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Challenges and Achievements in Mine Revegetation in New Caledonia

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Summary

New Caledonia, a French territory in the South Pacific, harbors exceptional biodiversity resulting from its geological history and isolation. The presence of ultramafic rocks gave rise to unique soils with high metal toxicity and limited organic matter. While nickel ore mining has enabled economic development, it has also led to significant vegetation and soil degradation, disrupting ecosystems and seriously impacting biodiversity.

Mine revegetation efforts aim to restore damaged areas and preserve biodiversity. The use of local and endemic pioneer species has given promising results, as they adapt well to the challenging conditions of the mining sites. These species require minimal maintenance, integrate well with the environment, reproduce effectively, and contribute to vegetation dynamics.

Revegetation techniques, such as hydroseeding and planting, have been employed on mine sites. Hydroseeding, with endemic or native shrub mixtures, offers cost-effective solutions, while planting provides immediate vegetation presence. Companies like SIRAS Pacifique have pioneered rehabilitation projects, combining ecological restoration and civil engineering works. Additionally, steps have been taken to preserve ecosystems, through seed orchards, and to conserve rare and threatened species, through propagation trials.

Despite progress, further research and collaboration between government, industry, and research institutions are needed to safeguard endangered species and enhance understanding. New Caledonia should therefore successfully balance economic development with the preservation of its remarkable natural heritage.

INTRODUCTION

New-Caledonia is a French territory located in the South Pacific, about 1 500 km from the Australian East coast. When this archipelago separated from Gondwana, about 80 million years ago, it underwent complex subduction-obduction episodes which resulted in the installation of an ultramafic rock layer, on the New Caledonian basement. Once the land re-emerged, erosion reduced the extent of the ultramafic layer, to about 1/3 of the main island's area.

The ultramafic rocks evolved into two particular soils called ferralic and hypermagesian. These are characterized by a high metallic toxicity (due to high concentrations in Nickel, Chromium, Iron, Manganese and Cobalt), a low organic matter content and a low water retention capacity. All these unfavourable conditions, together with the geographical isolation of the island have resulted in the evolution of uniquely adapted flora and fauna and have led to the development of an extraordinary biodiversity, on this rather small territory. As a consequence, New-Caledonia hosts an extraordinary biodiversity, with many endemic and sometimes archaic species (such as *Amborella trichopoda* – the most primitive angiosperm). Within the plant kingdom, 3 300 vascular plant species have been identified in New Caledonia, 76% of which are endemic.

But on the other hand, because of their nickel ore content, the ultramafic soils have made of the island one of the largest reserves of this valuable metal in the world. The country is therefore faced with the paradoxical challenge of having to manage both:

- preservation of its natural heritage, recognized as one of the most original and precious on the planet.
- economic development based on considerable mining resources.

Mine Revegetation in New-Caledonia and Its Challenges

Mine revegetation is one way of participating in preservation of biodiversity. Unfortunately, many difficulties are encountered.

Open-pit nickel exploitation began in 1873 and represents a very important part in the New Caledonian economy. Up until 1975, extraction was carried out with no environmental precaution and mine waste was spilled down the mountain slopes, leaving many scars in the vegetation. Since the mid 70's, techniques have fortunatly evolved in a positive way, for instance:

- topsoil is reused,
- wastes are transported and stored in dedicated discharges.

Nevertheless, nearly 150 years of mining activities have led to significant destruction of vegetation and soils, disturbance of ecosystems and a loss of biodiversity.

Moreover, the areas left by the mining activity have very different characteristics compared to the original soils on which the vegetation developed:

- their surface is hard and compacted,
- they present severe nutrients shortages,
- high levels in phytotoxic elements,
- no microflora,
- steep slopes,
- extreme rainfall and wind conditions.

Enabling vegetation to resettle in such conditions is therefore particularly difficult.

The first trials aiming to revegetate mining sites were carried out in the early 1970's using exotic and a few native species. The poor results led the researchers to experiment on a mix of local and endemic pioneer species. This work resulted (in 1992) in the establishment of a list of 67 species which can be used in mine revegetation projects. These well adapted species show all the necessary characteristics enabling succes:

- no maintenace is required once they have been planted,
- they perfectly integrate in the environment,
- they are able to reproduce, and colonise the surroundings,
- by growing they create shade, mulch, organic matter and enhance vegetation dynamics.

In the long term, all these steps allow preservation of biodiversity.

They nevertheless present one disadvantage: their growth is extremely slow and results become tangible and visible only many years after revegetation action has been carried out.

Some examples of revegetation projects in New-Caledonia

SIRAS Pacifique is a company specialized in rehabilitation of degraded sites and has been working in this fied for 30 years. With the years, the company developed different skills and revegetation techniques by adding civil engineering works in ecological restoration projects (such as gabions or wooden walls), ecological engineering, outdoor landscaping and erosion control works. It is today recognized as being a major actor of environmental restoration.

The two main techniques used on many ancient or active mine sites are hydroseeding and planting.

Hydroseeding is generally preferred because it is the most cost-effective revegetation method. It also allows to treat steep and limited access surfaces (figure 3). In our operations we only use endemic or native maquis shrub mixtures. All the species are pioneers of the maquis shrub, 70 to 80% of them being Cyperaceae. **Figure 1** gives examples of the results obtained several years after hydroseeding works on 2 mine sites, *i.e.* Opoué mine, (Eramet Group) and the ancient Brisson mine. It shows how the vegetation evolved in a few years and how efficient the technique can be, even on poor lateritic soils.

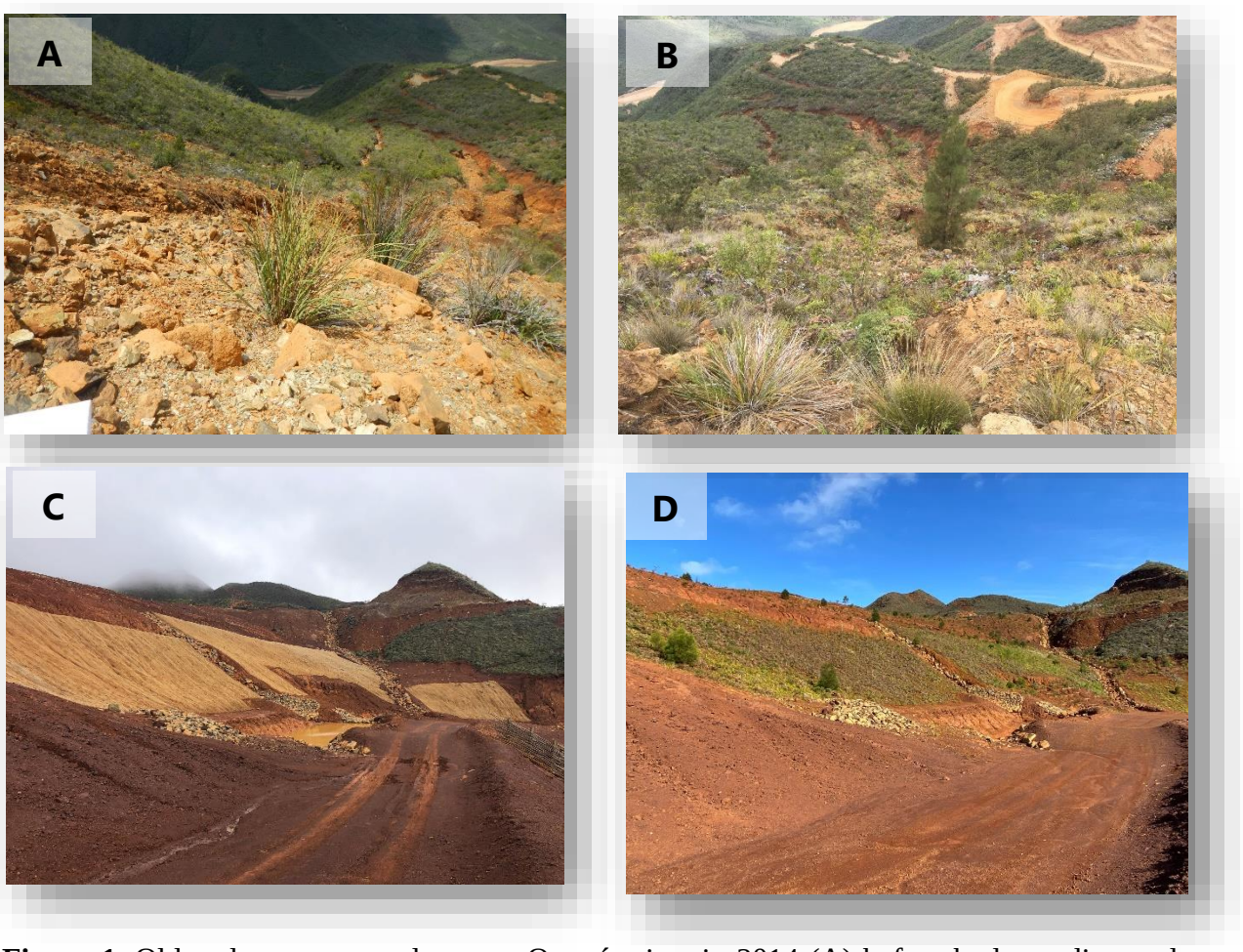

Figure 1. Old and steep waste dump on Opoué mine, in 2014 (A) before hydroseeding and 2018 (B) showing vegetation now completely covers and heals the opening that had been created by the spills. Remodeled areas, covered with jute nets (in order to control erosion and optimise seed germination), in 2019 before hydrodeesing (C) and in 2021.

Sometimes hydroseeding is not the best technique as vegetation installation can be very long (between 18 to 24 months), especially in the Northern part of New Caledonia, where the climate is much drier.

Planting is therefore recommended in some situations because plants are instantly present. At least 20 different species are generally used, all of them being endemic or native. For instance, on the same ancient Brisson mine, almost 19.000 plants were reintroduced together with reinforcement techniques, such as fascines or windbreakers (**Fig. 2**).

Extra skills and activities

In order to ensure the reliability and efficiency of the company, all the plant material supplies are integrated within SIRAS Pacifique. The Seed Management sector organises the whole pathway from collection of endemic species' seeds (in the natural environment) all the way through to their use (in hydroseeding works or in the nurseries). In the early 2010's, it became obvious that mine revegetation demands would increase drastically and that seed sampling in the natural environment would eventually have a depleting effect the resource.

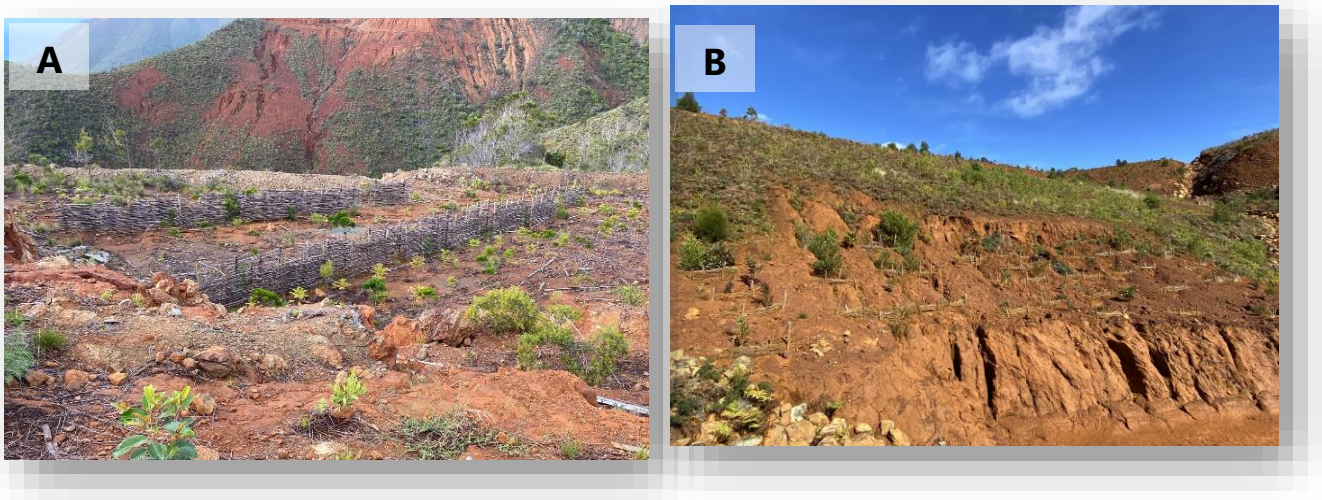

Figure 2. (A) Planting behind wooden windbreakers on sites where strong prevailing winds occur - (B) Planting behind fascines (or dead wood bundles), a technique used on slopes to reduce erosion.

The need to set up seed orchards thus appeared evident, especially for Cyperaceae. With the help of mining operators, several orchards have been implemented in different locations (**Fig. 3**).

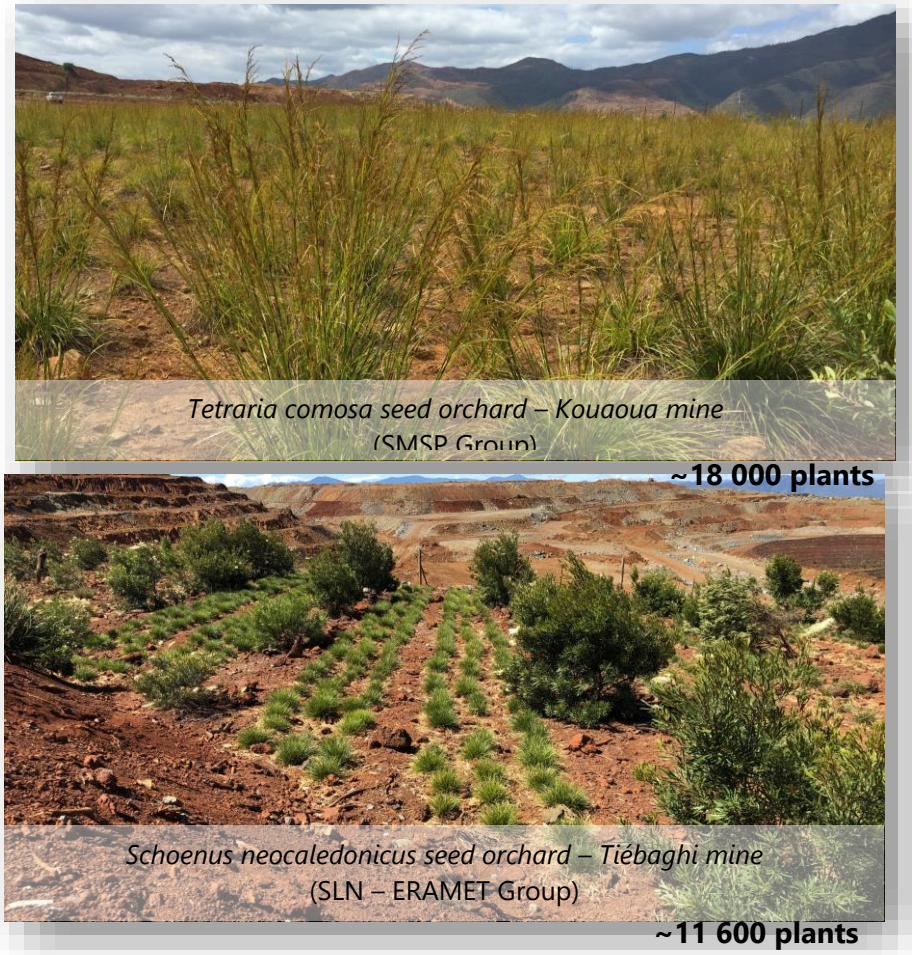

Figure 3. Two of the seed orchards created on mining sites : Kouaoua mine (SMSP group) and Tiébaghi mine (SLN-ERAMET Group).

Endemic plant supply is guaranteed by the Nurseries, which have been set up in three different locations. Altogether, the production capacity is of 350 000 plants and propagation is mastered for about 250 different endemic or native species. 60% of these belong to the maquis shrub, 30% come from the Caledonian dry forest or from the shoreline. The last 10% either grow in the rain forests or are endangered species.

Rare and Threatened Species Propagation

Because of mine exploitation, many rare endemic species are severely threatened in New-Caledonia. The mining operators have the legal obligation to protect them, when they are on their concessions. SIRAS Pacifique is thus sought to help with the protection procedures, to carry out propagation trials and reintroduction operations.

Since 2007, we have been propagating and re-introducing *Araucaria rulei* within a degraded population on Thio mine for SLN-ERAMET Group. 14 000 plants have been re-introduced. More recently, similar programs have allowed us to reintroduce two other Araucariacea species for Ballande Group, on Cap-Bocage and Kaala mines. Propagation of these species is now well mastrered.

Between 2014-2018**,** trials were carried out, for SMSP Group, to develop propagation methods for 18 threatened species, including several orchids, on Pinpin mine. We obtained varying results, depending on the species.

Since 2020, we have been missioned by SMGM company to propagate 26 species which are present on Vulcain mine. Amonst these 26 species, some are quite challenging. For instance:

- As with many Ericaceae, we are confronted with dormancy issues for *Styphelia enervia* and we have not succeeded in producing cuttings.
- *Polyscias scopoliae* is another demanding species, which also has dormant seeds. Although we have some encouraging results with head cuttings, we are here confronted with the limited availibility of plant material.
- An other tough example is *Homalium betulifolium*, because fructification is quite sporadic and our cutting trials have not been very successfull, up until now.

Fortunately, we have some achievements (**Fig. 4**), for instance with:

- *Arillastrum gummiferum* : when we are lucky enough to collect seeds and sow them immediately, the germination rate is satisfactory. Propagation by seedlings transfer has also revealed efficient.
- Our *Dendrophyllanthus conjugatus* var. *conjugatus* assays have also given satifactory results with 74% of cuttings being viable and 85% of seedlings transfered to the nursery surviving.
- *Lepidocupania tontoutensis'* results are slightly below, with cuttings viability of 30% and seedlings transfer giving 80% survival.

Overall, whatever the endangered species considered, the main difficulties are:

- the lack of plant material,
- a lack of knowledge,
- the lack of access to horticultural equipment (especially hormones),
- the lack of information and experiences exchanges with other experts.

Arillastrum gummiferum
(Myrtaceae)

Germination rate = 30 to 80%
Seedlings transfer = 90% survival

Dendrophyllanthus conjugatus
var. conjugatus
(Phyllanthaceae)

Cuttings viability = 74%
Seedlings transfer = 85% survival

Figure 4. Some of the propagation trials on endangered species (*Arillastrum gummiferum*, and *Dendrophyllanthus conjugatus var. conjugatus*) showing encouraging results.

Conclusion

Despite the difficult contexts and thanks to a collaborative approach between government, industry, and research institutions, the revegetation operations conducted in New Caledonia are now giving rather satisfactory results. This approach has resulted in the restoration of degraded areas and the reestablishment of native flora.

However, there is still a long way to go in terms of safeguarding endangered species. Foremost, knowledge about their botanical and ecological characteristics, their geographical localization and of their culture routes must still be improved.