



PHOTO: A SMALL-SCALE GOLD MINE IN ANTIOQUIA, COLOMBIA. KATHLEEN HURLEY, APRIL 2016.

SMALL-SCALE & ARTISANAL MINING IMPACTS ON BIODIVERSITY IN LATIN AMERICA

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underestimated, and distribution data are lacking for many species. Nonetheless, fish diversity data are
now sufficient to support basin-scale impact assessments

ACRONYMS

22 CFR 216	Code of Federal Regulations				
ARM	Alliance for Responsible Mining				
ASGM	Artisanal and Small-Scale Gold Mining				
ASM	Artisanal and Small-Scale Mining				
CAMEP	Carnegie Amazon Mercury Ecosystem Project				
CBD	Convention on Biological Diversity				
CETEM	Centro de Tecnología Mineral				
CI	Conservation International				
CINCIA	Centro de Innovación Científica Amazónica				
CMP	Conservation Measures Partnership				
IDAMHO	Instituto de Derecho Ambiental de Honduras				
ECLAC	Economic Commission for Latin America and the Caribbean				
EU	European Union				
FARC	Fuerzas Armadas Revolucionarias de Colombia				
GDP	Gross Domestic Product				
GEF	Global Environment Facility				
GIATOC	Global Initiative Against Transnational Organized Crime				
IGF	Intergovernmental Forum				
IHA	Indicators of Hydrologic Alteration				
IPIS	International Peace Information Service				
ITSCI	International Tin Supply Chain Initiative				
LAC	Bureau for Latin America and the Caribbean				
MAAP	Monitoring of the Andean Amazon Project				
MEA	Millennium Ecosystem Assessment				
MeHg	Methyl-mercury				
NGO	Non-Governmental Organization				
NRDC	Natural Resources Defense Council				
OECD	Organization for Economic Cooperation and Development				
RACCN	Región Autónoma de la Costa Caribe Norte				
RAGS	Responsible Artisanal Gold Solutions Forum				
RAISG	Red Amazónica de Información Socioambiental Georreferenciada				
RNA	Ribonucleic Acid				
SBGA	Swiss Better Gold Association				

SCIOA	Strengthening the Capacity of Indigenous Organization in the Amazon				
SECO	State Secretariat for Economic Affairs				
SNUC	Brazilian National Law for Conservation Units				
SPDA	Sociedad Peruana de Derecho Ambiental				
TSS	total suspended solids				
UNEP	United Nations Environment Programme				
UNEP-WCMC	United Nations Environment Programme World Conservation Monitoring Centre				
UNESCO-MAB	United Nations Education, Science, and Culture Organization – Man and Biosphere				
UNIDO	United Nations Industrial Development Organization				
UNODC	United Nations Office on Drugs and Crime				
UNMSM	Universidad Nacional Mayor de San Marcos				
US EPA	United States Environmental Protection Agency				
USAID	United States Agency for International Development				
USD	United States dollar				
USGS	United States Geological Survey				
WGC	World Gold Council				
WHO	World Health Organization				
WWF	World Wildlife Fund				

EXECUTIVE SUMMARY

Artisanal and small-scale mining (ASM) is a global phenomenon that supports tens to hundreds of thousands of workers in many Latin American countries. Although much of the work is difficult, dangerous, and often at the subsistence level, the pay is usually better than the alternatives in many of the rural areas where it occurs and can help support impoverished communities.

The extent of impacts on biodiversity from artisanal and small-scale mining (ASM) depend on the type of mining, the area in which it is occurring, and the location. Some communities have practiced local small-scale hard-rock mining for generations with minor local impacts. Other regions, such as the Madre de Dios in Peru, have experienced widespread devastation of primary tropical forests, with illegal alluvial gold mining serving as the leading cause of deforestation in the region. Although the Madre de Dios region receives the most media attention due to the graphic nature of the destruction, illegal and/or Artisanal and Small-Scale Gold Mining (ASGM) occurs in every department in Peru.

ASGM is also a leading cause of deforestation in highly biodiverse regions of Colombia, where most mining is also informal or illegal. Brazil has the largest ASGM mining area in the world in the Tapajos River basin, which is a tributary to the Amazon (Section 2.3.3). Less of the mining in Brazil is illegal, although conflict with indigenous community lands is increasing and regulatory oversight is often conflicting among agencies. ASM is less well documented and seems to be less pervasive in Central American countries, but still occurs in areas of high biodiversity. Although ASM may be a leading cause of deforestation in the areas where there are significant mining communities in Central and South America, it is dwarfed by forest loss due to agricultural conversion to ranching and farming land. (Section 4, Figure 13).

Impacts on biodiversity from ASM range from local destruction or degradation of habitat to watershedscale impacts from pollution to global lethal and sublethal effects of mercury bioaccumulation (Section 3). Multiple studies and projects have documented the extent of deforestation in the target countries using remote sensing, primarily in South America. Multiple studies in South America document severe water quality impacts from mercury, sedimentation, and acid mine drainage. Massive amounts of sediment are released into waterways from alluvial mining, causing downstream sedimentation, increases in turbidity, and changes in aquatic biota. Several studies showed changes in freshwater fish populations due to sedimentation from mining. Sediment plumes can impact rivers for many miles downstream and may also affect estuaries and coral reefs.

Many global studies and a few studies in Latin America have described impacts of mercury contamination on wildlife (Section 3.5.3). ASGM (artisanal small-scale gold mining) is the leading contributor of mercury to the environment globally, and the effects and extent of mercury contamination have been documented at the local, regional, and global scale. Mercury contamination is widespread in the Amazon basin both from natural sources and from widespread mercury use in ASGM. Methyl mercury, the more biohazardous form, bioaccumulates in the food chain and has been documented at high levels in people and wildlife near mines, in indigenous peoples far from active mining areas in the Amazon basin, and in fish and wildlife as far away as the Arctic, where breeding bird populations may be declining due to elevated mercury deposition. In addition to global transport of mercury, contamination can impact large areas downwind and downstream from mines and processing centers. Acid mine drainage is typically associated with hard rock mining, where sulfide-bearing rocks are exposed to oxygen and produce sulfuric acid. Heavy metals can also be released when cyanide is used to process gold-bearing ore since it also effectively leaches other metals. Studies along the Puyango-Tumbes river in Ecuador and northern Peru have documented extensive cyanide, mercury, and heavy metal contamination and associated impacts on biodiversity (Section 3.5.2).

The drivers of ASM depend on local conditions and are a complex mix of poverty, corruption, weak or conflicting regulatory oversight, economic pressures, organized crime, tradition, and lack of access to opportunity and education (Section 1.3.2). Attempts to reduce the impacts from ASM on the environment and on human communities have met with mixed results. Efforts to date have focused on education, formalization, enforcement, remediation, and reduction of mercury use in the case of ASGM. As with the wide array of biodiversity in the target countries, there is a wide diversity of conditions under which ASM is occurring and there appears to be no single approach that is proving most effective to reduce its negative impacts (Section 5).

Many organizations are working on aspects of the Minamata Convention, that, while focused on reducing mercury use and consumption, also includes reducing worst-practices, providing education, and formalizing ASGM. It is a global treaty with significant resources for implementation and most Latin American target countries have ratified the agreement, excepting Colombia and Guatemala, who have signed, but not ratified the treaty. A summary of existing treaties, policies, and programs addressing ASM is included in Section 5.

I. INTRODUCTION

This white paper on artisanal and smallscale mining (ASM) was developed for the United States Agency for International Development (USAID) Bureau for Latin America and the Caribbean (LAC) with the purpose of summarizing and documenting the current knowledge regarding adverse impacts of ASM on the environment and more specifically, on biodiversity. It also summarizes existing programs and strategies that address risks posed by ASM in target countries. Countries where USAID works with biodiversity funding bilaterally or regionally include Guatemala, Honduras, El Salvador, Nicaragua, Colombia, Perú, and Brazil (Map I). Although the paper addresses ASM in general, there is a particular focus on artisanal gold mining since it is widespread, comparatively welldocumented, and can have significant environmental impacts.

This white paper addresses how ASM impacts biodiversity within these target countries and focuses on four research questions, summarized below. Via these



Figure 1. Map showing overview of region of focus for ASM and biodiversity

four questions, this document will characterize the impacts of ASM in Latin America and the Caribbean and further the analytical work in support of USAID in the region regarding ASM in biodiverse areas.

ASM Research Questions

- 1. To what extent does ASM affect areas of high biodiversity?
- 2. What is the evidence that ASM has significant impacts (e.g., direct, indirect, or cumulative) on biodiversity?
- 3. Where ASM impacts are thought to be significant, how does ASM compare to other threats to biodiversity in the target areas?
- 4. What are successful principles and strategies for addressing threats posed by ASM to biodiversity in the targeted geographies?

I.I METHODOLOGY

This paper was developed in several stages to collect and synthesize information on artisanal and smallscale mining in the targeted geographies as well as potential or known impacts on biodiversity.

The following methods were used to collect data:

- An initial literature review to establish the level of existing documentation;
- Identification of subject-matter experts for telephone or in-person interviews;
- Expanded literature review and annotated bibliography;
- Telephone interviews with experts in the artisanal and small-scale mining field;
- Summary of existing research and knowledge in a draft document;
- Field visit to Peru for development of a site-specific case study.

1.1.1 DEFINITIONS OF BIODIVERSITY TERMINOLOGY

The definition of artisanal and small-scale mining varies by geographic location; most countries where ASM occurs have a legal or regulatory definition, which can vary considerably from country to country.

This paper uses ASM as defined by the Minimata Convention on Mercury and adopted by the USAID Sector Environmental Guideline on Artisanal and Small-Scale Mining: "Mining conducted by individual miners or small enterprises with limited capital investment and production" (Minimata Convention on Mercury 2013, USAID 2017).

The USAID Sector Environmental Guideline indicates that ASM typically includes informal activities characterized by a "low degree of mechanization, high degree of labor intensity, poor qualifications and mining labor competence, poor occupational and environmental health standards, little capital and inefficient productivity, deposit exploitation, little consideration of environmental issues, limited access to land and markets, and chronic lack of capital" (USAID 2017).

In general, artisanal mining occurs at a small scale and involves small groups of people using manual labor or rudimentary mining techniques. Small-scale mining uses some mechanization and occurs over a larger area or on a larger scale than artisanal mining. Medium-scale mining uses mechanical equipment such as dredges or heavy equipment, occurs over a larger area than small-scale mining, and has the capacity to process significant amounts of ore. Medium-scale mining may or may-not be formalized. Formalization means that the mining is recognized and occurs within local, regional, or national regulatory or legal frameworks. Large-scale and industrial mining generally uses capital-intensive methods to extract and process large quantities of ore and are typically formalized. In general, most ore is produced by relatively few large-scale mines with the remainder produced by many artisanal and small-scale miners scattered around the country or concentrated near existing large-scale mine operations.

The terminology used to describe the effects of ASM on biodiversity are aligned with USAID definitions based on the Open Standards for the Practice of Conservation (Conservation Measures Partnership (CMP) 2013) and described in USAID's Biodiversity How-To Guides¹. Concepts used in this paper include:

¹ <u>https://usaidlearninglab.org/library/usaid-biodiversity-programming-how-guides</u>

Biodiversity Focal Interest: An element of biodiversity (species, habitat, and/or ecosystem), within the defined scope, on which a program has chosen to focus. Examples: Tropical forests, wetlands, and streams.

Direct Threat: A human action or unsustainable use that immediately degrades one or more biodiversity focal interests. Examples: Unsustainable logging, ASM, and unsustainable agricultural development.

Driver: A constraint, opportunity, or other important variable that positively or negatively influences direct threats. Examples: international demand for timber or minerals; inadequate law enforcement; or limited job opportunities in a region.

Stress: An altered key ecological attribute of biodiversity focal interest. In many cases, a stress is the biophysical way in which a direct threat impacts a biodiversity focal interest. Multiple stresses can result from each threat. For example, reduced or fragmented habitats, increased sedimentation in streams, and compacted soils.

Ecosystem Service: Service that functioning ecosystems, species, and habitats provide and that can benefit people. Example: Clean water produced by minimally disturbed watersheds.

Impact (Effect): A direct result of an action which occurs at the same time and place; or an indirect result of an action which occurs later in time or in a different place and is reasonably foreseeable; or the cumulative results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions (40 CFR 1508.8).

This paper uses these definitions to summarize the potential impacts of ASM activities on the environment, biodiversity focal interests, and to a lesser extent, human health. Additional descriptions and definitions of mining-related terms and activities are described in Section 3.

I.2 ORGANIZATION OF THIS PAPER

This paper first provides a background on the issue of ASM in Latin America (Section 1), including a description of trends in the ASM sector. Section 2 describes the status of biodiversity in the targeted countries and characterizes the level of ASM occurring in each area. Section 3 summarizes the pathways in which ASM impacts biodiversity. Section 4 then places ASM in the context of other biodiversity threats in the region, the report concludes with a summary of known programs, policies, and activities covering aspects of managing ASM impacts in Latin America (Section 5).

1.3 BACKGROUND ON ASM IN LATIN AMERICA

1.3.1 ASM PRODUCTION

Key points

- ASGM production has been increasing globally over the past 25 years.
- The ASGM workforce in Latin America more than doubled over the last 15 years to almost 1.5 million, with the largest increases in Brazil and Colombia (Table 1).
- The percent of gold produced informally or illegally (mostly from ASGM) ranges from 10 percent (Brazil) to 80 percent (Colombia) of total production. While the average ASM gold production in Peru is 28 percent, in some areas like Madre de Dios, over 90 percent of production is illegal.
- ASGM can be a major economic driver in rural areas, providing above average wages. It can also be a driver of human trafficking and be subject to organized crime.

Globally, ASM produces approximately 10 to 25 percent of gold, 15 to 20 percent of diamonds, 20 to 25 percent of tantalum and tin, and 80 percent of colored gemstones (Villegas et al., 2012). Much of the growth has occurred in ASM gold as gold prices increased over the past two decades (Figure 2). As



Figure 2. Changes in gold prices, forest area converted to mining in the Madre de Dios region, and Peruvian mercury imports 2002-2010. (Swenson et al., 2011)

production has increased, so have impacts. Figure 2 illustrates the relationship between gold price, the amount of mercury imported to Peru (primarily for processing gold), and the area of gold production in the Madre de Dios region in Peru between 2002 and 2010. Although gold prices have declined from a high of \$1,900/oz in 2011, gold is currently valued at about \$1,200/oz, which is over four times higher than the price at the turn of the millennium. Rising mineral prices, especially following the 2008 global financial crisis, caused mining rushes worldwide with ASGM activity and production increasing substantially in the past 25 years (Swenson et al. 2011, Alvarez-Berrios and Aide 2015, Intergovernmental Forum (IGF) 2018). Mercury use and mining has continued to increase in the Madre de Dios region since 2010 (see Section 2.3.2).

The global ASM sector has undergone significant growth over the past 25 years from an estimated 13 million miners in 1999 to 30 million in 2014 to 40.5 million in 2017 (IGF 2018). Due to the laborintensive nature of ASM, over 75 percent of the global mining labor force works in artisanal mining, of which approximately 30 percent are women (IGF 2018; Hinton et al. 2003). ASM is one of the most important sources of rural livelihoods, especially for youth. A similar ratio occurs in ASGM, where approximately one-third of the estimated 10-19 million artisanal gold miners are women and children (Esdaile and Chalker 2018). In Latin America, the ASM workforce has increased from an estimated 641,875 workers across 17 countries in 1999 to 1,442,700 ASM workers in 19 countries as of 2014 (IGF 2018). The largest number of ASM workers are in Brazil and Colombia, with a significant presence in Peru as well (IGF 2017, Table 1). Table 1 summarizes estimates of the total gold production, production by ASGM methods, the percent of total gold production mined illegally, the ASM population (most of which work in gold production), and mining (ASM and industrial) as a percent of gross domestic product (GDP) for each target country in the LAC region. Due to the informal and illegal nature of ASGM production, estimates vary considerably by source.

TABLE I. GOLD PRODUCTION, ASGM POPULATION, AND MINING AS PERCENT OF GDP BY

COUNTRY					
Country	Total Gold production 2014 (tons)	Estimated ASGM Gold production 2011 (tons)	Percent of total produced illegally (%)	Estimated ASM worker population 2014	All mining as % of GDP
Brazil	79.6	21 – 64.9	10	467,500	4.3%
El Salvador	Negligible	-	-	-	-
Colombia	57.0	41.4 - 50.8	80	385,000	2.1%
Guatemala	5.9	-	-	-	1.1%
Honduras	2.7	-	-	I,000	1%
Nicaragua	8.6	1.2	13	20,000	3.5%
Peru	147.8	40.0	28	110,000	14%
World	3,270.0	379.4 – 448.7	-	30,000,000	
Source:	United States Geological Survey (USGS) 2017	Seccatore et al. 2013	Global Initiative Against Transnational Organized Crime (GIATOC) 2016	IGF 2018	Fonseca & Cardoso 2013; Wascaster 2014; ICMM 2014; EITI, 2014; De la Flor 2014

The world's rising mineral prices have led to exploitation of mineral resources in previously untouched areas, including at least seven World Heritage Sites and World Wildlife Fund (WWF) priority landscapes globally (Villegas et al., 2012). ASGM is widespread throughout Latin America; for example, it occurs in every department in Peru at some level, and most ASGM activity is informal and/or illegal (Piñeiro et al., 2016). However, it subsidizes local economies in rural areas and has been practiced for generations in

some communities. There are areas where ASGM is simultaneously a major driver of economic growth as well as environmental destruction, such as the Madre de Dios region in Peru, the Choco and Antioquia regions in Colombia, and Tapajos province in Brazil. Continued environmental impact has been exacerbated by lack of a coordinated or systematic effort to curb activities in critical conservation zones until the previous decade (Villegas et al., 2012)

1.3.2 ASM DRIVERS

To fully understand the environmental consequences of ASM, it is important to recognize the underlying drivers of unsustainable ASM mining practices. According to the USAID Foreign Assistance Act 118/119 Tropical Forest and Biodiversity Best Practices Guide² **drivers** are constraints, opportunities, or other variables that indirectly influence the direct threats to the environment and biodiversity. This can include institutional arrangements, economic variables, poor technical or management capacity and sociopolitical factors.

Globally, ASM is driven by numerous factors, such as fluctuations in mineral values, poor governance, poverty and lack of alternative livelihoods and economic opportunity, lack of resources and knowledge, conflict and instability, and lack of land and resource tenure. In addition to the global factors driving ASM, factors such as easy access to mineral-rich areas (in poor or rural areas in particular), the low amount of investment required, the availability of simple technologies that require little expertise, and the high potential profit margin have also driven increases in ASM, particularly as an informal or illegal activity (McMahon et al. 1999). With the value of gold exports exceeding cocaine exports in both Peru and Colombia, organized crime is also a driving force behind ASGM activities, particularly in Colombia (GIATOC 2016).

USAID (2017) describes the following four cross-cutting factors as key drivers of ASM:

Poor governance. Governments can have a significant impact on the ASM practices within their jurisdictions. For example, policies that ignore local conditions or contradict national strategies can be ineffective, while policies that prioritize production over sustainability will likely have negative environmental consequences. Often government ministries that are responsible for ASM activities are underfunded or understaffed, which makes zoning, planning, and/or enforcement (particularly for informal activities or activities in remote areas) difficult to undertake. Corruption within government can further exacerbate environmental impacts through inadequate enforcement or legislation and/or improper allocation of resources.

Poverty. Poverty and a lack of diverse economic opportunities can drive individuals into riskier jobs, such as ASM. Once involved, miners often become trapped in a poverty cycle because of low productivity due to limited technology and poor geo-prospecting. These factors, along with dangerous working conditions, competition over land and resources, and organized crime can further enmesh miners in the informal economy and limit their ability to improve their standard of living (IGF, 2017).

Lack of resources and knowledge. At the local level, there may be inadequate knowledge of and/or access to ASM best practices that can mitigate environmental and human health impacts, as well as a lack

² <u>https://rmportal.net/biodiversityconservation-gateway/gateway-resources/foreign-assistance-act-sections-118-119-tropical-forest-and-biodiversity-analysis-best-practices-guide</u>

of training and technology/equipment to implement best practices. Further, without an understanding of the economic benefits of ecosystem services and natural resources, it is unlikely that there will be incentive to prioritize environmental stability in ASM activities.

Conflict. Geopolitical unrest at various levels can prevent the formalization of ASM activities, which reduces the prospects for sustainable practices. For example, conflicts between ASM and industrial mining concessions can lead to land dispossession, community relocation, and general instability for ASM miners, all of which hinders formalization and exacerbates social disparities. Further, where organized crime networks exist, environmental impacts can be particularly severe because of the quick-profit objectives of these groups (GIATOC 2016, Section 2.3.1.2).

2 TO WHAT EXTENT DOES ASM AFFECT AREAS OF HIGH BIODIVERSITY?

This section addresses research question 1.

This section addresses the first key question by describing the types and levels of biodiversity present in each region and country reviewed. It then describes the extent of ASM activities in each area. Limited research has been conducted on how ASM impacts biodiversity (summarized in Section 3). Since ASM is frequently informal or illegal and often takes place in remote areas, the extent of impacts on biodiversity can be difficult to quantify. The most commonly cited impacts of ASM include hydrological impacts (e.g., dredging, sedimentation), mercury contamination, deforestation, and human settlement (Esdaile and Chalker 2018; Fernandez, pers. comm., 2018; McMahon et al., 1999; Villegas, pers. comm., 2018). Several studies utilize remotely-sensed data to document forest cover and land use change from mining, which can be used a proxy for biodiversity loss since much of the deforestation occurs in previously undisturbed landscapes. Otherwise, biodiversity loss can be inferred indirectly from levels of ASM activity that are occurring in areas with high biodiversity, given the associated impacts on the biophysical environment (Section 3.2).

2.1 **BIODIVERSITY HOTSPOTS**

Central and South America are home to highly diverse landscapes crossing several climatic zones. There are six main biodiversity hotspots located in these regions. Biodiversity hotspots are defined as threatened terrestrial ecosystems with high biodiversity by the Critical Ecosystem Partnership Fund (CEPF, 2001, 2004, 2015). Figure 3 provides an overview of the target countries and illustrates major ecosystems, the location of existing ASGM sites, and areas that are being explored for potential gold mining opportunities. Additional detail is provided in Annex B1.



Figure 3. Map showing major ecosystems and biodiversity hotspots in target countries. Most of these ecosystems have been degraded and no longer cover the full extent of the area depicted. Data source: USGS, 2017c.

2.2 CENTRAL AMERICA

<u>Key points</u>

- Central America is a region with high biodiversity and includes the Mesoamerica biodiversity hotspot. Guatemala has the highest rates of endemism in Central America.
- Overall, there is insufficient information to assess the impact of ASM on biodiversity in this region.
- In El Salvador, all metal mining (industrial and ASM) was banned in 2017, although some may still occur illegally. There remain a few towns where ASGM has occurred for generations.
- Mining in Nicaragua accounted for about 3.5 percent of GDP in 2014, with approximately 10-15 percent of gold produced by an ASGM workforce of about 20,000.
- ASGM in Nicaragua often occurs near industrial mine sites located in the 'mining triangle' in Northeastern Nicaragua, in proximity to two natural reserves and a relatively large undeveloped area to the north. Estimates of biodiversity impacts from ASM in Nicaragua are not available.

Central America is a highly biodiverse region due to its unique position connecting two continents and dividing two oceans. Figure 4 depicts areas where gold mining (both industrial and ASGM) occurs in Central America along with the geologic zone where gold deposits are likely to occur. This section provides a summary of biodiversity and ASM activities for each target country in Central America.



Figure 4. Map showing active gold mines and gold mineralization belt in Central America. Source: Steiner 2010.

2.2.1 GUATEMALA

Guatemala has the highest percentage of endemic species in Central America at 13 percent of documented species (Convention on Biological Diversity (CBD), n.d.). The highest biodiversity rates for fauna in Guatemala are found in the mountains of Lacondón, near Peten, Chamá, Santa Cruz and part of the Mayan Mountains. Despite the high levels of biodiversity, many species are endangered, including flowering plants (1,522 endangered species), birds (194 endangered species), reptiles (160), and arthropods (138) (Byers, Sandoval and Lopez-Selva, 2016). An assessment carried out between 2009 and 2012 on Guatemala's Protected Areas System found that out of 77 areas assessed (covering 58 percent of the protected area system), only 12 were effectively managed.

Desktop research provided little information regarding ASM in Guatemala. Conflicts between landowners (and indigenous communities in particular) and industrial miners have been described in the media and in reports (Amnesty International 2014). The mining sector in Guatemala accounted for 2.2 percent of the GDP in 2014, with 97 percent from metal mining (\$754.7 million dollars). As indicated in Table I, gold production was 5.9 tons in 2014, with no information available on ASGM contribution, percent mined illegally, or estimated number of ASGM workers. Given the lack of information regarding ASM presence and extent in Guatemala, it is not possible to determine the extent that ASM affects biodiversity in this country.

2.2.2 HONDURAS

Both tropical and subtropical ecosystems are present in Honduras; as a result, it has a high level of terrestrial, marine, coastal, and freshwater biodiversity. Endemic species are concentrated in hotspots outside of human influence, primarily in mountain areas with cloud forests above 1,000 meters above sea level (CBD, n.d.). Honduras's biodiversity is considered highly threatened. For example, almost half of amphibian endemic species are threatened, endangered or extinct, and about 27 percent of endemic reptile species have declining populations.

Honduras has 113 protected areas, consisting mostly of national parks (25), wildlife refuges (15) and biological reserves (16). Honduras also has three United Nations Education, Science, and Culture Organization – Man and Biosphere (UNESCO-MAB) Biosphere Reserves, one World Heritage Site, and ten Ramsar Wetlands of International Importance (United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), 2018). Due to limited resources, the government of Honduras prioritizes protected area management based on endemic and endangered species, as well as ecosystem vulnerability.

All types of mining in Honduras contributed approximately 2.1 percent to real GDP in 1999 and has decreased since then to about 0.7 percent of the real GDP. There are approximately 300 mining concessions in the country and scant information available on ASM in Honduras (D'Emilio, pers. comm., 2018). Total gold production in 2014 was 2.7 tons with no estimates available for the amount contributed by ASGM or illegal mining activity (Table 1). Approximately 1,000 workers were estimated to be employed in ASGM in Honduras in 2014, largely in southern Honduras where hard-rock mining occurs in the mountains near the town of El Corpus (IGF 2018; Palencia 2008). Mining families have worked small mines for generations in this region, some of which date back to Spanish conquest in the 1500s. Little environmental oversight exists, and miners use mercury to process the ore. Overall, little

information was available on ASM activities in Honduras; thus, conclusions regarding the effects on biodiversity cannot be confirmed.

2.2.3 EL SALVADOR

El Salvador has the least biodiversity among countries in Central America due to its smaller size, environmental degradation, and lack of coastal rainforests. No endemic species have been identified in El Salvador alone, although 17 of 23 species of birds endemic to northern Central America are found in El Salvador. El Salvador has 168 protected areas, covering almost nine percent of land area and less than one percent of marine area. The government of El Salvador has struggled with the management of protected areas because of competing priorities between conservation and land needs of the surrounding communities.

In March 2017, El Salvador became the first country in the world to ban all metal mining to protect water quality. The ban was primarily in response to severe water scarcity generated by high rates of deforestation and environmental degradation; the ban affected hundreds of families that have practiced ASGM for generations, as well as industrial-scale mining (Fernandez, 2017). The ban has also affected about 600 mining families in San Sebastian, where artisanal hard-rock mining has been a significant part of the local economy. Water quality sampling downstream from abandoned mines in the area found substantial heavy metal contamination due to upstream ASGM activities (Fernandez, 2017). Although metal mining has been banned in El Salvador, it may still occur illegally in historic ASGM districts and there is some evidence that aquatic biodiversity in localized areas of historic mining have been and may continue to be affected by legacy effects from mining.

2.2.4 NICARAGUA

Nicaragua has diverse terrestrial and marine habitats due to its landscape of volcanoes, seven types of forests (including tropical rainforest, cloud forest, mangroves, and tropical dry forests), two coastlines, and the region's largest lake, Lake Nicaragua. Nicaragua is home to 95 protected areas, including 57 nature reserves, three UNESCO Man and Biosphere (MAB) Reserves, and nine Ramsar Wetlands of International Importance. About 37 percent of terrestrial area in Nicaragua is protected, compared to only three percent of marine areas. The Bosawas Biosphere Reserve in North Central Nicaragua, coupled with nearby protected areas and the Rio Platano Reserve in Honduras, forms the largest area of protected tropical forest in Central America, covering 854,000 hectares.

In 2013, Nicaragua exported about \$450,000 worth of gold, accounting for seven percent of total exports and about 3.5 percent of GDP (Table 1). Most gold production is from three industrial mines located in the 'mining triangle' located near the municipalities of Bonanza, Rosita, and Siuna in the North Atlantic Autonomous Region (GIATOC 2016). ASGM occurs in eight departments in Nicaragua: Chontales; Región Autónoma de la Costa Caribe Norte (RACCN); Chinandega; León; Matagalpa; Estelí; Nueva Segovia; and Rio San Juan. Most ASGM activity takes place in the Chinandega, Chontales, and the mining triangle areas (World Gold Council (WGC) 2016). Nicaraguan artisanal miners use a local whole-ore processing technique called 'rastra' to mill and amalgamate gold ore using large rocks dragged in a trench with the mercury and ore. It is not a very efficient gold extraction process and it releases up to 4,850 kg of mercury into the environment annually (WCG 2016). The second most common ore

processing technique in Nicaragua uses ball mills, which is inefficient as it is a whole-ore amalgamation technique.

A short-lived ASGM mining boom lasted 2011 through 2014; and it slowed due to depletion of easily obtained surface deposits (WGC 2016). ASGM is conducted by individuals, informal mining groups, or mining cooperatives, and much of the ore is processed by an ore processing service sector at (i.e., the miners pay to have their ore processed by a local processer). In Nicaragua, ASGM often occurs on or near mining concessions granted to industrial miners, and some industrial miners have started buying and processing ore produced by nearby artisanal miners. This allows the industrial miners to obtain ore that may otherwise not be cost effective to obtain and provides for more environmentally-friendly processing (WGC 2016).

Although the effects of ASM on biodiversity have not been studied in Nicaragua, ASGM and industrial mining in the mining triangle area of the RACCN occurs near the Reserva Natural Cerro Santa Cruz, the Reserva Natural Cola Blanca, and a large relatively undeveloped area to the north. Nicaragua also has more people working in ASGM than the other Central American countries (Table 1).

2.3 SOUTH AMERICA

Key Points

- Recognized biodiversity hotspots are present throughout South America and overlap with active ASM areas.
- Brazil has the highest number of protected areas affected by illegal mining, followed by Peru and Colombia.
- Between 2007 2013, forest loss was greatest in southwest Amazon in Peru and in the Guinean moist forest regions (Figure 6).
- Alluvial gold mining causes large-scale land transformation and is a primary cause of deforestation throughout the region.

South America has numerous biodiversity hotspots spanning diverse ecosystems including tropical rainforests, savanna, temperate forests, mountains, mangroves, wetlands, beaches and rocky shores. In addition to abundant biodiversity, Latin America also has the highest percentage of terrestrial areas under protection of any region in the world (Leisher et al., 2013). However, protected areas have had mixed success as land and forest degradation inside protected areas doubled between 2004 and 2009 and is relatively widespread (Leisher et al., 2013; Duran et al., 2013; Alvarez-Berrios and Aide 2015; Figure 5).



Figure 5. Map showing illegal mining in protected areas in South America as of 2014. Source: GIATOC 2016.

Several studies have used remote-sensing to estimate habitat loss from mining in the target area including Colombia (United Nations Office on Drugs and Crime (UNODC) 2016), northern South America (Alvarez-Berrios and Aide 2015), the Amazon (Monitoring of the Andean Amazon Project, Asner et al. 2013; Swenson et al. 2011; Red Amazónica de Información Socioambiental Georeferenciada (RAISG) 2018), and the Madre de Dios region specifically (Markham and Sangermano, 2018). Some of the studies do not differentiate between ASM and industrial-scale mining; however, ASM often is co-located with industrial mining. Figure 6 illustrates the extent of illegal mining (primarily ASGM) in protected areas in northern South America. Brazil has the highest number of protected areas affected by illegal mining, followed by Peru and Colombia. Figure 6 shows changes in forest cover associated with gold mining (both ASGM and industrial) in tropical moist forest over two-time periods, with a significant increase in forest cover loss occurring in the latter period due to increase in global demand for gold amidst the international financial crisis (Alvarez-Berrios and Aide 2015). The occurrence of mining within protected areas is frequent throughout the region: 94 percent occurs in multiple use zones of protected areas; six percent occurs within strict protection areas; and 31 percent of the total deforestation occurred within ten kilometers of 32 protected areas (Alvarez-Berrios and Aide 2015).



Figure 6. Maps showing distribution of small-, medium-, and large-scale gold mining sites with significant changes in forest cover from 2001-2006 and 2007-2013 in northern South America. Source: Alvarez-Berrios and Aide 2015.

The following sections highlight the biodiversity and protected area status of target USAID countries in South America, explaining where and how ASM impacts these areas.

2.3.1 COLOMBIA

Key points

- Colombia has the most biodiversity per square kilometer than any other country in the world.
- As of 2016, approximately 83,620 ha had been affected by alluvial gold mining, with approximately 80 percent occurring in Antioquia and Choco departments.
- Approximately 24,450 ha of ecologically important vegetation were lost as of 2014, with 77
 percent occurring in the Choco department.
- As of 2013, approximately 80 percent of gold production occurring in country was illegal, and organized crime plays a greater role in Colombia than in other LAC countries. (These seems to be two separate points)
- Mercury pollution is particularly high in the Antioquia department, with concentrations in urban areas, where gold is processed approximately 1,000 higher than World Health Organization Guidelines.

2.3.1.1 BIODIVERSITY & PROTECTED AREAS

Colombia is the second most biodiverse country in the world and has the most biodiversity per square kilometer than any other country (CBD, n.d.). It is home to 10 percent of the world's known species, ranking first in number of bird and orchid species and second in number of plant, butterfly, freshwater fish, and amphibian species. Colombia has hundreds of ecosystem types and is particularly well-endowed with aquatic resources due to its large watersheds that feed the Amazon, Orinoco, Pacific, Caribbean and Magdalena-Cauca basins. Biodiversity hotspots in Colombia include the highly endemic Andean ecosystems, the Amazon rainforests, and the humid Chocó region (CBD, n.d.).

Colombia has 1,006 protected areas of various designations, the majority being forest reserves, civil society reserves, regional parks, national parks, or integrated management districts. Colombia also has five UNESCO-MAB biosphere reserves, two World Heritage sites, and seven Ramsar wetlands of international importance. Protected areas cover almost 15 percent of the land territory and 17 percent of the marine territory (UNEP-WCMC, 2018). Colombia's decades-long conflict between the government and Fuerzas Armadas Revolucionarias de Colombia (FARC) exacerbated the degradation of natural resources, particularly in protected areas, which were mostly located in conflict zones. Part of Colombia's peace strategy (following the signing of the peace agreement between the Government and FARC in 2017) is strengthening the nation's network of protected areas and increasing research expeditions into areas previously considered conflict zones (Palmer, 2017). In recent years, Colombia has made significant advances in this strategy, including increasing the area protected under the Malpelo Fauna and Flora Sanctuary, creating the new Yuruparí-Malpelo integrated management district (WCS, 2017); expanding the Serranía de Chiribiquete World Heritage Site to 4.3 million hectares, making it the world's largest protected tropical rainforest national park (WWF, 2018), and in August of 2018 creating the new protected area of Cinaruco (332,000 hectares), with special management prerogatives in previously underrepresented eastern flooded savannas and gallery forest ecosystems.

2.3.1.2 ASM IN COLOMBIA

ASM in Colombia is a growing sector and largely occurs in Antioquia and the Choco Region (80 percent of production), with additional activity in Caquetá, Cauca, Valle del Cauca, Cordoba, Nariño, and Bolivar (Map 3, Map 4; Sarmiento et al. 2013). Mineral-rich Colombia has a complex history with ASM, with Afro-Colombian and indigenous communities participating in subsistence mining over generations and the comparatively recent influence of organized crime in the mining sector. Approximately 80 percent of Colombian gold production in 2013 was illegal and valued at 2 billion US dollars (GIATOC 2016). Despite increases in production over the past decade, gold production still constitutes less than 5 percent of Colombian GDP (Sarmiento et al. 2013). In addition to gold, Colombia is also one of the leading exporters of emeralds, which are mined by both large-scale operations and ASM in the Muzo Valley in Cundinamarca and Boyacá departments. National policy has focused on regulation of large-scale mining, resulting in a lack of enforcement and high rates of informal and illegal mining among artisanal and small-scale mining (Sarmiento et al. 2013).

A national study of alluvial gold mining in Colombia (UNODC 2016) using remote-sensing data found that almost 79,000 hectares were affected by alluvial gold mining in 2014, in 17 out of 32 departments. The area increased to 83,620 ha between 2014 and 2016, when the study was updated in 2018 (UNODC 2018). Seventy-nine percent of ASM activity was concentrated in Antioquia and Choco, with the municipality of Nechi in Antioquia accounting for 6,232 hectares (UNODC 2016). Antioquia is Colombia's largest gold producing region in which 15,000-30,000 ASM miners produce 10-20 tonnes of

gold per year (GIATOC 2016). As of 2016, approximately 30,900 hectares of land in Antioquia had been degraded from alluvial mining (UNODC 2018).

Figure 7 shows the density of ASM alluvial mining throughout Colombia in 2016, as well as forest reserve zones. The 2016 study found that only less than two percent of alluvial mines were properly permitted, approximately 40 percent were partially documented, and approximately 60 percent had no records (UNODC 2016). Five national parks had mining activities within their boundaries, and mining was close to an additional nine national parks. Mining within national parks more than doubled from 45 ha to 111 ha between 2014 and 2016 (UNODC 2018).

In 2010, gold rushes in the Valle de Cauca brought over 7,000 miners, 236 bulldozers, and 100 dredges into the area. Similar gold rush activity also occurred in the Tolima and South Bolivar departments (Sarmiento et al. 2013). These gold rushes led to significant conflict with local communities and left a legacy of environmental destruction. Some reforestation has occurred in areas controlled by paramilitary groups in Nechi and Caucasia, possibly due to abandonment of agricultural lands due to conflict (Figure 7, Alvarez-Berrios and Aide 2015).

Loss of ecologically important vegetation due to alluvial mining was estimated at 24,450 hectares in 2014 with 77 percent occurring in the Choco department, which is considered one of the most biodiverse areas in the world. While not as biodiverse as the Choco department, the Antioquia department is home to portions of the Magdalena forest reserve and the Paramillo and Los Katios national parks, all of which experienced increased alluvial mining between 2014 and 2016 (Figure 7, UNODC 2018). The study concluded that alluvial mining is one of the main drivers of deforestation in Colombia (UNODC 2016).



Figure 7. Map showing forest reserves and density of alluvial mining in Colombia in 2016. Source: UNODC 2018.

Pollution from mining includes mercury, cyanide, and sediment. Mercury pollution rates in Colombia are some of the highest in the world, with 50 to 100 tons of mercury released into the water per year (Sarmiento et al. 2013). In some urban areas of Antioquia, mercury levels are 1,000 times higher than World Health Organization (WHO) accepted levels (Delgado 2010; Palacios-Torres et al. 2018; Schmidt 2012). Mercury contamination and other pollution impacts are summarized in Section 3.5.

An estimated 44 criminal networks are involved with illegal gold mining, many of which extort a 'vacuna', which is a fee or tax on mining operations. At one point, FARC was estimated to receive 20 percent of its funding from illegal gold mining (GIATOC 2016). Illegal mining and gold exports are also used to in money laundering to support drug dealing or other illicit activities. Forty-six percent of ASM occurs in Afro-Colombian special territories, primarily in the Choco department; other indigenous lands in Antioquia and the Choco are also vulnerable to mining (UNODC 2016). ASM in Afro-Columbian communities is complex as ASM is a critical source of income. In addition to impacts on biodiversity, forced labor and sex trafficking in ASM areas is widespread, particularly in rural areas controlled by guerrilla, paramilitary, and narco-trafficking groups (Figure 8; GIATOC 2016).



Figure 8. Gold mines in Colombia in the areas controlled by guerilla groups in 2014.

2.3.2 PERU

Key points

- Peru is mega-diverse country with habitats ranging from tropical rainforests in the Amazon lowlands to high-elevation ecosystems with high levels of endemism.
- Mining (both industrial and ASM) is a major component of Peru's economy; illegal mining and ASM occurs in every department.
- The most active ASM regions are Madre de Dios, the south-central region (including Ica, Ayacucho, and Arequipa), and Puno (Kuramato, 2001).
- In the Amazonian Madre de Dios region, ASGM is the leading cause of deforestation, responsible for an estimated 63,800 ha of forest loss since 2001, including in buffer zones and national parks.
- Approximately 50,000 -70,000 miners are estimated to be working in the Madre de Dios region and 99 percent of the ASM operations are illegal.

2.3.2.1 BIODIVERSITY & PROTECTED AREAS

Peru is considered a mega-diverse country with about 10 percent of worldwide flora species, 2,000 fish species, 1,736 bird species, 32 amphibian species, 460 mammal species and 465 reptile species (World Bank, 2013). The main ecosystems in Peru are mountains, coastal hills, rainforests, dry forests, wetlands, and moors. Ninety-four percent of forests in Peru are tropical forests which possess a high diversity of flora and fauna, including economic resources such as timber. (CBD, n.d.) The Peruvian Amazon, covering 260,000 square miles, is one of the largest carbon sinks in the world, but also one of the world's most threatened areas in terms of deforestation and forest degradation (WWF, n.d.).

Peru has 238 protected areas covering 21 percent of its terrestrial area and only 0.5 percent of its marine area. Almost half of the protected areas are private conservation areas, followed by regional conservation areas (18), national parks (15), and national reserves (15). Peru also has four UNESCO Biosphere Reserves, four World Heritage Sites, and 13 Ramsar wetlands of international importance (UNEP-WCMC, 2018). Manú National Park located in the region of Madre de Dios, one of Peru's World Heritage Sites, is one of the most biodiverse national parks in the world, which serves as a transition zone between the Tropical Andes and Amazon Basin. Until recently, the relative isolation of the region has allowed top predators to flourish, such as jaguars, pumas, giant otters, and Harpy eagles (UNESCO, n.d.).

2.3.2.2 ASM IN PERU

Peru is the sixth largest producer of gold in the world and is a top producer of silver, copper, zinc, lead, tin, and molybdenum. Mining output constitutes about half of Peru's total exports and about 14 percent of GDP (Table I, Piñeiro et al. 2016). About 85 percent of ASM in Peru is gold production (Piñeiro et al. 2016). In 2014, it was estimated that about 28 percent of Peru's gold mining was from illegal or informal sources (Table I). Official estimates for legal gold production in 2014 range from 147.8 tons (USGS 2017) to 178 tons (GIATOC 2016), with an additional 112 tons worth about \$3 billion United States dollar (USD) officially exported, which was likely from illegal gold mining activity in the Madre de Dios region (GIATOC 2016).

The pervasiveness of illegal mining is "likely the result of the lack of a clear and effective process of formalization, the government's limited resources and capacity to address and curb the activity's expansion, and there being few other economic opportunities for local workers" (Piñeiro et al. 2016).

ASGM currently contributes to approximately 10 percent of the total gold production in Peru (although estimates vary, see Table 1 and GIATOC estimate above). Illegal and/or artisanal mining occurs in every department in the country and has historically been focused in the Madre de Dios, Puno, and La Libertad departments. It has expanded into new areas in Cajamarca, Piura, Amazonas, Ucayali, Lima, Ayacucho, Apurimac, Moquegua, and Tacna (Piñeiro et al. 2016). A 2007 survey found that informal ASGM operations constituted approximately 69.5 percent of operations in La Libertad, 80.3 percent in Pasco, 51.8 percent in Moquegua, and 99 percent in Madre de Dios (Piñeiro et al. 2016). Government efforts to formalize small-scale miners have been underway since 2002 with limited success.

In Peru, ASGM activities increased by over 50 percent since the 1990s in the Amazonian Madre de Dios region, a sparsely populated rainforest province in Southeastern Peru that is one of the most biologically diverse places on earth. Recent completion of the Interoceanic Highway has increased access to Madre de Dios, where 50,000-70,000 miners are estimated to be operating, mostly without legal permits, and generating about half of the regional GDP (GIATOC 2016; Wang 2016; Gardner 2012, Piñeiro et al. 2016). An estimated 250 mechanized dredges were operating illegally Madre de Dios in 2011 most of which produce enough to qualify as medium-sized mines (Piñeiro et al. 2016).

The rate of forest loss from gold mining in the Madre de Dios region accelerated from 21.6 km² per year before 2008 to 62.56 km² per year after the 2008 global financial crisis. (Alvarez-Berrios and Aide 2015). However, estimates on the amount of forest clearing from mining the Madre de Dios region vary considerably by study. Alvarez-Berrios and Aide (2015) estimate that gold mining cleared 473 km² between 2001 to 2013, which represents 28 percent of the total forest loss in the region. They also estimated that 2,700 hectares had been cleared from the buffer zone for Bahuaja Sonene National Park, 10,300 hectares from the buffer zone of the Communal Reserve Amarakaeri, and 6,600 hectares from the buffer zone of Tambopata National Reserve (Alvereza-Berrios and Aide 2015). CINCIA (2018) estimates 957.5 km² has been deforested due to mining between 1985 – 2017; the majority of which has occurred between 2009 -2017 (645.86 km²).

The monitoring of the Andean Amazon Project estimates that mining has cleared about 63,800 hectares through 2017 in Amazonian Peru. The study also noted that over 550 hectares have been cleared in the Tambopata National Reserve as of 2016 with additional minor incursions into the Bahuaja Sonene National Park and the Amaerakaeri Communal Reserve, although illegal mining in those areas had been stopped as of 2017 (Monitoring of the Andean Amazon Project (MAAP) 2018). In addition to the Madre de Dios Region, the study noted new clearings from gold mining in the adjacent regions of Cusco and Puno, and in the northern Peruvian Amazon in the El Sira Communal Reserve, along the Rio Santiago, and along the border with Ecuador in the Condor mountain range (Figure 13, MAAP 2017).

Mercury use and associated environmental contamination is extensive in the Madre de Dios region with an estimated 50,400 kg of mercury released annually (Piñeiro et al. 2016). Recent studies indicate that emissions levels may be increasing (Martin Arana, Artisanal Gold Council, unpublished). High levels of mercury have been found in both fish from local rivers and human hair of regional residents. Women of childbearing age were found to have mercury levels about 3 times the Ippm benchmark limit set by the United States Environmental Protection Agency (US EPA) (Carnegie Amazon Mercury Ecosystem Project (CAMEP) 2013). Diesel and gasoline spills in the Madre de Dios region are estimated to exceed 547,000 gallons per year (Piñeiro et al. 2016). Given the extensive documentation of deforestation from mining in the Madre de Dios region, there is sufficient evidence to conclude that ASGM is the leading cause of biodiversity loss in terrestrial and aquatic ecosystems in that department. The evidence is lacking in upland areas of Peru where ASGM is known to occur and where impacts on biodiversity have not been adequately documented.

2.4 BRAZIL

Key points

- Brazil is the most biodiverse country in the world with 20 percent of global biodiversity.
- Although Brazil has one of the largest ASGM producing regions in the world, with over 400,000 miners working, mining (both industrial and ASM) contributes less than 5 percent to Brazil's GDP.
- Approximately 10 percent of the ASGM is illegal and occurs primarily in the Amazonian region.
- Deforestation in the Tapajos River Basin area of the Amazon was estimated at 18,300 ha between 2001 and 2013 due to ASGM, which was approximately 11 percent of the total deforestation during that period.
- Brazil is one of the leading sources of mercury emissions in the world with 105 tons released each year.

2.4.1 BIODIVERSITY & PROTECTED AREAS

With numerous and varied terrestrial and marine habitats and a massive land area, Brazil is the most biodiverse country in the world, with an estimated 20 percent of global biodiversity. Brazil has the largest number of plant (over half of which are endemic), amphibian and primate species in the world, ranks second for the highest number of mammal and reptile species, and ranks third for the highest number of bird species. Brazil has the sixth largest presence of endemic vertebrates, with 37 percent of endemic reptile species and 57 percent of endemic amphibian species (Ministry of the Environment, 2016).

In Brazil, there are 2,299 protected areas covering almost 30 percent of terrestrial area and almost 27 percent of marine area, with most of the terrestrial protected areas located in the Amazon biome. Most protected areas are designated Indigenous Lands (708), Natural Heritage Private Reserves (426), Parks (345), and Environmental Protection Areas (255) (UNEP-WCMC, 2018). The Brazilian government has a comprehensive process for establishing conservation priority areas: Every five years, it hosts a series of participatory workshops to identify biodiversity traits, goals and targets. These data are eventually translated into a map identifying priority areas, that are then recognized by the Ministry of Environment and can be used in decision-making. Based on the most recent exercise, which identified 1,530 priority areas, found that 16.5 percent of priority areas were not protected (Fonseca and Venticinque, 2018). However, this "spatial conservation gap" is distributed unevenly across biomes, depending on the number of protected areas found therein. The Amazonian spatial gap is relatively small (7.4 percent) because of the high number of protected areas, where as the Atlantic Forest (16.4 percent), Cerrado (26.5 percent), Caatinga (28.1 percent), Pantanal (43.6 percent) and Pampa (43.8 percent) have much higher gaps due to smaller protected area coverage (Fonseca and Venticinque, 2018).

2.4.2 ASM IN BRAZIL

Gold production in Brazil in 2014 was 79,600 kg with estimates of the ASGM contribution ranging from 15 percent (USGS 2017 estimate) to over 80 percent (Seccatore et al. 2013 estimate, Table 1). Minerals accounted for 4.3 percent of GDP (Table 1), 15 percent of Brazil's exports, and were valued at \$34 billion in 2014, with gold as the second most valuable export following iron ore (USGS 2017b). Other minerals produced by ASM in Brazil include tantalum, gemstones (primarily diamonds), manganese, iron, and tin (Centro de Tecnologia Mineral (CETEM), nd). Illegal mining accounts for 10-15 percent of total gold production in Brazil and primarily occurs in the states of Para, Mato Grosso, Rondonia, and Roirama (GIATOC 2016, Table 1, Figure 9). Illegal mining has been historically prevalent in the Brazilian Amazon, and continues to expand, especially in remote indigenous territories. The significant presence of illegal mining, as well as illegal logging, reveals the lack of economic opportunities in remote areas and becomes a vital source of income. In some cases, these activities are the only opportunities of survival for isolated communities in the rural Amazon. Contributing factors to illegal mining include unrealistic or lack of proper policies and regulations, lack of political will, lack of infrastructure to enforce existing regulations and lack of incentives to miners to comply with legal requirements (CETEM, nd).

ASGM activities in Brazil are centered in the Tapajos River Basin in the southwest of the Pará; with its 100,000 km² size, it is the largest small-scale gold mining area in the world (Kolen & Mathis 2013). Much of the ASGM activity in this area is illegal or poorly regulated. Other ASGM producing areas include Sul do Para, North of Mato Grosso, Amapa, Rondonia, Roraima, Gurupi, Amazonas, and Goias (Sociedad Peruana de Derecho Ambiental (SPDA) 2014). With the increase in gold prices over the past two decades, the number of small-scale miners in the Brazilian Amazon has increased, with varying estimations. One study estimates an increase from approximately 20,000 to over 200,000 small-scale miners between 1990 and 2010; another estimate indicates there were 467,000 small-scale miners in the region in 2014 (Alvarez-Berrios and Aide 2015, IGF 2018). Deforestation from gold mining between 2001 and 2013 is estimated as a loss of 18,300 hectares in the Tapajos-Xingu moist forest in Brazil due to gold mining (primarily from ASM), contributing 11 percent of the total deforestation in the region (Alvarez-Berrios and Aide 2015). In comparison, a study of industrial mining in the Brazilian Amazon found that forest loss occurs up to 70 km beyond lease boundaries, resulting in a loss of 116,700 hectares between 2005 and 2015 indicating the follow-on effects of mining (Sonter et al. 2017).

In 2006, seven conservation units were created in the Tapajos Region; two with full protection and five with sustainable use management. These units overlap with the previously established small-scale mining reserve of Tapajos and other areas where mining permits have been issued. This has caused confusion as by law, mining is illegal in the conservation units.³ However, many mines were established prior to the conservation units and the National Department of Mining Production is still issuing mining permits in those areas. There is conflicting enforcement between the mine permitting agency and the environmental agencies leading to uncertainty and likely expansion of mining in important biodiversity areas (Kolen et al. 2013).

³ SNUC Law (Brazilian National Law for Conservation Units) is restrictive when it comes to mining activities within Conservation Units. It prohibits the direct use/exploitation of any natural resources in Protected Areas categorized as "integral protection units" and conditions the use of renewable natural resources to management and/or use plan in the areas categorized as "sustainable use units". In addition, mineral exploration is also prohibited in Protected areas categorized as "Extractive Reserves".

Protected areas have been subject to gold mining (primarily ASGM) and forest clearing, although mining is officially permitted in the multiple use Tapajos Environmental Protection Area (Figure 9). Rio Novo National Park in the State of Para lost 1,200 hectares of forest from ASGM within the strict protection area, and 8,400 hectares within the buffer zone. The Tapajos Environmental Protection Area lost 14,200 hectares of forest from ASGM between 2001 and 2013 (Alvarez-Berrios and Aide 2015). Extensive forest loss within the protected areas was also documented from grazing occurring simultaneously with ASGM (Alvarez-Berrios and Aide 2015).

Pollution from ASGM is extensive in the region due to sedimentation, mercury, and cyanide contamination. Miners operating in the Tapajos basin discharge one to two tonnes of sediment per gram of gold produced, impacting phytoplankton productivity and aquatic biodiversity (Lobo et al., 2017). Whole-ore amalgamation is commonly used, resulting two to three times as much mercury loss when compared to amalgamating an ore concentrate. Mercury levels in tailings and fish collected from local rivers far exceeded safe levels of 0.5 ppm total mercury (Sousa and Veiga, 2009). Brazil is one of the leading sources of mercury emissions in the world with 105 tons released each year (IGF, 2018). Some studies have questioned the role of ASGM in widespread mercury contamination; background mercury levels in the Amazon are naturally high and can be released by ground-disturbing activities such as forest clearing, fires, grazing, road construction, and mining (Miserendino et al., 2018). However, the data around mercury use in mining (Section 3.5) indicates anthropogenic contribution of mercury from ASM.

Given the documentation of deforestation from mining in the Tapajos region, there is sufficient evidence to conclude that ASGM contributes to biodiversity loss in terrestrial and aquatic ecosystems in areas in the Brazilian Amazon. The evidence is insufficient in other areas of Brazil where the extent of ASM activities and impact on biodiversity have not been adequately documented.



Figure 9. Map of illegal mining areas in Brazil. Source: Adapted from GIATOC 2016.

3 WHAT IS THE EVIDENCE THAT ASM HAS SIGNIFICANT IMPACTS ON BIODIVERSITY?

This section addresses research question #2.

3.1 MINING TYPES

Key points

- Mining methods and deposit types generate different impacts on biodiversity.
- The two main mineral deposits are hard-rock and alluvial:
 - Hard-rock deposits are usually concentrated veins of ore located underground or near the surface and are mined by removing the ore with as little of the surrounding rock as possible.
 - Alluvial deposits are mineral deposited by moving water along stream banks or in terraces and can be scattered over large areas.
- Alluvial mining results in large-scale land use change, sedimentation, and pollution, while hard-rock mining generates waste rock that may cause acid mine drainage and leach heavy metals.

Deposit type, mine location, mining methods, scale, and local governance all affect the degree to which ASGM- derived stresses impact biodiversity (described in more detail in Sections 3.2-3.5). Of importance are the two deposit types in ASGM, hard-rock and alluvial, which determines the methods used to extract and process the ore, the scale of the operation, and the associated stresses. For example, a hard rock mine where miners work a highly concentrated vein or deposit underground may constrain how many miners can access the deposit and mitigate the scale of environmental impacts. Hard rock mines, however, are more likely to produce tailings that generate acid mine drainage and leach heavy metals into the environment than alluvial mines.

Hard rock, or underground mining, refers to underground mining techniques that are used to extract minerals such as gold. In southern Ecuador, small-scale miners extract gold by hard-rock mining techniques and gravity concentration following crushing and grinding. Gold is then recovered from the resulting heavy mineral concentrates by mercury amalgamation (Tarras-Wahlberg et al., 2000). In Peru, where artisanal hard-rock mining is common in the Ica and Arequipa departments, hard-rock mining is very labor intensive and is based on hand drilling using chisels and sledgehammers. In Peru, about half of the artisanal mines are less than 50 meters deep and only 20 percent are deeper than 150 meters; deeper mines are impractical due to difficulties in maintaining adequate ventilation and disposing of waste rock. ASGM miners can mine deposits that are too small for larger-scale operations to profitably mine (McMahon et al., 1999).

Alluvial deposits are mined using a variety of methods including hand panning, sluice boxes, heavy equipment, hydraulic mining, and dredging. Alluvial mining deposits can occur across vast areas, can be accessible to large numbers of miners, and are frequently mined by artisanal- to medium-scale operations.

Alluvial mining involves extracting minerals from alluvial (water-borne) deposits, usually in floodplains, terraces, or alluvial fans at the base of mountains ranges or hills. The land surface is cleared, and the organic layer and topsoil removed, using equipment such as bulldozers, loaders, or excavators, or is washed away using high-pressure water jets (hydraulic mining) (McMahon et al., 1999). The water is used to erode sediment before being re-diverted into constructed ditches which run through makeshift sluices to trap the gold (Dalu et al., 2017). Most of the topsoil and organic matter is washed away, causing downstream pollution and rendering the mined landscape infertile.

Alluvial mining is also used in riverbeds, in ponds created by blocking off a portion of the river, or by excavating a pond. Suction dredging uses high-volume pumps to suck sediment and mineral containing water from the bottom of the river or pond, which is then processed by sluicing or other techniques to separate the mineral (usually gold) from the ore (described in Section 3.4). Suction dredging operations can range from small operations using lawnmower-sized pump engines to huge building-sized floating dredging platforms that can process tons of ore per minute. Tailings are usually dumped adjacent to the operation and, in the case of the larger dredges, can produce large piles of rock that are devoid of soil or organic material and that can take decades to revegetate. Suction dredging is common in the Peruvian Amazon and in Antioquia, Colombia. Examples of alluvial and hard-rock deposits are illustrated in Figure 10.



Figure 10. Alluvial (top figure) and hard-rock (bottom figure) mining deposits. Source: Kirk et al. 2003.
3.2 BIOPHYSICAL STRESSES FROM ASM

Key points

- The primary stresses from ASM include deforestation and soil displacement, fragmentation of habitats, habitat loss, changes in hydrology, and pollution, including from sedimentation and mercury.
- Pollution from ASM can include spills of oil and gas from equipment, solid waste, sediment and acid mine drainage released into waterbodies, air pollution, and widespread mercury contamination.
- Indirect stresses from ASM include migration, which increases the local population, and expansion of infrastructure.
- ASGM is the leading source of mercury contamination in the world. Mercury bioaccumulates in organic form and causes neurological damage in humans and wildlife.

Table 2 summarizes the stresses associated with ASM actions that affect biodiversity focal interests and cause biodiversity impacts. There are several items to note about the ASM actions and stresses listed in Table 2:

- Table 2 includes actions and impacts that are caused directly by ASM as well as indirect actions and impacts from increases in population that are associated with ASM mining. Communities may spring up near active gold mining areas to provide food, housing, equipment, supplies, petrol, skilled labor, and sex workers. Farming, hunting, and fuelwood collection may supplement imported supplies.
- In some cases, ASM is a community affair that occurs seasonally and may have occurred on a limited basis over generations. ASM may have long-term but localized effects (e.g., San Sebastian, El Salvador). In other cases, gold is discovered in an area and a large influx of miners, families, and others (e.g., service providers) move into an area to exploit the resource, causing significant impacts (e.g., Madre de Dios, Peru).

The biophysical impacts of different types of mining have different time scales for recovery. Areas that have been deforested for mining, hydraulically mined, or contain tailings piles, for example, are stripped of vegetation and topsoil, churned up, and can contain heavy metal contamination that could take decades to centuries to revegetate and naturally recover. Mercury released into the environment can have long-term and persistent effects over geographically large areas. In contrast, areas impacted by population increases that are subject to forest fires, fuelwood collection, or even conversion to pasture or cropland could have limited recovery in a shorter time. Some impacts associated with population increases such as introduction of invasive species, roads, and extirpation of local species could also create long-term stresses.

Based on the literature and expert consultations, the most frequent stresses biodiversity from ASGM included: deforestation, land use change leading to fragmentation, the effects of dredging, and impacts of mercury contamination. The relative importance and ranking of these stresses in the research varied by source, but most indicated the above four stresses as the primary issues. Other stresses mentioned

include pollution, changes in natural flow patterns and water quality, and species loss. Prioritizing actions related to ASGM depends on what aspect of biodiversity is of concern; if mercury bioaccumulation in mammals is the concern, then mercury emissions from ASGM would be the focus, but if the priority issue is species viability at a mine site, then deforestation and land surface removal from mining would be a greater priority (Telmer, pers. comm., 2018).

Some aspects of ASM impacts on the environment and biodiversity are more extensively studied than others. Generally, studies on ASM impacts in the target countries tend to focus on one type of biophysical impact (e.g., mercury contamination, habitat loss) or in a specific geographic area where impacts have been significant (e.g., Madre de Dios region). In other cases, ASM has been included in broader studies of environmental impacts such as deforestation in the Amazon basin, which has been studied in association with climate change impacts and other threats. Other studies focus on the impacts of industrial mining, which is easier to study due to scale and availability of information. Finally, some studies do not distinguish between types of mining. The studies reviewed for this paper tend to be large-scale studies that often rely on modeling or remote sensing data and/or small-scale studies that examine the ASM-induced stresses at the species-level in an area. Studies on ASM impacts at the watershed scale, population level, or on the cumulative impacts of mining in any specific area are few and complicated by other factors such as increases in local populations, road building, logging, and habitat conversion to agriculture.

ASM Actions (Direct)	Stresses	Example Biodiversity Focal Interests	
Land surface removal/modification, including: - Logging - Clearing - Burning - Tailings	Habitat loss Displacement Habitat fragmentation Increased runoff/sedimentation Topsoil loss Microclimate changes Contamination Reduced biodiversity/complexity Change in species/population composition Behavioral disruption	Forests Grasslands Wetlands Rivers and streams Endangered wildlife	
Changes in hydrology, including: - Dewatering - Diversions and discharges - Ponding - Hydraulic mining - Suction Dredging	Increased runoff Change in natural flow patterns Dewatering Stagnant water Erosion Habitat fragmentation Behavioral disruption Displacement Change in species/population composition Habitat loss	Rivers and streams Wetlands Paramo Fisheries Endangered species	
Pollution, including:	Mercury/cyanide toxicity Smoke/dust	Forests Grasslands	

TABLE 2 EXAMPLES OF ASM ACTIONS STRESSES AND BIODIVERSITY FOCAL INTERESTS

	JINS, STRESSES / IND BIODIVERSITT FOC/ IE	INTERESTS
ASM Actions (Direct)	Stresses	Example Biodiversity Focal Interests
- Air - Surface water - Groundwater - Solid waste - Noise/light	Sedimentation Contaminated water Local disturbance Reduced survival/reproduction Change in species/population composition Reduced soil productivity Reduced viability Increased competition from invasive/weedy species	Wetlands Rivers and streams Endangered wildlife Fisheries
ASM Actions (Indirect)	Stresses	Example Biodiversity Focal Interests
Local population increases, including: - Increased land clearing (see above) - Increased roads and traffic - Increased fuelwood collection, fires, logging - Increased hunting - Increased pollution (see above) - Domestic animals and livestock/grazing - Increased wildlife trafficking - Increased lawlessness	Habitat loss Habitat fragmentation Reduced survival/reproduction Behavioral disruption Change in species/population composition Changes in natural flow patterns Reduced soil productivity Smoke/dust Increased runoff/sedimentation Increased competition from invasive plants/feral animals	Forests Grasslands Wetlands Rivers and streams Endangered wildlife Fisheries

TABLE 2. EXAMPLES OF ASM ACTIONS, STRESSES AND BIODIVERSITY FOCAL INTERESTS

3.3 LAND SURFACE REMOVAL/MODIFICATION FROM ASM

Hard-rock mining generally occurs in mountainous or hilly areas and the mining takes place underground, reducing the area impacted by deforestation or surface modification. Access roads, processing areas, and tailings piles associated with hard-rock mines can affect the landscape surrounding active mines fragmenting habitats and landscapes. In some cases, the overburden (non-ore bearing rock) above a deposit may be removed to access economically viable deposits, although this practice occurs infrequently outside of industrial-scale mining.

In alluvial mining, the land surface must be cleared to access the mineral-bearing layers. This involves logging and clearing the land, and often washes topsoil (with all its nutrients and life forms) into nearby waterways. Fine sediment is washed into the water and a landscape of poorly sorted gravel and cobble tailings piles remains amidst extraction pits and ponds (Figure 11).



Figure 11. Aerial view of alluvial mining in the Madre de Dios region, Peru. Source: Mongabay.com

Few studies focused specifically on how habitat loss from ASM affects biodiversity. Biodiversity in the Amazon in general is poorly catalogued due to its vast size and poor access; however, by extrapolating from similar cases and locations, it is understood that logging and mining completely transform the habitat. According to the Millennium Ecosystem Assessment (MEA) (2005), habitat change due to land use and land use change has had the highest impact of all drivers of biodiversity loss over the past century globally. Alvarez-Berrios et al. (2016) studied mining effects on bird and frog diversity in the buffer zone of Tambopata National Reserve in the Madre de Dios region in Peru. An active mine site was compared with an abandoned mine site and an adjacent forest site. Although a similar number of species were observed at each site (24-28 species), the study found that habitat generalist species were found three times more often at the disturbed sites than at the undisturbed site, potentially indicating displacement of specialist species. The authors suggested that birds may "abandon sites due to disturbance from noise, loss of habitat, and disruption of cue detection or when erratic noise is perceived as a threat" (Alvarez-Berrios et al., 2016). In contrast, the study found a higher number of frog species near active mine sites than in forested sites suggesting the frog species have poor dispersal capacity limiting their ability to escape areas of disturbance.

Habitat quality in areas actively being mined is severely degraded, and areas formerly mined are slow to recover (Esdaile and Chalker 2018; Peterson & Heemskerk 2001). Research has demonstrated that forests recover more slowly following mining activities than from other activities, such as agriculture and logging, due to topsoil loss. The CINCIA research consortium (2017) investigated survivorship of 51 tree species in alluvial mined areas and demonstrated that restoration using native plants is feasible in the Madre de Dios region, but survivorship is limited by level of soil degradation and seasonal flooding. The research group is also investigating the effects of biochar application on restoration of former mining sites.

3.4 CHANGES IN HYDROLOGY

Water is usually an integral part of mining and proximate aquatic habitats can be affected by mining in several ways. In artisanal hard-rock mining, groundwater may need to be pumped out of mine shafts and discharged into nearby waterways, changing flow regimes. Tailings are often dumped into nearby valleys and streams disrupting runoff and flows. Sensitive habitats such as wetlands or paramo may be affected if they are near the operation via extraction of water and changes in hydrological processes via extraction

of water or other changes in hydrology. Water is frequently used to process ore to concentrate gold and other minerals and is diverted from nearby sources potentially dewatering or changing the natural flow regime.

Alluvial mining typically occurs in or near streams and rivers or in nearby terrace deposits. Water is used as a tool to separate the gold from sediment by using water pumps, suction dredges, high-pressure hoses, and diversions, ditches, and sluices. Small streams and even major rivers can be diverted, channelized, and disrupted. Runoff and erosion increase from exposed soils and tailings, and fine sediment washes downstream (McMahon et al., 1999).

Use of water in ASM can cause short- to long-term changes in flows, stressing aquatic organisms adapted to natural flow regimes. At the mine site, aquatic habitat is directly destroyed or fragmented by modifying the rivers and riverbanks, altering timing of flows, channelizing and diverting flows, creating ponds, and by increases in turbidity and sediment composition. Downstream habitats are affected by changes in flows, increased sedimentation, changes in water quality and temperature, and pollution. Sensitive habitats such as wetlands, riparian zones, and intermittently flooded forests near mining operations can also affected (Lobo et al., 2017, McMahon et al., 1999, USAID 2017). Erosion related to small-scale gold mining reduces fish diversity and shifts community structure because of (1) increased turbidity resulting from an increased load of suspended sediment and (2) a reduction of instream habitat diversity related to sedimentation (Mol and Oubuter, 2004). Aquatic organisms can also be sucked into diversions and pumps, displaced from stream segments impacted directly by mining or tailings, directly and indirectly affected by increased flows or dewatering of stream segments during dry periods, and affected by sedimentation and pollution (described in Section 3.5).

Effects on aquatic organisms from changes in the hydrologic regime are well documented in temperate regions, but the research on Latin American organisms is limited (Indicators of Hydrologic Alteration

(IHA) application database n.d.). Hydrologic alterations include habitat fragmentation, conversion of freeflowing water to slow-moving river habitat, variable flow and thermal regimes, degraded water quality, altered sediment transport processes, and changes in timing and duration of floodplain inundation (Pringle et al., 2000). Impacts on biodiversity include (Pringle et al., 2000):

- Local extinction of migratory diadromous fish;
- Inhibited movement of potamodromous (migrating within freshwater) fish which limits reproductive success and distribution;
- Habitat fragmentation and conversion of lotic, free-flowing rivers to more lentic environments, which effects small-bodied fishes;
- Expansion of lentic fishes and expansion of their typical home range;
- Reduction and/or alteration in floodplain inundation, which may impact reproduction and growth (Sakaris, 2012); and
- Decrease of freshwater flows to estuaries, which threatened delta smelt in San Francisco Bay

Biodiversity in the Neotropics is highly vulnerable to changes in hydrology because of high habitat heterogeneity and diverse communities, which leads to high rates of endemism (Sakaris, 2012). There are more than 2000 species of fishes in the Amazon alone, with about 90% endemism (World Conservation Monitoring Centre 1992). Dams and other hydrologic modifications can result in the loss of endemic species, in some cases by promoting faunal exchange and hybridization. Alteration of riparian and riverine habitat via ASM may decrease the availability of food, refuge, and nursery habitat for young

fish. This is particularly relevant as many South American fish species are highly migratory, have complex life cycles, and depend on seasonal floodplain inundation for reproduction, growth, and food (Sakaris, 2012).

Many of the existing studies reviewed focused on mercury impacts on aquatic ecosystems, with a few discussing the impacts of siltation and turbidity (see Section 3.5 for more detail). The lack of information on effects of ASM on the hydrology, aquatic species, and habitats in Latin America represents a significant data gap.

3.5 POLLUTION

ASM generates different types of pollution that can stress ecosystems at different scales. The most prevalent and widespread pollution includes sedimentation from alluvial mining, acid mine drainage and heavy metal leachates, and mercury contamination. Other types of pollution associated with ASM include oil and gas spills, solid waste, air pollution (smoke and dust), and noise and light pollution. These secondary pollutants are widely acknowledged but have not been well documented. An estimate of diesel and gas contamination in the Madre de Dios region calculated that over 547,000 gallons of diesel and gasoline could be released into the environment each year, based on estimates of fuel consumption in the region (Peneiro et al., 2016). A study in eastern Brazil described the impact of mine noise and associated truck traffic on black-fronted titi monkeys, showing less calling activity and the masking of calls by mining noise (Duarte et al., 2018). Although the study was focused on an industrial mine, similar noise occurs from traffic, dredges, pumps, and earth moving equipment in alluvial mines in the Amazon. The study on birds and frogs in mining areas in the Madre de Dios region also identified noise as affecting habitat selection by birds (Alvarez-Berrios et al., 2016). Other stresses from mining-associated pollution are poorly documented and there remains a data gap.

3.5.1 EROSION AND SEDIMENTATION

Soil erosion from mining operations can dramatically increase sediment load in streams located downstream from gold mines. ASM related sediment discharges can exceed those generated by other land-use changes, including logging, agriculture, road-building, or urbanization (Brosse et al. 2011). One study in the Tapajos River Basin in the Brazilian Amazon found that ASM contributes 90 percent of the sediment load in the river and often peaks during the dry season, which is opposite of natural cycles (Lobo et al., 2017). Streams impacted by mining had available light for phytoplankton productivity reduced from six meters to 1.7 meters, which can affect plankton, macroinvertebrates, and fish populations (Lobo et al., 2017). Decreased water clarify caused by high total suspended solids (TSS) via erosion can block light, resulting in lower dissolved oxygen levels as photosynthesis is reduced. High sediment loads can also absorb more sunlight increasing water temperatures and reducing dissolved oxygen capacity. Sediment can cover in-stream habitat elements, smother spawning beds, and decrease habitat complexity.

High sediment in streams can impact fish in several ways: increased mortality due to clogged or damaged gills; degraded spawning habitat and developmental stages; interference with natural migration; reduced food availability by reduced primary and secondary production (i.e. invertebrates); reduced visual hunting effectiveness; and loss of habitat (Mol and Ouboter 2004). A study of streams affected by sediment from ASM in neotropical Suriname found "low species diversity, low proportion of young fishes, high proportion of midchannel- surface-feeding fishes and fishes adapted to low light, low proportion of visually orienting fishes and fishes that hide in leaf-litter banks and woody debris, and low

relative biomass of food fishes" (Mol and Ouboter 2004). A study of ASM impacted streams in Guiana found increased numbers of smaller, shorter-lived fish species and habitat generalists, representing a "significant shift in the functional structure of fish assemblages" (Borrillo-Hunter, 2004). These changes were observed to last several months after mining activities had ended. In a study of mining impacts on fish assemblages in an Indonesian river, the authors noted that the extent of recovery 10 months after mining ended depended on the duration of mining and severity of the impacts (Brosse et al. 2011). In

The effects and stresses of mine-related sedimentation can be carried far downstream, and in some cases, out to the ocean, impacting coral reefs. A study in Colombia documents sediment impacts on a Caribbean reef complex near the mouth of the Magdalena River, the largest in Colombia. The river drains 24 percent of the country including a significant portion of the northern Andes where many ASGM mines are located. The sediment originates upstream in the basin from terrestrial sources, including Antioquia, a high-ASM area, however the source of sediment is not identified in the study (Restrepo et al. 2016).

3.5.2 ACID MINE DRAINAGE

Acid mine drainage and heavy metal leachates are different but often inter-related types of pollution. Acid mine drainage occurs when sulfur-bearing minerals associated with hard-rock gold deposits are exposed to oxygen and water and form sulfuric acid. Acidic leachate also dissolves and mobilizes other toxic heavy metals such as cadmium, lead, copper, zinc, and arsenic that can be released into surfaceand ground-water if they are not contained properly. Acid drainage can leak from mine shafts, but more frequently forms in tailings piles where sulfur minerals in the finely ground tailings are exposed to air and water. It has been estimated that over 13 billion m³ of effluents have been discharged into Peru's water courses due to all types and scales of mining and metallurgy (Bebbington & Williams, 2008). Acid mine drainage has been studied extensively and it reduces the species richness and abundance of aquatic macroinvertebrates (Gray & Delaney, 2008; Hodgson & Harding, 2011). Streams impacted by acid mine drainage are characterized by few tolerant species, impaired ecosystem processes, weakened food webs, and slower microbial processes, such as decomposition (Hodgson & Harding, 2011).

Heavy metals can also be released when cyanide is used to process gold-bearing ore and tailings. Cyanide effectively leaches gold and is used in most industrial gold processing world-wide. However, it also efficiently leaches other heavy metals and requires significant expertise and technological equipment to do properly (Telmer, pers. comm., 2018). Although cyanide is not as commonly used by individual miners as mercury, regional small-scale cyanide processing centers are located throughout Peru and Ecuador that work with ASM miners (Telmer, pers. comm., 12 September 2018). These centers will often re-process ore and tailings that have already been processed with mercury once to extract the remaining 70-80 percent of the gold that the mercury did not extract. A study on the Puyango-Tumbes River in Ecuador found that most of the mercury contamination in the river was likely the result of cyanide mobilization from processing centers rather than from artisanal mining sources. The authors estimated that approximately 1.9 million tons of tailings and cyanide pulps containing free cyanide and heavy metals were dumped into the river (Schudel et al., 2018). Another water guality study in the same area found heavy metal concentrations exceeded human safety standards in surface water and in sediment sampled downstream of processing centers that use cyanide (Marshall et al., 2018). A study in the same area in 2011 determined that about 0.65 tons of inorganic mercury and 6,000 tons of sodium cyanide were

released into the river each year. The cyanide inhibited bacterial activity downstream, which reduced mercury methylation rates resulting in lower methylmercury concentrations downstream of the mining site than upstream (Guimaraes et al., 2011). Previous studies in the area indicated lethal effects on aquatic biota, reduced biodiversity, loss of fish, and changes in species composition (Tarras-Whalberg et al., 2000). Benthic macro-invertebrates were eradicated in reaches immediately below mining activity, and reduced numbers of taxa were found 160km downstream to the mouth of the Tumbes River. Likewise, fish were absent from the same reaches denuded of benthic life although local fishermen still fish upstream of the mining areas (Tarras-Whalberg et al., 2000).

3.5.3 MERCURY CONTAMINATION

3.5.3.1 SOURCES AND PATHWAYS OF MERCURY CONTAMINATION

Mercury use in ASM is often unregulated and uncontrolled, causing long-term mercury contamination via water and air, often causing contamination far from the source since mercury is both persistent and highly mobile (Driscoll et al. 2013). Use of mercury in ASGM is a common practice globally as it is a cheap and fast process to extract gold from ore. ASGM is now the largest source of mercury emissions in the world (Swenson et al. 2011). Recent studies estimate that up to 1400 tons of mercury are released into the global environment annually from ASGM (37% of total global emissions), with about one-third released into the atmosphere and two-thirds released into waterways and tailings piles (Figure 11; Swenson et al., 2011; Seccatore et al., 2014; Telmer and Veiga, 2009; Esdaile and Chalker, 2018). When tailings piles dry, mercury can evaporate or spread with tailings dust in the wind over large areas (McMahon et al., 1999).

A study on the Puyango-Tumbes river, which flows from Ecuador into Peru, found mercury contamination as far as 160 kilometers downstream from the source in the Tumbes Delta in Peru (Marshall et al., 2018). As the price of gold has increased, the ASGM activity in Latin America has risen accordingly, and with that, the use of mercury over the past 15 years (Figure 11).

There are many documented examples of local and regional mercury contamination across Latin America, although Latin America is relatively efficient at recovery compared with the rest of the world. (Marshall et al., 2018; Schudel et al., 2018; Barbieri et al., 2009; Delgado 2010; Tarras-Wahlberg 2000; Wasserman 2003; Veiga et al., 1999).



Figure 11. Mean mercury use, emissions, percent global ASGM Figure deforestation in Madre de Dios, gold production, mercury emissions, and number of miners in ASGM. Esdaile and Chalker 2018.

3.5.3.2 MERCURY IMPACTS TO BIODIVERSITY

The most problematic form of mercury contamination is from organic mercury, which forms methylmercury (or mono-methylmercury) under complex and generally anoxic processes in the environment. Methylmercury is more toxic than inorganic mercury and tends to bioaccumulate in the food chain. Consumption of mercury contaminated fish, especially by top predators, is a leading source methylmercury exposure for both humans and wildlife (Diringer et al., 2014; Dorea and Barbosa 2007). In the Amazon, for example, studies on fish collected from rivers and bought in fish markets have documented high levels (greater than 0.3 ppm, a US EPA reference value for fish) of methylmercury downstream from ASGM areas (CAMEP 2013; Uryu et al., 2001; Diringer et al., 2014). Studies have also documented high background levels of mercury in the Amazon basin independent of ASGM, likely due to a combination of natural geologic sources, long-term atmospheric deposition of mercury that remains available due to low sequestration rates in the tropical environment, and release of mercury from deforestation and fires (Schmidt 2012; Veiga et al., 1999; Uryu et al., 2001).

Impacts to wildlife are succinctly described by Evers (2018):

Mercury is a potent neurotoxin that can cause physiological, neurological, behavioral, and reproductive harm to wildlife, thereby affecting fitness. It readily biomagnifies, resulting in increasing concentrations of Methyl-mercury (MeHg) in the ecosystem as it moves from water and sediment to plants, aquatic insects, invertebrate predators (e.g., spiders in terrestrial systems), fish, and wildlife. Once absorbed by organisms, MeHg is generally eliminated slowly. As a result, top predators in a food web, such as birds and mammals that prey on organisms that are themselves high in the trophic food web, may have concentrations of MeHg in their tissues that are many orders of magnitude higher than the concentrations found in the water (often >10⁶–10⁷ higher). Generally, each trophic exchange in the food web accounts for an order of magnitude of increase in MeHg concentrations.

While specific studies of the impacts of mercury contamination have generally not been undertaken in the countries targeted in this white paper, evidence of mercury's impacts on wildlife are largely based on laboratory studies or from tissue samples from birds, fish, and other organisms, mainly from temperate regions (Evers 2018; Spalding et al. 2000). Most studies of mercury effects on wildlife are dosing studies where captive animals or birds are fed a diet incorporated with mercury at various concentrations to determine no- and lowest-observed-adverse-effect levels and lethal doses or concentration levels (Evers 2018). Numerous dosing studies also sample mercury levels in wildlife through lethal methods (measuring mercury levels in various organs such as the liver, kidney, and brain) or through non-lethal methods (collecting blood, fur, eggs, muscles, or feathers). Observed adverse effects of elevated mercury levels include physiological, neurological, behavioral, and reproductive changes. Since mercury provides no beneficial biological function and is a potent neurotoxin, impacts from increasing mercury doses are inevitably negative (Evers 2018). Methylmercury toxicity primarily affects the central nervous system causing symptoms that include sensory and motor deficits, behavioral impairment, anorexia, lethargy, and eventually convulsions and death at higher doses (Wolfe et al., 1998). Impacts of mercury toxicity on non-captive wildlife are then usually extrapolated from the dosing studies, although environmental stresses such as disease, malnutrition, parasite loads, and other factors reduce the levels at which mercury toxicity may impact behavior, reproduction, and survival in wild populations (Spalding et al. 2000). There is considerable variation within and across species in impacts from mercury exposure and ability to process and purge mercury.

Few population-level studies have been conducted in the wild on impacts from mercury contamination; a few studies exist on loons in northern forests and egrets and ibis in Florida (Evers et al., 2008; Spalding et al. 2000; Scheuhammer et al., 2007). One study focusing on dietary methylmercury impacts on North American piscivorous species indicated that population effects vary with species life history, dietary concentrations of methylmercury, local methylation rates, and atmospheric mercury deposition rates. Toxic effects at environmentally realistic concentrations include behavioral, neurochemical, hormonal, and reproductive changes including hatching success and survival rates. Population modeling suggested that reductions in mercury emissions could have substantial benefits for common loon populations and potentially other piscivorous species (Scheuhammer et al., 2007).

Due to their exposure to mercury from coal-fired power plants, loons are one of the better studied piscivorous species in the wild. An 18-year study on loons in freshwater lakes found that mercury body burdens in adult loons increased 8.4 percent per year and loons with the highest mercury loads produced 41 percent fewer fledged young than low-exposure loons. Negative impacts on behavior, physiology, and survival and reproduction were observed. The paper concluded that mercury contamination is "a driving stressor for creating breeding population sinks" in parts of Maine and New Hampshire (Evers et al., 2008).

A population model for American toads exposed to mercury found complex relationships where multiple exposure paths (through larval diet and maternal transfer) reduced population size and increased extinction probability, but that the results are highly specific to that species and the conditions of the model (Willison et al., 2012). A study on wild songbirds (Carolina Wren) along a mercury contaminated river in Virginia, USA, found that birds nesting at contaminated sites had a 34 percent reduction in nesting success and were three times more likely to abandon their nests than birds at uncontaminated reference sites (Jackson et al., 2011). This was the first field study to document the relationship of blood mercury concentrations on breeding performance in wild songbirds and demonstrate negative reproductive effects at relatively low mercury concentrations. Although the effects of mercury contamination are comparatively well-documented at the individual level on various species through dosing studies, the paucity of studies at the population level, particularly in Latin America, is a significant data gap.

3.5.3.3 MERCURY IMPACTS TO BIODIVERSITY IN THE LAC REGION

In the LAC region, several studies have sampled mercury levels in fish in the Amazon basin, demonstrating that mercury levels depend on a variety of factors including location, environmental conditions (river type, natural mercury sources, season (wet or dry) and anthropogenic factors such as ASGM, fish type, weight, feeding patterns, and others. A study published in 2000 regarding mercury contamination in the Tapajos Basin, Brazil, found mercury levels in omnivores and piscivores living near gold mining areas were high and risked toxic effects, particularly to reproduction. The mercury levels in fish were high enough to have detrimental effects on animals at higher trophic levels that feed on them such as the giant otter, piscivorous bird species, river dolphins, and jaguars. The toxicity of methylmercury increases with temperature and that most studies on methylmercury were conducted in temperate climates and that the effects may be greater in the Amazon than indicated in those studies (Uryu et al., 2000). The authors conclude that their results would apply to other mining areas in the Amazon, and that since conditions are favorable for continued mercury contamination, the problem is likely to persist indefinitely (Uryu et al., 2000). A study on the Madre de Dios River in Peru sampled fish in local markets and determined that 60 percent had mercury levels that exceeded international

guidelines (0.3ppm) with the species highest on the food chain having the highest levels. Mercury levels increased in 10 of 11 species analyzed between 2009 and 2012 indicating an increasing trend in mercury contamination. Seventy-eight percent of adults sampled had mercury concentrations above international limits (1ppm for hair) and 25 percent reported working in ASGM (CAMEP, 2013). A recent study found elevated mercury levels in fish and people along the Atrato River in a biodiversity hotspot in Choco, Colombia from ASGM activities. Mercury levels were higher in higher trophic levels of fish, and most had levels that exceeded safe consumption limits for people. Sediment samples in the areas had lower than expected concentrations, possibly due to heavy rain (Palacios-Torres et al., 2018).

A study in Peru found higher mercury concentrations in bats near ASGM sites than at the control sites with certain species (insectivores), juveniles, and reproductive females having levels exceeding 10ppm, which could cause changes in brain neurochemistry, physiology, and behavior (Kumar et al., 2018).

Freshwater microorganisms are highly sensitive to mercury, with no-observed-effect-levels on photosynthesis and/or growth factors between I and 50 ug/L for inorganic mercury, and 10-100 times lower for methylmercury compounds. In general, aquatic plants are affected at mercury concentrations as low as I mg/l in water, and at much lower concentrations of organic mercury. A study of floating water cabbage exposed to mercuric chloride found high doses (up to 20 mg/l) "decreased chlorophyll content, protein, ribonucleic acid, dry weight, catalase and protease activity and increased production of free amino acids." (Boening, 2000).

Terrestrial plants, and especially woody plants, are not very sensitive to mercury contamination (Boening, 2000). Mercury tends to accumulate in roots rather than in stems and leaves indicating that the roots act as a barrier to uptake (Patra and Sharma, 2000). Due to low uptake in most species, mercury concentrations in terrestrial plants do not appear to be high enough to impact humans or species that may consume them; some plant species bred specifically for bioremediation of mercury may be the exception.

Mercury contamination is a widespread and persistent environmental threat that is exacerbated by the increase of ASM globally coupled with weak governance and enforcement and lack of formalization in the sector. Mercury contamination is a global problem, with ASGM the foremost contributor. For example, species in supposedly pristine environments such as the Arctic are contaminated with mercury; a 2016 study of shorebirds breeding in the Arctic demonstrated that elevated mercury deposition may be a factor in declining populations (Perkins et al., 2016). Even though the number of studies describing the effects of mercury contamination on populations are few, there is substantial evidence linking mercury contamination to reduced survival and reproductive success in individuals and that added stresss encountered by wild populations are likely to reduce the threshold at which mercury has a detrimental effect (Spalding et al., 2000).

3.6 ASM, MIGRATION, AND IMPACTS ON BIODIVERSITY

ASM has been shown to attract human populations to remote areas of high biodiversity where minerals are present; this migration can be considered an indirect impact. Impacts from population increases on biodiversity and ecosystems are well documented in other contexts and include increases in road density and traffic; increased land clearing for development, agriculture, and cattle grazing; increased logging, fires, and fuelwood collection; increased hunting and wildlife trafficking; increased pollution; increases in domestic animals, livestock, and invasive species; and increased strain on law enforcement/regulatory bodies (Table 2). Population increases are particularly problematic in protected areas or areas that previously had comparatively low populations. ASM in the Madre de Dios region is an example of a large influx of people into a highly biodiverse region with consequential impacts. Migration issues are exacerbated by improved road penetration into remote areas and the opening of the trans-oceanic and trans-Amazonian highways, which facilitate access to formerly remote areas and the transportation of goods, equipment, gold, contraband, and people. Roads can result from development in a region and are "one of the most important drivers of deforestation in the Amazon, particularly since they facilitate human access and activities related to agriculture, cattle ranching, mining, and logging" (MAAP, 2018).

4 HOW DO THREATS FROM ASM COMPARE TO OTHER THREATS TO BIODIVERSITY IN THE TARGET AREAS?

This section addresses Research Objective #3.

- Based on available information, ASM is not considered one of the leading threats to biodiversity in Central American countries, but should be monitored for future activity.
- In Latin America in general, land conversion for agriculture and ranching causes over 90 percent of deforestation (Figure 12).
- ASM can be a significant threat to forests at a regional or local scale. For example, one study found that mining (both ASM and industrial) caused 28 percent of the deforestation in the Southwest Amazon (mainly the Madre de Dios region in Peru), nine percent in the Magdalena-Uraba forests of Colombia, and 11 percent in the Tapajos-Xingu forests in Brazil.
- Gold mining is one of the leading threats to biodiversity in certain regions such as the Antioquia and Choco departments of Colombia, the Madre de Dios region in Peru, and the Tapajos basin in Brazil.

As described above, ASM in many countries is conducted illegally or informally with little government oversight or regulation. Estimates on the amount of ASM occurring in each country are usually developed from indirect indicators such as the amount of gold exported (which is problematic since gold is often smuggled across borders), the amount of mercury imported (ASGM is the main use, but mercury is also smuggled or reused), or remote sensing information (of more value in forested areas like Colombia and the Amazon). Other threats to biodiversity are similarly difficult to quantify, tropical land conversion from forest to agriculture or ranching being the possible exception.

4.1 CENTRAL AMERICA

Although ASM in Central America can affect biodiversity in the vicinity and downstream of ASM operations, it is not occurring on a scale that is likely to have widespread impacts on biodiversity relative to other factors in most areas of Central America. None of the biodiversity assessments in Central America reviewed for this report listed mining (industrial or ASM) as one of the main threats to biodiversity, except for industrial mining impacts on Lake Cocibolca/Nicaragua.

The main threats to biodiversity in Guatemala include conversion, loss, degradation and fragmentation of natural habitats (mainly due to agricultural burning and clearing for ranching and palm oil plantations); overexploitation of certain species (particularly high-value timber); invasive species; pollution and contamination of natural habitats or species (primarily from oil palm processing liquid waste discharge); and climate change (Byers, Sandoval and Lopez-Selva, 2016).

In Honduras, the main threats to biodiversity include rapid deforestation (conversion for agriculture, firewood extraction, forest fires, etc.); overfishing (and destructive fishing practices); wildlife poaching; increasing biofuel monoculture (which isolates forest fragments); pollution from pesticides, wastewater

and solid waste; invasive species; and weak environmental legislation, including unsustainable development, (Hansen and Florez, 2009; Flora & Fauna International, n.d.).

The main threats to biodiversity in El Salvador are habitat loss, fragmentation and degradation; overexploitation; pollution and contamination; invasive species; and climate change (Kernan and Serrano, 2010).

The main threats to biodiversity in Nicaragua include habitat conversion (to monocultures, agriculture, and grazing lands); contamination and sedimentation; overexploitation, harvest and trade of natural resources (primarily via logging and illegal wildlife trade); human-induced fires; and climate change (McGinley et al., 2009). Lax environmental regulation has also allowed environmental degradation from industrial mine sites (GIATOC, 2016). Industrial mining activities are one of the main threats to the preservation of the Lake Cocibolca/Nicaragua, the largest freshwater lake in Central America. Open-pit mining and the extraction of construction materials have contributed to problems of soil degradation and increasing sedimentation within the basin (Montenegro-Guillén, 2003).

Given the lack of data on ASM activity in Central America and the significant negative consequences of ASM, it is important to monitor potential development of the sector in the region to prevent broad scale impacts to biodiversity as in parts of South America. While countries in the region have active ASM, the import and use of mercury is relatively low compared to countries in South America (IGF, 2017); currently, the risk of mercury contamination in Central America appears to be low. However, the extent of ASM is relatively unknown; thus, to protect biodiversity in Central America, continued monitoring is needed given the stresses of land use change, deforestation, pollution, and habitat loss, among others associated with ASM.

4.2 SOUTH AMERICA

Causes of biodiversity loss vary by location but logging and land conversion to agriculture and ranching in the Amazon leads by a wide margin. The 2010 State of Biodiversity in Latin America and the Caribbean report listed the five main pressures on biodiversity as land degradation, climate change, pollution from nutrients, unsustainable use, and invasive alien species. Commercial agriculture is responsible for almost half of the habitat loss due to reduction, loss, and fragmentation of forested habitats. Roads were also identified since most habitat degradation occurs within 30km of identified roads. At a local scale, ASM does pose a demonstrable threat to biodiversity via habitat loss, fragmentation, pollution, and other biophysical stresses.

In Colombia and Peru, the value of gold exports has overtaken the value of coca exports and although coca cultivation is declining in Colombia and Peru, it is still prevalent (GIATOC, 2016, MAAP 2017). ASM is often overlooked in analyses of deforestation because it historically occupied relatively small areas, but deforestation from ASM has increasingly become a problem in some of the most remote and better-conserved primary forests in tropical South America as described in Section 2 (Alvarez-Barrios and Aide, 2015; GIATOC, 2016; UNODC, 2016; MAAP 2017).

Figure 12 shows the drivers of deforestation and degradation from 46 countries grouped into continental regions. In Latin America, mining is a relatively small contributor to deforestation relative to agriculture (Kissinger et al., 2012). The estimate of mining impacts in Figure 12 was likely based on

official reports of mining activity, which would focus on industrial-scale mines and likely underrepresents ASM activity.



Figure 12. Continental estimations of the importance of deforestation drivers as reported by 46 countries: (a) in terms of overall continental proportions as sum of country data weighted by net forest area change by country (km2/y, FAO, 2010a) for the period 2000–2010 (b) the same data shown in terms of absolute national net forest area change by (km2/y, FAO, 2010a), and (c) for continental estimations of relative importance of degradation drivers (Source: Hosonuma et al., 2012). Source: Kissinger et al. 2012

Deforestation associated with industrial and ASM gold mining activities in tropical moist forest biomes in South America between 2001 and 2013 and found that 28 percent of forest loss was associated with mining in the southwest Amazon (mainly Madre de Dios in Peru), 11 percent was associated with mining in the Tapajos-Xingu forest (Tapajos basin in Brazil), and nine percent was associated with mining in the Magdalena-Uraba forests in Colombia (Alvarez-Berrios and Aide2015), (Figure 7).

A study of industrial mining in Brazil from 2005-2015 found that deforestation associated with industrial mine leases extended for 70 km beyond the lease boundaries and was 12 times the amount that occurred within the official lease boundaries. The total mining-related deforestation accounted for nine percent of all Amazon forest loss during the period of study, which is significantly higher than official estimates. The authors attributed the additional forest loss to mining infrastructure establishment, development of supply chains, and urban expansion (Sonter et al., 2017). Most of these factors also apply to ASM activities indicating a significant potential footprint beyond the location of the mining itself.

The Monitoring of the Andean Amazon Project (MAAP) used remote sensing to track deforestation in the Andean Amazon (Colombia, Ecuador, and Peru) between 2001 and 2017 and documented the major

threats causing deforestation and degradation as: "gold mining, agriculture (oil palm and cacao), cattle ranching, logging, and dams. Agriculture and ranching cause the most widespread impact across the region, while gold mining is most intense southern Peru" (MAAP, 2018). The list of threats from the 2016 report also included illegal coca cultivation and roads (MAAP, 2017).

Gold mining is a major threat in southern Peru, while large-scale agriculture and major new roads are latent threats. (Figure 13; MAAP, 2017). Between 2001 and 2017, 4.2 million hectares have been cleared in the Andean Amazon with 66 percent of the clearing from small-scale (<5 hectare) events, 31 percent from medium-scale (5-50 hectares) events, and 3 percent from large (>50 hectares) events typically associated with industrial agriculture. The average forest loss per year is variable but follows an increasing trend over the 2001-2017 study period with the highest forest loss observed in 2017 (MAAP 2018). The average annual deforestation rate for the 17-year period for the three countries was approximately 247,000 ha per year. In comparison, the average deforestation rate for Brazil over the past several years was 639,400 ha per year (MAAP, 2018). Figure 13 shows deforestation hotspots in the Andean Amazon between 2015 and 2017 using the following key for the indicated areas:

A. **Central Peruvian Amazon:** Over the last 10 years, this zone, located in the Ucayali and Huánuco regions, has consistently had one of the largest concentrations of deforestation in Peru (**Inset A**). Its principal threats include palm oil and cattle grazing.

B. Southern Peruvian Amazon: This zone, located in the Madre de Dios region, is impacted by gold mining (Inset BI), and increasingly by small- and medium-scale agriculture along the Interoceanic Highway (Inset B2).

C. **Central Peruvian Amazon:** A new oil palm plantation located in the San Martín region has been identified as a recent large-scale deforestation event in this zone (**Inset C**).

D. **Southwestern Colombian Amazon:** Cattle grazing is the principal deforestation driver documented in this zone, located in the departments of Caquetá and Putumayo (**Inset D**).

E. Northern Colombian Amazon: There is expanding deforestation along a new road in this zone, located in the department of Guaviare (Inset E).

F. **Northern Ecuadoran Amazon:** This zone is in the Orellana province, where small- and mediumscale agriculture, including oil palm, is the principal cause of deforestation (**Inset F**). (MAAP 2018)



Figure 13. Major deforestation hotspots in the Peruvian Amazon 2015-2017. Source: MAAP 2018.

The main threats to biodiversity in Colombia are land-use changes (primarily from cattle ranching); overexploitation (primarily timber extraction, but also over-hunting and over-fishing); invasive species; pollution (mainly municipal waste discharges); and climate change (Gómez et al., 2014). 2017 was the year of the highest rate of deforestation in the Amazonian region of Colombia in the past 18 years, largely from small-scale events and cattle ranching (MAAP, 2018; Figure 13). Mining was a greater cause of vegetation loss than coca in the Choco department; an estimated 15,404 hectares were cleared for coca crops in 2013 and 24,450 ha were affected by alluvial mining (UNODC, 2016).

The main threats to biodiversity in Peru are deforestation and land-use change (primarily due to palm oil and cattle grazing); overexploitation of fisheries, timber and bushmeat; illegal and informal gold mining; infrastructure development; habitat degradation (such as changing flood regimes in river from hydropower or mercury contamination from gold mining in rivers); and urban markets and mass production (which encourage homogeneity, reducing diversity) (Queiroz et al., 2014; MAAP 2018; Figure 13).

The major threats to biodiversity in Brazil are infrastructure (particularly hydropower energy infrastructure); a weakened Forest Code due to political lobbying; land conflicts and unclear land tenure (primarily in the Amazon, where deforestation is highly correlated with unclear land tenure); illegal logging and illegal mining; conversion of forest for cattle ranching and large-scale agriculture; and climate change (Anderson, 2012).

In addition, existing and proposed hydropower developments in the Amazon pose a considerable risk to biodiversity across the region (Figure 14). Large dams reduce fish diversity, access to habitat in floodplains, free movement, migration, and population connectivity. Fish passage in tropical dams has had limited success, so dams have blocked the fish that migrate hundreds of kilometers due to seasonal flood pulses. Dams simplify habitats, reduce productivity and diversity, and block passage of sediment and nutrients (Winemiller et al., 2016). Figure 14 lists existing and proposed dams in the Amazon basin along with ecoregions and number of endemic fish species, indicating the potential risk to aquatic biodiversity in this highly diverse area (Winemiller et al., 2016).

While multiple factors cause deforestation in Colombia, Peru, and Brazil, ASM is a primary driver of deforestation on a local and/or regional level, as demonstrated in the Antioquia and Choco regions of Colombia, the Madre de Dios region of Peru, and the Tapajos region of Brazil. Agricultural and infrastructure expansion remain the primary threats on a larger scale. ASM, however, has negative consequences in addition to deforestation, including mercury contamination, erosion and sedimentation, habitat loss, and changes in hydrology, all of which have long-term impacts on aquatic and terrestrial organisms within the region.



Figure 14. Fish diversity and dam locations in the Amazon. In addition to basin-wide biodiversity summaries (upper left), each basin can be divided into ecoregions (white boundaries). Many species are found only in a single ecoregion (black numbers), and sub-basins within each river basin differ widely in their total species richness (shades of green illustrate breakpoints between quartiles in rank order within each basin). Dozens of new taxa are discovered every year in each basin; hence, actual fish diversity is underestimated, and distribution data are lacking for many species. Nonetheless, fish diversity data are now sufficient to support basin-scale impact assessments. Source: Winemiller et al. 2016.

5. WHAT PRINCIPLES AND STRATEGIES EXIST TO ADDRESS THREATS POSED BY ASM TO BIODIVERSITY IN THE TARGETED GEOGRAPHIES?

This section addresses research objective #4.

This section summarizes existing programs and strategies that address risks posed by mining in the target area. There are numerous initiatives at the country and international level to address the social, environmental, and economic issues associated with ASM. Mining is a widespread activity that supports the economies of many Latin American countries at both the artisanal and commercial levels. The countries of focus in this analysis have attempted to regulate mining at the national scale with mixed results while international treaties and strategies often focus on improving specific aspects of the mining industry (Table 3).

TABLE 3. RELEVANT INTERNATIONAL AGREEMENTS IN CENTRAL AND SOUTHERN AMERICA			
NAME	REACH	COUNTRY OR COUNTRIES	DESCRIPTION
Minamata Convention on Mercury, United Nations Environment Programme (UNEP)	Global	Colombia and Guatemala (signatories) Brazil, Peru, El Salavador, Honduras, and Nicaragua (parties)	Global treaty to protect human health and the environment from the adverse effects of mercury.
Global Mercury Partnership, UNEP	Global	Honduras, Peru	A three-year UNEP partnership including governments and other stakeholders that aims to reduce mercury emission by focusing on capacity building and training.

TABLE 4. EXAMPLES OF CUR	RENT PROGRAMMING	IN LATIN AMER	ICA
PROGRAM NAME	IMPLEMENTER AND/OR FUNDING SOURCE	COUNTRY OR COUNTRIES	DESCRIPTION
Conditional cash transfers to protect community tropical forests in the Amazon region	GIZ, Ministry of Environment	Peru	The goal of the program is to provide conditional cash transfers that can be used to promote initiatives supporting sustainable forest use by indigenous communities.
Regional cooperation for the sustainable management of mining	GIZ and the Economic Commission for Latin America and the Caribbean (ECLAC)	Colombia, Peru	Programs aims to ensure that the mining sectors in the target countries are managed responsibly in economic, social, and environmental terms.
Conservation of Biodiversity in Landscapes Impacted by Mining in the Choco Biogeographic region	Global Environment Fund, United Nations Development Programme	Colombia	The goal of the project is to protect the biodiversity of the Choco biogeographic region from the direct and indirect impacts of gold, silver, and platinum mining.
CANEF-Promoting Sustainable Practices in the Mining and Forestry Sectors	Inter-American Development Bank	Colombia, Peru	The goal of the project is to support and promote environmental sustainability in the extractive industries sector.
Fairmined Initiative	Alliance for Responsible Mining (ARM)	Colombia, Peru	The initiative was created by the non- profit ARM to support responsible artisanal and small-scale mining. It forms partnerships with local communities and organizations.
Various Projects	Red Social	Peru	Red Social is a non-profit based in Peru that is researching and working to promote more socially and environmentally responsible artisanal mining.
Strengthening the Capacity of Indigenous Organization in the Amazon (SCIOA)	PACT	Brazil, Colombia, Peru	SCIOA aims to increase the influence of indigenous communities in the Amazon to protect the region's environment and human rights. The focus is on the negative impacts of infrastructure projects and extractive activities on Amazon forests and water resources.

TABLE 5. ADDITIONAL INTERNATIONAL RESOURCES AND PROGRAM EXAMPLES

PROGRAM NAME	IMPLEMENTER AND/OR FUNDING SOURCE	COUNTRY OR COUNTRIES	DESCRIPTION
Combatting Conflict Minerals	European Commission	Global	European Union (EU) passed a new regulation in May 2017 to stop 1) conflict minerals and metals from being exported to the EU; 2) global and EU smelters and refiners from using conflict minerals; 3) mine workers from being abused and 4) supports the development of local communities.
CRAFT Code	Alliance for Responsible Mining, European Partnership for Responsible Minerals, and RESOLVE	Global	This code facilitates the relationship between the gold industry and the ASM sector, since it is a detailed tool that enables the application of the Organization for Economic Cooperation and Development (OECD) Due Diligence Guidance while laying out a progressive path toward the improvement of industry practices.
IMPACT		Africa's Great Lakes Region	Create incentives for artisanal gold miners to channel their product to legal exporters—and eventually responsible consumers.
International Peace Information Service (IPIS)	Public Private Alliance for Responsible Minerals Trade (PPA)	Democratic Republic of Congo	Artisanal Gold Monitoring Pilot involved developing a low-cost methodology to produce a continuous data flow on a wide range of indicators related to the operational, security and human rights context of artisanal gold mining.
International Tin Supply Chain Initiative (ITSCI) – Better Sourcing Program	Upstream supply chain	Burundi, Democratic Republic of Congo,	ITSCI's purpose is to create responsible mineral supply chains that avoid contributing to conflict, human rights abuses, or other risks such as bribery.

TABLE 5. ADDITIONAL INTERNATIONAL RESOURCES AND PROGRAM EXAMPLES			
PROGRAM NAME	IMPLEMENTER AND/OR FUNDING SOURCE	COUNTRY OR COUNTRIES	DESCRIPTION
		Rwanda and Uganda.	
Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict- Affected and High-Risk Areas	Organization for Economic Cooperation and Development (OECD) `	Global	The guide provides detailed recommendations to help companies respect human rights and avoid contributing to conflict through their mineral purchasing decisions and practices. This Guidance is for use by any company potentially sourcing minerals or metals from conflict- affected and high-risk areas. The OECD Guidance is global in scope and applies to all mineral supply chains.
Various Projects	Delve (World Bank and Pact)	Global (in Burundi as of 2015)	Delve is a global platform for artisanal and small-scale mining data that will allow for a complete picture of how the sector can contribute to global development.
Responsible Artisanal Gold Solutions Forum	USAID and others	Africa's Great Lakes Region	Responsible Artisanal Gold Solutions Forum (RAGS) a multi- stakeholder coalition seeking to learn about and address critical barriers to the production and trade of artisanal gold from conflict-affected and high-risk areas in a way that meets national and regional law and OECD Due Diligence Guidance and considers voluntary responsible sourcing standards.

Efforts to reduce mercury use and environmental and health impacts have had mixed results. Safer technologies exist, but adoption has been slow. Approaches to improve mercury recovery include preprocessing the gold ore to increase gold concentrations prior to mercury amalgamation and using retorts when the amalgam is burned to recover mercury vapor. The factor that will likely have a longer-term impact on mercury use is the Minamata Convention, which came into force in August 2017.

Although implementation has been slow, there is recognition that mercury use is likely to continue in the near term unless ASGM-friendly approaches are developed. USAID programs in Colombia (Oro Legal) and the U.S. State Department support in Peru focus on reduction of mercury use in mining, formalization of the ASM sector, introduction of mercury-free technologies, and combatting the criminality of ASM.

Education, integration into legal frameworks, and technical training were cited as critical pieces for reducing ASM's impact on biodiversity.

The Minamata Convention on Mercury (2013) aims to protect human health and the environment from the detrimental effects of mercury use. The Convention bans new mercury mines, outlines the phaseout of existing mercury mines, and the phase out and phase down of mercury use in various products and processes. Article 7 of the Convention is specifically focused on artisanal and small-scale gold mining. Signatory countries with artisanal and small-scale gold mining must take steps to reduce and, if possible, eliminate the use of mercury. If the artisanal and small-scale gold mining activities in a country are significant then the country must develop a national action plan, which includes a list of priority practices to be eliminated and a plan for formalization or regulation of the mining sector (Minamata Convention 2013). To date, Brazil, Peru, El Salvador, Honduras, and Nicaragua have signed and ratified the convention⁴, while Colombia and Guatemala are signatories. No signatory country in the target area has completed their national action plans although many are underway with the support of international NGOs. The globally focused and UNEP-led Global Mercury Partnership works with stakeholders towards the ratification and effective implementation of the Minamata Convention. There are a variety of programs, categorized under eight partnership areas, being implemented under the umbrella of the Partnership, including reducing mercury in artisanal and small-scale gold mining.

Each country in Latin American has unique laws, regulations, and approaches to regulating the mining industry. The legislation often focuses on defining the types of mining activities occurring in the country, regulate mining concessions, and regulate the environmental factors associated with mining. In 2013, Colombia passed a law in which it was established that the country would begin to transition into reducing the use of mercury in gold mining within five years. In July 2018, the complete ban was implemented in full force (Ossa, 2018). Experts interviewed for this paper questioned the efficacy of this approach since most ASGM activity is already illegal and some is associated with criminal organizations.

In March of 2017, to protect its natural resources, El Salvador passed a law banning all forms of mining in the country (Palumbo and Malkin, 2017). In Nicaragua, most ASGM activity is informal, with little regulatory oversight. One study reported attempts to assist ASGM groups to formalize was discouraging due to limited availability of mining concessions, costs, and timelines associated with obtaining permits, a lack of a clear formalization process, and little motivation due to lack of oversight (WCG, 2016).

Peru has intermittently increased enforcement against illegal mining in the Amazon by destroying mining equipment and camps. and while Brazil has one of the largest ASM sectors in the region, management ASM does not appear to be a pressing priority (Telmer, pers. comm., 12 September 2018).

In consultation with subject matter experts, certain programs were highlighted as effective; however, most indicated education, integration into legal frameworks, and technical training are critical pieces for reducing ASM's impact on biodiversity. In addition to the Minamata Convention, the Better Gold

⁴ Per the Minamata Convention website which tracks signatories and parties. http://www.mercuryconvention.org/

Initiative and the Global Environment Facility (GEF) GOLD program were highlighted. The Better Gold Initiative is a public-private partnership that was launched in 2013 as a joint effort between Swiss Better Gold Association (SBGA) and the Swiss Government, State Secretariat for Economic Affairs (SECO). It focuses on supply chains to improve social and environmental conditions of ASGM around the world. In 2013, Peru was the first country to launch the Better Gold initiative, which demonstrated some successs between 2013 and 2016 in Peru showed successful results by exporting 1,500 kg of gold from certified mines to Switzerland and the consolidation of value chains. The initiative's success in Peru allowed the program to expand to Bolivia and Colombia (Better Gold Initiative, 2017).

The aim of the GEF GOLD program is to lead the development of the artisanal and small-scale gold mining sector into a professional segment of the industry and to work towards reducing the use of mercury and other factors causing environmental and social impacts. The implementing partners include UNEP, UNDP, the United Nations Industrial Development Organization (UNIDO), and Conservation International (CI), along with other partners from industry, governments, and civil society. One of the program's goals is to develop and connect responsible producers to international markets through transparent supply chains. The program will be active in Burkina Faso, Colombia, Guyana, Indonesia, Kenya, Mongolia, Peru, and the Philippines (Artisanal Gold Council, 2018).

Other regional programs include the Fair-Mined Initiative being implemented by the Alliance for Responsible Mining (ARM), which works to certify gold producers as environmentally friendly to command a premium. To date, the number of certified producers is still small, but growing. One hurdle faced is that participants must be formalized, which is a barrier for many ASM producers (IGF, 2018)

In addition to these programs, stakeholders identified various areas of improvement and potential paths forward for addressing the impacts of ASM. Two ideas that were mentioned frequently were the roles of formalization and importance of education. Experts consulted mentioned the importance that formalization of the sector has in regulating and increasing oversight (Vauter, Villegas, Torres, pers. comm., 2018). Formalization is the focus of many ASM reform activities as informal mining can contribute to health and safety issues, environmental degradation, poverty, corruption, criminality, and loss of tax revenue (IGF, 2018). As a predominantly poverty-driven activity, ASM supports millions of rural workers yet also limits further opportunities due to lack of formalization, education, and resources that result in poor conditions and lack of productivity. Many attempts to formalize the ASM sector have failed to address the underlying issues associated with poverty (IGF, 2018). Recommendations to increase success in formalization include creation of appropriate legal frameworks, development of a streamlined licensing process, provision of access to geologic data and prospected land, access to capital, access to equipment, capacity building in ASM communities, and increased dialog between ASM stakeholders (IGF, 2018).

Additionally, many experts emphasized the importance of education to progress in the sector, including training and technical assistance (D'Cuire, pers. comm., 2018). Education has been suggested as a critical precursor to formalization since most ASM lack resources and education to navigate the regulatory hurdles or comply with regulations (IGF, 2018). Other approaches to reducing ASM impacts include developing alternative livelihoods and diversifying economic opportunity, although results from recent efforts have been mixed.

6. DATA GAPS SUMMARY

Biodiversity is well-documented in Latin America at a general scale but lacks detailed baseline data for monitoring of specific species and/or populations. Biodiversity hotspots and biomes have been delineated and estimates of species and endemism are underway or have been completed (CBD, n.d., World Bank 2013). Data gaps remain as new species are regularly discovered in the Amazon; for example, over 381 new species of vertebrates and plants were discovered over a two-year period in 2014-2015 (National Geographic, 2017). The lack of data on populations of key taxa throughout the region create a challenging scenario for monitoring impacts from ASM stresses.

Estimates of ASM production and the number of ASM workers are similarly difficult to determine as much of the activity is informal or illegal and often occurs in remote or rural areas. Methods vary widely by study and often involve modeling or estimations based on other more easily measured variables such as gold exports or mercury imports, which leads to variable results (IGF 2018; Seccatore et al., 2013). The sector can also undergo relatively drastic changes particularly if there is a rapid expansion of mining due to a 'gold rush' as happened in the Valle de Cauca in Colombia in 2010 (Sarmiento et al., 2013).

Several studies have tracked deforestation due to mining (both ASM and industrial) in South America, and several studies and ongoing programs are studying deforestation in general in the Amazon (UNODC 2016, 2018; Alvarez-Berrios and Aide 2015; MAAP 2018). These studies primarily use remote sensing (e.g., satellite imagery, drones) to track changes in forest cover, which can be used as a proxy for habitat loss, and to a lesser extent, biodiversity loss. There are a few studies focused on ASM impacts on specific species of fish, bats, birds, or frogs in the Amazon, but very few studies consider larger-scale impacts on populations or species diversity in an area affected by mining. Most studies use proxies of biodiversity loss, such as deforestation, impaired water quality, sedimentation, and geographically limited studies of species impacts are used to infer the impacts of ASM on biodiversity. The lack of baseline data against which to measure biodiversity loss are critical and represents a significant data gap.

While mercury impacts on piscivorous species are relatively well studied, few studies are focused on South America. A few studies have sampled fish populations for mercury contamination near ASGM sites, but the focus has mainly been on potential human health impacts from consuming contaminated fish rather than the impacts on the fish themselves or other piscivores. Data gaps include lack of research on population-level effects on organisms and lack of representation of impacts of mining across taxa.

7. FINDINGS AND CONCLUSIONS

This document characterizes the ASM activity and its consequences related to biodiversity in selected Latin American countries. To describe core issues related to ASM and biodiversity, the research was based on four key research questions:

- To what extent does ASM affect areas of high biodiversity?
- What is the evidence that ASM has significant impacts (e.g., direct, indirect, or cumulative) on biodiversity?
- Where impacts are thought to be significant, how do they compare to other threats to biodiversity in the target areas?
- What are successful principles and strategies for addressing threats posed by ASM to biodiversity in the targeted geographies?

Many of the areas where ASM occurs are areas rich in biodiversity, ranging from tropical rainforest in the Amazon basin to Andean cloud forests with high rates of endemism to the Meso-American biodiversity hotspot. The informal and often illegal nature of most ASM limits regulatory oversight, resulting in widespread environmental degradation in areas where mining occurs. ASM can be a major economic driver in rural areas, providing above average wages. It can also be a driver of human trafficking and be subject to organized crime. With increases in the price of gold coupled with the financial incentive for selling gold, ASM production has been increasing globally over the past 25 years. It is an important economic activity in much of Latin America. As such, the ASM workforce in Latin America more than doubled over the last 15 years to almost 1.5 million, with the largest increases in Brazil and Colombia. The percent of gold produced informally or illegally (mostly from ASM) ranges from 10 percent (Brazil) to 80 percent (Colombia) of total production. While the average ASM gold production in Peru is 28 percent, in some areas like Madre de Dios, over 90 percent of production is illegal.

Central and South America are home to highly diverse landscapes crossing several climatic zones. There are six main biodiversity hotspots located in these regions. Central America is a region with high biodiversity and includes the Mesoamerica biodiversity hotspot. Guatemala has the highest rates of endemism in Central America.

ASM is present in Central America and may occur in these highly biodiverse landscapes. In El Salvador, all metal mining (industrial and ASM) was banned in 2017, although some may still occur illegally. There remain a few towns where ASGM has occurred for generations. Mining in Nicaragua accounted for about 3.5 percent of GDP in 2014, with approximately 10-15 percent of gold produced by an ASGM workforce of about 20,000. ASGM in Nicaragua often occurs near industrial mine sites located in the 'mining triangle' in Northeastern Nicaragua, in proximity to two natural reserves and a relatively large undeveloped area to the north. Estimates of biodiversity impact from ASM in Nicaragua are not available. Overall, there is insufficient information to assess the impact of ASM on biodiversity in this region.

In South America, the body of evidence regarding concurrence of ASM and highly biodiverse landscapes is more extensively documented. Landscapes in Peru, Colombia, and Brazil are classified as highly biodiverse, despite this, ASM is actively pursued in throughout these landscapes disrupting ecosystem function, population dynamics, and more via land surface removal/modification (deforestation), fragmentation of forests, habitat loss, changes in hydrology, and pollution, including sedimentation and mercury contamination. Pollution from ASM can include spills of oil and gas from equipment, solid waste, sediment and acid mine drainage released into waterbodies, air pollution, and widespread mercury contamination. ASM is also associated with indirect stresses such as migration, which increases the local population and pressures on natural resources and expansion of infrastructure.

In Latin America in general, land conversion for agriculture and ranching causes over 90 percent of deforestation. Based on available information, ASM is not considered one of the leading threats to biodiversity in Central American countries and should be monitored for future activity. It is important to note that in Latin America, <u>ASM can be a significant threat to biodiversity at a regional or local scale</u>. For example, one study found that mining (both ASM and industrial) caused 28 percent of the deforestation in the Southwest Amazon (mainly the Madre de Dios region in Peru), nine percent in the Magdalena-Uraba forests of Colombia, and 11 percent in the Tapajos-Xingu forests in Brazil. Gold mining is one of the leading threats to biodiversity in certain regions such as the Antioquia and Choco departments of Colombia, the Madre de Dios region in Peru, and the Tapajos basin in Brazil. Thus, the documented presence of ASM in these highly biodiverse landscapes implies stresses to biodiversity exist in these regions.

There are numerous programs, policies, and activities focused on various aspects of ASM, from formalization, training, improvement of working conditions, and introduction of new technologies, among others. Efforts to reduce mercury use and environmental and health impacts have had mixed results and while safer technologies exist, adoption has been slow. Education, integration into legal frameworks, and technical training were consistently cited as critical pieces for reducing ASM's impact on biodiversity.

The lack of data on populations of key taxa throughout the region creates a challenging scenario for monitoring impacts from ASM stresses. Furthermore, aside from deforestation estimates in ASM areas, measurements of other stresses such as erosion and sedimentation, mercury contamination, acid mine drainage, habitat loss, among others are not measured consistently across ASM areas. Estimates of ASM production and the number of ASM workers are similarly difficult to determine as much of the activity is informal or illegal and often occurs in remote or rural areas. Methods vary widely by study and often involve modeling or estimations based on other more easily measured variables such as gold exports or mercury imports, which leads to variable results (IGF 2018, Seccatore et al., 2013). Thus, the impacts of mining on biodiversity in the countries of focus is often extrapolated from impacts of these stresses in other areas of the world to active ASM areas in LAC.

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ANNEX I. BIODIVERSITY HOTSPOTS IN LATIN AMERICA

Atlantic Forest. The Atlantic Forest covers 1,315,460 km² along Brazil's east coast on the Atlantic Ocean. It contains diverse habitats including mangroves, shrublands, grasslands, and tropical forests and is home to many endemic species, including 40% of vascular plants and almost 60% of vertebrates. The Atlantic Forest is threatened by expanding human developments and economic activities, resulting is almost 11,000 species being threatened with extinction (Sen Nag, 2018).

Cerrado. The Cerrado (Brazilian savanna) covers more than 20% of Brazil and is considered the world's most biodiverse savanna, spanning forest savanna, gallery forests, park savanna and savanna wetlands. The Cerrado contains five percent of all global plant and animal species including 14 endemic mammals and ten endemic birds. Further, the Cerrado is home to over 10,000 species of plants, of which almost half are endemic. This biodiversity hotspot is the second most threatened and overexploited region in Brazil (after the Atlantic Forest) in terms of vegetation loss and deforestation. (Sen Nag, 2018; WWF, n.d.)

Chilean Winter Rainfall- Valdivian Forests. The Valdivian forests are located along Southern South America's west coast extending from Chile into Argentina. Long periods of historical isolation have resulted in high amounts of endemism, including 90 percent for seed plants. These temperate forests are also home to South America's smallest wild cat, the kodkod, and the world's smallest deer, the southern pudú. Since colonial times, forest cover in this hotspot has declined by one-third (Sen Nag, 2018; Smith, n.d.).

Tumbes-Chocó-Magdalena. Tumbes-Chocó-Magdalena extends along South America's Pacific coast through Western Colombia, Ecuador and Northwest Peru and includes the Galapágos Islands. This hotspot covers a variety of habitats including mangroves, beaches, rocky shores, coastal wilderness, and one of the world's wettest rain forests, the Colombian Chocó. Tumbes-Chocó-Magdalena is home to 11,000 vascular plants, 5,000 of which are found in the Colombian Chocó. Half of the region's endemic mammal species are found on the Galapágos, such as the endangered Galapágos Islands fur seal. Deforestation from human settlements and agricultural expansion is the greatest threat to this hotspot (CEPF, 2001).

Tropical Andes. The tropical Andes are a narrow region covering 1,542,644 km2 crossing through Colombia, Ecuador, Peru, Venezuela, and Bolivia. This region is one of the most biologically diverse hotspots in the world, containing about one-sixth of global plant life including 30,000 species of vascular plants. For amphibians, birds, mammals, and plants, the Tropical Andes are the global leader in species endemism. Different parts of the Tropical Andes are degraded to differing degrees. In the Inter-Andean valley, where population numbers are large, less than 10 percent of the original habitat remains. However, in isolated regions of Venezuela and Colombia, and on the slopes of the Andes in Bolivia, Peru, and Ecuador, there are extended area of intact primary forests (CEPF, 2015).

Mesoamerica Biodiversity Hotspot. The Mesoamerica Biodiversity Hotspot includes the subtropical and tropical ecosystems extending from central Mexico to the Panama Canal and including islands in the Caribbean Sea and Pacific Ocean. This hotspot is home to the highest montane forests and the best-protected cloud forests in Central America. Mesoamerica has 17,000 species of vascular plants, of which 3,000 are endemic, as well as 440 mammal species, of which 65 are endemic. Some of the more visible symbols of mammal diversity include the endangered Central American spider monkey, the endangered

Mexican black howler monkey, the endangered Baird's tapir and the Jaguar (the last two of which are flagship species). Reptile, amphibian, and freshwater fish species are also vast, with 690 reptile species (240 endemic), 550 species of amphibians (350 endemic), and 500 fish species (350 endemic). Central America has experienced some of the highest global deforestation rates, with only 20 percent of the original habitat remaining. El Salvador is the most severe case, with less than five percent of original forest remaining (CEPF, 2004).

ANNEX 2. ASM IN NON-TARGET SOUTH AMERICAN COUNTRIES (ECUADOR, GUIANA, GUYANA, SURINAME)

ASM is additionally present in Ecuador; Portovelo-Zaruma, contains approximately 6,000 ASM gold miners. Contaminant discharges in these areas have caused certain river sections downstream of mining and processing operations to have a severely reduced fauna or to have lost all aquatic life (Miserendino et al., 2013; Tarras-Wahlberg et al., 2000).

The Guianan forests of Suriname, Guyana, French Guiana and Venezuela have some of the highest deforestation rates from mining in South America, with up to 68 percent of deforestation in Guyana between 2001 and 2010 caused by mining. Most deforestation has been due to small and medium scale operations, but large-scale operations have also contributed. Priority conservation areas affected by mining (both industrial and ASM) include Tepuis in Venezuela, and Brownsberg Nature Park in Suriname (Alvarez-Berrios and Aide 2015). Numerous studies on the impacts of ASGM have been conducted in this region (Borrillo-Hunter 2016, Burger et al. 2018, Peterson et al. 2001, Brosse et al. 2011, Durrieu et al. 2003, Laperche et al. 2014, Rojas Challa et al. 2008).