitoring rules about forest use and access in this vereda?"; and "Who are the three most important actors for enforcing rules about forest use and access in this vereda?" Respondents select up to three actors per role from a list of 22 categories, which we group into six actors: *armed groups* (armed group); *community action boards* (Junta de Acción Comunal, JAC); *environmental authorities* (the regional autonomous corporations CDA, Corpoamazonia, and Cormacarena, and forest rangers); *national government* (national government authorities, police, military); *municipal government* (municipal mayor's office, municipal land office); and *other local organizations* (community leaders, peasant organizations, religious leaders, community committees, indigenous authorities, livestock committees). Responses naming courts, NGOs, private firms, the Forest Roundtable, SIDAP, or "other" are not assigned to any of the six actors.

Governance functions (primary specification): For each actor, the number of the three roles (rule-making, monitoring, enforcement) for which the household names that actor, ranging from 0 to 3. Regressions use the z-scored version.

Governance shares: Within each role, each named actor receives an equal share of $1/n$, where n is the number of the six actor groups named for that role. Multiple categories mapped to the same actor group count once, and unassigned categories are excluded from the denominator. Shares are then averaged across roles in which the household names at least one of the six actors. Roles in which the household names only unassigned categories are treated as naming no actor. By construction, the six shares sum to one for every household naming at least one of the six actors.

Dominant governing actor: The actor holding the household's largest governance share. Households in which two or more actors tie for the largest share form separate co-governance categories; the armed–JAC dyad category comprises households in which armed groups and community action boards tie for the largest share. The comparison group consists of households that name no governing actor for any of the three roles.

Governance and conservation outcomes

Monitoring and Enforcement Index: The mean of two standardized five-point items, re-standardized to unit variance in the analysis sample. The exact questions are (E18): "How effectively are rules about forest use and access monitored in this area?" and (E19): "How effectively are rules about forest use and access enforced in this area?" Higher values indicate more effective monitoring and enforcement.

Clearing Rules Exist: This variable equals 1 if the household reports rules restricting forest clearing. The exact question is (E6): "Are there rules in this village that regulate or restrict clearing virgin land in forest/wooded areas?"

Rule Violations Punished: This variable equals 1 if the household reports penalties for breaking clearing rules. The exact question is (E8): "Are there penalties for breaking the rules about clearing virgin land?" The question is asked only of households reporting that clearing rules exist.

Satisfied with Forest Management: This variable equals 1 for the top two categories of a five-point satisfaction scale. The exact question is (E17): "Overall, how satisfied are you with how forests are managed in this area?"

Perceived Government Effectiveness: This variable equals 1 if the respondent agrees or strongly agrees (top two categories of a five-point agreement scale) with the statement (H1): "The Government's efforts to combat illegal deforestation in this vereda are effective."

Compliance Index: The mean of two standardized items, re-standardized to unit variance. The components are (E10): "In your opinion, what proportion of people in this vereda follow the rules about clearing virgin land?" (reverse-coded) and (F2.5): "How often do you see people who are not authorized to be in this forest cutting trees/logs/wood?", each oriented so that higher values indicate more compliance.

Local Authorities Protect Forest: This variable equals 1 if the respondent agrees or strongly agrees with the statement (E20): "Local authorities protect forests from being taken, invaded, or settled in without permission."

Cleared Virgin Land: This variable equals 1 if the household cleared virgin land in the past year. The exact question is (I1): "Did your household clear any virgin land in the past 12 months?"

Plans to Clear: This variable equals 1 if the household intends to clear virgin land in the coming year. The exact question is (I8): "Do you intend to clear more virgin land in the next 12 months?"

Forest Loss (satellite): Five-year forest loss (Global Forest Watch, 30% canopy threshold) within a 3-kilometer buffer around the household, expressed as a share of the buffer area and standardized. The Supplementary Information also reports loss as a share of the household's year-2000 forest cover (winsorized at the 99th percentile) and results at a 5-kilometer buffer.

Moderators

Tolerates Illegal Cattle Ranching: This variable equals 1 if the respondent agrees or strongly agrees with the statement (H7): "Illegal cattle grazing is part of local income-generating opportunities."

Tolerates Coca Cultivation: This variable equals 1 if the respondent agrees or strongly agrees with the statement (H6): "People should be allowed to produce coca to provide money to feed their families."

Household controls

All regressions include: respondent age and gender; an indicator for being born in the vereda; household size; indicators for livestock ownership, holding a formal title on at least one field, land in a protected area, JAC membership, forced displacement, food insecurity, high forest dependence, and a history of coca cultivation (participation in substitution programs); top-quintile indicators for owned land area and durable assets; standardized indices for trust in local actors (neighbors and the JAC), collective efficacy, trust in government (judges, police, and the national land agency), conservation attitudes (z-mean of three items), and tolerance of illegal activities (z-mean of the two tolerance items above); and the two tolerance indicators. Combined-sample regressions add a polygon-sample indicator.

Geographic covariates

Regressions with satellite outcomes add eight geographic covariates: elevation, slope, precipitation, and year-2000 forest cover, each averaged over the same 3-kilometer buffer as the outcome; and straight-line distances from the household to the nearest road, town, water body, and navigable waterway.

Coca-price exposure (SI only)

Predetermined Coca Exposure: Hectares of coca cultivation in 2001–2004 (SIMCI/UNODC) within the household's 3-kilometer buffer, interacted with the national 2016–2022 change in coca-leaf prices and standardized; see the exposure-design section of this appendix.