Madre de Dios, Peru

The promise of quick profits has led to a modern-day gold rush in the ecologically diverse and culturally important Madre de Dios region of Peru. Walking through the capital of Madre de Dios, Puerto Maldonado, it is hard not to notice the small shops selling motors, pipes, chainsaws, and other mining-related equipment. Jewelry shops and gold buyers surround the central market in town, offering to pay cash for gold. In this region threatened by many human-driven disturbances, the rapid expansion of small-scale gold mining (SSGM, defined in Veiga et al. 2006 as small, medium, informal, legal, and illegal mining using rudimentary techniques to extract gold) has emerged as a major concern for conservationists and public health advocates alike, who fear the long-term impacts of SSGM on humans and the environment.

Flying into Puerto Maldonado, the effects of the current gold boom can be seen from the sky. Large, open-air pits where rainforest once stood scar the landscape, interrupting the expanse of verdant forest. Over the past decade deforestation from small-scale gold mining has increased by over 400 percent in Madre de Dios, outpacing agriculture and timber extraction as the leading driver of deforestation. Since 2008, between 10,000 and 30,000 Peruvians have migrated from the Andean Highlands into Madre de Dios to mine for gold causing widespread destruction of ecosystems and endangerment of human health from toxic mercury used in gold extraction. My second day in Madre de Dios, I visited a mining site and witnessed firsthand miners working a large pit, moving huge quantities of earth using no more than a dredge and sluice powered by a small car engine. The physical impacts of mining on the landscape are readily apparent from the stark juxtaposition of cleared, almost desert-like mining areas, surrounded by lush rainforest. The effects of mercury from the mining process are far more discrete and insidious as mercury moves through the ecosystem from mining pits to surrounding waterways.

Miners are directly exposed to mercury through the gold extraction process, which has also created a significant pollution source as mercury tailings leach into waterways and infiltrate surrounding areas. The goal of my pilot study this summer was to understand how mercury is transferred from these aquatic ecosystems to adjacent terrestrial ecosystems via food web interactions. The transfer of mercury from mining sites to people through fish consumption is well documented in hair and urine sample from residents of Madre de Dios. Fish is the cornerstone of people's diet in Puerto Maldonado and not only culturally important, but also oftentimes the only source of protein in people's diet. Given our understanding of mercury

accumulation in fish, I set out to better understand how mercury makes its way into organisms on land. To do so, I chose to focus on bioindicator species, or organisms that act as sentinels of ecosystem change due to their sensitivity to contamination. My bioindicators were families of orb-weaving spiders who exclusively prey on emerging aquatic insects. These spiders build their webs along the edges of rivers and lakes to capture insects as they emerge from waterways. Given their small body size and relative abundance, these spiders are both easy to catch and an important source of information allowing us to determine whether mercury is present in the environment.

My pilot study involved collection of orb-weaving spiders and aquatic insects in abandoned mining pits and un-impacted oxbow lakes located within a protected area in Madre de Dios. I partnered with a team of researchers at the Centro de Innovacion Cientifica Amazonica (CINCIA) in Puerto Maldonado, to design a study that could provide information to help inform remediation and reforestation projects being carried out by CINCIA. The logistical support and expertise I received from CINCIA were invaluable in allowing me to complete my pilot study. In addition, given the outreach efforts that CINCIA is undertaking to educate the general public on the dangers of mercury contamination in fish, I also developed a project with them to create a user-friendly guide to identify orb-weaving spider families and aquatic insects to be used for rapid bio-assessments in mining-impacted areas. This project will help government agencies, landowners, and NGOs collect these bioindicator species and quickly assess whether mercury is present in an area.

The actual collection of spiders and insects involved constructing emergence traps from PVC pipe drilled with 2-inch holes to allow water to flow through them. I built 12 of these traps and placed them around small ponds and lakes around Puerto Maldonado to test whether they were effective at catching adult insects emerging from the sediment. After a couple of weeks of refining my sampling methodology, I set out with a local field assistant to sample five oxbow lakes inside of the Tambopata National Reserve in Madre de Dios. This reserve is considered a global biodiversity hotspot and is strictly protected from extractive activities, thus making it a good reference site for my study. While on my weeklong expedition in the reserve, I stayed at a control post manned by the Peruvian park service. Cruising along the muddy red waters of La Torre River, looking for oxbow lakes, and collecting spiders along the banks of these lakes was one of the highlights of my trip. The diversity of flora and fauna within Madre de Dios is truly

astounding and I felt very privileged to be able to work in such a unique area.

After I returned from Tambopata, I had the chance to go out with CINCIA's research team to a mining concession located off the Madre de Dios River and collect insects in abandoned mining pits. CINCIA has established relationships with landowners in mining concessions to reforest abandoned mining areas. In most cases, mining is still occurring on the land, but certain areas have been put aside for reforestation in an effort to comply with the standards established by Peruvian laws regulating small-scale mining operations. The area I visited in the district of Laberinto had already been replanted with native tree species chosen for their hardy and fast-growing characteristics. The mining pits that I visited were quite large, over 500-feet in diameter, and had been abandoned for one to two years. After collecting my last samples from these sites, I began to sort and analyze my samples.

Processing and sorting aquatic insects and spiders to taxonomic family requires a lot of time, so I have yet to analyze all of the samples for mercury presence. However, I was able to use CINCIA's lab to analyze two samples collected from abandoned mining pits. The concentration of mercury within the spider and insect samples was relatively high compared to samples CINCIA has processed from fish and sediments. These concentrations are far above the margin of error of the mercury detector, meaning that there is a detectable amount of mercury in these organisms. The results of these analyses and remainder of my samples, which will be processed at UCB, will help to inform where I sample in my next field season. In addition, establishing differences in mercury concentrations between impacted and non-impacted areas and proving that there is a pathway of mercury transfer from aquatic to terrestrial ecosystems will help inform CINCIA's remediation efforts. I also hope that completion of the field guide for identification of spiders and aquatic insects will be useful for local stakeholders to be able to utilize these bioindicator species to quickly establish mercury presence in the food web.

My experience in Madre de Dios was incredibly fruitful both intellectually and professionally. I feel that after these two months, I am much better prepared to return for a full field season knowing full well many of the logistical challenges that exist in my study. I am also thankful for the opportunity to collaborate with local partners who have helped me design a study that can provide useful information for people working on the ground, trying to grapple with restoration of this region and a resolution to mining conflicts. Finally, I feel that after two months in Peru, I have a much more nuanced understanding of the social context that informs

patterns in mining in this area. Understanding how historical drivers of migration and national-level economic policies have actually helped to promote mining in this region, gives me a better understanding of how to effectively communicate my scientific results to local actors.