Lien vers le diaporama

Ambatovy project: Mining in a challenging biodiversity setting in Madagascar

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Abstract

The Ambatovy project nickel and cobalt mine is close to the ecotone between lowland eastern and montane forest, in Madagascar. It is a forest mosaic of largely intact to heavily disturbed patches. The mine's footprint is nested within this area. The key biodiversity components of this forest matrix include structurally distinct forest types (azonal, transition, zonal) linked to different substrates, streams, and seasonal ponds. The zone is biotically diverse with a flora of at least 1367 flora species and fauna of 214 vertebrate species, which includes 13 confirmed lemur species. Main residual impacts to biodiversity result from progressive forest clearing. In light of these sensitivities, the Ambatovy project developed a biodiversity management program including a biodiversity-offset initiative with projected conservation outcomes leading to no net loss to biodiversity. The onsite biodiversity program includes impact avoidance, minimization, and reclamation measures. Impact avoidance was achieved by creating a forest conservation zone that includes two tracts of distinctive azonal forests overlying the ore body. Impact minimization was attained through paced and directional forest clearing associated with taxa-specific salvaging and monitoring activities. For that effect, specific management programs for plants, lemurs, frogs, and fish were designed and implemented. In parallel, the multifaceted biodiversity offset program is being developed with the establishment of a large conservation zone with biodiversity components similar to the impacted site. Other offset components include buffer zone protection with joint Ambatovy-community management of forest corridor linkages, wetland protection, and re-vegetation activities. The mine closure plan is based on a progressive re-vegetation process, which will reestablish a multi-functional replacement forest with restored biodiversity values to be accounted for in the offset calculations.

Keywords: Madagascar, mining, biodiversity, impact, mitigation, offset

Résumé

Le projet minier nickel cobalt d'Ambatovy est proche de l'écotone situé entre les terres basses de l'Est et la forêt de montagne. Il s'agit d'une mosaïque de massifs forestiers quasi-primaires à perturbés. L'empreinte minière est imbriquée dans cette zone. Les principales composantes de la biodiversité de cette matrice forestière comprennent des forêts structurellement distinctes (azonal, transition, zonale) différenciées par le substrat, des ruisseaux, des marres saisonnières ainsi qu'une faune (214 espèces de vertébrés dont 13 espèces de lémuriens et cinq espèces de poissons endémiques au niveau régional) et une flore (1367 espèces) diversifiées. Les principaux impacts résiduels sur la biodiversité résultent du défrichement progressif des forêts. Etant donné ces sensibilités, le projet a élaboré un programme de gestion de la biodiversité comprenant un volet de compensation de la biodiversité avec des effets positifs de protection aboutissant à l'absence de perte nette de la biodiversité. Le programme de gestion de la biodiversité sur site comprend l'évitement des impacts ainsi que des mesures d'atténuations et de réhabilitation. L'évitement d'impact est acquis par la création d'une zone de conservation forestière incluant deux sous zones distinctes de forêt azonale empiétant le gisement. L'atténuation d'impact est effectuée grâce à un défrichement directionnel associé à des activités de sauvetage et de suivi d'espèces ciblées. A cet effet, des programmes de gestion de la flore, des lémuriens, des grenouilles et des poissons ont été conçus et mis en œuvre. Parallèlement à ceci, le programme de compensation de la biodiversité se développe avec la création d'un site d'une superficie importante contenant des composantes similaires de biodiversité comparables à celles du site impacté. Les autres volets du programme de compensation consistent à protéger la zone tampon avec une gestion privée par le projet lui-même, des transferts de gestions communautaires, ainsi que de rétablir

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des connectivités forestières, conserver des zones humides et mener des activités de reboisement. Le plan de fermeture progressif de la mine permettra de rétablir une forêt multifonctionnelle de remplacement avec une valeur restaurée en matière de biodiversité qui pourra être prise en compte dans les calculs de compensation de la biodiversité.

Mots clés : Madagascar, projet minier, biodiversité, impact, mitigation, mécanismes de compensation

Introduction

General context

The Ambatovy project is a nickel mining and refining project in Madagascar with a designed annual capacity of 60,000 tones of nickel and 5,600 tones of cobalt. The Ambatovy project is comprised of two companies Ambatovy Minerals SA and Dynatec Madagascar SA each owned in the same proportion by Sherritt Incorporated, Sumitomo Incorporated, Kores, and SNC Lavalin. The Malagasy Ministry for Environment granted the permit in December 2006. Construction began in early 2007 and production is due to begin by the end of 2010, reaching full capacity by 2013. The project's expected lifecycle is 27 years, although operation beyond this is likely.

Project components

The Ambatovy project has six components, including the mine, the slurry pipeline, the processing plant, the tailings management facility, the harbor extension, and resettlement sites (Figure 1). The project covers a large territory extending over two of Madagascar's 22 regions. The Ambatovy mine lies within the mid-altitude forests, at the ecotone between an eastern rain forest known as the Ankeniheny-Zahamena corridor and montane Central Highland forests. The forests of the mine area have undergone considerable human-induced pressures including hunting, selective logging, slash and burn agriculture, uncontrolled fires, and exploitation for commercial trade (see Goodman & Raselimanana, pp. 36-37, for definitions of the forest types occurring in the mine area).

The slurry pipeline, buried over the majority of its route, passes through 2 km of relatively intact forest surrounding the mine, crosses a Ramsar aquatic site (avoiding the wetlands by following an old railroad spur), and traverses the Ankeniheny-Zahamena forest corridor, avoiding residual forest fragments whenever possible to reduce residual impacts. The pipeline then continues to the coast through hilly terrain of the former eastern lowland forest that has been largely transformed into anthropogenic habitats by extensive slash and burn agriculture. The industrial complex, including the processing plant and the refinery, the tailings, and the harbor, is located within a human-modified coastal landscape in a suburban setting. The plant and harbor are within the industrial zones of the east coast city of Toamasina.

The proposed Ankerana biodiversity offset (definition of offset is provided below) site, which is equidistant between the mine and Toamasina, is a large, mountainous dome covered with largely intact forest, encroached only by slash and burn agriculture in surrounding valleys where frontier hamlets exist. The pristine character of the site is a result of its remoteness and the low density of surrounding human populations.

Biodiversity setting and existing threat level

Madagascar is a hyper-diverse and highly threatened region widely regarded as a top conservation priority for global biodiversity (Myers *et al*., 2000; Ganzhorn *et al*., 2001; Mittermeier *et al*., 2004). For instance, about 92% of all vascular plants (excluding ferns) known from Madagascar occur nowhere else in the world and, hence are endemic to the island (Goodman & Benstead, 2005). Lemurs are 100% endemic to Madagascar. The average annual deforestation rate in the eastern forest corridor is between 0.36 – 2.20% (Dufils, 2008). In total, between 1990 and 2005, Madagascar lost 6.2% of its forest cover, approximately 854,000 ha. The current annual loss of the residual eastern rain forest is equivalent to 14,000 ha per year (Conservation International, http://www.conservation.org/xp/CIWEB/regions/africa/madagascar.xml).

Biodiversity offsetting

The Ambatovy project has adhered to the Business and Biodiversity Offset Program (BBOP) and developed its program following its guidelines (www.forest-trends.org/biodiversityoffsetprogram/guidelines/). BBOP defined biodiversity offsets are measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken. The goal of biodiversity offsets is to achieve no net loss and preferably, a net gain of biodiversity on the ground with respect to species composition, habitat structure, ecosystem function, and peoples' use and cultural values associated with biodiversity. Also,

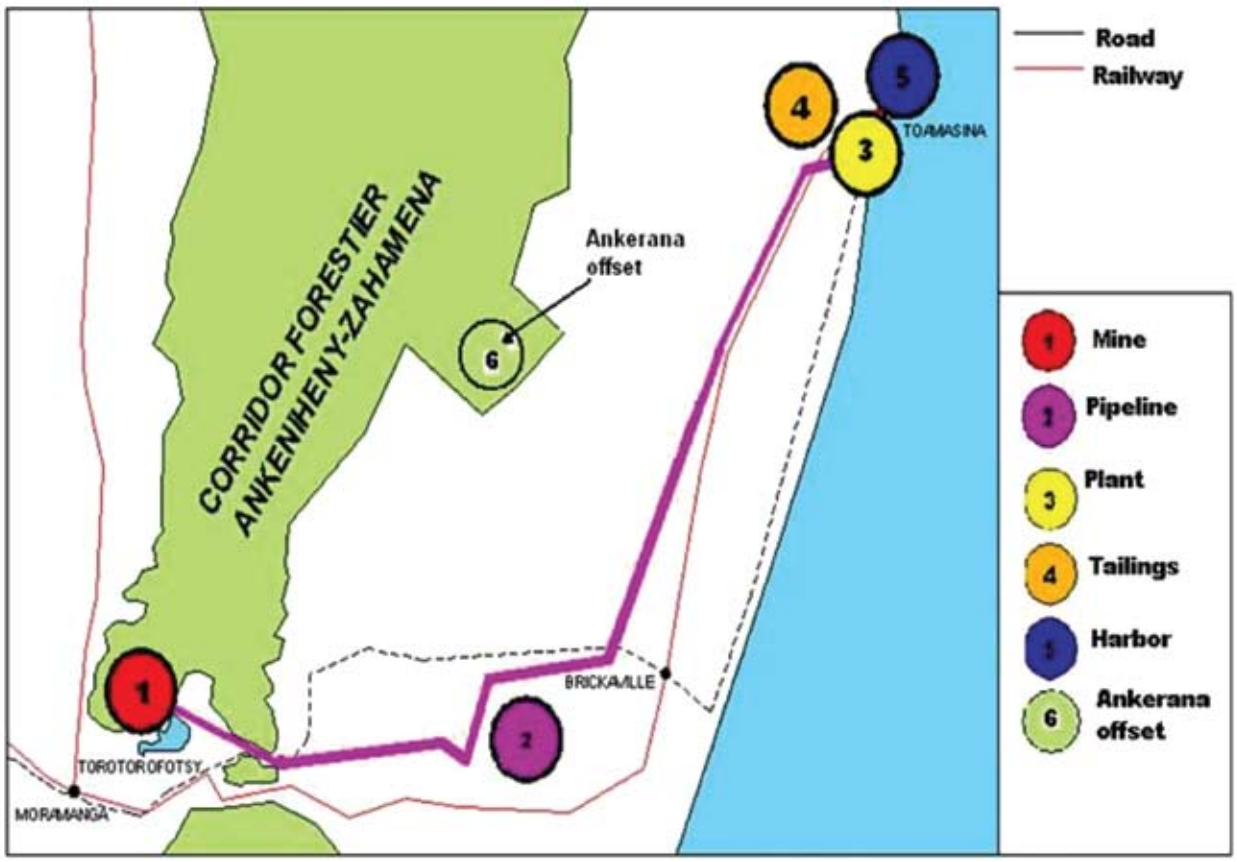

Figure 1. Ambatovy project location and components map.

BBOP guidelines state that a biodiversity offset should be designed and implemented to achieve *in situ*, measurable conservation outcomes that can reasonably be expected to result in no net loss and preferably a net gain of biodiversity (net gain meaning a gain in biodiversity conservation areas, for example).

Project impacts and setting priorities for biodiversity management

The environmental and social impact assessment (ESIA) for the Ambatovy project completed in 2006 included the assessment of impacts to flora, fauna, aquatic ecology, and overall biodiversity (Ambatovy Project, 2006). The ESIA was conducted as per World Bank and International Finance Corporation (IFC) standards. The project's principal impacts on natural systems and biodiversity will occur at the mine area, through the phased clearing of the mine footprint within an ecologically sensitive natural forest mosaic; the mine footprint is a large tract of land (1,336 ha) that includes all perimeters and structures used for the mine construction, commissioning, operation, and closure, which include retention and sedimentation ponds, mine pits, waste stock piles, low grade ore stock piles, camps, roads, pipelines, etc.).

The sensitivity of this mosaic arises from the considerable local heterogeneity in terms of geology, geomorphology, substrate, topography, and meso-climate. Approximately 90% of the pipeline's 218 km right-of-way will require the clearance of secondary, non-sensitive, and mostly non-ligneous vegetation, which has resulted from historical slash and burn and has comparatively little terrestrial biodiversity value. Disturbed land will ultimately be rehabilitated using species appropriate to current land use in the different pipeline sectors (including provision of fuel wood species to reduce pressure on native forests); local community consultation will help determining which species will be used. However, two sections of the pipeline cross sensitive habitats. The first corresponds to the first 2 km of zonal, largely undisturbed forest at the mine area; these losses are integrated in the mine footprint loss calculations. The second is the Ankeniheny-Zahamena forest corridor area, which led to the clearing of 16.5 ha of zonal forest, despite planning and routing efforts to avoid the residual native forest fragments present there.

The processing plant, currently under construction, covers 2.6 km^2 of Toamasina's industrial zone. The tailings management facility has a footprint of 14 km^2 and is located in a highly degraded, slash and burn

agricultural matrix, where human-induced depletion of the original natural habitats and associated biodiversity occurred during forest clearance over recent history. The harbor expansion requires the construction of an extended pier to accommodate the unloading of equipment during the construction and the importation of raw material, as well as the loading of nickel, cobalt, and ammonium sulphate (the later is a production by-product) once exploitation commences. The project's ESIA notes that the industrial complex will have negligible residual impacts on biodiversity, which will nonetheless be included in the project's offset program.

The level of residual impact was characterized after the application of mitigation actions, by combining the scoring of criteria for direction, magnitude, geographic extent, and duration as per standard environmental impact assessment practices. Residual impact was ranked as either: negligible, low, moderate or high. The assessment used the then draft International Finance Corporation (IFC) Performance Standard 6 (http://www.ifc.org/ifcext/sustainability.nsf/Content/PerformanceStandards) as a main reference against which to assess biodiversity impacts. Unavoidable high consequence impacts and possibly even moderate consequence impacts would need to be compensated through biodiversity offsets, in order to meet IFC guidelines for no net loss and preferably net gain of biodiversity from project activities.

A main concept that aided impact analyses for individual taxa and biodiversity overall was that of priority species. For the ESIA, Priority 1 species were potentially endemic to the project footprint. These species had the potential to go extinct if the project proceeded. The project therefore committed to conduct all necessary activities to understand the distribution of these organisms prior to construction, mainly through a program to search for them in proposed nearby on-site conservation areas, or if necessary further a field. In the case that they were not located away from the project's footprint area before construction, species-specific management programs would be required, to ensure viable populations remain secure at safe sites in the project area. Priority 2 species were potentially endemic to the "local study area", which included the project plus a buffer zone that would include on-site conservation areas and surrounding forest managed with help from the project. Priority 3 species are endemic to Madagascar but with a distribution greater than the exploitation zone. At the time of writing of the impact assessment in late 2005, the situation with Priority 1 and 2 species was as follows:

1) Flora: 29 Priority 1 species — 40 Priority 2 species - over 2000 specimens still undergoing identification (listed provided in Ambatovy Project, 2006);
2) Terrestrial fauna: 3 Priority 2 species — an ant (*Pilotrochus besmerus*), a frog (*Boophis* sp. nov.), and a snake (*Liophidium* sp. nov. 1.);
3) Fish: 2 Priority 2 species — (*Ratsirakia* sp. nov. and *Rheocles* sp. nov.).

A variety of mitigation actions were committed to, with associated monitoring, including species salvage and relocation. Taking all criteria into consideration, the environmental consequence of direct impacts from the project on natural habitats and biodiversity was predicted to be high during construction and operation, and moderate during project closure (as defined in the ESIA impact analyses). This finding was directly related to the linkage between the azonal habitats and the soil of the ore bodies that are to be mined. Compensation was thus required and stringent mitigations to ensure no species go extinct globally or locally (extirpation). The setting aside of on-site azonal conservation areas was considered an important mitigation commitment. However, given the high ecological consequence of impacts during construction and operation, the continued investigation of additional off-site conservation areas to serve as a biodiversity offset also remained a priority. The Ankerana site was provisionally identified as a biodiversity offset area. The overall commitments with respect to mitigation and offsets for the whole project were presented in the ESIA (Ambatovy Project, 2006). It was emphasized that these efforts were beyond all other on-site reclamation efforts proposed as part of the closure plans for each project component.

Developing a Biodiversity Management and Offset Program

Developing a project biodiversity vision and policy

Due to its setting and magnitude, the Ambatovy project elaborated a vision. The vision states that the project will develop and operate a sustainable mining and processing enterprise that significantly contributes to Madagascar, while delivering outstanding safety, environmental and social records, and generating attractive economic returns. The environmental strategy designed to honor the project's vision to deliver outstanding environmental records consists of:

1) Ensuring full regulatory compliance and conformity with international loan agreements;
2) Minimizing residual impacts through the stringent application of the mitigation hierarchy;
3) Reducing environmental risks through dynamic management guided by Malagasy know-how and stakeholder consultation; and
4) Producing positive conservation outcomes on biodiversity through the offset program that aims at achieving no net loss on biodiversity, and possibly net gain, in order to sustain 'a good citizen project' status in a host country recognized as constituting an internationally important biodiversity hotspot.

The Ambatovy project's actions with respect to biodiversity are guided by a project-specific biodiversity policy (Ambatovy Project, 2007). The vision of the policy is that responsible attention to the maintenance of biodiversity is in the best interest of the Ambatovy project, the human communities in which the project operates, and the world at large. The biodiversity policy sets the projects biodiversity end goals and the approach to achieve them, namely through the biodiversity management plan presented below.

Ambatovy Biodiversity Management Plan (BMP)

Five goals have been developed to support the project's biodiversity vision:

1) That there be no species loss in project areas;
2) That impacts to flora, fauna, and aquatic resources be minimized;
3) That the project realizes an actual net increase in the conservation of rare habitats, for example as the number of hectares of protected areas;
4) That the viability of priority habitats be assured by maintaining or increasing habitat connectivity; and
5) That project actions in support of biodiversity be linked to other regional biodiversity initiatives.

These project specific goals are expressed through a Biodiversity Management Plan; additional guidance on development of the program comes from a number of good practice guides (International Union for the Conservation of Nature, 2004; International Petroleum Industry Environmental Conservation Association, 2005; International Council for Mining and Metal, 2006; International Finance Corporation, 2006). The priorities for mitigation and monitoring are laid out in the plan, for each component, which includes listings of especially sensitive (priority) species. Broad priorities by project component (mine, pipeline etc) emerged based largely on the absolute amount of natural habitat that could not be avoided and would be directly impacted by the project, plus the rarity of those natural habitat types. High priority areas are as follows:

1) Mine site: flora and fauna of the azonal forest and azonal shrub habitats; aquatic resources from less disturbed streams and ephemeral ponds.
2) The Torotorofotsy Ramsar wetlands: although predicted to be minimally impacted by the mine, this area near the mine site is a BMP high priority site.
3) Slurry pipeline: flora and fauna of largely intact forest near the mine site and within the Ankeniheny-Zahamena forest corridor, including aquatic species at river crossings.
4) Plant site: no high priority BMP actions.
5) Tailings facility: marine biology, including coral reefs offshore from tailings leachate (liquids draining from the tailings) outfall to the Indian Ocean.
6) Port expansion: no high priority BMP actions.

Priorities for taxa, mainly at the species level, were initially set by considering the following criteria:

1) Endemism (local, regional, national), with a focus on local endemics;
2) IUCN status (IUCN, 2009), with a focus on "Endangered" (EN) and "Critically Endangered" (CR) species; and
3) Additional status comments from Malagasy biota specialists.

The BMP followed the mitigation hierarchy approach, by implementing appropriate avoidance, minimization and restoration measures to avoid species extinction and extirpation (EN and CR species), avoid sensitive areas where possible and minimize impacts on flora, fauna, and aquatic resources. The mitigation hierarchy was completed through the design of a multifaceted biodiversity offset program, following the Business and Biodiversity Offset Program (BBOP) guidelines.

Key Biodiversity Components

The BMP follows an adaptive management approach, allowing the integrating of lessons learned and new data collected during implementation. The plan was implemented in early 2007, before

infrastructure construction, based on biodiversity priorities identified during the ESIA. Considerable supplementary biodiversity data were collected during the early implementation phase. The key biodiversity components in the mine area and upper slurry pipeline portion can be summarized as:

1) Priority species, with home ranges overlapping (and or potentially overlapping) the mine footprint;
2) 13 confirmed lemur species, including *Prolemur simus* (IUCN CR), *Propithecus d. diadema* (IUCN EN), *Indri indri* (IUCN EN), *Eulemur rubriventer* (IUCN VU), *Daubentonia madagascariensis* (IUCN NT), *Hapalemur griseus* (VU), *Allocebus trichotis* (IUCN DD);
3) 62 bird species, including *Tyto soumagnei*, *Anas melleri,* and *Sarothrura watersi* (all IUCN EN);
4) 123 herpetofauna species, including *Mantella aurantiaca* (IUCN CR), *M. crocea* (IUCN EN), and *Sanzinia madagascariensis* (IUCN VU);
5) Five fish species, including *Rheocles alaotrensis* (IUCN VU) and at least two new species to science of the genera *Ratsirakia* and *Rheocles*;
6) 24 insect species, which are considered rare at the national level;
7) Approximately 1759 plant species, including 209 "Species of Concern", which are considered rare in Madagascar and 44 IUCN CR and EN species. (These figures are based on November 2009 data and the exact number of plant species remains to be confirmed by ongoing research of the Missouri Botanical Garden, see Phillipson *et al*., p. 44);
8) Three structurally distinct habitat types: zonal, transitional, and azonal forests (the latter including seasonal ponds and upper watershed stream systems) and their fauna and flora communities; and
9) The landscape-level habitat assemblage with the functional interaction between the zonal, transitional, and azonal forests.

Implementing the BMP

Specific avoidance strategies include the use of conservation barriers (e.g. 5 km physical barrier between the mine footprint and the azonal forest) to physically isolate the on-site azonal conservation areas from construction activities in surrounding areas and ensure that modification of the mine footprint follows a strict environmental protocol. The pipeline route was designed during the ESIA planning phase to ensure optimal avoidance of the forest fragments located between the mine area forest and the Mantadia National Park. This approach allowed reduction of forest clearing along the right-of-way to a minimal 16.5 ha of degraded forest (this excludes the first 2 km of forest that were cleared and accounted for in the mine forest losses). The pipeline route also avoided, when possible, wetland areas located in the Torotorofotsy Ramsar site.

A substantial impact minimization program was implemented through the BMP including activities such as:

1. Directional and paced forest clearance to optimize the natural dispersal of terrestrial fauna. Clearance procedures were provided to the forest clearing team manager as part of specific protocol. The proper implementation of the actions is monitored on a daily basis by the mine environmental team and any deviation reported for immediate action;
2. Biological surveys, supplementary to the baseline data, in the clearing perimeter and surrounding areas prior to any forest clearance in order to inventory fauna taxa present, particularly priority species (IUCN categories EN and CR) but also including lemurs, other mammals, birds, reptiles and amphibians not falling within these categories. The surveys facilitate the development of taxa-specific mitigation measures. For example, a considerable number of lemur species and individuals were captured and fitted with radio collars and subcutaneous microchips in order to monitor their dispersal patterns. The specific aim was to understand movements from a forested area as it was cleared and the impact-reaction of other lemur populations after the displacement of new individuals in their territory (see Mass *et al*., p. 192). For plants, a list of Species of Concern, which are defined by their level of endemicity, was drawn up during the ESIA baseline studies in collaboration with the project's botanical expert partner. Pre-clearance work involves identifying whether Species of Concern are present in the forest clearing perimeters and searching for these Species of Concern in conservation zones outside the mine footprint to avoid potential local species extinction. It is important to note that the Ambatovy project has launched in parallel to the taxa specific mitigation activities a forest conservation zone program, to secure the survival of the flora and fauna priority species in the forest adjacent to the mine footprint; details of this program are provided

in section hereafter ('Forest management and the BMP'). For fish in streams, a spatial and genetic survey (endemicity assessment) was conducted to determine whether the species present were endemic to the mine footprint. Until genetic results became available, fish from impacted streams were collected and temporarily maintained in aquaculture systems; subsequent management actions are currently being undertaken (for example identifying relocation and conservation streams and preparing the fish conservation and management program).

3. Monitoring of fauna during and after forest clearance. For example, the spatial dispersion of lemurs was monitored during forest clearance to assess their capacity to (i) disperse (avoid immediate impacts); (ii) settle in their new home range (a medium-term impact), and (iii) reproduce and maintain population viability (a long-term impact). The biomedical health of these wild animals was assessed in parallel to behavioral appraisals with the aim of improving analysis of trends in the project's long-term lemur population viability assessment program.
4. Salvaging activities focused on fauna likely to require human aid to migrate towards the forest conservation areas located adjacently to the mine footprint. A team of 80 technical agents was trained by experts to identify and salvage all small mammals, stranded lemurs, birds, and herpetofauna. Exhaustive salvage of these taxa was undertaken for all mine, pipeline, and plant site clearings, under the supervision of external experts (e.g. biologists from the Université d'Antananarivo) and the Ambatovy biodiversity team. Fauna species and the number of individuals rescued were recorded relocated to the refuge forests and then monitored. Rescuing of target flora species was also conducted. Some Species of Concern required *ex situ* conservation, with individuals translocated to an on-site nursery area, while searches for these species in areas outside the footprint were completed. Tissue samples from all of these Species of Concern were collected for cryogenic conservation and propagation; plant propagation involves the production of more plants by seeds, cuttings, grafting or other methods. To date, viable populations of most Species of Concern have been identified off the footprint area, and the project and its botanical partners remain confident that this will be the case for all remaining taxa. In the event that Species of Concern are not found outside of the exploitation area, then the flora mitigation actions aspect will be applied.

In addition to the generic BMP, four taxa specific conservation management plans were developed for priority species. Although these programs were developed as part of the BMP, their importance is reinforced by the aim of conserving species assemblages present in the mine area forest habitats, including the two azonal forest tracks nested within the conservation zone. The taxa specific plans were developed through lessons learned from the early clearing management phases, in line with the project's adaptive management approach. The vision of these programs is to ensure the absence of any species extinction and any measurable adverse impacts on the ability of the mine area forests to support the established fauna and flora Species of Concern and IUCN EN and CR populations. An outline of the different programs include:

1. Flora Management Program -- This program is managed by the project's full time botanist and several expert partners, including Missouri Botanical Garden; Centre National de Recherche en Environnement; Université d'Antananarivo Faculté des Sciences (départments de Biologie Animale, d'Ecologie, de Biologie et de Physiologie Végétale); Laboratoire des Symbioses Tropicales et Mediterrannéennes, and involves spatial surveys, taxonomic identification, and all phases of the mitigation activities (cells sampling, storing, propagation, and rescuing activities) for flora. The program's objectives are to:
   - Avoid the extinction of any Species of Concern and ensure their population viability in the conservation zones by the implementing a Species of Concern management program;
   - Avoid extirpation of any IUCN CR and EN taxa;
   - Reduce the loss of flora biodiversity present on the mine footprint through the implementation of flora mitigation measures; and
   - Ensure the protection and connectivity of the mine area forests as conservation zones for priority species through a forest management program for the mine area forests.
2. Lemur Management Program -- which includes the Lemur Population Viability Assessment Program. The lemur management program consists of several components including spatial

and health monitoring of lemurs found within the mine area forests (see Mass *et al*., p. 192). Two full time primatologists manage the program and there are several expert groups implicated that are actively involved in lemur research, such as Groupe d'Etudes et de Recherche sur les Primates de Madagascar (GERP), Henry Doorly Zoo's Madagascar Biodiversity Program (HDZ-MBP), and Madagascar National Parks (MNP, ex-ANGAP). The main objectives of the spatial monitoring program are to:

- Identify changes in population densities and abundances of species;
- Assess the ability of lemur species to move away from impact areas (the mine footprint) and to assess the viability of displaced populations in their refuge areas;
- Assess the cascade effect of displaced lemur populations on recipient lemur populations located in the refuge forests (i.e. the conservation zone);
- Detect any changes in lemur behavior, demography, and population viability due to mining activities post clearing within their refuge forest habitats;
- To compile the data collected via spatial monitoring in a lemur species population impact assessment matrix and lemur assemblage integrity index; and
- Ensure that any negative trends are detected at an early stage and that corrective mitigation actions are implemented.

3. *Mantella* Management Program -- The program is co-managed by the biodiversity team and Madagasikara Voakajy, a conservation and research organization that is running a regional *Mantella aurantiaca* program. The objectives are to:
   - Bridge significant information gaps (e.g. lack of distribution data and biological information) of *M. aurantiaca* and *M. crocea* populations present on the mine footprint and mine area, in terms of distribution, population dynamics, as well as the habitats they use;
   - Avoid extirpation of the populations present on the mine footprint through the implementation of mitigation measures; and
   - Ensure the viability of populations in the mine area forests throughout the project's life span, using control areas to determine any non-project related impacts.
4. Fish and Aquatics Management Program -- The program is co-managed by the biodiversity team, an aquatic ecology consultancy (TLC Services International Ltd), and the Université d'Antananarivo, Département de Biologie Animale. The program covers both the mine area and the slurry pipeline as aquatic biodiversity sensitivities remain within this component, despite heavy deforestation along the right-of-way. The program's objectives are the same as that for the flora mentioned above, and the objectives with regard to the slurry pipeline are to:
   - Assess pre-construction ecological conditions to set a benchmark to ensure priority species are conserved,
   - Monitor conditions during construction to implement further mitigation, and
   - Assess post-construction conditions to determine performance and determine the need for any rehabilitation.

Forest management and the BMP

In light of existing human threats (e.g. slash-and-burn agriculture, fire, etc) to forests, the project aims at designing and implementing multifunctional forest management programs that fulfill community needs as well as project biodiversity commitments in the mine area forest. These forests are part of the project offset program and include the forest around the mine and Ankerana; the objective is to ensure these forests are managed by Ambatovy in partnership with local communities to ensure long-term conservation.

In order to secure any long term landscape-level gene flow for the taxa groups, the project will also spearhead maintenance of forest connectivity between the mine area, the Ankeniheny-Zahamena forest corridor and Mantadia National Park) and the Torotorofotsy Ramsar site. A forest area is currently being delineated by the project in collaboration with Conservation International and will also be part of the project's biodiversity offset program. Both the forest conservation zone and the proposed forest connectivity area linking the mine conservation zones to the Ankeniheny-Zahamena forest corridor and Mantadia National Park are presented in Figure 2.

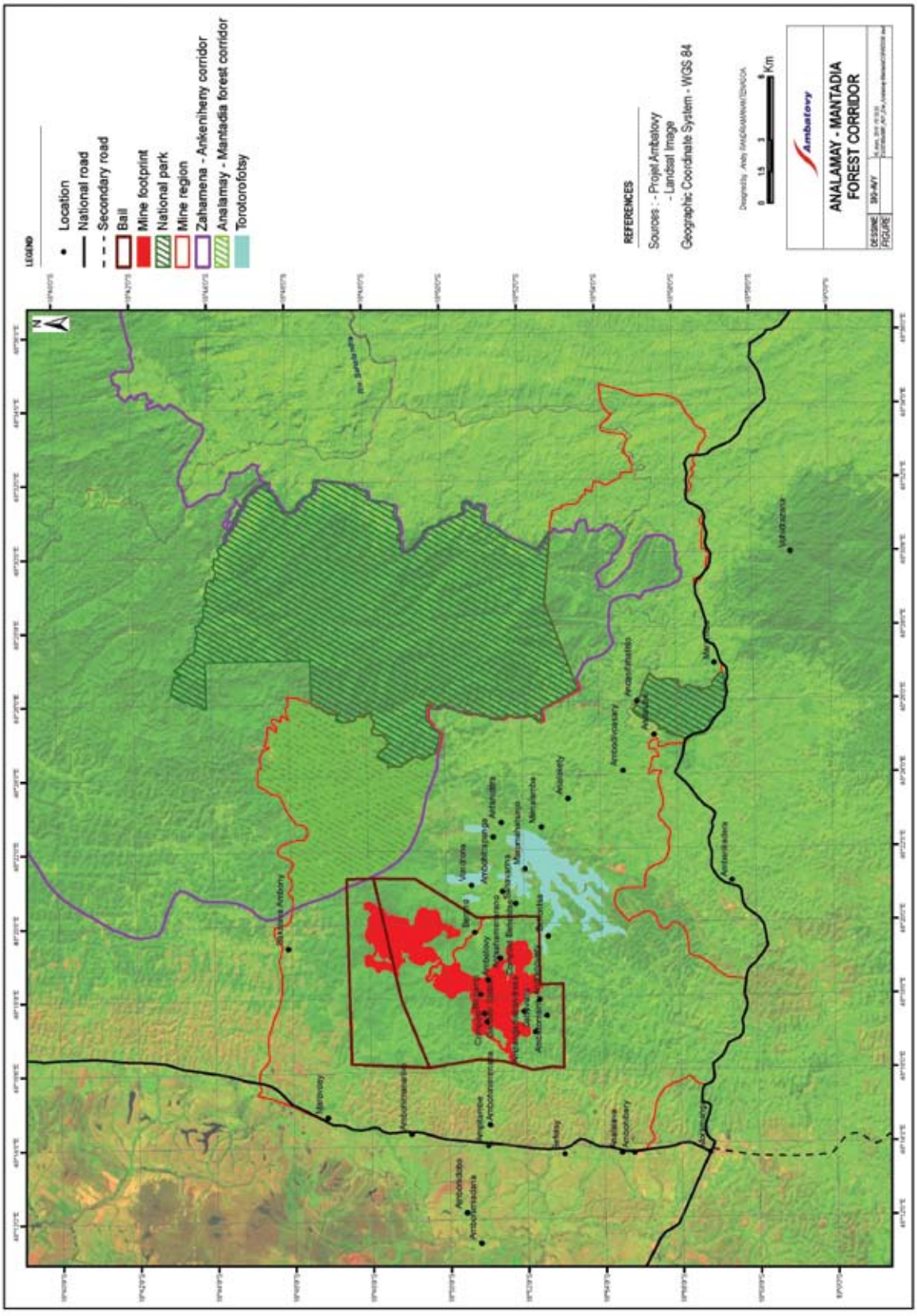

Figure 2. Ambatovy mine area forest conservation zones (49 km^2 green) and the proposed forest link (green hashed area) between the mine conservation zone, the Ankeniheny-Zahamena forest corridor, and Mantadia National Park. The mine footprint is shown in red.

Scientific Consultative Committee

The project developed a "Scientific Consultative Committee" associated with biodiversity aspects, specifically to give focused consultations on further development and implementation of the BMP. This committee provides independent scientific consultation to assist the Ambatovy project to develop its biodiversity management program, including strategic advice to consolidate its policies, and technical advice and feedback on the project's biodiversity management program. The committee is set up to be linked to the regional biodiversity initiatives (e.g. local partners such as MNP, the Université of Antananarivo and local taxa specialists) and also includes international specialists (ex-IFC members, international biologists, ecologists, and taxonomists). The committee meets twice per year.

Progressive restoration

The mine restoration program is based on progressive footprint rehabilitation. The pit from which the ore will be excavated, is scheduled to be opened successively during the mine's 30 year life span. Consequently, this means that the mine footprint will be cleared and rehabilitated progressively too. The progressive rehabilitation will be conducted through erosion control, reforestation with targeted species, and facilitated secondary successions. Several test plots have already been launched to determine the optimal floral species succession composition for the soil matrix after mining operations are completed; the objective is to obtain a set rehabilitation procedure for the mine site. It is important to note that the process will integrate specific ecological aspects such as the selection of the flora species that can favor species recolonization of the rehabilitated pit areas. For example, the Ambatovy biodiversity team and the lemur and botanical collaborators determined a list of preferred flood plants for lemurs. These plants will be integrated in to the rehabilitation program. Overall, the rehabilitation program's aim is to produce a replacement forest with biodiversity values that can be included in the offset gains by reducing the residual impact on biodiversity that will require offsetting; the multifunction forest aims to fulfill human community and conservation needs alike. The pipeline restoration program will focus on targeted reforestation of the right-of-way.

Linkage to regional biodiversity conservation initiatives

A number of specific mitigation activities involve linkage to regional conservation initiatives. These include:

1. Reforestation activities to the fragmented forests located along the slurry pipeline route in the Ankeniheny-Zahamena corridor. The objective is to participate to the eastern forest corridor reconnection initiatives presently underway. The project is conducted in collaboration with both governmental authorities (Direction des Eaux et Forêts) and a local conservation NGO, Man and the Environment (MATE). Ambatovy is currently in discussion with this NGO to determine the exact areas to be replanted, as the NGO will conduct the technical aspects, while Ambatovy will provide the funding.
2. Monitoring in, and support for, management of the Torotorofotsy Ramsar Site. Ambatovy is collaborating with both governmental authorities (Direction des Eaux et Forêts, Ministère de l'Environment) and local conservation NGOs (Taratra and Mitsinjo) to update the wetland management plan. The wetland is under severe threat from human activities such as draining, eucalyptus plantation, fires etc. The Ambatovy project financed the zoning of the wetlands (e.g. biodiversity surveys) to determine the remnant priority areas, which will be the focus of a new management plan.
3. Ankerana forest management programs. The Ambatovy project will be responsible for the management and protection as the site is part of its biodiversity offset program. The project will be developing site specific management plan and seek NGO partnerships to ensure on-site day-to-day management.

Ambatovy's biodiversity offset program

To meet its vision, the Ambatovy project developed an environmental strategy aiming to produce positive conservation outcomes on biodiversity through an offset program. The offset program aims at achieving no net loss on biodiversity, and preferably net gain. Net gains refer to the creation of additional conservation areas with important biodiversity in them. However, the project believes that certain areas located on the mine footprint with relatively low biodiversity values (e.g. Analamay deposit degraded areas) can be

rehabilitated to zonal type forests which can harbor, after the elapse of some time, greater biodiversity values than there at present. The business benefit is essentially linked to risk management and aims to sustain 'a good citizen project' status in a host country recognized to constitute a biodiversity hotspot but suffering from chronic poverty; details of the financial return to Madagascar are presented Ambatovy Project (2009a).

The Ambatovy project offsets program has several components. The program has been adopted voluntarily to go beyond the project's impact management strategy as required by its exploitation permit requirements and national legislation. The program includes:

The Ankerana offset: the off site covers 11,600 ha of seemingly intact forest, with similar abiotic and biotic conditions to those found at the mine site as showed the 2005 preliminary site surveys (Ambatovy Project, 2006) the project aims to ensure its long-term protection through legal arrangements, financing the site protection, and community consensus. The project's social and environmental teams are present at the site and implementing a community awareness program presenting the offset program and the associated required protection measures. Community buy-in is critical for the success of the site protection.

1. Two azonal forest sites: two on-site (mine) azonal forest conservation areas occur partially over the ore body footprint; the project aims to ensure the long-term protection of these two sites through legal and managerial commitments.
2. The mine area conservation forest: the conservation forest area around the mine footprint is 4,900 ha; the project aims to ensure its long-term conservation as part of the priority species management program and maintenance of the ecological services for the local human communities.
3. The Analamay-Mantadia forest corridor: the project is spearheading the establishment of a forest corridor between the mine area forests and the nearby Ankeniheny-Zahamena corridor; the forest corridor aims at long-term landscape level connectivity for the protection of the biodiversity living close to the mine area. This will be accomplished through partnerships with government, NGOs, and local communities.
4. The Torotorofotsy Ramsar wetland ecosystem: the project is supporting the site management plan design and implementation in conjunction with government and local NGOs; these efforts aim to ensure the permanency of legal and managerial commitments in partnership with government and a local NGO.
5. The pipeline right-of-way reforestation program: the program aims at enhancing forest connectivity in targeted areas of the Ankeniheny-Zahamena corridor through expanded reforestation activities along the slurry pipeline right of way in partnership with government and local NGOs.
6. The mine footprint replacement forest: the project aims to create a replacement, multifunctional forest using native species on the footprint during progressive reclamation with an established, integrated managerial structure by mine closure.

The offset program, prepared in January 2009, is presented in more detail in the BBOP Pilot Project Case Study (Ambatovy Project, 2009b).

Conclusion

The Ambatovy project recognizes that it is operating in an area of considerable sensitivity in terms of biodiversity in the region of the mine. The mine footprint is located within a forest tract, which is part of a former, probably continuous, forest expanse between coastal eastern areas and the central highlands. This forest tract is biologically diverse in terms of flora and fauna, and has been the object of extensive and on going biological inventories and research conducted by biologists working for the project and other consultants (see Goodman & Raselimanana, p. 35). Even though the local forests have been impacted by humans and largely fragmented, the project biodiversity program attempts to ensure that the remaining biodiversity components are conserved and possibly even rehabilitated. The Ambatovy project conducted its environmental impact assessment in compliance with national legislation and international regulations.

The project has developed a Biodiversity Management Program, in line with international guidelines, to mitigate impacts on the local biota. To address conservation issues for key taxa, specific action plans have been designed and implemented for plants, lemurs, *Mantella* frogs, and fish species. It is evident that successful species management in the mine area is linked to habitat conservation, which is addressed through the project's biodiversity offset program following the Business and Biodiversity Offset Program guidelines. The offset program compensates the unavoidable residual impacts on biodiversity and forms an integral part of its license to operate. The offset program aims at producing

measurable conservation outcomes that deliver no net loss of biodiversity or preferably a net gain.

The biodiversity program has ensured that the Ambatovy project successfully meets its vision and biodiversity policy, including the sensitive construction phase. The biodiversity management program's adaptive approach ensure results will be continually assessed during the project's life span and allow for continuous improvement. It is hoped that the efforts deployed by the Ambatovy project for biodiversity conservation will contribute, despite the many challenges still lying ahead, to the global biodiversity management knowledge base and serve as a benchmark for future developments in Madagascar and throughout other biodiversity sensitive locations globally.

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