SCIENCE BRIEF FOR POLICY MAKERS

FORMALIZING ARTISANAL GOLD MINING TO MITIGATE ENVIRONMENTAL IMPACTS: LESSONS LEARNED FROM MADRE DE DIOS, PERÚ

NORA ÁLVAREZ-BERRÍOS[1], JESSICA L'ROE,[2] AND LISA NAUGHTON-TREVES[3]

1 International Institute for Tropical Forestry, San Juan, Puerto Rico, 00926
2 Department of Geography, Middlebury College, Middlebury, USA, 05753
3 Department of Geography, University of Wisconsin, Madison, USA, 53706
4 Authors arranged alphabetically

THE PROBLEM

Artisanal and small-scale gold mining activities (ASM) in tropical forests are expanding rapidly, fueled by soaring gold prices and improved road access. Despite the 'artisanal' label, the associated mining activities use toxic chemicals and heavy machinery. Thus, ASM is causing irreversible damage to the ecosystems, including deforestation, increased sedimentation in waterways, and mercury pollution of water and soil. In response, many governments are trying to 'formalize' ASM by registering concessions and creating gold mining zones. The environmental outcomes associated with formalization efforts in the tropics have seldom been analyzed systematically. Here we shared lessons from our research on changes in deforestation associated with formalization of ASM in the Department of Madre de Dios (MdD), in the Peruvian Amazon. The complete manuscript is available at *Environmental Research Letters* (https://iopscience.iop.org/article/10.1088/1748-9326/abede9).

KEY FINDINGS

- The extent to which zoning can confine artisanal and small-scale gold mining (ASM) activities depends on enforcement and public buy-in.
- Formalization often *follows* ASM activities, not vice versa. This limits its protective effect.
- The vision of 'settled' ASM miners stewarding their formal concessions over the long term is unrealistic.
- Title holders are not necessarily the miners, and mining in titled areas does not signify compliance with environmental regulations.
- There is seldom 'open' land to set aside for ASM mining, thus formalization typically also requires attention to clarifying agricultural and forestry land titles.

INTERNATIONAL INSTITUTE OF TROPICAL FORESTRY
CARIBBEAN CLIMATE HUB
Middlebury
DEPARTMENT OF GEOGRAPHY
University of Wisconsin-Madison

SUMMARY OF OUR RESEARCH

We focused on Madre de Dios, Perú, where we tracked mining-related deforestation from 2001-2014, when agencies worked to formalize ASM by issuing provisional mining titles and trying to restrict mining to a >5,000 km^2 corridor (Figure 1). We analyzed changes in patterns of deforestation associated with formalization efforts by using panel regression models and matching methods to control for gold price, geology, and accessibility. We supplemented the quantitative analysis with interviews with 47 key informants.

Mining-related deforestation expanded by almost 40,000 ha during this period – both inside and outside formalized areas. The effectiveness of titles and zoning varied over time, but after ~2010, new mining sites were increasingly likely to be located within formalized areas (Figure 2).

However, mining continued to expand outside the corridor in a few hotspots, often in protected area buffer zones and indigenous territories. Even for mining in formalized areas, there was little evidence of improved environmental outcomes because relatively easy-to-acquire provisional titles came to serve as replacements for completing the full process and thus circumvented compliance with attendant environmental rules. Completing the full titling process was also difficult due to overlapping land claims for agriculture and forest use. Meanwhile, provisional titles were used to bolster territorial claims, avoid policing, obtain credit, and recruit 'guest' miners. Responses to formalization varied with changing enforcement pressure and political and economic context.

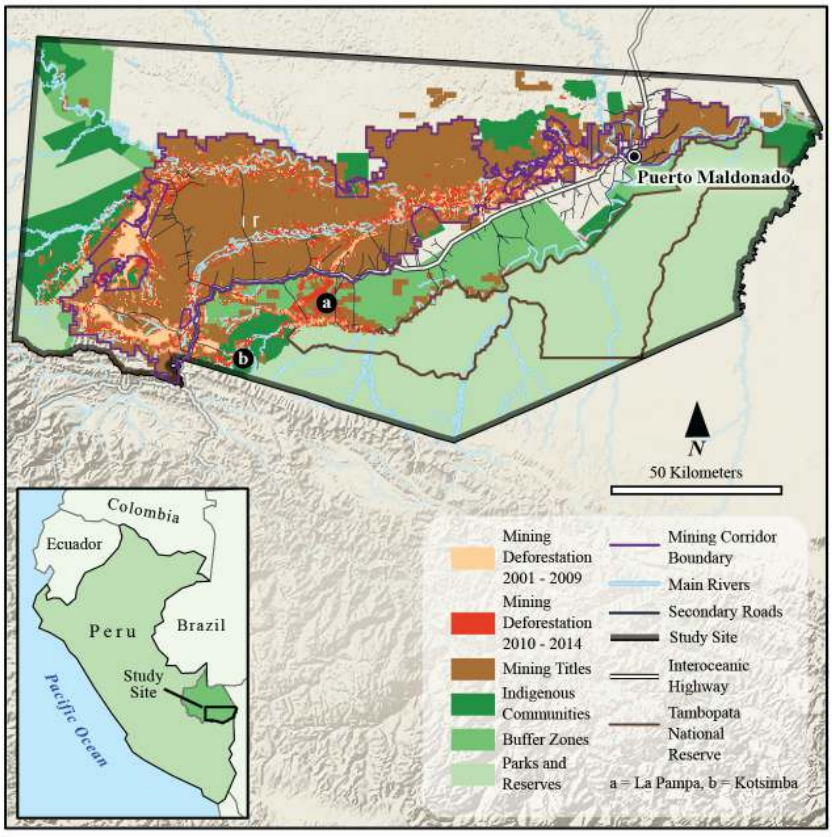


Figure 1. Map of study area, Madre de Dios, Peru highlighting the distribution of provisional mining titles, the Mining Corridor, and mining-related deforestation between 2001 and 2014.

Graphic: K. McNair & T. Andersen/UW Cartography Lab

Quote from a local resident: *"My dad's friend has 40 [provisional] titles but doesn't even own a motor. He lives off the royalties of guest miners. "*

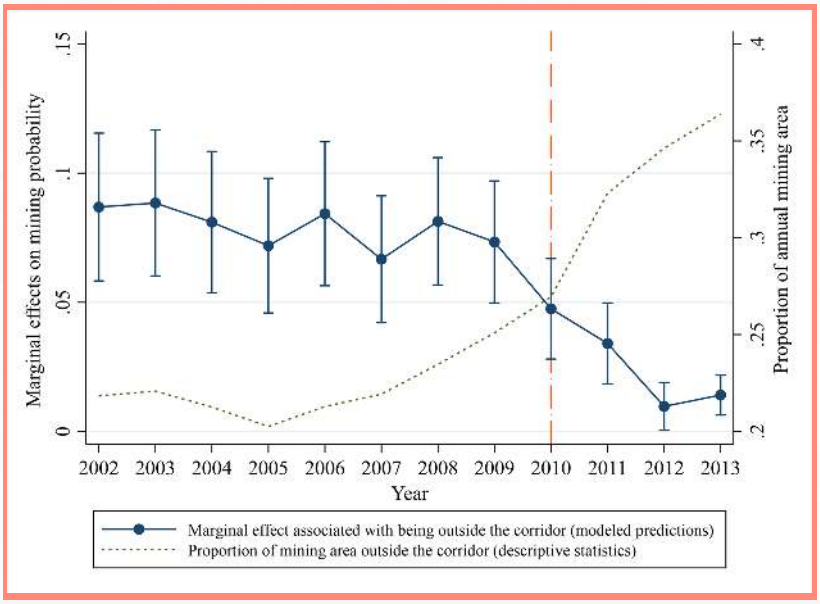


Figure 2. The probability of new clearings in areas outside the mining corridor falls after the corridor is declared in 2010. However, the region outside the corridor accounts for an increasing proportion of total annual clearing for mining, as new deforestation beyond the corridor consolidates into a few major hotspots.

IS FORMALIZATION THE SOLUTION FOR CONTROLLING ARTISANAL MINING?

HOW IT MIGHT WORK

Formalization is the process of zoning and establishing legal property rights over informal ASM activities, to bring those activities under regulation. There are three general mechanisms by which formalization might be expected to reduce environmental problems, coming from theory developed around other land uses:

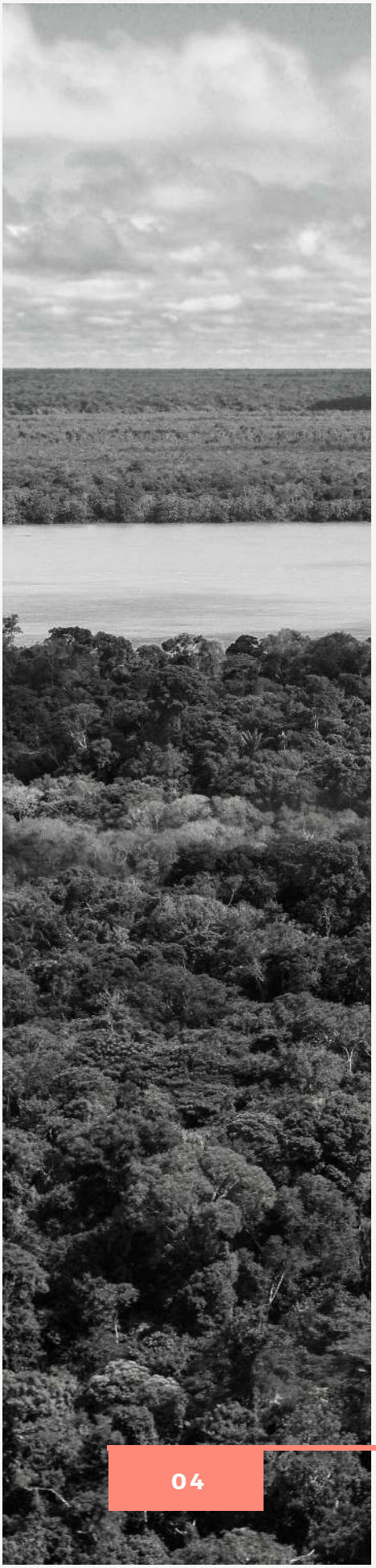
- Zoning- Formalization efforts aim to confine the activity to assigned areas to decrease the impacts on sensitive ecosystems.
- Security- Formalization efforts aim to ensure that miners have secure tenure over a given site. It is thought that a miner with secure tenure may be less likely to rush to exploit a site using the most polluting methods and can instead obtain loans to invest in cleaner technology, encouraging the sustainable stewardship of forests and water resources.
- Legibility – Formalization efforts aim to legally recognize and map concessionaires so that these can be held accountable for environmental damage and may be more inclined to adhere to regulations requiring environmental impact statements and management plans.

WHY IT OFTEN DOESN'T WORK

There is as yet little evidence that the logic behind these mechanisms. drawn from experiences with smallscale agriculture and forestry, is applicable to the context of artisanal gold mining.

- Adherence to zoning and environmental regulations may be difficult to enforce in remote places or with limited resources.
- Gold mining removes forest cover and topsoil completely, is non-renewable, and isn't practiced in sites where miners live longterm, decreasing chances that secure tenure will lead to sustainable stewardship.
- Miners may resist formalization and opt to continue illegally.
- Corruption or confusion around land rights may lead to inaccurate, incomplete, or inconsequential titling processes.

Before investing heavily in formalization as a policy solution to control artisanal mining, it is critical to assess whether it is effective, and to understand the conditions that can undermine effectiveness.



TESTING THE IMPACTS OF FORMALIZATION

Whether formalization mitigates the environmental damages of ASM has been difficult to assess because formalization is rarely fully implemented, effects can be associated with other changing circumstances, and some impacts are difficult to monitor.

If formalization interventions have not yet been implemented, it is worth considering whether they could be deployed in a staggered way that would facilitate randomized control trials, to help to account for confounding factors that might affect the timing and location of mining. When this is not an option or if programs have already begun, see Blackman (2013). It is important to evaluate programs even when they are only partially implemented, both because it may never be possible to achieve full implementation, and because behavioral responses begin as soon as stakeholders are aware of potential programs. Interviews with local informants can illuminate unanticipated behavioral responses to the program that can attenuate or undermine environmental outcomes, and talking with many stakeholders can strengthen causal inferences about how formalization interventions may or may not be working.

There are multiple environmental impacts of ASM that could be affected by formalization programs. Deforestation is one consequence, and see Asner and Tupayachi (2017) for remote sensing methods to distinguish artisanal mining from other types of deforestation, but ASM is difficult to detect with remote sensing when clearings are small or sites are located within shifting river corridors. Furthermore, impacts of ASM go beyond forest clearing because it totally removes soil horizons, introduces toxic chemicals into waterways, and can indirectly lead to increases in hunting pressure and exploitation of other forest resources. Thus, environmental impacts of mining clearings depend on their extent, their location, and the equipment and technologies used. Ideally, a systematic study of the effectiveness of formalization interventions will include a combination of satellite monitoring to detect changes in mining across broad remote regions, including potential spatial spillover effects, and field based monitoring to illuminate impacts on less visible instances and aspects of mining.

Asner G P and Tupayachi R 2017 Accelerated losses of protected forests from gold mining in the Peruvian Amazon Environ. Res. Lett. 12 94004

Blackman A. 2013 Evaluating forest conservation policies in developing countries using remote sensing data: An introduction and practical guide For Policy Econ 34 *1-16*

FORMALIZATION - LESSONS LEARNED FROM MDD

- The extent to which zoning can confine mining depends largely on enforcement, which during our study was inconsistently applied at MdD due to physical challenges, political shifts, and alleged corruption.
- Formalization often follows the miners rather than prescribing where and how mining should occur. In MdD titles were sought for areas where mining had already begun. The corridor was declared atop of a region that was mostly already titled.
- The vision of 'settled' miners stewarding their concessions over the long term is far afield from MdD conditions. Title holders are not necessarily the miners, and mining in titled areas does not signify compliance with environmental regulations.
- Although most miners at MdD want more secure working conditions, the issuance of provisional titles did not slow the 'rush' mindset. Thus, we caution against assuming that because more secure ownership tends to favor forests in the context of smallscale agriculture, the relationship will hold for alluvial mining, a non-regenerative activity.
- Regulators and miners agreed that it is difficult to apply and enforce regulations derived from hard-rock mining in the Andes to Amazonian ecosystems. For example, prohibitions about mining near waterways are hard to enforce when river courses regularly shift, and the water table lies near the surface.
- Last, in MdD as in the Andes, adherence to regulations may be weakened by divisions within the government about prioritizing mining or the environment. This power struggle partly explains why formalization rules were 'bent' to accommodate miners.

*"**Mining and Agriculture agencies have each managed their own cadaster. They [the Mining Agency] never verify coordinates but just give permission to the miner no matter the surface claim. Having a [title] gives the miner a bit of power. [he says] 'I have in hand the permit. You only own the surface.' Some [farmers] can negotiate but the miner has more money [..] the farmer has to give way".*** Mining Reforestation Specialist National NGO

MANAGING ASM IN TROPICAL FORESTS

- Limit roads and access to heavy machinery into gold-rich forests.
- Combine formalization efforts with investments in enforcement.
- Invest in strengthening land rights for smallholder farmers, forest stewards and indigenous people in gold rich areas. This includes improving records and transparency, and it requires increasing coordination among government institutions.
- Design regulations and strategies specific to address gold mining in alluvial ecosystems (vs. 'importing' models for hard-rock mining).

Acknowledgments
Research support came from the NSF GRFP, the Moore Foundation, and UW LACIS. We are responsible for any errors. All research at the USDA Forest Service IITF is done in collaboration with UPR. This work was approved by UPR IRB #1314-235 and UW IRB #2014-0628.