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INNOVATIVE BROWNFIELD REGENERATION FOR SUSTAINABLE DEVELOPMENT OF CROSS-BORDER REGIONS

BrownReg LLI-325

The project of the Interreg Latvia-Lithuania cross border cooperation programme 2014-2020

GUIDELINES

REMEDIATION OF DEGRADED AREAS

RESEARCH. PLANNING. MANAGEMENT.

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JELGAVA, 2019

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Guidelines
Remediation of degraded areas
Research. Planning. Management.

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AUTHOR'S FOREWORD

The industrial heritage left for us by previous generations can be very diverse. It can enhance the site's recognisability and identity, but this heritage can also appear as dangerous, abandoned and polluted areas in the urban landscape. One of the most characteristic industrial heritages in the Baltic States is that of the Soviet period, because it was during this time that extensive industrialisation processes took place. However, after the restoration of independence of the Baltic States, when the amount of production decreased, several industrial zones became deserted areas with high environmental pollution - ruins of industrial buildings, soil contamination with chemical and other products. Almost always, these areas have a significant potential to become important elements of public or public private outdoor spaces - parks, office or residential buildings, new industrial sites, sites of multifunctional character,etc.

To develop an understanding of the processes of brownfield formation and problems associated with them, as well as the possibilities to return them to the infrastructure of urban and rural territories and economic cycle, experts from various fields of Latvia University of Life Sciences and Technologies have prepared a guide book «Remediation of Brownfields. Research, Planning and Utilisation." This publication has been developed within the framework of the Interreg Latvia-Lithuania Cross Border Cooperation Programme 2014-2020 project "Innovative Brownfield Regeneration for Sustainable Development of Cross-Border Regions" (BrownReg, LLI-325). The BrownReg project started in 2018. Its aim is, in close cooperation with Latvia University of Life Sciences and Technologies and the municipalities of Latvia (Ludza) and Lithuania (Kupiskis and Ignalina), to acquire, implement and promote new experiences for innovative, locally-based and environmentally friendly brownfield regeneration. Within the framework of the project, the phytoremediation method was used in pilot areas of project partners in Latvia and Lithuania to clean up contaminated soils. Within the theme of brownfields, several informative and educational materials have been developed and thematic seminars and other activities have been organised.

One of the project activities is the development of educational and practical guidelines on brownfield remediation options. The publication includes both theoretical insights and practical examples. Therefore, we hope that this edition of the guidelines will provide a better understanding of brownfield issues and opportunities, and will serve as educational and practical information material for students, industry practitioners, spatial planners and decision makers in municipalities and other responsible governmental institutions.

Dr. arch. Daiga Skujāne
BrownReg project leader,
Latvia University of Life Sciences and Technologies
Dean of Faculty of Environment and Civil Engineering,
professor, lead researcher

RESPONSIBLE AND SUSTAINABLE LAND MANAGEMENT - A HERITAGE FOR THE FUTURE GENERATIONS

Probably many of us have heard the old Indian saying that we have not inherited the land but have borrowed it from future generations. Therefore, we must pay particular attention to how we use the land and how we pass it on to the next generation. Unfortunately, the data on land use do not show a positive trend, and the areas of productive land continue to decline. This is one of the reasons why, as global economic growth increases, so does the intensity of land use. This, in turn, explains why a number of international decisions have been made in recent years to ensure sustainable land use and prevent land and soil degradation. On 25 September 2015, the United Nations General Assembly adopted a resolution entitled "Transforming our world: the 2030 Agenda for Sustainable Development". This resolution sets out 17 sustainable development goals covering economic, social and environmental aspects. One of the goals of environmental management is to restore degraded land and soil and strive to achieve a land degradation-neutral world. Therefore, every effort to restore brownfield sites is significant and of great future value. In my opinion, the development of guidelines that offer new methods, including the use of ecosystem services for the regeneration of brownfields, is an important step in preventing us from being reproached by future generations.

Edvīns Kāpostiņš
Head of Land Policy Unit
Ministry of Environmental Protection and Regional Development of the Republic of Latvia
Spatial Planning Department

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Highlights

What are degraded areas?

From different information sources we can find three types of degradation:

Brownfield is an area that has been used in the past for factories or offices, and that could now be used for new building development. *From: https://dictionary.cambridge.org/dictionary/english/brownfield*

A brownfield is a property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.
From: https://www.epa.gov/brownfields/overview-epas-brownfields-program

Land Degradation is defined as the temporary or permanent decline in the productive capacity of the land, and the diminution of the productive potential, including its major land uses (e.g., rain-fed arable, irrigation, forests), its farming systems (e.g., smallholder subsistence), and its value as an economic resource. *From: International Encyclopedia of the Social & Behavioral Sciences, 2001*

Soil degradation is defined as a change in the soil health status resulting in a diminished capacity of the ecosystem to provide goods and services for its beneficiaries. Degraded soils have a health status such, that they do not provide the normal goods and services of the particular soil in its ecosystem.
From: http://www.fao.org/soils-portal/soil-degradation-restoration/en/

Why is regeneration of degraded areas important? What are the main benefits?

Land is a limited nature resource and its efficient use in the economy is an essential condition for the sustainable development of urban and rural areas.

Degraded areas are an unused resource that often has a negative impact on the perception and development of a particular area due to its visually low quality, presence of various types of contamination and low safety issues. Thoughtful revitalization and reintegration of these areas into the socio-economic circulation of the region **could bring significant benefits to the development of a particular place or region.**

How to use the guidelines?

Who should use the guidelines and what do they include?

The Brownfields Remediation Guidelines include both theoretical insights and practical examples and are intended as informative educational material for territory developers, planners, entrepreneurs, municipal decision-makers, students and those interested in the issue of brownfields.

Visual depiction used in the guidelines

Thematic parts

Main highlights of the topic

Practical examples of activities

RESEARCH

THE PROBLEMATIC ISSUES REGARDING BROWNFIELDS

Maija Bērziņa

The issue of degraded territories or brownfields in the Baltic States is a relatively new problem, the terminology of which has not yet been fully developed, recognized and used in political documents, legislation and educational field. In other countries, the issue of brownfield regeneration began to play an important role in political programmes in the 1970s.

In Latvia, brownfields as a particular problem was identified about ten years ago. There is still no extensive research or good practice in addressing the problem.

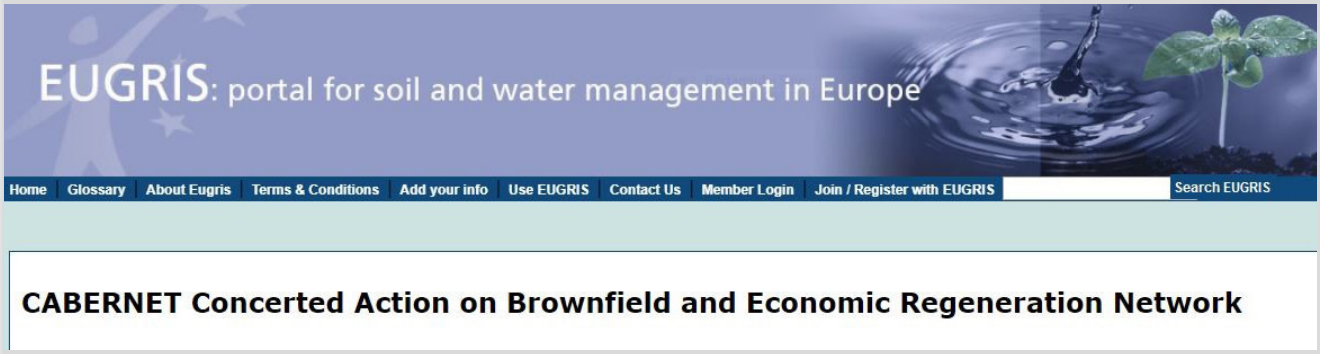
What is a degraded territory or brownfield?

In the Land Management Law the term "degraded territory" is used, which is a territory with a destroyed or damaged upper layer of ground or an abandoned territory of construction, extraction of mineral resources, economic or military activities.

THE EU EXPERIENCE. URBAN ENVIRONMENT

Within the European Union, the member states' experience is summarised through the development of a common strategy for the revitalization of brownfields. Currently, this work is being carried out within the international project "CABERNET" (CABERNET - "Concerted Action on Brownfield and Economic Regeneration Network" is a multidisciplinary European network of expert collaboration whose aim is to facilitate sustainable rehabilitation of brownfields, thus strengthening public welfare, environmental quality and economic recovery). The vision of CABERNET is to enhance the rehabilitation of brownfield sites in the context of sustainable urban development by providing an intelectual cooperation network for co-ordinated research and development of brownfield revitalization tools. Representatives from 21 countries participate in the CABERNET project. Riga Municipality is also involved in it.

In the CABERNET project materials brownfields are defined as sites (land,building, real estate) that have been affected by the former uses of the site and surrounding land, are derelict or underused, may have real or perceived contamination problems, are mainly in developed urban areas and require intervention to bring them back to beneficial use. (http://www.eugris.info/displayproject.asp?Projectid=4415)



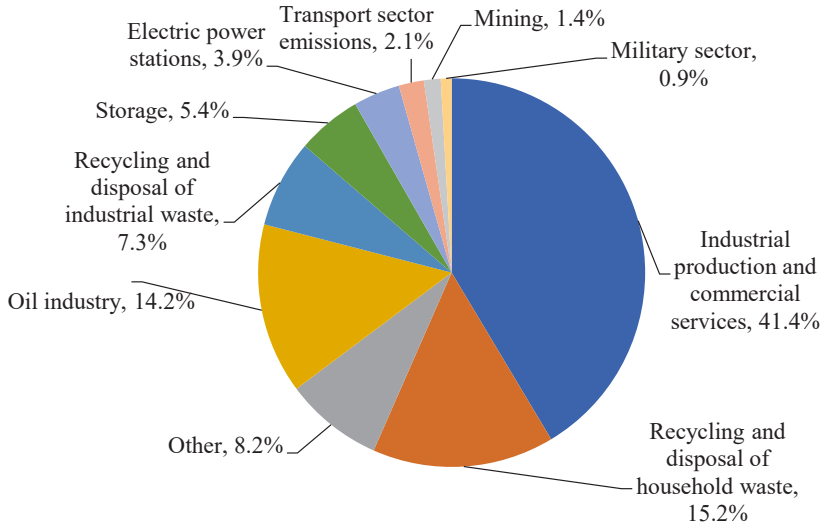
Portal for soil and water management in Europe (http://www.eugris.info/)

RURAL ENVIRONMENT

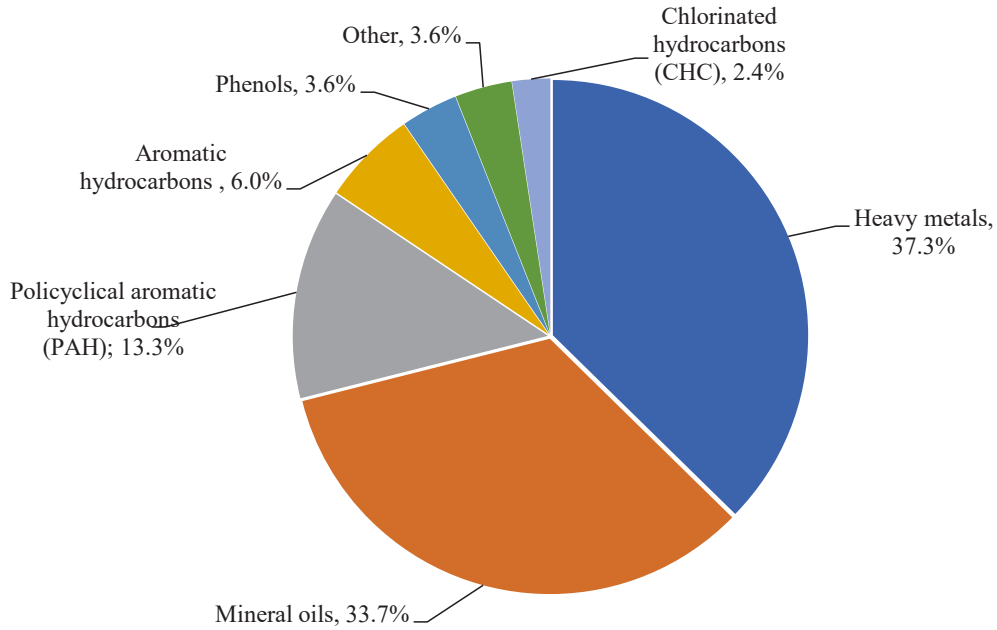
"Europe 2020 Strategy – a resource-efficient Europe".

Land must be managed with the most sustainable means possible, and the obstacles that hinder the improvement of land use efficiency should be eliminated.

This means that the land must be managed with the most sustainable means possible, and the obstacles that hinder the improvement of land use efficiency should be eliminated. The strategy sets out measures for soil recovery to reduce soil erosion and increase the amount of organic matter in it by the year 2050.



An overview of the activities causing soil contamination in Europe (Created by author)



An overview of the contaminants affecting the ground and groundwaters in Europe (Created by author)

IN LATVIA

The formation and existence of contaminated territories or brownfields is one of the consequences of civilization's activities, which has a negative impact on the environment as well as on the people themselves as direct causes of pollution. The emergence of such areas developed rapidly in the 20th century and is still ongoing. The main reason for this is economic development, which is accompanied by the use of natural resources and mostly their excessive use that is aimed at gaining maximum profit at the present moment rather than in the long term. All countries have experienced that, but especially those where there is a change in the political system of the country.

The 90s of the 20th century in Latvia was a period when brownfields emerged on a massive scale. Thus, the main groups of brownfields are associated with the territories where heavy industry and its servicing infrastructure were developed as well with abandoned military territories, unfinished buildings, etc. As a principal difference of Latvian situation from that of Western Europe is the political environment of brownfield formation. Since there are no large mining industrial objects in Latvia and coal mining or iron mining are not represented, the scale of brownfields is also much smaller than in those countries where the mining industry was or has been widely developed. This only means that the so-called continuous brownfields, when as a result of the collapse of the Soviet system a large number of non-functioning enterprises were left behind, which, as elsewhere were also found in Latvia - mainly

in the sector of the building material production, including construction, and wholly or partly developed but not recultivated mineral quarries (sand, gravel, dolomite, etc.).

Environmental Policy Guidelines 2014-2020. Chapter 3 - Soil and subterranean depths discusses the use and protection of soil and subterranean depths, as well as waste management issues. One of the policy objectives is to ensure the sustainable use and protection of soil. This section summarises the problems in the field of soil protection, the objectives to be achieved and the directions for action to achieve the objectives. The following issues are mentioned as most topical:

- the soil classification system used in Latvia differs substantially from that of the UN Food and Agricultural Organization's (FAO) classification.
- there is a lack of systematic information on soil quality: there are no upgraded soil maps; no accurate information on the areas affected by degradation, lack of recommendations and measures to be taken, based on these recommendations to reduce degradation, no regular and systematic evaluation of agro-technical properties of soil; impact of energy crops on soil;
- change of land use type, transforming agricultural lands into construction land, especially in areas adjacent to large cities;
- institutional uncertainty of soil management, since there is no public administration body whose functions or tasks would address the issue of brownfields.

The history of brownfields in Latvia is quite similar to other Eastern European countries and partly also to Western European countries. Most of these territories in Latvia have emerged after the collapse of the Soviet system. The determining factors of their genesis are associated with the transition to a market economy and as a result of that with radical changes in the production sphere. The most typical types of these territories and objects are the former (usually heavy) industrial areas and their servicing engineering infrastructure, abandoned military territories, residential areas around them, and non-finished buildings that were still under construction in the Soviet period. As a significant difference in the situation in Latvia from that of Western Europe the political conditions for the formation of brownfields should be noted.

The physically run down residential buildings of the 19th century and early 20th century that do not meet the standards of modern amenities and the manufacturing facilities of the Soviet period which were poorly constructed and occupy large areas, are typical examples of brownfields.

There are two main periods in which the structures and territories created constitute the bulk of brownfields. The first is the period of rapid industrialisation of the 19th century, when the zones of production were forming around the city centre and, with a significant increase in population, intensive construction of residential buildings took place. The second stage is related to the development of the industry forced on by the Soviet era and the ruthless extensive use of the territories. The degradation of these areas is associated with the transition to a market economy and, as a result of that - to radical changes in the production sector. The physically run down residential buildings of the 19th century and early 20th century that do not meet the standards of modern amenities and the manufacturing facilities of the Soviet period which were poorly constructed and occupy large areas, are typical examples of brownfields.

The Soviet legacy also includes contaminated sites (former waste dumps and quarries) and chaotic areas of community gardens. The question is still controversial whether the status of the brownfield should be assigned to community gardens located in the immediate vicinity of the city centre. The use of these territories is rather extensive and economically inefficient; the places are mostly eye sores and have a negative impression in the surrounding area. Although there are no capital structures in these territories, their complex reconstruction may be hampered by the need to take into account the interests of many owners of the community gardens and to find another place for establishing the gardens. These territories are unattractive to investors, since "green", undeveloped areas are still sufficiently available in Riga. This is evident by the relatively low activity of the real estate market in areas where brownfields have been identified.

The scale of brownfields in Latvia is considerably smaller.

The main reasons for the existence of brownfields in Latvia are the decrease in the number of inhabitants and the availability of "green" undeveloped areas and, consequently, the decline of market activity in brownfields. Copying the experience of other countries is not the best solution. Characteristics corresponding to the particular circumstances and needs should be chosen.

The current reasons for the existence of brownfields are different:

- socio-economic factors - lack of funds that prevent the renovation of old residential building development;
- administrative obstacles - for example, the protection of cultural heritage prevents free handling of historical buildings; the intensions of private persons contradict the requirements; speculative interests contribute to the degradation of historical building, since buildings and territories have not been managed for a long time;
- municipal resources and capacity: a lot of buildings in the centre are without elementary engineering infrastructure: no sewerage and heating;
- availability of free territories, opportunities to acquire them (there are no strictly defined restrictions on the use of "green" areas and respective priorities and support in the restoration of brownfields);
- ambiguities in the city's strategic development issues, including the development of production areas.

The existence of brownfields creates or reinforces the existing **problems in the spatial organization of the city, quality of the urban environment and efficiency of the use of the territory.** These problems are:

- the expansion of construction in natural areas that does not comply with the principles of sustainable development;
- anthropogenic load, soil, water and air pollution in the city, building development in "green" areas;
- inadequate urban functional organization that increases mobility and traffic intensity, creating additional transport problems;
- deterioration of the urban environment, insufficient physical and aesthetic quality of the building development;
- non-compliance of production and technical infrastructure with environmental requirements;
- losses in the urban economy due to the inefficient use of the territory.
- residential building development (houses in the state of severe degradation),
- former dump sites (equivalent to C) - contaminated sites,
- abandoned or inefficiently used transport infrastructure territories;
- inappropriately and inefficiently used port territories.

Initially, it may not seem that a derelict rail track, abandoned army barracks, or contaminated industrial territory are parts of serious problems in any country. The fact that there is even a lack of research on the extent of the damage caused by brownfields creates further difficulties. Even when brownfields had started to be recognized as a problem and were defined, there was a misunderstanding about the responsibilities, management and coordination issues. Case study: brownfields in the Czech Republic give an insight into how much effort the country has to invest in dealing with brownfield recovery and regeneration issues.

Brownfields are also closely linked to the transformation of an industrial society into a post-industrial. This means powerful changes not only in the economy and types of economy, but also in spatial standards, land and property use, types of administration and also in people's lifestyles. These new activities should be in a dominant position and redirected to brownfields as a priority. This is necessary in order to ensure the integration of brownfields into the new economic cycle and benefit from the use of the adjacent areas. In the post-industrial society, much less space is needed for production, but much more for services, consumption and entertainment. These new activities should be directed to brownfields!

Brownfields usually have an impact not only on their owners, but also on the wider community. In addition to the already mentioned factors that discourage investors, it should also be mentioned that the price of real estate in the vicinity of large brownfields is lower, the quality of the landscape deteriorates, health and safety problems are increased, the level of public services decreases.

The real estate aspect of brownfield revitalization is one of the most important aspects, as it usually determines the future use of the territory. Therefore, the location is the determining factor for any type of brownfield and a more serious problem is usually the integration into the area. Quite often, a brownfield, where there once was a large factory, is now in the hands of several owners. One of the owners may own the buildings, but not the land on which the buildings have been built or the access roads to them, etc. Buildings can be leased to several lessees on different terms for a very long time at a very low price

or with unfavorable rental terms. It happens that it could be the case when the lessees have made large investments in technical improvements which has reduced their taxes, and moving can cause problems with tax authorities. And all this is just the tip of the iceberg!

Brownfield projects are heavily dependent on fluctuations in the real estate market and the overall state of the national economy.

During an economic downturn, the demand for real estate drops. It is possible, therefore, that the completion of an already started project must be postponed until the situation improves and the demand returns. As already mentioned, the revitalization of brownfields requires experience and skills in the real estate market. It is a key area where there is usually a lack of local expertise.

The issue of brownfields is closely associated with the use of territory, territory administration, management, planning and spatial planning. In line with the EU principle of subsidiarity, these issues are a national responsibility. Standards, accepted practices, regulations and understanding of brownfields vary from country to country, therefore collecting comparable data is very difficult. Moreover, in a number of countries (according to the same principle of subsidiarity), the decision to use local territories has been handed over to the municipalities. The brownfields in the territories they oversee have a direct impact on the quality of life and real estate prices. As already mentioned, in most cases brownfields are privately owned, so their fate depends mostly on private investors. The system at regional and national levels should be such as to allow investors interested in brownfields to be attracted effectively (planning, property issues, support for project development, providing technical support to owners, etc.)

It seems obvious that brownfields are a problem of their owners. Owners and their attitudes towards brownfields may vary, but this is a problem affecting the immediate neighborhood. They discourage potential investors, reduce the value of real estate and hinder local economic development. Therefore, local residents and self-governments should actively deal with the following issues: identification of brownfields, reduction of their harmful effects, support to those brownfield owners who revitalize them, promotion of brownfield revitalization idea, demonstration of initiative in the use and planning of the territory, attracting public attention to brownfield projects, investing municipal funds in brownfield sites (schools, hospitals, institutions, etc.) to prevent the emergence of new brownfields.

However, the only way to find out whether a piece of land or an object is a brownfield is to have a site survey to determine the purpose of the property use, as well as some other, mostly qualitative, aspects. Undoubtedly, this is a very subjective way to identify a brownfield site. Greater objectivity to the process is given by photographing the site. Other necessary information (scales, building, infrastructure, size of the populated area, location, owners, their number, etc.) can be collected by analyzing documents (GIS, land cadastre, etc.). In order to reduce accounting costs, the information on each brownfield should be concise, but in a format that allows it to be analysed: grouped with the possibility of gaining a broader picture.

Not all countries have publicly available or collected registered national data. The same pertains to the collection and storage of the data across the country in a uniform format. In Central Europe, the most common are land and property cadastral registers and various planning documents. In some countries, such as the Czech Republic, Poland, Slovakia and the UK, property registers do not include details of the conditions associated with brownfields (environmental damage, etc.). At the same time, in countries such as Germany and Hungary, such transparency in national property registers is required by law (including possible damage, remediation measures, and obligations regarding the property). The brownfields do not yet appear in all planning documents, since in some Central European countries the identification and inventory of brownfields is not yet on the local and regional planning agenda.

Latvian legislation highlights the inadequate use of land and water and their pollution, but not the degradation of the landscape with old buildings and ruins. A lot of work still needs to be done to improve the legislation regarding brownfields.

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THE RESEARCH, PLANNING AND USE OF DEGRADED TERRITORIES

Mārtiņš Turks

In order to successfully restore and clean up degraded territories, an accurate process of identifying and determining land degradation is needed, which is a combination of several complex activities.

Land and soil degradation should be identified at the earliest possible stage of its formation, preventing it from worsening and expanding over larger areas.

Identifying a specific type of land and soil degradation would give us an idea of the situation and extent of this degradation in the country. Thus, the identification of territories affected by land and soil degradation is necessary for ensuring sustainable land management and the availability and topicality of the necessary information on land and soil degradation, and for promoting a move towards a neutral situation in land degradation, which means that no new degraded territories are forming, the existing ones are no longer expanding and their upkeep is ensured.

A number of high-level decisions have been taken in recent years on land and soil degradation and prevention issues, aimed at preventing these processes. On September 25, 2015, the United Nations (hereinafter - the UN) General Assembly adopted a resolution entitled "Transforming our world: the 2030 Agenda for Sustainable Development". This resolution sets 17 sustainable development goals, which include the economic, social and environmental dimensions. One of the goals of the environmental dimension (Goal 15) is: "to halt and reverse land degradation achieving a land degradation-neutral world". Point 15.3 of sustainable development aims by 2030 to combat desertification, restore degraded land and soil, including also the land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world. Although Latvia is not directly threatened by desertification and it has not been observed there, land degradation exists in this country.

The Global Indicator framework for the Sustainable Development Goals includes the indicator "Proportion of land that is degraded over total land area in the country" to assess the implementation of this goal. Accordingly, Latvia should also provide information on the proportion of degraded land areas. A report on the implementation of the resolution should be presented at least twice every fifteen years. The first report on the situation in Latvia: "Latvia's report to the UN on the implementation of the Sustainable Development Goals" (hereinafter - the Report") was presented in 2018. It was presented at the Annual High Level Policy Forum on July 17, 2018. The report was based on the mapping of Latvia's policy in 2017, in line with the UN's sustainable development goals. This means that in order to determine which of the UN sustainable development goals are to be prioritised in the case of Latvia and to what extent they are being implemented, mapping of the sub-goals for sustainable development has been carried out in accordance with the national policy. The report shall be based on a mid-term assessment of the implementation of the National Development Plan of Latvia and shall describe the progress and approach used to achieve sustainable development goals, as well as their assessment in the context of Latvia and a description of each of them. The report does not include information on the goals set out in sub-goal 15.3 of sustainable development (to restore degraded land and soil, and to strive to achieve a land degradation-neutral world) and their fulfilment. There are several reasons for this. Latvia has not developed and adopted a regulatory framework for the uniform identification and determination of land and soil degradation, so there are no specific data on how many areas affected by land and soil degradation the country has.

The EU strategy "Europe 2020 – a resource-efficient Europe"(hereinafter -the Strategy) highlights the need for land management with the most sustainable possible means and to remove obstacles which prevent the improvement of land use efficiency. The strategy calls for soil recovery measures to reduce soil erosion and increase organic matter in soil by 2050.

On January 19, 2003, Latvia became a member of the United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (hereinafter - the Convention). The Convention was adopted in Paris on June 17, 1994 and entered

into force on December 26, 1996. The fulfilment of the obligations under the Convention also applies to European countries, including Latvia, which means that Latvia must have a strong position against the removal of fertile soil. The use of fertile soil should be targeted for agricultural purposes or environmental protection, and soil fertility losses and soil degradation should be avoided as much as possible. A study on land and soil degradation related issues in the country was carried out in 2004 in the context of the implementation of the Convention. The results of the study show that there is practically no clarity at the national level on the situation and extent of land and soil degradation in the country.

Article 16 of Section 2 "Scientific and technical cooperation" states that the countries which have acceded to the Convention according to their respective capabilities agree to integrate and coordinate the collection of data, analysis and exchange of relevant short term and long term data and information to ensure a systematic observation of land degradation by applying advanced technologies for data collection, transmission and assessment of the extent of land degradation.

Taking into consideration the fact that Latvia is a member state of the Convention, it has committed itself to the principles set out in the Convention. Article 3 of the Convention lays down the principles by which Member States shall be guided to achieve the objective of the Convention. According to the first principle of the Convention, all the decisions relating to land degradation are taken with the participation of the public and local government,and the exchange of information takes place at both the national and local level. The second principle stipulates that all public administration institutions should work effectively without creating an additional administrative burden and new public administration institutions, and public finances, human resources, organisational and technical resources should be used rationally. The third principle stipulates that Member States should ensure cooperation among all levels of government, local governments, non-governmental organisations, and landholders to establish a better and uniform understanding of the nature and value of land and water resources in areas affected by land degradation, to work towards their sustainable use. It follows from these principles that municipalities should identify and determine land degradation using the information and resources already available, as well as the information obtained from national information systems.

Sustainable land management is a key factor in the rational use of land resources, including the reduction of land degradation and the clean-up of degraded territories. It is therefore necessary to ensure the prevention of land degradation processes as well as to work towards the rational use of the existing degraded areas.

Three terms related to degradation are distinguished by the Land Management Law: soil degradation, land degradation and degraded territory. Soil degradation is defined as changes arising from and taking place due to natural processes and human activity, which reduce the potential to use soil in the implementation of economic, environmental and cultural functions. Degraded territory is a territory with a destroyed or damaged upper layer of ground or an abandoned territory of construction, extraction of mineral resources, or an abandoned territory of economic or military activity. Land degradation is defined as reduction or disappearance of land and of economic or ecological value of the resources related thereto as a result of action or failure to act from people or as a result of natural processes.

Article 105 of the Constitution of the Republic of Latvia states that every person has the right to own property. However, there are also limits to exercising these rights, since property must not be used contrary to the public interests. The right to own property also includes the social obligation of the owner to society: the property must not be used contrary to the public's interest, which is based on ensuring the sustainable use of the land. The fundamental rights referred to in Article 105 of the Constitution may be limited, not only by narrowing the scope of a person's ownership rights, but also by imposing certain property-related duties on the person. The Land Management Law contains a number of legal provisions to limit land and soil degradation processes and reduce such unusable areas. For example, the law stipulates that the local government, when planning new building sites, should plan them first in the degraded territories or in areas where building has once taken place, and the territory is currently abandoned and unused. The land owner is obliged to inform the owner of the real estate when dispossessing the land that has been affected wholly or partly by land degradation. The Land Management Law lays down the obligations and rights

of land users in relation to the land degradation processes. In addition, the Law sets out measures for the management of the degraded territories and prevention of degradation in order to prevent the formation and expansion of land degradation and to ensure that the land user can make full use of the land without harming it. The Law also sets out the responsibility of land users when soil degradation has occurred as a result of their actions or omission of actions. The statutory framework of the Law is based on the need to obtain reliable and up-to-date information on degraded territories, their size and location in the municipal territory in order to promote sustainable planning for the development of the territory in the country.

At present the territorial development (spatial) planning in Latvia is being implemented at a national, regional and local level. Spatial planning is an important tool for the management of territories, linking land use in a particucular area to the priorities of the development of the territory, policies and approaches of the development programmes. The aim of spatial planning is to ensure efficient use of the territory, which contributes to both the economic development of the planned territory and the development of a quality life environment for each individual and society as a whole. The development planning process also includes the identification of the current situation, including the identification of the situation regarding degraded areas.

The process of land management is continuous. In order to promote the identification and revitalization of the territories affected by land degradation, the public sector – local governments and public authorities – should be particularly active.

Local governments should be responsible for the development of land management processes, they should ensure effective monitoring of land use and manage degraded areas within their administrative territory. At present, local governments have the right to be involved in the prevention of land degradation, and land users have to take into account the costs of recultivation on a voluntary or coercive basis. Currently, there is no complete and comprehensive information available in the country on the location and the extent of the areas of the degraded territories, at the municipal level. Such information is collected in individual municipalities, but in the absence of uniform criteria for the classification of degraded territories, this information is not comparable and usable at the national and international level.

However, those land users, whose action or omission of action have led to land degradation, to some extent also in the present situation without the regulatory framework for the identification and determination of land and soil degradation, can be punished. To some extent, this is in line with the principle of environmental protection, as set out in the Environmental Protection Law, " the polluter pays", which requires a person to cover all costs which are related to the assessment, prevention and limitation of the consequences caused due to his or her act or failure to act. However, the Latvian Administrative Violations Code (hereinafter – the Code) determines what acts or failures to act are to be recognised as an administrative violation and what administrative sanction may be applied to it. Several articles in the Code provide for administrative responsibility for the various land use offences, which are largely connected with land and soil degradation and aimed at preventing it. For example, the Code provides for an administrative fine for the land user for non-compliance with mandatory land protection measures to protect the soil from water or wind erosion or other processes that contribute to the deterioration of the fertile topsoil or its quality; for the non-fulfilment of measures to limit the spread of invasive plant species; for the pollution of air, land, forests or inland waters (surface or underground) by wastewater, chemicals, including hazardous or other harmful substances, and other activities which cause ground contamination. Many other laws also regulate the environment, including the reimbursement of losses caused to land.

In order to identify the specific types and the extent of the degraded territories within the country to classify them, the types of land and soil degradation should be determined according to common criteria. Considering the fact that degraded territories are formed due to the activities of people and as a result of natural conditions, the Ministry of Environmental Protection and Regional Development, in developing the draft Cabinet regulations on " Land and Soil Degradation Criteria and Assessment", proposes to identify the following types of land degradation - degraded building territory; non-

recultivated site of mineral extraction; non-recultivated waste dump or landfill; contaminated area with hazardous substances; site invaded by invasive plants, as well as the following types of soil degradation: water, wind and technogenic soil erosion, as well as physical and chemical degradation of soil. It should be envisaged that the local government may, where necessary, lay down further new criteria for the designation of degraded territories, provided that these identified types of land and soil degradation are not changed.

The local government, taking into consideration the specific circumstances and efficiency considerations, should be able to choose the way in which the land degradation is detected - using the information available to the local government, the information from the State information systems or by carrying out an on-site survey. The on-site survey in nature should not be mandatory, it should only be carried out if the information already available from the local government does not clearly identify the type of land degradation and due to that reason a decision on granting the status of a degraded territory cannot be made. In order to determine if the territory is degraded, it would be necessary for the local government to make a decision on the basis of uniform criteria for determining land and soil degradation. In addition, the local government, when making a decision on granting the status of a degraded territoty according to a new criterion for the determination of land degradation, would need to provide a justification for the establishment and eligibility of the new criterion for the type of land degradation determined.

Soil degradation can be determined by soil mapping or agrochemical research of soils. It should be noted that agrochemical research of soils in Latvia is carried out on the basis of a person's proposal and is currently conducted on a small scale in the country. Moreover, only historical soil maps made over the period of 1960 - 1991 in several rounds over different periods, using different soil classifications are available in Latvia.

A local government's decision may be made by the local government council or an institution authorised by it in accordance with the Law On Local Governments. The local government, in performing land monitoring in its administrative territory, shall co-operate with the environmental protection institutions, such as the State Plant Protection Service, which specialises in the identification and determination of invasive plants, as well as with the State Environmental Service. The State Plant Protection Service operates for this purpose in conformity with Cabinet Regulation No. 559 of July 14, 2008 "Regulations for Restriction of Proliferation of Invasive Plant Species - Sosnowsky's hogweed" and Cabinet Regulation No. 467 of June 30, 2008, " Regulations on Proliferation of Invasive Plant Species". The State Plant Protection Service performs monitoring and control of the distribution of invasive plant species, identifies the distribution of invasive plant species, performs monitoring of the spread of invasive plant species in agricultural land. Using a global positioning system, orthophoto maps and topographic maps, monitoring of the the spread of hogweed is carried out. The State Plant Protection Service supervises the State Plant Monitoring Information System, the aim of which is to maintain up-to-date information on the situation in the field of the plant protection situation in the country and to ensure free access to the information.

Determination of land degradation status for real estate would not have any limiting effects on economic activity and property in general.

Determining land degradation does not mean automatically imposing limits on a land unit. However, in such cases, the land user should be held under administrative responsibility and be obliged to clean up the degraded area. The purpose of identifying and determining land and soil degradation is to obtain information on the extent of the degraded areas in the country and to facilitate their arranging and clean up. Although the terms "land degradation" and "degraded territory" could be associated with a ban on economic activity or a restriction on a land unit, or with the fact that the degraded area cannot be used for economic activity, degraded territories should be defined in order to ensure the protection of the population against objects which endanger human health, life and the environment and to protect persons from the purchase of real estate affected by land or soil degradation. The state must have full and freely accessible information on abandoned, uninhabited residential houses or public buildings which are no longer in use or are no longer inhabited, abandoned or under-utilised areas or structures of a manufacturing nature which no longer function in performing economic activity or which do not fulfil their intended function and which, due to their physical depreciation, endanger a person's health or life, affect visual quality of the landscape or do harm to the environment.

In situations where land degradation prevention measures are necessary to ensure the public's common interests, the local government asks the land user to take these measures within a specified time period. If the land user does not take land degradation prevention measures within the period specified by the local government, it has the right to perform these measures, but the costs related to land degradation prevention measures shall be covered by the land owner or holder. In order to revoke the status of a degraded area, the land user would need to notify the local government and to submit documents attesting to consolidation or revitalization after the elimination of land degradation. The following documents could be considered as evidence of the prevention of land degradation:

- documents certifying the conservation, demolition, reconstruction and restoration of the building;
- documents certifying the elimination, stabilisation and disposal of the source of pollution, as well as documents certifying the results of the monitoring;
- documents certifying the measures taken to recover the mineral deposit extraction sites;
- documents certifying the measures taken to limit the spread of invasive plants;
- and other documents certifying land and soil degradation prevention measures, which would be considered valid by local government.

Taking into account the requirements of the Convention that the identification of territories affected by land and soil degradation should be carried out using modern technologies, the establishment of the information system for degraded territories would achieve a uniform display of these territories and ensure that such information is up-to-date and freely available. The creation of such an information system would provide the required information for identifying and determining land and soil degradation, using the data collected by some other institutions. Thus the accessibility to and the use of geospatial information which has once been collected from different data sources for particular needs (state defence, territorial development, environmental protection, etc.) would be provided for having and upgrading the information on the degraded territories. The introduction of a uniform classification and assessment of land and soil degraded territories, the input of these data into the information system and its public availability would ensure complete availability of land degradation information at the local and national level, which is essential for the implementation of sustainable land management.

Storing information and spatial data on the degraded territories in the information system would provide an easy and convenient processing of the data, carrying out spatial analysis, and the preparation of cartographic materials.

The spatial display of the data, the relationship between them and their interaction can provide an entirely new view of what is happening in the municipality in relation to degraded territories and many other important parameters associated with degradation, the assessment of which would be limited without the spatial aspect. Spatial data play an important role in making thoughtful and substantiated decisions. In addition, such an information system would make it easier for municipalities to attract investment in the rehabilitation of various degraded industrial business territories or other degraded territories, in order to adapt them to the deployment of new businesses or extension of already existing businesses, thereby contributing to employment and economic activity in these municipalities. The information system would allow one to assess the potential of the various degraded territories and determine the requirements and restrictions needed to use them, create favourable conditions for business development and the attraction of investments, including the European Union funds, to the degraded territories. The use of its data would allow to create the conditions for ensuring the quality of the environment, the prevention of environmental risks, to preserve natural and cultural heritage, landscape and biological diversity and to increase the quality of cultural landscapes and populated areas.

It should be noted that the information system on the degraded territories should provide for the following:

- public access to the residents of the country,
- maintenance and updating of the information entered,
- compatibility of information with other information systems.

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APPLICATION OF REGULATORY ENACTMENTS IN THE IDENTIFICATION AND MANAGEMENT OF DEGRADED TERRITORIES

What local governments and society need to know about the degraded territories

Velta Paršova

The Constitution of the Republic of Latvia provides that everyone has the right to own property. However, these property rights also include the owner's social obligation to the community - the property must not be used contrary to the public interest, and each owner is responsible for ensuring the sustainable use of land. The Constitution provides not only for the narrowing of the amount of property rights, but also the imposition of certain property-related obligations on the owner.

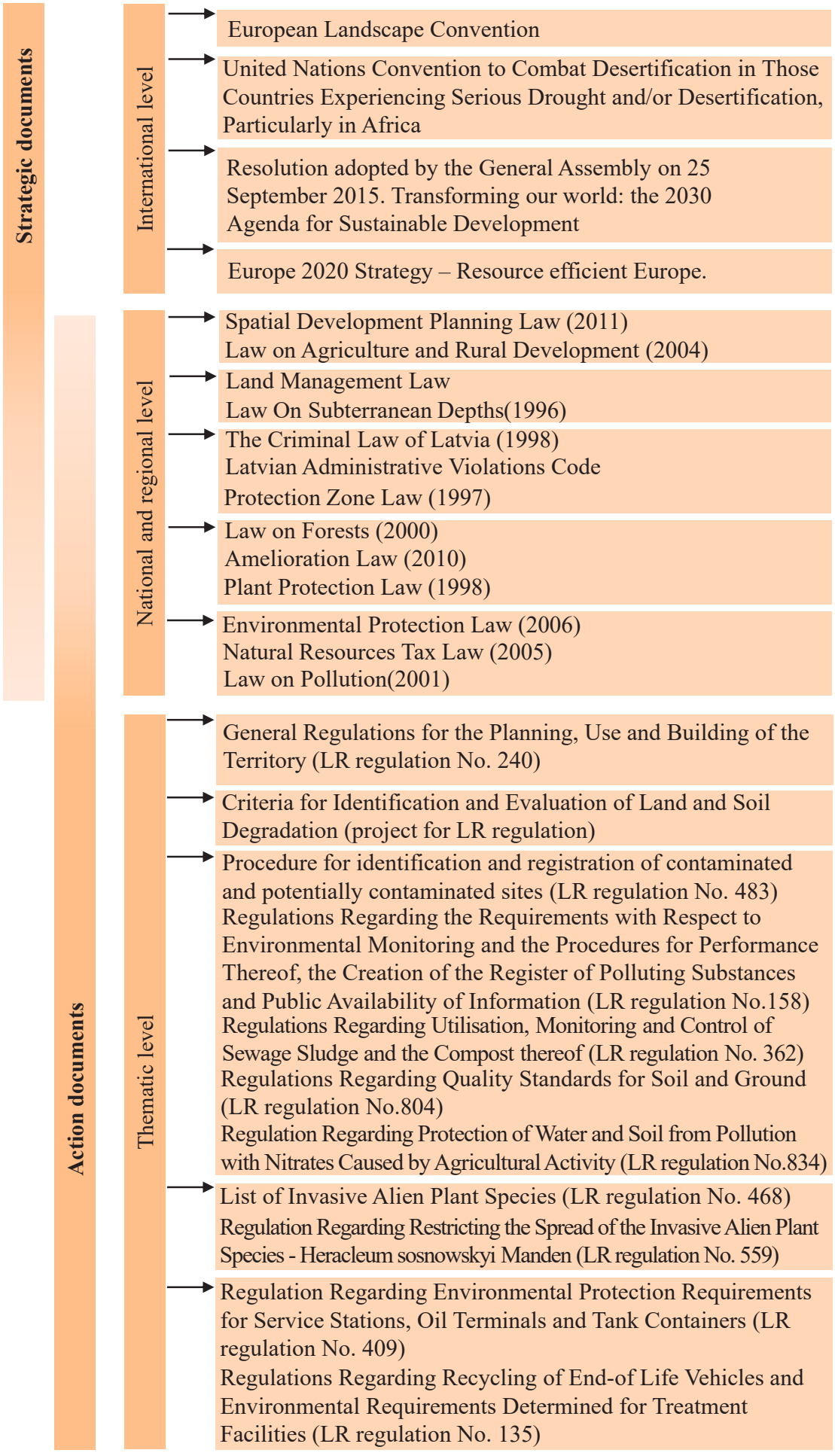
With the growth in the global economy, the intensity of the use of one of the basic natural resources - land - is also increasing. Land is a non-renewable resource with limited availability, so it is so important to ensure the conservation and sustainable use of the land's beneficial properties. As a result of human activity and natural conditions, land and soil degradation processes are observed, resulting in degraded territories.

There are a number of international high-level decisions that have been taken, aiming at the prevention of land and soil degradation.

1. The United Nations Convention to Combat Desertification/Land Degradation in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (UNCCD). In 2003, Latvia became a member state of this Convention. With regard to the European Union countries, the Convention provides for the fight against the waste of fertile soil, preventing the loss of soil fertility and even its degradation. The research carried out in 2004 showed that in Latvia the issues of land degradation and soil protection have been the least solved both at the national level and the level of the Baltic region. The Convention stipulates that states that have acceded to the Convention, including Latvia, in accordance with their actual abilities, need to integrate and coordinate the collection, analysis and exchange of all temporary and long-term data and information in order to provide systematic observations on land degradation using modern technologies for data collection, transmission, assessment and evaluation of land degradation. Each member state is committed to the following principles:

- all the decisions relating to land degradation are taken with the participation of public and local governments, and the exchange of information takes place at both the national and local levels;
- all public administration institutions should work efficiently at both the national and local levels, without creating additional administrative burdens and new public administration institutions, but if necessary, financial, human, organisational and technical resources should be increased where they are needed;
- member states establish cooperation among all levels of government, communities, non-governmental organisations and landowners to establish a better and unified understanding of the nature and value of land and water resources in the areas affected by land degradation and to work towards their sustainable use.

2. The UN General Assembly Resolution of 25 September 2015 "Transforming Our World: the 2030 Agenda for Sustainable Development". It is the first global document that provides extensive and comprehensive action. This resolution set 17 goals for a sustainable development, encompassing economic, social and environmental aspects. One of the goals of the environmental dimension is to "restore degraded lands and strive for a neutral world of land degradation". In order to assess the implementation of this goal, the Global indicator framework for the Sustainable Development Goals and targets includes the indicator “The proportion of land that is degraded over the total land area”. Consequently, Latvia will also have to provide information on the proportion of degraded territories in the country. At least twice in fifteen years Latvia will have to report on the implementation of the resolution. The first report on the situation in Latvia “Latvia's Report to the UN on the Implementation of Sustainable Development Goals” on 17 July, 2018 was presented at the annual High-Level Political Forum.



Levels of regulatory enactments regulating brownfield regeneration (Created by Author)

3. The EU Strategy "Europe 2020 – a resource-efficient Europe". Since 2010, it has been Europe's strategy to create fast, sustainable and inclusive growth. The strategy "Europe 2020" was an essential tool for the European Commission to prepare strategic guidelines for member states to implement structural reforms and a sustainable fiscal policy. The EU strategy "Europe 2020" is a comprehensive framework for the proper use of the EU budget resources and provision of regulatory incentives. National efforts towards progress in achieving the goals will be supported in the future. Land should be managed with the most sustainable means possible, and the obstacles preventing the improvement of land use effectiveness should be removed.

The underestimation of land degradation problems is due to a lack of public awareness and qualified staff in this area, as well as an unbalanced proportion of degraded lands and the degree of their degradation. Quite often socio-economic aspects are valued above environmental issues. This is mainly due to the lack of criteria to compare and evaluate them. The lack of an effective mechanism for tackling the problem of land degradation is evident, because in different national legislation documents different land use restrictions have been stipulated aiming to protect and improve land, but in practice they are not observed.

The cadastral information system data analysis in some cases shows the degradation of land and soil. After 1990, when land amelioration diminished to a considerable extent, swamps overtook the territories and the process of formation of agricultural land overgrown with shrubs and forests started, thus turning it into uncultivated land. These processes were also promoted by changes in the agricultural system, forms of ownership and land use subjects, as well as adverse economic conditions. As the land owners were not able to manage their land, they leased it to other persons or abandoned it.

Legislation regulating land degradation issues in Latvia

Although there was no uniform understanding and rules on land degradation in Latvia until 2015, however, after 1990, regulatory enactments were adopted to regulate certain aspects of land degradation.

1. Latvian Administrative Violations Code (1984). The code determines which action or inaction shall be acknowledged as an administrative violation and what administrative sanction may be imposed. In certain sections of the Code, the administrative liability and administrative sanctions are provided for various violations of land use, and, to a great extent, they are associated with the prevention of land and soil degradation. The Code lays down administrative sanctions to be imposed on the land user for the failure to carry out the mandatory land protection measures to protect the soil from water or wind erosion or other processes that contribute to the deterioration of the fertile top soil or its quality on the whole. The Code also stipulates the sanctions for the failure to undertake measures to prevent the spread of invasive plant species, non-use of agricultural land for agricultural purposes, violation of rules regarding the protection of subterranean depths, for the pollution of air, land, forests or inland waters (surface or underground) by waste water, chemicals, including hazardous ones, or other harmful substances, materials or waste, littering or other harmful effects on them.

2. Law on Subterranean Depths (1996). The use of subterranean depths is one of the land uses where improper usage can cause damage to the land. The purpose of the law is to ensure complex, efficient, environmentally friendly and sustainable use of subterranean depths, as well as specify the requirements for the protection of subterranean depths. One of the uses of subterranean depths is the search, exploration or extraction of minerals. The law defines the obligations of the users of subterranean depths. The most important duties of the users are the following: to remove and preserve the part of fertile soil for recovering and to recover at their own expense damages to the land caused as a result of the use of subterranean depths within the term indicated in the authorisation document or license.

3. Protection Zone Law (1997). The purpose of the law is to determine the types of protection zones and their functions, the basic principles for their establishment, modification and elimination of protection zones, the procedures for the maintenance and control of the condition of protection zones, as well as restrictions of economic activity in these zones. Surface runoff is associated with one of the main types of soil degradation - soil water erosion. In the Protection Zone Law, the environmental and natural resource protection zones, which are related to the prevention of water erosion, are determined along the coast of the Baltic Sea and Gulf of Riga, water bodies, watercourses and artificial water bodies. The Baltic Sea and the Gulf of Riga coastal protection zone has been established to reduce the impact of pollution on the Baltic Sea, to preserve the protection functions of the forest, to prevent the development of

erosion processes, to protect coastal landscapes, to ensure preservation and protection of coastal natural resources, including resources necessary for recreation and tourism and other territories important for society, and their balanced and continuous use. The surface water body protection zones are determined for water reservoirs, water courses and artificial water bodies to decrease the negative impact of pollution on aquatic ecosystems, to prevent the development of erosion processes and to restrict the economic activity in the flood zones, and to preserve the landscape characteristic of the area. The protection zones of surface water bodies in port areas are determined to balance environmental protection requirements and the economic development of ports in the interests of sustainable development, as well as to reduce the negative impact of pollution on aquatic ecosystems and to prevent the development of erosion processes.

To reduce the risk of erosion, in the protection zone of coastal dunes and on the beach, it is forbidden to drive motorised vehicles off the road, on the beach, in the forest and on agricultural land, if it is not related to the management or monitoring of these areas. It is also forbidden in these areas to modify the terrain, damage and destroy the natural ground cover, perform the final felling, except for tree felling for the elimination of the consequences of emergency situations, as well as for the elimination of the consequences of windthrows, windfalls and snow damage to trees. It is also forbidden to carry out construction in the forest, establishing parks, forest parks and agricultural land there, as a result of which the area is deforested and it is forbidden to carry out construction in the glades, establishing parks, forest parks and agricultural land without the appropriate order of the Cabinet of Ministers.

In order to reduce the risk of erosion in the protection zone of surface water bodies, it is prohibited to place extracted soil outside of the specially designated areas after the dredging or cleaning procedure of surface water body, performed in accordance to the regulations stipulated in the regulatory enactments; it is also forbidden to carry out clear felling within a 50 m wide zone, with the exception of cutting trees to eliminate the consequences of emergency situations and for the elimination of the consequences caused by windthrows, windfalls and snow damage to trees, as well as for the regeneration and management of floodplains.

From the sanitary protection zones it is important to mention the protection zones around landfills, waste disposal sites, high capacity incineration or processing plants for animal origin by-products which are not intended for use as food, and around waste water treatment plants. These protection zones are designed to protect the adjacent areas from the negative impacts of the above mentioned objects.

The main task of the safety protection zones is to ensure the safety of the environment and people during the operation of these objects and in the event of possible accidents, as well as the safety of the objects themselves and objects in their vicinity. From the types of safety protection zones, those ones around hydrocarbon extraction sites, oil, petroleum products, hazardous chemical substance and product pipelines, tanks, repositories, processing and transshipment plants and petrol stations may be associated with land contamination, and thus land degradation. The protection zones along these sites are designed to ensure the operation and safety of hydrocarbon extraction sites, oil, petroleum products, hazardous chemicals and products pipelines, tanks, repositories, processing and transshipment plants, petrol stations, and to minimize their potential negative impact on the environment and people during the operation of these facilities and in the event of possible accidents.

4. Plant Protection Law (1998). The purpose of the law is to regulate the activities of natural and legal persons in the field of plant protection in order to prevent the import, introduction and spread of harmful organisms in the territory of the country and the European Union, as well as to ensure that plant protection measures and plant protection products do not have an adverse effect on human health and on those species of animals, which people raise or utilise for food, and also on the environment, and to prevent the accumulation of plant protection product residues in the manufactured products, in the soil and in water above the allowable limits. In this law, one of the competences of the Cabinet is related to invasive alien plants. This means that in the field of plant protection, the Cabinet of Ministers issues regulations regarding the procedures for restriction of the spread of the invasive alien plant species, the procedures for including them in the list of invasive alien plant species, the procedures for monitoring and state supervision and control of these species, the procedures by which state administration institutions provide information regarding distribution of invasive alien plant species in other target groups of land use. According to the Plant Protection Law, the Cabinet of Ministers also specifies the information that

shall be freely available to the public on the spread of invasive plant species, as well as the regulations on the state institution that controls the introduction of invasive plant species on the state border and the procedures by which restriction measures regarding the spread of invasive alien plant species shall be performed, and the methods for restricting particular invasive alien plant species and, if necessary, labour protection requirements.

5. The Criminal Law (1998). The law provides for criminal liability for offences against the natural environment - violating of regulations with regard to management and use of the land, subterranean depths and water, contamination of land, forests or inland waters (surface or underground) with hazardous or other harmful substances, materials and waste, littering or causing any other substantial harm to the natural environment, property or economic interests.

6. Forest Law (2000). Forest law regulates the use of forests. The purpose of the Law is to promote economically, ecologically and socially sustainable management and use of forests, for all the forest owners or legal possessors, ensuring equal rights, inviolability of property rights and independence of economic activity and establishing equal duties; to regulate the conditions of state forest land management and expropriation. It defines the responsibilities of individuals in the forest. The forest owner or legal possessor is obliged to regenerate the forest stand after the effect of felling or other factors if the basal area of the forest stand has become smaller than the critical basal area, as well as ensuring the tending and thinning of the regenerated or established forest stand. This is important to avoid the formation of degraded land and the forest soil would not rinse away. When managing forests, the forest owner or legal possessor is obliged to comply with the general requirements for nature conservation in order to ensure the preservation of forest biodiversity, to preserve the forest's ability to protect the soil from erosion, protect surface and underground waters from pollution, preserve essential elements of cultural heritage in the forest, and promote the forest resilience and adaptation to climate change.

7. Law on Pollution (2001). The purpose of this law is to prevent or reduce harm caused to human health, property and the environment due to pollution, to eliminate the consequences of harm caused, as well as to prevent pollution caused by polluting activities or, if it is impossible, reduce emissions into soil, water and air. The law also imposes an obligation to prevent or, if it is impossible, reduce the use of non-renewable natural resources and energy through polluting activities, and reduce the generation of waste, exposure of humans to environmental noise and limit the odours caused by polluting activities.

Identification of polluted and potentially polluted sites within the national territory and their registration should be provided, measures for investigation and remediation of polluted and potentially polluted sites should be specified.

The law also aims to reduce greenhouse gas emissions and increase the removal of carbon dioxide by taking into account cost efficiency, ensuring participation in the European Union Emissions Trading System, and fulfilling the commitments of Latvia in relation to greenhouse gas emissions reduction and removal of carbon dioxide, as well as public participation in the decision-making process in relation to the issuing of permits for the performance of polluting activities or review of such permits, as well as in relation to the division and allocation of greenhouse gas emission allowances. The law also lays down procedures for the prevention and control of pollution, as well as procedures for the identification of particularly sensitive areas, including requirements for urban and other communal waste water treatment, and for the protection of water and soil in the areas concerned.

The quality of the environment is determined in comparison with the desirable quality of air, surface water, underground water, soil and subterranean depths or other environmental components, for the provision of which environmental quality requirements expressed in quantitative indicators are determined. In order to prevent harm to human health or the environment and ensure the preservation of biological diversity within a longer period of time, considering the necessary security reserves, the Cabinet of Ministers has determined the quality requirements for air, surface water, underground water and soil.

8. Law on Agriculture and Rural Development (2004). The purpose of this Law is to provide a legal basis for agricultural development and to specify a sustainable agricultural and rural development policy in accordance with the Common Agricultural Policy and the Common Fisheries Policy of the European

Union. The law prescribes the use and preservation of land. In order to ensure the sustainable use of agricultural land, agrochemical research on soils should be carried out to obtain information on the level of fertility of agricultural land and its changes, and to establish and maintain the agrochemical research database of soils. Planting of woody plants in the land used for agriculture is allowed if it complies with the requirements of the spatial development planning documents and if the plantations are established in the drained areas in accordance with the requirements of the Land Reclamation Law, and if the relevant territory is not included in the state register maintained by the Nature Protection Board as a specially protected habitat (including the grassland habitat of EU significance) or a habitat of specially protected species.

9. Natural Resources Tax Law (2005). In this law, natural resources are mentioned as part of nature, also soil, ground, subterranean depths, air, waters and biological diversity. The purpose of the natural resources tax is to promote economically efficient use of natural resources, restrict environmental pollution, reduce manufacturing and sale of environment polluting products, promote the implementation of new, environmentally friendly technologies, support sustainable development of the economy, as well as ensure environmental protection measures financially. The law prescribes the procedure for calculating the tax on the extraction and use of natural resources.

10. Environmental Protection Law (2006). The purpose of the law is to ensure the preservation and recovery of the quality of the environment and the sustainable use of natural resources. In this law, soil and subterranean depths are referred to as natural resources. Provisions regarding the liability for the damage caused to the environment are applicable to damage, including the cases if it is caused by air pollutants, done to specially protected nature territories, micro-reserves, as well as specially protected species and habitats, water, soil and subterranean depths.

The Environmental Protection Law establishes the principle "the polluter pays", according to which a person shall cover all the costs related to the assessment and limitation of pollution or elimination of the consequences caused due to his or her activities.

11. Amelioration Law (2010). The purpose of the law is to ensure such mechanism for the management of amelioration systems which promotes sustainable management and use of natural resources, ensures the water regime necessary for the safety and welfare of inhabitants, development of infrastructure, as well as construction, operation, maintenance and management of amelioration systems in rural and urban lands. The State limited liability company "Real Estates of the Ministry of Agriculture" issues technical regulations for the following activities in ameliorated lands and in operational protection zones around amelioration structures and devices for construction of engineering structures, their relocation and conversion, structures and utilities for the extraction of mineral resources, establishment of forests, planting of woody plants in the ameliorated agricultural land, as well as for other activities where it may interfere with the operation of the amelioration system regime.

12. Spatial Development Planning Law (2011). The purpose of the law is to ensure such spatial development planning that would raise the quality of the living environment, ensure sustainable, effective and rational use of territories and other resources, as well as targeted and balanced development of the economy. The principles included in the Development Planning System Law, as well as the principles listed below shall be observed in the spatial development planning:

- the principle of sustainability - spatial development is planned to preserve and create a quality environment for existing and future generations, balanced economic development, rational use of nature, human and material resources, development of natural and cultural heritage;
- the principle of succession - new spatial development planning documents are developed, evaluating the existing development planning documents and their practical implementation;
- the principle of equal opportunities – sectoral and territorial interests, as well as the interests of private individuals and those of society are assessed in conjunction with the aim of promoting the sustainable development of the territory concerned;
- the principle of continuity – spatial development is planned continuously, flexibly and in cycles, supervising this process and evaluating the latest information, knowledge, needs and possible solutions;
- the principle of openness - public involvement and transparency of information and decision making in spatial development planning and the development of documents is ensured;

- the principle of an integrated approach - economic, cultural, social and environmental aspects are coordinated, spatial development priorities are coordinated at all planning levels, cooperation is target oriented, and the impact of the planned solutions on the surrounding territories and the environment is assessed;
- the principle of diversity - spatial development is planned, taking into account the diversity of natural, cultural environment, human and material resources and economic activity;
- the principle of coherence - spatial development planning documents are developed by coherently coordinating them, and evaluating other spatial development planning documents.

MANY CABINET REGULATIONS HAVE BEEN ISSUED BASED ON THIS LAW

1. Cabinet Regulation No. 483 of 20 November 2001 "On the Procedure for Identification and Registration of Polluted and Potentially Polluted Sites". The polluted and potentially polluted sites are identified by collecting and summarising the information available from different sources on the economic activities that might have affected the quality of soil, ground and groundwater. Analysing the direct information on economic activities and environmental sensitivity parameters, the activities that cause pollution, activities that may cause pollution at the appropriate production level, as well as activities that at certain level of production volume and use of technologies might cause soil, ground or groundwater pollution are assessed. In order to identify potentially polluted sites, they are divided into two categories depending on the possible level of pollution of soil, ground and groundwater and the sensitivity of the site to pollution.

2. Cabinet Regulation No. 804 of 25 October 2005 "On Soil and Ground Quality Standards". The regulation defines quality standards for soil and ground. The soil and ground (rock and sediment layers below the soil where economic activity can be performed) apply to any soil and ground in the territory of Latvia, regardless of its use. The target value (A value), precautionary limit value (B value) and critical limit value (C value) are determined as soil and ground quality standards.

3. Cabinet Regulation No. 362 of 2 May 2006 "On the Utilisation, Monitoring and Control of Sewage Sludge and Compost". The regulation prescribes the procedures for the utilisation, monitoring and control of sewage sludge and the compost thereof. Sewage sludge or compost shall be placed for temporary storage and compost shall be prepared in a stationary place specially provided and organised, preventing sewage sludge and compost, as well as filtrating water from entering the soil, surface waters and groundwaters. In stationary temporary storage places, sewage sludge or compost may be stored no longer than three years. If sewage sludge is stored for more than three years, it shall be done in comformity with the regulatory enactments regarding waste management. There is a procedure for the utilisation of sewage sludge and compost for soil fertilisation of agricultural lands, while Chapter 5 sets out the procedures for the use of sewage sludge and compost in forestry. Treated sludge and compost is allowed to be utilised in plantation forests, but for afforestation of low fertility sandy soil, degraded forest soils and burnt-out forests only compost may be used. Procedures for the utilisation of sewage sludge and compost for the recovery of degraded areas have been identified. It is defined that degraded areas are the areas with destroyed soil cover which have resulted from the mining of clay, sand, gravel, and other minerals using an open-cut method (in quarries) performing earthworks in construction, as well as other work related to the destruction of the soil cover.

4. Cabinet Regulation No. 468 of 30 June 2008 "List of Invasive Alien Plant Species". This regulation was issued in accordance with the Plant Protection Law. In this regulation only Heracleum sosnowskyi Manden is mentioned as an invasive alien plant species.

5. Cabinet Regulation No.559 of 14 July 2008 "Regulation Regarding Restricting the Spread of the Invasive Alien Plant Species – Heracleum Sosnowskyi Manden". This regulation prescribes the measures for restricting the spread of invasive alien plant species - Heracleum sosnowskyi Manden (hogweed), the procedure and the methods of its eradication; the procedures by which the State admimistration institutions shall provide information on the spread of hogweed at the target groups of land use and the content of the information that shall be freely available to the public and labour protection requirements, when taking the measures for restricting the spread of hogweed.

6. Cabinet Regulation No. 158 of 17 February 2009 "Regulations Regarding the Requirements with Respect to Environmental Monitoring and the Procedures for the Performance Thereof, the Creation of the Register of Polluting Substances and Public Availability of Information".

The Regulation prescribes the requirements with respect to the environmental monitoring and the procedures for the performance thereof, the procedures by which an operator shall control the amount of emissions and perform monitoring, as well as the procedures by which an operator shall provide information regarding the results of monitoring. The regulation prescribes the organisers of environmental monitoring, who, according to their competence, shall organise or perform land monitoring in accordance with the laws and regulatory enactments regarding the fertility level of land used for agriculture and changes therein, protection from pollution with nitrates caused by agricultural activities, protection against ionising radiation and in accordance with the legal acts of the European Union, as well as observations of geological processes on the coastal areas of the sea and rivers in accordance with international conventions. The data and information shall be kept in the register of polluting substances for 10 years.

7. Cabinet Regulation No. 135 of 22 February 2011 "Regulations Regarding Recycling of End-of-Life Vehicles and Environmental Requirements for Treatment Facilities". The regulation prescribes that the least possible harm is done to the soil, and territories are not degraded.

It is stipulated in the regulation that in the places intended for the storage (including temporary storage) of end-of-life vehicles prior to their treatment or intended treatment, the operator shall ensure surfaces impermeable by water and polluting substances with the provision of surface spillage collection facilities, decanters and cleanser-degreasers, as well as the equipment for collecting and treatment of sewage and rainwater in accordance with regulations regarding the emission of pollutants into water. The operator should also ensure the storage facilities for dismantled, re-usable elements, also for storage of oil-contaminated elements, to prevent oil leakage.

8. Cabinet Regulation No. 409 of 12 June 2012 "Regulation Regarding Environmental Protection Requirements for Service Stations, Oil Terminals and Tank Containers". The Regulation prescribes the environmental protection requirements laid down for the operation of service stations, oil terminals and tank containers. When drawing up a building design of a service station or an oil terminal, the operator shall ensure the investigation of groundwater and soil by assessing the initial pollution against the quality standards of total petroleum hydrocarbons, benzene, toluene, ethylbenzene and xylenes, on the basis of criteria laid down in laws and regulations regarding the quality standards of soil and ground and regarding the quality of surface waters and groundwater quality. It has been established that regular monthly tests of tanks and pipelines should be carried out to detect the signs of fuel leakage (fuel humidity, spots), as well as signs of fuel leakage on concrete, soil and the like.

9. Cabinet Regulation No. 240 of 30 April 2013 "General Regulations for the Planning, Use and Building of a Territory".

Each municipality needs to have a Spatial plan in whose regulations for the planning, use and building of a territory, risk and problem places are listed, including those places and problem areas, that affect soil and land degradation.

Flood risk areas, geological risk areas (risk areas of landslides, mudslides, watercourse erosion risk areas) and potentially polluted areas are mentioned as risk territory problem areas associated with soil and land degradation. As regards the general rules for the use of water, forests and farmland, the requirements that should be observed in economic activity are also included in order to avoid soil and land degradation.

10. Cabinet Regulation No. 834 of 23 December 2014 "Regulation Regarding Protection of Water and Soil from Pollution Caused by Agricultural Activity". The regulation prescribes the requirements for the protection of water and soil from pollution with nitrates caused by agricultural activity and protection of particularly sensitive areas, which are subject to increased requirements for the protection of water and soil from pollution with nitrates caused by agricultural activity, determining their boundaries and criteria for their determination.

Land management law

Currently, spatial planning in Latvia is implemented at the national, regional and local government levels. Spatial planning is an important territory management tool that links land use in a specific territory to the development priorities, policies, and development programme of that area. The task of spatial planning is to ensure efficient use of the territory, which promotes both economic development of the

planned territory and creation of a quality living environment for each individual and society as a whole. The development planning process also involves identifying the current situation, including the identification of the situation of degraded territories.

There are a number of issues pertaining to land use and protection that are not adequately regulated in the existing regulatory enactments, but this regulation is required to ensure the sustainable use of land, for example, land use and protection principles, prevention of land and soil degradation, the role of national and local authorities in land management, public water management, etc.

The main regulatory enactment, currently regulating land degradation issues in Latvia is the Land Management Law. According to this law, a degraded territory is a territory with a destroyed or damaged upper layer of ground or an abandoned territory of construction, extraction of mineral resources, economic or military activities. Land is degraded where the industrial or other activities or inactivity have caused so much damage to it that it is impossible to start its purposeful utilisation without special recovering measures. The aim of the prevention measures of land degradation is to promote the sustainable use of land.

The law provides explanations of the terms used. "Soil degradation" and "degraded territory" are defined in the context of the the UN Convention to Combat Desertification/Land Degradation in those Countries Experiencing Serious Drought and/or Desertification, as well as other documents of international conferences. Obligations of land users are listed to ensure rational use of land, reduce and prevent the risk of degradation.

The local government may give out the land, which is included in the Land Fund, for a short-term lease for up to 12 years without building rights to ensure its rational use and to prevent its degradation (e.g. overgrowing of agricultural land). If a private person does not use this leased land unit according to the terms of the lease agreement, the local government is entitled to unilaterally terminate the lease. The purpose of this requirement is to ensure that the land is properly managed. Detailed requirements for the leasing of these land units should be laid down in the regulations of the Cabinet.

There are processes listed that can cause land degradation (for example, land abandonment, which, according to the Rural Support Service surveys, is a current trend in Latvia), and types of soil degradation that affect the condition and quality of the land and soil, as well as future land management, and on which the measures laid down in the law for land and soil protection depend.

Agricultural land where soil erosion has been detected can be used when anti-erosion measures are taken, such as the introduction of appropriate crop rotation, loosening of topsoil lower layer, liming of soils, application of contour farming in field treatment. Regional environmental boards and local governments are the responsible institutions that can set special rules for land use in areas where land or soil degradation processes occur or where there are risks of degradation. It has been established that in order to ensure the common interests of the society, the local government has the right to take the necessary measures to prevent land degradation, regardless of ownership, by giving prior notice to the owner. The expenses related to the measures for the prevention of land degradation shall be covered by the real estate owner. This rule is needed, for example, to allow the local governments to timely prevent land degradation or its risk, for example, to prevent floods or their risks in polder territories where, due to some permanently unused land unit, amelioration systems are damaged causing flooding of other land units. Liability of land users is also envisaged if soil degradation has occurred as a result of their action or inaction.

The law clearly defines the rights and obligations of land users, measures to prevent the risks of land degradation and measures of land protection, while not significantly increasing the burden of administrative procedures. The statutory regulation allows the local governments to use various tools effectively to meet the needs and interests of society while respecting the interests of land owners.

The law stipulated that already in the first half of 2015, the Cabinet of Ministers regulations on classification of the degraded territories and their identification should be developed. Taking into account the specifics of these regulations and limited public administration capacity, it was only in 2018 when the regulations were developed for land and soil degradation criteria, the procedure for identifying and assessing land and soil degradation and its probability, as well as the procedures for determining land and soil degradation prevention measures and monitoring their implementation.

10. Draft Regulations of the Cabinet of Ministers "Land and Soil Degradation Criteria and Evaluation Rules"

Pursuant to the formulation of Section 13, Paragraph one, Clause 6 of the Land Management Law,

the draft project "Regulations Regarding Land and Soil Degradation Criteria and Assessment" is being developed with the aim of ensuring the sustainable use and management of land and soil by promoting the identification and recovering of unmanaged, abandoned and damaged lands.

The draft regulations define the criteria for land and soil degradation and their classification, the procedures for the identification and assessment of land and soil degradation, as well as measures for the prevention of land and soil degradation and supervision of their implementation.

The purpose of the regulations is to ensure sustainable land management and the availability and topicality of the information on land and soil degradation, as well as promote the advancement towards a neutral situation in land degradation. The aim of the classification and assessment of the land and soil of the degraded territories is to provide uniform and classified information on degraded territories at both national and local levels. Currently, there is no information available on the extent of degraded territories in the country, as well as on the areas of such territories at the level of local governments. In some local governments, such as in the city of Riga, such information is compiled, but since there are no common criteria developed for the classification of the degraded territories, this information is not comparable and it cannot be used to prepare information for international institutions. Likewise, situations occur when degraded territories, depicted in the spatial plans of local governments, have inaccurate borders, in some spatial plans information on degraded territories is only mentioned in the textual part of the plan, and in some spatial plans this information is included neither in the textual nor in the graphical part.

Considering that it is necessary to achieve a unified representation of degraded territories in one place and to ensure the topicality and availability of information, work is already underway on the development of the Information System on the degraded territories. This information system is intended for entering and presenting upgraded information on land and soil degradation. The information system is currently under development, with the Ministry of Environment and Regional Development cooperating with the State Regional Development Agency.

This information system will provide the information necessary for the identification or detection and determination of land and soil degradation using the data collected by other institutions, thus providing geospatial information collected from different data sources for specific purposes (national defence, territorial development, environmental protection, etc.) and accumulated in one place, as well as provide access to information on the degraded territories and maintenance of its use. The introduction of the classification and assessment of degraded land and soil territories and the entry of the data into the information system and its public availability will ensure full availability of information about land degradation at local and national levels, which is essential for the implementation of sustainable land management.

When developing a spatial plan the information system will give an opportunity for the local government to develop the spatial plan for the sustainable and rational use of its territory and resources, assessing the degraded territories located in the administrative territory of the local government. The information system will make it possible to assess the potential of the various degraded territories and to determine the requirements and restrictions for their use, create favourable conditions for business development and investments, including the attraction of the European Union funds for the degraded areas, as well as create conditions for ensuring environmental quality, prevention of environmental risks, preservation of natural and cultural heritage, landscape and biological diversity, and make it possible to improve the quality of cultural landscape and populated areas.

The draft regulations shall define the criteria for land and soil degradation and their classification, the procedure for the identification and assessment of land and soil degradation, and apart from that also providing for the measures for the prevention of land and soil degradation and the supervision of the implementation of these measures.

The regulations provide for the classification of land degradation into the following types and using the following criteria for their determination:

- degraded building territory:
  - degraded residential or public building territory or structure;
  - degraded industrial territory or structure;

- degraded military territory or object;
- non-recultivated mineral extraction site - degraded mineral extraction site;
- waste disposal and storage at sites not designated for this purpose;
- land contamination - contamination of the territory with hazardous substances;
- spread of invasive alien plants - territories invaded by invasive alien plants.

The regulations also provide for indications according to which the degraded territories or objects are recognized.

A degraded residential or public building territory or structure is an abandoned or uninhabited residential or public type of building where economic activity no longer takes place or which is not inhabited, and which due to its physical wear and tear endangers human health or life, affects the visual quality of the landscape or causes damage to the environment.

A degraded industrial territory or structure is a territory which is abandoned or incompletely used area or structure of industrial character which no longer sustains economic activity or which no longer performs the functions intended, and due to its wear and tear endangers human health or life, impairs the visual quality of the landscape or does harm to the environment.

A degraded military territory or object is an abandoned military territory or object that has been used or intended for military purposes, but currently no economic activity is taking place there.

A degraded mineral extraction site is an abandoned and non-recultivated mineral extraction area if its area is more than 0.5 ha.

Disposal and storage of waste at the sites not designated for this purpose is a landfill and waste dumping grounds where no recultivation, monitoring and suitable management have been carried out after their closure, as well as disposal and storage of waste take place in the sites not designated for this purpose.

Contamination of the site with hazardous substances is characterized by local or dispersed contamination of the soil by pollutants to a degree that poses a significant risk to the normal functioning of the ecosystem, and appropriate actions must be taken to mitigate this undesirable impact on the basis of the criteria laid down in the legislation on soil and ground quality standards and in regulatory enactments regarding the quality of surface and groundwater, as well as taking into account the regulatory framework for the procedure of identification and registration of contaminated and potentially contaminated sites.

The territory is invaded by invasive alien plants, if at least one invasive plant grows there.

Taking into account the different environmental, geographical and other aspects of the territory of Latvia, the regulations provide that the local government may, if necessary, additionally determine new criteria for the identification of degraded land without changing the types of land degradation. Such a provision has been established because there are foreseeable risks for the probability of developing new, so far non- conceptualised criteria for the identification of degraded lands. As the information will be entered into the Information System, it will only be possible to add land degradation criteria, which means that it will not be possible to change or add new types of land and soil degradation. When deciding on granting the status of the degraded territory, the local government will need to justify the decision to establish the new criterion and its compliance with the type of land degradation specified in the regulations.

The municipality is the institution that can identify and determine land degradation in its administrative territory when implementing land monitoring. According to the regulations, the State Plant Protection Service shall cooperate with the local government in the identification and determination of the type of land degradation "Spread of Alien Invasive Plants". Both institutions are already cooperating. The State Plant Protection Service may enter into a cooperation agreement with local governments on the content and form of information contained in the database of the spread of invasive alien plant species in the national information system on monitoring of cultivated plants which is under its control. The State Plant Protection Service carries out state supervision and control of the spread of alien invasive plant species. Using global positioning systems, receivers, orthophoto maps and topographic maps, the monitoring of the spread of invasive plant species on agricultural land is carried out.

Taking into account the specific circumstances and considerations of efficiency, the local government may choose the way to perform the identification and detection of the land degradation by

using information available to the local government, information from the state information systems, or by conducting a site survey in nature. This real-life inspection or surveying in nature is not obligatory, it should only be done if the information already available to the municipality does not clearly identify the type of land degradation, and accordingly the decision to grant the status of degraded territory cannot be made. The State Plant Protection Service, in its turn, detects land and soil degradation in accordance with the procedures specified in the regulatory enactments regulating environmental and plant protection.

In order to identify a territory as a degraded territory, the municipality shall decide on the granting of the status of degraded territory in its administrative territory. The decision determines the type of land degradation according to the established criteria and their classification. The owner of the land or the legal possessor (land user) shall be informed of the decision taken within 10 working days. The decision may be taken by the council of the local government or its authorized institution in accordance with the requirements of the law "On Local Governments".

In order to cancel the status of degraded territory, the land user shall notify the local government after the land degradation has been prevented and submit the documents confirming the clean-up or revitalization of the territory. The documents certifying the prevention of land degradation are: documents certifying the preservation, demolition, reconstruction and restoration of the structure; documents confirming the elimination, stabilisation and disposal of the source of pollution, as well as documents confirming the results of the monitoring; documents certifying the measures taken for the recultivation of the mineral extraction site; documents confirming the implementation of measures to control the spread of alien invasive plants and other documents confirming the land and soil degradation prevention measures which the municipalities consider to be valid. The municipality shall evaluate the documents submitted by the land user for the prevention of land degradation and, if necessary, carry out a site inspection in the nature area and take a decision regarding the cancelling of the degraded territory status. The decision is sent to the land user within 10 working days.

The regulations provide for the establishment of measures for the prevention of land and soil degradation and for monitoring their implementation. The local government and the State Plant Protection Service are those institutions which, in accordance to their competence, supervise the compliance with the requirements of the regulations. When deciding on granting or canceling the status of the degraded territory, the local government shall enter the information on the degraded territory into the Information System under the supervision of the Ministry of Environmental Protection and Regional Development. According to the State Information Systems Law, the Information System manager is the Ministry of Environmental Protection and Regional Development, while local governments provide the functions of the information system user. The access to the information system will be provided only to authorised users. The information system provides the possibility to perform the authenticity identity check of the system's user.

The information system will provide access to the data on potentially degraded areas, from the Latvian Geospatial Information Agency on the ruins, from the state Ltd company Latvian Environment, Geology and Meteorology Centre on polluted and potentially polluted sites, mineral extraction sites, etc. and from State Plant Protection Service on the spread of hogweed. These data will make it easier for the local government to identify the degraded territories in its territory, and the data can also be used for depicting the degraded sites, determining their areas and entering the information available to the municipality in the information system. The information system manager ensures the availability of information in the national single geospatial information portal (www.geolatvija.lv). The information system manager also develops guidelines for the assessment of degraded territories, the information requirements to be included in the information system and the procedures for their inclusion, as well as the requirements for uniform information display.

The legal framework for the regulations will have a direct impact on local governments and land users. Local governments and the State Plant Protection Service are obliged to provide, maintain and update information on degraded territories. The legal framework will promote sustainable land use by identifying these territories and promoting their clean-up or revitalisation at both national and local level. This will also affect the business environment in terms of obligations for small, medium-sized enterprises, micro-enterprises and start-ups to clean up the degraded territories located within their

property or revitalise them. The cleaning up of land and soil degrading areas that contribute to the environmental pollution will be identified and promoted, thus resulting in a positive impact on the environment.

To initiate the identification of a degraded area, no additional costs will be incurred for a physical or legal person. Additional costs for natural or legal persons will arise only if the status of the degraded area is determined by the decision of the municipality about the property. The clean up or revitalization of the degraded territories must be carried out by the land user. The same pertains to the costs related to this work. If the land user does not perform the activities specified in the decision within the specified term, these activities shall be performed by the local government at its own expense. The costs associated with the measures to prevent land degradation shall be passed on to the land user.

Taking into account the different environmental, geographical and other aspects of the territory of Latvia in order to provide additional explanations for the use of the information system, as well as for the identification and determination of land and soil degradation, the Ministry of Environmental Protection and Regional Development is developing guidelines for the assessment of degraded territories and their representation in the information system.

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PLANNING

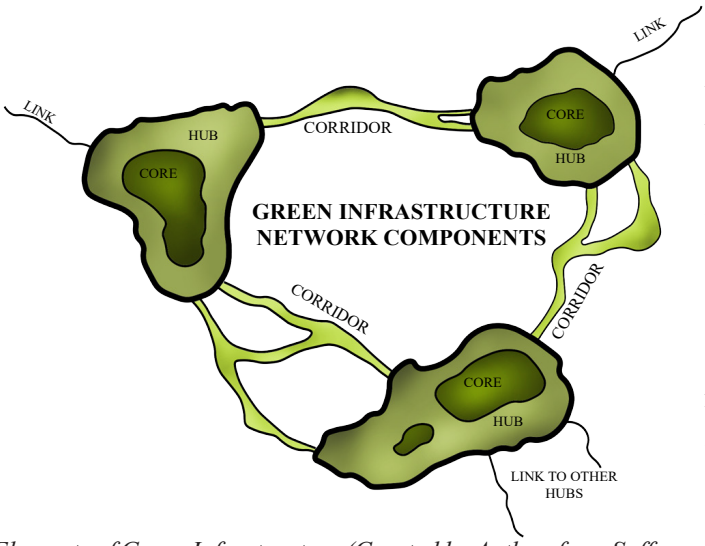
THE ROLE OF DEGRADED AREAS IN THE GREEN INFRASTRUCTURE. LANDSCAPE ECOLOGICAL APPROACH IN THE REVITALIZATION OF BROWNFIELDS

Daiga Skujāne, Aiga Spāģe

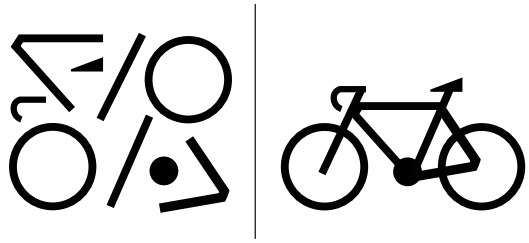
Brownfields tend to range from overgrown agricultural land to abandoned and often contaminated former industrial or storage sites. What they do have in common, however, is that they are all unused and abandoned areas that can be revitalized and developed in a way that they could bring the greatest contribution to the economy and development of a particular place. Often, brownfields cannot be revitalized in a short period of time due to the lack of financial resources or the time needed to eliminate contamination. Then for some period these territories may become areas for temporal use, which are only in the process of fully revitalization and assignment of new functions. One of the development scenarios is the inclusion of revitalized territories or those brownfield territories which will be temporarily used in the green infrastructure of a city, thus also contributing to the reintegration of these areas into the socio-economic circulation of the city.

What is Green Infrastructure?

The concept of 'Green Infrastructure' is new, although at the level of individual ideas and projects it has its origins in 150 years of history. The definition of green infrastructure is recognized as a network of green spaces or natural areas, which provides not only ecological functions but also includes social and economic benefits for society.



Elements of Green Infrastructure (Created by Author, from Saffuan, Zanudinb, Ahmadc (2013))



A set of elements has a higher value than the sum of individual elements (Created by Uzunoglu (2011))

The planning process of green infrastructure in Europe is closely linked to the EU 2020 Biodiversity Strategy. For the implementation of the strategy the action document the EU Strategy on Green Infrastructure has been developed. As part of this strategy, EU Member States should integrate actions for the development of green infrastructure within the plans of various scales and regulatory enactments at national, regional, municipal and local levels until 2020.

The scientific and practical literature examines the basic elements for the creation of green infrastructure, which consist of nodes (patches) and linkages (corridors) that, through mutual interaction, provide the continuity and sustainability of green network.

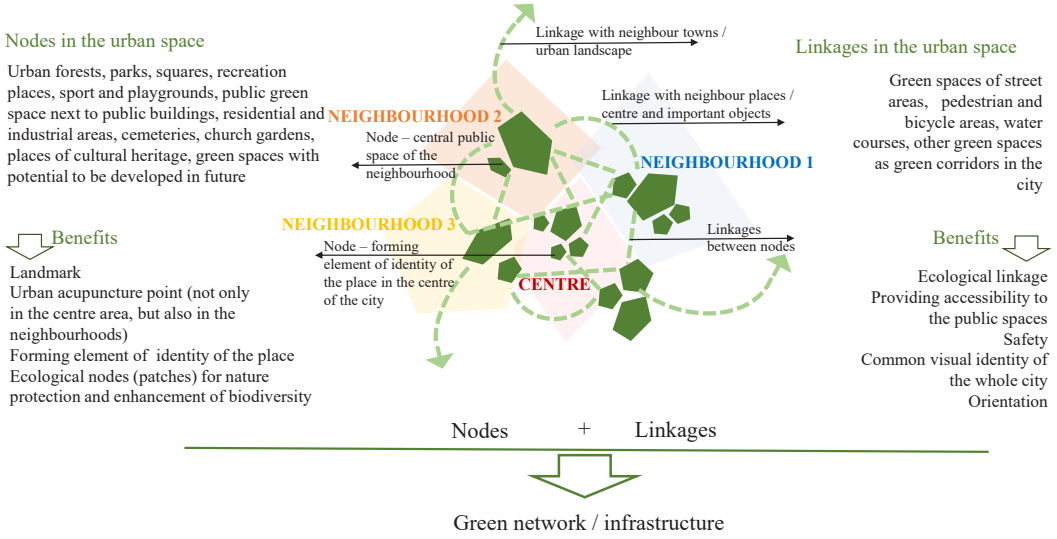
The positive effect of an integrated green infrastructure is also based on the Holism Theory, which states that the whole is more than the sum of its parts.

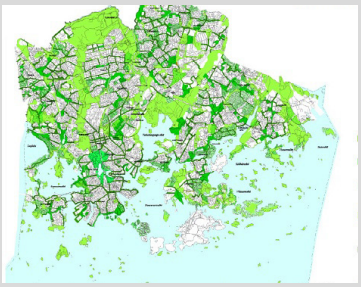
The development of an integrated and continuous Blue-Green Infrastructure, Green Network provides and promotes:

- ecological linkage in the landscape;
- protection of nature values and biodiversity;
- unity of visual space and better orientation in urban environment;
- highlighting the landscape identity forming elements and its accessibility;
- safe movement through the area for residents and tourists.

Nodes in the green infrastructure of urban space populated area are urban forests and parks, squares and pocket gardens, separate recreational areas, children's playgrounds, activity and sport areas, public green spaces in public, and other zones, cemetery and church gardens, cultural heritage sites and public spaces that could be potentially developed, etc.. Highlighting of particular nodes (plantings, environmental objects, activities, recreation facilities, etc.) not only in the city center but also in different parts of neighbourhoods allows activating also a populated area on the whole. This approach is supported by the concept of Urban Acupuncture that has been used in the planning process of several European cities.

Linkages at the city planning level are landscape elements that provide safe movement or/and movement from one node to another on a daily basis and for recreational, and tourism promotion and they also have to ensure the ecological linkage. Linkage elements in the city include landscaped street green zones , pedestrian and bicycle paths, zones of watercourses and water bodies, linear public green spaces (parks etc.), etc.





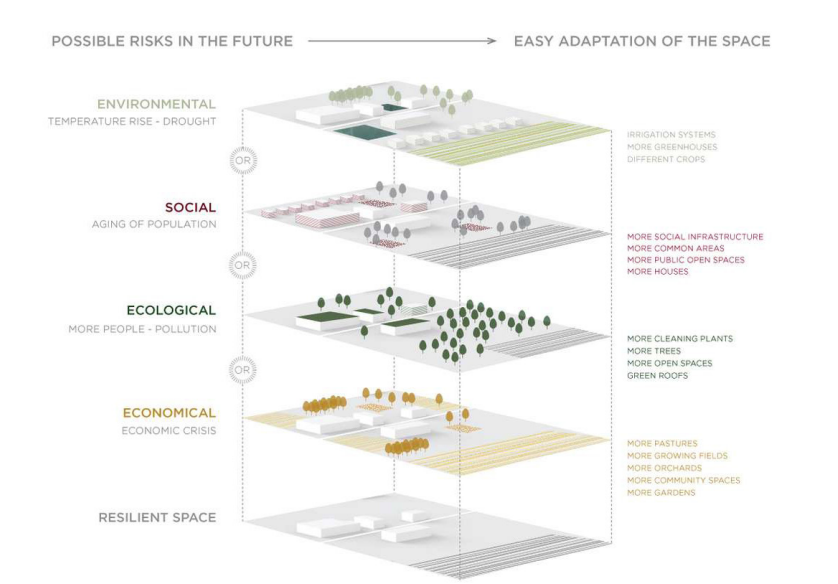
A number of European cities have already adopted green infrastructure plans and, based on them, are developing a network of streets, bicycle trails and pedestrian paths, squares and other outdoor public areas. The example of the City of Helsinki (see Figure) shows how separate green spaces and nature areas connected to the "green corridors" form a common green network of the city.

Helsinki Green Structure (https://fluswikien.hfwu.de/index.php?title=File:Helsinki_green_structure.jpg)

Landscape changes should be considered in the planning process. Planning should be based not only on ecological processes, but the impact of all the surrounding elements should also be taken into account. Restoration of destroyed or degraded nature areas is much more expensive than protecting and preserving the existing values. Thus, the green infrastructure is an ecological base for sustainable land use. It is important to identify and protect the existing valuable nature objects and corridors before the designing and constructing of roads, infrastructure and buildings has been started. Not only does the restoration of destroyed nature areas entail high costs, but a man-made natural environment will never correspond to the one made by nature itself.

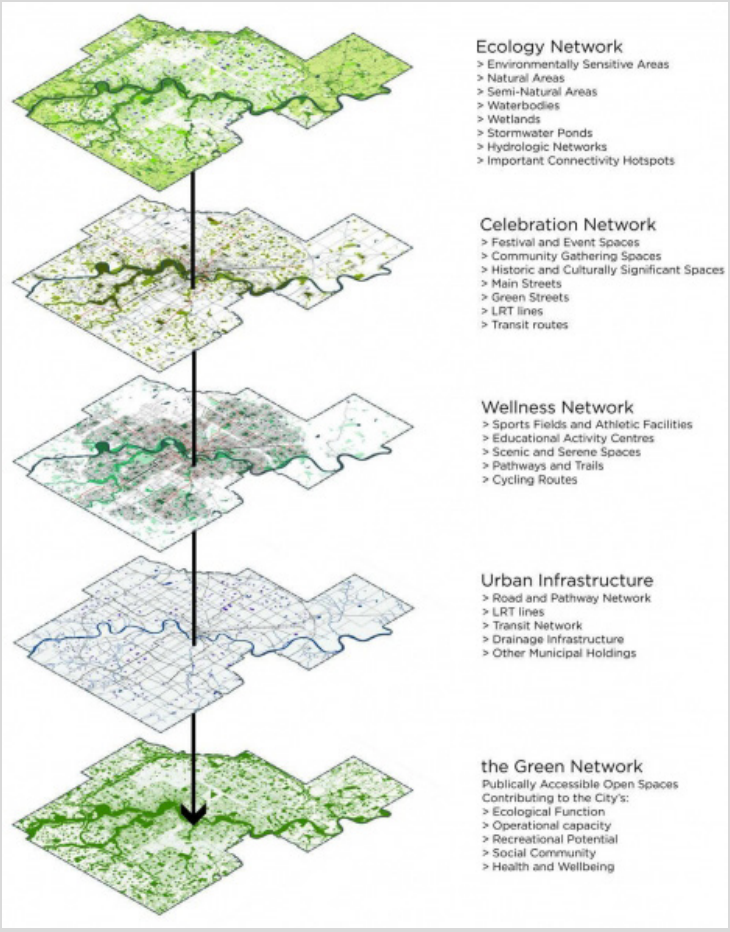
In situations where territorial development has already taken place, it is still important to identify areas where the restoration of the natural environment would benefit people and provide important ecological processes. Successful implementation of green infrastructure is based on the ability to recover or restore elements of the natural environment. The revitalization of degraded infrastructure or other objects is one of the approaches to bring nature back into the city due to the high biological diversity occurred during the abandonment of the degraded area. Revitalized former industrial or technical areas can serve as bio-corridors in the city preventing the fragmentation of the ecological network of green spaces and providing a connection between separate public areas. Nowadays green infrastructure not only provides for ecological and sustainable processes, but it also includes economic and social benefits.

Attractive green spaces make a major contribution to strengthening the identity of the place, highlighting the values of historical heritage providing a wide range of functions for peaceful recreation and everyday activities in the multifunctional areas of revitalized brownfield sites. Based on the city development tendencies, in many cases former industrial or technical areas are located close to the central part of the city, therefore causing the fragmentation of the city's green network. Continuity of a green network is an important aspect for enhancing public health and the quality of life. A green network promotes the possibilities for walking and bicycling in a safe environment by using the appropriate green network.



Preventing potential risks through green infrastructure planning (http://futurearchitectureplatform.org/projects/70d2bbb1-1f89-4935-a216-a4f3227c5eae)

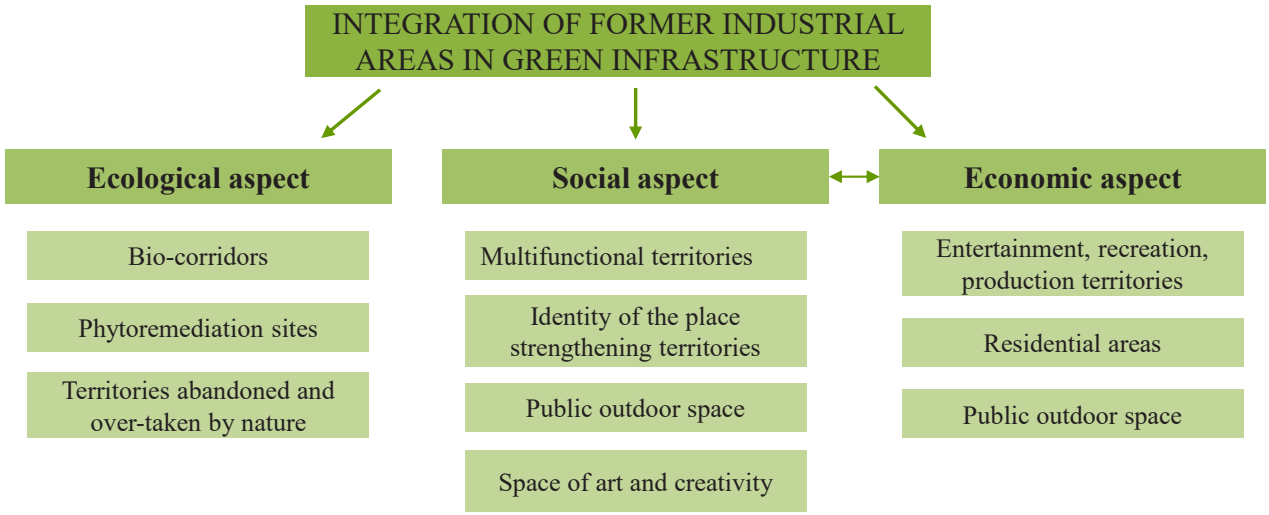
Nowadays, continuous urban and industrial development is taking place with a strong impact on the environment. The adverse effects of this development can be mitigated by using ecological design principles in territory planning. Historical sites are often important elements of a green infrastructure. In many cases, these areas have a high biological and natural value, in addition to the value of the historical heritage, since they have been abandoned for a long time and nature has taken over the environment crated by people. Such natural processes can be promoted by the revitalization of the degraded areas.



Green infrastructure as part of the overall structure of the city (https://www.csla-aapc.ca/awards-atlas/breathe-edmontons-green-network-strategy)

Green infrastructure planning is based on different public space elements, where each can contribute differently to a structured and user-friendly infrastructure. Example of a green infrastructure in the City of Edmonton (Canada) (see Figure) includes an ecological network, spaces for public events and wellbeing, as well as an urban infrastructure that provides safe movement for pedestrians and bicyclists, sustainable storm water management systems etc. By grouping different levels of the green infrastructure, it is possible to identify possible risks and problematic places and highlight areas of a particular value. Thematic planning of layers of the green infrastructure (see Figure) allows one to evaluate each of the elements contributing to the city development separately. The green infrastructure is one of the key elements promoting the quality of an urban environment, but it is not the only factor. Thus, there is a need to focus on problem areas at all levels and aspects of planning for development of a sustainable, attractive and user-friendly urban environment.

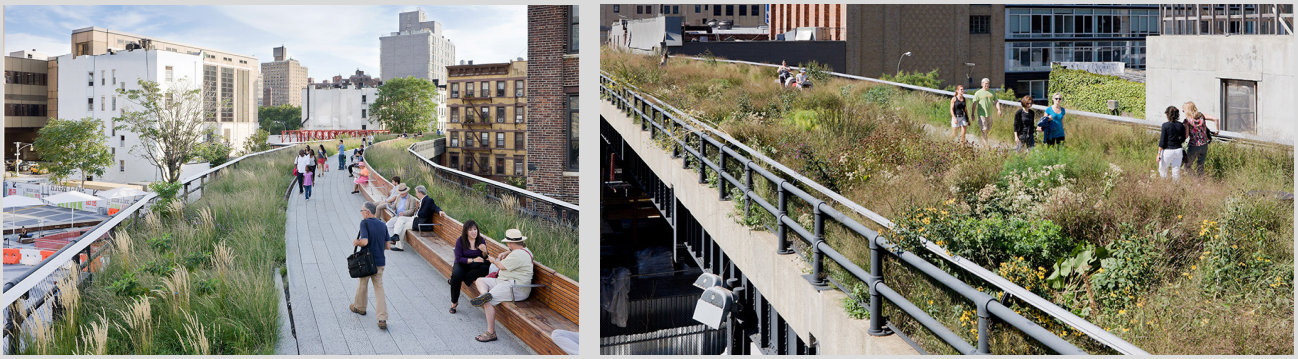
Former industrial areas in the context of green infrastructure planning can serve as:
- multifunctional areas which may include entertainment, educational, production, etc. functions;
- biodiversity enhancement areas (abandoned and nature over-taken former industrial areas);
- bio-corridors (former railway lines areas or other linear facilities, for example, High Line Park in New York, USA);
- phytoremediation sites due to the need to clean up historical contamination in former industrial or technical areas;
- objects strengthening the identity and visibility of the place;
- art and creativity space;
- a place for public involvement and activities;
- public space for temporary use until investors are attracted or new functions are set



Integration of brownfields into green infrastructure (Created by the author)

Integration of brownfields into a green infrastructure by using **ecological design** principles:

High Line Park as a bio-corridor in an urban environment



High line park in New York (https://www.thehighline.org, http://www.landezine.com)

Conservation of biodiversity in **the Schöneberger Südgelände Park in Germany**, established in the former railway areas closed more than 60 years ago.

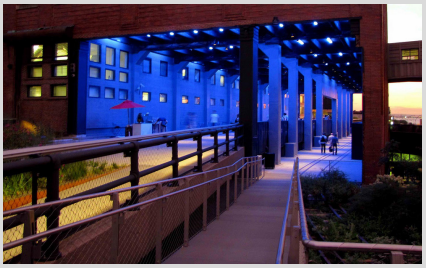
Schöneberger Südgelände park in Germany (https://gruen-berlin.de/en/natur-park-sudgelande, http://www.landezine.com)

Phytoremediation of soil and water in **Landschaftspark Duisburg Nord Park, Germany**



Landschaftspark Duisburg Nord park in Germany (https://www.landschaftspark.de/en/, http://www.landezine.com)

Integration of brownfields into the Green Infrastructure by applying **social aspects**.
Art objects


(https://newyork.cbslocal.com; https://arrestedmotion.com)

Principle of temporary use in **Rhine Park, Germany.**



Rhine park in Germany (http://www.landezine.com)

Public involvement and participation in development of art space by providing second life for unused buildings opened for creativity, public activities within the programme **Free Riga** activity.



(https://freeriga.lv)

Historical industrial heritage as an identity forming element in **Zollverein Park, Germany**, developed on the site of a former coal refinery.



Zollverein park in Germany (http://landezine.com/index.php/2017/11/zollverein-park-by-planergruppe-gmbh/)

Integration of brownfields into the green infrastructure by using the **principles of economic** character. Multifunctionality at **Gleidsdreieck Park in Germany**.

Gleidsdreieck park in Germany (https://gruen-berlin.de/en/park-am-gleisdreieck)

Although different uses of territories can be distinguished in brownfield revitalization, they cannot be strictly applied separately from each other. Often, the use of territories can involve several aspects.

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ASSESSMENT OF THE REVITALIZATION POTENTIAL OF BROWNFIELDS (POST-INDUSTRIAL SITES)

Anna Katlapa, Daiga Skujāne

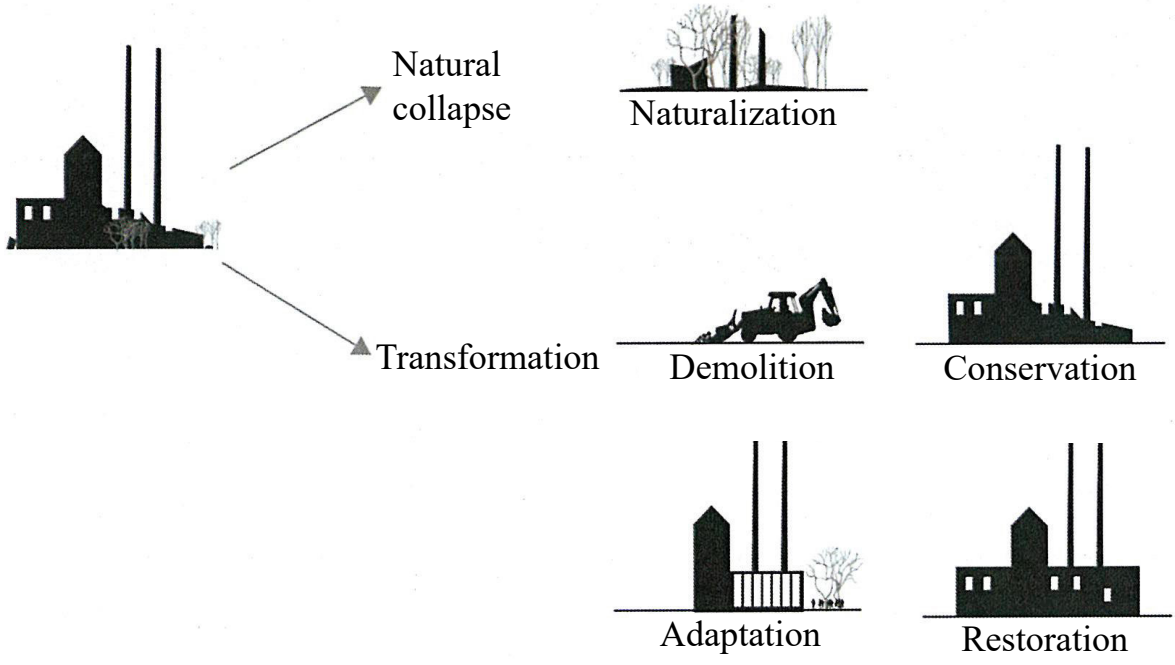
Post- industrial landscapes

The concept of "post-industrial" began to spread in society along with significant changes in the economy, marking a new period of transition from intensive production to the service sector. Industrial ruins are an integral part of this period characterised by the changes in technologies, emergence of new market opportunities and the increasing of globalization.

Abandoned industrial sites have attracted the interest of several groups in society today. These include scientists, artists, journalists, tourists and other groups. On the one hand, society expresses regret about the passing and non-exsistence of such sites, but on the other hand, people are also delighted with the achievements of the civilized and formal pattern of culture. The uniqueness and unusual beauty of the industrial ruins is one of the most attractive elements in the tourism industry. The joy of industrial ruins is also reflected in a number of websites offering virtual tours of the derelict industrial buildings around the world, such as England (www.derelictlondon.com), America (www.detroityes.com) and Russia (www.abandoned.ru).

Derelict factory sites in Great Britain (Source: https://www.derelictlondon.com/)

Nowadays, industrial ruins can experience various development scenarios, ranging from natural processes (renaturalization) with nature gradually taking over once so powerful industrial structures, to human intervention in the revitalization process of these areas, demolishing the old, unused structures, conserving these structures and adapting them to new functions or completely restoring them.



Development scenarios of the former production sites (Source: created by the author)

PUBLIC OPINION ON THE INDUSTRIAL HERITAGE IN LATVIA

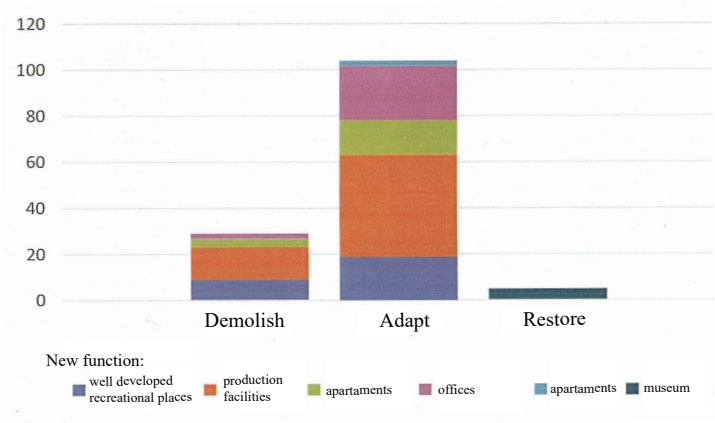
Ruins often symbolise finality and sudden doom, reflecting memories and the historical significance of a place, and sometimes the tragedy or loss of a place. Ruins, even though abandoned, are often used for daily recreation, dog walking, a gathering place for teenagers, a place of memories for older residents, and a source of inspiration for artists. Unfortunately, former industrial sites are also often exposed to negative activities such as vandalism, arson, using addictive substances and stealing non-ferrous metals.

Abandoned industrial sites are in contrast to a well-organized urban environment and may not be mentally acceptable by the public. However, for some members of society, these sites are for enjoying a different kind of aesthetics - the one that is related to the past, stories and events of the place. The industrial structures of the former sites of the factories are huge and unimaginable on a human scale, creating a powerful atmosphere in which one can fully sense the grandeur of industrialization. Quite often the “inhumane” proportions of the factories give them a sense of threatening beauty that speaks about the impact of human activity on the changes and transformation of the landscape or place.

Industrial heritage sites are often perceived ambiguously in society, mostly as degraded places in the urban environment. Therefore, in order to find out the opinion of the current and potential role of these sites in the development of the urban environment, the surveys of the public and experts (architects, landscape architects, urban planners) involved in revitalizing of the former industrial sites are an important step in this process. In 2017, within the framework of A.Katlapa Master's thesis, an electronic survey of residents and experts was conducted by means of a questionnaire.

The resident survey consisted of 11 questions with the purpose to find out how people interact with abandoned industrial sites on a daily basis, as well as to hear their views on the current situation and possible directions of development. The questionnaire was partly based on a study by Luis Loures entitled "Post-industrial landscapes as drivers for urban redevelopment: Public versus expert perspectives towards the benefits and barriers of the reuse of post-industrial sites in urban areas", adapted to the situation in Latvia. The study compared the views of residents and experts on the limitations or barriers and potential benefits of redevelopment of abandoned industrial sites.

In total, 138 respondents aged 18-64 participated in the survey. Almost all of the respondents (92.8%) had noticed abandoned production complexes or sites in urban areas. Most of the population (76.3%) encountered abandoned production sites when moving around the city for work or leisure purposes. Others had no direct contact with these areas on a daily basis (11%), or they admitted seeing them from the window of their place of residence (8.3%) or workplace (4.4%). Being close to an abandoned industrial site, most of the respondents (31.7%) perceived it as life threatening and dangerous or depressing (27.9%), while 31.7% of the residents expressed interest in the history of the area and its present condition. If the opportunity arose to visit abandoned production areas, the number of respondents who would not like to visit and who would like to visit these sites if a well developed recreational area were created was almost the same – 35.5% and 34.9% respectively. 23.1% of the respondents expressed their wishes to visit the area if special events were organized and 5.5% of the respondents were already using the area for walking and recreation.



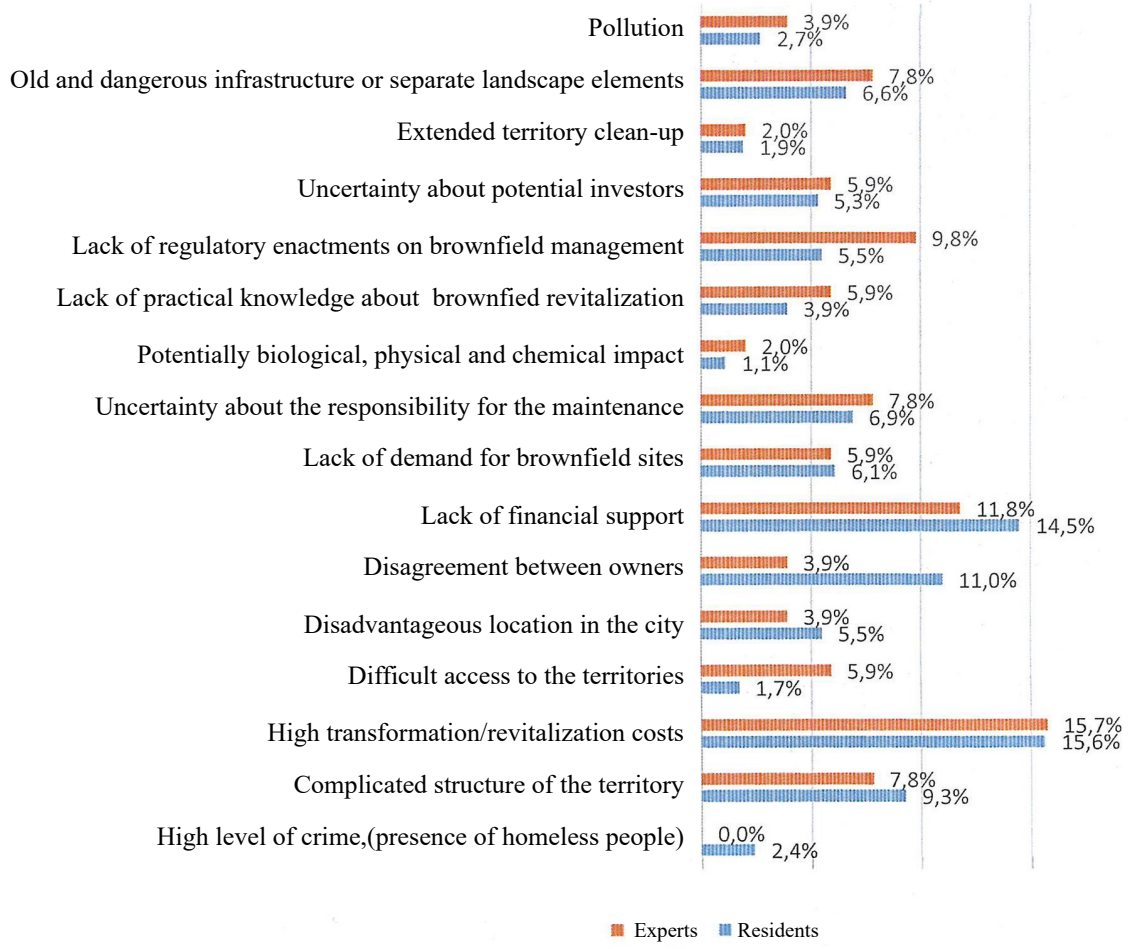
Direction of brownfield development according to the results of resident survey (Source: created by the author)

The residents were asked about the future directions of the development of brownfields, and most people think that the best way to use these sites is to adapt the brownfield buildings and structures to new functions. Most of the respondents would like to see a new manufacturing plant, then offices and only then well developed recreational areas. 21% of the respondents believe that such factories should be demolished and new ones should be created instead, while only 3.6% of the respondents were in favour of converting the site into a museum. The residents value the sites mainly by the visual condition and physical

condition of the buildings. Keywords in the questionnaires - slum, broken windows, glass, trash, bottles, uncleaned, demolished, dangerous condition, abandoned. Many respondents had noticed that brownfields are quite a popular gathering place for teenagers. Surprisingly, almost half of the respondents (47%) did not know of any successful examples of redevelopment of former manufacturing sites. But these are the most popular examples both in Latvia and in the world. In the territory of Riga - State Electrotechnical Factory, Spikeri, Kipsala Gypsum Factory, Aurora - hosiery and socks factory, Aldaris; in Jelgava – Riga (Auto)bus Factory; in Cesis - Cesis Brewery; in Liepaja -a meat factory and metalworking shop; in Valka - dairy and agricultural machinery quarters – which are well kept and include several production companies and a sports complex. Regarding the examples from abroad, the respondents knew the Highline Park and Gas Works Park in the United States, the Media Post in Dusseldorf and the Duisburg Industrial Park in Germany.

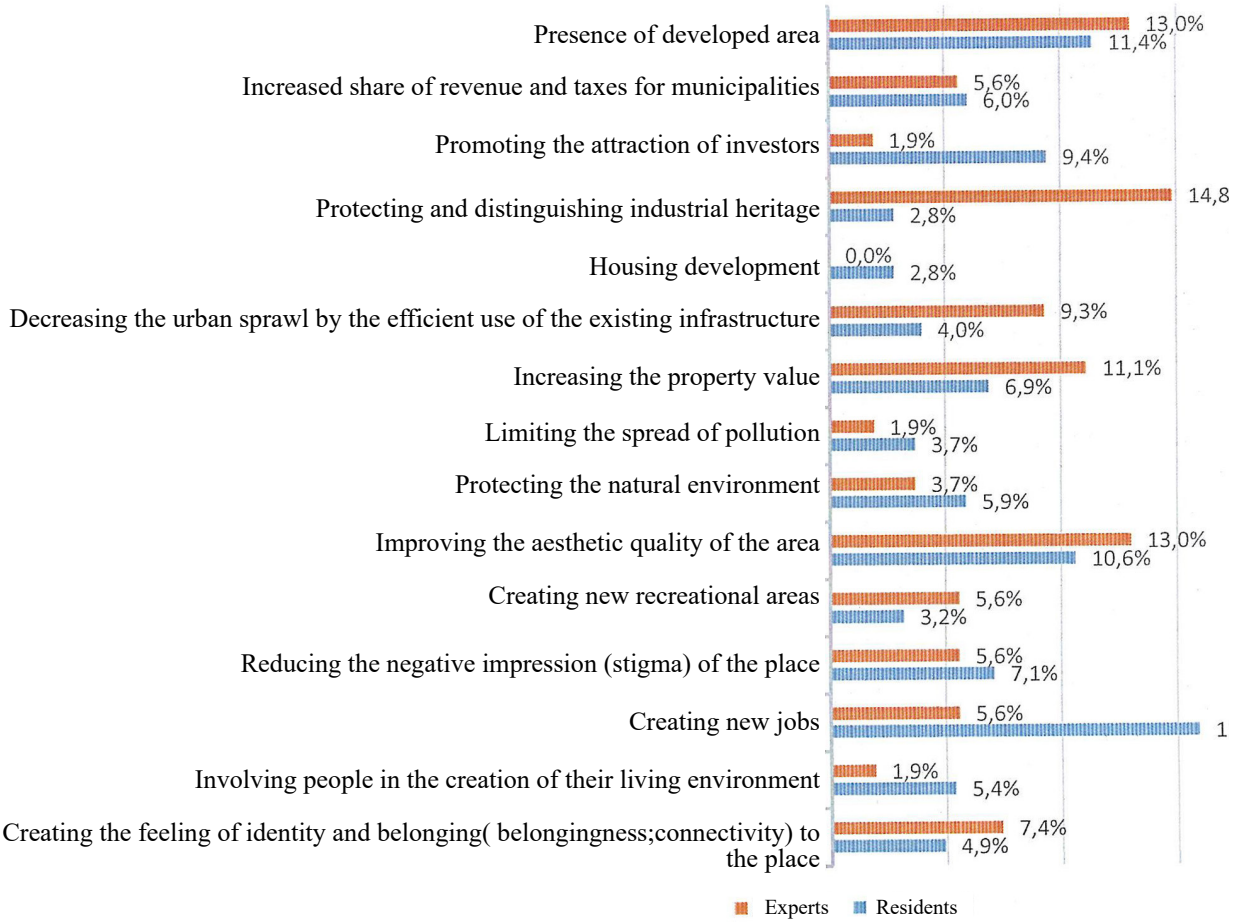
The expert survey consisted of 6 questions related to their experience in planning brownfield sites and the difficulties they encountered in the planning process. 11 experts from landscape architecture and architecture sectors participated in the survey. 63% of the respondents had been involved in their daily work with the redevelopment projects of brownfields, creating public spaces, shopping malls, offices and residential buildings. Preserving and distinguishing of the existing historical testimonies and values (buildings, chimneys, manufacturing traditions) and making the site publicly accessible, linking it with the surrounding landscape were mentioned as key methods of transforming brownfield sites.

The limitations and complications that extended the planning and design time were the customer's ambition and project budget, as well as the site fragmentation into many land parcel properties that could be partly bought or leased. The surveys also included two questions for both residents and experts. The questions concerned the barriers or limitating aspects of brownfield development and the expected benefits of the development of these sites. The views of residents and experts regarding the barriers coincided. Both residents and experts believe that the main barriers to the development of brownfields are economic aspects - high conversion costs and lack of financial support. The third aspect hindering the development of brownfield sites according to the residents' opinion was the disagreement between the owners, while the experts consider the third factor to be the lack of regulatory enactments regarding the management of brownfield sites.



The barriers impeding revitalization. Comparison of resident and expert opinions (Created by the author)

Residents and experts have different views on the benefits. Residents believe that the greatest benefit would be opportunities for employment, while experts think that by restoring the old plants the region's industrial heritage will be distinguished and protected. There was a huge difference between the views of residents and experts on this issue. This indicates that the majority of the population do not regard old factories as sites of cultural and historical importance. Experts believe that the development of industrial heritage in Latvia is slow, hindered by lack of investment and the location's economic indicators and location in relation to the city's main roads and center play a key role. The concept of spatial development of the territory should be based on some type of business (a new factory, hotel, offices, lofts, etc.), a landscaped area such as a park, can be considered as inefficient investment.



Benefits gained by redeveloping brownfields. Comparison of resident and expert opinions (Created by the author)

If the site is conveniently located, it is adapted to a new industrial activity or a place of public interest (shopping centre, museum, apartaments and offices), where the historical buildings and elements preserved in the site are incorporated into the new development concept. The areas outside the center, on the other hand, are completely developed anew. They are stripped of the remnants of historical buildings and other elements and the landscape of the area is rebuilt, since the transformation process of old factories is complicated. There are many obstacles, both in terms of inspection of the premises and in construction, such as the construction of new engineering structures. There is also a risk of chemical pollution, ground cleaning and reinforcement work. In the designing process the balance between the preservation of historical heritage and the needs of today's people should be maintained. Positive examples include the Gypsum Factory as well as the Aurora Factory Residential Complex at Mara Pond, where both areas have been developed into high quality living environments.

The expert surveys identified the evaluation criteria to be taken into account when assessing industrial heritage. The development potential of a site depends mainly on its location: whether it is located in the city center or on the outskirts, it also depends on the fragmentation extent of the property structure.

ASSESSMENT OF THE REVITALIZATION POTENTIAL OF BROWNFIELDS

Industrial heritage is more endangered and subject to extinction than other heritage groups, since it is not always perceived positively and unequivocally, and there is a lack of legislation documents related

to the preservation of industrial heritage. Likewise, the future development of these areas is often unclear, as it is mainly linked to the attraction of significant financial resources. Therefore, it is essential to develop an approach to the assessment of the development potential of former industrial sites, which would allow the investors and municipalities to evaluate and select the most appropriate solution for the development of a specific area.

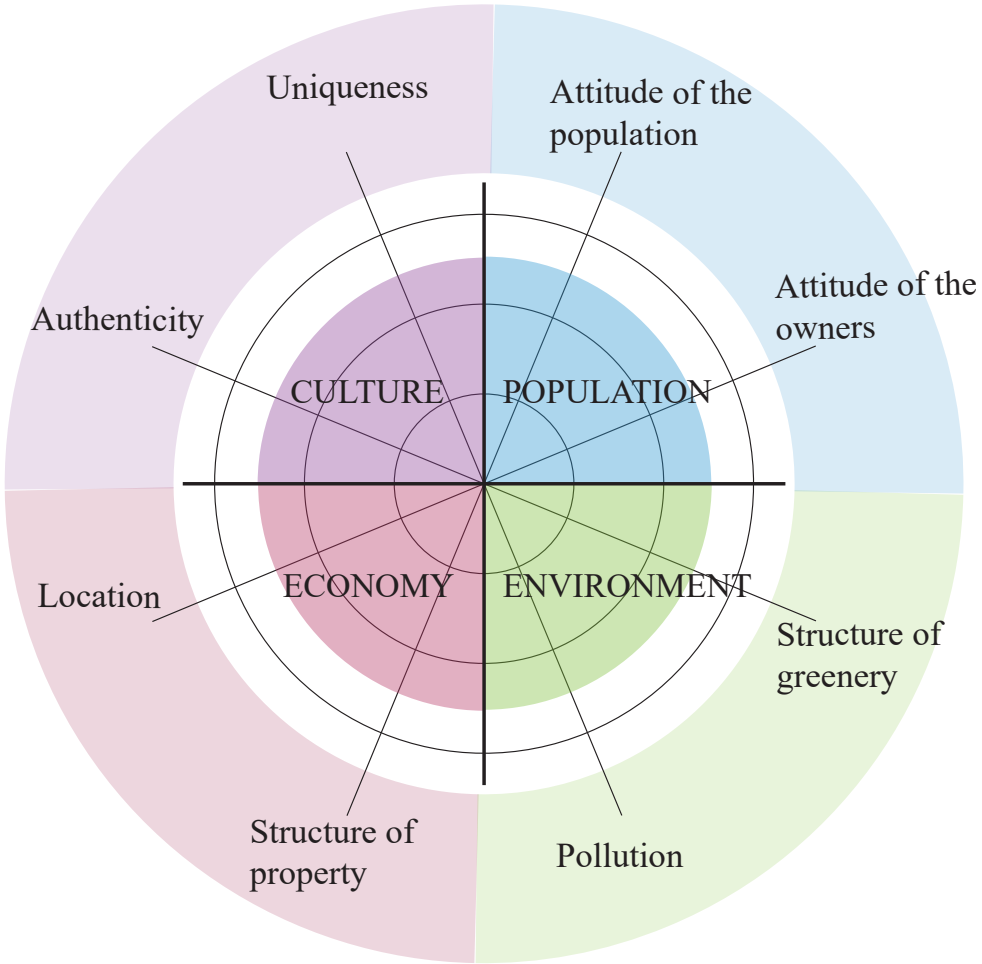
One of the approaches to assessing the development potential of former industrial sites is based on the basic principles characterising sustainable development, which, in addition to the three basic elements already known - economy, ecology and society - also includes culture. From the perspective of urban planning and landscape architecture, "culture" is like a retrospect into history, where through the heritage of a place its character is determined and its identity and sense of belonging to the place are created.

The approach to assessing the development potential of brownfield sites includes an evaluation matrix of eight criteria which have been grouped and which reflect the basic principles of sustainable planning - economy, environment, society and culture.

Based on the above-mentioned expert surveys, the development potential from the **economical** point of view depends mainly on the location in relation to the city center and the main roads, as well as the structure of the site's property. The more fragmented the area, the more complicated the planning and design processes can be.

The factors most influencing the **ecological** aspect are the levels and types of pollution in the area, mainly considering whether the site is included in the register of contaminated sites and whether the survey identifies ecological, visual and other types of pollution. Equally important are also the structure and biodiversity of the plantations on the site and their suitability to the surrounding ecological system.

When assessing the **social aspect**, the attitudes of the parties involved in the management and use of the site toward the history of the production site, its current state and potential development must be taken into consideration. The **cultural** aspect can be judged by the authenticity of the elements present on the site, assessing their current technical and visual condition, as well as the uniqueness of the site - its ability to reflect the industrial history of the region or city.



Assessment criteria in the context of sustainable development (Created by the author)

Each of the criteria is rated on a scale of 0 to 3. The higher the site is rated, the better its potential for development in any direction, with relatively less investment in the site's clean-up, management, renovation of buildings and creation of the site's identity. The assessment matrix is designed to illustrate the strengths and weaknesses of the production area.

Site assessment criteria

Criterion	3	2	1	0
Location	City centre (<1km)	Outside the city centre (2-3km)	On the outskirts of the city	Rural area
Property structure	One property, one type of property	Territory is divided into different properties (2-5)	Territory consists of many properties (5-10)	Territory consists of many properties (10+)
Residents' attitude	Consider the territory as such which arouses interest. Are interested in its development	Consider the territory as threatening, but are interested in its development	Not interested in the development of the territory	If nobody lives in the vicinity
Owners' attitude	Owner is motivated to develop the site, is open to cooperation, including also attraction of investment	Owner is planning to sell the property, has no motivation to develop, restore or renovate it, the site is conserved , expecting the investor	Owner is not interested in the development of the site	No information available about owner's attitude
Pollution	Site has been managed and there is no pollution	Household waste is concentrated in one point	Construction debris and household waste pollution has been spread all over the site. The site has been defined as potentially polluted	Territory has been polluted by construction debris and household waste.Soil contamination has been registered
Plantings and biological diversity	Different vegetation types, forming diverse grouping of plants corresponding to the local ecological system	Not very big diversity, one or two big groups, and plantings correspond to the local ecological system	Small diversity, no contrast in vegetation. Plantings do not correspond to the local ecological system	No planting structure. Chaotically formed spontaneous vegetation areas
Authenticity	Buildings in good technical condition, reflecting architectonic trends and production processes of the respective building period	Buildings need reconstruction (collapsed constructions, collapsed roof, missing architectonic elements). Partly reflect the architectural construction trends and production processes	Buildings are in the state of ruins. Only parts of the original building have remained. The former production history of the site cannot be clearly traced	Buildings and landscape elements characterising the production history of the site are destroyed
Uniqueness	Significant investment in the industrial development of the region or country. Outstanding scenery	Significant production object of local (city, region)importance,but similar to the objects in the region	Common throughout the region	Generic production object, common throughout the country

Based on this assessment, it is also possible to create a list of recommended activities outlining the steps that should be taken to improve some of the aspects. For example, in order to improve the location of an industrial site, it is necessary to improve access to the site, and municipalities should include that in their development plans so that it becomes attractive to investors as well.

In contaminated areas of low ecological value the structure of the plantations should be redesigned in harmony with the surrounding landscape, using local species. It is also necessary to provide for regular clean-ups of the places where there is frequent movement of people in the area or to limit it in order to reduce unauthorized access. As public discussion and public involvement in urban planning have become important in recent years, informing the community about spatial development plans and involving people in the planning processes through the establishment of public consultation and

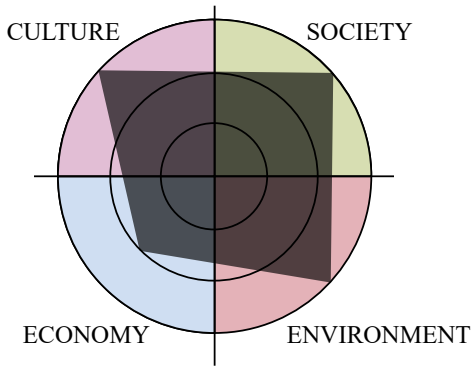
working groups are also very important activities. In order to distinguish and preserve the cultural and historical value of the territory, it is necessary to carry out additional research and documentation - recording and documenting the current situation. The objects should be included in the structure of tourism, creating theme tours.

Development activities

Aspect	Activities
Economic	➛ At the municipal level – including in the spatial plan with a clear development vision; ➛ Elaboration of detailed plan with functional zoning; ➛ Construction or repair of access roads; ➛ Promotion of entreprenairship – tax relief – apartaments, new production facilities, commercial activities, offices; ➛ Development of tourism;
Ecological	➛ Designing the structure of plantings; ➛ Coordination of planting structure with the surrounding environment (focusing on local species); ➛ Elimination of contamination, using innovative methods (phytoremediation method in treating soil and water pollution); ➛ Regular maintenance of the area (garbage collection, grass mowing, stopping the burning of grass); ➛ Site containment to reduce pollution;
Social	➛ Informing the community about the site development; ➛ Public involvement in the processes of planning, implementation and maintenance (work groups, clean-up campaigns, social activities, etc.); ➛ Creating a programme of activities on the site;
Cultural and historical	➛ Preservation and conservation of cultural and historical objects and/or their adaptation or inclusion in a new pattern; ➛ Documentation of the site changes (photographs, people's stories and cartographic materials); ➛ Organising theme excursions ('Landscapes of the Lielupe river", "Brick manufacturing industry and building materials", "Manor houses on the banks of the Lielupe river")

Functional examples of transformation of abandoned industrial areas/brownfields

Recreation model
Park
Promenade



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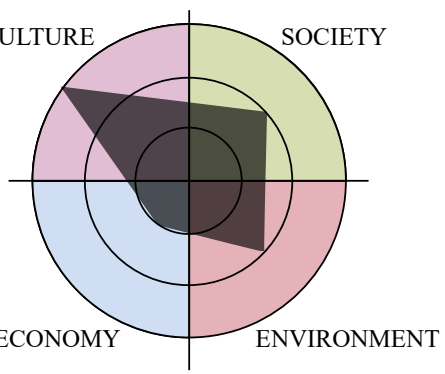
Cultural and historical model

Museum



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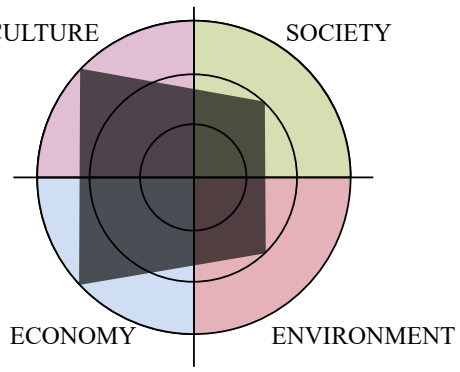
When revitalizing significant post-industrial sites as cultural landscapes, the values of the landscape should be preserved by developing a clear vision and strategy for the area, applying the multidisciplinary planning principles, providing resources for maintaining a newly created landscape and promoting species diversity, social stability and economic development. However, the technical suitability of buildings, their environmental compatibility and their environmental impact should be taken into account when renovating individual buildings. Adaptive application is the adaptation of abandoned or unused buildings or areas for future use, while preserving their historical/ archaeological, visual/ cultural, economic, functional and psychological values. Assessing a particular former production site, it is possible to obtain different development models, depending on which of the criteria is the most highly evaluated.

Social model
Luxury apartments
Theatre
Concert hall
Creative section



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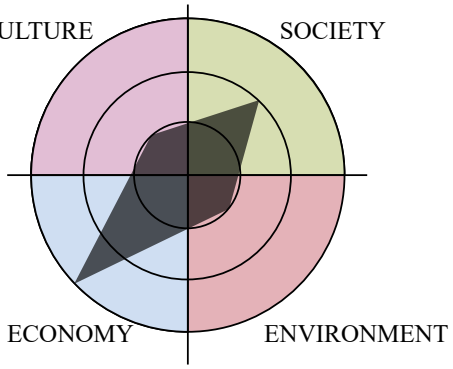
Production
Offices
Business park
Warehouses
Logistics centre
Production facility



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The transformation of brownfield sites into landscaped public parks is the most mentioned strategy for transforming landscape architecture. And depending on the elements in the industrial landscape, different park planning strategies have been used, emphasizing industrial heritage, sustainable environmental technologies and social relationships.
In Latvia, it is common to create housing or jobs instead of old brownfield sites - to make the most of the site because of the high cost of redevelopment. The best examples are State Electrotechnical Factory offices, Riga (Auto)bus Factory industrial center in Jelgava, Aurora - hosiery and socks factory apartments, Kipsala gypsum factory apartments. Significant transformations from factory to park are the transformation of Jelgava sugar factory area into a promenade.

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BASIC PRINCIPLES OF BROWNFIELD REVITALIZATION CREATING A NEW IDENTITY, IMAGE AND SOCIAL VALUES OF THE PLACE AND COMMUNITY PARTICIPATION IN THIS PROCESS

Natalija Ņitavska

Brownfields not only negatively affect the quality of the environment as a whole, but also degrade the landscape physically, visually, and often also mentally causing an unfavorable public attitude towards abandoned and potentially polluted areas.

This negative public attitude is often passed on to the cognitive level, when the danger and pollution of the place is no longer topical, but the negative identity of the place persists for a long time. This situation can be changed by creating a new identity of the place in the process of revitalizing brownfield sites.

The social aspects of brownfields are closely related to the identity of the place, which is one of the tools in the revitalization process.

IDENTITY OF THE PLACE AND ITS IMPORTANCE IN THE DEVELOPMENT OF THE TERRITORIES

The concept of identity encompasses: culture, history and traditions, subconscious and cognitive processes, collective memory and mythology, stereotypes and clichés, aspects of political and economic processes.

Understanding of the concept of identity works more at the level of the subconsciousness and mind, and it is less associated with sensory organs. The concept of identity is related to a person's desire to explore and understand himself/herself. Today, this concept has a much broader meaning and several levels of perception, ranging from the identity of the individual to the national identity of the whole country. In Latvia, the issue of identity became particularly topical in the 80s, 90s and before joining the European Union. In general, it is related to the fear of losing one's existence - traditions, culture, environment, habits, etc.

Memory and mythology are also considered to be the components of identity. Often, the term "collective memory" is used in this context. Scientists consider that both concepts are separated and addressed separately in the context of national identity, since they can act both jointly and in opposition. The effect of collective memory on the process of identity formation is closely related to a broader concept – that of the memory and consciousness of race and nation, which affects not only the language, traditions and conceptual state structure, but also the daily behaviour, actions and peculiarities of perception.

Quite often, the process of identity formation is associated with stereotypes and clichés that simplify and transform cultural elements and traditions to better subject them to market needs related to the tourism industry. This process is often promoted by works of art, mass media reports, advertisments and politicians' speeches.

Landscape identity, in its turn, is a versatile concept. It is used by politicians, historians, geographers, architects and landscape architects alike. The concept of landscape identity is presumably connected with the definition of landscape, where the landscape is an objective reality, a part of the land's surface with characteristic natural conditions and formations, as well as a collection of human-made elements. Landscape identity is a cultural value that reflects the collective memory and consciousness of society on the one hand, and the relationship of the individual with the environment on the other hand. Due to the multifaceted influencing factors, landscape identity is not stable and clearly defined. Landscape identity is a process, not a constant object.

On the one hand, landscape identity is formed by a collective memory that presents the interpretation of history, culture and traditions, subject to mass media and political forces, as well as the economic situation, and on the other hand, by an individual who is subject to this collective memory. However, every individual has a personal experience and memories, family traditions and culture, a changing emotional state and sensory organs.

Landscape researchers emphasize the importance of the political and economic processes in the changes of landscape identity. The research of landscape identity is closely connected with the study of the history and location of the territory, as well as the collective identity of the nation or ethnic group. Landscape identity is also affected by the relationships between the social and ethnic groups. Landscape researchers use matrices to characterise historical events, describing the development phases in the context of the political and economic system, dominant ethnic and social groups, functional changes and the emergence of new symbols in the landscape. Landscape functional load is an integral part of landscape identity since it creates preconditions for landscape perception - both visual and cognitive. The functional load of the landscape can also be the result of historical events, which have accumulated throughout several centuries, or preconditions of nature. That is why brownfields are subject to social transformation through political forces, interpretation of facts and events by mass media and the peculiarities of symbolic perception.

The close relationship of architecture with politics and managing style in each individual stage of the country's development influences the overall landscape identity, bringing along the expressive architectural language through form, scale, dimensions, proportions, colours and moods. During the Soviet period, as the Baltic republics evolved, common features of mono-industrial cities appeared. The Soviet censorship and the use of standard projects reduced the opportunities for different solutions. The present day brownfields during the Soviet period were often functionally active and most intensively used territories - factories and their service areas, farms with buildings and areas in use. Architectural expressionism was often characterized by expressive dominants of water towers and large scale structures, which left a great impression on the spatial structure of the landscape, creating a characteristic image that is already recognizable to the public.

The cognitive side of landscape identity is also formed by the names given by people to places - they create an additional connection with memories, associations and perception. These names often have a symbolic meaning that can change the perception of our place. Knowing the symbolic name of the place, we are influenced by the given information and are no longer able to perceive this place freely, and vice versa, a special name given to an ordinary landscape, creates preconditions for a special and memorable perception - thus creating a landscape identity. Many people worked in plants and factories in those days - these are human memories that are closely related to the identity and name of a particular landscape – that was how many places obtained their names. Today, even though the plant or the factory no longer exist, the place name remains. Changing the name of a place in an official way, it still remains in the people's language for a long time and it is also part of the cognitive side of landscape identity.

Many landscape elements are easily perceived and associated with a specific place - usually they are distinct forms of the relief, large structures – altogether forming a clear structure and shape of the landscape, but in some places landscape elements are less distinct, and here the identity and feelings of the place are more expressed through emotions and nuances, which is often a cognitive and inconspicuous part of the landscape. Brownfield sites - abandoned plants and factories are among those most prominent elements as large-scale structures that cannot be left unnoticed either visually or cognitively.

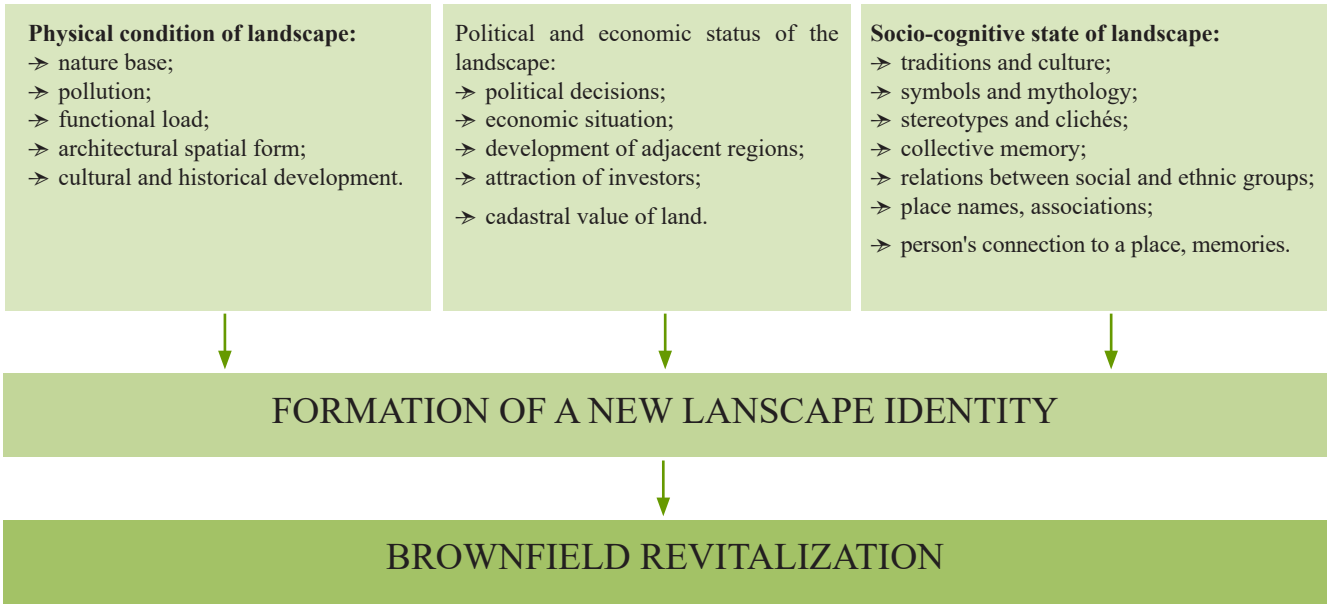
In landscape research often two terms are used that do not apply to the landscape as a whole, but more to a particular space - a place. They are - a sense or feeling of a place, a sense of belonging to a place, the aura of the place and its identity, which are closely related and both are based on people belonging to a nation, traditions and culture, the emotional state of each individual and many other social, economic and political aspects, which are often difficult to perceive and recognize in a particular landscape. The sense of place and the identity of the landscape are also influenced by many other factors - how often and for how long the individual has visited the landscape, the information in tourism and advertising social networks, in what weather conditions and seasons of the year the place has been visited, how vegetation and other natural phenomena have influenced it, etc. All that proves that it is impossible to achieve a fixed sense of place or landscape identity, it will always be a whole spectrum with a different vision and assessment for each individual or group of individuals. By understanding people's close links with brownfields, a new identity of the place should be made in a tolerant way without denying the whole historical and visual context of the landscape, but leaving connections with the cognitive aspects of landscape identity.

BASIC PRINCIPLES OF BROWNFIELD REVITALIZATION

The process of revitalizing brownfields encompasses a multitude of aspects pertaining to economic, political, cultural and social aspects.

Therefore, working on the revitalization of brownfields each of the aspect groups should be respected, and there should be an action plan in each aspect.

Landscapes reflect the physical condition of the natural base of the spatial structure and the cultural development, pollution and functional load.



Landscape factors involved in the revitalization process of brownfields (Created by the author)

Physical condition of landscape – there are several factors which are important and which are responsible for the existing nature base type, nature pollution, the functional load of the territory under the question and the adjacent territories, the existing architectonic elements of the territory and their value, as well as for the cultural and historical development of the territory.

Nature base plays an important role here, since it restricts or facilitates certain planned activities - relief, water bodies and water courses, especially the proximity to specially protected areas or the presence of protected species. All this together determines whether there will be a chance to carry out certain revitalization activities and often dictates all the possibilities of the territory. Water facilities – their restoration and incorporation into the new planning- are those which involve both a lot of opportunities and, unfortunately, a lot of threats as well. In this case attention should be paid to the quality of the water, species living in the water and near the water, as well as to the shoreline conditions and vegetation in the vicinity of the waterbody.

The functional load of the territory and the activities of the adjacent territories determine the direction of revitalization, which in the context of the location of the object determines the specifics of further revitalization - what kind of objects can be planned and what activities can be developed, what will be demanded. The functional load factor is closely related to the architectural objects to be preserved in the territory. Architectural objects can be cultural heritage monuments, city dominants and simply expressive buildings which form an identity of the environment - recognizable by several generations and also by city visitors, or they are closely related to the traditional activities in the region or city. One of the decisive criteria is also the safety of buildings and the possibility of restoring and preserving them for future use.

The cultural and historical development of the territory itself can also become a value - as a symbol of urban or rural development and traditions, as well as signs of identification, which are the key to maintaining and developing identity.

Landscapes political economic situation reflects the economic situation as a whole both in the village and adjacent regions, investor interest and political situation.

Politically economic condition of landscape - a combination of these factors unites a variety of economic and political aspects that influenced the development of the area in the past and can influence it in the future. It should be noted that this aggregate of factors is difficult to predict and influence, but it often plays a key role in the analysis of today's political situation. Both the economic development of the country and the region as a whole, and the attraction of successful and loyal investors have a significant impact on the future of the area - in what direction and to what extent the development will take place and what will the cash flow be for the revitalization process. The local government's position and vision of the development of the territory as a whole is very important in this respect. It is equally important to view and understand the cultural heritage, architectural and natural values of a particular territory. By attracting investors or developing the territory on their own, the development priorities and strengths of the adjacent regions are also important in order to avoid duplication of the already developed sectors and to avoid the mistakes made before. The aggregate of political and economic factors of landscape can only be viewed in the context of a combination of natural, cultural, historical and social factors, otherwise it is possible to make irreversible decisions, as the recent history of Latvia has already proven.

The socio-cognitive state of the landscape reflects the emotional connection to the landscape through culture, tradition, individual and collective memory, associations, local history and symbolism.

Socially cognitive conditions of landscape is a set of factors that reflect the emotional side of the landscape – a highly variable and subjective one, which is often impossible to prove by using quantifying methods, calculate and even precisely define. Our traditions and culture are like a living organism that changes and evolves alongside each individual, creating a common emotional ”cloud” that includes both the ancestral wisdom and traditions, and the paradigms of the modern world. Every nation, and within one country, even every region, has its own nuances of culture and traditions reflected in symbols and mythology. This aggregate of symbols, in the process of transforming through the daily prism of events, is reflected in understanding and the emotional perception of our daily affairs. Everything together creates a cognitive landscape identity - the way we perceive the surrounding landscape. Often, this perception is subject to stereotypes and clichés, both from the mass media and from the effects of globalization. The series of major events in the country create our collective memory and collectively cognitive perception, which is subject to individual perception peculiarities, personal memories and emotional state.

One of the most paradoxical features in the process of creating landscape identity is the place name and its perception, the way it is related to traditions or former activities, how strong and emotionally persistent the aura of this name is - this is one of the keys to the formation of a new place identity. The name of the site can be associated with a success story and a brand of recognizibility, which is an essential tool for revitalization.

SOCIAL ASPECTS OF BROWNFIELDS

The impact of brownfields is not limited to the physical impact only. On the one hand, the impact is direct - pollution, non-functionality, limited use of the territory, but on the other hand, the impact of brownfields is indirect - economic downturn, cadastral decline also in the adjacent territories, unattractive environment for investors, discomfort and dissatisfaction of the residents, doubts and even fear. If the direct impact is measurable and understandable, the indirect impact is unpredictable and closely related to several social aspects.

Community involvement and participation in the revitalization of brownfields

The participation of the community in the revitalization of brownfields requires the involvement of the public on the part of the territory’s owners or managers. It is important to understand the definition and the activities involved here.

"Participation is a form of public involvement activity in which cooperation with the government is ensured through active involvement of the public in the formulation and development of policies. At the highest level of participation, the public is directly involved in the formulation of proposals on policy making and offers concrete solutions to the problem. The involvement process may include cooperation between NGOs and the government to help the government prepare new operational programmes. In this case, NGO representatives are involved in the work of government agencies or relevant committees. The methods of public participation include referendums, formation of public assessment groups, public discussion groups or granting the authorisation to the public to make decisions independently."

Revitalization of brownfields is the responsibility of the owners, but often people are deeply concerned about the fate of the closest neighborhood, especially if there is a close cognitive link between several generations. The procedure for public participation in Latvia is determined by the Regulation of the Cabinet of Ministers "On the Procedure of Public Participation in the Development Planning Process". The purpose of the regulation is to promote effective, open, inclusive, timely and responsible public participation in the development planning process, thus increasing the quality of the planning process and the compliance of the planning results with the needs and interests of the society. Public or community participation cannot take place formally, and, in reality, it involves people's own activities which are carried out by various formal groups of society - associations, unions, foundations, trade unions, employers' organizations, religious organizations and informal groups - unregistered groups of initiatives and interest groups. It must be admitted that the involvement of the public is often in the hands of the individual active and interested physical persons.

When it comes to the revitalization of brownfields, it must be admitted that public involvement and participation in this process can go far beyond identifying the public interest and needs. Understanding the physical and mental interaction between the community and the brownfield site, it is possible to successfully carry out the indentity formation of a new place in the context of the future development of the territory. Creating a positive new identity can be facilitated by a sense of belonging in the population - so that the inhabitants feel like the owners of their city who have a positive influence on different economic processes. In the brownfield sites, it could be participation in clean-up activities, development of new products and services, defence of city interests, etc.

Public participation can be ensured through a variety of events - meetings and workshops, public information, newspapers and brochures, demonstrations, exhibitions and information centers, animated visual products, information hotline, report and survey.

Possible measures to promote copperation between the community and local government:

1.Meetings and creative workshops:

- One to one meetings;
- creative workshops;
- wide public events.

Thus, a large number of people can be provided with information, misconceptions can be corrected and concerns can be identified. This can take place both at the beginning of the project/activity and during the project/activity.

2. Informing the community through newspapers and brochures:

Informing the community through news, newspapers, brochures is useful for projects or events or activities which affect a large number of people. This is a good way to keep in touch with the community, to inform it about the intentions, the progress of the project and the results of the work. The publications created may have different formats and regularities depending on what the community is informed about.

3. Demonstrations, exhibitions and information centers:

- Information placement is mainly used to introduce project variants and solutions, and it can also be used to educate people on a particular topic;
- information can be placed in shopping centers, banks, reception rooms, libraries, information centers and other places;
- information center, created for an activity or project, provides the people with the necessary

information and receives quality information from the people. It can only work in the early stages of an activity or project when the greatest number of questions and requirements related to the project are expected;
- formal exhibitions are usually organized as an integral part of the project implementation process.

4. Animated visual products

The administration may prepare animated visual material to help people understand certain processes. They can be 15 minute long or longer videos. They may be available on the administration's or project's web site or on television.

5. Information call center

Most often it is organized by the project coordinators or public relations specialists of the administration. The information call center has the opportunity to answer questions, provide information and receive quality information from the public.

6. Review and survey

The review can be created using a questionnaire completed by the respondents, or through an interview, as well as a combination of both. This is a relatively easy way to collect large amounts of data, but the surveys must be of high quality.

Public involvement in the revitalization of brownfields provides the following specific benefits:
- it gives the opportunity for owners or managers of the brownfield sites to obtain additional sources of information and identify different options and potential solutions. It also improves the quality of the decisions on the development of brownfields;
- it draws the attention of developers to additional social risks and problems that cannot be identified, using only the administatively available information;
- it helps to monitor the development processes in the revitalization of brownfields and points to the necessary changes over time;
- it facilitates the development of collaboration between stakeholders and developers to discuss issues and seek solutions for achieving the best results;
- it promotes public confidence in developers and the legitimacy of their decisions.

In each individual case, the ultimate goal of revitalizing brownfields should be understood - how important the territory is for the residents, whether it is in close proximity to people's place of residence or workplace. More active public involvement would be necessary if there is a physical and mental connection to the place. Less public involvement is required if it is a remote territory in rural area, but in any case, publicly available information on ongoing activities and future development plans should be provided.

A positive example of successful involvement of residents in environmental improvement is the Great Cleanup event and the courtyard competition organized within the framework of the Great Cleanup event, which takes place every year in Riga and other Latvian cities. The idea of the event is based on voluntary participation in cleaning up the environment, creating unity, positivism and the feeling of a job well done.

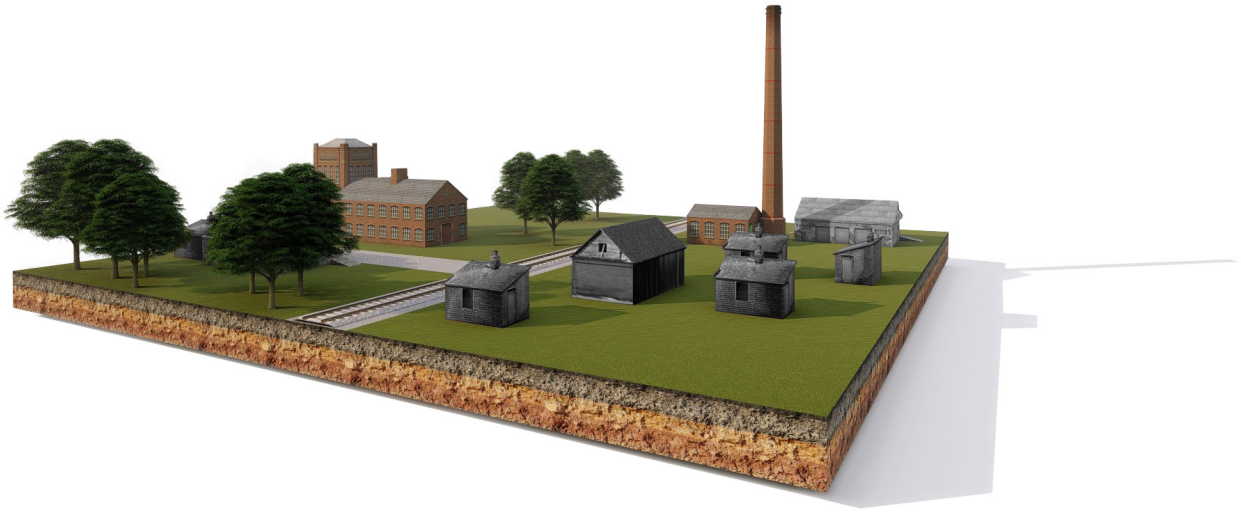
Revitalization as a tool of changing the identity of the place

The term "revitalization" originates from the English word including the Latin word "vitalis","viable","lively", which nowadays is defined as the functional activation of an old building complex by adapting it to a new social function (Dictionary of foreign words).

In the process of revitalization, the old built up area has a decisive role – there will always be a question of preserving the values. Depending on the amount and type of retention of this old built up area, two approaches can be distinguished - the strategy for the preservation of point type objects and the strategy for preserving the spatial structure

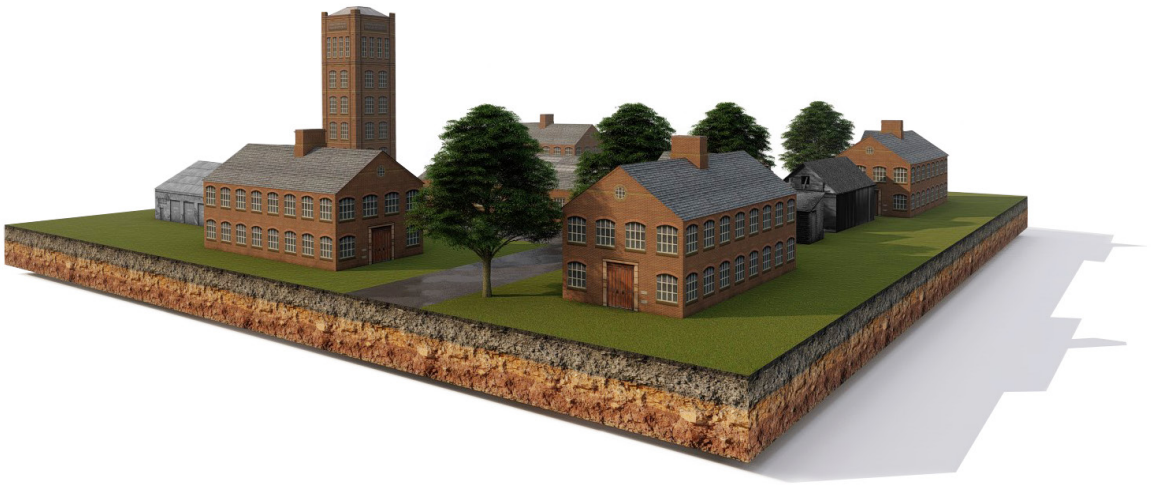
A point type preservation strategy of the objects can be used when most of the former architectural objects (warehouses, residential buildings, observation towers, technological structures) and infrastructure objects (roads, railway lines) are not in good condition and it is impossible to preserve the entire spatial structure that was once established. In such cases, architecturally expressive objects are retained which are easy to read in the landscape and which can serve as the basis for a new identity - chimneys, observation towers, railway lines, hangars with unusual architecture or large-scale objects. In the future, these objects will be given a central role in the revitalization process, and new spatial structures with a new function will be created around them, while retaining the nature of the place and traditional materials or forms.

The following objects can serve as examples:
Shopping center in Poznan "Stary Browar", designed as a modern art and shopping center in the central part of Poznan. The main dominance of this object is the old chimney, which also serves as a symbol of identity of the place. Unfortunately, many buildings could not be preserved from this object, therefore an additional modern building was created around the old chimney.
Park am Gleisdreieck in Berlin was created in a place where there once was a railway depot. Since most of the territory was occupied by railway lines and different types of structures and buildings, the decision was made to retain only a few objects from the former infrastructure - some lines and separate structures, where the museum and artists' workshops are now located, as well as public activity centers. The main benefits here are the reconnection of parts of the city, which is now actively used by residents and extensive planting areas.
Rhine Park in Duisburg is located on the banks of the river, and the people visiting the park can gain access to the riperian landscapes. The park offers recreational opportunities for all generations. From the former industrial area, it was possible to preserve only the point type objects that cannot be used as features and symbols of space identity, but only as those of place identity.



Preservation strategy of point type objects (Created by the author)

The strategy of preserving spatial structure can be used when most of the architectural objects and part of the infrastructure objects are preservable, adapting them to a new functional load.
The following objects can serve as examples:
Shopping mall and leisure complex "Manufaktura" located in the Polish city of Lodz. A private investor in the area of the former textile factory developed a new city center occypying the territory of 27 ha, preserving and reconstructing a large part of industrial buildings, which generally preserve and depict the spatial structure of the entire industrial territory.
Schöneberger Südgelände Park in Berlin after prolonged non-use, gained a new quality – in the former railway hub vegetation grew rapidly, taking over a large part of the infrastructure of the industrial area, creating an "urban jungle forest". In order to preserve the newly created habitat, the former infrastructure has not been eliminated in many places and the park has preserved its linear spatial structure and several buildings with a dominant tower.
Zollverein Park in Essen has preserved the structure of a former coal processing plant - with larger structures and railway lines. One of the technical structures became a recognizable symbol of the revitalization of all industrial areas of the German Ruhr region.
Landscape Park Duisburg Nord once was a coal-processing company with a large area (220 ha), but since 1992 it has acquired a new function, retaining its spatial structure – both most of the technical structures and also the infrastructure objects. Currently, the buildings serve both private and corporate events, and the area is open to visitors as a vast scenic park with technical buildings and symbols of the territory that are closely related to art.



The strategy of preserving spatial structure (Created by the author)

The revitalization of each brownfield has an individual approach strategy based on several aspects - the spatial structure to be preserved, the aura and identity of the place, political, social and economic processes, respecting the heritage landscape and the presence of nature factors.

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PHYTOREMEDIATION PROCESS AND APPROACHES TO REVITALIZATION OF DEGRADED TERRITORIES USING THE PHYTOREMEDIATION METHOD

Jovita Pilecka, Inga Grīnfelde

Phytoremediation is the use of plants and a complex of microorganisms associated with them to reduce the concentration of contaminants or their toxic effects in the environment.

It is a relatively new technology and is considered to be cost-effective, efficient, environmentally friendly and oriented to solar-powered technology. Its research began in the 1990s. It is suitable for large areas of pollution where other treatment methods are not cost-effective or practical. Phytoremediation has low implementation and maintenance costs compared to other remediation methods. In addition, establishing vegetation in the contaminated areas helps prevent soil erosion and contaminant leaching. Fast-growing plants and plants with high biomass growth, such as willows, poplars and aspens, can be used for phytoremediation and energy production.

Environmental remediation can be implemented in two ways: in situ and ex situ. Ex situ methods include treatment of contaminated soil and groundwater outside the contaminated location. Traditionally, the contaminated substrate is excavated, transported to a treatment site, physically and/or chemically cleaned, and then returned to its place, already cleaned, or it is burnt or buried. Ex situ phytoremediation is carried out in treatment sites or in greenhouses where the plants which can bind or accumulate the contamination are planted in the contaminated soil. Using In situ traditional methods, decontamination is carried out on-site using physical, chemical or mechanical methods, such as phytohydraulics of contaminated groundwater, decontamination and infiltration in deeper layers of groundwater. In situ phytoremediation is carried out on by planting plants in the contaminated area.

In many environmental remediation projects, phytoremediation is used after the initial decontamination procedure. If there is a low-concentration contamination, phytoremediation can be a very economical and effective solution. In locations where contamination is less toxic, phytoremediation is suitable as a long-term solution to the problem.

Advantages of phytoremediation:

- it treats from organic and inorganic contamination;
- it is a passive technique;
- it constitutes only 10 - 20% of mechanical treatment costs;
- it is faster than natural remediation;
- it is an environmentally friendly method;
- no water and air pollution;
- the use of this method does not require fossil natural resources;
- it can be used as in situ method;
- it can be used to clean up vast territories

Drawbacks of phytoremediation:

- depth of plant roots is a limiting factor;
- in the case of high concentrations of contamination, it may be dangerous for animals feeding on plants;
- the need for plant mass utilization;
- it is a time-consuming method;
- it is effective only in the case of moderate contamination;
- toxicity to biodegradation products is unknown;
- contamination may enter the groundwater;
- affects soil and climate change;
- sunlight is required.

PHYTOREMEDIATION METHODS

Several methods are distinguished: in situ phytoremediation method, in vivo phytoremediation method and in vitro phytoremediation method. Methods differ depending on the location where the

remediation of contamination takes place – in the place where contamination has originated (in situ) or in some transferred place (ex situ).

In situ phytoremediation

In situ phytoremediation method involves the placement of plants in contaminated surface water, soil or sediments, or in soil that is in contact with contaminated groundwater. With this approach, it is not necessary to displace the contaminated material before phytoremediation. If plants absorb and accumulate pollutants instead of transforming them, the plants used for phytoremediation can be collected for disposal in landfills or for regeneration. In situ the main requirement is that contamination should be directly accessible to plant roots. The in situ method is usually the most economically advantageous type of phytoremediation.

In vivo phytoremediation with transferred contaminants

In areas where contamination is present in deeper soil or water carrying layers, an alternative method of phytoremediation is possible - ***in vivo*** phytoremediation. When using this method, the contaminated water or soil is transferred by use of mechanical means, then it is transferred to a temporary remediation location, where it is subjected to optimal phytoremediation. After treatment, the treated water or soil can be returned to its original location and the plants can be removed for utilisation if necessary. Regarding the economical aspect, this approach to phytoremediation is more expensive than the one described before. Remediation can be carried out either at the location of contamination or at another suitable location.

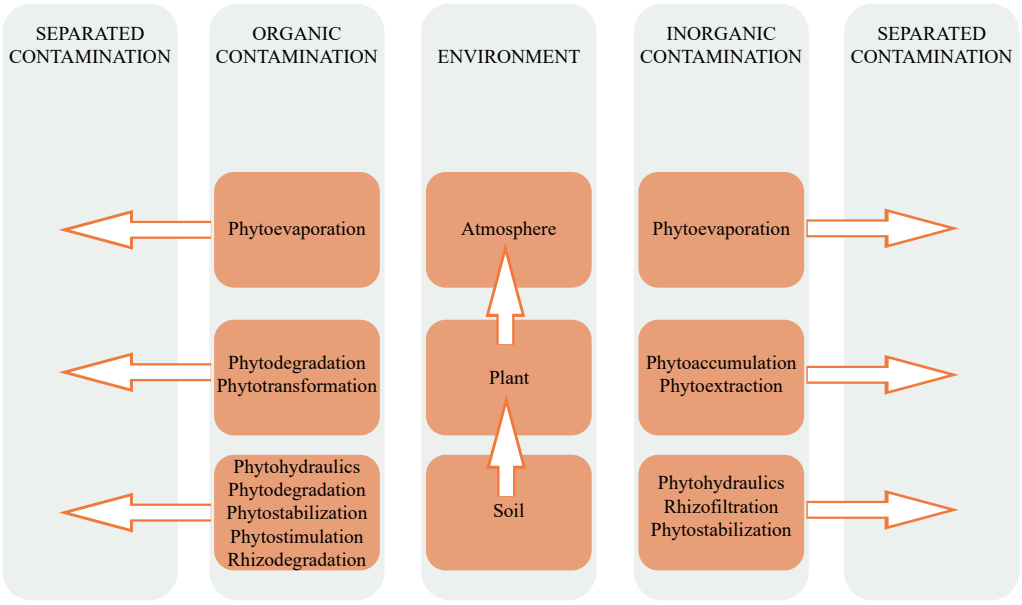
In vitro phytoremediation

In the above mentioned methods of phytoremediation the ability of growing plants to absorb pollutants is used. ***In vitro*** phytoremediation method is based on the ability of plant exuded enzymes to neutralize contamination. This method can be applied on the site, for example, by using plant preparations to clean contaminated water bodies or wetlands. Such an approach may also be applied to the remediation of contaminated substrate that is moved to temporary storage. Theoretically, this is the most expensive phytoremediation method because of the high costs of preparing and obtaining plant enzymes.

TYPES OF PHYTOREMEDIATION

There are several ways of phytoremediation of how plants can reduce contamination: phytoaccumulation, phytostabilization, phytotransformation, phytodegradation, phytovolatilization, and rhizodegradation.

All these types of phytoremediation are based on various methods of reducing contamination and each of them is suitable for reducing a specific type of contamination, for example, phytoaccumulation and phytostabilization are more effective in cleaning up salts and heavy metals, but less effective in cleaning organic contaminants and explosives, where it would be more advantageous to use phytodegradation. The contaminants that can be remediated by the phytoremediation method are listed in Table.



Types of phytoremediation (K. Valujeva according to the materials of I. Grinfelde's study course "Applied Ecology")

Types of contaminant remediation or cleanup

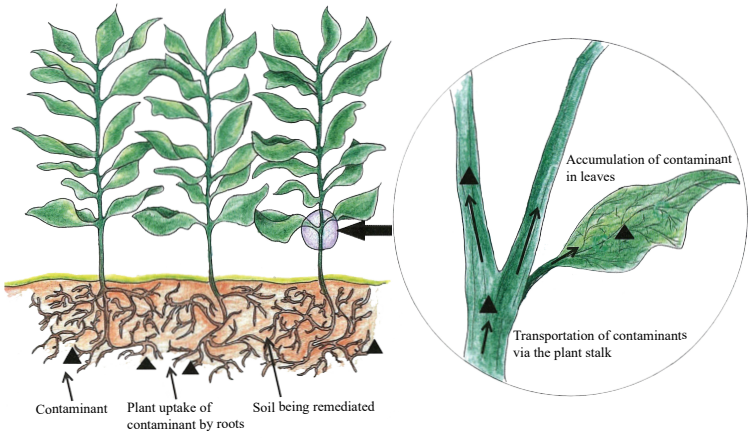
Type of phytoremediation	Contaminants
Phytoaccumulation (phytoextraction)	Cadmium, chrome, lead, nickel, zinc, and other heavy metals, selenium, radioactive isotopes, BTEX (benzol, ethylbenzol/ethylbenzene, toluol and xylene), pentahlorophenol, short chain aliphatic compounds and other organic compounds
Phytodegradation/ Phytotransformation	Ammunition (DNT, HMX, nitrobenzol, nitromethane, picric acid, RDX, TNT), atrazine, solvents containing chlorine (chloroform, carbon tetrachloride, hexachloroethane, tetrahloroethane, trichloroethane, dichloromethane , vinyl chloride, trichloroethanol, dichloroethanol, trichloroacetic acid, monochloroacetic acid, tetrachloromethane, trichloromethane), DDT, methyl bromide, tetrabromomethane, tetrachlorethane, other chlorine and phosphorus based pesticides, polychlorinated phenols and other phenols.
Phytostabilization	Heavy metals, ammunition waste,solvents containing phenol and chlorine
Phytostimulation/ rhizodegradation	Petroleum hydrocarbons, atrazine, alachlor, polychlorinated biphenyl (PCB), tetrachloroethane, trichloroethane and other organic compounds
Phytovolatalization	Chlorine-containing solvents (tetrachloroethane, trichloromethane and tetrachloromethane), mercury and selenium
Phytohydraulics/ Rhizofiltration	Heavy metals, organic chemical substances and radioactive isotopes

The following factors affect the uptake and transportation of chemicals in the plant:

- physical and chemical properties of the contaminants and compounds (e.g.water solubility, vapor pressure, molecular weight and octanol-water partition coefficient used for chemical risk assessment);
- environmental characteristics (e.g. temperature, pH, organic matter and soil moisture content);
- plant properties (e.g. root type and type of enzymes).

Phytoaccumulation/Phytoextraction

Phyto-accumulation is based on the principle that the plant's contaminant is not transformed, but accumulates in plant parts.



Phytoaccumulation/Phytoextraction (K. Cirse acording to Yaapar et al., 2008)

The phytoaccumulation technique does not destroy the soil structure and fertility. There are plant species that accumulate metals (such as nickel, zinc, copper, chromium) and radionuclides. Accumulation of heavy metals is the accumulation of contaminating substances in plant tissues more than 0.1% of the weight of dry matter (0.01% for cadmium). Of the most common elements, such as iron and manganese, accumulation occurs when more than 1% of the chemical element from the total plant mass is found in plant tissues. In this process, some plants can accumulate contaminants to the allowable levels in the soil.

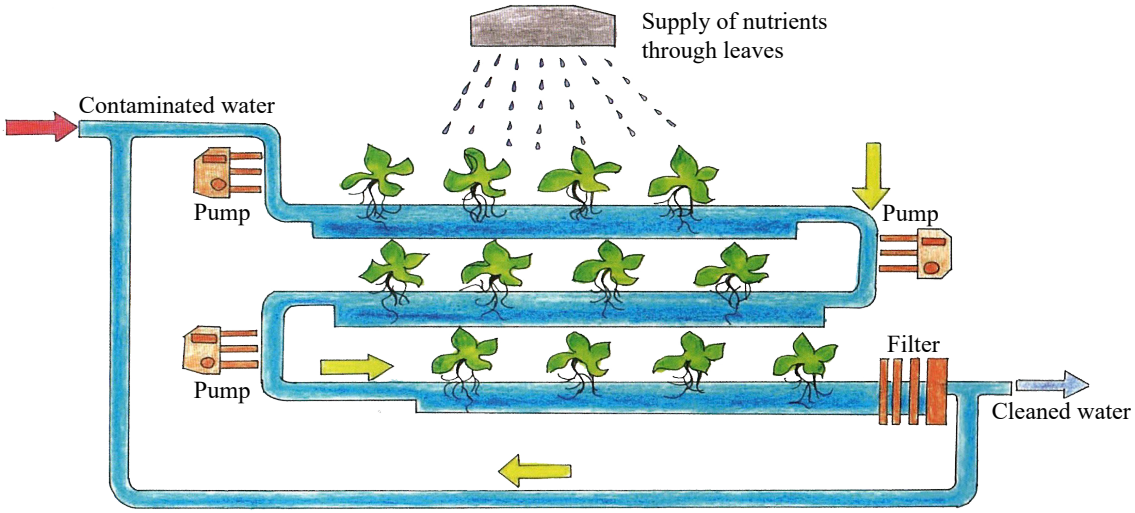
Some plants can grow in contaminated areas and accumulate metals and other contaminants, such as perchlorate, while other plants may not withstand and they may die as a result of the accumulation process. However, less tolerant plants can be used in contaminated areas, but in this case they must be collected and disposed of after the contaminants have been accumulated. If necessary, such species can be planted repeatedly to complete the cleanup of the contaminated area.

If the purpose of the cleanup is to collect the accumulated contamination, it is desirable that the selected plants move the contaminants from the root to the surface parts, such as the stem and leaves. If the contaminant stays in the roots, its collection for disposal or recycling could be more complicated and expensive.

Phytohydraulics/Rhizofiltration/Water Balance Control

Phyto-hydraulics is another type of phytoremediation that can be used to prevent or reduce the spread of contamination.

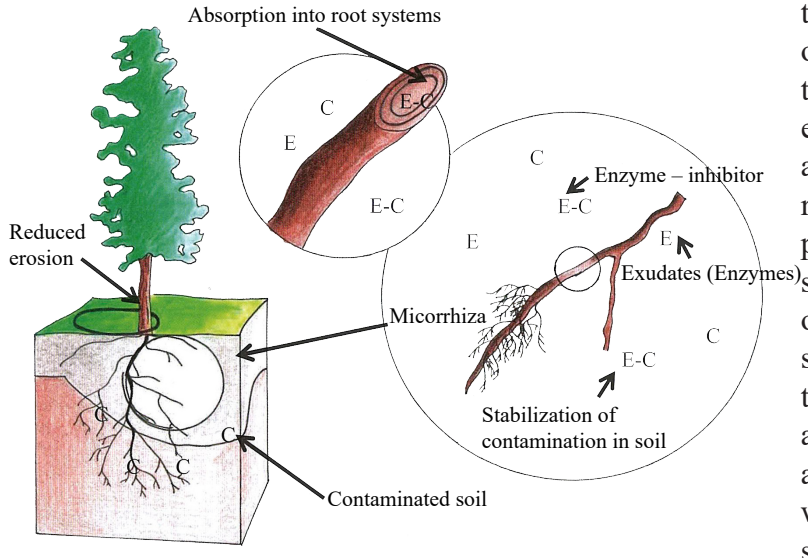
In this case, the plants are used as large organic "pumps" - they absorb water, in which toxic or chemical substances are dissolved, they also carry out the filtration of contaminated water through the root system. Willow species (Salix spp.) are the most suitable for phytohydraulics. They can use up to 200 litres of water a day. On a hot summer day, willows can use up to more than 750 litres of water. All plants with these properties can provide a cheap alternative "mechanical pump" and thus clean shallow groundwater.



Phytohydraulics and water balance control (K. Cirse acording to Yaapar et al., 2008)

Phytostabilization

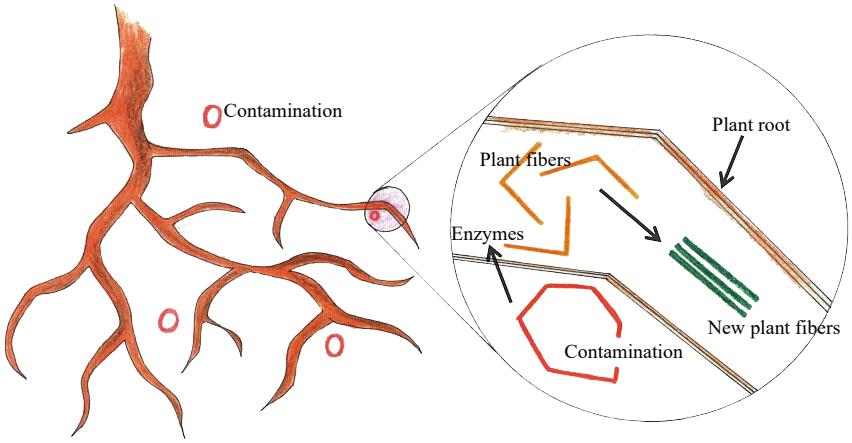
Phytostabilization is a type of phytoremediation that can be used to reduce the spread of contamination in the soil (see Figure). During the phytostabilization process, toxic pollutants are stabilized in the long term and excluded from the circulation of substances. This process is based on the ability of plant roots to change the environmental conditions of soil, such as pH and soil moisture content. Many root excretions attract metal ions and promote their sedimentation in root systems, thus reducing the bioavailability of contamination. The advantage of this strategy, unlike phyto-accumulation, is that there is no need for plant utilization after rehabilitation. By selecting and using appropriate plant species in the interaction with relevant soil conditions it ispossible to stabilize certain contaminants (especially metals) in the soil.



Phytostabilization (I.Kalnina, according to Yaapar et al., 2008).

Phytodegradation/phytotransformation

In the phytodegradation or phytotransformation process, plants absorb contamination and metabolize it into less harmful compounds, and accumulate the contamination in tissues, besides, the contaminants can also be broken down by plant-released enzymes.



Phytotransformation/ Phytodegradation (K. Cirse acording to Yaapar et al., 2008)

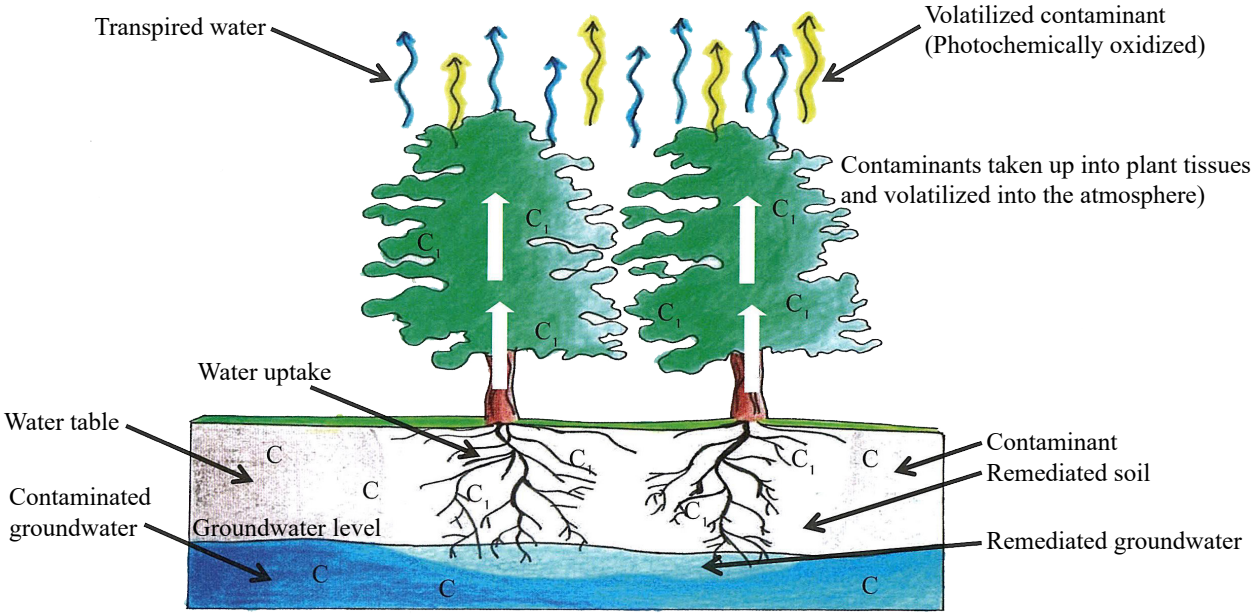
For example, phenols are broken down by enzymes – peroxidases, which are found in horseradish, potatoes and white radish. Plants contain also enzymes that can break down and transform munition waste, chlorinated solvents and herbicides.

In the phytotransformation process, it is possible to convert chlorinated, phenol, aromatic, explosive and other nitrated compounds, as well as phosphorus organic pesticides.

Phytovolatilization

Phytovolatilization is a mechanism in which plants are able to convert pollution into a volatile form, thereby eliminating contamination in soil or water.

For example, plants with microorganisms can convert selenium into dimethylselenide. Dimethylselenide is a less toxic, volatile form of selenium. Phytovolatilization is a cost-effective way of eliminating selenium from sites with high levels of selenium contamination. Similarly, some genetically modified plants are capable of converting organic and inorganic mercury salts into the form of volatile compounds.



Phytovolatilization (I.Kalniņa, acording to Yaapar et al., 2008)

Rhizodegradation

Rhizodegradation is the biological treatment of contamination with increased bacterial and fungal activity in the vascular plant rhizosphere. Rhizosphere is a root zone in the soil with an increased density of microorganisms and activity around the root system. Plants with a neutral geochemical environment in the rhizosphere provide ideal conditions for the development of bacteria and fungi, and they can degrade organic contaminants. Plant residues and root enzymes provide nutrients, such as nitrates and phosphates, which, in turn, reduce the need for fertilizer additives. Plant roots in the soil provide soil aeration and promote biodegradation.

TOPICALITY OF HEAVY METAL CONTAMINATION PROBLEM

The problem of heavy metal contamination is becoming more and more topical taking into account the ever increasing industralisation and the disturbances of natural biogeochemical cycles. Unlike organic matter, heavy metals are not biodegradable and they accumulate in the environment. The accumulation of heavy metals in soil and water poses a threat to the environment and human health. These elements accumulate in the tissues of the body (bioaccumulation) and their concentration increases. Heavy metals in soil have toxic effects on soil microorganisms, which can lead to a reduction in their number. Regarding the role of heavy metals in biological systems, they are classified as essential and non-essential. Essential heavy metals are those that are necessary for living organisms in minimal quantities for providing physiological and biochemical functions such as iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), chromium (Cr) and nickel (Ni). Non-essential heavy metals are those that are not necessary for living organisms to provide physiological and biochemical functions, such as cadmium (Cd), lead (Pb), and mercury (Hg). If heavy metal concentrations exceed certain limits, they have a negative impact on health by interfering with the normal functioning of the body's systems. Pursuant to the laws and regulations of the Republic of Latvia, the target values and limit values for heavy metals in underground and surface waters are determined by the rules on surface and groundwater quality, but in the ground and soil, heavy metal target values and limit values are determined by the rules on soil and ground quality standards.

The sources of heavy metals in the environment and their impact on human health

Heavy metals enter the environment from both natural and anthropogenic sources. The most significant natural sources are atmospheric dust, erosion and volcanic activity, but anthropogenic sources include the extraction of metals, melting, the use of pesticides and fertilizers, utilization of sewage sludge, industrial by-products, atmospheric sediments, etc..

Anthropogenic sources of particular heavy metals in the environment

Heavy metals	Sources
Arsenic (As)*	Pesticides, wood preservatives
Cadmium (Cd)	Paints and pigments, plastic stabilizers, cadmium coatings, plastic burning, phosphate containing mineral fertilizers
Chromium (Cr)	Leather and steel industry
Copper (Cu)	Pesticides, fertilizers, textile industry
Mercury (Hg)	Medical waste, fluorescent lamps, organic pesticides containing mercury
Nickel (Ni)	Industrial waste water, kitchen appliances, surgical instruments, steel alloys, batteries
Lead (Pb)	Batteries, herbicides and insecticides

Impact of heavy metals on human health

Heavy metals	Harmful effect
Arsenic (As)*	Affects cellular processes
Cadmium (Cd)	Carcinogenic, mutagenic, and teratogenic, causes kidney failure and chronic anemia
Chromium (Cr)	Leads to hair loss
Copper (Cu)	Causes brain and kidney damage, liver cirrhosis, anemia and gastrointestinal inflammation
Mercury (Hg)	Causes autoimmune diseases, anxiety, depression, balance disorders, drowsiness, fatigue, hair loss, insomnia, irritability, memory loss, recurrent infections, unrest, visual disturbances, tremor, temperament outbreaks, ulcers and damage in brain, kidney and lung functioning
Nickel (Ni)	Causes allergic dermatitis ("nickel itching"), lung, nose, sinus, throat and stomach cancer, leads to hair loss
Lead (Pb)	Affects development, causes temporary loss of memory, impaired perception and coordination problems in children. Causes kidney failure, promotes the development of cardiovascular diseases
Zinc (Zn)	Causes dizziness and fatigue

**Depending on the modification, arsenic can have both metal and non-metallic properties*

Treatment of soils contaminated with heavy metals

The concentration of heavy metals in the environment is increasing every year, therefore the treatment of soils contaminated with heavy metals is essential to reduce their impact on ecosystems.

It is a technically complicated process involving high costs. So far, various physical, chemical and biological methods have been used. Conventional remediation methods include soil incineration, digging and disposal in landfills, soil washing and rinsing. These methods cause irreversible changes in soil properties and disturbance of soil microflora. Chemical methods can also cause secondary pollution problems.

Treatment of soil contaminated with oil products

In the case of a large extent of pollution, it is economically advantageous and efficient to use physical and mechanical soil remediation methods. Ex situ methods for removing oil pollution are mechanical cleaning of soil (e.g. rinsing), thermal treatment, mechanical treatment of soil (plowing, harrowing), biological treatment in stacks and bioreactors. In situ methods for eliminating oil pollution are vacuum pumping, biodegradation, solidification, pressure air injection and biphasic pumping. These methods, except biodegradation, allow achieving results within a relatively short period of time, however, they are very expensive. Phytoremediation in this aspect is a new and little researched direction that needs to be developed by launching experimental studies.

Phytoaccumulation of heavy metals

Phytoremediation can be used to remove heavy metals and radionuclides, as well as organic contaminants. Plants usually take up substances without affecting the topsoil. Phytoaccumulation is the main and most commonly used method of phytoremediation to remove heavy metals and non-metals from contaminated soils, sediments and water. The effectiveness of phytoaccumulation depends on many factors, such as the type of the heavy metals, concentration and soil properties.

For plants that are suitable for phytoaccumulation, the following characteristics and properties are desirable:

- rapid growth;
- large surface biomass;
- widely branched root system;
- ability to absorb heavy metals from the soil;
- ability to transport heavy metals from roots to shoots and leaves;
- resistance to toxic effects;
- good adaptability to environmental and climatic conditions;
- resistance to pathogens and pests;
- easy growing and harvesting.

The phytocumulative potential of plant species is determined by two main factors - metal concentration in the substrate and plant biomass.

Hyperaccumulators are plants that have relatively lower surface biomass, but more heavy metals accumulate in them. Such plants are more important for phytoremediation than for biomass production. By using hyperaccumulators, a higher metal concentration is obtained per plant biomass unit, which is economically more advantageous and facilitates the recycling or disposal of metals. If the plants that produce more biomass and accumulate less metals are used, the metal extraction and release from biomass will not be cost effective.

Plants that produce more than one crop during one growing season may have greater potential for accumulating heavy metals. For accumulation, grasses are more suitable than shrubs or trees due to their rapid growth lower amount of biomass.

The use of cultivated plants for the phytoaccumulation is problematic, since contamination enters the food chains and the circulation of substances. When using cultivated plants for phytoremediation, they should not be used for food and feed.

Possibilities of further utilization of plants

The method of further utilization depends on the plant species used in phytoremediation.

It is a necessary procedure to reduce the risks to the environment that can occur if plants have accumulated contaminants in their tissues at concentrations that are hazardous to other living organisms.

If woody plants, that have accumulated contaminants in the leaves, are used, it is necessary to collect fallen leaves in the autumn period and dispose of them. If a fast-growing tree plantation is established, it is advisable to harvest the trees periodically at a time when the trees are able to form new shoots, thus ensuring continuous remediation. If the remediation does not result in a contaminated biomass, the biomass obtained during phytoremediation can be used to generate energy, produce inorganic substances such as heavy metals or ensuring animal feed. The type of plant utilization or disposal is selected based on the results of the plant analysis. When designing a phytoremediation project, it is recommended using plant species that deplete hydrocarbons by converting them into H2O un CO2, thus eliminating the need for further plant utilization.

Restrictions of phytoremediation

Although phytoremediation is a promising approach to the remediation of soil contaminated with heavy metals, it requires the following prerequisites for its successful process:

- the ability of metals hyperaccumulators to absorb heavy metals;
- bioavailability of soil contamination;
- low and medium concentration of metals in the contaminated location.

The main disadvantages of this remediation method are the risk of food chain contamination and its time-consuming nature. Phytoremediation is a relatively new area that requires long-term and systematic research. Currently, most of the research has been performed in laboratories and/or in greenhouses, only a few studies have been conducted under field conditions. Thus, actual results may differ from those obtained under laboratory and / or greenhouse conditions, because in a natural environment the plant can be influenced by a combination of factors and conditions that cannot be provided under laboratory and/or greenhouse conditions. The main factors that may affect phytoremediation include temperature fluctuations, the amount of available nutrients, precipitation and moisture content in the soil, plant disease agents, uneven distribution of contamination, and soil type, its pH and structure.

Currently research is being conducted in the world to identify gene codes for hyperaccumulators. Identification of properties and successful gene transformation allow the development of "supervirus" plants for phytoremediation. By combining various desirable plant properties in this way, you can get a plant that will be able to clean up the contaminated area quickly and efficiently. However, gene interaction is difficult to predict, it is very complex and it can do harm to the environment in the future.

Despite these shortcomings and the necessary preconditions for ensuring effective phytoremediation, it is nevertheless considered to be one of the most promising remediation methods for the elimination of low or medium concentration contamination.

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SELECTION OF PHYTOREMEDIATION PLANTS DEPENDING ON CLIMATIC AND ECOLOGICAL CONDITIONS, INDICATOR PLANTS THAT INDICATE THE POLLUTION IN NATURE

Inga Straupe

Plants and plant communities or vegetation are formed in the process of interaction with the environment and other organisms in it, thus forming an ecosystem.

The system as a whole is self-regulating and self-sustaining while also being open. The vegetation reflects certain regularities that allow us to indirectly judge about the humidity, lighting, soil reaction and other conditions of the place of growth. It also makes it possible to judge whether the transformation of natural vegetation has started in the place of growth due to the economic activity and introduction of non-typical species. The best indicators of the processes taking place in nature are ground vegetation plants - not individual species, but plant community or phytocenosis in general, and the quantitative distribution of plants is also important.

Each species requires an optimal set of ecological factors to ensure growth, development and reproduction. In addition, at the same time each organism is exposed to the influence of complex ecological factors during its existence.

Each species has specific requirements for the environment in which it is located, and also certain adaptations to live in a particular environment.

The size and configuration of the area of distribution of each plant species depend on the relationship of the species with the environment: its requirements for particular environmental conditions and its ability to respond to the changes in these conditions.

The key factors influencing and regulating plant species in the environmental complex are climate (especially light conditions) and soil characteristics (the amount of nutrients, water and soil oxygen available to plants, as well as soil reaction).

Plant development is influenced by the interaction of these factors, with only a few of the “most aggressive” plant species being able to occupy habitats that match their physiologically optimal conditions. Most plant species have to "put up" with only partially optimal growth conditions.

HEREDITY AND VARIABILITY OF PLANTS

Plant tolerance is their ability to resist the effects of unfavorable external conditions, minimizing their loss of viability.

Plants have heredity and variability due to which the tolerance to certain negative external environmental conditions is developed. Throughout their lives, plants may face unfavorable conditions such as too low or too high temperatures, water shortages or abundance, too much or too little light, too high concentration of soluble salts in the soil, diseases and pests, as well as air and soil pollution. Due to various unfavorable factors plants may develop various tolerances, such as cold tolerance, frost and heat tolerance, winter tolerance, shade tolerance, tolerance to drought, smoke, gasses as well as imunity (Mauriņa, 1987).

Plant heat tolerance and drought tolerance are interlinked because transpiration is intensified in the case of tissue overheating. Most plants of temperate climate do not tolerate temperatures above 45 – 50 ^{o}C, but there are some plants with higher heat tolerance, such as succulents belonging to a group of drought tolerant plants. In the cells of heat tolerant plants, protoplasm is more tolerant to coagulation in cases of elevated temperatures. They also retain the ability of synthesis and do not accumulate harmful metabolic toxins.

Plants often have to tolerate both soil and atmospheric drought. Soil drought can occur when there has not been rain or in winter periods with a poor snow cover. Drought tolerant plants are less susceptible to the changes in cell protoplasm permeability due to drought, plants are more likely to endure and recover from drought-related disturbances. Physiological disorders of drought tolerant plants occur when they have lost a large amount of water, and the consequences become apparent later than in other plants. Over time, plants are forced to adapt themselves to external environmental conditions, therefore the plants that once have survived the drought have become more drought resistant. The same pertains to their descendants.

Plant cold tolerance is their ability to withstand low but positive temperatures without significant damage. Cold tolerant plants develop metabolic disorders due to low temperature, there is no photosynthesis in these plants, growth is inhibited and the rigidity of protoplasm increases. The frost tolerance of the plant is the ability to tolerate a low negative temperature that does not result in damage, and the plant can successfully continue its physiological processes after the frost ends. Protective substances such as glucose, sucrose and oils increase the resistance of the cell to low temperatures, lowering the freezing point in the cells and changing the properties of their biocolloids. Frost damages visually resemble the burns and the damaged leaves look withered. Tree trunks are mostly frost resistant, but under low temperatures, ice is formed in the trunk, resulting in frost cracks that can be 3 cm deep and stretch for several meters.

Winter hardiness is the ability of the plant to tolerate unfavorable external environmental factors such as heaving, disappearance, drowning and drying out. Heaving occurs when the upper layer of soil rises as a result of the expansion of frozen water. The roots which are anchored in the soil are ruptured, thus the regeneration node is lifted above the soil surface and dries out in the spring. Disappearance occurs when snow covers unfrozen soil, since the temperature below the snow cover may be higher than 0 °C, so the soil does not freeze. Under these conditions, intensive plant respiration takes place during which nutrient reserves are consumed, as a result of which plants become weak and lose their frost tolerance. If the weakening of the plants is too serious, they die or are smothered. Drowning occurs when plants are under water for a long time, consuming all the available O_2, and when it is totally consumed, the plants die. For a short time, the plants perform anaerobic breathing, which results in alcohol that has a devastating effect on the living cells of the plant. Drying out, for example, of woody plants occurs in situations where their surface parts in the winter period are above the snow cover, thus transpiration takes place that results in reduced water reserves, since the soil is frozen and the roots are unable to absorb water. In order to limit transpiration, plants form thickenings on the outer walls of the cells, resin is exuded on the surface of the scaly buds, and the scars of the fallen leaves are overgrown with a layer of cork cells. Shade loving plants are adapted to dim lighting conditions, their leaves are larger, but thinner than those of the sun loving plants. Leaves have a sparse venation and physiological processes take place more passively than in the case of the sun loving plants. The maximum light intensity for photosynthesis is half of the total sunlight.

Under the influence of industrialization, gaseous substances (emissions, exhaust gases from road transport) mix with the atmospheric air and penetrate into the plants through their stomata. As a result of a chemical reaction, sulphuric acid and sulphurous acid are produced in the plants causing their death. Deciduous trees and shrubs are more resistant to harmful gases than conifers, since they are able to drop their leaves, thus getting rid of the pollution. From the herbaceous plants, the most common is Dactylis glomerata, Phleum pratense and Elytrigia repens. Plant tolerance or resistance to gases is determined by: 1) the duration of the leaves; 2) the activity of the stomata – the species, whose stomata spend more time in an open state are more likely to absorb harmful substances and die; 3) the ability of cells to neutralize the gases which have penetrated into them; 4) the ability of cells to resist the impact of the accumulated harmful gases.

THE IMPACT OF ABIOTIC FACTORS ON THE PLANT GROWTH AND DEVELOPMENT

Plant growth and development are among the most important processes in plant life, and they are closely related. Growth is an increase in the organism's dimensions that manifests itself in the increase in plant mass, number and volume of cells, number of organs and their size, serving as the most important sign of development. Development is the life cycle of the plant, from the formation of the zygote to the death of the organism.

The most essential abiotic factors affecting plant growth and development are temperature, light, length of the day, humidity as well as the content and amount of the mineral substances.

TEMPERATURE

Growth and development depend on the temperature minimum, optimum and maximum. For most temperate zone plants, the minimum temperature is 5 ^{o}C, and they can tolerate lower temperatures, but then their growth does not take place. Intensive growth occurs at an interval of between 6^{o} and 30 ^{o}C, but over 30 ^{o}C, growth is inhibited. Approximately between 40^{o} and 45 ^{o}C, growth is completely stopped. At minimum and maximum temperatures, plant growth and development are stopped, but their viability is ensured. In order for the seeds to germinate, they sometimes need stratification, which requires a temperature between 0^{o} and +5 ^{o}C, and good aeration conditions, preventing premature seed germination. Temperature is required for the realization of various enzymes and also for biochemical processes.

Various life forms or ecobiomorphs have emerged when plants adapt to seasonal temperature fluctuations and factors related to them. They characterize plants according to their adaptability to resist unfavourable conditions during the wintering period: the condition of the plants' reproductive organs, hibernation buds or young shoots in relation to the topsoil, or their condition in relation to the snow cover or water surface during the unfavorable period of the year (winter).

- Epiphytes - plants that grow on the stems of other plants and do not have direct contact with the soil;
- Phanerophytes are plants (trees and shrubs) whose perennating buds and branches during the winter period are above the snow cover (trees, shrubs and vines) and whose surface parts are capable of completely withstanding unfavorable conditions or dropping the leaves (at least 25 cm high);
- Chamaephytes are small shrubs or dwarf shrubs - plants whose surface parts under Latvia's weather conditions can withstand winter in a snow cover and their height is usually no more than 25 cm (dwarf shrubs: *Vaccinium myrtillus L.*, *Vaccinium vitis-idaea L.*, *Vaccinium uliginosum L.* and *Ledum palustre L.*) they can fully or partially overcome the effects of adverse conditions only if they are covered with snow or some organic debris;
- Hemicryptophytes - perennial herbaceous plants whose surface parts almost completely die, with the exception of the roots and the base of the stem with buds located on the surface of the soil and protected from external adverse effects by organic debris and topsoil;
- Cryptophytes - plants whose perennating buds are in soil or bodies of water. These plants perennate, for example, with bulbs, tubers or rhizomes. Sometime cryptophytes are subdivided into subgroups - helophytes (aquatic plants rooted in the substrate at the bottom of the body of water), geophytes (bulbous plants) and hydrophytes (freely floating aquatic plants);
- Therophytes – annual herbaceous plants that perennate in the form of seeds or spores because the plant itself dies.

Light

Plant seed germination takes place in the soil, and the ability of the plant to grow in height under dark conditions is very important, because the new shoot should be able to stretch high enough to reach the surface of the soil and use the light for further growth. Light promotes cell division, but slows down growth by stretching. Comparatively smaller plants are found in mountainous areas, as they are more exposed to blue-violet rays that prevent growth. In the dark the growth is faster than in the light, and the growth is periodical. The growth in the dark is facilitated by using the rezerve nutrients contained in the seed or some other part of the plant. If the plant is not exposed to sunlight for a long time, then parts of it, such as leaves start dying off. The growth of the root system and the surface parts is in constant interaction. If the plant has more leaves, it receives more nutrients that promote the development of the root system. If the root system is sufficiently well developed, the surface parts will also be stronger, since the root system will be able to supply the other parts with the required minerals and water.

Depending on the requirements for lighting, plants are divided into:

- heliophytes, or light-loving plants,
- sciophytes or shade-loving plants;
- embryophytes or shade-tolerant plants.

Effects on growth are caused by the simultaneous exposure of plants to light and temperature. The sun creates both light and heat, so with the increase in lighting the temperature also increases. The most intense lighting in Latvia is observed at the beginning of spring. The most unfavorable growing conditions are in the mountains, because the daylight is too strong, but at night the temperature is too low, so the plants are shorter and with smaller leaves.

Moisture

Water is one of the most important factors in plant growth, since each physiologically active cell contains about 80% water, therefore growth can only occur if the plant is supplied with a sufficient amount of water.

The lack of it can adversely affect the plant's stretching phase. In the case of water deficiency, the leaves begin to wither and their suction power increases, taking away water from the other parts of the plant, such as the growth cone and stretching parts. The number of cells decreases and their stretching is impaired, thus decreasing the growth of the plant. Temporary drought does not significantly affect the rate of plant development, but it inhibits its growth and negatively affects the organs that develop during the period of drought.

Depending on the requirements for moisture, plants are divided into the following groups:

- hydrophytes - plants that entirely or partially grow in water (Typha spp.);
- hygrophytes - plants of wet vegetations (Caltha palustris and Salix spp.);
- mesophytes – plants of normal moisture vegetation (Trifolium pratense, weeds and deciduous trees)
- xerophytes – plants of dry vegetation. They are divided into sclerophytes (the required amount of water is obtained by a very strong root system extending up to 10-15 m deep), succulents (characteristic trait: juicy stem or leaves where the plants accumulate water reserves), ephemerals (annual herbaceous plants that withstand drought in the form of seeds) and ephemeroid plants (perennial herbaceous plants that endure periods of drought in the form of tubers, rhizomes and bulbs).

Soil

Soil is a layered environment where the properties of layers change by centimeters, creating different ecological gradients in relatively narrow spatial dimensions.

In addition, the mechanical composition of soil, its porosity and organic matter content also determine the characteristics of water infiltration and evaporation, as well as the temperature regime. Soil properties change not only in the vertical but also in the horizontal direction. It is determined by the terrain and its interaction with wind and water flows. The chemical properties of soil are formed by the interaction of mineral components and living organisms. They directly and indirectly determine the spread of living organisms on land, but at the same time living organisms also change the soil itself: living organisms loosen the parent rock and form the soil structure. The content of plant nutrients in the soil is determined by their amount in minerals and organic matter, but the availability of these elements for plants by the solubility and ion absorption on solid phase particles. Elemental solubility depends on soil reaction - soil acidity or alkalinity, which is largely a result of microbiological processes. These are plants that are most closely related to the soil, they interact with the soil through their root systems.

Plant roots are characterized by mycorrhiza, a form of symbiosis, when one of the organisms is the highest plant, such as a woody plant or herbaceous plant, and the other is a fungus.

In the conditions of ectotrophic mycorrhiza, the fungus forms a closed top layer around the root. Root hairs die off, so the nutrients are absorbed by the fungus. The threads of hyphae wrap around the root and grow minimally in the root tissues. In the condition of endotrophic mycorrhiza, root hairs do not die and the fungus hyphen threads grow in the root bark cells, with the exception of a few threads that do not grow in the root. Ectoendotrophic mycorrhiza is similar to endotrophic, only in the case of ectoendotrophic mycorrhiza, the fungus grown into the root tissues forms the top layer on the root surface. With the help of mycorrhiza, it is possible for plants to absorb organic nitrogen and phosphorus compounds, which they would not be able to absorb without mycorrhiza. The fungus, in its turn, absorbs carbohydrates, vitamins and other active substances that the plant synthesizes. Robust or strong mycotrophic trees are *Quercus robur, Pinus sylvestris, Picea abies, Larix spp., Abies spp., Fagus sylvatica and Carpinus betulus.* Medium strength *mycotrophs are Betula spp., Ulmus glabra, Ulmus laevis, Corylus avellana, Acer spp., Alnus spp. and Populus tremula,* but non-mycotrophs are *Fraxinus excelsior, Euonymus spp., Lonicera spp. and Sambucus spp..*

In the case of bacteriorrhiza, symbiotic relationships are also formed between plants and microorganisms.

There is a rhizosphere around the plant root zone, where the number of microorganisms is 10 to 100 times higher than in the rest of the soil. The most important rhizosphere bacteria are Rhizobium - the bacteria that supply the plant with nitrogen, receiving carbohydrates and other carbon assimilation products in exchange. On the roots of ash one can find big perennial Rhizobium - tubers the formation of which are promoted by fungi-actinomycetes. Here too, nitrogen is bound.The formation of the plant root system is influenced by the mechanical composition of the soil. In sandy soils, the roots are longer than in clay soils. If there is a shallow groundwater level, the plants usually form shallow root systems to provide oxygen access.

Of the 94 naturally occurring elements, living organisms contain about 26, which are called biogenic elements. Six of them (H, O, C, N, Ca, K) make up the biomass of almost all living organisms, while the other 20 are needed in smaller quantities. The most important of the chemical properties of the soil are the content of nutrients in the soil, acidity and alkalinity of the soil, as well as the salinity of the soil. One of the main factors determining the solubility of elements is the soil reaction.

Depending on the desired reaction of plants, three ecological groups are distinguished:

- acidophilic plants that grow in acidic soils, such as bogs and coniferous forests (*Sphagnum spp., Calluna vulgaris, Oxycoccus palustris, Vaccinium vitis-idaea, Vaccinium myrtillus, Rumex acetosella and Equisetum arvense*);
- calciferous plants that grow in lime soils (*Quercus robur, Filipendula vulgaris, Bromus mollis, Polemonium caeruleum and orchids*);
- neutral plants formed by the majority of species (*Trifolium pratense, Medicago sativa and Phleum pratense*).

Some species are adapted to growth in soils with a very high chemical content – the plants of saline soils or halophytes. They are usually found in the soils of arid regions (deserts, semi-deserts) or on the shores of a flooding sea (mangroves flora, *Salsola kali, Atriplex spp.*).

ASSESSMENT OF ECOLOGICAL CONDITIONS USING PLANTS

Ecological conditions - both climatic and edaphic - are best assessed by the standard scales developed in Central Europe - Ellenberg's vascular plant indicator values, taking into account soil moisture, reaction, nitrogen amount, climate factors (temperature, continentality) and lighting. Each species has a specific numerical value that characterizes its attitude to various ecological factors. Using Ellenberg's scales, it is possible to indirectly characterize the complex of ecological factors prevailing in a particular habitat. Ecological behavior is expressed in a nine-point scale, where 1 denotes the lowest value of a particular factor and 9 represents the highest value, while x indicates neutrality or tolerance, respectively the factor has a wide range or different behavior is observed in different areas.

The first group refers to three climatic factors:

Range of light conditions scales:

L = the value of light conditions which varies from very low (1) to full lighting in an open landscape (9);

Full shade 1	Shade 2 - 3	Half shade 4 - 5	Half light 6 - 7	Full light 8 - 9

Range of temperature scales:

T = temperature value from arctic or alpine (1) to Mediterranean climate (9);

Cold climate 1 - 2	Cool climate 3 - 4	Moderately warm 5 - 6	Warm climate 7 - 8	Very warm climate 9

Range of continentality scales:

C = Continentality value - from the Atlantic Ocean shore (1) to the Eurasian inland areas.

Euoceanic 1	Oceanic 2 - 3	Suboceanic 4 - 5	Subcontinental 6 - 7	Continental 8 - 9

The second group refers to three soil factors:

Range of humidity indicators' scale:

F = moisture indicators' value – ranging from a thin layer of soil on dry rock slopes (1) to wet, swampy soil (9), three additional values (10-12) indicate plants distributed in the range from shallow to deep waters;

Very dry 1	Dry 2 - 3	Somewhat moist 4 - 5	Moist 6 - 7	Wet 8-10	Water 11 - 12

Range of soil reaction scales:

R = soil reaction from acid (1) to alkaline substrate (9);

Very acidic 1	Acidic 2 - 3	Moderately acidic 4 - 5	Neutral 6 - 7	Alkaline 8 - 9

Range of nitrogen scales:

N = nitrogen value - the concentration of plants on the soils ranging from those with very low (1) to excess amount of mineral nitrogen (NH4, NO3) (9).

Very poor 1	Poor 2 - 3	Medium rich 4 - 5	Rich 6 - 7	Very rich 8 - 9

Practically no species has identical values of all the factors with any other species. However, species with similar values of ecological factors can be listed under one ecological group. Ecological indicators show that herbaceous plants have smaller ranges of values compared to trees, which is mainly associated with the existing high competition between species in ground cover, which is more than ten times higher than in the tree layer. Not only the indicator species of dry areas, but almost all the other species achieve their physiological optimum in medium soil moisture, acidity and fertility conditions. In areas where these species are present at the highest concentrations, other species simply cannot be sufficiently competitive. Thus, the ecological optimum of these species differs significantly from their physiological optimum, in other words, their ecological existence differs from their ecological potential.

Groups of ecological species provide information on environmental conditions affecting the entire plant community. Therefore, when assessing a particular habitat, the ecological behavior of all species in the plant community should be taken into account. The simplest way to use indicator values for all plant community members is to calculate the average factor values such as average moisture value. Average factor values provide only an approximate idea of the environmental conditions in a particular location, but it is an excellent way to assess the relative importance of various natural environmental factors.

PLANT STRATEGIES

The species strategy describes the plant's competitiveness. Plants have very different characteristics that determine their existence (ability to survive) in time and space. Plants differ in foliage, root system, seed quantity, growth rate, requirements for nutrients, soil reaction, heat, light and moisture. These characteristics determine plant attitudes to stress (plant growth is limited by inadequate conditions - light, moisture, nutrients and temperature) and disturbances (plants or parts of plants are destroyed by herbivores, frost, drought, fire, or they are trampled down, mowed and damaged during soil treating processes).

Plant strategies (including plant functional types or groups) are groups with similar or analogous genetic characteristics that are widely repeated between species or populations and determine a similar ecology. The primary purpose of identifying plant functional types is to understand the interactions between plant communities and ecosystems, and to explain their reaction to environmental changes and management. The more challenging task is to distinguish functional types that reflect not only the environmental impact, but also the interaction with other plants, resources, herbivores, predators, microorganisms, disease causing agents, and the essential impact of climate change and anthropogenic interference on the development of vegetation.

The most widely recognized and used is the three-strategy model based on the idea of four habitat types, which include very high and low productivity and very large and small disturbance - as a result of which it is clear that vegetation can only exist in three of the four habitat types because plants are unable to grow in places that simultaneously match low productivity and big disturbance. The three remaining types, each reflecting a certain degree of productivity/disturbance, refer to the primary types of plant strategies - competitors (C), stress tolerant (S) and ruderals (R), which have different characteristics and incidence worldwide.

Competitors or strong plants, are trees, shrubs, and less often - herbaceous plants with a high competitive ability due to their morphological and/or physiological characteristics. They are best characterized by the ability to quickly occupy the area and make full use of environmental resources by building strong root systems, new shoots and rich foliage.

Stress-tolerant or enduring plants in the struggle for existence are not distinguished by the life process and growth energy, but by their enduring quality to withstand permanent or temporarily unfavorable conditions. They can survive, for example, at low temperatures, drought and poor soil conditions. Typically they are small trees, shrubs, herbaceous plants, lichens and mosses. These are species with small morphological and/or physiological adaptation to the conditions where growth is seriously restricted, for example due to lack of nutrients.

Ruderals or fillers, are plants with very low competitiveness, but they are able to quickly occupy a free area by filling the spaces between stronger plants. These are pioneer species - fast growing annuals

and biennial plants that regenerate with seeds and spores, and perennials that propogate vegetatively by creeping roots and root shoots, and they can be dominant species in affected habitats (abandoned arable lands, etc.). Ruderals are characterized by a short life span and a tendency to quickly hide their obtained resources to create offsprings.

Most commonly plants have mixed strategies (CSR). The basic assumption of CSR theory is that in non-fertile habitats or in case of frequent and severe vegetation disturbances, the role of competition among species decreases, whereas the greatest competition is in conditions where the availability of resources is sufficient to develop large individuals with the ability to monopolize resources and to use these resources rapidly for their development. It is assumed that, under resource constraints, such use of resources would be dangerous to the plant, therefore the plant in unfavourable conditions ensures conservation and protection of resources using only low-value, long-lived shoots. If the vegetation is regularly disturbed and destroyed, there is little chance of generating large and dynamic vegetative structures, and the competition for resources is characterized by discontinuity, since the accumulated resources are used to develop new shoots that are subject to sudden destruction. Thus it can be concluded that the development of vegetation and the advantages of large plant individuals are limited by the low availability of resources and/or frequent disturbances that limit the interaction of adjacent individuals. Conversely, productive, relatively undisturbed environmental conditions allow for the benefits of high competitiveness.

Alternatively, there is an R hypothesis for CSR theory: competition is also important in infertile conditions, but manifests itself through a different mechanism, where the decisive factor is the ability of particular species to reduce the amount of limiting nutrients in the soil to such an extent that other species cannot maintain their populations. Such a mechanism is characteristic of long-lived, slow-growing plants found on infertile soils. This could be explained by the fact that ruderals are characterized by low nutrient losses, slow tissue replacement and high tolerance to herbivores.

C, S and R strategists represent extreme conditions available to plants, while secondary plant strategies have developed in habitats with moderate productivity and disturbance intensity. In addition to the three basic types, four secondary strategies have been identified that correspond to the specific relationships between productivity, disturbance intensity and competition for resources and form a triangular model.

Secondary strategies are divided into:

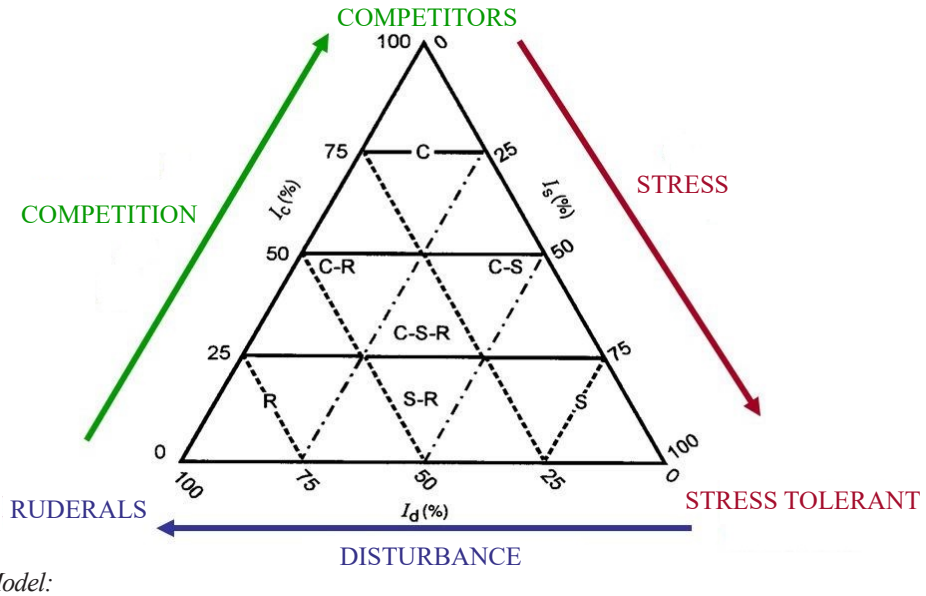
- competitors ruderals (C-R) - adapted to low stress conditions, where competition is limited by moderate intensity disturbances;
- stress tolerant ruderals (S-R) - adapted to easily disturbed, unproductive conditions;
- stress tolerant competitors (C-S) - adapted to relatively undisturbed conditions and average stress level;
- C-S-R strategists - adapted to conditions where competition is limited by moderate intensity stress and disorder level (usually rosette plants or small perennial species that use the opportunities of space and time very well and that have a medium life expectancy).

Relationships between large and small size plants are characterized not only by competition for resources but also by dominance, which includes both competition and other processes, including beneficial effects. **Dominance is characterized by the following two components:**

- the dominant plant reaches a larger size than the surrounding plants - this mechanism depends on belonging to a particular strategy (environmental conditions);
- larger plants negatively affect the health of smaller plants – stress from shading, depletion of mineral nutrients and water in the soil, leaf debris and release of phytotoxic substances occurs.

Most often dominants suppress plants in their juvenile life stage (young shoots). It has often been observed that species diversity is the highest in plant communities, where stress tolerants dominate, mainly due to their slow development. In the communities dominated by competitors and ruderals, rapid plant development and replacement occur, resulting in a very unproductive and dangerous environment for smaller plant species.

With increasing anthropogenic impacts and changes in land use, many plant species are becoming less common or even extinct. Research shows that countries with a high population density (100 inhabitants/km2) are experiencing changes in CSR strategies – the proportion of the stress tolerants is decreasing, but that of competitors and ruderals is increasing.



Plant Strategies Model:

Ic - relative impact of competition; Is - relative impact of stress; Id – relative impact of disturbance (Grime, 2002).

The tolerance and recovery ability of certain ecosystems after a disturbance can be predicted by the following hypotheses:

- the reaction to an extreme case depends on whether the ecosystem has previously been subject to similar effects;
- tolerance and regeneration ability are higher in communities with a high diversity of species, based on the assumption that species-rich vegetation also has a greater diversity of genetic features that provide higher tolerance and regeneration capacity.

Triangular model of primary plant strategies:

- higher tolerance is inherent in stress tolerants, which is associated with the longevity of these species in the course of evolution;
- most plants that grow in non-productive habitats have vigorous leaves and shoots, so they are tolerant to being trampled down and to the impact of herbivores;
- ruderals and competitors have higher ability to regeneration due to their growth and resource accumulation rates. Ruderals are able to regenerate the fastest, since they have a shorter life expectancy and relatively unstructured and fast-organising communities;
- regeneration strategies.

There are several plant regeneration strategies:

- vegetative distribution (V) with tubers, rhizomes, etc.;
- seasonal regeneration during vegetation interruptions (S), divided into autumn regeneration (mainly in grasslands) and spring regeneration (in the northern and continental regions in temperate zone);
- regeneration by permanent seed or spore bank (Bs);
- regeneration involving the spread of a large number of seeds and spores by wind (W);
- regeneration with a permanent seedling bank (Bsd).

Bs and W strategies provide the ability of juvenile plants to avoid the impacts created by adult plants, while V and Bsd strategies provide regeneration opportunities only if the link to the mother plant has been preserved or if there is a benefit from physical contact with some mature plant. Species with multiple forms of regeneration are also among the species with a high occurrence in the world flora.

TYPES OF SEED DISPERSAL

The dispersal of the seeds of plant species determines the plant's survival potential. Greater opportunities for seed survival are farther away from the mother plant, as animals and disease-causing agents tend to focus on the majority of seeds directly by the mother plant, and competition with other adult plants may also be less when the seeds get dispersed farther away from the mother plant. The dispersal of seeds also allows plants to reach a more suitable environment and new places for their survival. The seeds are dispersed in different ways.

- The plant can disperse seeds itself: because of internal stresses, the seed is thrown out of the fruit when the tissues of the plant, which include the seed, rupture.

- Mammals and birds disperse the seeds, both by carrying them in their fur and feathers and by eating and hiding them for food. The dispersal of seeds by people is similar, only the seeds get farther due to human mobility, which promotes the appearance of invasive species.
- Those seeds that are most often carried by wind have either special growths (wings, hairs, etc.) that determine good flying ability. Such plants often produce very large quantities of seeds.
- Many aquatic plants and plants growing close to bodies of water produce seeds that do not sink in water, so they can be moved by the stream.
- The dispersal of seeds with the help of ants is a way of spreading ground vegetation. The seeds of these plants have juicy appendages that attract the ants.

The plants which can be used for phytoremediation of heavy metals under Latvia's conditions
Festuca ovina L.
Triticum aestivum L. *
Hordeum vulgare L. *
Quercus robur L.
Typha latifolia L.
Caltha palustris L.
Iris pseudacorus L.
Brassica napus L. s.l. *
Brassica juncea (L.) Czern. *
Festuca rubra L.
Trifolium pratense L.
Medicago sativa L.
Kochia scoparia (L.) Schrad. *
Mentha aquatica L.
Helianthus annuus L. *
Avena strigosa Schreb.
Ambrosia artemisiifolia L.
Juniperus communis L.

The plants which can be used for oil product phytoremediation under Latvia's conditions
Trifolium repens L. *
Lolium perenne L.
Populus deltoides x Wettstein *
Populus hybrid *
Salix schwerinii x viminalis
Juncus effusus L.
Juncus conglomeratus L.
Juncus bufonius L.
Artemisia campestris L.
Elytrigia repens (L.) Nevski
Festuca arundinacea Schreb.
Tussilago farfara L.
Pinus sylvestris L.
Tanacetum vulgare L.
Poa compressa L.
Poa pratensis L.
Juncus articulatus L.
Carex hirta L.
Festuca rubra L.
Calamagrostis epigeios (L.) Roth

Leymus arenarius (L.) Hochst.
*Carex arenaria L. **
Juncus filiformis L.
Equisetum arvense L.
Convolvulus arvensis L.
Cirsium arvense (L.) Scop.

** plant species which have not been granted a specific value for ecological conditions*

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MANAGEMENT

BENEFITS FROM BROWNFIELD REGENERATION FOR THE DEVELOPMENT OF A REGION AND SUSTAINABLE USE OF RESOURCES

Anda Jankava

THE NEED FOR BROWNFIELD REGENERATION AND ITS IMPORTANCE

Taking care of brownfields and their maximal and efficient engagement in economic activity is one of the key tasks of the sustainable use of resources, which makes significant contribution to the development of the region. Latvia's Sustainable Development Strategy states that the government should implement a state-level natural capital conservation plan, which would also include spatial planning for nature conservation and regeneration and the opportunities and risks of the use of biotechnologies.

The process of brownfield formation in Latvia has been similar to that of other Eastern European and partly Western European countries. Most of the brownfields were formed after the collapse of the Soviet Union. Their development was influenced by the transition to a market economy and industrial change. Typical brownfields are industrial sites and their infrastructure, abandoned military bases, adjacent territories, and construction objects, uncompleted construction objects which were started during the Soviet period, but left unfinished. Compared to some Eastern European countries, such as the Czech Republic and Romania, the size of brownfields in Latvia is considerably smaller. According to the information available from the Ministry of Environmental Protection and Regional Development, there is a total of 5,826 ha of degraded land in the municipality and private property. Through the European Union funding for the period of 2014-2020, it has been envisaged that 556 ha or 9.5% of brownfields that can be used for business purposes will be regenerated.

Brownfields are closely linked to the transformation of industrial society into post-industrial life. It means great changes not only in the economy and in the types of economy, but also in spatial standards, land and property use, administration types and also in people's lifestyles. These new activities should be in a dominant position and redirected to brownfields as a priority.

It is necessary to ensure the integration of brownfields into the new economic cycle and benefit from the use of adjacent areas. In post-industrial society, much less space is needed for production, but more for services, consumption and entertainment. These new activities should be directed towards brownfields!

The general objective of the revitalization of brownfields is to promote the sustainable development of the urban or rural areas by eliminating the degraded territories as much as possible and thus contributing to their environmental regeneration. This includes both solving environmental problems and increasing the economic efficiency of the use of the territories, improving the visual and structural functional quality of the environment, as well as the humanisation elements of the social environment.

The specific circumstances in each region determine which aspects should be given more attention in the context of the situation. No less of an important factor is that by regenerating the abandoned construction site brownfields, not only do we obtain the territories which are more adapted in terms of landscape and functionality adding to the attractiveness and sustainability of a particular city, but these sites also use the existing engineering networks and other communications economically.

In other countries, the issue of brownfield regeneration began to play a prominent role in political programmes in the 1970s. This means that the search for an international approach to solving the problems of brownfields has been around for almost 50 years. They are now closely linked to a wider range of sustainable urban and regional development issues. The regeneration of brownfields not only strengthens the vitality and efficiency of cities, but also helps remove the developmental pressure from agricultural lands (greenfields) located on the outskirts of cities.

The reuse of brownfields has a significant impact on sustainable development as it meets all three of its objectives: improving the economy, improving social cohesion and the environment.

The term “greenfield” describes non-built-up, usually agricultural lands, forests or unused lands that are in demand and made available for development. “Greenfield” building is easier, cheaper and faster compared to brownfields. The abolition of the rules of the use of these territories reduces the opportunities of the use of brownfields, as well as the economy of land use and influences overall sustainability

It helps return the unused land in the cities into the functional cycle and improves the land use economy. When economic activities return to brownfields, they are, first of all, significantly improved and, secondly, “greenfield” lands are preserved. New activities taking place in the former brownfields create new opportunities for the public, increasing employment and income. The remediation of brownfields can also improve social consolidation, prevent risks to the environment, protect cultural and historical values and improve the quality of life. The development of brownfields has the added benefit of strongly influencing the surrounding urban environment. An important aspect is that the regeneration of brownfields has a positive impact on real estate prices in the area. Further savings are achieved through the opportunities offered by the already existing resources and infrastructure (buildings, energy and sewage networks, etc.) and transport options.

Customised planning solutions that take into account public needs can considerably contribute to the public life and benefit the developers and owners after the regeneration of brownfields. As a result, the sustainability of a specific brownfield and wider area is promoted.

One of the main promoters of brownfield regeneration is the economic revitalization of the urban area and potential profits. Assessing the impact of economic globalization and increasing difficulties on the current European real estate market, we can conclude that the role of brownfields in supporting economic development and competitiveness in Europe has become increasingly important. This is most often the case in traditional former industrial areas, where economic opportunities are increasingly becoming evident as a result of the changes in the development of brownfields.

Revitalization of brownfields is an incentive for economic development and it affects different market areas: land market, real estate market, labour market, capital market, financial market, resource market, infrastructure market and innovation market. The link between the land market and the real estate market with the revitalization of brownfields has been identified as the most influential factor in the revitalization process.

Analysing foreign experience, it can be concluded that, irrespective of the end use of brownfields, their regeneration aims to develop sustainable neighbourhoods with a higher quality of life. In the past, too little attention was paid to the areas where people live, work and spend their free time. One of the key elements of high-quality urban development is good connection with open space and accessibility to it. In designing these public spaces, the attracting of pedestrians, good quality bicycling, and public transport, as well as a great sense of space, are essential.

Many of the "changing places" have served for some time as "engines" that fueled the industrial revolution - coal mines, quarries and canal edges. With the decline of heavy industry, these often huge areas became abandoned. Many of them were unofficially used as playgrounds and recreational areas, but most of them were left neglected, until they were abandoned and sometimes dangerous.

There are many examples in the world with longer history and relevant experience, where in the place of abandoned industrial territories, public and commercial centres, museums and exhibition galleries, entertainment and recreational areas, amusement parks, sports centres, and other attractive social and cultural objects have been built for the inhabitants and guests of the city. They often change the face of the city and the habits of their inhabitants, their gathering places. The challenge of architecture can also be the transformation of old abandoned industrial buildings into residential and office spaces, as due to the growth of the cities, the former factories can happen to be located in city centre that are more suitable for offices and apartaments. Also in rural areas, through the regeneration and management of brownfields, it is possible to use land efficiently, which brings profit to the owners or users of these lands and differentiates rural production opportunities. Here further, we will look into the future use of brownfields in cities and rural areas.

Opportunities for brownfield regeneration in urban areas

The development of urban areas is based on the more efficient use of an existing built-up land and by restoring brownfields, envisaging the existing building areas with an already built infrastructure for a new construction development, thus preventing new investments in the development and maintenance of transport and other type of infrastructure.

Getting acquainted with the activities of several Eastern European countries (The Czech Republic, Hungary, East Germany, Romania and Poland) in the regenerating of brownfields one can reveal several similar features. The big cities are undergoing major changes in functions. New activities take place on the premises and territories of former industrial companies and in areas where military barracks and railway lines were predominant. These spontaneous changes in post-socialist countries took place in a shorter period of time than in Western Europe. As a result, the regeneration of brownfields became one of the first issues of territorial development along with changes in property rights after the cessation of industrial activity and the real estate market reorganization after 1990. Functional changes are typical of industrial zones close to the city centre, where it was easier and cheaper to reconstruct or completely demolish buildings and they have other priority features to replace industry with other functions.

It has to be mentioned that during the privatisation a large part of these former industrial territories were subject to speculation, the new owners were more interested in selling the property. The better the end-users of these properties were secured with capital, the more territories were planned for demolition and reconstruction, and the least important aspect was the preservation of these buildings as architectural monuments. Therefore, most of the original buildings were demolished and new office buildings or shopping centres, science and technology parks were built in these areas, especially if they had the potential – the proximity to a university or other scientific centre. Functional changes are also characteristic of the less favoured abandoned industrial areas with a less favourable location, where a typical phenomenon is the continuous preservation of previous buildings, simply replacing their earlier functions with commercial, warehouse and logistics functions. However, the importance of maintaining industrial buildings and structures as monuments of the respective era and their use for cultural, educational and tourism purposes is becoming increasingly important in a number of abandoned areas of industry and infrastructure. Such urban brownfield regeneration projects have become the economic, social, cultural and artistic benefits for the inhabitants of these cities.

Collecting and analyzing scientific publications on brownfields regeneration and evaluating their benefits, several regularities and brownfields development options can be distinguished:
- establishment of shopping centers;
- development of science and technology parks
- conservation of industrial heritage;
- cultural, educational and business centers
- housing and office space
- parks for recreation and amusement, amusement and sporting activities.

Building of shopping centres

One of the most widely accepted forms of using the abandoned industrial territories in Eastern Europe is the construction of shopping centres. The changed economic environment also gave rise to a change in consumer habits, with a major shift in retail activity. In the 1990s, in the areas of abandoned production sites with good locations (proximity to the metro, traffic junctions and good access), the construction of a new type of commercial centres was started, thus contributing to functional changes in these areas. For example, in the mid-1990s, several new shopping centres with ten thousand square meters of floor space and large parking lots were built in Budapest. The investors were looking for places with lower land prices, but suitable for the construction of these large commercial sites. Shopping cenres generally had a positive impact on real estate prices, improving the prestige of their environment, thus contributing to the development of the surrounding areas and changing the structure of trade, consumer habits and requirements.

The first shopping centre of this kind "Duna Plaza" in Budapest was opened in 1996, on the basis of an abandoned industrial area, and the Polus Centre (Pólus Centre) was built on the square of former military barracks. "Duna Plaza" centre has a good access to the North-South metro line and the avenue that crosses Budapest in the northern direction. The Polus Centre, on the other hand, was built on the outskirts of the city, the area where the commercial area per thousand inhabitants was the lowest, so the shopping centre also played an important role in servicing the local population and populated areas included in the aglomeration of Budapest. Over time, the Polus Centre lost in the competition with the shopping centres that were built later, mainly due to the poor access to it by public transport from the city centre. In 1999, there were already 33 shopping centres in Budapest. That year the WestEnd City Centre –a multifunctional centre was opened (commerce, offices, hotel and entertainment), which has become one of the most successful shopping centres thanks to its favourable location and considerable investment. According to the project, involving large areas of the surrounding area and including the former unused railway zone have greatly contributed to the modernisation and regeneration of the surrounding area.

Shopping centre "Duna Plaza" in Budapest (Hungary) (http://dunaplaza.hu/)

However, not all shopping centres built on abandoned production sites have been successful. For example, the Lurdy-Ház Centre was built in a low-purchasing area and has poor access. Its business use index is very low and it is increasingly performing office functions that are becoming more and more widespread (for example, a Hungarian airline company moved its headquarters to Lurdy Ház).

Other Eastern European countries also have examples of the conversion of abandoned industrial sites into commercial centres. For example, in Poland, the inhabitants of the city Lodz are well aware of the processes that can be denoted with the words revitalization, modernization, adaptation. In recent years, they have observed many of these processes, especially when the historical plants are experiencing the second stage of life. Lodz is considered to be a city of industrial revolution. The dynamic development of this once small settlement began in the 19th century, when steam and electricity innovation shook the world economy and changed the lives of many cities and people. Like in England's Manchester or in German cities by the river Rhine, large factories mushroomed in Lodz, which had been shaping the character of the city for decades. However, the big cities that seemed like a climax of modernism several decades ago, have lost their goal today. In Lodz there are several interesting examples of post-industrial recovery. The most famous of these transformed territories is the former Poznanski factory complex, now a multifunctional shopping and entertainment complex called Manufaktura. In the late nineties, the brick building of the former textile factory was purchased by a private investor. Until 2006, a larger shopping centre was opened on its premises, but 260 stores are not the only choices offered by Manufaktura. There are also cinemas, museums, a luxury hotel and a huge public square with a fountain and many outdoor activities taking place there. Manufaktura, one of Europe's largest revitalization projects, has caused a lot of controversy - this complex has become a victim of its success to some extent. The former Poznanski factory turned out to be a magnet for visitors and soon became a new city centre. It was blamed for the bankruptcy of many stores in the city centre. However, over time the city has found a balance between the new and old centres.

Development of science and technology parks

In several countries, the development of science and technology parks plays an important role in the functional changes of brownfield sites. In these parks, in the territories of former industrial and military sites, if they were close to universities, research and technology oriented companies were created. A typical example is Budapest (Hungary), where science and technology parks (Infopark and Graphisoft Park) were established in brownfields. Infopark, the first Central and Eastern European science and technology park, was established in Budapest in 1996.

Manufaktura shopping and entertainment centre in Lodz (Poland) (https://www.manufaktura.com/)

The site was first selected for the World Expo exhibition, but after the closing of the exhibition it was necessary to find a new function for its use. With a government decree the Infopark concept was declared - basing on the entrepreneurship - to build a state-owned joint-stock company in cooperation with two nearby institutions of higher education: the Technical University of Budapest and the Eötvös Loránd University. According to the concept, the land area of the park remained state-owned, while private investors were entitled to land use and construction. As the first flagship, the American company IBM appeared in 1996, but the activities of the rest of Infopark and the development of the park were carried out by a German real estate development agency. This company builds office buildings and laboratories, which are then 'content-filled' by state-owned, mainly non-profit companies. Infopark promotes innovation processes, research and development and renders support for start-ups. Thanks to the proximity of the universities, lessees are mostly IT, software development, telecommunications and Internet service providers (IBM, Hewlett-Packard, Magyar Telekom, Panasonic, Maxell, etc.). It is planned that around 4500 people will be employed after the completion of the park. In the long run, Infopark could become a regional high-tech centre.

Preservation of industrial heritage

The problem of how to develop post-industrial space is a problem that many countries are facing around the world - from the United States, France, England and Germany to Poland. Everywhere cities are looking for ways to preserve and redesign their factory buildings. In some ways, they are monuments - valuable examples of the 19th and 20th century architecture and important relics of the past. In Germany, France, England and Poland, the empty factories, mines and steelworks have begun to face metamorphoses which have resulted from the new functions, while still retaining their architectural qualities. The protection of historical buildings and monuments is a deliberate interference with more than 100-year-old historical process characterized by permanent disappearance, transformation and replacement of the built heritage. The existence of an industrial culture was very important in Europe, it has been the driving force of the economy since the Industrial Revolution. As a result of the global restructuring of the world's economy, the remarkable production capacity no longer exists. This process ended after the political and economic changes in the 1990s. In the preservation of eternity the focus is on the reorganisation of the physical environment, the closure of factories and renovation programmes.

Buildings constitute the majority of industrial heritage, but equipment and technological devices can also play an important role. The monuments of industrial architecture were started to be reconstructed already back in the 1960s, followed by a focus on engineering, steel, iron and railway structures. In Western Europe, extensive research was carried out on the preservation of industrial heritage. One of the biggest problems in this field is that quite often industrial buildings were not built to last long in terms of their management, and the fact is that the structures of these buildings were seriously damaged during their service time.

Industrial heritage can be protected in several ways: as industrial sector museums and open-air museums with technologically significant monuments; as well as taking industrial buildings and complexes under the state's protection as industrial and cultural monuments of the respective period in history. The preservation of these industrial monuments is often hampered by the large size and complexity of these buildings. There are several examples (breweries and infrastructure systems) where continuous initial function maintenance is taking place, but there are not many of these cases anymore. The most effective way of preserving these monuments can be by finding new functions for their use, but it is a difficult task.

By preserving these monuments as museums and using modern technologies, a double effect can be achieved, thus combining the protection of industrial heritage with cultural tourism. The increasing number of technical and scientific museums point to this effect. For example, several military, transport and industrial museums have been set up in Hungary, as well as a metalworks museum, a collection of electrical engineering items, a museum of lifts, a museum of mills, a museum of fire fighting, etc. A successful example is the Millenáris Park, built on the Buda side of Budapest, which is designed as a comprehensive industrial rehabilitation project. Other examples of industrial heritage conservation can be found in other countries as well, such as the old brewery in Poznań (Poland) and the Zollverein coal mine monument complex in Essen (Germany), etc.

Multi-profile public and commercial center Stary Browar in Poznan (Poland) (https://starybrowar5050.com/en/)

Coal mining complex "Zollverein" in Essen (Germany) (http://www.landezine.com)

Cultural, educational and business centres

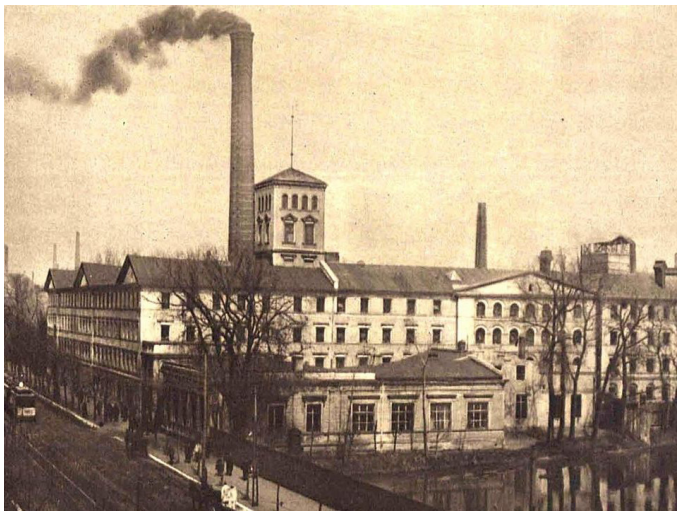
Part of the national industrial heritage, with its aesthetic values and individual appearance, is suitable for cultural purposes. However, reconstruction costs are often very high, especially when it comes to monuments, and these costs are difficult to cover due to the low profitability and non-profit character of cultural institutions. The use of industrial buildings for cultural purposes in Europe began in the 1960s and 70s as a result of social and economic transformation, coupled with the support of urban policy and, at the same time, with large-scale publicly funded architectural and cultural prestigeous investments (Centre Pompidou, Musée d 'Orsay in Paris, Tate Modern and Millennium Dome in London). Quality cultural life strengthened the individual character of cities in the tough competition between them. There was an increasing role for cultural urban policies, which promoted projects for the creation of cultural institutions, and most of these projects were related to the reconstruction of former industrial buildings, thus creating many symbolic values (protection of historical buildings and environmental protection). The creation of cultural projects added value to the economic and tourist attraction of cities and the value of urban land also increased.

The museum d'Orsay in Paris (https://www.casao-paris.com)

Millennium Dome in London (https://www.theo2.co.uk/)

Several Polish cities are an example of their former factories becoming shops, offices or hotels, demonstrating that these post-industrial sites are best suited for culture. For example, the Art Factory (Fabryka Sztuki) in Lodz is a complex of three buildings dedicated to the representatives of "creative industries". The culture and business centre "Art Incubator" was opened in 2014 and it features art studios, conference rooms, art production rooms, a hall and galleries, a café and a club. Other post-industrial buildings of former factories have also been modernised and expanded to include a 3D cinema, a science centre, a planetarium, a studio, workshops and laboratories, a gallery, a sound theater as well as seminar and conference rooms. It should be noted that several former factories have been

transformed into history museums of the respective sectors of industry, for example, the Museum of Textile History has been housed in Lodz for more than half a century at the former Geyer Biała Fabryka. The successful examples of Poland include the old beer brewery “Stary Browar” in Poznań, which is a modern shopping centre and at the same time also a real cultural and educational centre. Here you can go shopping in at least 200 stores, have good meals and communicate with art and good design, participate in various activities, such as concerts and shows, and meet with interesting people.



Geier White factory in Lodz (Poland) earlier and now (https://lodz.travel/)

In Germay there are also some excellent examples of transforming post-industrial objects into cultural and artistic objects. The best known is the above-mentioned 'Zollverein Coal Mine Industrial Complex' in Essen, which was awarded the title of UNESCO World Heritage Site in 2001 and is one of the most impressive industrial monuments on the planet. Since the last work shift in 1986, Zollverein, the former coal mine and industrial complex, has become the main object of art, culture and creative sectors, attracting over two million visitors a year. This building symbolizes structural change in the metropolis of Ruhr more than any other.

Housing and office spaces

There are several examples in Poland of how the former factory buildings (one of them - a spinning mill founded by Karol Scheibler in 1825), especially the largest ones, are transformed into modern, post-industrial living spaces. The monumental buildings of the mill are thoroughly renovated to preserve and emphasize the distinctive features of architecture.

Meanwhile, the creation of residential premises is in harmony with the location of offices.We can also find examples of post-industrial transformation in Latvia, for example, the extraordinary residential complex "Gypsum Factory" in Riga, which is located in an exclusive place on the bank of the Daugava with a wonderful panorama of the historical part of the capital of Latvia and established in the territory of the former Kipsala Gypsum factory.

Living and office complex “Gypsum Factory” in Riga (https://latviainside.com)

Parks for recreation and entertainment, amusement and sports activities

Foreign experience shows that parks can also be created in areas not intended for this purpose (ship building yards and swamps) and on land that must first be cleaned of harmful substances (former plants, factories or railway tracks), while preserving the historical memory of their industrial past.

If all the selected examples of foreign parks were to be arranged in chronological order, regardless of the country in which they are located, some industrial zones' transformation into urban parks could be observed. It should be noted that since the 1980s of the last century, two to six new parks have emerged in European countries in the period of each decade. There are several types of squares that can be distinguished in the place of their location, which have been recultivated as post-industrial parks:

- plants and factories (gas, tire, tile, automobile, etc.);
- ports and shipyards (shipbuilding plants, fish processing companies);
- abandoned railway tracks with different structures (stations, aqueducts);
- even an abandoned nuclear reactor area, swamps and other areas.

There are many examples of parks that have developed in the places of former industrial or other economic activity territories, mainly from the 80s-90s of the last century. However, one of the pioneers of this trend in landscape architecture is the Tuileries Park in Paris (France), which was established in 1564 instead of the former tile manufacturing factories. In 1985 La Parc de La Villette was established in Paris instead of the former slaughterhouses and livestock market, in 1987 Park Del Clot in Barcelona (Spain) was established instead of a former factory and a railway track, in 1995 the amusement park Wunderland Kalkar amusement park in Kalkar (Germany) in the former nuclear reactor area and other parks. On a wider scale the development of such parks in post-industrial areas has evolved in this - 21st century, and their national spectrum is very diverse: for example, in 2000. - Promenad Plante Park in Paris (France) instead of the former railway viaduct; in 2001 – Chiang Mai (China) Park instead of a bankrupt shipyard; in 2002 - MFO Park in Zurich (Switzerland) at the site of a former engine production plant; in 2003 - «Parque da Juventude» in San Paulo (Brazil), instead of the former investigative isolator; in 2006 - Diagonal-Mar Park in Barcelona (Spain); in 2007 - Cliché-Batyn Park in Paris (France), instead of the former railway station; in 2010 - a park in Shanghai (China) on an abandoned industrial site on the banks of the Huanpu River; in 2011 - Park Dora in Turin (Italy), etc.

Gleisdreieck park in Berlin (http://www.landezine.com)

Natur-park "Schöneberger Südgelände" in Berlin (http://www.landezine.com)

Recent examples should include several parks in Germany, which have developed instead of the former industrial sites, still retaining historical evidence of these sites. The most outstanding of these are the Gleisdreieck Park in Berlin (Germany), opened in 2011, established in the former railway crossing area, the Natur-Park Schöneberger Südgelände in Berlin, which, after 50 years of desolation, was built around the closed Tempelhof station. Both of these parks have become real oases of natural diversity and historical experience in the city.

INVOLVEMENT OF BROWNFIELDS IN THE ECONOMY IN RURAL AREAS

The economic aspect is essential for the regeneration of brownfields, therefore in rural areas it is also important to evaluate the use of these areas and the benefits gained after their recultivation.

Several examples of land use have been analysed in Latvian and foreign literature after the brownfield recultivation in rural areas. The emphasis in these publications is on cleaning the territories by using plants (willows) for energy. The economic studies of brownfields show that the involvement of these areas in the economic cycle is important, however, there is also a need for large financial resources. The fact that not all areas can be used in agriculture or in the production of bioenergy is a barrier to the wider involvement of brownfields in economic activity, due to the different levels of degradation and the location of brownfields. Assessing the existing woodchip production and trade, it has been concluded that the industry is perspective suggesting that the establishment of willow plantations for energy purposes is a promising measure under the condition that brownfields and peatland areas should be carefully selected.

Economic studies of brownfields show that the involvement of these areas in economic activity is important, but large financial resources are also needed.

It is also concluded that there are all prerequisites for developing the cultivation and processing of cloudberries and lingonberries (frozen berries, jams, additives for other products) in Latvia, as there is a large potential market for cloudberries and lingonberries in Europe, especially in Germany, Austria and Eastern countries, including China. The establishment of lingonberry plantations and their industrial cultivation is one of the most promising plans for the reclaiming of peatlands, because some Latvian varieties have been created and foreign varieties offered, and there is experience and potential in planting and offering young plants for plantations. Lingonberries are well-known berries in Latvia and abroad, and their use as food is very wide. The investment in lingonberries starts paying off in the third year and lingonberries are a good export product to European, American and Asian countries.

Brownfields usually have an impact not only on their owners, but also on a wider community. In addition to the already mentioned factors that discourage investors, it can also be mentioned that the price of real estate in the vicinity of large brownfields is lower, the quality of the landscape is deteriorating, health and safety problems increase, the level of public services decreases, the quality of life decreases, which encourages young and talented members of society leave this place and look for a higher standard of living elsewhere. For this reason, public interest in the future of society and also in the regeneration of brownfields is crucial.

Equally important is the management of society (both elected and public). If the management level is low and the population cannot demand improvement or take it on its own, the depressive landscape of brownfields remains unchanged.

Revitalization of brownfields often creates opportunities for the development of new industrial parks or zones, which, in turn, creates new jobs in different professions, specializations and sectors that is an opportunity of raising the living standard and the promotion of local economic development in cities and regions where brownfield revitalization has been carried out.

The term "brownfields" is useful for attracting national-level attention to a particular location or for making the site a regional or local priority. However, by naming a territory as "degraded", it is labeled as suggesting possible additional difficulties, and prejudices can reduce the potential for its remediation. It is not advisable to mention degradation when looking for investors, as many of the potential investors will associate it with contamination and complications. At this stage, it is advisable to refrain from the terminology of brownfields and, instead of that, talk about the "re-use and revitalization of urban land".

It can be concluded that the main factors for the regeneration of brownfields are the economic and environmental aspects. Similarly, cultural and social aspects are also essential for the regeneration of brownfields. Sustainability in this context means appropriate land use and urban design, which creates social, economic and environmental benefits.

According to the information summarised, **potential benefits and synergy of surrounding areas after brownfield regeneration** are:

- recreational and health improvement opportunities (eg. land use associated with low intensity traffic, low-level emission enterprises and green zones for various uses);

- premises and facilities for sports activities (such as sports fields, fitness centre, bicycle paths and hiking trails);
- closer distances for delivering goods and services and access to fields;
- expanding leisure and entertainment facilities (eg. restaurants, pubs and cinemas);
- educational and social infrastructure (eg schools, youth centres and sports clubs);
- a family-friendly and child-friendly environment (eg. land use associated with low intensity transport, fewer streets, playgrounds, green areas);
- increase in property values;
- security, reduced crime rates (eg. street lighting, limiting of anti-social behaviour by reducing the number of dark spaces);
- identity (eg. preservation and re-use of historical buildings for other purposes, use of local language/ religion);
- population growth (as a synergistic effect for adjacent applications such as commercial and industrial areas, housing demand).

However, the **negative impact mentioned in the publications that could result from brownfield regeneration** should also be considered:

- noise, vibration;
- traffic;
- service interruptions (water, electricity, etc.);
- dust;
- fumes (health problem);
- potential pollution /contaminants;
- odours;
- aesthetics / perceived visual pollution;
- damage to the natural environment;
- decrease in property value;
- increase in rent;
- new competitors for existing companies;
- unclear impact (i.e. understanding of the devaluation of buildings due to new infrastructures).

Without viable land use, the remediation of brownfields in itself will not bring much to the revitalization of the area. Municipalities play the most important role in urban regeneration and reconstruction. They define the boundaries of development projects in accordance with local planning documents, land use planning and zoning plans, thus preventing unwanted urban sprawl.

Municipalities also play an important role in promoting urban revitalization by providing a policy framework and resources that can contribute to the revitalization of urban brownfield sites across Europe. To achieve this goal, local authorities need to work with different organizations and institutions at regional, national and European levels.

Municipalities, when deciding on new building sites, should carry out a thorough cost-benefit analysis, including all potential costs associated with new construction and prospective future use, and their environmental impact, including impacts on GHG emissions and risks associated with climate change. It is necessary to stimulate the construction of new buildings in former production territories and other unused building territories. Similarly, in order to utilise the land efficiently and prevent the risk of land degradation, while carrying out the spatial planning process, the possibilities of using the previously planned construction territories should be assessed and the return of unused building territories should be promoted for their economic use.

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RECYCLING OPPORTUNITIES OF RESOURCES AND MATERIALS FROM BROWNFIELDS

Una Īle

GROUPS OF BROWNFIELDS

As a result of various economic activities and natural conditions land and soil degradation processes have been observed, resulting in brownfields which have a negative socio-economic impact and are contrary to the principles of sustainable development, and their existence points to an inefficient use of territories. Brownfields can be divided into several groups that include the territories formed as a result of human action or, just the opposite - as a result of human inaction.

Groups of brownfields:
- territories with destroyed or damaged topsoil or abandoned building development;
- mineral extraction sites;
- territory of economic or military activities.

CRITERIA FOR SUSTAINABLE DEVELOPMENT

Therefore, in order to better protect nature, and thus provide the public with a quality environment, optimal living conditions, sustainable and balanced development, it is necessary to ensure a sensible and economical use of natural resources, which is the best method of environmental protection. Based on natural resources, their division, and the dynamics of reproduction, it is possible to set five criteria for the sustainable development of mankind for a longer perspective, including also the features and characteristics of brownfield groups.

Criteria for sustainable development for a longer perspective:
- preventing the reduction of the quantity of renewable natural resources (plants, forests) or their ability to produce biomass, ensuring at least a simple reproduction of these resources;
- maximum slowdown in the use of non-renewable resources (natural subterranean wealth) in future;
- decrease in the amount of surplus products in the manufacturing sector. It is necessary to introduce the technologies of small amounts of left-overs/waste or leftover/waste-free technologies.
- reducing the amount of household waste;
- preventing the increase of the existing level of environmental pollution, ensuring reduction of pollution to a socially and economically acceptable level.

Hence, by meeting the criteria set it will be possible to maintain the natural environment at an acceptable level for future generations. The reuse and revitalization of brownfields is a complex process. In some countries, large-scale national programmes have been developed to address brownfield problems, where the national or regional funding invested is supervised by institutions especially created for this purpose. Other countries follow the legislative frameworks and regulatory enactments that promote private initiative, reduce investment risk, provide for personal responsibility and require to act upon orders.

For these reasons, it is not easy to find a good example that would clearly show what and how to do and what could be easy to use in another place. Differences exist not only in national legislation, but also in the capacity of public authorities, in the educational system, in the system of problem-solving and coordination of activities within the country at different levels of influence of national, regional and local authorities. However, the principles of re-development of brownfields are general and do not change in different countries. It is not always easy to choose the correct support model for brownfield regeneration, because the range of issues to be addressed is very wide. It is important to remember that the knowledge of brownfield regeneration is acquired during the work process. Those who will be engaged in this work will inevitably make mistakes from time to time and learn from these mistakes in the long run. The source of knowledge can also be the experience that other countries have accumulated over 40 years in revitalizing brownfields, where both success and failure have been experienced.

IMPORTANCE OF THE USE OF NATURAL RESOURCES AND CLASSIFICATION

Natural resources are a combination of natural conditions, elements and material resources needed to meet the needs of society and production, or they are the means of human existence that exist in nature, regardless of man, or which are restored by nature and propagated by the help of humans.

In a narrower sense, this means natural resources (land, water, forests, minerals and the animal kingdom resources) that are needed to provide the material production. To rationally manage the natural economy, it is necessary to understand the classification of natural resources. Natural resources are categorised by their distribution, depending on the extent of their use in economy, and the most widely used classification of natural resources is by their availability or scarcity in nature and by their renewability and non- renewability capacities.

The first and most important task of nature protection is to discover the cause and effect relationships in the process of interaction between human society and nature. Finding the means to eliminate the causes or the adverse effects of human activity is an important and even more complex task. Rational use of natural resources is a scientifically substantiated complex and planned use of natural resources in the interests of the economy and all the population, satisfying as far as possible the economic needs, maintaining healthy living conditions and ensuring the implementation of environmental protection measures, eliminating the harmful consequences of exploitation of natural resources. The use of natural resources is diverse. They can be used as raw materials (minerals, forests, agricultural produce and horticultural products, etc.) as energy sources (coal, oil, natural gas, wood, peat, etc.) as sources of consumption (water, vegetables, fruits, mushrooms, fish, game animals, etc.), recreation or leasure related life activities (climate, terrain, forests, water reservoirs). For example, forests are one of Latvia's most important natural assets that must be preserved and enhanced to meet ecological, economic and recreational needs of the society. Tree harvesting and timber production involves a lot of residues, exceeding half of the total timber production. Therefore, it is important to ensure complex processing of wood, rational use of waste as raw materials for the chemical industry or for the production of fuel briquettes and wood chips.

Land protection, which, in fact, is the preservation of land quality, restoration and improvement of land, is a very important issue. One of the most important issues in maintaining soil fertility is protection against pollution, littering, and protection against building up of bogs and erosion of soils. Protection is necessaty against pollution, such as atmospheric pollution caused by industrial plants, pollution from road transport exhaust gases etc., littering - waste disposal in non-approved areas, littering in recreational zones, etc.

NATURAL RESOURCES PROTECTION PRINCIPLE

Protection of natural resources is compatible with their active use, but the particular use must not lead to the destruction or depletion of natural resources. It should involve the improvement and increase in the amount of specific resources.

Public production in every economically developing country is constantly confronted with two groups of problems: protection and reproduction of natural resources as well as their rational use. Undoubtedly, it does not apply to non-renewable resources, they cannot be reproduced, and their protection must be understood as an economical use of these resources. Positive and negative changes in the environment are always related to human activity, but negative consequences have become especially evident during the period of scientific and technical revolution. Therefore, it is necessary to constantly pay close attention to nature conservation measures.

LATVIA'S NATURAL RESOURCES

Latvia's nature is not rich in minerals - it has been discovered by geologists when drilling and evaluating mineral resource deposits in the upper layer of the Earth's crust to a depth of up to 50 m. Our country's natural resources - land, its fertility, forests, their productivity, water resources, terrestrial and aquatic fauna and flora, and, in particular, mineral resources and their amount prove that a very rational management of natural economy is required in this country, alongside with the development and implementation of a rational austerity programme, which, as one of the essential

conditions for increasing efficiency of production and ensuring economic independence, should provide for the small or limited amount of surplus/waste and surplus/waste-free production or introduction of clean technologies, but if surpluses occur, they should be included in the wider economic cycle.

Clay is found throughout Latvia. In general, clay is used in the production of bricks, roof tiles, tiles, pottery, drain pipes, ceramsite concrete and cement. **Limestone** - a widespread sedimentary rock, mainly made up of calcite, which may have some dolomite admixture, quartz and clay minerals. Limestone found in South Kurzeme is widely used for cement production. **Gypsum** deposits are one of the largest in Northern Europe and gypsum is used in the production of construction gypsum and cement, interior decoration of buildings, sculpture and medicine, but boulders (rocks) are used both in construction and in the production of crushed stone and can be classified according to their size and volume. **Boulder** groups are classified into giant boulders and large boulders. Giant boulders are over 5 m in length and they are of outstanding landscape value. They are protected natural objects, whereas large boulders are those whose length is 2-5 m, they can be used in sculpture and architecture. In Latvia, one of the most widely used mineral resources is **peat**, and about 10% of Latvia's territory is covered with bogs. The average thickness of the peat layer is 1-3 m, but the thickness of the individual deposits is over 10 m, it can be used as fuel, litter (mulch) and peat - for ammonia fertilizer preparation and other agricultural purposes. **Sapropel** is a lake sediment formed in nutrient-rich, standing waters in the process of accumulation and transformation of aquatic plant residues deposited with sand, clay and lime. Sapropel is mainly used in the chemical industry, in the production of fodder yeast, as an additive in animal feed, in balneology, as a binder in the manufacture of blockboards, and as an effective fertilizer for crop farming and floriculture. The use of sapropel can provide significant raw material resources for the production of paints, varnishes, solvents, perfumes, plant protection products, electricity, fertilizers, pharmaceuticals, various plastics and other products. In Latvia, one of the most saturated sediments in the water basin is sludge, which is made of inorganic materials of various sizes and plant residues. **Sludge** is used in different healing processes, agriculture, and sludge fertilization is used in the recultivation of brownfields. Recultivation is a complex of ameliorative, crop culture technical and agrotechnical measures to rebuild the soil cover of brownfields. The advantages of sludge fertilizer are the following: reuse of plant nutrients takes place; contaminants are excluded from the human food or animal feed chain; relatively low costs; large sludge fertilizer amount can be used in a small area, thus reducing transportation and application costs. The disadvantages are: local pollution of the territory and the risk of groundwater contamination. Brownfields are recultivated by only one application, but significantly higher sludge fertilization amount compared to soil fertilization on agricultural lands. The amount of sludge dosage depends on the purpose of recultivation. In general, the recultivation of brownfields using sludge fertilizer is carried out according to a specially developed recultivation project, indicating the granulometric composition of the bottom surface layer of the brownfield and environment reaction, as well as the hydrogeological research of the brownfield, but limonites are naturally occurring iron hydroxides forming brown and bog iron ore. Once bog iron ore was industrially processed, smelted, and cannons were cast and other items were made, but nowadays, ore is no longer of industrial importance. The **geothermal energy** resource and its quantity depends on the quantity of the heat flow of the subtrranean depths and geohraphical structure of the location. Geothermal energy is ecologically clean, the use of such a resource and the implementation of various projects would be very topical and important. **Underground freshwater** is the main source of water supply for cities and populated areas, but mineral waters have specific properties and therapeutic effects, and they are underground waters with increased amounts of minerals, organic matter and dissolved gases. **Mineral waters** containing carbon dioxide, hydrogen sulphide, nitrogen and methane are of therapeutic importance, they are extracted from wells or from the surface of the ground in the form of springs. The underground geological structures where underground gas storage facilities can be installed are also included in the resources of Latvia's subterranean depths. The installation of such underground storage facilities could serve as lucrative gas transit reservoirs. In its turn, oil deposits in Latvia are small, as well as other minerals: magnetite (iron quartzite) ore (found in the vicinity of Staicele and Gārsene), brown coal in the south-western part of Latvia - not large in volume and located in deep rock horizons.

ENERGY RESOURCES, THE POSSIBILITIES OF THEIR USE

The groups of energy resources

The whole development is based on the use of energy resources. Currently, the world's greatest focus is

on energy resources, since traditional fossil fuel deposits and volumes are dwindling rapidly. In addition, energy development is closely related to scientific and technological progress and is one of the most important factors determining the quality of life of the population. Power industry comprises all fuel mining, processing industries, electric power with its related industries and electric power supply lines.

Overall, there are two groups of energy resources:
- exhaustable (non-renewable) energy resources - coal, oil shale, oil, natural gas, etc.;
- inexhaustible energy resources (renewable or alternative energy) that are practically inexhaustible since they regenerate - water, wind, solar, geothermal and other types of energy.

Water resource(Photo by the author, 2019)

Exhaustible energy resources are still used for heating buildings, operating plant equipment and vehicles, etc. It should be concluded that the current ever increasing use of fossil fuels as an exhaustible resource results in major negative changes in the balance of the world's natural environment and is the cause of environmental pollution. Nowadays, the amount of pollution begins to suppress the regeneration capacity of the natural system. Water and air pollution has increased significantly. As a result, with the increase in the consumption of exhaustible (non-renewable) energy resources, more and more attention is being paid to the use of inexhaustible energy resources, which do not cause harm to the environment or cause it only to a small extent compared to the exhaustible energy resources.

The purpose of the search for alternative energy sources is the need to obtain energy from renewable or practically inexhaustible natural resources and phenomena, paying attention to the ecological and economic aspects of these energy sources. In general, non-exhaustible energy resources include hydropower, geothermal energy, solar and wind energy, biofuels, tidal and wave energy. Resource depletion can be affected by both over-exploitation and changing environmental conditions. The use of resources can also be determined by such factors as quantity and quality; accessibility; available technologies; economic efficiency and environmental impact.

THE USE OF SECONDARY MATERIAL RESOURCES

Material resources are different types of products (raw materials, semi-finished products, fuel, heat and electrical energy) which are used in the production and auxiliary production processes.

Material resources are different types of products (raw materials, semi-finished products, fuel, heat and electrical energy) which are used in the production and auxiliary production processes, whereas secondary material resources are production and consumption surpluses/waste that can be recycled in new materials or other types of products: metal chips and various small waste products, worn out and broken parts of machines and vehicles, thermoplast residues and worn out articles, waste paper, broken glass fragments, etc., which can most often be found in abandoned brownfields. It should be noted that the reuse of raw materials and material residues is one of the ways to increase purposeful utilisation of these resources. As a result, it is necessary to collect production surpluses that can no longer be used as full-fledged substitutes for material and also consumption or utilisation residues, as well as household waste for further processing, such as waste paper, end-of-life metals, worn out glass and plastic products, and which as recycled material resources (recycled raw material) should be processed to produce a new material or another type of product.

THE USE OF SECONDARY RESOURCES BY REPLACING THE PRIMARY ONES

The reuse of various waste materials and residues as secondary material resources can expand the raw material base, for example, by recycling waste paper we preserve forest wealth, by recycling plastic products we save oil and gas, by recycling scrap metal, the need for primary metal decreases, by recycling glass chippings and worn out glass items, the consumption of quartz sand and electricity decreases. The use of recycable resources is rationally advantageous due to the fact that the collected

material can be fed into the technological production process, bypassing the initial stage of processing, which, in turn, shortens the overall production cycle, thus reducing expenses. Undoubtedly, there is a need for finances to be involved in the production of secondary raw materials, but the expenses are generally significantly lower than those required for the production process from primary raw materials.

The efficient use of secondary resources, replacing the primary resources overall makes it possible:
- to preserve primary or natural resources for a longer period of time;
- to better preserve and protect the environment;
- to reduce the amount of capital investment;
- to reduce production costs, as secondary raw materials are cheaper than primary, and energy consumption also reduces;
- to increase production efficiency and profitability;
- to reduce the areas needed for creating landfill sites;
- to increase the motivation of inhabitants to collect and hand over various household waste for recycling and to preserve the environment.

POTENTIAL FOR THE REUSE OF EXISTING STRUCTURES

Bioresources are all the resources that can be obtained from water, land, air, as well as those that are formed as surpluses/waste in the production processes and everyday life. Environmentally friendly methods can be used as bio-resources and in the use of any other materials. However, unlike the use of non-renewable resources, one may often face the fact that, when using bio-resources, a person perceives this use as a positive effect on the environment by calling it "green" or "environmentally friendly", but not always with proper justification. In this way, on the contrary, one may unintentionally do harm to the environment. Therefore, by expanding the use of bio-resources and increasing their amount in the Latvian economy, it is particularly important to use proper methods of assessing and reducing the impacts to avoid unreasonable management.

By analysing the suitability for transformation regarding the reuse, three different types of structures can be distinguished:
- the least suitable, practically impossible to transform: monolithic technical structures, such as chimneys, freezers, ovens, containers, transmission lines, as well as special purpose constructions such as shafts and lift towers;
- moderately suitable, hard to transform: large and high or monolithic multi-storey buildings;
- most suitable, easily transformable: institutional buildings, smaller multi-storey or one-storey frame production platforms with infrastructure and office buildings.

Ruined structures by the sea (Photo by the author, 2019)

METAL AS A RECYCLING RESOURCE

Aluminium is one of the metals that is widely used today in various fields of the economy. From the recycling point of view the most popular aluminium products are those with a short lifetime, such as aluminium containers and packaging materials - foil, trays, etc., about 80% of the aluminium products are (beer and soda pop) drink cans. The advantage of aluminium is that it can be recycled 100%. Advantages of aluminium recycling compared to storage are the following: energy saving, savings in the cost on waste storage; profit is obtained by selling recycled aluminium. Scrap **iron**, in turn, can be divided into two major groups: industrial and household scrap iron. Industrial scrap iron is generated in a variety of metalworking processes, usually it is unpolluted with other types of waste, therefore it is easily recyclable, but household waste is made up of all iron or steel products whose expiration date has ended. Household iron scrap is always contaminated with other types of waste, plastics, wood, paper, food waste, etc.

GLASS, ITS POTENTIAL IN RECYCLING

Glass is obtained from sand, soda, limestone, metal salts and similar inert components. As a result, glass waste is not hazardous to the environment, but it is not biodegradable either. When released

into the environment, it slowly decomposes to form sand. By volume, glass waste accounts for about 2% of total solid waste. Thus, recycling will significantly reduce the amount of waste in storage sites. In order to carry out glass recycling, the same problems must be solved that exist for other types of waste: collection, sorting, transportation, market for its utilisation. In glass waste collection there are two main problems: glass must not contain any impurities of other materials in it; glass must be sorted by colour. In cases where glass waste is used for the production of new glass containers, it must not contain impurities: stones, ceramics, heat-resistant glass and laminated car glass, as they are covered with a plastic film. From the collected glass, new products are melted and produced, usually they are glass containers, but the following types of glass use can also be practised: as an additive to asphalt, forming road surfaces; as an additive to building materials (concrete, clay and insulation materials); as a component of reflective paints (in the form of small glass beads); as an additive to polymer materials; in abrasives; for soil drainage or humidity control, etc. Overall, glass recycling can save energy, prolong the life of the melting furnaces (15-20%), because the melting process can be carried out at a lower temperature, and it can also save the waste storage costs.

Plastic as a recycling material

Plastic is a general name given to a man-made material that is widely used in our life and it can be recycled in a wide variety of products: by means of casting, pressing, extrusion and vacuum forming techniques. Plastic is much more technological than wood, metal, ceramics, and its re-processing methods are used in: recycling; chemical destruction (hydrogenization, glycose, pyrolysis, production of synthetic gas); incineration; destructive extrusion (low molecular weight products, oils, waxes, lubricants, etc. are obtained). The two most widely used methods are recycling and incineration. The plastic mixture can also be recycled unsorted, and recycling will never be the only plastic waste re-processing option, it should always be combined with incineration, pyrolysis and chemical destruction. As a result, the mixtures obtained are non- homogenious, and a very limited range of products can be made from them, such as park benches, compost boxes, fence boards, road curbs, trash recepticles, etc.

Recycling of durable wood articles

The advantages of the use of **wood** are the following: pronounced structure, natural beauty, easy to work, good insulation material, healthy, safe, light in weight, strong, durable, with a wide range of possible combinations. Hardwood and treated wood obtained in the process of demolishing buildings are particularly valuable: since they are weather resistant, they can be recycled in shingles, used for building garden sheds, for coatings and fencing. The possibilities of using treated wood depend on the type of treatment used and the local legislation. Reusables can be wooden boxes and pallets, if necessary they may be repaired, or other damaged pallet parts, plywood or particle boards are used. Garden sheds and other gardening items are starting to be produced from parts of the pallets and packaging material. Furniture manufacturers are increasingly using pallets in furniture design.

Stump harvesting technologies for the production of energy wood

Stumps from clear cuttings are a source of renewable energy that, under optimal conditions, can produce 150-200 MWh of energy per hectare of a harvested forest. Stump harvesting can be combined with soil preparation for forest regeneration. In addition, stump harvesting makes it possible to limit the spread of root decay by removing the decayed parts of the trees. Stump grindings or chips can be used in district heating and cogeneration plants. Spruce, birch, aspen and alder cutovers are most suitable for stump harvesting. In pine cutovers, the extraction of stumps is difficult if the diameter of stumps exceeds 60 cm. Stump harvesting is not recommended in poor mineral soils, where stumps and tree roots form an essential part of the organic matter reserves. Heavy-duty crushers designed for crushing bulky wood are used to produce stump chips for energy purposes. The advantages are the following: stump harvesting improves soil structure by reducing its density and improving air exchange, resulting in favorable conditions for the development of new trees. Alongside with stump harvesting, one can simultaneously carry out micro-amelioration of the area to be regenerated, diverting the excess moisture in some places. Stump energy wood from spruce, birch and aspen stands can replace more than 90% of the currently used energy wood which is used in district heating and technological processes.

The amount of wood used to substitute other materials

The production and processing of wood is not only very energy efficient, which gives wood products a particularly low carbon footprint (carbon emissions), but in many cases wood can also be

used to replace materials such as steel, aluminium, concrete or plastics that require a lot of energy in their production. Wood is a renewable and versatile raw material. It can be used in construction, finishings, furniture manufacturing, food circulation, packaging, pallets, transportation devices. At the end of the life cycle, wood or wood products can be reused, recycled and used as a carbon neutral source of energy. For example, the wood chips and sawdust resulting from the process of producing sawn timber, are used in the same company for the production of heat and energy, in kilns and in other operations, as well as for the production of particle boards, pulp and paper. For example, waste paper is no longer homogeneous, so recycling it is only possible by sorting it according to certain types. Otherwise, its processing options are limited. Cardboard, on the other hand, is one of the most widespread materials for packaging various goods, which is mainly accumulated in various shopping centres, warehouses, transport centres, and is often found in brownfields. It is possible to produce new cardboard from the recycled cardboard as well as wall decoration plates, book covers, etc. Particular attention is paid to avoiding contamination, the presence of which makes cardboard unsuitable for recycling: metal and wood admixtures, food left-overs, protective coatings (polymers, waxes), foam polymers that are often used as shock-absorbing material in cardboard boxes and containers. For example, US scientists have calculated that one ton of newsprint recycling will release 2.5 m3 of land in landfills, pollute air by 74% less, and water by 35% less than when it is done in the process of first-time production, and recycling of paper requires 70% less energy and 60% less water compared to the first-time treatment. In total, recycling of one ton of newsprint will save about 40 trees. In contrast, books and magazine covers, most often covered with protective coatings, are the most difficult items to recycle, since the covers are made of paper other than pages and are coated with a polymer or cellophane protective coating.

Use of timber for shore strengthening (Photo by the author, 2019)

Willow plantations

By using willow plantations in brownfields it is possible to promote and gain the following:

- a significant amount of "green" energy without harmful impact on the environment;
- the establishment of willow plantations contributes to the sustainable development of rural regions and reduces dependence on fuel suppliers;
- the wood of this species can be stored in the plantation as a natural storage place, without loss of quality and then used for heat or electricity production.

Cultivation of fast-growing willows

Cultivation of fast-growing willow species is one of the ways to promote sustainable development in the energy sector.The issues of efficient use of energy resources and search for alternatives in the context of sustainable development are at the center of several scientific studies, regarding both households and businesses.

With the development of alternative energy production, especially that of bioenergy, the production of cheap wood chip material is becoming topical. Thus, one of the solutions is the cultivation of fast-growing willows in brownfields and other areas not suitable for agricultural activities. Fast-growing willow plantations in Latvia currently occupy more than 1000 ha. Overall, establishing willow plantations for energy purposes is a promising measure under the condition that brownfield and peatland areas should be carefully selected.

Tree branches and bark

Other natural materials that can be used in various ways are tree branches and bark, which make up 10-15% of the total mass of the trunk. Wood bark can be used in construction as a thermal insulation material. For example, in some countries, the bark of deciduous trees is used to produce furfural, but the Japanese, according to their patents, also obtain artificial leather and material for ladies' fur coats. Wood branches, on the other hand, can be the raw material for the production of valuable products such as ethanol or ethyl alcohol, methanol, acetic acid, turpentine and furfural. In general, at least 30 different therapeutic substances and other valuable products can be obtained from the green mass of branches.

Wood trends

In Europe, much is being done to create new markets of renewed wood and to create new products: wood and plastic composite materials; bedding for animals (baskets for pets, horse pens and fencing for horseback riding); surface coatings (mulch, walkways, playground coverings); material for compost additives; charcoal production.

Soil resource

In order to quantitatively and qualitatively assess soil resources, as well as to determine their usefulness for various purposes, the continuous soil cover that exists in nature must be subdivided into certain imaginary units - taxa, i.e., units that can be identified, separated and interconnected on the basis of specific, soil characteristic similar properties which, in turn, are different from other soil group characteristics. Consequently, the classification of soils helps to move from the general concept of "soil" to an individualised object with distinct characteristics, the distinction and characterisation of which is very important in agriculture, forestry, environmental management and other areas of human activity.

Straw and reeds

According to the Danish model, it would be useful to recycle unused straw into briquettes, resulting in high-quality fuel for almost all rural inhabitants. In construction, straw is used for filling in special frames, which are built into the walls of buildings as thermal insulation material. The craftsmen, like it was practised before the war, can use straws to produce straw hats, decorative straw mats, and other artistic items. On the other hand, the path of the reed obtained would be their chemical treatment in pulp, high-quality paper, viscose silk, furfural and other products that would save forest resources. Reeds are generally an extremely valuable building material, and as straw can be filled into special frames, for example in Finland, they are used as a cheap and comfortable thermal insulation material in the walls of buildings. Reeds as an aesthetic material are used in constructing long-lasting roofs. The experience of the elders gained with new technical improvements could also be used more widely today. They are widely used for decorative wall coverings, window and door coverings, as well as for covering greenhouses, which enables the underglass plants to prolong their vegetation period for several weeks.

Cloudberries and lingonberries

The cultivation of cloudberries and lingonberries in brownfields could ensure a sustainable development of brownfields, as well as diversification of the range of products offered in the food industry in Latvia, but prior to that biological studies and economic calculations should be carried out.

Cloudberries are not grown industrially, but it is possible to buy seedlings for private use. At present, there are two obstacles to the cultivation of cloudberries, which do not encourage their cultivation in brownfields: the establishment of the area and obtaining a sufficient amount of planting material, as there is no basic material for sproutings and insufficient awareness of potential consumers. Taking into account the experience of Scandinavian countries, focusing on the visually appealing view of the berries and other outstanding organoleptic qualities and using marketing tools, it would be possible to achieve good results. Regarding the industrial cultivation of lingonberries, it has a long history and the establishment of their plantations could be less expensive because of the development and introduction of certain varieties of lingonberries and some experience in establishing lingonberry plantations which has been accumulated in Latvia under the leadership of Dr.biol. Alfreds Ripa. The creation of lingonberry plantations and their industrial cultivation is one of the most promising activities for utilising peatlands, because Latvian varieties have been developed and foreign varieties proposed, as well as experience has been acquired and there exists a potential in plant growing and establishment of plantations. On the other hand, when evaluating the cultivation of cloudberries in Latvia and abroad, the offered opportunities of the plant material, the supply of the existing cloudberries and processing products in Latvia, it can be concluded that the cloudberry market actually does not exist here. Thus, there are all the prerequisites for developing the cultivation and processing of cloudberries.

SUMMARY

In general, brownfield research and the materials available so far show that the involvement of these territories in the economic cycle is important but it also requires large financial resources.

The fact that not all areas can be used in agriculture and in the production of biomass, is an obstacle to the wider involvement of brownfields in the economic activity, as the degree of degradation and the geographic location of brownfields differ in each territory and location. Consequently, these aspects determine the amount of materials and resources with regard to recycling.

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EXAMPLES OF PROJECT PILOT-AREAS. PHYTOREMEDIATION PROCESS, IMPLEMENTATION AND MANAGEMENT

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The BrownReg project included the remediation of three brownfield pilot-sites in Latvian and Lithuanian municipalities. These were the territory of the former fuel storage polygon in Kupiskis municipality (Lithuania), former fuel storage station in Ignalina municipality (Lithuania) and the area of former flax factory in Ludza (Latvia).

On each of the project pilot-sites:
- environmental risk assessment was carried out;
- soil samples were collected and analyzed to identify the level of existing contamination;
- the spatial structure and elements of the landscape were analyzed;
- research and analysis of the existing vegetation was carried out;
- according to the research results cleaning of territories from the remnants of former factory buildings, road cover and other infrastructure objects which are no longer used and cause danger has been carried out;
- the most appropriate bioremediation approaches have been analyzed based on the results of soil analysis and contamination found in the territories; pilot-areas for the study of the phytoremediation process in a real situation were established; plants for phytoremediation plantings were grown at the LLU premises (greenhouses and territory);
- phytoremediation plants were planted in each of the pilot-area for the decontamination of the soil and water;
- monitoring of contamination in pilot-areas was performed before planting and three months after planting; monitoring of soil and water contamination will continue after the implementation of the project.

Environmental risks in the degraded areas fall into three main groups:
- the risks associated with the declining of air quality and negative effects on biota; the main contaminants are volatile compounds and byproducts from biochemical processes in soil;
- the risks associated with the infiltration of organic and inorganic compounds into the soil resulting in a change in the biochemical, hydrochemical and mechanical properties of the soil;
- the risks associated with groundwater contamination, where dissolved organic and inorganic compounds migrate into groundwater streams and create a contamination threat to surface water bodies and drinking water resources.

The areas, where soil samples were collected and analysed, were divided into several sample- plots, forming a grid of 8-10 quadrants. Soil samples were collected at the intersections of quadrants. For each sampling point coordinates were defined by using GPS, so that soil samples can be re-collected at the same locations. Nine soil samples were tested and analysed. For the analysis, 0.9-1.0 g of dry soil (pre-dried at 105 ° C for 14 hours) was used, then 15 ml of 65% HNO_3 (nitric acid) was poured on it and 3 ml of 30% H_2O_2 (hydrogen peroxide); the liquid obtained was filtered through a paper filter and diluted to 50 ml with distilled H_2O; the measurements were done by Thermo Scientific Inc. ICP-OES spectrometer "iCAP7000").

The limit values for heavy metals in agricultural soils according to the EU Directive 86/278 / EEC are as follows:

Limit values for heavy metals concentration in soil (86/278 / eec)

Parameter	Min value mg/kg	Max value mg/kg
Cadmium (Cd)	1	3
Copper (Cu)	50	140
Nickel (Ni)	30	75
Lead (Pb)	50	300
Zinc (Zn)	150	300
Mercury (Hg)	1	1,5

Bioremediation is the use of organisms (microorganisms and /or plants) for the treatment of contaminated soils. It is the only cost effective soil treatment method where soil remediation is the result of natural processes. Bioremediation, which includes phytoremediation, is an environmentally friendly method because soil remediation is done by plants and through natural processes. In the case of phytoremediation the contaminated soil has been treated on the site. It has economic and ecological benefits because it is not necessary to relocate the contaminated soil to another place for treatment, as well as replace contaminated soil with clean soil. Heavy metals do not disappear anywhere during bioremediation, they are transformed from one biological complex or oxidation state to another. They become either less toxic, more volatile, more soluble in water, and thus can be extracted through leaching, or vice versa contributing to their less water solubility, which makes them easier to precipitate and remove from the contaminated area. The phytoremediation method is more suitable for cleaning large areas contaminated with heavy metals.

Research on **landscape qualities** of the project pilot-areas was carried out in early spring by field studies including the evaluation of the following:

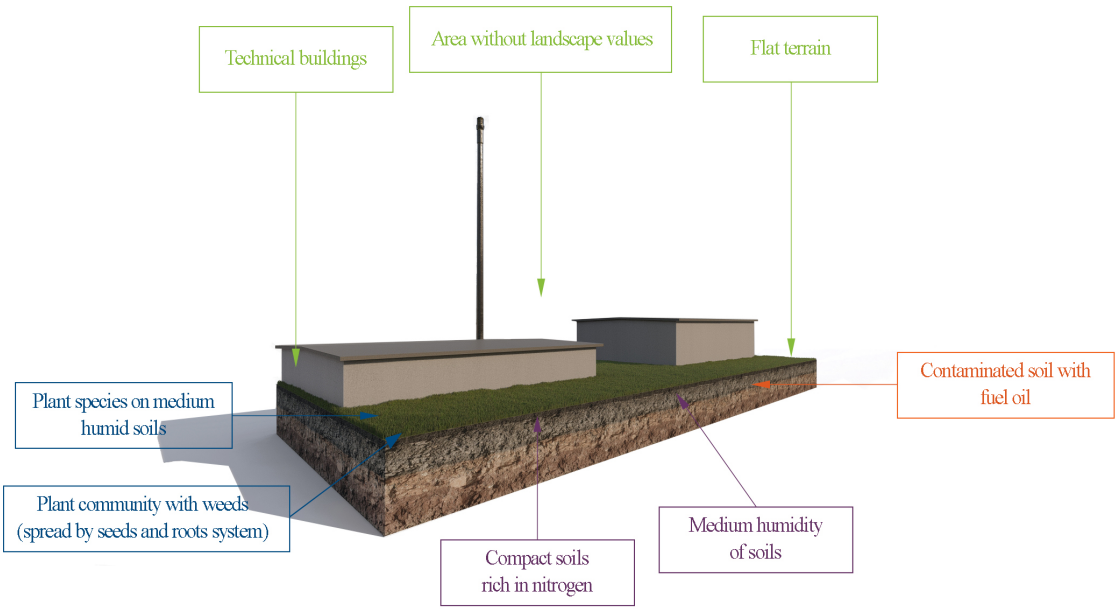
- the location of the elements of the project area in correlation with elements of the surrounding landscape;
- functionality of the adjacent areas and interfaces with the project area;
- spatial structure of the landscape, total amount and condition of vegetation, location and condition of the existing buildings and other structures;
- functionality of the project area, whether and how it is being used;
- views and valuable landscapes in the area.

Vegetation research was carried out in early summer, when the plant species represented in the areas and their distribution, condition of soil, terrain, water elements and other nature elements could be fully evaluated. For each site a list of the plant species represented and their distribution on the site was prepared, as well as conclusions were drawn on the prevalence of specific contaminant indicator species.

THE FORMER FUEL STORAGE STATION AREA IN IGNALINA MUNICIPALITY, LITHUANIA

The first of the sites researched and revitalized in the BrownReg project is located in the rural area of Kazitiškis, Ignalina Municipality, Lithuania. The territories are located in rural areas between other technical areas and are adjacent to agricultural land.

Location of the territory, Kazitiškis, Ignalina municipality, Lithuania. (www.google.com/maps/)



The former fuel storage station area in Ignalina municipality,Lithuania. Location of the site and landscape characteristics identified during the study (Created by the author)

Environmental risk assessment

Contamination with fuel was found both inside the abandoned boiler house and was also spread around the house into the surrounding soil. It could cause air pollution risks, especially during the summer period, when air temperatures rise and volatile organic compounds are released from the fuel. The groundwater level fluctuates seasonally with the highest peak in the spring after the snow melts and a minimum level in low water period in summer. The area is uphill. Therefore, there is a significant risk that pollution can contaminate the closest surface water sources.

Analysis of soil samples before site remediation activities

In the area the soil is contaminated with black fuel oil. Therefore the mechanical properties of the soil have been significantly changed as the pores in the soil are filled with black fuel oil, thus increasing the plasticity of the soil. Infiltration of water in such soils is difficult. As a result, there are long-standing water patches contaminated with soluble petroleum products. Soil aeration is reduced and oxygen-free zones are formed where anaerobic processes occur or even any biochemical processes stop.
Lead (Pb), Chromium (Cr), Arsenic (As), Zinc (Zn), Cadmium (Cd), Copper (Cu), Mercury (Hg) and Nickel (Ni) are common elements in contaminated soils. In the samples taken from the pilot-areas Arsenic (As) was present in all samples (2.1 mcg/g in Kupiskis, 2.4 mcg/g in Ludza and 1.5 mcg g in Ignalina).

Concentration of elements in the soil of project pilot-area in Ignalina

Sample	Weight, g/50ml	Al	Ba	Ca	Co	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	P	Pb	Sn	Sr	Ti	Zn
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Ignalina	0.9667	2795 ±5	25,9 ±5	15107 ±5	2,21 ±5	6.2 ±5	6.8 ±5	6852 ±5	682 ±5	4281 ±5	201 ±5	110 ±5	17.9 ±5	320 ±5	8.6 ±5	0.2 ±5	16.7 ±5	48.5 ±5	45.3 ±5

Analysis of landscape spatial structure and elements

The site is located in a rural area. It is an agricultural technical service base located adjacent to other similar facilities and agriculture land. The spatial structure of the landscape consists of one-storey technical buildings from silicate bricks and an open agricultural landscape.

The existing buildings and technical elements of the project area (Photo by the author)

Characteristic elements – buildings forming a small courtyard; agricultural land; a water tower in the background; various types of buildings; vegetation of deciduous trees and coniferous trees.

The existing landscape elements (Photo by the author)

In general the area has a flat terrain, characteristics of rural landscape with technical elements and partly preserved infrastructure.

Research and analysis of vegetation

Dominated by *Dactylis glomerata* (in fertile soils), *Taraxacum officinale* (in fertile soils) and *Plantago major* (in compacted soils). The plant community is formed by weeds with a shallow root system (*Poa annua, Polygonum arenastrum, Stellaria media, Ranunculus repens*), species typical of roadsides and certain species of natural grasslands (meadows and pastures). In general, the plants identified on the site show the presence of moderately moist, fertile, compacted soils rich in nitrogen. Almost half (45%) of the detected plants are spread by animals (including birds), almost 1/5 (18%) by humans, slightly less (16% and 16%) by wind and self-seeding and only 5 % of plants are spread by ants.

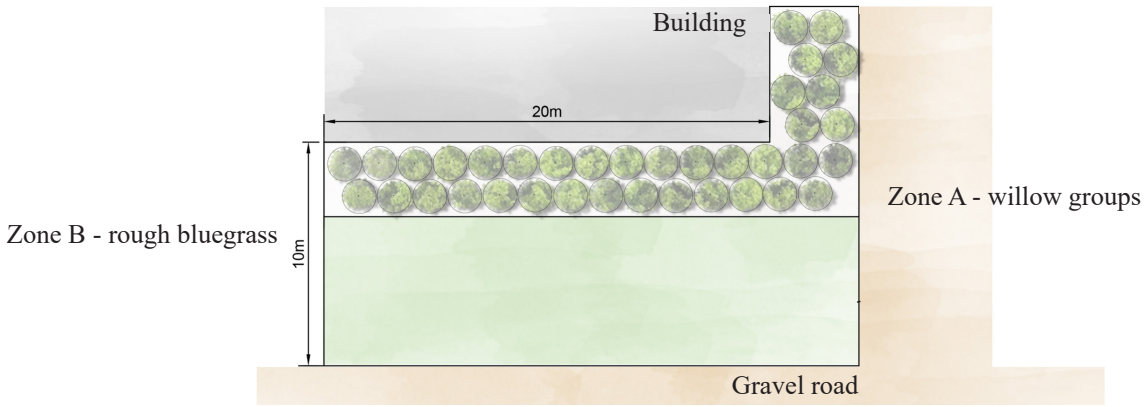
Plant species identified in the area

No.	Latin name	Characteristics
1.	*Dactylis glomerata*	On fertile soils Common in artificial and natural grasslands Expansive species
2.	*Poa annua*	On moderately moist soils Annual plants, weeds
3.	*Ranunculus acris*	On moderately moist soils Common in grasslands
4.	*Ranunculus repens*	On moderately moist and moist soils Weeds, wet grassland species
5.	*Anthriscus sylvestris*	On moderately moist soils On fertile soils rich in nitrogen Common in forests, lawns and on roadsides
6.	*Pastinaca sativa*	Common in dry grasslands and on roadsides
7.	*Taraxacum officinale*	On fertile soils Weed
8.	*Artemisia vulgaris*	On fertile soils Weed, common in grasslands and on forest edges
9.	*Achillea millefolium*	On dry soils Grassland species
10.	*Arctium tomentosum*	On dry soils Weed, common on forest edges and on roadsides
11.	*Urtica dioica*	On fertile soils rich in nitrogen Weed, wet grassland species
12.	*Plantago major*	On compacted soils Common in courtyards and on roadsides
13.	*Rubus idaeus*	On soils rich in nitrogen Common in forests, clearings and on roadsides
14.	*Fragaria vesca*	Common on forest edges and roadsides
15.	*Stellaria media*	On moderately moist, fertile soils Weed
16.	*Trifolium repens*	On moderately moist soils Common in grasslands and on roadsides
17.	*Vicia cracca*	On moderately moist soils Grassland species
18.	*Veronica chamaedrys*	On moderately moist soils Common in grasslands, forest edges and on roadsides
19.	*Polygonum arenastrum*	Weed, annual plant On compacted soils Common in courtyards

Legend: dominant species are marked in colored rows

The use of the phytoremediation method in the pilot-area established on the project site

Representatives from Ignalina (Lithuania) municipality, students of LLU landscape architecture and planning speciality and local inhabitants took part in the planting of the phytoremediation plants. The plantations of phytoremediation plants were divided into two zones - zone A with a group of willows and zone B with Poa pratensis L. The plants were planted in the spring to allow them to take root, as well as to provide the phytoremediation process through the season within the established pilot-area.



Placement scheme of phytoremediation plants (Created by the author)

Assortment of phytoremediation plants in the pilot-area of Ignalina municipality

No.	Latin name	English name	Photo
Zone A - 80 m^2			
1	*Salix (dasyclados) burjatica 'Monika'*	Willow	
2	*Salix (dasyclados) burjatica "Visvaldis'*	Willow	
3	*Salix smithensis*	Willow	
4	*Salix viminalis*	Basket Willow	
Zone B - 120 m^2			
5	*Poa pratensis L.*	Bluegrass	

Establishment of phytoremediation pilot-area (Photo by the author)

Monitoring of contamination level after project implementation

Three months after the establishment of the phytoremediation pilot-areas, repeated soil analyses were carried out to evaluate the efficiency of the phytoremediation process. In each pilot-area the average value of each contamination element was summarized before and after the project implementation and the limits of uncertainty of the result were presented. In the pilot-area of the project site of Ignalina municipality the soil was contaminated with fuel oil before the project was started (see Table 1). The mechanical properties of the soil were significantly altered as the pores were filled with heavy fuel oil, thus increasing the plasticity of the soil. Infiltration in such soils was difficult, resulting in long-standing water patches contaminated with soluble oil products. After the implementation of the project the hydrocarbon index of oil products had decreased 100 times (see the table). This is mainly the result of soil remediation using the traditional soil extracting method, where the contaminated soil is collected and recycled. The extracted soil is replaced by clean soil. In the repeated analysis the values of all elements, except oil products, were below the target value A (according to the "Regulations on soil and soil quality standards"), which indicates good soil quality at Ignalina project site that does not pose any hazard to the environment (see table). Minor positive or negative changes in the elements are connected to inhomogeneity of the soil and the amount of soil replaced.

Average concentrations of elements in the soil before and after the implementation of the project in Ignalina municipality

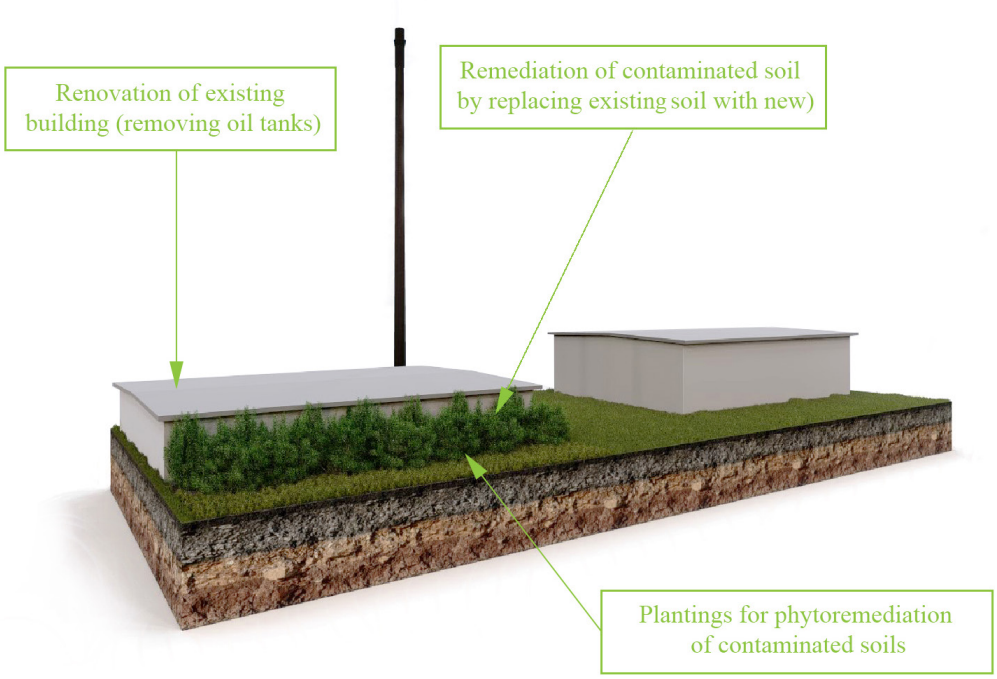
Measurable parameter	Units	Result	Uncertainty of the result	Result	Uncertainty of the result	Changes	Soil quality class
Hydrocarbon index for oil products	mg/l	45900	4100	431.5	43.0		C → B
Cu	mkg/g	6.8	0.07	5.6	0.07		A
Pb	mkg/g	8.6	0.2	9.1	0.2		A
Ca	mkg/g	15107	2	12578	2		N/A
Fe	mkg/g	6852	1	3785	1		N/A
Zn	mkg/g	45.3	0.07	42.1	0.07		A
Cr	mkg/g	6.2	0.1	8.1	0.1		A
Mn	mkg/g	201	0.4	215	0.4		N/A
Ti	mkg/g	48.5	0.03	51.2	0.03		N/A
Al	mkg/g	2795	0.3	2389	0.3		N/A
P	mkg/g	320	1	331	1		N/A
K	mkg/g	682	5	678	5		N/A
Ni	mkg/g	17.9	0.5	15.7	0.5		B → A
Co	mkg/g	2.21	0.06	2.13	0.06		N/A
Mg	mkg/g	4281	0.3	4156	0.3		N/A
Na	mkg/g	110	2	126	2		N/A
Sr	mkg/g	16.7	0.05	15.9	0.05		N/A
Ba	mkg/g	25.9	0.1	23.6	0.1		N/A
Sn	mkg/g	<0.2	0.2	<0.2	0.2		N/A

Changes are analyzed, where in the table the positions showing the decrease are marked green and those positions where the change is positive are indicated in orange. In addition, a target value and limit value are given in accordance with the "Regulations on soil and soil quality standards" where:

- target value (**value A**) - indicates the maximum level beyond which sustainable soil quality cannot be reached;
- precautionary limit value (**value B**) - indicates the maximum level of contamination beyond which adverse

effects on human health or the environment could occur, and the level to be achieved after remediation, unless stricter requirements are stated ;

- critical limit value (**value C**) - indicates that when it is reached or exceeded, the functional properties of the soil and ground are seriously disturbed or that there is a direct risk to human health or the environment from contamination.



Activities in Ignalina pilot-area (Created by the author)

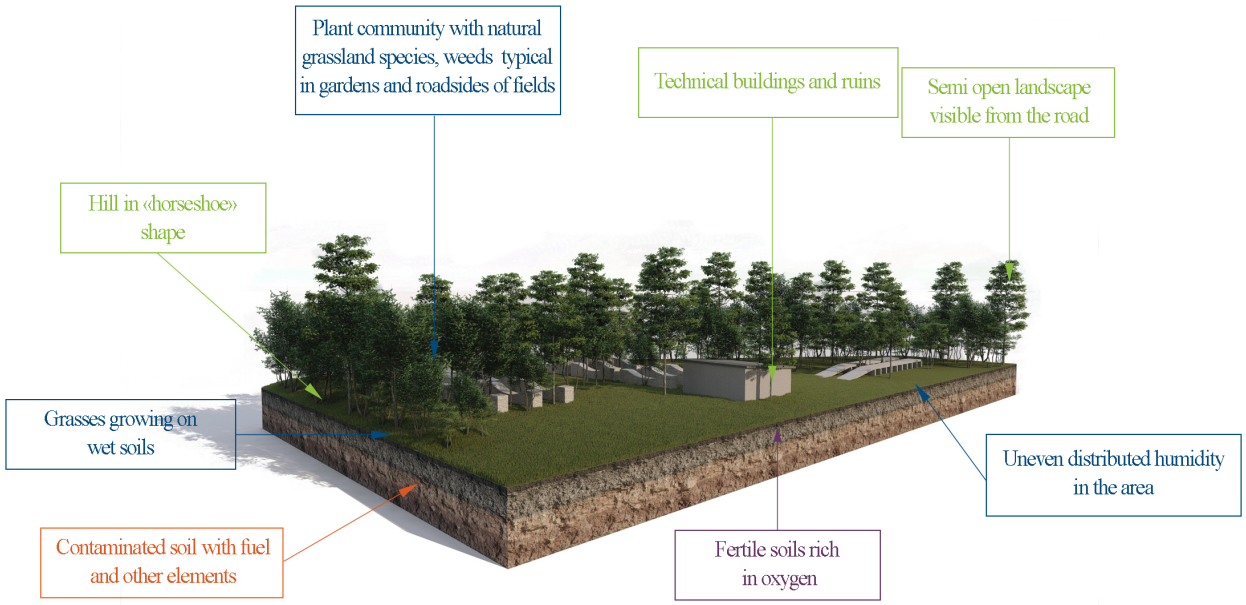
The following activities were carried out for the remediation of the pilot-area of the project site in Ignalina municipality, Lithuania:

- removing the oil tank and other technical elements from the building, renovation of the building, removing the existing soil and replacing it with clean soil;
- Use of the phytoremediation method in the established pilot-area.

THE FORMER FUEL STORAGE STATION AREA IN KUPISKIS MUNICIPALITY, LITHUANIA

The former site of the fuel storage station is located in a rural area and borders with agricultural land and other areas of technical character, residential areas adjacent to the site.

Location of the project pilot-area and landscape characteristics identified during the study (www.google.com/maps/)



Location of the site and features identified by the study (Created by the author)

Environmental risk assessment

No air pollution problems were identified in the former fuel storage facility. However, it should be taken into account that starting or performing any excavation or levelling work may result in the risk of air pollution with volatile organic compounds. They can be emitted during excavation, especially in summer, when volatile organic compounds can be released from oil products in the soil as a result of rising air temperatures. Groundwater levels in the area fluctuate seasonally with the maximum after snow melting in the spring and the minimum during the low water period in the summer.

Analysis of soil samples before the site remediation activities

Soils can become contaminated with heavy metals and metalloids accumulation due to emissions from rapidly growing industrial areas, mine waste, large metal waste disposal, leaded petrol, paint and fertilizer use, animal manure, sewage sludge, pesticides, coal incineration, oil product leaching into the environment and evaporating into the atmosphere. Soil is the main accumulation place for heavy metals released into the environment by the aforementioned anthropogenic activities. Unlike organic contaminators which are microbiologically oxidized to carbon (IV) oxide, most metals are not subject to microbial or chemical degradation.

Concentration of elements in the soil of project pilot-area in Kupiskis

Sample	Weight, g/50ml	Al	Ba	Ca	Co	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	P	Pb	Sn	Sr	Ti	Zn
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Kupiški	0,9487	4676 ±5	34.9 ±5	18989 ±5	3.81 ±5	8.6 ±5	8.9 ±5	7362 ±5	1029 ±5	5736 ±5	227 ±5	113 ±5	8.0 ±5	470 ±5	6.5 ±5	0.2 ±5	22.9 ±5	24.9 ±5	30.4 ±5

Analysis of landscape spatial structure and elements

The project pilot-area in the Kupiski municipality is located outside the city and is part of the former technical service area of agricultural territories. The area is next to the road and is easily accessible as well as located close to the residential area with views of the project site. The site has dense vegetation with deciduous shrubs and trees developed as a result of overgrowth of the abandoned territory. The area is surrounded by open landscape of agricultural land.

Landscape spatial structure and elements (buildings and structures) (Photo by the author)

Landscape elements are parts and remnants of buildings and elements of infrastructure. Technical elements from concrete no longer function and are overgrown with shrubs. The former fuel storage facility is enclosed by an earthen wall – up to 1.5m in height.

The existing landscape elements - ruins of buildings and the surrounding wall (Photo by the author)

In general the area has characteristics of an agricultural landscape with natural layout and open spatial structure.

Vegetation research and analysis

This is a wet area with rough terrain. Plant species common for wet areas alternate with species typical of moderately wet soils. Wet grasses dominate - *Alopecurus pratensis* (species common for wet areas), as well as *Poa pratensis* (common on moderately wet soils) and *Dactylis glomerata* (common on fertile soils). *Aegopodium podagraria* (nitrophile - a nitrogen-loving species that grows on fertile soils) and *Taraxacum officinale* (common on fertile soils). Plant communities included natural grassland (grassland and pasture) species, weed species and roadside species. In general, the plants showed fertile soils rich in nitrogen and uneven humidity distribution in the soil. From the identified plants 40% are distributed by animals (including birds), slightly more than 1/4 (26%) self-spreading, nearly 1/5 (18%) spread by water, 11% by wind and only 5% as a result of human activities.

Plant species identified in the area

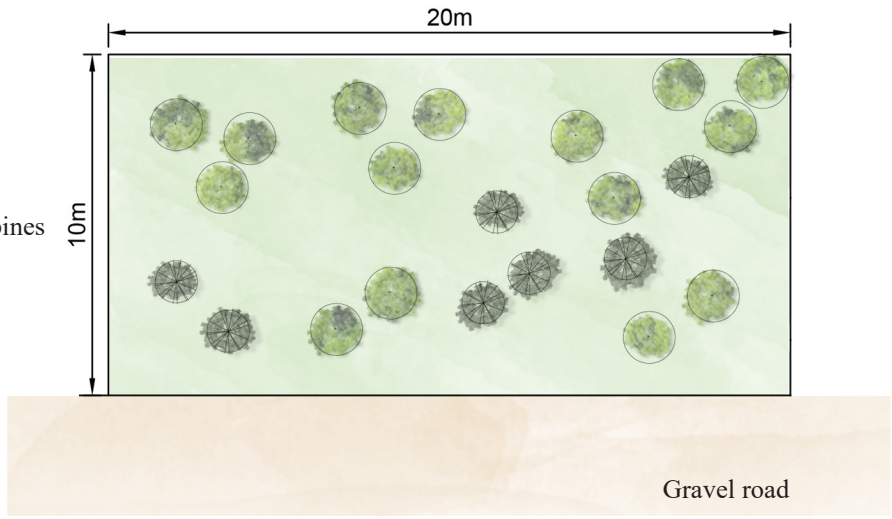
No.	Latin name	Characteristics
1.	*Alopecurus pratensis*	Common in wet places Natural grassland species
2.	*Dactylis glome-rata*	On fertile soils Common in seeded and natural grasslands Expansive species
3.	*Poa pratensis*	On moderately moist soils Natural grassland species
4.	*Ranunculus acris*	On moderately moist soils Grassland species
5.	*Ranunculus repens*	On wet soils Grassland species
6.	*Heracleum sibiricum*	On moderately moist soils Common in grasslands and on roadsides
7.	*Aegopodium podagraria*	On moderately moist, fertile soils rich in nitrogen Weed
8.	*Taraxacum officinale*	On fertile soils Weed
9.	*Achillea millefolium*	On dry soils Grassland species
10.	*Urtica dioica*	On fertile soils, rich in nitrogen Weed, wet grassland species
11.	*Thlaspi arvense*	On fertile soils Weed
12.	*Rubus idaeus*	On soils rich in nitrogen Common in forests, clearings and on roadsides
13.	*Alchemilla vulgaris*	On moderately moist soils Grassland species
14.	*Geranium palustre*	On wet soils Wet grassland species
15.	*Lathyrus pratensis*	On moderately moist soils Grassland species
16.	*Vicia cracca*	On moderately moist soils Grassland species
17.	*Veronica chamaedrys*	On moderately moist soils Common in grasslands, forest edges and on roadsides
18.	*Epilobium hirsutum*	On moderately moist soils Grassland species
19.	*Galium album*	On moderately moist soils Grassland species

Legend: dominant species are marked in colored rows

The use of the phytoremediation method in the pilot-area established on the project site

Representatives from Kupiskis (Lithuania) municipality, students of LLU landscape architecture and planning speciality and local inhabitants took part in the planting of phytoremediation plants. The selection of phytoremediation plants was based on the specific features of the area - the whole area is sown with a mixture of grass seeds, pine and aspen trees are planted in free groups. Plants were planted in the spring to allow them to take root, as well as to provide the phytoremediation process throughout the season within the established pilot-area.

A mixture of grass seeds and pines with aspen in the base



Placement scheme of phytoremediation plants (Created by the author)

Assortment of phytoremediation plants in pilot-area

No.	Latin name	English name	Photo
grasses / flowers per 200 m²			
1	*Lolium x boucheanum syn. Lolium x hybridum*	Hybrid Ryegrass	
2	*Lolium perenne*	Perennial Ryegrass	
3	*Trifolium pratenese*	Red Clover	
tree plants per 200 m²			
4	*Pinus sylvestris 'Jogeva'*	Scots Pine	
5	*Populus tremula*	Aspen	

Establishment of phytoremediation pilot-area of Kupiskis municipality (Photo by the author)

Monitoring of contamination level after project implementation

Three months after the establishment of the phytoremediation pilot-areas, repeated soil analyses were carried out to evaluate the efficiency of the phytoremediation process. In each pilot-area the average value of each contamination element was summarized before and after the project implementation and the boundaries of the uncertainty of the result were also presented. In the former fuel storage facility before the implementation of the project, the amount of oil products in the soil was below the B limit value (see the table), which does not pose any environmental risks and has no impact on human health. The slight increase in the amount of oil products in the soil samples after the project implementation (see the table) is due to extensive soil removal and mixing operations. Therefore slight increases in contaminant concentrations may be associated with condensation of oil products beneath fuel tanks and concrete slabs demolished on the site. The limit values B have not been exceeded, thus it can be considered that the project's objectives have been reached. The existing oil products are naturally degraded by soil aeration and the successful work of the rhizosphere. According to the "Regulations on soil and soil quality standards", the values of all regulated elements, except oil products, in the results of soil analyses from the Kupiskis project site are below the target value A. This indicates good quality of the soil that does not pose any environmental risk (see the table). Minor positive or negative changes in the elements are connected with the inhomogeneity of the soil and the mixing of deeper layers of soil with the fertile part of the soil because of demolition works at the project site.

Changes in average concentrations of elements in soil before and after project implementation in Kupiskis

Measurable parameter	Units	Result	Uncertainty of the result	Result	Uncertainty of the result	Changes	Soil quality class
Hydrocarbon index for oil products	mg/l	61	5	119	11		B
Cu	mkg/g	9.1	0.07	8.9	0.07		A
Pb	mkg/g	6.6	0.2	6.5	0.2		A
Ca	mkg/g	18856	2	18989	2		N/A
Fe	mkg/g	7389	1	7362	1		N/A
Zn	mkg/g	31.1	0.07	30.4	0.07		A
Cr	mkg/g	8.9	0.1	8.6	0.1		A
Mn	mkg/g	219	0.4	227	0.4		N/A
Ti	mkg/g	23.9	0.03	24.9	0.03		N/A
Al	mkg/g	7611	0.3	4676	0.3		N/A
P	mkg/g	469	1	470	1		N/A
K	mkg/g	1068	5	1029	5		N/A
Ni	mkg/g	8.1	0.5	8.0	0.5		A
Co	mkg/g	3.79	0.06	3.81	0.06		N/A
Mg	mkg/g	5789	0.3	5736	0.3		N/A

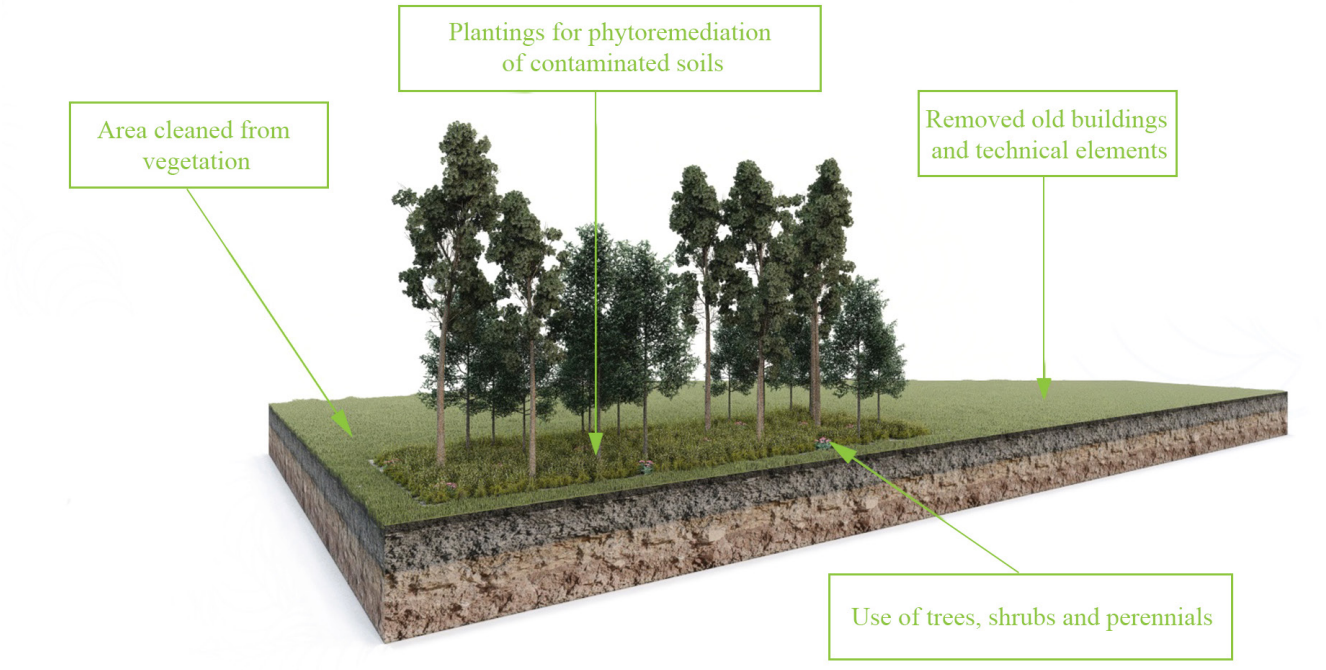
Measurable parameter	Units	Result	Uncertainty of the result	Result	Uncertainty of the result	Changes	Soil quality class
Na	mkg/g	120	2	113	2		N/A
Sr	mkg/g	22.6	0.05	22.9	0.05		N/A
Ba	mkg/g	35.1	0.1	34.9	0.1		N/A
Sn	mkg/g	<0.2	0.2	<0.2	0.2		N/A

Changes are analyzed, where in the table the positions showing the decrease are marked green and those positions where the change is positive are indicated in orange. In addition, a target value and limit value are given in accordance with the "Regulations on soil and soil quality standards" where:

- target value (**value A**) - indicates the maximum level beyond which sustainable soil quality cannot be reached;
- precautionary limit value (**value B**) - indicates the maximum level of contamination beyond which adverse effects on human health or the environment could occur, and the level to be achieved after remediation, unless stricter requirements are stated ;
- critical limit value (**value C**) - indicates that when it is reached or exceeded, the functional properties of the soil and ground are seriously disturbed or that there is a direct risk to human health or the environment from contamination.

The following activities were carried out for the remediation of the pilot-area of the project site in Kupiskis municipality, Lithuania:

- Removing remnants of the former fuel storage station and other technical elements from the pilot site, levelling off the area;
- Use of phytoremediation method in the established pilot-area.

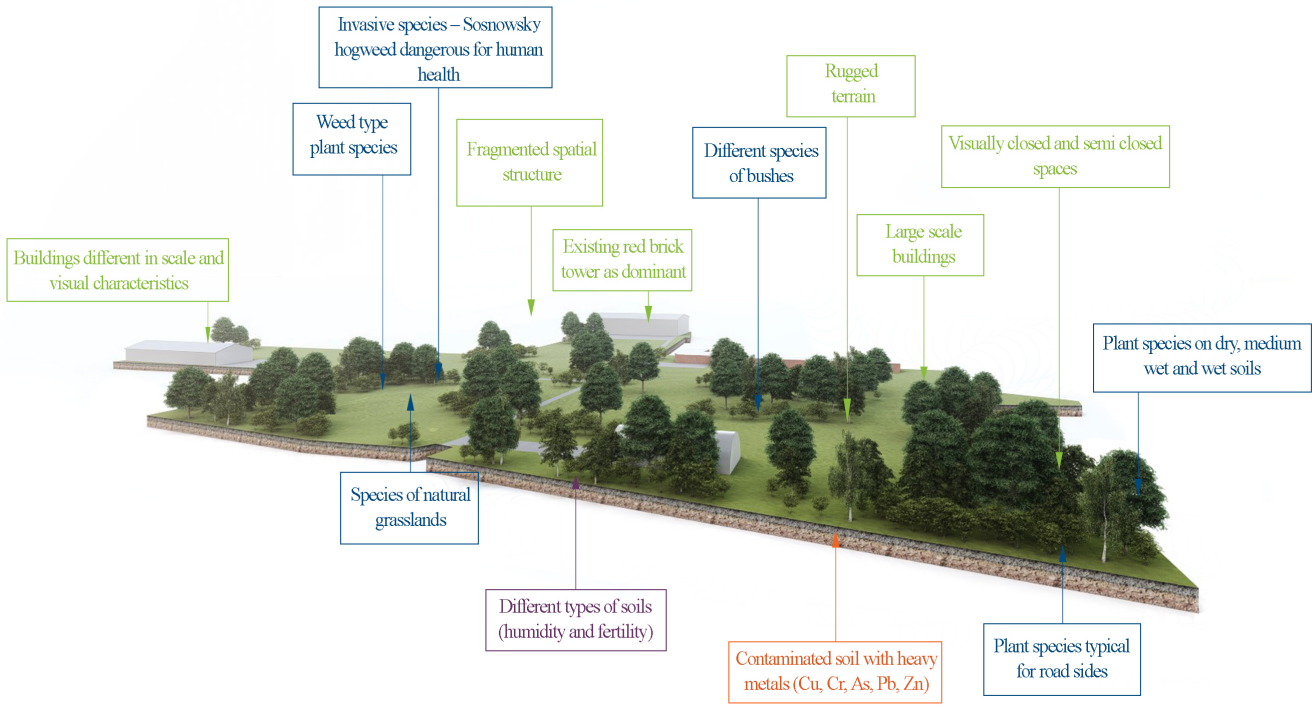


Activities carried out in Kupiskis pilot-area (Created by the author)

THE TERRITORY OF THE FORMER FLAX FACTORY IN LUDZA, LATVIA

The last of the sites studied and revitalized in the BrownReg project is located within the boundaries of the town Ludza along the A12 road. The project pilot-site borders with the newly developed Garden of Light, as well as technical areas, and a residential area.

The location of the former flax factory site and the characteristics identified during the research (www.google.com/maps/)



The location of the former flax factory site and the characteristics identified during the research (Created by the author)

Environmental risk assessment

The air quality in the former flax factory area is characterized as good, since there are no volatile oil products and no economic activity takes place there. No specific lichen species indicative of air pollution were found in the area. Groundwater levels in the site fluctuate seasonally with the maximum level after snow melting in the spring and minimum level during the low water period in the summer. The area is surrounded by a network of ditches and a pond, where contamination from the tannery ponds of the former flax factory is possible.

Analysis of soil samples before the site remediation activities

Although heavy metals are naturally present in the soil, anthropogenic activities increase their concentration and heavy metals become harmful to both plants and animals. In the area of the former flax factory, the soil is potentially contaminated with various chemical elements remaining in the flax tanning ponds.

Concentration of elements in the soil of project pilot-area in Ludza

Sample	Weight, g/50ml	Al	Ba	Ca	Co	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	P	Pb	Sn	Sr	Ti	Zn
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Ludza	0.8939	3812 ±5	71.8 ±5	22595 ±5	3.50 ±5	7.4 ±5	7.5 ±5	9003 ±5	762 ±5	5695 ±5	612 ±5	121 ±5	7.7 ±5	875 ±5	7.2 ±5	0.2 ±5	22.1 ±5	41.6 ±5	34.5 ±5

Analysis of landscape spatial structure and elements

The former flax factory is located in an urban environment of the town Ludza and is closely linked to residential areas, as well as to the general infrastructure and network of the streets and roads of the city. The landscape spatial structure is formed of large-scale technical buildings and infrastructure objects of the former flax factory.

The ruins of the former flax factory buildings. One of the dominant elements is the tower from red bricks as a sign of a place of identity (Photo by the author)

The area is formed of several landscape elements - structures, fences, tree alleys and rows, groups of shrubs and water elements (adjacent to the site).

Landscape spatial structure before cleaning the area from the remnants of industrial buildings and other elements. Big trees and groups of shrubs dominate in the site. Hogweed has spread out in several places (Photo by the author)

Vegetation research and analysis

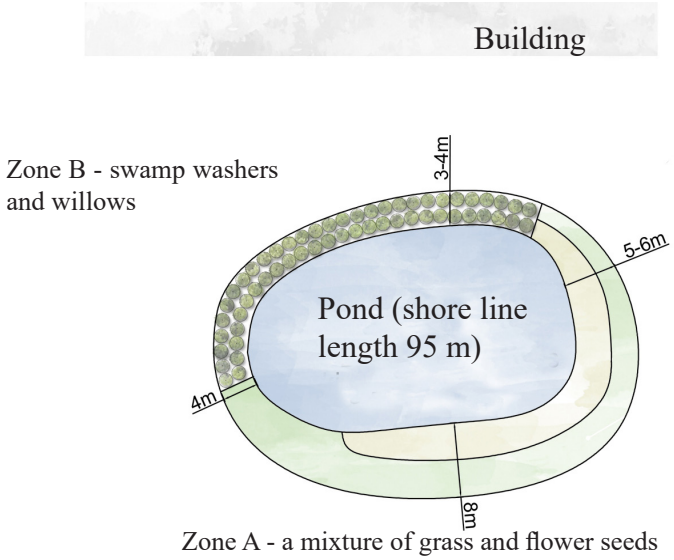
The area has an uneven terrain. There are species common for dry, moderately moist and humid places. The plant community includes both natural grassland species, weed species, and roadside and shrubland species. In general, the plants show soils of different moisture and fertility. An aggressive

invasive and human-threatening species, the Sosnowsky hogweed, has been identified. Hogweed propagates widely and spreads in the area. More than half (57%) of the detected plants are spread by animals (including birds), almost 1/5 (18%) by humans, slightly less by wind and self-seeding (11% and 14%).

Plant species identified in the area

No.	Latin name	Characteristics
1.	*Dactylis glomerata*	On fertile soils Common in seeded and natural grasslands Expansive species
2.	*Poa annua*	On moderately moist soils Annual plant, weed
3.	*Anthoxanthum odoratum*	On dry and moderately moist soils Grassland species
4.	*Ranunculus acris*	On moderately moist soils Grassland species
5.	*Anthriscus sylvestris*	On moderately moist, fertile soils rich in nitrogen Common in forests, grassland and on roadsides
6.	*Heracleum sosnowsky*	Invasive and aggressive species Common in grasslands and on roadsides
7.	*Aegopodium podagraria*	On moderately moist, fertile soils rich in nitrogen Weed
8.	*Taraxacum officinale*	On fertile soils Weed
9.	*Artemisia vulgaris*	On fertile soils Common in grasslands and forest edges
10.	*Artemisia campestris*	Common in dry grasslands
11.	*Achillea millefolium*	Common on dry soils Grassland species
12.	*Arctium tomentosum*	Common on dry soils Common in grasslands, forest edges and on roadsides
13.	*Tanacetum vulgare*	In dry and moderately moist grasslands
14.	*Tussilago farfara*	On gravel and clay soils, grasslands
15.	*Centaurea jacea*	In dry and moderately moist grasslands
16.	*Urtica dioica*	On fertile soils rich in nitrogen Weed, wet grassland species
17.	*Plantago major*	On compacted soils Common on roadsides and in courtyards
18.	*Rubus idaeus*	On soils rich in nitrogen Common in forests, clearings and on roadsides
19.	*Potentilla anserina*	Common on roadsides, in courtyards and grasslands
20.	*Alchemilla vulgaris*	On moderately moist soils Grassland species
21.	*Filipendula ulmaria*	On moderately moist and wet soils Common in forests and grasslands
22.	*Geum rivale*	On moderately moist and wet soils Common in forests and grasslands
23.	*Agrimonia eupatoria*	On dry soils Common on roadsides, forest edges and in grasslands

No.	Latin name	Characteristics
24.	*Barbarea vulgaris*	Common on roadsides and in grasslands
25.	*Trifolium repens*	On moderately moist soils Common in grasslands and on roadsides
26.	*Trifolium pratense*	Common in grasslands and on roadsides
27.	*Trifolium medium*	Common in grassland, on roadsides and forest edges
28.	*Vicia sepium*	On dry and moderately moist soils Common in grasslands and on roadsides
29.	*Melilotus albus*	On dry soils Common in grasslands and on roadsides
30.	*Lathyrus pratensis*	On moderately moist soils Common in grasslands
31.	*Veronica chamaedrys*	On moderately moist soils Common in grasslands, on forest edges and roadsides
32.	*Galium album*	On moderately moist soils Grassland species
33.	*Geranium pratense*	Common in moderately moist grassland
34.	*Glechoma hederacea*	Common in grasslands and forests, on roadsides Weed
35.	*Epilobium hirsu-tum*	On moderately moist, fertile soils Grassland species
36.	*Chamaenerion angustifolium*	On dry soils Rapidly introduces if disturbance of habitat has occurred
37.	*Chelidonium ma-jus*	On fertile soils Common in bushland and grasslands
38.	*Knautia arvesnsis*	Grassland species
39.	*Rumex confertus*	On fertile soils Common in natural and cultivated grasslands, on roadsides
40.	*Rumex obtusifolius*	On compacted soils Common on roadside, in bushland and grasslands
41.	*Equisetum arvense*	On dry and acid soils Common in grasslands, agricultural fields and on roadsides
42.	*Equisetum pratense*	Common in grasslands, forests and on roadsides



Placement scheme of phytoremediation plants (Created by the author)

The use of the phytoremediation method in the pilot-area established on the project site

Representatives from Ludza (Latvia) municipality, students of LLU landscape architecture and planning speciality, local inhabitants and students from local schools took part in the planting of phytoremediation plants. The plantations of phytoremediation plants were divided into two zones - zone A seeded with mixture of grasses and annual flowers and zone B with groups of willows and Iris pseudocorus L. The plants were planted in the spring to allow them to take root, as well as to provide the phytoremediation process through the season within the established pilot area.

Assortment of phytoremediation plants in the pilot-area of Ludza municipality

No.	Latin name	English name	Photo
Zone A 400 m²			
1	*Lolium x boucheanum syn. Lolium x hybridum*	Hybrid Ryegrass	
2	*Lolium perenne*	Perennial Ryegrass	
3	*Medicago sp.*	Barrelclover	
4	*Helianthus annuus*	Sunflower	
5	*Trifolium pratenese*	Red Clover	
Zone B 200 m²			
6	*Iris pseudocorus L.*	Yellow Iris	
7	*Salix (dasyclados) burjatica 'Monika'*	Willow	
8	*Salix (dasyclados) burjatica "Visvaldis'*	Willow	
9	*Salix smithensis*	Willow	
10	*Salix viminalis*	Basket Willow	

Establishment of phytoremediation pilot-area (Photo by the author)

Monitoring of contamination level after project implementation

Three months after the establishment of the phytoremediation pilot-areas, repeated soil analyses were carried out to evaluate the efficiency of the phytoremediation process. In each pilot-area the average value of each contamination element was summarized before and after the project implementation, and the boundaries of the uncertainty of the result were presented. In the former flax factory site before the implementation of the project, the amount of oil products in the soil was below the B limit value (see the table), which does not pose any environmental risks and has no impact on human health. The slight increase in the amount of oil products in the soil samples after the project implementation (see the table) is due to extensive soil removal and mixing operations. Therefore, slight increases in contaminant concentrations may be associated with condensation of oil products beneath fuel tanks and concrete slabs demolished on the site. The limit values B has not been exceeded; thus, it can be considered that the project's objectives have been reached. The existing oil products are naturally degraded by soil aeration and the successful work of the rhizosphere. According to the "Regulations on soil and soil quality standards", the values of all regulated elements, except oil products, in the results of soil analyses from the Ludza project site are below target value A. This indicates good quality of the soil that does not pose any environmental risk (see the table). Minor positive or negative changes in the elements are connected to inhomogeneity of the soil and the mixing of deeper layers of soil with the fertile part of the soil because of demolition works at the project site.

Changes in average concentrations of elements in soil before and after project implementation in Ludza

Measurable parameter	Units	Result	Uncertainty of the result	Result	Uncertainty of the result	Changes	Soil quality class
Hydrocarbon index for oil products	mg/l	32	4	48	4		B
Cu	mkg/g	7.8	0.07	7.5	0.07		A
Pb	mkg/g	8.1	0.2	7.2	0.2		A
Ca	mkg/g	21845	2	22595	2		N/A
Fe	mkg/g	89543	1	9003	1		N/A
Zn	mkg/g	34.1	0.07	34.5	0.07		A
Cr	mkg/g	7.2	0.1	7.4	0.1		A
Mn	mkg/g	621	0.4	612	0.4		N/A
Ti	mkg/g	43.1	0.03	41.6	0.03		N/A

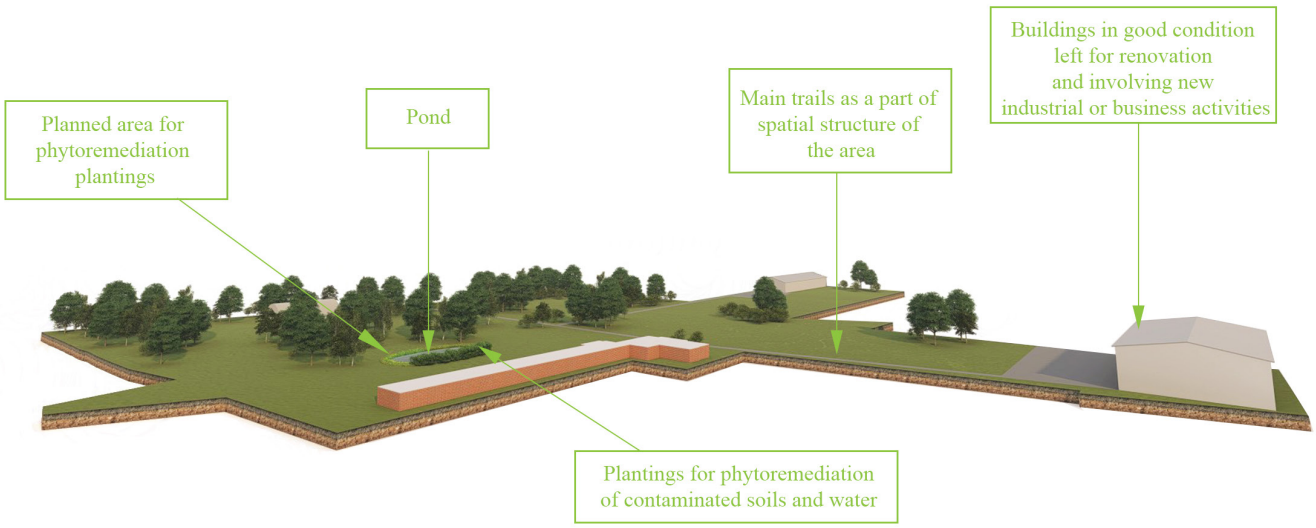
Measurable parameter	Units	Result	Uncertainty of the result	Result	Uncertainty of the result	Changes	Soil quality class
Al	mkg/g	3796	0.3	3812	0.3		N/A
P	mkg/g	883	1	875	1		N/A
K	mkg/g	771	5	762	5		N/A
Ni	mkg/g	7.4	0.5	7.7	0.5		A
Co	mkg/g	3.7	0.06	3.5	0.06		N/A
Mg	mkg/g	5581	0.3	5695	0.3		N/A
Na	mkg/g	132	2	121	2		N/A
Sr	mkg/g	22.9	0.05	22.1	0.05		N/A
Ba	mkg/g	71.9	0.1	71.8	0.1		N/A
Sn	mkg/g	<0.2	0.2	<0.2	0.2		N/A

Changes are analyzed, where in the table the positions showing the decrease are marked green and those positions where the change is positive are indicated in orange. In addition, a target value and limit value are given in accordance with the "Regulations on soil and soil quality standards" where:

- target value (**value A**) - indicates the maximum level beyond which sustainable soil quality cannot be reached;
- precautionary limit value (**value B**) - indicates the maximum level of contamination beyond which adverse effects on human health or the environment could occur, and the level to be achieved after remediation, unless stricter requirements are stated ;
- critical limit value (**value C**) - indicates that when it is reached or exceeded, the functional properties of the soil and ground are seriously disturbed or that there is a direct risk to human health or the environment from contamination.

The following activities were carried out for the remediation of the pilot-area of the project site in Ludza municipality, Latvia:

- Removing the remnants of non-operating buildings and other technical elements from the pilot site, levelling off the area;
- Use of phytoremediation method in the established pilot-area.



Activities in Ludza pilot area (Created by the author)

FURTHER RECOMMENDATIONS FOR THE MANAGEMENT OF THE AREA

- Promoting restoration of the fertile soil layer in the project areas and in all green areas, and promote rhizosphere activity by watering and providing the necessary plant nutrients;
- Continuing the commercial use of the existing facilities requires all the necessary preventive activities to reduce contamination risks.

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BEST PRACTICE EXAMPLES

FORMER INDUSTRIAL TERRITORIES

Entertainment and shopping centre “MANUFACTURE”

Drewnowska 58, 91-002 Łódź, Poland

Client: a private investor
Architects: Virgile&Stone and Sud Architects
Scale: 27 hectares
Year: 2006

The city of Łódź in Poland reflects the industrial revolution. Like cities along the Rhine in Ruhr region in Germany, Łódź grew around large factories that have shaped the character of the city for decades. Łódź used to be a small settlement before the industrial revolution in the 19th century when innovation in electricity generation not only revolutionized the world economy, but also changed people's lifestyle, urban infrastructure and appearance. Łódź formed as an industrial city. With the change of industrial technologies in the 20th century several industrial territories lost their original functions, thus, the question of the future of this industrial heritage arose. New features and uses have been planned to prevent these areas from becoming degraded and abandoned and to preserve the industrial heritage which often forms the identity and the image of the city.

One of the most known post-industrial areas in Poland is a former factory complex of Izrael Poznański in Łódź . It is currently used as multifunctional shopping and entertainment center called Manufaktura. This is one of the largest revitalization projects of former industrial sites in Europe. Adding new functions to the site of a former textile factory has not only revitalized the degraded and abandoned industrial area, but has also created a new public space. The former Poznański Factory turned out to be a magnet for visitors and soon began to serve as a new city centre.

Approaches used in the remediation of the area:

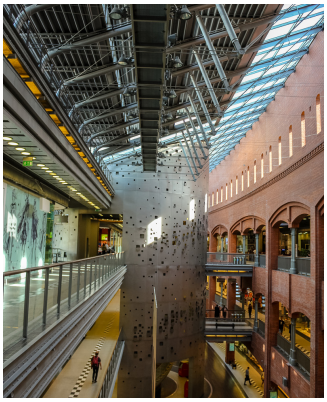
- **reconstructed and partly rebuilt buildings of the former factory.** New structures become a part of historical complex and can provide new functions (for example multi-storey car parking structures;
- **multifunctional public space created,** including mainly entertainment functions - shops, cafes, cinema, etc., while preserving the historical heritage and aura of the former textile factory that could be experienced in the factory museum;
- **transformable outdoor space** that allows the public to participate in different seasonal activities - artificial beach with sandy area, beach volleyball, cafes in summer; ice rink in winter, as well as thematic and special events, etc.;
- **strengthening the identity of the place** by preserving specific scale, building volumes, materials (red brick) of the former industrial area, creating new elements associated with textile production – "thread elements" integrated in benches, signs and other elements.
- the city of Łódź now has a **new city center** that reflects historic values and creates the **image of the city.**

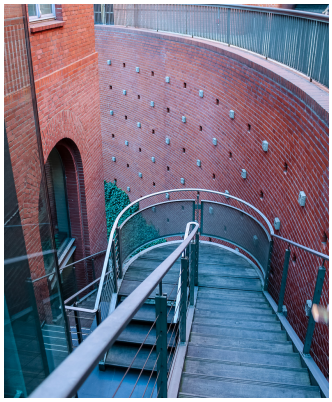
Entertainment and shopping centre "STARY BROWAR"

Półwiejska 42, Poznan, Poland

Client: Fortis / since 2015 - Deutsche Asset & Wealth Management
Architecture: Studio ADS
Scale: 130 000 m2 (building)
Year: 2003

The area of entertaiment and shoping centre Stary Browar was built in the place of a former brewery opened by the German brewer Ambrosius Hugger. Today Stary Browar in Poznań is a modern shopping center and an authentic center of culture and education. You can go shopping, eat, communicate with art and good design, take part in numerous workshops and events, such as concerts, shows or meetings with interesting people. Art in the Old Brewery is defined not only by the sculptures, installations and great architecture present there, but also by the new true urban experience: the art of buying, selling and creating.





Approaches used in the remediation of the area:

- ➛new **multifunctional public space** has been created based on a historically significant industrial area, buildings and elements;
- ➛historical red brick chimney and thematic features reminding of the traditions of the old brewery create an **identity of the place** and **connection with the history** of this area;
- ➛a **new identity is searched** for by involving contemporary arts elements on facade, interior and outdoors of the entertaiment and shopping mall.
- ➛**art is presented in various ways** - as separate spots, as artwork to be sold or bought, as art activities that can be created there.

ZOLLVEREIN PARK

Gelsenkirchener Str. 181, 45309 Essen, Germany

Landscape Architect: Planergruppe GmbH
Design year: 2005 – today

The Zollverein mine is one of Germany's most important industrial relics. Created in 1847, it occupied an area of over 80 hectares which included coal shafts and a coking plant to supply steel mills. After two decades of work, the old mining operation which was closed at the end of the twentieth century and subsequently declared a UNESCO World Heritage Site is now a large park combining industrial archaeology, green landscape, leisure installations, and cultural facilities. Zollverein Park has already become one of the most important points along the European Industrial Heritage Route. The area is a large park that naturally interacts with the industrial heritage and the archeology of the place, the natural environment, and recreational and cultural elements. The natural environment developed in the area is an essential part of the green infrastructure of the city of Essen. The wilderness of Zollveiren Park contrasts sharply with the "tidy" greenery in the urban environment, giving it a special sense of intact nature. There are more than 540 species of ferns and flowers and 100 species of lichens. At least 60 species of birds, 20 species of butterflies and 6 species of reptiles have been observed. Historic heritage of the site is formed from old buildings that are now restored and used as a museum, arts and craft studios, cafes and a place for various other activities. The infrastructure of the railway tracks is preserved and is now developing a network of paths and trails for cycling, walking and hiking. Picnic places and repose areas are designed in a simplistic style appropriate for this site.



Approaches used in the remediation of the area

- **preserved values of the place** – remnants of **industrial heritage** and rich **biodiversity** developed during the abandonment of the site;
- **the identity of the place** is made up of preserved industrial objects - buildings, technical elements which impress with their scale. Individual elements have become **symbols and create the image of the site;**
- **multifunctional public space** consisting of a natural park with a network of paths and recreational areas, historic buildings and elements used as part of the tourist infrastructure;
- the area is **a part of the city's green infrastructure.**

LANDSCHAFTSPARK DUISBURG NORD

Emscherstraße 71, 47137 Duisburg, Germany


Landscape Architect: Latz + Partner
Team Members: Latz + Partner, Latz-Riehl
Design year: 1990
Year of construction: 1992 – 2002
Area: 230 hectares

Within the International Building Exhibition Emscher Park (IBA) in the Ruhr District, Germany, approximately 100 projects were implemented to demonstrate to the public and professionals the principles of revitalization of former industrial sites into ecologically, economically and socially integrated public areas. The landscape park Duisburg Nord is one of these projects, where the existing patterns and fragments formed by industrial use were taken, developed and integrated into a new ”landscape”. The area was cleaned of technical elements degrading and contaminating the environment, phytoremediation plantings were created for accumulation of heavy metals in the area. The park has a total area of 230 hectares. In the landscape park Duisburg Nord, individual systems operate independently, such as the low-lying water park, the single fields and clumps of vegetation, the promenades at street level connecting parts of the town which were separated for decades, and the railway park with its high level

promenades and the rail harp. They connect only at certain points through specific visual, functional or merely imaginary linking elements.

The park is divided into the following zones: Blast Furnace Park; Water park; Sinter park; Railway park; Ore Bunker Gallery; Play-points. Created collectively as an artwork by engineers, the rail harp reflects the centennial history of the place. The huge land art slowly emerged again due to a careful vegetation management with the help of the gardeners.

The area has a multifunctional character defined by separate functional areas - a museum, exhibition and information center area along with an integrated children's day center, event space, a huge water reservoir for diving, an active sports and play area with a climbing wall, phytoremediation plantings, walking trails and more. New trees, meadows and ornamental plantings were planted in the areas between the industrial ruins.





Approaches used in the remediation of the area:

- **cleaning** of the industrial site from **contaminating and unsafe technical elements**;
- **cleaning of lightly contaminated soils and water by phytoremediation** - plantings accumulating heavy metals;
- localization and **isolation of heavily contaminated areas**;
- **introduction of new functions** in the existing industrial buildings - creating **multifunctional** public space;
- **linking with other former industrial sites** in the Ruhr region;
- development of a **bicycle track network** and bike rental;
- **environmental and cultural history education** by placing art objects and information boards.

RAILWAY AREAS

PARK AM GLEISDREIECK

Möckernstraße 26, 10963 Berlin, Germany
Owner: Grün Berlin
Design: Atelier Loidl
Scale: 26 hectares: Ostpark 17 hectares, Westpark 9 hectares
Year: 2013 – 2019

Berlin in Germany has positioned itself as a green metropolis with a large diversity of green areas. Several recreational areas have been established in the territories of the former railway areas. Those areas no longer fulfill their original functions and therefore there was rich biodiversity formed during

these years. Park am Gleisdreieck is one such example. The former railway area after World War II became an abandoned and degraded area, where at the same time unspoiled nature took over the once man-made environment. The area is rich in vegetation and high biodiversity. The development of the park was started with the initiative and participation of residents because the area is located between the densely built up residential sites. By developing the area as a multifunctional public space, it has not only created a place for residents to relax and engage in activities, but has also created a functional and ecological linkage between the two parts of the city, thus becoming an important element of the city's overall green infrastructure.Various areas have been carefully designed in the park, leaving both natural areas created over the years and new recreational areas.

Approaches used in the remediation of the area:

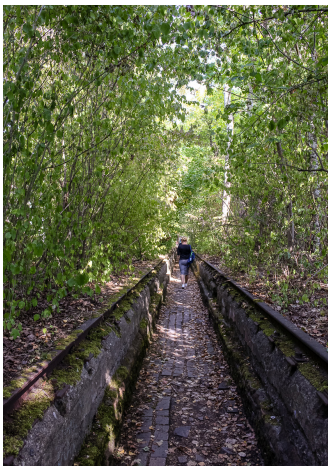
- ➛main values are preserved in the territory - cultural heritage (railway infrastructure elements) and high biodiversity;
- ➛multifunctional area with diverse functions and spaces is created – open and wide areas for sports activities, biodiverse wildlife areas, playgrounds and sports fields, community gardens, outdoor cafes, premises for bussiness and creativity, and a museum of the former industrial site;
- ➛elements and spaces are supplemented with information boards located in the nature and wildlife areas to promote environmental education and awareness of nature;
- ➛the park is an important part of the city's green infrastructure, it is a bio-corridor that naturally developed on the former railway infrastructure on which the park is based;
- ➛the park is a functional linkage between two parts of the city, divided by the existing railway.

SCHÖNEBERGER SÜDGELÄNDE PARK

Prellerweg 47-49, 12157 Berlin, Germany

Owner: Grün Berlin
Planning: Working group planland / ÖkoCon, Berlin; Sculptor group ODIOUS
Scale: 18 hectares
Year: 2008-2009

The Tempelhof railway area was closed after World War II and became an abandoned and unused post-industrial site. In 50 years since the site was left untouched, it has become a rich natural oasis in the center of an urbanized environment. Today, the area is a peculiar site of wildlife, industrial heritage and a place for experiencing art. It is the Schöneberger Südgelände Park. As a reflection of the former industrial site, the park retains specific historic buildings, such as "Brückenmeisterei" (an administrative building) and the water tower, which is a vertical dominant and recognizable element of the place. The walkways of the park, arts and recreation areas are integrated into the parts of the old railway infrastructure that remain today. A historic locomotive has been preserved and exhibited in the area to show the history of the place. The building formerly used for repairing trains has become a place for experimental art. There are theater performances and concerts as well as other artistic performances that take place there.
The Südgelände Nature Park includes a nature reserve with a high biodiversity value, due to the long-term abandonment of the area, a small exhibition hall, an outdoor art space, various remnants from the historic use of the site (railway tracks, locomotive, water tower, etc.) and walking routes.



Approaches used in the remediation:

- **the site has been partly self-cleaned** by the plant species which have appeared as a result of more than 50 years of abandonment. Interesting and specific plant communities have developed in the area. The **plants accumulate soil contamination typical of railway areas;**
- the park is designed as **a multifunctional public space** including nature areas, walking and art areas;
- **identity forming elements** of the place are preserved as symbols and dominants;
- the park is a **unique place in the dense urban environment**, it contrasts sharply with its specific environment and has thus become an interesting place for recreation in the nature;
- the linear structure of the park serves as **bio-corridor and functional linkage** in the city;
- **information boards displaying the history** of the site and information on **biodiversity and species of flora and fauna** are located in the park.

NEW HANZA AREA

Hanza Street 16a, Riga

A former Riga cargo railway warehouse in the New Hanza area has been reborn as a concert hall – a platform for culture, art, music and other events. Combining the building's more than 100 years of history with a modern approach it has become an efficient and functional space to organize and hold events. After renovations, the building will retain its historical image, remaining a landmark of the city's rapid industrial development, yet gain a new purpose that will be noticed and recognized as the destination for culture in Riga. Hanzas Perons is a place for artists to meet their audiences, for creative minds to implement their ideas, for culture buffs to discover new talents.
https://www.hanzasperons.lv/ (Photos: Lauris Vīksne, Uldis Bertāns)

Approaches used in the remediation of the area:

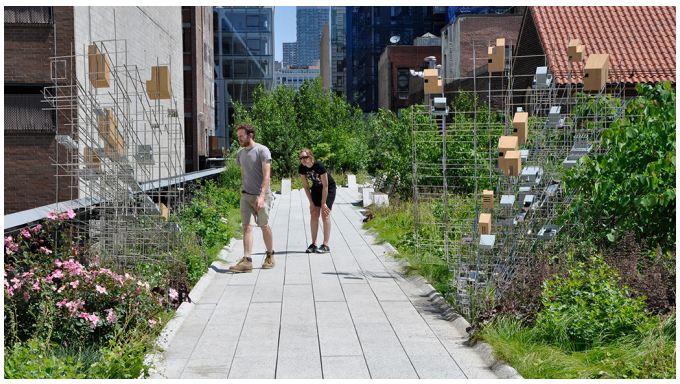
- preserved values and visibility elements of the historic heritage site - the old building is integrated into the volume of the new building;
- multifunctional public space has been created with greater emphasis on organizing cultural events.

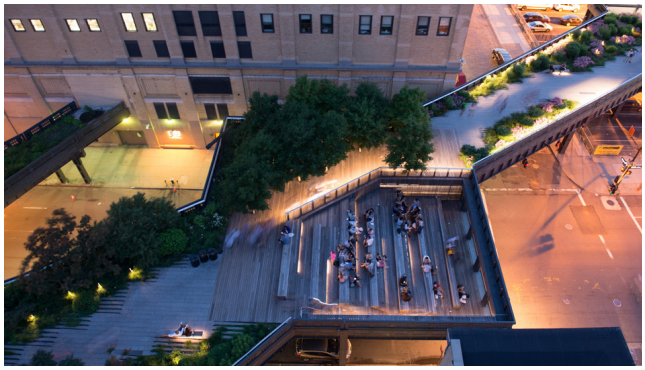
HIGH LINE PARK

New York, USA

The High Line Park is located on a 2.3 kilometer former railway line in New York, USA, called the West Side Line. The idea of the design of the park is to add new functions to the area that has lost its original use while preserving the site's identity within the structure and elements of the park. The area has developed from a brownfield into a public space and an important element (bio-corridor) in the city's green infrastructure.

The park also serves as a functional linkage providing safe passage through an active and dense urban environment and connecting various public sapces and buildings in the city (shops, recreational facilities, etc.). Paths are designed based on principles of universal design providing accesibility for different groups of visitors – people with reduced mobility, separetly developed intensive and calm walking areas etc. Plantings are based on principles of biodiversity and sustainability. Plant arrangements used in plantings do not need extra maintanance. To strengthen the identity and create the image of the place the existing railway tracks, as well as the new elements are designed in a uniform style and correspond to the railway theme. The High Line Park has also become a venue for various artistic events. *https://www.thehighline.org/*





Approaches used in the remediation of the area:
- degraded and dangerous area transformed into **safe and attractive green space** in dense urban environment;
- the park is designed as **multifunctional public space** including natural areas, walking, recreation and art areas;
- elements forming **the identity of the place** were preserved and used in the park structure;
- the design is based on **biologically diverse and sustainable plantings;**
- the park is a **unique place** in the dense urban environment, it contrasts sharply with its specific environment and has thus become an interesting place for recreation;
- the linear structure of the park serves as a **bio-corridor and functional linkage in the city;**
- information boards displaying **the history of the site** and information on **biodiversity and species of flora and fauna** are located in the park.

DEGRADED RIVER AREAS

RIGA WAREHOUSES

Maskava Street 6, Riga, Latvia

The warehouse district until the liquidation of the Riga fortress (from 1857 to 1863) was located outside the fortress and was known as Lastadija – which in German means cargo loading and unloading place. For the first time Lastadija was mentioned in historical materials in 1348. The first stone warehouse was built in 1864, but the last one in 1886. The total number of warehouses built on the site were 58.

The warehouses form a spatially not completed, but monolithic ensemble of buildings. According to special building regulations elaborated for the warehouse district, all warehouses must have matching facades, i.e. facades that have similar and harmoniously attuned design. They are designed in the so-called „brick style" – one of formal varieties of the 19th century eclectic style that prevailed in the architecture of industrial structures, warehouses and other commercial buildings.

The aim of the revitalization project for the former warehouses area was to turn the street block into a publicly accessible, cultural and educational quarter, of interest to both locals and tourists. The territory is attractive since the warehouse block is located in the historical centre, which is included in the Unesco World Cultural Heritage list.

Approaches used in the remediation of the area:

- **the identity and image** of the former Warehouse area was preserved by reconstruction and **adaption of historic buildings to new functions;**
- the quarter was developed as a **multifunctional public space** providing shopping, concerts, theaters, city festivities and more;
- the area serves as **a functional and visual linkage** between the city and the river.

SHANGHAI HOUTAN PARK

Shanghai Expo area, China

The main idea of the project: Landscape as a living system. The park is developed on the former industrial site near the Huangpu River. From a brownfield site it has been transformed into a unique ecological system that cleans contaminated water of the river, protects the city from flooding, creates places for food production, education and recreation.

The aim of the project is to demonstrate the principles of an eco-friendly design and use of the park. As part of the Shanghai Expo the park should be able to host a large number of visitors between May and October demonstrating green technology.

As a result of the project approximately 242 tonnes of carbon dioxide are absorbed by trees and plants in the area. The infrastructure of the park is based on utilized waste that was removed from the site before the park was established. 37 tonnes of steel and 34 000 bricks were reused.

Special constructed elements - terraces have been built for water purification. Plants are planted for phytoremediation or decontamination of water in each terrace. The water is purified sequentially – water which is the most contaminated is in the first terrace and the purest water is in the last terrace.




Approaches used in the remediation of the area:

- the park is designed as a **multifunctional public space** including nature areas, as well as walking and recreation areas, education and other activity areas;
- the park is like **a living system** that cleans the area from contamination and protects it from flooding;
- **recycled materials were used** to create the park infrastructure;
- the park is a **unique place in the dense urban environment**, it contrasts sharply with its specific environment and has thus become an interesting place for recreation;
- the linear structure of the park serves as a **bio-corridor in the city.**

GYPSUM FACTORY

Balasta dambis 72, Riga, Latvia

The former Gypsum factory is located on the bank of the river Daugava. The factory is an example of brick architecture in Riga at the end of the 19th century with splendid brick elements and textures, interesting wooden constructions, characteristic window rhythm and division. As a result of renovation the factory has been converted into a modern residential ensemble – the first loft complex in Latvia. The ensemble contains 34 apartments, a restaurant, sauna and an underground parking place.

The project complex is located in the state-protected, historic area of Kipsala Island. A "suburban" oasis—right in the middle of Riga—Kipsala is part of the buffer zone of the historic center of Riga, which is included in the UNESCO World Heritage List.

During the first reconstruction phase of the Gypsum Factory, which began in 2002, only a selection of the complex's buildings were reconstructed. These included the four buildings surrounding the courtyard and the large smokestack in the southern part of the block. During this phase of reconstruction, a residential complex with 34 apartments was completed, together with the Fabrika (Factory) restaurant, a sauna, and a private marina. Phase 1 was completed in 2004. The aim of phase 2 was to complete the architectural development of the entire factory complex—while meeting urban, suburban and historic considerations. This monument of industrial heritage is important to Riga, both because of the view it offers to the right bank of the Daugava River and its cultural heritage. Therefore it demands careful and sensitive reconstruction. During phase 2 of the project, original buildings of value are being renovated, and an impressive range of new architecture integrated within the existing structure of the Gypsum Factory complex and its Daugava left-bank prospect.
https://www.gipsafabrika.lv/

Approaches used in the remediation of the area:
- **values and visibility elements of the historic heritage site are preserved** and used in the new infrastructure and buildings;
- **multifunctional pubic space** has been designed, but with more emphasis on residential development;
- **identity forming elements of the site are preserved** and used as dominants and symbols.

RHINE PARK

Liebigstraße 70, 47053 Duisburg, Germany

Landscape Architect: Atelier LOIDL
Area: 40 ha
Design: 2009

The concept of the park was based on the river landscape. Basic elements of the landscape are imitated polders and low places between them. Polders create a link with the river with a bridge over an existing railway line. The low places between polders provide space for various activities. Preserved elements of industrial structures and walls have been ornamented with bright graffiti. They have become the identity forming features of the place. The park is a temporary used public space until new potential

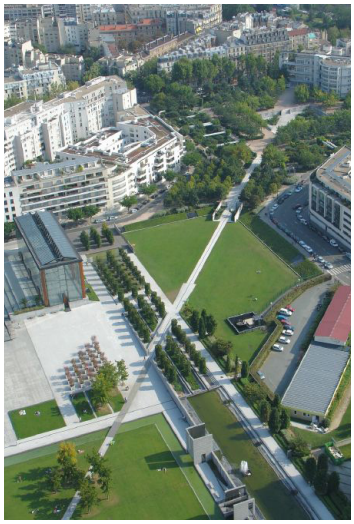
functions and uses will be set. An example of a temporarity is the asphalt area left over from the formerly operating industrial site. Now, the square is used for local markets involving inhabitants and visitors.




Approaches used in remediation of the area:
- ➛the area is cleaned of technical elements;
- ➛use of polder **elements characteristic of the riperian landscape** to solve access to the river and crossing of the existing railway line;
- ➛fragments of industrial structures have been used to **keep alive the identity and aura of the place**;
- ➛**multifunctional** public space;
- ➛visual, emotional and functional **linkage to the river**;
- ➛public space for **temporary use**;
- ➛**public involvement.**

PARC ANDRÉ CITROËN

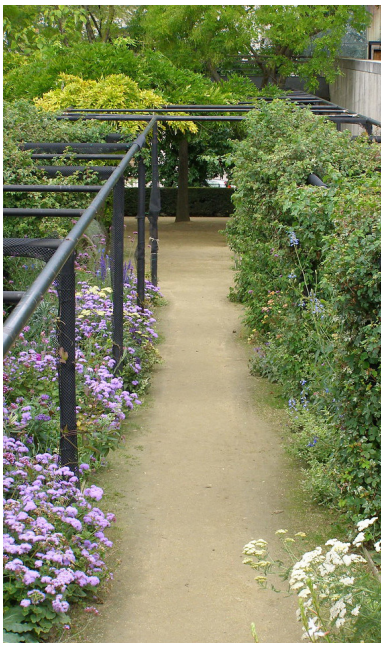
2 Rue Cauchy, 75015 Paris, France

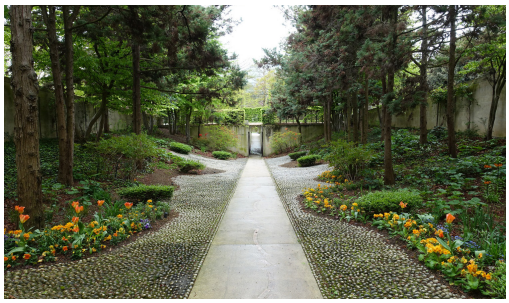
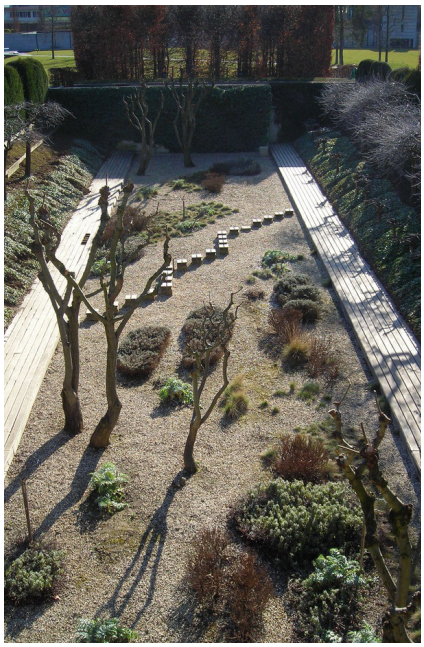



Andre Citroën built a factory on the Seine coast in 1915. It operated until its closure in 1970, when the 24 hectare site was opened for the city development and included in the city`s "urbanization" policy plan. Now there is a public park and new buildings. The public park with its wide lawns, wintergardens, fountains and many other water elements, thematic gardens and rich vegetation occupies 14 hectares. Another 10 hectares are covered by residental and office buildings, including the ultra-modern Le Ponant de Paris, bordering Citroen Park.

Andre Citroen Park consists of separate parts: the White Garden in the East of the area (1 hectare), the Black or Dark Garden in the West (2 hectars) and the Central Park (11 hectares). The park was designed

by French landscape designers Gilles Clement and Alain Provost, and architects Patrick Berger, Jean-Francois Jodry and Jean-Paul Viguie.



Approaches used in the remediation of the area:

- the park is designed as a multifunctional public space including green spaces and waterfront areas, large lawns, as well as walking and art areas, recreational zones, thematic gardens, office and residential buildings;
- elements forming the identity of the place are preserved and used as dominants and symbols (remnants of industrial structures, elements etc.);
- the park is a unique place in the dense urban environment, it contrasts sharply with its specific environment and has thus become an interesting place for recreation;
- the park is a bio-corridor and functional linkage in the urban environment.

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