Brownfields over the years: from definition to sustainable reuse
Guillaume Jacek, Anne Rozan, Maylis Desrousseaux, Isabelle Combroux

To cite this version:
Guillaume Jacek, Anne Rozan, Maylis Desrousseaux, Isabelle Combroux. Brownfields over the years: from definition to sustainable reuse. Environmental Reviews -Ottawa- National Research Council, 2022, 30 (1), pp.50-60. 10.1139/er-2021-0017. hal-03639159

HAL Id: hal-03639159
https://cnam.hal.science/hal-03639159
Submitted on 3 Jan 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Brownfields all over the years: an exploratory analysis of scientific literature (4530 mots)

JACEK Guillaume *1;2;3; ROZAN Anne 1;2; DESROUSSEAX Maylis 4; COMBROUX Isabelle 3

(1) ENGEES, GESTE UMR MA8101, 1 quai Koch, F-67000 Strasbourg, France
(2) Université de Strasbourg, F-67000 Strasbourg, France
(3) Université de Strasbourg, UMR 7362 CNRS LIVE, Institut de botanique, 28 rue Goethe, F-67000 Strasbourg, France
(4) CNAM-ESGT, Laboratory of Geomatics and Property, Le Mans, France

* Corresponding author: JACEK Guillaume, Institut de botanique ;28 rue Goethe, F67000, Strasbourg

guillaume.jacek@engees.unistra.fr

Email addresses

JACEK Guillaume : guillaume.jacek@engees.unistra.fr
ROZAN Anne : anne.rozan@engees.unistra.fr
DESROUSSEAX Maylis : maylis.desrousseaux@lecnam.net
COMBROUX Isabelle : combroux@unistra.fr
Abstract: (243 mots)

In urban areas, the limitation of sprawl is often confronted to the lack of available space. The central location and the benefit linked to their redevelopment highlighted the potential of brownfield sites for sustainable city planning. This interest led to the development of numerous research areas and topics. However, no comprehensive analysis of brownfield research has been carried out so far. In this review, we analysed research on brownfields topic from term use to an analysis of described study cases. This exploratory research was carried out through an analysis of the scientific literature available on Web of Science database.

Starting in North America, the brownfield term rapidly became popular in the rest of the world, especially Europe. However, except for the United States, no direct legislation specifically related to these sites seems to exist and they often depend on biodiversity, environment or soil pollution directives or laws (e.g., environmental liability directive (EU)). Moreover, the perception of brownfield’s potential varies greatly between regions of the world and international collaborations are very limited. The majority of the described type of site reuse are soft reuse (53%) and seem to be more depending of urbanisation gradient and world area than on brownfield past use.

Despite the growing interest for these sites, many questions concerning the future of these sites remain unanswered. Factors influencing the success of their redevelopment are still unclear and further research is strongly needed to ensure genuine sustainable reuse of these sites.
Highlights:

- Europe is the biggest contributor in brownfield redevelopment research, but People’s republic of China is the country with the highest rate of international collaborations.

- Brownfield redevelopments represent real opportunities for sustainable city growth yet except for the US Brownfield legal approach is often indirect through soil or water protection. In Europe, the direct legal responsibility for the management of brownfields is state dependant.

- Brownfield soft reuse represent majority of studied case in scientific literature.

- Brownfield reuses depend more urban gradient and pressure than on former site use.
1) **Introduction**

The concept of sustainable development came into prominence in 1987 with the definition given by Brundtland Commission. This commission defined sustainable development as “the development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland, 1987). This concept is articulated around three major pillars that are social, economic, and environmental sustainability (Kahn, 1995). The report of the open working group mandated after Rio+20 defined 17 major sustainable development goals to establish a Green economy in the context of sustainable development, eradicate poverty and create an institutional framework for sustainable development (U.N. General Assembly, 2014). The 11th goal stated the need to “make cities and human settlements inclusive, safe, resilient and sustainable” (Jandl, 2017). The keys to achieve this goal and make city and human settlement sustainable, include among other aspect: (i) integration of natural environmental elements, (ii) emphasizing of public transportation, (iii) high quality public realm and (iv) promotion of compact, efficient and mixed land use (Kenworthy 2006). Yet with around 66% of world population being urban by 2050 (UN 2014), integrating these key points in future city planning will be challenging, especially in terms of space availability. The search of available places combining social improvement, pollution mitigation and limitation of urban sprawl is often confronted to increasing scarcity of available land in compact urban areas. This highlights the potential of old urban industrial sites and make their regeneration a vital part of sustainable land use (Hombre, 2014).

Old industrial sites, commonly called ‘brownfields’ (Tyman, 2008), are often located in inner cities or close suburbs, near or within deprived neighborhood (Gallagher and Jackson, 2008; Hird, 1993; Smary and DeWitt, 1998). Therefore, they present high sustainable redevelopment potential. Incited by a growing interest for this sites, numerous research fields associated with the redevelopment of brownfields emerged. These research fields encompass brownfield site remediation (Petrová et al., 2017; Song et al., 2019), legal and incentives tools analysis (Vanheusden, 2009; Thornton et al., 2007), social impact and perception (Loures and Vaz, 2018;
However, the lack of common agreement on a precise definition (Loures and Vaz, 2018; Alker et al., 2000) sometimes leads to a misunderstanding of what is considered or not as a brownfield. This represents a significant barrier to a global perception of their potentials. The principal shift in the definition of brownfields is the compulsory former presence of soil pollution (Thornton et al., 2007, Adams et al., 2010). United States legislation defines brownfields as “real properties, the expansion, redevelopment or reuse of which may be complicated by the presence or potential presence of hazardous substance pollutant or contaminant” (Brownfield Act, 2002). This definition is mostly used in the United states (US), Canada and Northern or Eastern European countries, where development pressure may lighter (Oliver et al. 2005). In opposition, the definition use in the United Kingdom argues that “not all brownfield land is contaminated nor derelict” (POST, 1998; Meyer, 2004). In order to improve and characterize future research needs, a clear definition is needed and review of the main studies conducted on the topic of brownfields and their redevelopment would be welcome.

Through this review of scientific literature, we gave an overview of the studies dealing with brownfields thematic considering use of ‘brownfield’ term itself to the reuse of these sites. A temporal analysis was done and linked to countries contribution, legal approach, and industrial history. We especially analysed the geography of collaborations. Due to the potential of brownfields for sustainable city development, we focused on how the topic is addressed in scientific literature. We also studied how different factors including surroundings, countries or site previous use influence the redevelopment of brownfields sites.
2) Material and methods

2.1) Selection of bibliography

Bibliographical research was done at the beginning of 2020 on Web of Science (WOS) platform, using web of science core collection database. The research was done on documents published between 1975 and 2019. The study protocol was divided into three major phases described in figure 1.

2.1.1: The term ‘brownfield’ : origins and use

For the period between 1992-2019, a specific search of the term ‘Brownfield’ has been done in the topic section (TS) regardless the type of publication. It led to a result of 1804 publications, we thereafter called Corpus 1. All use of the term brownfield before 1992 were not affiliated to our meaning of brownfield (e.g. family names, site name etc…) and were removed from the corpus for the analysis. Associated research events (i.e. conferences; symposium….) that could impact number of publications were highlighted using data from WOS analytic tool “meeting titles”. Apart scientific conferences and events it is also known that the enactment of a statutory text or treaty can have a strong impact in publications of some research field. For example, the European water framework directive led to a massive increase of publication in water research.
area (Boeuf and Fritsch, 2016) that’s why a quick literature review of European, Chinese, and American policies has been done.

2.1.2 Bibliographical study of “brownfield redevelopment” research field

All the exploratory analysis was done in ‘Topic’ section for the period 1975-2019 and only reviews and articles were selected. From preliminary research, four different synonyms of the term brownfield have been selected: ‘wasteland’; ‘industry’; ‘factory’ and ‘derelict’ associated with dereliction adjectives like ‘former’; ‘old’ or ‘derelict’. Other terms like abandoned, ‘vacant’, ‘ancient’ etc. did not fit our requirements in term of relevance of publications. These terms were merged into the following equation (TS1):

\[
TS1 = ("brownfield" \text{OR} "wasteland" \text{OR} ("derelict" \text{OR} "former" \text{OR} "old") \text{NEAR/2} ("*indust") \text{OR} ("derelict" \text{NEAR/2} ("land" \text{OR} "area" \text{OR} "site" \text{OR} "zone")).") \text{OR} (("former" \text{OR} "old") \text{NEAR/2} ("factory" \text{OR} "factories")))
\]

The second step was the selection of the term associated with the concept of ‘redevelopment’ (See equation TS2 in fig1). Four terms were selected out of a preliminary list of 19 due to their usual use in association with brownfields: ‘redevelopment (and re-development)’, ‘regeneration’, ‘reuse (and re-use)’, and ‘restoration’. The crossing of these 4 terms (TS2) with TS1 led to the final following equation for the bibliographic search:

\[
\text{Topic} = \text{TS1 AND TS2} = ("Regener" \text{OR} "Restor" \text{OR} "reuse" \text{OR} "re-use" \text{OR} "redevelop" \text{OR} "re-develop")
\]

A screening was done on the 784 results, keywords and title were analyzed and when no clear link with brownfield redevelopment appeared the publication was removed from the corpus. The remaining 376 publications formed the corpus 2 (see fig. 1).

2.1.3 Bibliographical study of the type of reuse

We then analysed how brownfields were redeveloped and which factors could possibly impact their transformation. Title and abstract of the corpus 2 were analysed. The articles that
described specific redevelopment project formed corpus 3 (101 articles). All these articles were analysed. The articles that fully described one or multiple projects, from brownfield past to current redevelopment, were kept in corpus 4 (fig.1).

2.2) Article analysis

Using corpus 2, collaborations and contributions of each country/area were highlighted using R bibliometrix package tools (Aria et Cuccurullo, 2017). Affiliation of every authors were considered. For each publication, the selected country contribution corresponded to the proportion of authors affiliated to the selected country. The global contribution of each country/area was estimated by summing theses proportions. For this analysis Europe (continent) was considered as one single entity. When it comes to collaborations, multiple country publication (MCP) were extracted. Number of countries co-occurrence in all corpus correspond to their number of collaborations.

A term occurrence analysis was made on publication titles using wordcloud R package (Fellows, 2018). We only present here the results for Europe, US and PRC since they present a sufficient number of publications for this analysis. Terms present in at least 10% of the publication titles were represented in wordcloud and the word “Brownfield”, strongly predominant, has been removed from the figure.

For the study of the type of reuse, information like site former use, size, surrounding context and reuse type were considered and extracted from each article. Former uses were categorized using ISIC sections (International Standard Industrial Classification of All Economic Activities; 2008) which led to 6 different categories. ISIC sections were also used to categorise the reuse types but were complemented by two lacking categories: residential areas (housing as dominant purpose) and natural area. Site surrounding context was divided in 3 categories: urban; suburban and rural. Decisions were made using André et al. (2014) decision tree.
2.3) Statistical analysis

A Chi 2 test was used to evaluate the independence between former use and future trend in brownfield redevelopment and was followed by a network analysis performed with R “Bipartite package” (Dormann et al., 2008). A multiple component analysis was done on the 78 detailed examples presented in the 35 publications of corpus 4. This was done to highlight potential links between brownfield redevelopment project characteristics and their reuse using “factomineR” package (Lê et al., 2008).

3) Results and discussion

3.1) ‘Brownfields’: origins and uses of the term.

The term brownfield was officially introduced during a session of American congress field hearing on the 28th of June 1992 (Dehoorne et al., 2016; Jones & Welsh, 2010). It was created in opposition to the term ‘greenfield’, which was basically referring to sites that didn’t face any previous development pressure nor infrastructure (Green, 2016; Greenberg et al., 2001). For this review we considered as brownfields, all former industrial sites, factories, manufacturing area, quarries, mines (and other type of extraction site), developed military sites with military abandoned infrastructures, warehouses, abandoned waste management sites, harbours, railroads and roads if part of a transport hub. In opposition, agricultural brownfields with no constructed building, single building with no affiliated land and abandoned single road or rail track were not considered as brownfield sites.

For the period 1992-2019, 1804 publications were found using the term ‘brownfield*’ in their topic on WOS database. Despite the fluctuations in its definition the use of the term ‘brownfield’ increased strongly in the last 20 years from less than 40 publications in 2000 to 150 in 2019 (figure 2a). Three different periods could be distinguished in the use of the term ‘brownfield’ which are: appearance, internationalisation, and stabilisation phases.
Figure 2: Evolution of the use of the term “brownfield” in scientific literature

Bibliographical analysis of the term Brownfield in Web of Science core collection for years 1975 to 2019 (1804 documents).

a) Temporal evolution of the number and type of publications. Conferences that potentially led to an increase in publications are indicated in blue box. Pink diamonds represent the number of countries publishing documents with “brownfield” term in abstract, title or keywords.

b) Repartition of publication author origins according to the author addresses indicated in WOS database. For the EU (blue) the hatched part corresponds to articles from UK.

c) Comparison of EU, USA and PRC legislations and major programs devoted to brownfield redevelopment.

Dotted red lines delimitate major phases in the use of the term ‘brownfield’.
3.1.1) The appearance of the term brownfield in literature

Appeared in the early 90s on WOS database, the term brownfield was, for the first decade, mostly used in English-speaking countries with a predominance of the United States (20 to 40 occurrences per year; figure 2b). In 1993, US Environmental Protection Agency (EPA) established the “brownfield economic redevelopment initiative” (figure 2c). Through this pilot program local governments could apply for federal funds to assess brownfields and create the partnerships necessary to address barriers to reuse. The objectives were to promote less contaminated site redevelopment than the one concerned by “Superfund legislation” (Reisch and Bearden, 2003; US EPA, 2006). After its inception in 1994, this initiative quickly became a pillar for contaminated sites management (Thornton et al., 2007) also leading to the first appearance of the term brownfield in WOS database in 1994 (Figure 2a). Later, other incitation methods have been set in the US such as the ‘Brownfield taxes incentives’ in 1997, 2002 ‘Brownfield Act’ or 2018 ‘Build Act Provision’ (figure 2c). These legislations have strongly contributed to encourage clean-up of brownfields in the US (Sousa; 2005). In Europe, the legislation and research on derelict land started during the 80’s (Grimski and Ferber, 2001). The use of the term brownfield therefore only started to spread to these countries during the early 2000’s (Figure 2b).

3.1.2) Internationalisation of the term ‘brownfield’: Europe and People’s Republic of China cases

An internationalisation of the use of the term ‘brownfield’, characterized by the increasing number of countries involved and especially European countries (Figure 2a & 2b), was observed at the beginning of 2000. Four major international symposiums could possibly explain the diffusion of ‘brownfield’ term around Europe. The first International Conference on ‘Assessment, Rehabilitation and Development of Brownfield Sites’ held in 2002, was hosted by the Wessex Institute of Technology in Cadiz Spain. Following this symposium, and for all the other that followed, all proceeding papers were published in books called “brownfield sites”.
The publications of these books every two years led to a significant increase in the number of publications related to brownfield subject. In 2002 the proceeding papers issued from the first conference represented almost 40% all publications using “brownfield” in their topic. The early 2000’s was also characterized by the development of multiple European scientific networks centred on brownfields assessment or regeneration like CABERNET (Concerted Action on Brownfield and Economic Regeneration Network) (2002-2005). According to Nathanail et al. (2007), the CABERNET project produced four major outcomes including conceptual models creation, multi-stakeholder approach, and recommendation for future research on brownfield topic and European policies.

In contrast to the United States, the legal approach to brownfield sites in the European Union is indirect. The management of brownfields is based on texts on the protection of the environment, water and soil which will oblige the Member States to ensure the management of these sites. One of these examples is the environmental liability directive (2004/35/EC) which establish an environmental responsibility framework using the polluter-pays principle. This directive applied to water and biodiversity can also be applied for soil compartment, leading to significant impact on polluted brownfields (Garcia Burgues, 2009). Except for these kinds of indirect impacts, brownfields issues remain closely linked to states level leading to limited EU legal competence. In September 2006, an amendment of environmental liability directive part of the "thematic strategy for soil protection" was proposed by the European Commission (figure 2c) (Vanheusden, 2009). Implementation of this directive would have resulted in member states implementing measures to prevent soil pollution, by limiting the input of hazardous substances on or in the soil, identification and inventory and remediation of contaminated sites on their territory. However, some countries, including France and Germany, were opposed to the implementation of this directive. They emphasised the principle of subsidiarity and the negative impacts of the directive on the measures already implemented at the national level (Desrousseaux, 2014; Vanheusden, 2009). These oppositions led to a failure in the establishment of common policies in the European union. On figure 2 we can see that
the submission of this amendment is quickly followed by the "environmental crime directive" with which brownfields sites contamination may be seen and treated as a criminal offense (Vanheusden, 2009). The proposition of amendment and the environmental crime directive appearance coincide with a slight but constant increase of European research for the ‘brownfield’ subject with, since 2006, a constant increase of European countries participation (figure 2b).

In People’s Republic of China, research studies on brownfields were more recent (figure 2b) and also often soil pollution related. According to Li et al. (2015) three different periods can be observed in PRC policies with soil pollution management. The initial stage from, 1979 to 1982, stood when where China started to formulate principles of soil protection. It was followed by the period of prevention and control of soil pollution from 1983 to 2003. Then in 2004 policies shifted from the principle of prevention to the principle of remediation of soil pollution. The beginning of this third period coincided with the appearance of Chinese authors in the scientific bibliography (figure 2b). During this period multiple legal documents were published (figure 2c) (e.g. “the special act on national soil status, survey and pollution prevention (2004), the “Notices on Effective prevention and control of environmental pollution for industrial enterprise” (2004) or “Administrative measure for assessment and restoration of Industrial polluted site “(2009)). The explosion of the number of administrative, legal or technical documents publication during this period is clearly described in Li et al. (2015).

3.1.3) Brownfield term current and potential future use

A third period started since 2014 when the term brownfield became the reference term in articles dealing with industrials sites redevelopment projects. The number publications per year seems to have stabilized over the past 5 years around 150 publications per year. Authors from more than 35 countries used this term with a strong dominance of European countries (Figure 2 a & b). However, a period of 5 year is not enough to conclude to a real stabilization in the amount of scientific publications. Further studies on brownfield research production are needed to ensure this stabilisation phase. Furthermore, authors from new countries would for
sure join brownfield research in close future as the growing number of the publications from the “other countries” category in (figure 2b) let suppose. The deindustrialization processes, at the origin of brownfield sites creation, first started in the US in the late 60s quickly followed by European countries during the 70’s (Rowthorn et al., 1997, Adams et al., 2010). A same pattern seemed to occur in asian countries in late 80s explaining the delayed appearance of China in brownfield research (figure 2b). In a close future the contribution of other countries that are currently facing post-industrial society shift would therefore certainly increase.

3.2) Brownfields regeneration as a research field

An advanced research on Web of Science core database returned 382 publications dealing with at least one or multiple aspect of brownfield redevelopment. The analysis of the top 10 most used words in titles, showed that the term ‘brownfield’ present in more than 63% of them and often directly associated with the notion of regeneration or redevelopment and derived adjectives (44% of the case) (Figure 3a). This mean that in all term used in our research (e.g. wasteland; industrial sites etc…), ‘brownfield’ is the most used term one and often related to the idea of site redevelopment. The fact that these sites represent potential opportunities for sustainable urban development (Dorsey, 2003) is also reflected in the results obtained, given that the terms ‘urban’, ‘city’, ‘environmental’ and ‘sustainable’ represent 4 of the 10 most used terms in the publications titles.
More than half of the contributions were originated from European Union and close countries (51%) (Figure 3b), followed by the USA with 25% and People’s Republic of China (PRC) with almost 10% of the global production. Collaborations between areas was quite limited and most collaborations happened between the five former industrial areas which are Europe, China, USA, Canada, and Australia but never exceeding 11 multiple countries publications (MCP) (Europe/USA). European and American authors mostly tend to publish with authors from the same country with only 13 to 16% of multiple country publications (MCP) and 84 to 87% of single country publications. The results are even the same between members of the European Union (15.8% of internal MCP). On the opposite Chinese authors tend to seek for collaborators out of their country with more than 51% of their publications which are MCPs.

Figure 3: Global perception and collaborations in the brownfield regeneration research

a) Top ten of the words present in whole corpus publication titles

b) Map of countries collaborations and word associated with brownfield redevelopment for the period 1975 to 2019. The size of circles represent on the countries/area is proportionate to their contribution into the corpus. Countries of European continent were merged into one single entity. Blue lines represent the collaborations between countries, wider they are more the countries share common publications. Wordcloud analysis has been done on publication titles, word present in less than 10% of the titles were removed. The term ‘brownfield’ was also removed for clarity reasons. MCP: Multiple countries publications SCP: Single country publication.
That could be explained by the fact that Chinese legislation on brownfield assessment and redevelopment is relatively recent (3.1) compared to American and European ones.

Regardless the area, the term brownfield and redevelopment were part of the most used terms in each of the considered areas. However, considering different global areas, they were associated with different other terms (Fig 3b). These differences in language would explain the poor intercontinental collaborations in this research field. Silverthorne (2006) recognize through a literature review that definitions of regeneration success are strongly influenced by local values, between countries, stakeholders, and projects. One clear example is the use of the word ‘regeneration’ in the European countries versus ‘redevelopment’ (Figure 3a). The term ‘regeneration’ corresponds to an approach that do not exclude the possible reuse of the old infrastructure (Nathanail, 2011) taking in account past cultural and historical impact of some of these sites. At the opposite redevelopment, used in other area of the world, involves the creation of a whole new landscapes (Nathanail, 2011). Furthermore, Adam et al. (2010) highlighted specific differences between England and US perception of brownfield redevelopment. In fact, in England brownfields were seen as real opportunities for housing creation and greenfield preservation in urban area. At the opposite in the US brownfield sites redevelopment is often seen with a desire of economic improvement and greenfield consumption seems to stay more attractive than brownfield redevelopment for residential reuse (Adams et al., 2010).

3.3) Brownfield from past trend to future prospect

Osman et al., (2015) showed in Czech Republic, that brownfield characteristics like size, transportation availability, typology, or characteristic of surrounding strongly influence brownfield redevelopment successes and projects. Out of the 101 selected publications 35 were selected (see 2.2) and described a total of 91 brownfields redevelopment examples. Only the 78 that clearly display information like brownfield precise description or brownfield surrounding context were kept for analysis. Usually a major part of brownfields is, according to ISIC classification (International Standard Industrial Classification of All Economic Activities;
2008), former manufacture (Section C - e.g. chemical industry, metal product manufacture or textile industry etc…). They represent in our corpus more than 44% of all brownfields. They’re followed by waste management (23%), mine and quarry (11%), military (10%), transport and storage (9%). More than a quarter of these sites transformation (26.5%) led the creation of recreational like art district, greenspace or park. 20% of the detailed project included residential or natural area creation and 18% agriculture or forestry other types of transformation were less present (Figure 4). 35% of the publication present project with more than one transformation.

Soft-reuse is defined as “an intended temporary or final re-uses of brownfield sites which are not based on built constructions or infrastructure” (Bardos et al., 2016). It represents more than half (53%) of the reuse in the study case from the scientific literature. These could be explained by the change of perception and the global agreement of positive impact brownfield soft reuse on society, economy and environment (Bardos et al., 2016). However, it can also be explained by the fact research projects were more developed in the case of reuse as greenspace. This could lead to an overrepresentation of this type of site reuse in scientific literature.
A Chi² test revealed a significant dependence between brownfield past trends and future prospect with a P-value of $2.2e^{-16}$. Most of the former landfill tend to be transformed in agricultural zone, then natural area or recreation area (Fig 4). Actually most of the articles dealing with waste management brownfield tend to be transformed in managed forest (e.g. Rawlinson et al., 2004) and, when close to city, in parks and recreational areas (e.g. Klenosky et al., 2017; Li et al., 2019). It is also the case for former mine or quarry which tend more often to have a soft reuse. Defence brownfields which tend to be transformed into residential area in the major part of the cases. The other brownfield types did not exhibit any trend in term of reuse (Figure 4).

Other factors than past use can also potentially impact brownfield reuse (Fig. 5). Soft reuse tend to be more frequent after mine and quarry or waste management use, especially in rural areas.
Sites present in an urban context seemed to be more correlated with hard reuse project whereas rural sites have more often a soft reuse (Fig. 5). Recreational sites which could be included in hard reuse (like museum) or in soft reuse (like parks) are located in our MCA in the buffer zone between hard and soft reuse sites (Fig 5).

Redevelopment into natural areas occurred mainly in suburban and rural areas independently from the past use (Fig 5a, d & f), especially in North America. Furthermore, American brownfields seem to be less multi-type with only one type of redevelopment in general. No significant correlation link between past use and future prospect seem to be highlighted in this analysis (except for mine, quarry, and waste management more correlated to soft reuse). We could thus emphasize that former uses (and potential pollution) are not any more compelling...

Figure 5: Multiple component analysis of different brownfield characteristics that could potentially affect their regeneration
For each case same colour dot are part of a same group. Coloured square represent the barycentre of each group.
the reuse of brownfields sites. Their reuses are mainly imposed by the actual need of land uses.

Multiple site factors seem to influence brownfield reuse and especially soft and hard reuse. Soft reuse represents the majority of studied cases in the literature. However, residential area creation, commercial site creation or other hard reuse could potentially be more present in grey literature or project without any scientific studies, leading to a potential bias in our analysis. The majority of soft reuse are currently concentrated in suburban and rural areas, whatever they are mostly needed in urban area (Haaland and van den Bosch, 2015; Wolch et al., 2014).

Research on brownfield redevelopment was strongly developed in the last decades. However, there is still a gap in the understanding of underlying social and technical factors that influence their reuse. Furthermore, there is a huge lack of feedback on mid- and long-term success evaluation in terms of social, ecological or sustainability perspectives.

4) Conclusion and perspective

The desire for urban renewal and the integration of sustainable measures have led to an expansion of research on brownfields. Even if popularized in the late 90’s and the increase of available data, the problem of brownfields is still often studied and considered only on a local or national scale. Limited exchanges between countries, and those that despite attempts to set up a common definition (e.g. Alker et al.; 2000), lead to the existence of disparities in the perception or management of this type of sites (e.g. Adam et al. 2010). These sites often need a strong legal support to ensure their redevelopment, yet with the exception of the Us, these sites are often approached indirectly for the rest of the world through the prism of polluted sites and soils and environmental liability.
It is widely recognized that these sites and their redevelopment can be part of a sustainable development approach (Dorsey, 2003; Sousa, 2008). They can enable the integration of ecosystem services and a reconnection with nature in urban and peri-urban environments (e.g. De Valck et al., 2019; De Sousa, 2003). Vaz and Loures (2018) clearly puts forward the fact that, to do so, it is important to understand that all brownfields are not equal and that a more contextual approach is necessary. We have highlighted that, in scientific literature, apart from a few special cases such as mines and gravel pits, the past of these brownfields does not represent a determining factor in the type of redevelopment that is applied. The context in which these wastelands are found in terms of level of urbanization seems to be more preponderant.

Although scientific literature currently describes a certain number of cases of redevelopment, little attention has yet been paid to the success evaluation of this redevelopment. If we also wish to understand the impact of these projects and particularly those integrating green and/or natural spaces on the provision of ecosystem services or on human well-being, it will necessary to set up evaluation tools specific to this type of site and thus considering all aspects of brownfields redevelopment.
References


https://cran.r-project.org/web/packages/wordcloud/wordcloud.pdf (Consulted on: 26/08/2020)


