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# Mining sites: Landscape degradation or Opportunity for Biodiversity?

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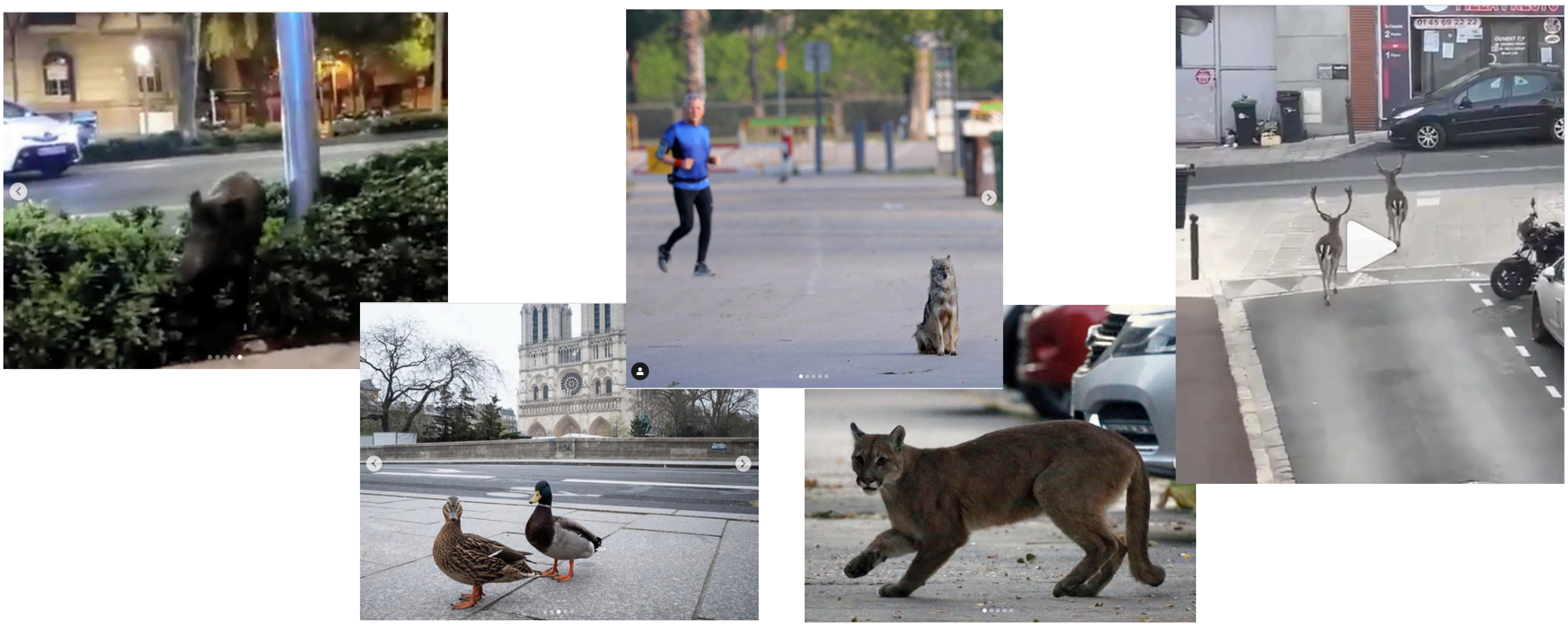
# Nature taking over when humans are absent

These days, we keep seeing pictures of animals strolling around empty cities, while humans are in lock down.



Boar in Barcelona, ducks in front of Parisian Notre-Dame cathedral, jackal in Tel Aviv, puma in Santiago, deer in Parisian suburb.

Image source: Paris March magazine on instagram @parismatch_magazine

# In mining sites too

We observed this phenomenon in a preliminary study in 2010, where we interviewed 42 quarry managers of 46 quarries and sand and gravel pits, in North Eastern France. Interviewees reported presence of many animal and plant species on site. Birds, tods, rabbits, foxes would often be present on site when they arrive to work in the morning. Fish would inhabit water bodies rapidly  after their creation. Spontaneous vegetation would be very rapid on bare soil.

It made us think that mining sites might be a neglected opportunity for biodiversity.

# What is biodiversity ?

Biodiversity is the variety of life on Earth, it includes all organisms, species, and populations; the genetic variation among these; and their complex assemblages of communities and ecosystems.

Species are becoming extinct at the fastest rate known in geological history, and most of these extinctions are tied to human activity. Some conservation organizations estimate species are heading towards extinction at a rate of about one every 20 minutes.

Biodiversity conservation provides substantial benefits to meet immediate human needs, such as clean, consistent water flows, protection from floods and storms and a stable climate.

The loss of biodiversity is dangerous and its consequences are immediate:

- Fewer opportunities for livelihoods, for better health, education, and a better life
- Fewer fish in the sea, means less food for our survival
- A lack of clean water
- A lack of forest resources such as food, or plants for medicine
- In the long term, it also means less income for communities, which are often already amongst the poorest on Earth

Source : UNEP - UN Environment Programme, 2010 https://www.unesco.pl/fileadmin/user_upload/pdf/BIODIVERSITY_FACTSHEET.pdf

# What about mines ?

Mining sites, active or closed, represent almost 1 percent of Earths' surface. Mine safety imposes physical protection and isolation of mines by high fences ; human activity, other than extraction, is most often legally restricted in mines and extraction is mostly taking place in one relatively small part of the mine. Hence the human disturbance is low.

Yet, active and closed mines are rarely regarded as an opportunity for biodiversity. They are rather commonly regarded as degradations that require intense fixing actions.

Instead of constantly rehabilitating them, in order to make them less dangerous for local populations or in order to transform them in another source of economic benefit (agriculture, forestry, landfill, industrial zones, fishing) should we keep them protected and look at them as potential biodiversity reservoirs?

Should we rehabilitate mining sites or let them be biodiversity sanctuaries, where nature will develop itself as is suits her?

# Method

The study was performed in 4 active or recently abandoned (less than one year) quarries and sand and gravel pits in North Eastern France. We conducted a detailed study over 3 seasons (spring, summer, autumn), on 29 plots and 18 transects, in zones that undergone different types or rehabilitation:

| | |
|---|---|
| T1 | mineral base (after or without earthworks) was left to spontaneous succession |
| T2 | mineral base was only covered by fertile topsoil |
| T3 | mineral base was covered by topsoil and planted with trees and shrubs |
| T4 | mineral surface was covered by topsoil, sown with grass and herbs seed mixtures and planted with trees and shrubs |

For flora, 2mx5m plots, divided into 10 square meter quadrats were randomly located in zones T1-T4, and all the vascular plants were recorded.

For reptiles and lepidopterans, 50m long transects were defined in zones T1-T4. Inventories consisted in recording specimens while walking at very low speed. In addition, for reptiles, shelters plates (black rubber, 0.8m x 0.8m) were placed on both ends of every transect in advance and raised during inventories. For lepidopterans, all the specimens in an imaginary box (2m away from the transect on left, right and above) were observed and noted.

For amphibians and dragonflies, the transect was the tour around the water body of a gravel pit (one was T1, the other T3)  and inventories were conducted by walking at low speed. For amphibians, surveys involved both direct observations and listening of twilight song.

# 4 sand and gravel pits & quarries

# Inventories in gravel pits

# Inventories in quarries

# Data analysis

The species diversity was estimated through the use of the following indices:

- species richness
- Shannon index
- Simpson index

**Flora**

To compare the impact of four different rehabilitation techniques (T1-T4) on value of each one of three indices, we used the general linear mixed models (Type III) that included the random effect of successional stage nested into site location and the fixed effect of level of technical rehabilitation, as implemented in the nlme R-package.

**Fauna**

For each taxon, separately, we pooled by zone of intervention three seasonal inventories performed and calculated the species richness, and Simpson and Shannon indices.

# Results

In total, we recorded 186 species of plants, 14 individuals/2 species of reptiles, 479/11 of amphibians, 91/39 of butterflies and 325/27 of dragonflies.

**Plants**
We pooled the data of the three seasonal inventories. According to the general linear mixed model, the effect of type of rehabilitation (T1-T4) on species richness, Shannon and Simpson indices were significant ($p = 0.0389$, $p = 0.0137$ and $p = 0.0405$ respectively) with T1 being the best and T4 the least good.

**Amphibians and dragonflies**
We compared the influence of T1 and T3 on species richness, Shannon and Simpson indices for amphibians and dragonflies based on the optimal values - maximal for species richness and Shannon index and minimal for Simpson index. We first pooled the data from three seasonal inventories for all transects in one type of rehabilitation and then calculated species richness and Shannon and Simpson indices. T1, appears to be better than T3 for all the used indices for amphibians and dragonflies (Table 3 and Table 2).

**Butterflies**
We compared the influence of four types of rehabilitation on butterflies' presence on site. We first pooled the data from three seasonal inventories for all transects in one type of rehabilitation (for T1-T4) and then calculated species richness and Shannon and Simpson indices. Maximal values for species number, Shannon and Simpson indices are optimal (highest for species richness and Shannon index and lowest for Simpson index) for spontaneous succession (T1), followed by T3, T2 and T4 (Table 4).

Based on the foregoing, spontaneous succession, appears to be always the best solution.

# Tables

| Rehabilitation technique | T1 | T2 | T3 | T4 |
|---|---|---|---|---|
| Effect on species richness | 0 | -7.370089 | -4.700623 | -10.744943 |
| Effect on Shannon | 0 | -0.1447513 | -0.1083214 | -0.2802247 |
| Effect on Simpson | 0 | -0.02862615 | -0.02013450 | -0.03574136 |

**Table 1**: Effects of four rehabilitation techniques on Species richness, Shannon and Simpson index for plants in quarries and gravel pits, in a general linear mixed model analysis. Regression coefficients.

| Rehabilitation technique | Species Number | Shannon | Simpson |
|---|---|---|---|
| T1 | 16 | 0,801540308 | 0.174726296 |
| T3 | 8 | 0,749438087 | 0.28510054 |

**Table 2**: Effects of two rehabilitation techniques on species richness, Shannon and Simpson index on Odonates presence in gravel pits.

| Rehabilitation technique | Species Number | Shannon | Simpson |
|---|---|---|---|
| T1 | 5 | 0,60764948 | 0.29083461 |
| T3 | 3 | 0,4108278 | 0.43705674 |

**Table 3**: Effects of two rehabilitation techniques on species number, Shannon and Simpson index on Amphibians presence in gravel pits.

| Rehabilitation technique | Species Number | Shannon | Simpson |
|---|---|---|---|
| T1 | 12 | 0,986469897 | 0.01778656 |
| T2 | 5,5 | 0,549981311 | 0.02371542 |
| T3 | 7,5 | 0,71494624 | 0.08928571 |
| T4 | 5 | 0,44856239 | 0.02380952 |

**Table 4**: Effects of four rehabilitation techniques on species number, Shannon and Simpson index on Butterflies presence in quarries.

# Conclusions

For plants, the results of statistical analysis showed that spontaneous succession on mineral base (T1) gives better biodiversity results for the following indicators: species richness, Shannon and Simpson index, compared to other types of rehabilitation examined. Topsoil addition, followed by seeding and tree and shrub planting (T4) gave the least good results for all the three indicators. This method probably prevents colonization of the site by surrounding vegetation, and hence biodiversity present onsite is almost limited to seeded and planted specimens. Covering mineral base with topsoil followed by planting (T3) gives better results than just covering (T2), for all the three used indicators. Possible explanation might be that planted trees and shrubs attract animals that disperse plant seed and maybe also reduce development of invasive species, by creating shadow. It appears that the best solution for vegetation in quarries and sand and gravel pits is to leave the mineral base to spontaneous succession.

For amphibians, dragonflies and butterflies, even though we could not perform statistical analyses, the data show the same trend as for plant species. For amphibians and dragonflies, spontaneous succession seems to be better rehabilitation technique than covering with topsoil followed by planting. For butterflies, spontaneous succession is better rehabilitation choice compared to other types of technical rehabilitation examined; T4 gives the least favorable results, and the intermediary levels follow the same trend as for plants – covering with topsoil followed by planting favors butterflies presence more than covering by topsoil alone. For reptiles, we had very little results: we collected 14 individuals of 2 species of reptiles. This is possibly due to the fact that reptiles easily and quickly escape and hide from humans, even when we use shelters plates.

In general, based on our per-taxa conclusions, we conclude that spontaneous succession favors biodiversity development more than other examined technical rehabilitation methods. We show that different technical rehabilitation techniques do have different impact on biodiversity development in quarries and sand and gravel pits, for all taxa examined. We conclude that spontaneous succession should be favored in maximal number of cases. Covering by topsoil followed by seeding and planting should absolutely be avoided in any case, and tree and shrubs planting should be limited to rare cases where the presence of topsoil on site is substantial and its evacuation from site impossible due to legislation or technical reasons; we then recommend topsoil emplacement to limited surfaces, followed by tree and shrub planting. In general, we recommend to leave quarries and sand and gravel pits to spontaneous succession after the end of the exploitation of a whole or a certain part of quarry. This would most probably decrease the cost of rehabilitation as well.

# Discussion

Biodiversity is becoming one of a major topics in the news and people seem to start realizing its importance. The 2019 Amazon rainforest wildfires raised awareness of dangers of biodiversity’s depletion. Fires in Australia in 2019/2020, which caused death of nearly 8000 koalas and more than 480 million mammals, birds and reptiles, inspired many people all over the world to donate money to stop the fire and save wildlife.

The question remains whether mines should be used to enhance biodiversity on Planet or if other usages are more important for local populations.

Repurposing mines after closure does affect the biodiversity developed on site during years of mining.

Presence of many species in mining sites and their diversity indicates that mining sites might indeed be an opportunity for biodiversity, especially when rehabilitation works are not done; when mining sites are left to spontaneous succession.

This potential merits to be further studied and exploited in the future.


Thank you for your attention