

# Progressive reclamation in a tropical rainforest – French Guiana

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## Abstract

*Reclaiming impacted mining areas in a rainforest is a challenging endeavour. There are two commonly held and conflicting beliefs around this subject: the first is that reclamation in tropical zones is not necessary as disturbed areas quickly revegetate on their own. The second commonly held idea is that disturbed jungle sites cannot be properly rehabilitated, due to poor soil conditions. The case presented in the paper refutes both of these ideas and illustrates how with little money and the right species, successful reclamation is possible, even in the most challenging conditions.*

*There are few examples of reclamation projects in French Guiana, let alone successful ones. Facing the need to establish a reclamation strategy for its proposed project Camp Caïman in French Guiana, IAMGOLD Corporation created its own pilot project to establish the baseline information for its reclamation approach. The company chose an exploration site where mining operations had ceased 15 years prior. Similar to other sites, top soil have been removed and/or eroded and little natural succession of the surrounding rainforest had occurred.*

*Undertaken between 2008 and 2009, the project was designed to document the rehabilitation progress from start to finish. The first step for successful reclamation is to regenerate microbiological activity in the soil by planting pioneer, nitrogen-fixing species. These grow quickly and provide shade and debris that favour local species. The operation's success depends on the diversity of species that could be planted and would survive, ultimately allowing a gradual recolonisation by animals. The key to success was finding the right mix of pioneer species that were both nitrogen fixing and non-invasive.*

*More than two years after the plantation was established, success was confirmed by strong plant growth. The site enables thriving plantation of 5 ha, with the use of cuttings from pioneer species, seeds and plants from the IAMGOLD tree nursery, and, without addition of top soil. With a ratio of 2,000 plants and 100 different species per hectare, the project became an example of best practice for encouraging biodiversity in former mining sites and has been visited by many stakeholders in French Guiana.*

## 1 Introduction

French Guiana is a French department (86,000 km<sup>2</sup>) located in the northern part of South America between Brazil and Suriname. The vegetation of the department is typically tropical rainforest, covering approximately 95% of the territory.

The majority of existing mining activities are illegal small scale/artisanal mining sites, particularly gold mining. Activities have increased dramatically over the past 15 years, with an exponential increase in the past five years, as gold prices have risen. The net environmental result of this small scale mining activity includes substantial deforestation, land disturbance, and siltation of water courses. There is very little formal mining in French Guiana.

In the shadow of this illegal activity, IAMGOLD has a gold project that attempts to balance the economic benefits for the area and protect the biodiversity of the region. With few examples of responsible, regulated mining activities, fears of biodiversity loss and environmental impacts have surrounded modern mining. Similarly, there are little to no rehabilitation successes to illustrate how well-managed sites can restore disturbed areas.

It is within this context that IAMGOLD established that pilot project, in order to evolve its environmental management practises and to define the best protocol for the future reclamation of industrial mining activities. IAMGOLD's continuing commitment to environmental management and its strong vision of ZERO HARM in Health, Safety and Sustainability (HSS), sets out requirements for reclamation, but there

were relatively few examples of reclaimed mine sites in French Guiana to draw on, for example, research was needed to determine what the strategy should be. Consequently, the company chose an exploration site where mining operations had ceased 15 years prior and where little natural succession of the surrounding rainforest had occurred.

The project was undertaken in between 2008 and 2009, with the objectives of:

- Developing management practices for progressive reclamation in an environment with extensive biodiversity.
- Recreating conditions that promote biodiversity approximate to the tropical rainforest surroundings.

The project was developed in collaboration with Dr Denis Loubry of the Phytotrop Company; a Ph.D. in tropical vegetation biology and a reclamation specialist in the Guiana Shield rainforest.

## 2 Methodology

### 2.1 Site

The site chosen for this project was located on an IAMGOLD exploration permit where mining operations had existed 15 years ago. The five hectare site was considered representative of the potential future IAMGOLD site, in terms of topography and vegetation.

The site consisted of a small pit (200 x100 m, 100m depth) and a small quantity of waste rock lying on the side of a hill. Like many other mining operations, top soil had been removed from the site and there had been no previous reclamation efforts – the natural succession was the process for revegetating. Although the site is completely surrounded by forest, even after 15 years of ceased mining activities, only limited weedy species colonised it.

### 2.2 Baseline information on site

In order to document the project, a baseline survey was undertaken to identify the characteristics of the site (topographical, geological and pededological data) and establish an inventory of the present species in natural regeneration.

- Topography: Located on the flanks of a little mountain between 178 and 165 masl.
- Geological data: Mottled zone, upper part with saprolite.
- Pedological data: Little to no soil, ground cover was almost entirely just rock. Bedrocks, with compacted saprolite composes two-thirds of the site, with the last third being made up of aggregates from crushed quartz. These bedrocks form areas rich in claymineral and soft rock, particularly crumbly.

Bedrock's analysis samples were undertaken in order to determine the ground fertiliser's potential before reclamation. One sample was top soil from the forest to compare with the impacted soil.

**Table 1** Composition of bedrocks versus top soil

	pH	N (g/kg MS)	P (mg/kg MS)	K (mg/kg MS)
Top soil		2,8	520	336
Sample no. 1	5.2	<0.25	60	<100
Sample no. 2	4.8	<0.25	<50	<100
Sample no. 3	5.1	<0.25	62	129
Sample no. 4	5.2	<0.25	<50	189.9

## 2.3 Vegetation

Even after 15 years, there was little vegetation and that which did exist was a collection of weedy species with very low biodiversity. The constituent vegetation of this former industrial site was dominated by low herbaceous forms and some sparse arborescent forms: *Lycopodiella cernua* and *Gleichenia pectinata* for the herbaceous forms. Some Rubiaceae and Mimosaceae largely filled the areas. The few trees present (*Cecropia obtuse*) showed a weak development more than ten years after.

The original forest surrounding the site is an extensive, biodiversity-rich rainforest with a typical average of 150 trees species /ha. The total tree species identified in French Guiana reaches 1,100 species.

## 2.4 Protocols

Reclaiming impacted mining areas in a rainforest is a difficult challenge because the forest rarely re-establishes itself on barren soils without human intervention. The baseline survey demonstrates the typically poor vegetation observed on abandoned sites.

The purpose of reclamation is to restore forest composition within a short time frame and close to the conditions of the original forest. The goal was to establish 150 species of trees per hectare.

The project unfolded over 2 years:

- Year 1: Beginning in April 2008, the first steps were excavation and land levelling, followed by unpacking of the ground and planting. The goal of year 1 was to define the best procedure for reclamation on an experimental area of 1 ha, two different species protocols being tested (see protocol description below).
- Year 2: Based on the results from the two trial protocols, year 2 was about optimising the process (technical and financial) on the 4 ha project site. This would take place during the second year of the project.

The first step for successful reclamation is to regenerate microbiological activity in soil by planting pioneer, nitrogen-fixing species. The pioneer species would grow quickly and in difficult conditions (rocky and soil-less). These species were also intended to provide shade and debris, which then favour local species. The operation's success would depend on the diversity of species that could be planted (and survive), which would allow gradual recolonisation by animals, the scattering of seeds and the eventual recreation of an environment ecologically similar to original conditions.

Two protocols were thus retained on surfaces and soil conditions equivalent during the first year:

- Protocol n°1: Cuttings (pioneer species) + seeds (pioneer species) + forest species (from the nursery tree):
  - Planting of cuttings on lines: 13 different pioneer species especially *Clitoria fairchildiana* as high nitrogen fixing species.
  - Plantings of seeds in line space: 9 different pioneer species.
  - Planting forest tree species from the nursery on lines: 54 different species.
- Protocol n°2: Cuttings + seeds (all pioneer species) – around 20 species with 2 high nitrogen fixing species: for the cuttings (*Clitoria fairchildiana*) and for seeds (*Acacia mangium*):
  - Planting of cuttings in lines.
  - Planting of seeds in line space.

Under this protocol, the *Acacia mangium* was chosen as a very fast growing tree and high nitrogen fixing species. Its purpose was to two-fold; to provide the necessary shade for the more fragile forest species; to rapidly kick-start the mulching process that would replace the necessary soil for forest tree species. The challenge is finding the right combination of pioneer species that are nitrogen fixing and non-invasive.

## 2.5 IAMGOLD nursery

The source of the cuttings the seeds and the forest plants, was from the IAMGOLD nursery, located on the Camp Cayman mining concession, a 30 km<sup>2</sup> area covered by a tropical rainforest.

The forest plants from the nursery are the result of months of work, collecting seeds and young plants on the territory within IAMGOLD's Camp Cayman concession. The nursery was not built for reclamation, but for the specific purpose of this pilot project.

More than 75 identified forest species are available in the nursery and in addition, around 30 species are under identification process. In 2008, the nursery had a total of nearly 6,000 plants units. The recognition of species for the nursery was conducted with Dr Denis Loubry, a reclamation specialist in the Guiana Shield rainforest. Dr Loubry also played an important role in helping to select the species for the protocols described above.

## 3 Data

A first inventory was taken in July 2008, a short time after the initial planting to determine the quantity of surviving cuttings and trees, as well as the number of species: line by line, identification of each tree or cuttings. The basic inventory results for the initial 1 ha are as follows:

**Table 2 Inventory results – number of living cuttings and trees, July 2008**

	Cuttings	Tree	Total
Protocol 1	395	544	939
Protocol 2	335	101	436
Total	730	654	1,375

The total quantity of remaining cuttings and growing trees after 2 month was 1,375 units on 10,000 m<sup>2</sup>.

## 4 Results

Quantitative and qualitative growth of plants and trees were monitored to assess project success. A second inventory was undertaken in 2009.

**Table 3 Inventory results 2008/2009**

	Cuttings + Trees 2008	Cuttings + Trees 2009	Recovery Rate
Protocol 1	939	650	69%
Protocol 2	436	183	42%

The results, particularly for Protocol n°1, were very encouraging. By getting the right mix of species, re-vegetation could be seen at a very rapid rate, despite the barren soil conditions and lack of growth over previous 15 years at that site.

At the conclusion of Year 1, based on the recovery rate data for each protocol, IAMGOLD decided to define Protocol n°1 as the optimum reclamation protocol for any future reclamation works, which consists of:

- Planting of pioneer species in cuttings on spaced lines (*Clitoria fairchildiana*, *Ficus* spp) + seeds.
- In line space, planting of “forest plants” from the IAMGOLD nursery tree, (target 50 to 70 different species).

For the second year of the project, the goal was to focus on the optimisation of Protocol n°1 and expansion of the reclamation area by four hectares to a total of five. In total, 4000 trees were planted (a ratio of 1,000 plants per hectare) comprising of 66% pioneering species (specifically *Clitoria*, in the form of bare roots, in peat pots and small stemmed plants) and 33% stock from the IAMGOLD nursery tree.

The project included a full photo documentation of the site from start, through planting and growing. The photo record was in the form of a 360 degree view – photos taken from exact spots are stacked so the viewer can see each view (before, planting, growing) and has control of viewing the entire site from a number of view/vantage points.

#### **4.1 Cost**

The cost of such a programme can be broken down into two principle dimensions; labour and trees. As the IAMGOLD nursery was not built specifically for this project, the costs of nursery and harvesting of species from around the concession was not calculated for this project. Generally speaking however, the cost of the plants was minimal in comparison to the cost of labour.

The total labour cost for this project was 2,350 €/ ha for an estimate total of 11,750€. Considering the varying labour costs, even in neighbouring countries, it is more relevant to provide the projects' man hours (days), which are as follows:

- Year 1 = 33 man days/ha.
- Year 2 = 16 man days/ha.

### **5 Conclusion**

Upon commencement of the project, the site was representative of many mining legacy sites in tropical areas; barren soil, lack of assisted re-vegetation efforts and a zone that subsequently void of biodiversity.

The work conducted over a two year period demonstrates a need for human intervention in order to rehabilitate a disturbance. It highlights that, while reclamation in such an environment is challenging, it is also possible.

The challenge for this project and many others like it, is finding the right combination of species – pioneer species which can establish themselves in the ecologically harsh condition, which is non-invasive and which is also nitrogen-fixing, as to set the stage for subsequent species to flourish.

More than two years after the plantation was established, project success was confirmed by strong plant growth, as evidence with more than 100 different species per hectare. The project has been visited by many stakeholders in French Guiana and is an example of best practices to encourage biodiversity development at former mining sites. As part of IAMGOLD's commitment to corporate social responsibility around its proposed project in French Guiana, the protocol established in the pilot study will also be used to reclaim illegal mining sites in partnership with local contractors.

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