# Do Linear Transport Infrastructures Provide a Potential Corridor for Urban Biodiversity? Case Study in Greater Paris, France

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## Introduction

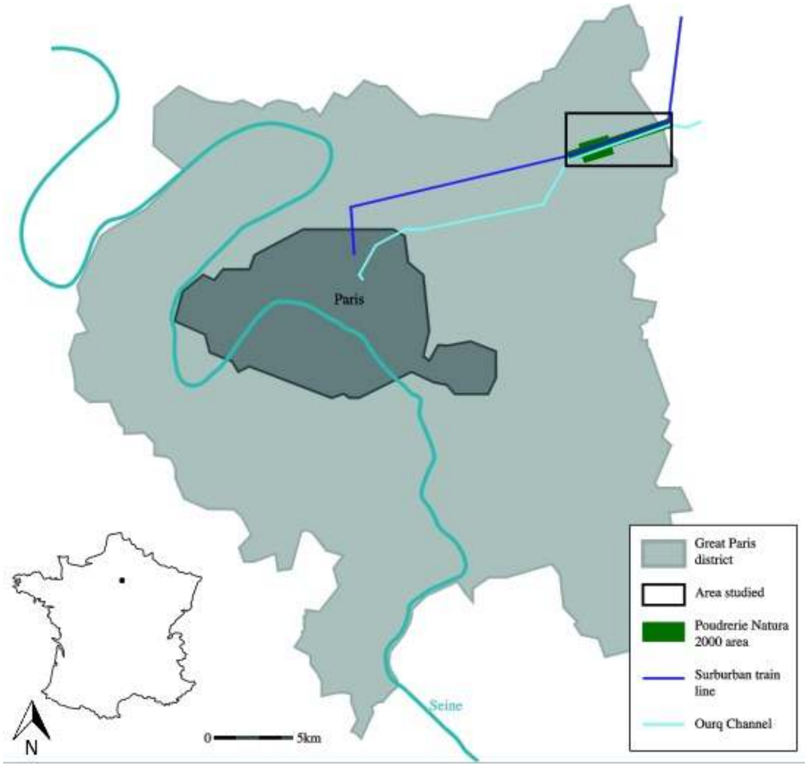
1 Recent studies have emphasised the increasing impact of Linear Transport Infrastructures (LTIs) on biodiversity. LTIs include, among other, railway, roads and highways, waterways and power transmission lines. Both negative (Seiler, 2001; Brown et al., 2006; Jackson and Fahrig, 2011) and positive (Ranta, 2008; Penone et al., 2012; Vergnes et al., 2013) impacts have been highlighted. Numerous authors explore various indices or values in order to identify these negative and positive impacts that this relates to genetic, specific, ecosystemic or functional biodiversity. Most of them especially use ecological assessment approaches, in particular to identify negative impacts (Seiler, 2001; Machado, 2004; Jackson and Fahrig, 2011). Overall, it is more and more established that LTIs may also have positive impacts and contribute to local and regional biodiversity preservation (Ranta, 2008; Penone, 2012; Penone et al., 2012; Vergnes et al., 2013). For Ranta (2008), it is

assumed that there are original habitats along railway and road corridors as well as urban habitats (Hobbs et al., 2006; Baker et al., 2007; Pouyat et al., 2007; Williams and Jackson, 2007; Byrne et al., 2008; Grimm et al., 2008). These LTIs and corridors are integrated into urban ecosystems (De Wet et al., 1998; Savard et al., 2000; Pellissier et al., 2012). On the other hand, a number of recent authors highlight the numerous ways to manage these positive impacts. In order to contribute to manage such more or less natural areas related to LTIs, most researches provide indices (Machado, 2004; Garcia-Garcia et al., 2016). They are useful for nature managers. The indices are developed with systematic analysis for expressing naturalness or biodiversity and also operational management activities (Vergnes et al., 2013; Haaland et al., 2015).

2 In urban areas, and especially in the Paris area, in the city and suburbs, the contribution of LTI edges to naturalness is more and more documented (Penone, 2012; Vergnes et al., 2013; Clergeau et Blanc, 2013). Authors highlight the biodiversity along the infrastructures and corridors as abandoned LTIs become vacant (Foster, 2014) or especially along active infrastructures (Penone, 2012). Most public policies aim to develop urban green spaces as a contribution to numerous ecological services such as energy saving and emission reduction (Nielsen et al., 2014; Zhang et al., 2014), pollution reduction (Blanusa et al., 2015), quality of life and well-being (Shwartz et al., 2014; Foo, 2016).

3 In France, ITTECOP (Land Transport Infrastructures, Ecosystems and Landscapes) is the scientific programme led by the French Ministry of Environment, whose purpose is to contribute to a better understanding of the impacts of LTIs on biodiversity. Our research is integrated into the French ITTECOP programme concerning the impacts of LTIs on biodiversity. Our purpose aims to demonstrate how LTIs can promote the spread of a specific biodiversity through a reservoir of biodiversity in the Paris area. In order to explore both such scientific and operational aims, we study patches of naturalness along LTI edges around the city of Paris, using a forest-to-urban gradient (Porter et al., 2001). Our aim is to understand the types of biodiversity developed. In this study, our purpose is to understand the impacts of LTI edges on a suburban forest whose context is particularly original in the Greater Paris area (Fig.1). In this paper we present specific studies in an original area of Greater Paris. We try to understand if a local natural area, a Natura 2000 area, may be a source for biodiversity and if LTI edges facilitate spatial development of biodiversity.

Figure 1 : Location map




## Area studied: the Poudrerie Natura 2000 area

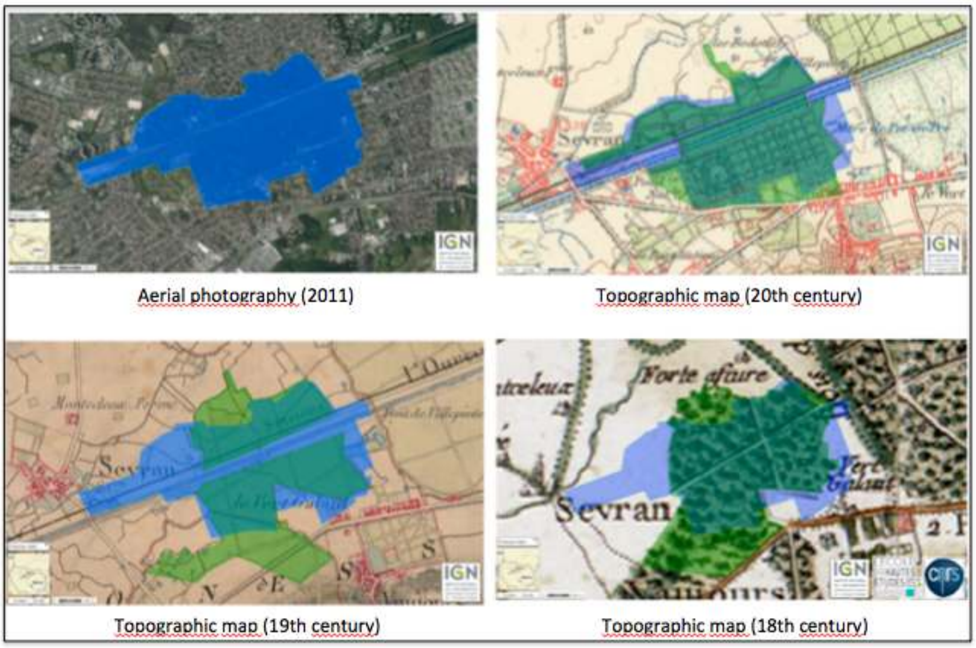
4 Our work consists in inventorying and analysing the Potential Biodiversity Index on the edges of two Linear Transport Infrastructures crossing a forest park in the northern part of the Greater Paris district (France). The study presented here concerns the Poudrerie Natura 2000 area. Located in the north-eastern part of Greater Paris, it is a forestry reservoir of biodiversity. Two linear transport infrastructures pass through this park: the Ourcq Channel (Canal de l'Ourcq in French) and a section of the suburban train lines.

5 One of the characteristics of this site is that it has been granted various natural heritage protection labels due to the availability of biodiversity. For instance it is part of CWA, Classified Wooded Areas (EBC in French), which is regulated by article L.130-1 of the French Urbanism code. The aim of this classification is "*to ensure the preservation of existing woodlands and forests, but also urban green areas, tree-planting projects, isolated veteran trees and any unwooded areas which could be potentially planted*". Thus the classification bans "*any land-use changes which could jeopardize the conservation and protection of afforestation, or the development of tree planting*" (Marcadet *et al*., 2011).

6 The forest park is also established as a natural zone of ecological, floristic and faunistic value (ZNIEFF in French). As "*a sector of high biological and ecological interest*" (MNHN, 2003-2015) it is also classified as "*a vast, rich and little altered natural unit offering major biological potential*" (MNHN, 2003-2015). This status was granted to the park by the Paris regional scientific council of natural heritage. Lastly, the forest park La Poudrerie belongs to the special protection zone called "*sites of Seine-Saint-Denis*" regulated by the European Natura 2000 bird directive (Marcadet *et al*., 2011). Being the only European site within a

dense urban area it includes 15 parks and forests spread across the departmental district, among which the park forest La Poudrerie (ECOTER, 2013), which has helped the site receive the Natura 2000 label in Seine-Saint-Denis because it harbours six of the twelve bird species listed in the European directive: the black woodpecker (*Dryocopus martius*), the idle spotted woodpecker (*Dendrocopos major*), the honey buzzard (*Pernis apivorus*), the European kingfisher (*Alcedo atthis*) as well as the Montagu's harrier (*Circus pygargus*) and the hen harrier (*Circus cyaneus*). The site is also characterized by a time continuity of afforestation, which is a relevant factor of biodiversity in a forest environment "*as it is considered one of the major elements of naturality*" (Dupouey et al., 2002; Lidermayer B. and Franklin J-F., 2002; Lundström, 2008), When using the *Géoportail* website to compare old maps with today's aerial photographs, we can clearly see that some of the original forest has been preserved since the 18th century (Fig.2).

**Figure 2 : Comparative evolution of Poudrerie Park Natura 200 area (in blue) and land occupations since the 18th century (Greater Paris)**






7 On a local level, studies made by the Ecoter research consultancy applying the Potential Biodiversity Index, PBI (Larrieu and Gonin, 2008; Larrieu et al., 2012; Emberger et al., 2013), have revealed the presence of "a rich and complex forest ecosystem" within the park (ECOTER, 2013). These various elements enable us to claim that the forest park La Poudrerie serves as a reservoir of biodiversity.

## Methods

8 This study examines the positive role played by the LTI edges in the development of the biodiversity identified in the park. The aim is to understand how and why the linear transport infrastructures edges are corridors that should become part of the green and blue ecological-network projects.

## Identifying the forest park as a reservoir of biodiversity

9 Studying maps from the Natura 2000 document "*Sites in Seine-Saint-Denis*" (Marcadet et al., 2011) has enabled us to assess the spread of the plant cover across the department area between 1800 and 2002. Moreover, a comparative analysis of various documents ranging from old Cassini maps, military and topographic maps to aerial photographs has been made using the *Geoportail* website. The current outlines of the park acreage have been cut out thanks to the tool called *Polygone* and superposed on each ancient map, using the same scale. This has enabled us to compare the spatial extent of the park at various times so as to assess the alteration of the park surface area from the 18$^{th}$ century up to the present day (fig.2).

## Identifying a landscape continuum

10 The analysis of a current aerial photograph (Fig. 3) clearly shows that the park has extended eastward, which is confirmed by the photos taken in the field showing similar landscapes (Fig.4). Shot from the eastern tips of the park where the extension lies and facing west, both photos present a view of the Ourcq channel with grassy berms on both sides of the infrastructure, a cycling path along the southern bank and wooded extensions of the berms.

Figure 3 : Landscape structures around Poudrerie Park Nature 2000 area (Greater Paris)

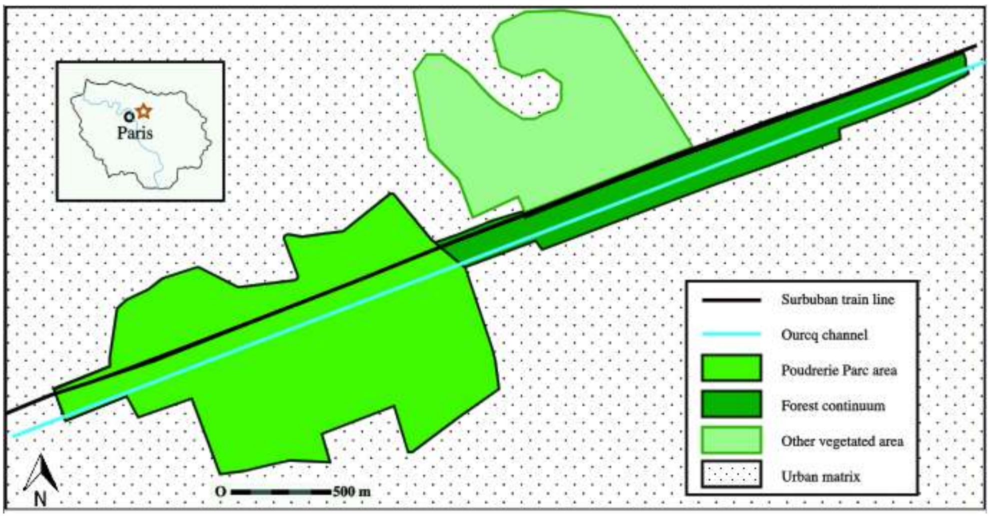
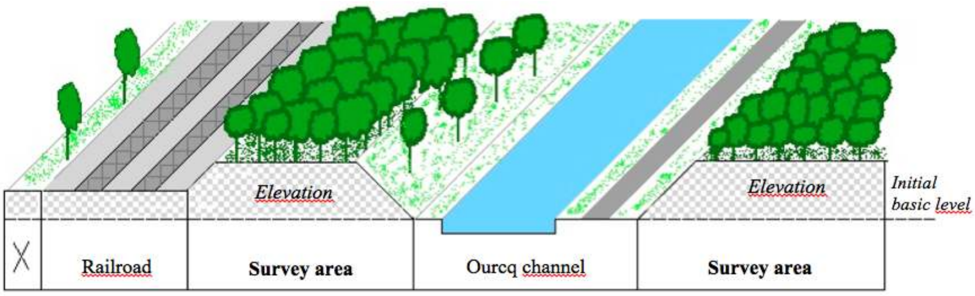


Figure 4 : Two pictures showing the Ourcq channel running below two sloping up berms with vegetation

11 The similarities in landscape have reinforced our decision to apply the Potential Biodiversity Index to study the role played by the rail and water ways edges within both the park and its land extensions, so as to compare the collected data.

12 The berms, which make up the land extension and on which a new wooded area has grown, are man-made. As illustrated in Fig. 4 and 5, the canal runs below the rail tracks and the sloping up berms. The berms had been artificially created when the canal was built as underlined by Pierre-Simon Girard in charge of the construction under Napoleon Bonaparte: "Our task is to erect, with the utmost regularity and definite slanting angle, the internal berms sloping up from the canal banks, the towpaths and the embankment or hillsides." (Girard, 1831).

Figure 5 : Drawing showing the two infrastructures, the channel below the rail tracks and the artificial berms




## Collecting data

13 The Potential Biodiversity Index, PBI, from Larrieu and Gonin (2008; Larrieu et al., 2012; Emberger et al., 2013) has been applied to survey the whole area covered by our study so as to focus on the capacity of the rail and water ways edges to harbour any forms of biodiversity. According to Larrieu and Gonin (2008) and Ferris and Humphrey (1999), potential biodiversity is the capacity to harbour biodiversity linked to present and varied characteristics, and in particular functional traits more or less related to environmental constraints (Cornelissen et al., 2003; De Bello et al., 2010; Swoczyna et al., 2015; Di Battista et al., 2016).

14 The PBI has been primarily designed for helping forestry management to carry out preliminary diagnoses so as to be able to identify the points to improve for an optimal development of biodiversity (Larrieu and Gonin, 2008; Larrieu et al., 2012). As far as this study is concerned, the index has helped to assess the potential capacity to harbour the

biodiversity developing on the rail and water ways edges or in the area around the LTIs, based on several criteria assessing the forest habitat (Garcia-Garcia et al., 2016; Pellissier et al., 2012).

15 The design of this PBI has been based on 10 indices, 7 of which are linked to tree-planting and forestry management and 3 are linked to the local environment (Table 1). Each factor ranges from 0 to 5.

## Description and justification of the indices

### Index A – Diversity of the native forest tree species

16 Larieu and Gonin (2008) justify the choice of the first factor by the fact that "most of the time species of the same kind tend to present both the same dynamic behaviour and quite similar biological characteristics and potential". Moreover, "the related biodiversity varies according to the species, but on the whole, growth depends on the number of native species" (Gosselin and Laroussinie, 2004; Larrieu and Gonin, 2008). When the index is applied in the field, "a species is included as soon as one individual is detected. The exotic species will not be taken into account since their biological potential is sharply inferior in our countries to that of the native species" (Larrieu and Gonin, 2008).

17 The rating scale of this index, that is to say 0 for 1 or 2 species, 2 for 3 or 4 species and 5 for 5 species and more, has been calibrated from the number of tree species observed in various stands of trees such as tree-planted plots which were heavily damaged by the 1999 storm and closed tree-planted plots made up of adult trees.

### Index B – Vertical structure of vegetation

18 Index B finds its origin in the influence of the number of layers on biodiversity. A stand of trees is classified in 4 levels based on the usual definitions in phytosociology (Delpech et al., 1985; Ferris and Humphrey, 1999. Bowers and Boutin, 2008): herb layers, shrub layers (less than 7 m high), lower arborescence (7 to 20 m), and higher arborescence (more than 20 m). The rating increases according to the number of existing layers: 0 for 1 or 2 layers, 2 for 3 layers, 5 for 4 layers (Larrieu and Gonin, 2008). Therefore, there is a close relationship between the abundance of bird life and the number of layers, linked to the amount of available cavities, all of this in various forest habitats (Larrieu and Gonin, 2008). Moreover, the abundance of nocturnal lepidoptora insects increases with the structural heterogeneity of the tree coverage (Larieu and Gonin, 2008).

### Indices C and D – large standing (C) and down (D) dead wood

19 These two indices are included in the potential biodiversity index because dead wood shelters saproxylic processions, thus playing a significant role in biodiversity (Grove, 2002; Bouget, 2007; Brustel 2001). The very nature of the saproxylic processions depends not only on the amount of dead wood but also on its characteristics: wood species, size and position, stage and mode of decomposition, microclimatic conditions (Gosselin and al., 2006; Larrieu and Gonin, 2008). So the rating of these two indices varies according to the position of the trunks, standing or lying on the ground. Indices C and D are used according to the quantity of dead wood with a circumference ranging from 120 cm to 130 cm (a 40 cm diameter). For these two indices, the Larrieu and Gonin (2008) rating scale

has been adapted to our field of study. Given the massive quantity of wood identified in the field and its high potential capacity to harbour some form of taxonomic biodiversity, two more indices have been added to assess the small dead wood on the ground (index value: 0.5) and the stumps and trunks with a circumference less than 120 cm (index value: 1).

### Indices E and F – Large living wood (E) and living trees bearing micro habitats (F)

20 Microhabitats are relevant indicators of biodiversity (Yang et al., 2015). Living trees bearing microhabitats play a significant role in biodiversity because they harbour specific taxons (Ferris and Humphrey, 1999; Gosselin et al., 2006; Winter and Moller, 2008; Larrieu and Gonin, 2008; Yang et al., 2015). Trees with large diameters are crucial for biodiversity since "they represent very heterogeneous habitats which can harbour many various specialised species living side by side" (Kollstrom and Lumatjarvi, 2000). Paganova et al. (2015) show the role played by the shape of trees. Moreover, as underlined by Larrieu and Gonin (2008), some saproxylic groups like the Syrphid diptera are more easily found in microhabitats associated with older trees than in those associated with dead wood.

### Index H – Age and condition of the forested area

21 As mentioned previously, the time continuity of the tree coverage is a relevant factor of bioversity (Dupouey and Dambrine, 2010; Vallauri et al., 2012). According to Larrieu and Gonin (2008) and Lundström (2008), it is clearly admitted that the age of the forest cover has an influence on the floristic diversity: several studies conducted in the mesophilic beech and oak forests in Western Europe have helped to set out a list of specific species which can be found in old-growth forests (areas which have been forested for more than 200 years), and "whose occurrence is much less significant, though not totally absent, in more recent forests" (Dupouey et al., 2002). Lastly, even if the age does not seem to affect the abundance of the specific vascular flora on a global scale (Lundström, 2008), it does increase the richness locally as it has been shown in recent research carried out in the Champagne alluvial forests ( Larrieu and Gonin, 2008).

### Index I – Wetland habitats

22 According to authors (Larrieu and Gonin, 2008; Le Viol et al., 2009; Sheffers and Paszkowski, 2013; Sokol et al., 2015), wetland environments, due to their specific composition, offer a different type of taxonomic diversity for trees growing there. They also contribute to increasing the diversity of the ecosystems. These environments are taken into account thanks to index I as soon as water bodies are larger than 100 m$^2$. The ecological diversity being a significant element for the structuring of wetland environments, the rating of this index is based on the diversity of these environments rather than the size of their total surface area. As a result 0 corresponds to no wetland environment, 2 for one type of environment only, and 5 for diversified wetland environments.

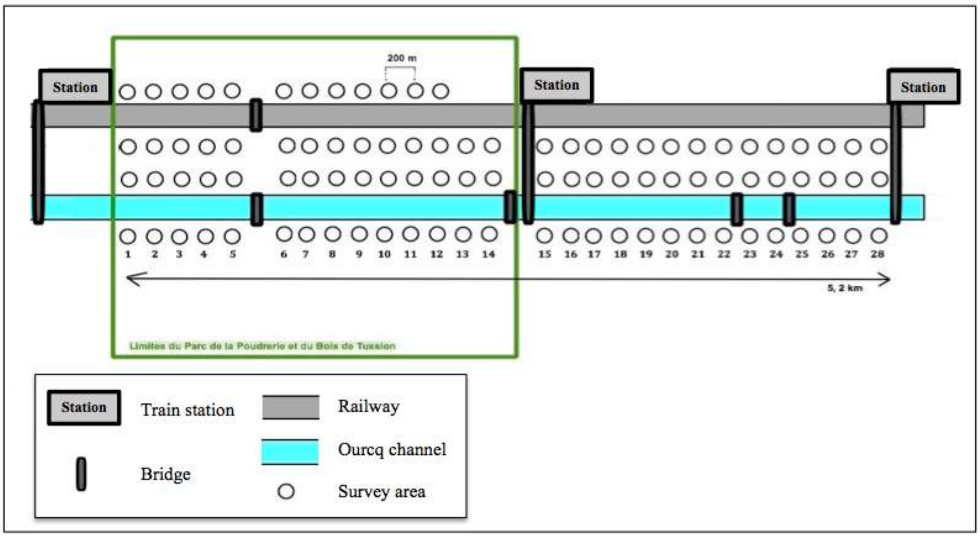
### Index J – Rocky environments

23 Rocky environments – screes, cliffs, rock plates – have site-specific characteristics which account for the development of a specific vegetation including many endemic species

(Pech, 2013). As stated by Gonin and Larrieu (2008), when they cover a significant surface area (a minimum of 1% of the studied surface area), rocky environments increase biodiversity, all the more so when they are diversified. The rating is thus the same as for factor I.

24 The potential biodiversity index has been applied every 200 metres along both sides of the linear transport infrastructures with a margin error of a few meters due to the field measurement conditions. The study fields are situated within 20 meters from the infrastructures, a distance which corresponds to the width of the slopes bordering the sides of the rail and water ways (Fig. 5 and 6). The distances have been calculated with a Bushnell laser and the collected data have been entered into a spreadsheet in order to be processed statistically. A total of 84 surveys have been carried out corresponding to the 33 hectares surveyed.

Figure 6 : PBI method explanation schema applied to linear infrastructures edges and forest park.




## Studying the biological potentialities

25 The potential capacity to harbour biodiversity in a forest stand largely depends on the type of tree species. Trees are the most influential elements in a forest ecosystem. Their characteristics have a major influence on the species found in the forest (Emberger and, 2013; Swoczyna et al., 2015). Consequently, the data collected in the field have been used to study the biological potential of each recorded tree species based on the rating table designed by Branquard and Liegeois (2005). Tree species have then been classified after applying the Potential Biodiversity Index.

# Results

26 The PBI surveys conducted in this study have helped to supplement those led by Ecoter in 2013 (ECOTER, 2013), but they also compare the results found around the linear transport infrastructures with those found in the forest park La Poudrerie itself. The PBI indices (which have been assigned letters) are set out in Table 1.

Table : Synthetic table of indices

| | Factors (per categories) | Rating | | |
|---|---|---|---|---|
| | | 0 | 2 | 5 |
| | Dependent on forest management factors | | | |
| | **Vegetation** | | | |
| A | Indigenous tree species richness | 1 or 2 species | 3 or 4 species | 5 species and more |
| B | Vertical vegetation structure | 1 or 2 layers | 3 or 4 layers | 5 layers et plus |
| | **Microhabitats associated with trees** | | | |
| C | Deadwood up big circumference | Almost absent: <1 plant/ha | 1 or 2 plant/ha | 3 plants/ha et plus |
| D | Deadwood big circumference on the floor | Almost absent: <1 trunk/ha | 1 or 2 trunks/ha | 3 trunks/ha et plus |
| E | Very large living wood | Almost absent: <1 plant/ha | 1 à 4 plants/ha | 5 plants/ha et plus |
| F | Live trees holders of microhabitats | Almost absent: <1 plant/ha | 1 à 5 plants/ha | 6 plants/ha et plus |
| | **Associated Habitats** | | | |
| G | Open areas | < 1 area /10 ha | 1 à 2 area /10 ha | 3 à 4 area /10 ha |
| | Contextual factors | | | |
| | **Continuity of forest ecosystem** | | | |
| H | Age of the wooded area | The settlement is part of a recent forest | The settlement adjoins an ancient forest | The settlement is clearly part of an ancient forest |
| | **Associated habitats** | | | |
| I | Associated habitats | None | Homogeneous: 1 type | Diversified: 2 types and more |
| J | Rocky environments | None | Homogeneous: 1 type | Diversified: 2 types and more |

Clevenot L., 2015 ; *from* Porter et al., 2001; Larrieu and Gonin, 2008; Nielsen et al., 2014 ; Paganova et al., 2015; Yang et al., 2015

## Index A – Native forest tree species

27 More than half of the surveys carried out over the whole study area have obtained the maximum score (5). Though 50% of the surveys carried out on the infrastructures themselves have received the average score with no minimum score (0) given, the scores obtained in the area situated in the land extension of the infrastructures tend to vary more. The average score has been obtained by 40.5% of the surveys and the minimum score by 4.5% of the surveys. Most of the surveys which have received the average or minimum scores were conducted either at the far ends of the study area or near bridges. While the maple tree is very present all over the study area, the hornbeam (*Carpinus sp.*) and the hazel tree (*Corylus sp.*) are the most common species found on the sections of the infrastructures passing through the park, namely in 50% of the surveys. The ash tree (*Fraximus sp.*) and the hazel tree (*Corylus sp.*) are the most common species found on the land extension of the park, namely in 75% of the surveys.

## Index B – Vertical structuring of the vegetation

28 The vertical structuring of the vegetation is very similar on both the infrastructures and the land extension. The maximum score was given to most of the surveys, that is to say 95% of the surveys in the park and 97.5% in the land extension. Over the whole study area only two surveys, which were conducted in the park, have received an average score. Similarly, only one survey, conducted in the land extension, has obtained the minimum

score. It can be explained by the fact that the surveys were conducted either near a road bridge or at the far ends of the study area.

## Index C – Amount of standing dead wood

29 Standing dead wood of wide circumference (more than 40 cm in diameter) has not been found on the infrastructures passing through the park but little of it has also been found on the sections of the infrastructures beyond the park. Over the whole study area, the minimum score has been obtained by 98.2% of the surveys. Standing dead wood of large circumference has only been found in one survey in the southern part of the rail tracks. This is probably due to the cleaning done by the rail management team for safety reasons.

## Index D – Amount of dead wood on the ground

30 Though the surveys, which have been conducted on the infrastructure sections crossing the park, show the significant presence of stumps and trunks with a circumference less than 120 cm which have been indexed 1 (78.5%), the size and the quantity of down dead wood vary more across the land extension. Though there is a significant presence of medium-size dead wood, namely branches and small dead wood indexed 0.5 in 52% of the surveys conducted in the land extension of the park, 31% of the same surveys show the presence of stumps and trunks indexed 1. However, the number of surveys showing the presence of at least one trunk or stump of more than 120 cm in circumference is the same all over the whole study area. Lastly, there are 4 surveys conducted across the land extension showing a total absence of down dead wood, which can be explained by the fact that they were conducted near highly frequented areas at the far end of the extension.

## Index E – Amount of large living wood

31 Little very large living wood has been found over the whole study area, the minimum score having been obtained by 88% of the surveys while no maximum score has been given. However, the average score, mainly corresponding to the presence of 1 or 2 large living wood items, has been given to 23% of the surveys in the park, as compared to only 2% of those conducted in the land extension. The fact that the park is an old-growth plantation while, conversely, the one in the land extension is more recent can account for the score.

## Index F –Number of microhabitats within the living trees

32 Trees bearing microhabitats can be largely found over the whole study area. 78% of the surveys have obtained the maximum score, 16.5% the average score and 4.5% the minimum score. It is important to mention that ivy, *Hedera helix* L., has also been taken account.

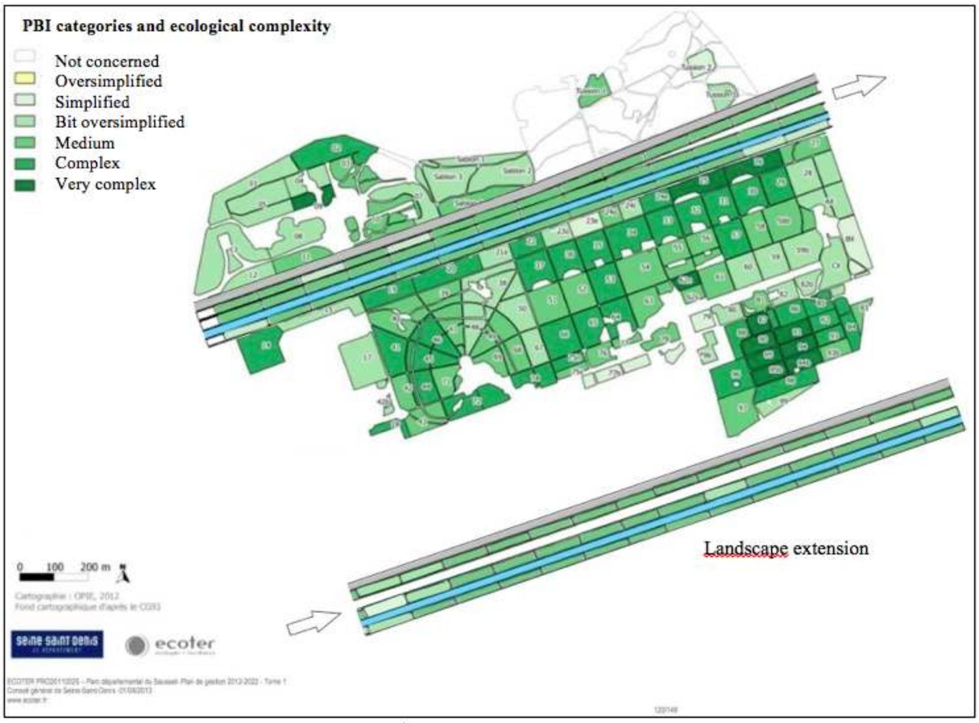
## Index G – Presence of open environments

33 There are few open environments found over the whole study area. 72.5% of the surveys have obtained the minimum score, 19% the average score, and 9.5% the maximum score.

These scores can be accounted for by the fact that there are no trees along the infrastructures and very few clearings across the area.

34 The study of the PBI surveys conducted on the impacts of the linear transport infrastructures over the whole study area has helped to show similar potential capacity to harbour biodiversity for the sections of the infrastructures passing through the park and those passing through the land extension, the former accounting for a 42%-12% PBI and the latter accounting for a 41%-13% PBI. We can find similar results when comparing the sum of all PBIs for each survey, ranging from 11 to 14.5 for the sections of the infrastructures passing through the park, and from 7 to 23 for those passing through the land extension. Thus Fig.7 shows that, over the whole study area, the potential capacity to harbour biodiversity has scored average.

Figure 7. Map of results with the PBI categories and ecological complexity along the two infrastructures (blue and grey lines) near Poudrerie Park




Clevenot L., 2015 ; *from* ECOTER, 2013

35 According to Branquard and Liegeois (2005) and Morgenroth et al. (2016), the biological potential of a woody species varies directly with the number of organisms with which it is directly associated through trophic and/or functional links (recycling of the nutriments, mycorrhiza, pollination, regulation of pest populations, etc.). Furthermore, as shown on Table 2, tree species affect more or less the germination of ancient forest species and the development of biodiversity (Thomaes et al., 2011). Table 2 is an illustration of the different species with high biological potential.

Table 2 : Main forest species and their biological potential

| Species | Biological potential | | | | |
|---|---|---|---|---|---|
| | Very high | High | Medium | Low | Uninformed |
| Birch | X | | | | |
| Hornbeam | | | | X | |
| Oak | X | | | | |
| Maple | | X | | | |
| Ash | | X | | | |
| Beech | X | | | | |
| Chestnut | | | | | X |
| Cherry | X | | | | |
| Hazel | | | | X | |
| Poplar | | X | | | |
| Robinia | | | | | X |
| Aspen | | X | | | |

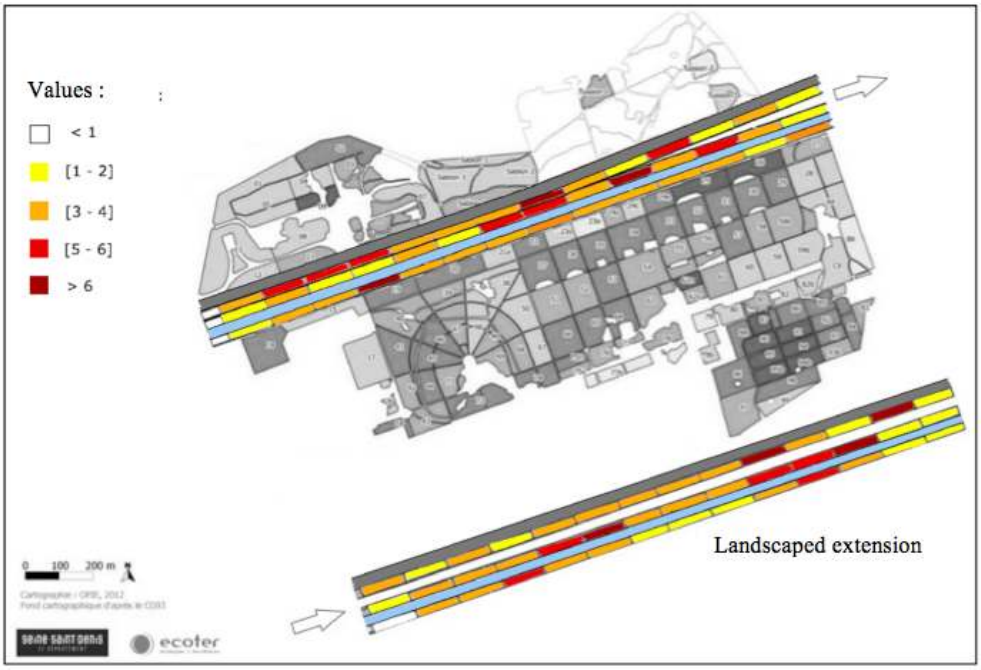
Clevenot L., 2015 *from* Larrieu and Gonin, 2008; Thomaes et al., 2011; Penone et al., 2012; Nielsen et al., 2014 ; Utorovia et al., 2014; Paganova et al., 2015; Swoczyna et al., 2015

36 The plant association of the whole study area mainly includes species with high biological potential, namely the maple tree (*Acer sp.*), the ash tree (*Fraxinus sp.*), the poplar (*Populus sp.*), and the aspen (*Populus tremula*), as well as very high biological potential such as the silver birch tree (*Betula sp.*), the oak tree (*Quercus sp.*), the beech tree (*Fagus sp.*), and the wild cherry tree (*Prunus sp.*). Though no species with average biological potential has been recorded over the whole study area, on the other hand the plant association does include two species with low biological potential, the hornbeam (*Carpinus sp.*) and the hazel tree (*Corylus sp.*). The chestnut tree and the locust tree are not classified according to their biological potential due to their absence from Branquart's and Liegeois's book (2005).

37 The analysis of the data collected by the PBI surveys shows that most of the species found in each survey have a high biological potential, the maple tree (*Acer sp.*) or the ash tree (*Fraxinus sp.*) being for instance present in respectively 83% and 54% of the surveys. Most often, *Acer campestre* L. is more or less typical of pioneer or ruderal lands (Utorovia et al., 2014). Functional traits of this kind of tree are characteristic of anthropogenic land covers. The oak tree (*Quercus sp.*) and the wild cherry tree (*Prunus sp.*), which have a high biological potential, are present in respectively 40% and 31% of the surveys. The results show a balance between the sections of the infrastructures passing through the land extension and those passing through the grounds of the park.

38 The data from the PBI surveys is also used for comparing the distribution of the forest species identified on the rail and water infrastructures of the study area in terms of biological potential (Fig. 8). The aim of this study being to show if there is a positive role of the linear transport infrastructures on biodiversity, we will only focus on the species with a high and very high biological potential.

**Figure 8 : Map of biological potential values related to woody species identified along the study area**




Clevenot L., 2015 ; *from* ECOTER, 2013

# Conclusion/Discussion

39 Although included in a important departmental network of greenways, the forest park La Poudrerie is located in a dense urban environment. It is an established reservoir of biodiversity owing to the time continuity of its tree plantation and the various natural heritage protection labels that it has received. Both transport infrastructures run for 2.5 km through the park offering a structural continuity of landscape, which the study of aerial and on-site photographs tends to show. Data to which the Potential Biodiversity Index has been applied, and resulting from the surveys conducted along the linear transport infrastructures edges, both within the grounds of the park and beyond the park across the land extension, show that, in this case, these infrastructures edges have the capacity to harbour average biodiversity. Thereby, a comparison with other similar sites is necessary in order to be able to completely affirm the positive role that LTI edges can have on biodiversity. The tree plantation of the forest park being older than that studied along both transport infrastructures passing through the land extension, the various elements resulting from the study tend to confirm the hypothesis that the edges of these linear transport infrastructures play a positive role in the development of biodiversity. So, these infrastructures and their edges can be seen as potential corridors which can be integrated into the blue and green ecological-network projects. And the denser the urban fabric, the more important the role played by infrastructures.

40 If we answer to the question: why choose the Potential Biodiversity Index ? It is well known that various managers of LTIs need awareness in order to apply best practices in green areas of their networks (Tomaes et al., 2011). As mentioned by Larrieu and Gonin (2008), studies concerning biodiversity are necessarily multi-disciplinary since

biodiversity implies the study of "genes, individuals, demes, metapopulation, species, communities, ecosystems, and the interactions between the various entities." (Lidermayer and Franklin, 2002). As explained by Machado (2004), a study based on a single criterion would make the results incomplete. While the study of biodiversity requires a multicriteria approach (Du Bus de Warnaffe and Devillez, 2002), the evaluation based on the comparison of the natural value with the reference value, as suggested by Du Bus de Warnaffe and Devillez (2002), requires using floristic inventories with re-covering of the vegetative strata as well as volume inventories, but which were not available in the study area. Given that this study focuses on the habitats favourable to biodiversity, a study of the landscape diversity would have led to incomplete results. The use of a specific or generic indicator of biodiversity would have been impossible due to the limited time and funding allotted for this study and the expertise that it requires. Besides, this method includes "nostalgic references" in its evaluation criteria, namely "hypothetical ecosystem which would have developed had there been no human interaction restraining its development" (Du Bus de Warnaffe and Devillez, 2002). This reference cannot be taken into account in an area such as that studied, due to the juxtaposition in time and space of the various modes of management. We provide another argument that local patches and fragmented habitats may have positive effects on biodiversity (Ethier and Fahrig, 2011; Pellissier et al., 2012; Nielsen et al., 2014; Potter, 2015).

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## ABSTRACTS

Recent studies have emphasised the increasing impact, both negative and positive, of Linear Transport Infrastructures (LTIs) on biodiversity. A significant body of scientific and technical knowledge is more and more available to help guide restoration practices concerning especially urban areas. This study explores a comprehensive approach to estimating restoration potential along the LTI edges in the Greater Paris region (in France) in terms of potential biodiversity. Our work consists in inventorying and analysing the Potential Biodiversity Index, PBI, on sites along two LTIs crossing a forest in the northern part of this district. The study concerns a Natura 2000 area, La Poudrerie Park. A total of 84 surveys were carried out corresponding to the 33 hectares surveyed. We studied sites along the LTIs. For this purpose, we chose 84 sites in the traffic corridors. Biodiversity parameter evaluations were performed for each site. These parameters are related to functional traits that make it possible to determine the Potential Biodiversity Index (PBI). These site assessments by PBI may reveal the positive impact of the LTI edges in developing biodiversity. We may establish that there is a positive impact of LTIs edges for ecological restoration and revegetation in an urban context.

Des travaux scientifiques récents démontrent l'impact croissant, à la fois négatif et positif des Infrastructures Linéaires de Transport (ILT) sur la biodiversité. Un ensemble de connaissances scientifiques et techniques significatives permettent d'offrir les moyens pour améliorer les pratiques de renaturation en particulier en contexte urbain. Cet article présente un indicateur permettant d'évaluer le niveau potentiel de renaturation le long des emprises des ILT dans l'aire du Grand Paris (France) en termes de biodiversité potentielle. Notre travail consiste à analyser les composantes d'un Indice de Biodiversité Potentielle (IBP) sur des sites étudiés le long de deux ILT – ferroviaire et voie d'eau - qui traversent la forêt de la Poudrerie, située au nord-est du Grand Paris, forêt appartenant au site Natura 2000 du département de Seine-Saint-Denis. Un total de 84 relevés ont été effectués sur les 33 ha concernés le long des ILT. Les paramètres étudiés sur ces 84 sites visent à connaitre la biodiversité potentielle à travers des traits fonctionnels en vue de définir l'IBP. Ces évaluations permettent de révéler les impacts positifs sur la biodiversité par les emprises des ILT. Ceci permet d'émettre l'hypothèse que les emprises des ILT peuvent avoir un effet positif en matière de renaturation en contexte urbain.

## INDEX

**Keywords:** biodiversity indicator, nature conservation, environmental assessment, greenway, urban transportation
**Mots-clés:** indicateur de biodiversité, conservation de la nature, évaluation environnementale, trames vertes, transport urbain

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