From Brownfield to Green Space-Typologies, Values, a nd Perspectives

2022, Vol.3 No.3
© Art & Design Research 2022
DOI: 10.37420/j.adr.2022.016
https://masonpublish.org

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Abstract
In the past 30 years, the development of brownland into green land has become an important way for the sustainable development and management of urban land. Fully understanding the various application scenarios and values of this approach is helpful to explore its efforts in providing ecosystem services and meet the development needs of different types of cities. This paper reviews the practice and literature of brownfield redevelopment from the perspective of landscape architecture, and obtains the process of its theoretical development and its understanding deepening. Through sorting out the relevant discipline literature, the seven main green space types and their potential broad benefits are summarized, and we realize that the brownfield itself has many values that cannot be ignored in the development process. On this basis, it proposes that there is a new cognition of the relationship between brownfield and green space.

Brownfields are mostly produced in prosperous industrial cities or declining and shrinking cities, which is the result of the transformation of urban social and economic structure. The presence of brownfields is thought to pose many problems such as environmental pollution, land idling, community decline, and urban space fragmentation. These problems not only cause a lot of inconvenience to the urban residents' life, but also hinder the further development of the urban economy. Therefore, how to redevelopment brownfield has become an important topic in the urban renewal transformation stage of the post-industrial era. In the past, brownfield redevelopment was generally dominated by industrial, commercial, residential and other types, aiming to attract private investment and generate more economic benefits, such as increasing jobs and raising fiscal taxes. However, with the deepening of the concept of sustainable development, people gradually realize that the redevelopment of brownfield should not only aim economic interests, but also consider social, ecological and other factors[1].

And urban green space is able to bring a variety of environmental, social and economic value of

one of the space type, mainly include: reduce pollution (such as noise and gas in the atmosphere or particulate pollutants), provide wildlife habitat, adjust climate, promote public health life, cultivate community pride and cohesion, provide jobs and through cooling and shading to save energy and so on. However, in the context of global urbanization, the land that can be developed as green space in cities is becoming more and more scarce. Therefore, the transformation of brownfield into green space (brownfield greening) has gradually become a hot direction for urban construction to optimize the green space system and restrict the urban expansion, which plays a decisive role in the sustainable land use mode and resilient development of cities. The recent climate warming and the COVID-19 pandemic has highlighted the urgent need for urban green space, and how to turn brownfields into green space to meet these challenges will become more critical in the future[2].

At present, the phenomenon of urban growth and contraction in China has emerged, and land urbanization and population urbanization do not matched for a long time, leading to the continuous growth of the number and area of brownfield[3]. How to better integrate the redevelopment of brownfield into the long-term urban planning and become the green infrastructure to support the sustainable development of the city is worth further exploration. Although domestic scholars have discussed the redevelopment of brownfield into green space in different directions, and there are many practice cases, the understanding of the overall value is still insufficient, and the relevant practices are mostly limited to limited project types. Therefore, this study expects through the integrity review related practice cases and research literature, summarizes the brown field redevelopment for green space contains the development of various types and bring a variety of value, so as to expand the landscape architecture about brown field redevelopment practice and research boundaries, and encourage more dimensions and category of thinking into the research and practice.

1.The definition of brown land

"Brownfield" is a planning term first proposed in Britain in the 1980s. This concept is "opposite" to "green field" (undeveloped land), meaning land that has already been developed. [4][5]The Small Business Responsibility Relief and Brownfield Revitalization Act defines brownfields as "real property that has its expansion, redevelopment or reuse due the known or possible presence of harmful substances, pollution sources or pollutants". The interpretation of brownfield in Europe is more diverse: in Western Europe, where densely populated and brownfield concentration are relatively high, the land is increasingly scarce and must be exploited. But in the northern Europe and Eastern Europe, where land supply is relatively small, the attention is more focused on the damage of site pollution to human health and the environment. On the whole, the definition of brownfield presents two orientations: (1) generally refers to the developed land, aiming to include more urban land in the exploitable category; and (2) focus on the known or possibly polluted land. At the same time, the brownfield has also been endowed with diversified concepts by scholars from different perspec-

tives, such as drosscape, terrain vague, manufacturing site, loose space, etc. Regardless of the specific definition of brownfields, the general consensus is that brownfields are developed land abandoned or very inefficient in cities and may be contaminated. Therefore, urban wasteland , urban clearing and urban wasteland can also be regarded as broad categories in brownfield and included in the research scope of this paper.[6]

2."From brown to green" from the perspective of landscape architecture

Transforming brownland into green space is not happening in recent decades. Founded in 1867, Parc des Buttes-Chaumont was built in Paris, France, as a typical case of the early transformation of quarries and landfills into public green space. In response, 29 years later, Shaoxing Xi 'an built the quarry with a history of more than 2,000 years into an exquisite open garden, becoming today's East Lake scenic area. Compared with the traditional strategy of covering up the traces of artificial intervention in the past, the above two practices happen to retain the topographic characteristics formed by the site excavation together, and the history of the site can be integrated into the shaping of the garden landscape. However, in the process of urbanization and industrialization, this simple environmental improvement strategy is gradually not enough to deal with the complex environmental problems of brownfield, nor can it adapt to the overall requirements and goals of urban development for the living environment.

Since the 1970s, a series of remarkable brownfield landscape practices have emerged. In 1975, the founder of the university of Washington department of landscape architecture Richard Haa g through industrial sites, site pollution control, the combination of public space construction design of Seattle Gas Works Park officially open to the public, become the first application of biological restoration technology of site pollutants in situ governance of industrial landscape, for brownfield development opened up a new paradigm. Landschaftspark Duisburg-Nord in Germany has become another benchmark of practice. —— landscape architect P eter Latz's transformation and reuse of industrial sites, as well as the bold retention of the natural process of spontaneous abandonment of the site, the two interaction to convey a unique place spirit . Soon after, Jam es Co r ner, then the head of the department of the University of Pennsylvania, led a team to transform the world's largest landfill into an ecological park, —— Clear Creek Park, the most ambitious plan to rebuild the brownfield in the 21st century.Jam es CornerThe concept of the "life landscape" was proposed in the plan, noting that the "life landscape" is "not just a place, but also a process". This process can not only restore the natural environment, restore wildlife habitats, provide popular science education and leisure activities, but also breed new adaptive management models and new energy utilization technologies, and form a "new ecology" over time. A review of these practices can be seen that the transition from brownfield to green space is no longer the construction of "static" open space,

but an important process and carrier connecting the past, present and future of urban land.

Compared with the practical fields, the relevant academic research focusing on the redevelopment of brownfields into green space is much later, and initially it mainly comes from landscape architecture. Among them was Niall G, then the head of the Department of Landscape Architecture at Harvard University. Kir kwood The collection of papers edited by the author is "Manufacturing Site: Post-reflective Industrial Landscape", which mainly reflects the engineering technology and design methods, related research progress and project cases in the local brownfield governance and landscape practice. Impact also include Charles Waldheim editor of the landscape urbanization reader and George Hargreaves participation edit "large park", the two proceedings to a certain extent, focus on the practice of brownfield landscape, the space composition, design technique and practical effect, and tried into the ecological, social, economic discussion."Landscape urbanism" is a planning concept advocated by Charles Waldheim et al. In his collection, believing that landscape energy can be used as a crucial "green infrastructure" for cities, thus providing a flexible space-time framework for dealing with various problems caused by excessive urban development. This "landscape as an infrastructure" understanding can be echoed by the many breakthrough brownfield landscape practices (some dating back to before the theory of landscape urbanism). In addition, all the above researchers have realized that the redevelopment of brownfield should adopt interdisciplinary cooperation to comprehensively solve various complex problems arising in the development. Although a lot of related research has been accumulated in the field of landscape architecture, landscape architects and scholars generally discuss the redevelopment of brownplanes under the framework of traditional green space from the perspectives of spatial aesthetics and environmental benefits.

3.A wide range of types and applications from brownfield to greenfield

"Brownfield Renaissance" and "brownfield regeneration" are the two main directions of brownfield redevelopment: "brownfield rejuvenation" aims to reuse these brownfields for residential or commercial purposes;[7] "brownfield regeneration" is to transform the brownfield into the green space needed for human and animals and plants to live or survive. This re-naturalization generally includes two strategies: manual intervention through different degrees of design and measures to provide different functions; relying on nature-led succession processes to restore the brownfield environment and provide ecosystem services. Although the research of the latter strategy is relatively backward, the research of brownfield pollution treatment mainly with a small amount of artificial intervention has gradually received attention, which brings greater possibility for the redevelopment of brownfield. For example, natural process-led mild remediation is characterized by low cost and low impact, and a wide range of remediation methods can focus on different pollutants and pollution levels, especially for the development of various green space types.

There is currently no universal development paradigm for transforming the brownfield into green space. Many factors, such as artificial and natural retention in brownfield, pollution status, the size and location of the site, the demands of community residents and the intentions of developers, will affect the type and function of green space. However, these types can be integrated into the network of green infrastructure, which have different effects on the overall benefits of the green space system. In the following discussion, seven types of green space developed from brownfields are summarized from the relevant literature.

1) Urban forest

Urban forest is a type of green space that has great potential in providing animal habitat, regulating climate and undertaking leisure activities. In the context of brownfield redevelopment, such green space is also called Industriewald, which is a nature-led brownfield reuse method. This new forest type, "spontaneously appeared in" or "artificially guided application" to abandoned industrial land, idle railway stations, urban wasteland and other scenarios. Because urban forest has relatively less capital investment, low maintenance cost and less management responsibility than traditional green space, some shrinking and declining cities also adopt this development strategy to maintain and improve the quality of life of their citizens. IBA Emsher Park in Ruhr, Germany, is an excellent case of this kind of green space practice. Industrial forests bring accessible natural experience to local residents and foreign tourists in the city and play an important role in nature science popularization and education.

2) Community garden

The abandoned land near the community is suitable to be transformed into a neighborhood garden shared by the residents. Neighborhood garden is the main place to encourage residents to communicate and interact and form community identity. Some gardens also have rental gardens to meet individual needs for food self-sufficiency and healthy eating. In many European cities, because of self-expression, self-realization and self-organization, more and more citizens participate in the creation of this cooperative space. In Shanghai, the community garden movement initiated by Liu Yuelai and others has also demonstrated the great potential of such green space at the social level.

3) Slow greenway

Transportation-oriented brownfield redevelopment is also often combined with linear green infrastructure. Reuse the abandoned transportation facilities in the city, or integrate the development of continuous brownland plots to create greenways suitable for walking and cycling. These Spaces can

encourage the public to choose green travel. If the remaining wilderness habitat of the brownfield is properly preserved, the residents can also subtly feel the charm of the natural succession process in their daily use. At the urban scale, adopting this brownfield redevelopment method can improve the accessibility of major communities such as universities and commercial centers, supplement and improve the original public transport system and connect it with the city. At the same time, some US cities see this as an important move to invigorate regional economies and attract investment.

4) Activities and leisure venues

The redevelopment of brownfield as an activity and leisure site can make up for the relative lack of traditional urban green space and meet the growing needs of citizens for sports activities and entertainment. A questionnaire survey of the community residents in North America shows that the activity and leisure space is one of the most popular types of brownfield redevelopment. Providing diverse and flexible functional spaces such as physical exercise, children's play, pet socialization, and large activities is key to the success of developing such green spaces.[8]

5) Biofuel cultivation

As a kind of clean energy, biofuel has been highly valued by people and has become the development trend in the future. But in the context of a growing population and an increase in food demand, it is also inappropriate to grow energy crops. Turning the brownfield on the edge of the city into biofuel farming becomes a means of land use. Such applications create reasonable profits by efficiently removing pollution from the soil, including heavy metals, and providing multiple ecosystem services by combining them with multiple remediation technologies, such as plant extraction (phytoextraction).[9][10]

6) Industrial heritage landscape

Industrial heritage landscape has a certain representative significance in the redevelopment of brownfield. Behind its landscape form are two interwoven cognitive threads: the redefinition of the industrial age, and the aesthetic shift to the wild nature in the post-industrial landscape. In the industrial heritage landscape, industrial civilization is no longer just the object of criticism from the perspective of environmental protection, but becomes a "cultural landscape" and the presentation of the complex relationship between people and the land. Therefore, this kind of landscape not only attaches importance to the protection and reuse of industrial buildings and artificial intervention traces (such as mines), but also values the "industrial nature" that spontaneously forms on the site. The Seattle Gas Gasworks Park in the above case and the North Duisburg Landscape Park in Germany are both excellent references for this change of thinking. Of course, due to the consideration

of public health and environmental quality, the control and elimination of site pollution is still an important theme in the industrial heritage landscape, and it is often expressed in the form of landscape language.

7) Informal green space

Informal green space refers to the "green space" in cities without maintenance or management, which is covered by spontaneous plants, with "a sense of wilderness", "temporary" and "flexibility". All kinds of brownfield fields have become informal green space because of people's spontaneous or accidental use. This kind of space can increase the potential available green space outside of parks, protected areas and other forms of green space, which has special environmental and social value, so it has gradually attracted the attention of scholars in recent years.

In addition to the above types, the combination of low-impact development and the transformation of brownfield into various kinds of rainwater management facilities, or the application of wildlife-friendly habitat technology to the green infrastructure such as ecological diversity roof of brownfield abandoned building roofs, all reflect the wide application of the transformation from brownfield to green space.

Turning brownfields into green space is also seen as the best option for shrinking urban renewal. [11] The economic structural changes of shrinking cities are generally accompanied by problems such as population loss and a large number of brownfields, which make these regions lack the competitiveness to attract investment and development. At the same time, the long idling of brown ground will increase local residents' concerns about site pollution and community violence. Faced with these difficulties, many post-industrial cities have chosen to transform brownfields into temporary green space as a transitional stage before finding a suitable development model. Usually, these cities also face the problem of budget tightening, and low intervention green space becomes one of the effective solutions. This kind of green space retains the semi-naturalized characteristics of brownfield, with less maintenance level and cost than that of conventional green space, but after the reasonable and limited design intervention can also promote urban biodiversity and provide extensive and flexible green space functions. Research shows that such strategies can not only "provide good public facilities for the public", but also play a positive role in "maintaining the urban framework and texture" and "reshaping the identity of residents".

4.Value studies from brownfield to green field

With the development of relevant practices and research, the overall cognition of the redevelopment of brownfield into green space is gradually deepened, and the research perspectives are increasing-

ly diversified.[8] All along, brownfield redevelopment has been closely linked with the theory and goal of sustainable urban development. However, compared with other development approaches (such as housing and commerce), most of the benefits of brownfield redevelopment as green land are not obvious. Helping decision-makers to fully realize that transforming brownfields into green space can achieve a wider range of opportunities and benefits will be of great help to their decision-making and planning process. Therefore, how to fully understand and excavate the various benefits generated in the process and results from brownfield to green land has always been the focus of scholars. De Sousa[8]The investigation and analysis of relevant practice projects in North America found that the redevelopment of brownfield into green space has great environmental value and can also bring considerable social and economic benefits, but to realize these values and benefits also faces many challenges different from the general projects. These challenges mainly include: responsibility and funding for environmental remediation, public concerns about site pollution, the difference between project objectives and actual effects, and the long-term maintenance and supervision of the site.

Applying a "logical model" helps to solve the above problems. [12][13] Logic model is one of the widely used management frameworks, which can explain and predict the relationship between the resources, activities and expected effects of the project. Doick, A tkinson application logic model of the redevelopment of green space case study, the results show that in the redevelopment for the development of green space, need to integrate the demands of different stakeholders, comprehensive environmental, social and economic goals and strategies, by conducting corresponding specific link can obtain the positive benefits of "development process", so as to reduce the potential conflicts and risks. For example, encouraging community participation in the evaluation, planning, and implementation phases of the site restoration can effectively reduce public concerns about the effectiveness of the restoration and reach more consensus. Therefore, to achieve various values and benefits, we cannot only focus on the later stage of development. These findings help the communication and advancement of the project and realize its short-and long-term value.

In addition, some scholars have studied the extensive benefits of brownfield redevelopment into green space from the perspective of ecosystem services.[14] Chowdhury et al have studied the potential of different types of green space types to provide ecosystem services. Different types of green space development will provide different services. For example, biofuel farms converted from brownfields can provide services, which most rainflood management facilities do not provide. Therefore, the green space construction projects usually encounter the problem of weighing the supply of ecosystem services, and it is necessary to consider the needs of different stakeholders for ecosystem services.[15] Washbourne et al. showed that different stakeholders' brownfield redevelopment into green space for different ecosystem services, indicating that most people are satisfied with the multi-purpose space. In terms of quantitative analysis, many scholars have also launched a

research.[16] Doick, et al., attempt to monetize the benefits of evaluating brownfield redevelopment into green land by quantifying specific ecosystem services. Z hong By combining the evaluation of ecosystem services, cost and benefit analysis and spatial pattern analysis, the potential of ecosystem services in different development modes is quantitatively evaluated at the urban scale, so as to provide reference and support for the decision-making and planning of brownfield redevelopment.

Although there is a diverse form of use from brownfield to green land, as a potential green infrastructure, the emphasis has been increasingly placed on its synergy with urban sustainable development goals. Therefore, this study refers to the environmental, social and economic aspects under the theoretical framework of sustainable development, and sorts out the value generated from brownfield to green land as a whole, and gives the possible correspondence according to different types of green space.

In addition to the above studies on the transformation of the brownfield green space, scholars are also gradually paying attention to the various characteristics contained by the brownfield itself, and the potential to combine these characteristics with the green foundation. Brownfields are themselves located in a "tra nsitional state" (tra nsitional state) that allows them to be well adapted to a variety of uses, such as protecting urban biodiversity and creating urban wilderness.

4.1. Brownfield and biodiversity

Limited by many factors, the abandoned or idle state of brownfield may last for a considerable period of time. Its diversified land use methods and lack of human management contribute to the occurrence of ecological succession and other natural processes, and the emergence of rich and unique community structure. Therefore, the brownfield itself has an important and unique value in promoting urban biodiversity and promoting habitat diversification.

First, brownfields can provide a wide range of habitats for different biological communities, not only the indigenous anime communities, but also even the rare and even endangered species. Support the survival of species populations in surrounding habitats by providing temporary nesting, food, water and shelter resources. Second, brownfields have complex environmental conditions that make urban habitats more diverse.[17] Bonthoux et al., McKinney concluded that brownfield habitat is mainly affected by six factors, namely, site age, area, soil, microclimate, human and animal interference, and plant community structure. These influencing factors are often quite different, so the site presents different habitat characteristics. In general, the more diverse the habitat is, the higher the biodiversity is. Therefore, in the process of brownfield transformation into green space, the different types of habitats formed under the superimposed influence of various factors are crucial to improving the biodiversity at the urban scale.[18][19] B run It proves the importance of

the brownfield as a component of the regional ecological protection network (such as the blue and green corridor in France) on the urban scale. These smaller abandoned Spaces distributed in the city greatly contribute to the formation of ecological continuity (ecological continuity).

4.2.Brownfield with "informal use"

Brownfields are not only influenced by natural forces, but humans may also use the site and shape its face in various ways. This type of use and space can be known as "in formal use" (in formal use) and "informal green space" (In formal green space).[20][21] Rupprecht, Pueffel, etc., the research on the use of such space by many urban residents, showing the diversified use of "informal green space", such as walking, picnic, party, vegetable garden and exploration, and has become a part of residents' life. The main reasons for residents to use such Spaces instead of traditional green Spaces are "close to home", "far away from people", "more different animals and plants" and "no constraint". It reflects that the public can get the needs and feelings that cannot be met in the traditional green space when using such space.

Brownfield also increases many opportunities for citizens to have contact with nature. Ecological succession under the lack of human intervention has different community characteristics and aesthetic charm at different stages, thus bringing rich natural experience. Children and adolescents using brownfields as an adventure park to explore nature have positive implications for their social, emotional and physical development.

Less attention is, "informal use" in the cultural level of urban development also plays an important role, European cities such as Berlin and Paris young people are keen on through the way of "bottom-up" transformation of land ownership fuzzy brownfield into outdoor bars, art creation, music show and other social cultural places, become the youth trend and fashion convergence (figure 1). Compared with common cultural industrial parks, these Spaces are more open and diverse, and different forms of "informal use" are shaping an innovative and inclusive urban culture. Although such cultural brownfields (cultural brownfield) are in line with the concept of using culture to strengthen community building, they are in a weak position in the economy-oriented development model. How to guide the cultural brownfield into the overall development of the city is a new challenge in urban planning and governance.[22]



Figure 1 Left: Artificial sand beach and outdoor theater in Berlin's Culture Container (photo by the author) Right: Outdoor Restaurant bar in RAW-Gelande, Berlin (Photo by author)



Figure 2: The transfer from brownfield to greenspace

5. Conclusions and Outlook

After this review and research, it can be seen that brownfield redevelopment for green space has a wide range of application types. These applications and practices can not only solve or reduce the possible problems of the site itself (such as soil pollution, low land use efficiency, poor public environmental perception, etc.), but also produce potential external benefits in the environmental, social and economic aspects (such as promoting the biodiversity of the city, improving the real estate value of the surrounding area, etc.). In-depth study of the values and benefits of different development types is helpful to expand the applicable scenarios of brownfield redevelopment (such as the "transitional" green space in shrinking cities).

So are brownfield and green space two completely opposite concepts? Whether in the natural dominant succession of natural system, or in human "informal use" under the interaction, or arouse memory and resonance of industrial heritage, brownfield under the years of material and energy exchange cycle obtained new characteristics and connotation, they are crucial to the realization of the green space multiple value. From this perspective, the transformation from brownfield to green space is not only the transformation of land nature and use mode, but also the profound extension of its characteristics and connotation in the diversified types and use modes of green space (Figure 2). Therefore, during the redevelopment of brownfield into green space needs to revisit the "natural process" and "social process" that occur on the site, so as to achieve broader value in the synergy of conservation, utilization and development. Based on the above understanding and requirements, this paper proposes three research directions to be further discussed.

1) Identify and analyze the social-ecological framework of the brownfield

To understand the full benefits provided by brownfields in urban environments, it is necessary to study how their social and ecological characteristics are interconnected and interdependent. At present, the classification of brownfield is mostly based on the past land use mode or the current pollution situation of the site, ignoring its unique environmental and social value. Therefore, it is necessary to identify and analyze brownfield features in a social-ecological framework, such as the key factors affecting brownfield features, and the social-ecological forces that function within these spaces.[23]

2) Protection and utilization of ecological benefits

Brownnfields may produce different ecological benefits at different scales (sites, cities, regions), such as: providing habitat for rare animals and plants, providing ecological stepping stone for migratory birds, and so on. The conversion from brownfield to green space should not be completely replaced by "old green" by "new green", but should complement each other and avoid unified and undifferentiated planning and management methods. Therefore, how to maintain the different types of green space of the integrity of brownfield ecosystem, encourage the public to perceive and participate in the ecological process, and realize the ecological, aesthetic, recreation, cognitive and other values —— requires the innovation of planning and design strategies and management mechanism.[24]

3) The process of multi-party participation

The redevelopment of the brownfield includes social, ecological and economic issues such as brownfield pollution control, site maintenance and management, and negative public perception. At

the same time, there are complex and contradictory demands among various stakeholders in the development process. The adoption of multi-agent participation strategies (such as "urban living laboratory" that encourage "interdisciplinary cooperation" and "jointly created by different stakeholders" can provide an effective way to resolve complex problems and reconcile different demands.

As an important land resource in the city, the development use and mode of brownfield are closely linked to the sustainable development of the city. While focusing on the brownfield problem and development potential at the site scale, we should also be aware that the brownfield can play an important role in enhancing the resilience and diversity of urban green space and ecosystems at urban and even regional scales. Considering the global rapid growth of brown field area and quantity, as well as the increasingly severe urban ecosystem service decline, climate change, brownfield redevelopment for green space should be regarded as an important opportunity to handle the relationship between city and nature, and need more from the perspective of human and natural coupling system to consider these problems comprehensively.

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