Supplementary Information for

Does formalizing artisanal gold mining mitigate environmental impacts? Deforestation evidence from the Peruvian Amazon

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Methods

Image Processing. Landsat images (TM and ETM+) were acquired as surface reflectance climate data record products from the USGS Earth Resources Observation and Science Center Processing Architecture (http://espa.cr.usgs.gov). Scenes with 60% or less cloud coverage were chosen for the study region (path/row 2/69 and 3/69) for years 2001 to 2014. Imagery for 2002 and 2012 were not available due to cloud cover and sensor malfunction. Image processing steps on the acquired images were conducted in Python and included: (i) image reprojection to WGS84_UTM zone19S, (ii) image normalization (1), (iii) image mosaicking, and (iv) study area extraction. Additionally, for each image date we derived spectral indices used to increase the separability of mined areas from other land cover types, including the Normalized Difference Vegetation Index (NDVI), Tasseled Cap indices (Brightness, Greenness, and Wetness), and the three principal components from a Principal Component Analysis (PCA) (2).

The Random Forest tree-based classifier in R was used to classify the processed images (3, 4). We collected reference samples for classifier training and model accuracy assessment by consulting high-resolution images available in Google Earth (e.g., Quickbird) and by characterizing the Landsat images based on fieldwork and experience on-site. Over 80,000 samples (pixels) were collected for mining areas, forests, agricultural/herbaceous fields, riverbanks, bare land, water, clouds and shadows. We used the per pixel probabilities to assign land cover classes based on the maximum class probability. Individual RF models were trained for each image date. The resultant RF models had OOBs (out-of-bag errors) accuracy estimates ranging from 0.94 to 0.99.

Data Structure. We used a hexagonal grid (5) with 25 ha hexagon cells to balance between a unit large enough to minimize spatial autocorrelation but small enough to meaningfully coincide with the scale of mining and titling (25 ha is a quarter of the size of the smallest mining concessions). All predictor variables were based on the status of the centroid of each hexagon. We used polygons rather than points as units so that we could examine annual clearing sizes (6). Figure S1 gives a sense of the variation across scales of the study site, the hexagon cell, and the area mined each year.

Creating the Matched Data Subset. To help account for the fact that parts of our study region outside of the mining corridor may be places where gold mining is infeasible, we did a pre-regression step using matching methods to create an appropriately trimmed and weighted spatial set of observations on which to run our temporally explicit models. We used Stata 16's **teffects nnmatch** module to generate nearest-neighbor matches outside the mining corridor for cells within the corridor. We sought exact matches for district and geology class, and closest match possible for distance to navigable rivers using the Mahalanobis distance metric. We eliminated regions outside of common support and generated a new subsample that consisted of mining corridor cells and their best nearest neighbor. We eliminated the bottom (worst) 10% of matches. Control cells outside the corridor could be used multiple times as matches for ‘treated’ cells inside the mining corridor. These steps trimmed our dataset from 83,428 hexagon cells to the 37,152 cells that we use in our regression models.

Event Study. As a robustness check, we used an event study framework to examine mining deforestation as it related to the timing of initiating the titling process. We excluded extinguished titles and titles that were given prior to the study period. As in our other analyses, we used a panel model with fixed effects for each 25-ha cell and for each year, with standard errors clustered at the level of 5km hexagons. We used the **eventdd** package written for Stata, with time-to-event set in reference to the year of initiating the titling process, including 7 leads and 7 lags (given our 14-year study period) and a baseline set at 5 years prior to titling (7). See results in Figure S3.

Other Model Robustness Checks. We conducted robustness checks with district-level time trends, the complete sample of hexagons prior to matching, different thresholds for amount of mining that needed to be detected to switch on the binary indicator, and without excluding extinguished titles; these yielded substantively similar results. Presented models exclude 2001 when mining deforestation was erratically low, likely due to the remote sensing masking procedure removing areas mined before 2000; the main results are not affected when it is included.

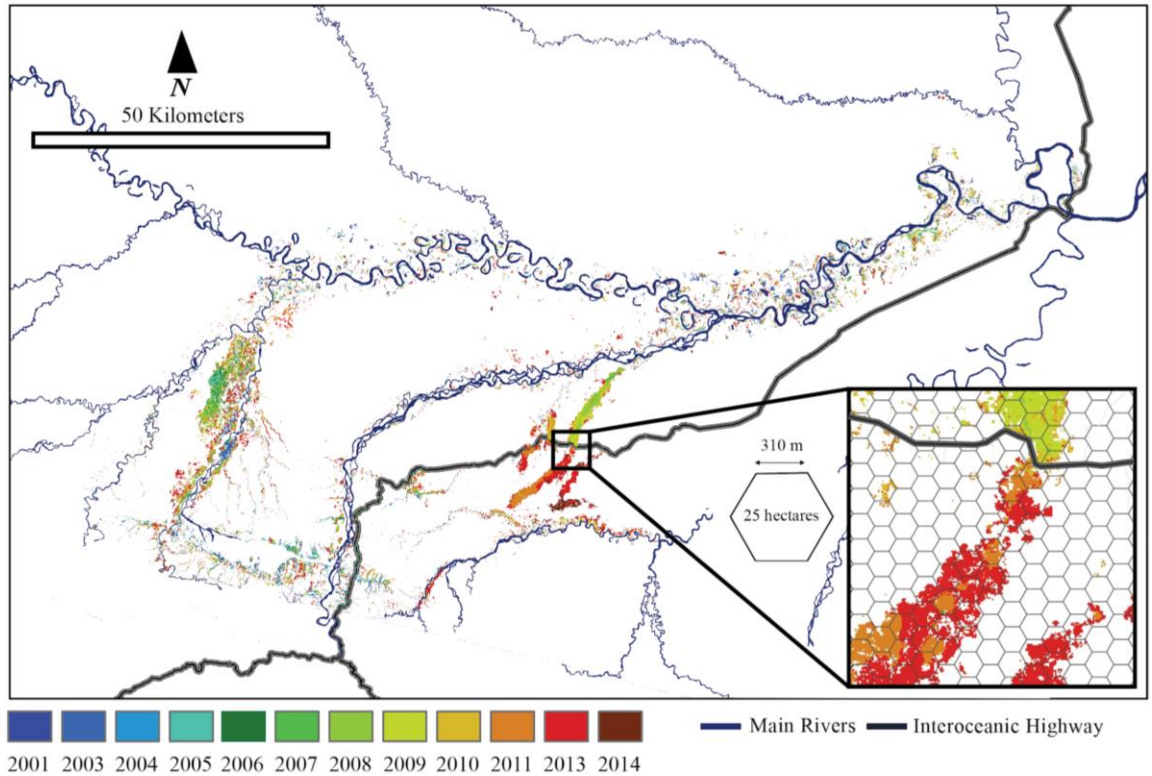

Fig. S1. Study site, unit of analysis, and outcome variable: new mining-related deforestation each year.

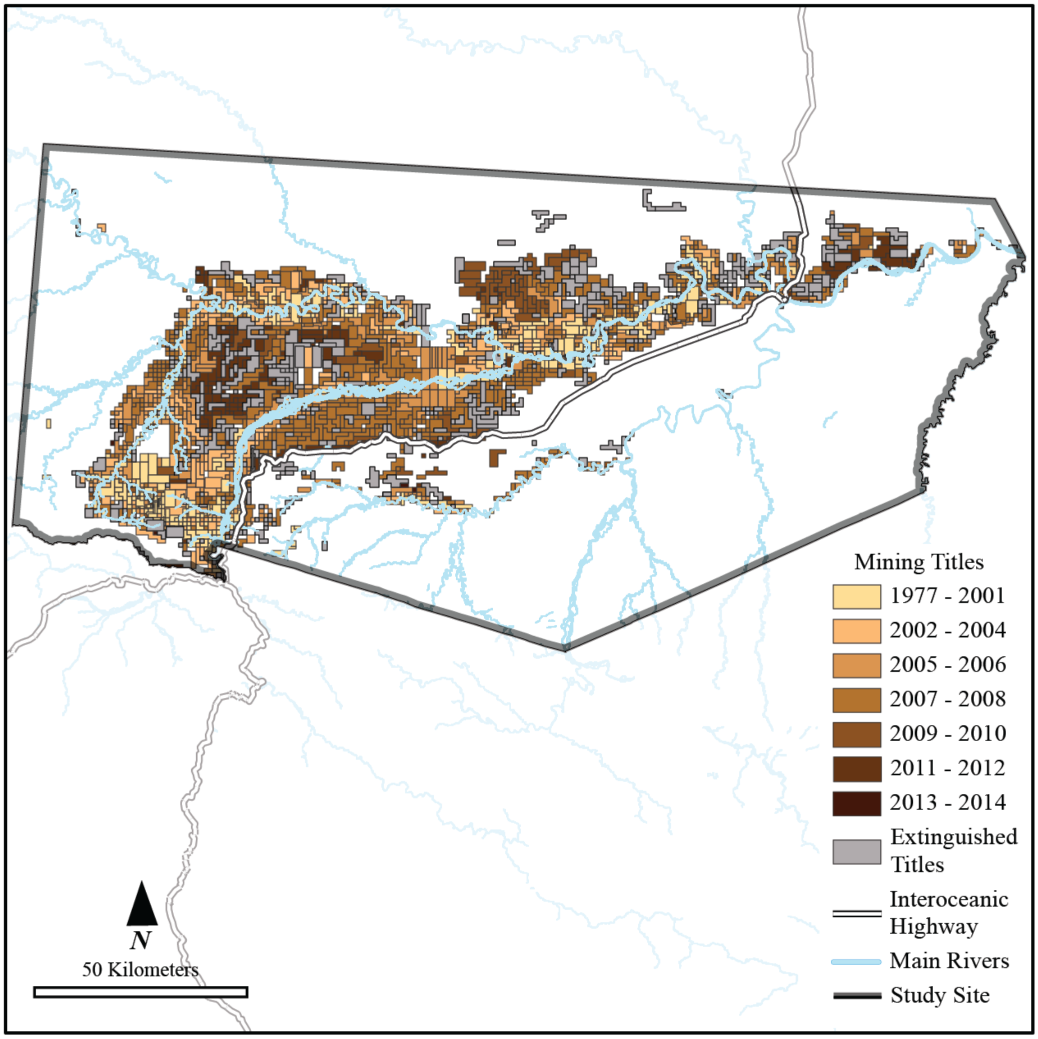

Fig. S2. Mining titles issued during 1977 to 2014. As of 2014, none of the titles were more than 'provisional' and some (in gray) had been extinguished due to unpaid annual fees.

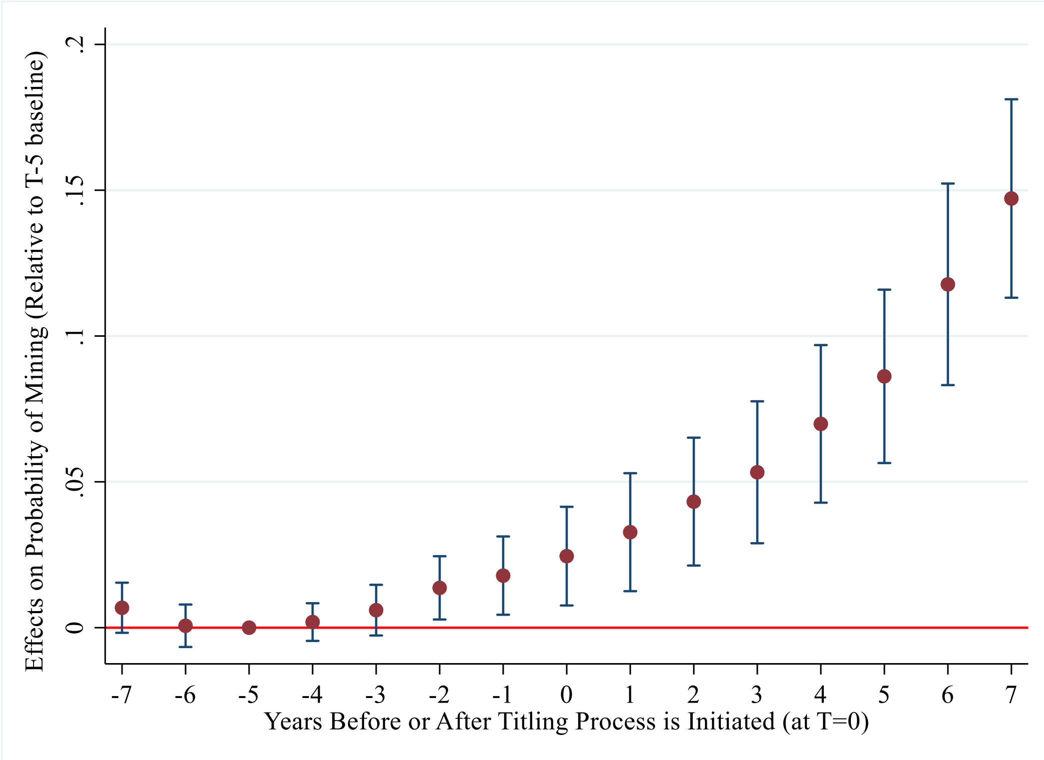

Fig. S3. Robustness check of title analysis using an event study framework. Probability of mining increases in the years following initiation of the titling process (at T=0), and to some extent in the years immediately preceding, relative to a baseline of 5 years before titling. Dots are point estimates and blue lines are 95% confidence intervals.

Table S1. Selected Formalization Events from 2002 to 2014 (*See sources below*)

Year	Event	Description
2002	Enactment of Law Nº 27651 - Formalization and Promotion of Small and Artisanal Miners	The Law of Formalization and Promotion of Small and Artisanal Miners introduces a legal framework to regulate mining activities. This law together with Legislative Dec. Nº 1040 and Regulation DS 013-2002-EM requires that before they start operations, miners must: (i) get a Unique Taxpayer Registry (RUC); (ii) acquire a Mining Right or Exploitation Contract; (iii) obtain a Certificate of Small Mining Producer or Artisanal Mining Producer (iv) obtain approval of the Environmental Certification and the Mining Operation Certification (8, 9).
2006-2008	Transfer of mining functions to the regional government of Madre de Dios	President Toledo (2001 - 2006) amends the constitution to transfer essential competences to the regions (10) . The Ministerial Resolution N ° 179-2006-MEM/DM) transfers functions related to granting mining concessions for Artisanal and Small-scale mining (ASM) in Madre de Dios to the Regional Office of Energy, Mining, and Hydrocarbon (DREMH) (11).
2006	New political administration under Pres. García	Alan García is elected President of Peru (2006 - 2011). During his term, President García creates the Ministry of the Environment and appoints the first Minister of the Environment (Antonio Brack Egg) who confronts illegal mining in MDD with military interdictions and creates legislation to promote ASM formalization processes (12).
2006 - 2011	The pavement of the Interoceanic Highway	The Interoceanic Highway section that connects the city of Puerto Maldonado with Cuzco and Puno is paved. The new highway facilitates mobilizing machinery and supplies, the influx of migrants, and the transportation of gold (13, 14)
2010	Creation of a multisectorial commission to implement the National Plan for the Formalization of Artisanal Mining	Supreme Decree No. 045-2010-PCM creates the Multisectoral Technical Commission for elaborating and monitoring the implementation of the National Plan for the Formalization of Artisanal Mining (11).
2010	Pronouncement of an emergency decree declaring gold mining in Madre de Dios an issue of national concern	President García's government, responding to pressures from the international community concerned with the environmental impacts of gold mining in the Amazon, passes the Emergency Decree No. 012-2010 declaring gold mining in Madre de Dios an issue of national concern, ordering the suspension of new mining requests (*petitorios*), prohibiting the use of dredges, and establishes the mining "corridor"(10, 15).
2011	New political administration under Pres. Humala	Ollanta Humala is elected President of Peru (2011-2016) after a campaign that had miners' financial support (10). President Humala's government strengthens formalization efforts initiated during the previous government declaring a series of legislative decrees to regulate ASM throughout Peru (15).
2011	Approval of the National Plan for the Formalization of Artisanal Mining	Supreme Decree No. 013-2011-EM approves the National Plan for the Formalization of Artisanal Mining that prioritizes actions in ten regions in Peru, including Madre de Dios, aiming to formalize and promote artisanal mining activities over five years.
2011	Public mining protests in Madre de Dios against DU 012-2010	Independent miners and miners' association strike at km 115 of the Interoceanic Highway against emergency decree DU-2010. The protest turns violent on March 1 resulting in 2 deaths and 14 injuries. This event marks the beginning of a series of strikes in subsequent years (9, 11)
2012	Legislative Decree Package concerning steps to formalization	Under Law No. 29815, Decree No. 1105 sets the steps for the formalization of artisanal and small-scale (14). See Figure 2 in manuscript.

2012	Pronouncement of a Legislative decree that regulates interdictions of illegal mining activities and permanently establishes a designated area for mining ('Mining Corridor')	DL 1100 declares illegal mining activities carried out without authorization and prohibits the use of certain types of equipment. The decree authorizes the confiscation or destruction of prohibited goods, machinery, equipment, and supplies as part of the interdiction actions. It also establishes the Mining Corridor (initially established in DU 012-2010), outside of which mining is not be allowed (8).
2012	Massive miners' protest in Madre de Dios	Thousands of miners, led by the Federation of Miners of Madre de Dios (FEDEMIN), sustain a nine-day strike against rules that penalize illegal mining. The protest turned violent with three deaths, several wounded and detained. Negotiations between FEDMIN and central government authorities yield an agreement to define mechanisms to accelerate formalization within the mining corridor, and to halt interdictions during formalization (11).
2012	Approval of the Corrective Environmental Management Instrument	Supreme Decree No. 004-2012-MINAM approves complementary provisions for the Corrective Environmental Management Instrument (IGAC), for the formalization of ongoing small-scale and artisanal mining activities. The Corrective Environmental Management Instrument - IGAC, regulated in Supreme Decree No. 004-2012-MINAM, is one of the requirements for the formalization of small-scale and artisanal mining activities (step 5). Its purpose is to mitigate and correct the environmental damage generated by ongoing mining activities and to establish permanent measures to promote more sustainable mining in the future (16).
2013	Appointment of a High Commissioner on Illegal Mining	A retired military officer is appointed High Commissioner for Mining Formalization Issues, Illegal Mining Interdictions, and Environmental Remediations. The commissioner is charged with the coordination and supervision of the National Strategy for the Interdiction of Illegal Mining (8, 11).
2014	Approval of the Small Mining and Artisanal Mining Sanitation Strategy.	The Legislative Decree No. 1105 (April 19, 2012) establishes April 19, 2014 as the deadline to complete the mining formalization process. Upon that date, the Small Mining and Artisanal Mining Sanitation Strategy is approved (Supreme Decree No. 029-2014-PCM) that sets a new goal for a "gradual, progressive and orderly" formalization process to culminate in 2016. On October 22, 2014, the Sanitation Registry of the activities of small-scale mining and artisanal mining is created, through Ministerial Resolution N .º 470-2014-MEM / D.M. By 2014, no individual had been able to complete the mining formalization process in MDD (11, 14).

Table S2. Data Used in Models of Formalization Impacts.

Variable	How Measured	Data Source
Mining Deforestation from 2001-2014	Presence / Absence of mining within a hexagon each year AND log-transformed mining area detected in a given year	LANDSAT images downloaded from USGS Earth Resources Observation and Science (EROS) Data Center (https://www.usgs.gov/centers/eros)
Concession Status	Indicator equal to 1 for places and years when the centroid of a hexagon fell within a concession where titling process had been initiated, and 0 if it was non-existent. Concessions with "extinguished" status in 2014 are excluded from title models.	Geological, Mining and Metallurgical Institute of Perú (*Instituto Geológico, Minero y Metalúrgico de Perú)* Web Service (https://geocatmin.ingemmet.gob.pe/geocatmin/)
Mining Corridor	Indicator equal to 1 when centroid of a hexagon was located within the eventual mining corridor, even in years before it was declared.	Presidency of the Council of Ministers of Peru (*Presidencia del Consejo de Ministros de Perú*) Emergency Decree 012-2010 http://www.pcm.gob.pe/InformacionGral/du012/DU-012-2010.pdf
Geology	Centroid membership in one of 22 geological categories. Models exclude some geology types in which mining never occurs.	Geological, Mining and Metallurgical Institute of Perú (*Instituto Geológico, Minero y Metalúrgico de Perú)* Web Service (https://geocatmin.ingemmet.gob.pe/geocatmin/)
Distance to Navigable Rivers	Straight-line distance from hexagon centroid to the border the nearest navigable river - note that this does not include smaller creeks and that there is some noise in this calculation due to shifting fluvial courses.	National Water Authority of Perú *(Autoridad Nacional del Agua)* Web Service http://geo.ana.gob.pe:8080/geoportal/
Protected Area Designations	Whether centroid was located within a protected area buffer zone, a recognized park or reserve, or none of the above	Natural Protected Areas National System (*SERNANP – Servicio Nacional de Áreas Protegidas)* Web Service http://geo.sernanp.gob.pe/visorsernanp/
Native Communities	Whether centroid was located within a recognized native community	Institute of Common Good *(Instituto del Bien Común)* Web Service https://ibcperu.org/mapas/sicna/
District	Membership in one of 6 government districts in study region	National Institute of Statistics and Informatincs *(Instituto Nacional de Estadística e Informática)* https://www.inei.gob.pe/contactenos/

Table S3. List of Respondents, Roles and Affiliations (9 women, 38 men).

Reference code	Interview Year	Occupation	Organization Type	Organization Name	Interview Place
RESP#1	2014	Employee	Natl. Govt. Agency	Geological, Mining and Metallurgical Institute (INGEMMET)	Pto. Maldonado
RESP#2	2014	Prominent politician and mining leader	Regional Mining Fed.	Fed. of Miners of Madre de Dios (FEDEMIN)	Pto. Maldonado
RESP#3	2014, 2020	Leader	Int. NGO	Solidaridad	Pto.Mald., ONLINE
RESP#4	2020	Geologist	Natl. Govt. Agency	Geological, Mining and Metallurgical Institute (INGEMMET)	Lima
RESP#5	2014	Director	Natl. Govt. Agency	Ministry of the Environment (MINAM)	Pto. Maldonado
RESP#6	2020	Mining Reforestation Specialist	Natl. NGO	Center for Amazonian Scientific Innovation (CINCIA)	Santa Rita
RESP#7	2014	Artisanal miner	Local Smallscale Mining Assoc.	Malinowsky River Small Farmers and Gold-Panners Association (APAYLOM)	Pto. Maldonado
RESP#8	2014	Employee	Regional Govt. Agency	Regional Directorate of Forestry and Wildlife	Pto. Maldonado
RESP#9	2014	Artisanal miner (participant in focus group of **4**)	Local Smallscale Mining Assoc.	Malinowsky River Small Farmers and Gold-Panners Association (APAYLOM)	Pto. Maldonado
RESP#10	2014	Staff	Natl. NGO	ProNaturaleza	Pto. Maldonado
RESP#11	2014, 2020	Forester	Natl. NGO	Peruvian Society for Environmental Law (SPDA)	Pto. Maldonado
RESP#12	2013	Leader	Local Smallscale Mining Assoc.	Malinowsky River Small Farmers and Gold-Panners Association (APAYLOM)	Manuani
RESP#13	2014	Leader	Regional Farming Fed.	Fed. of Agriculturalists of Madre de Dios (FADEMAD)	Pto. Maldonado
RESP#14	2014	Employee	Regional Enforcement Agency	Ecological Police of Madre de Dios	Pto. Maldonado
RESP#15	2020	Geologists **(2)**	Natl. Govt. Agency	Geological, Mining and Metallurgical Institute (INGEMMET)	ONLINE
RESP#16	2014	Planner	Regional Govt. Agency	Ministry of the Environment (MINAM)	Pto. Maldonado
RESP#17	2020	Ese'eja member	Regional Indigenous Fed.	Fed. Of Natives of Madre de Dios (FENAMAD)	Infierno

RESP#18	2014	Leader	Regional Indigenous Fed.	Fed. of Natives of Madre de Dios (FENAMAD)	Pto. Maldonado
RESP#19	2012	Researcher	Natl. NGO	Bartolomé de las Casas Center	Lima
RESP#20	2013	Artisanal miners **(4)**	Local Smallscale Mining Assoc.	Manuani Community	Manuani
RESP#21	2013, 2020	Leader	Regional NGO	Management Committee for Tambopata Reserve	Pto. Maldonado
RESP#22	2014	Leader	Natl. NGO	ProNaturaleza	Lima
RESP#23	2014	Director	Natl. Govt. Agency	Peruvian Service for Natural Protected Areas (SERNANP)	Pto. Maldonado
RESP#24	2014	Leader	Natl. NGO	ProNaturaleza	Pto. Maldonado
RESP#25	2014	Lawyers **(2)**	Natl. Govt. Agency	Ministry of Energy and Mines (MINEM)	Lima
RESP#26	2014	Employee	Regional Govt. Agency	Regional Directorate of Energy, Mines and Hydrocarbons (DREMH)	Pto. Maldonado
RESP#27	2014	Artisanal miner	Local Smallscale Mining Assoc.	Manuani Community	Manuani
RESP#28	2014	Employee	Regional Govt. Agency	Regional Directorate of Forestry and Wildlife	Lima
RESP#29	2014	Project Manager	Natl. NGO	Assoc. for Research and Integral Development (AIDER)	Pto. Maldonado
RESP#30	2014	Mining concessionaire	Informal status	Independent	Pto. Maldonado
RESP#31	2014	Planner	Regional Govt. Agency	Office of Spatial Data Infrastructure	Pto. Maldonado
RESP#32	2014	Administrator	Regional Govt. Agency	Regional Directorate of Energy, Mines and Hydrocarbons (DREMH)	Pto. Maldonado
RESP#33	2015	Lawyer	Natl. NGO	Peruvian Society for Environmental Law (SPDA)	ONLINE
RESP#34	2020	Lawyer	Regional Govt. Agency	Regional Directorate of Energy, Mines and Hydrocarbons (DREMH)	Pto. Maldonado
RESP#35	2020	Mining Reforestation Specialist	Natl. NGO	Center for Amazonian Scientific Innovation (CINCIA)	Santa Rita
RESP#36	2020	Director	Regional Govt. Agency	Regional Directorate of Energy, Mines and Hydrocarbons (DREMH)	Pto. Maldonado
RESP#37	2020	Lawyer	Regional Govt. Agency	Regional Directorate of Energy, Mines and Hydrocarbons (DREMH)	Pto. Maldonado
RESP#38	2020	Elected leader	Local Indigenous govt.	Ese'eja Community	Infierno
RESP#39	2020	Owner	Eco-tourism business	Ese'eja Community	Infierno

Table Note: The number of participants in focus groups is specified in parenthesis and bold font. Total number of participants in one-on-one interviews and group interviews = 47

Table S4. Mining Area (Ha) Detected Each Year.

Year	Total Mining Area	Untitled	Titled	Extinguished	Mining Area Outside Corridor	Mining Area Inside Corridor	Proportion Outside Corridor
2001	2,108	1,231	658	219	425	1,683	20%
2002	3,841	2,200	1,319	322	819	3,022	21%
2003	5,705	3,174	2,088	443	1,247	4,458	22%
2004	5,825	2,667	2,735	423	1,223	4,602	21%
2005	6,656	2,633	3,507	516	1,328	5,327	20%
2006	6,042	2,158	3,428	455	1,272	4,770	21%
2007	9,762	2,612	6,400	750	2,126	7,636	22%
2008	9,894	1,284	7,776	834	2,318	7,577	23%
2009	12,620	1,472	10,164	984	3,164	9,456	25%
2010	19,055	2,536	14,971	1,547	5,137	13,917	27%
2011	23,954	3,964	17,761	2,229	7,747	16,206	32%
2012	27,756	5,010	20,270	2,476	9,617	18,139	35%
2013	31,619	6,091	22,795	2,732	11,515	20,104	36%
2014	38,399	7,552	27,307	3,540	14,458	23,941	38%

[a] Some titles were extinguished during our study period because annual fees were not paid. We do not know the year in which titles were granted for these extinguished titles, thus we exclude them from our title-based analysis because we can't know whether they were active in a given year.

[b] We exclude instances of mining area less than .27 ha (3 pixels) because it is less certain that these are clearings related to mining vs. shifting river banks, crop fields, etc. Including these smaller clearings does not substantially change area totals – for example, overall mining in 2014 would increase from 38,399 to 38,630 ha.

c The dotted line highlights when the Mining Corridor was formally established (2010).

Table S5. Model Results for Changes in Mining with Titling

	(1) Probability of Mining Occurrence		(2) ln(Mining Area), when Mining Occurs		(3) Inverse-Hyperbolic Sine of Mining Area	
Titling Process Initiated	0.026	**	0.086		0.069	*
Year Effects (2002 baseline)						
2003	0.002	*	0.347	***	0.013	***
2004	0.004	**	0.333	***	0.014	***
2005	0.004	*	0.290	***	0.017	***
2006	-0.007	*	0.124	†	0.004	
2007	0.008	*	0.396	***	0.029	**
2008	0.001		0.314	***	0.017	*
2009	0.006		0.410	***	0.027	**
2010	0.029	***	0.702	***	0.071	***
2011	0.039	***	0.810	***	0.094	***
2012	0.058	***	0.851	***	0.123	***
2013	0.057	***	1.026	***	0.134	***
2014	0.076	***	1.252	***	0.178	***
Constant	0.054	***	-0.052		0.055	***
Cell Fixed Effects	Yes		Yes		Yes	
Num. obs	433,628		36,224		433,628	
Num. panels	33,356		5,560		33,356	
Predictive Margins for Linear Prediction of Mining Outcome						
Cells w/out title	0.075		0.596		0.110	
Cells with title	0.101		0.681		0.179	

Significance thresholds indicated with following symbols: †: p<0.1, *: p<0.05, **: p<0.01, ***: p<0.001

Model 1 is a linear probability model, Model 2 is a semi-elasticity model of ln(Area Cleared) conditional on any mining occurring, and Model 3 is the inverse hyperbolic sine of Area Cleared, unconditional on clearing.

All models use clustered standard errors based on 5km hexagons.

Table S6. Corridor Analysis Robustness Check using Inverse Hyperbolic Sine of Mining

	Inverse Hyperbolic Sine of Mined Area	
	A	B
Post-2010 x Outside Corridor	-0.11***	-0.19***
Post-2010 x in a Protected Area		0.02
Post-2010 x in a Buffer Zone		0.15*
Post-2010 x in a Native Community		0.16**
Post-2010 x within 0.5km of Nav. River		0.04*
Post-2010	0.28***	0.26***
Constant	-0.02	0.00
Effects for each year	yes	yes
Cell fixed effects	yes	yes
R^2 - within	0.08	0.06
R^2 - between	0.06	0.02
rho	0.66	0.64
Num obs	520,128	520,128
Num groups / panels	37,152	37,152
Num. clusters for se's	344	344

Significance thresholds indicated with following symbols: †: $p<0.1$, *: $p<0.05$, **: $p<0.01$, ***: $p<0.001$

This model generally accords with Models 1 and 2 in Table 1. Inverse-hyperbolic sine transformations can be interpreted conveniently as approximately the percent change in mined area corresponding to a step change in a predictor variable, unconditional on mining occurring (17).

After 2010, Model A shows an 11% decline in mined area outside the corridor relative to inside the corridor. This does not accord with the measured rise in proportion of mined area outside the corridor apparent in the descriptive statistics. The weight of a few significant and localized areas of expansion is imperfectly captured with the inverse hyperbolic sine transformation, whose distribution is still heavily skewed.

Table S7. Illustrative Quotes.

Topic	Respondent Code	Quote
Provisional titling functionally granted rights without responsibilities	RESP#5	"Starting in 2010, when the miner requests a title, the authorities stamp the document with a warning indicating that the provisional permit does not give any right to carry out the mining activity. Before this [2010], miners would immediately start mining their lands and that is why they have depredated almost all the buffer zone and the mining corridor. This area did not have special rules to regulate miners with provisional titles. Now there is a special arrangement in place allowing those who are in the mining zone and who have presented the declaration of commitment, to continue mining".
	RESP#3	"The authorization to deforest must be proved before [mining begins]. What happens here is that whomever has received a provisional permit is viewed as having the power to mine and indeed, they mine".
Provisional titles were used to compete for land and access credit to buy more powerful equipment	RESP#6	"They [miners] can acquire bank loans using mining titles as collateral. If miners find lots of gold flakes on their lands, then they proceed to take out the loans to invest in their mining operations for greater returns".
	RESP#7	"Farmers easily become prisoners of miners".
	RESP#14	"Motivation to invest is high when adequate gold [reserves] are found. A couple of million soles [~US$500k] may be invested in machinery as an initial investment. There are bank loans for these types of investments, which are not very cheap. But gold pays, as we have seen".
	RESP#15	"Within the corridor, almost all lands were already titled [..] Everything was already saturated. Miners are now asking for half of MdD to be opened".
The people actually mining in an area were often not titleholders	RESP#12	"Concessions have been invaded by the guests. Tejada, chino Huama, tía Goya [nicknames of large operators] promote the invasions and bribe the police".
	RESP#13	"Those who have their machinery exploded lose the ability to pay the workers and these workers move to the Pampa area [Fig. 1] carrying their engines".
Directing mining away from sensitive areas was difficult given erratic enforcement, especially for well-established operations.	RESP#12	"In the active sites (buffer zone), [miners] are extracting 200-300 grams per 10 hours. The miners replace the engine after being interdicted, and [it] gives the impression that nothing happened".
	RESP#17	"Madre de Dios was made famous by La Pampa [Fig. 1]. If it weren't for La Pampa, there wouldn't be a law against mining. The Pampa is desert, sand, prostitution, assault, assassination, slavery, and drugs […] this is how it is right now – go right now and you'll see this is how they are working there."
Andean derived environmental regulations were a bad match for the Amazonian ecosystems.	RESP#11	"At 5-8m [excavation], you already find water and do not know if you are allowed to operate. [..]"
	RESP#14	"We agree with NGOs that the formalization process in Peru should be different for primary mining and for alluvial mining. They are completely different [kinds of] mining, for example it is very difficult to apply the mining process for gold in veins [as in primary mining] to alluvial mining. Madre de Dios is a delicate [ecosystem] and a unique case".

Indigenous concerns	RESP#6	“There are mining titles within native communities. They [indigenous people] found out that there is gold in titles superimposed with their community…They invite guest miners and charge a commission…They are mining via guest miners.”
	RESP#16	"Indigenous people view Kotzimba [an indigenous reserve, Fig. 1] as the model for how Amazonian natives should manage mining on their land. They have become rich”.
	RESP#17	"According to the State, the subsoil belongs to the State. They give it to anyone. [..] mining should be formalized but the State is at fault for giving concessions without following the Law of Prior Consultation".
Costs and bureaucratic bottlenecks	RESP#3 2014	"Before 2010 the [environmental] studies were simpler, they weren't that expensive. The most expensive was the environmental impact study that cost between 5,000 to 10,000 soles [~US$1400-2800]. We could estimate a total of 15,000 to 20,000 [~US$4100-5600] from the previous formalization process. Later, with the new environmental regulations and forests permits, it became much more expensive. It would cost you between 20,000 to 30,000 soles [~US$5600-8,500]".
	RESP#3 2020	"There is a requirement for miners that they have to pay a fee each year to keep the title, and after five years, they have to pay a fine if there is no production [mining]. The law says [the miner] has five years when he does not need to pay for non-production, but after five years, the miner should have formalized operations and should have started operating. It is a requirement so that the miner starts producing and does not hold lands eternally without mining in them. However, those in the exclusion zone could not produce because the norm prohibited mining there… yet they still had to pay the fine for not producing. It is counterproductive".

Table Note: Interview transcriptions were codified via Dedoose (Version 8.0.35 (18)). To protect the informants' anonymity, we replaced names with a code.

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