for better building

Promotion of biodiversity at the mineral extraction sites of HeidelbergCement

Valid for Europe

HEIDELBERGCEMENT

Contents

1 Preface

The principle of sustainability is deep-seated in the company strategy of HeidelbergCement. We provide a safe and healthy work environment for our employees and take on responsibility at all our locations worldwide. We understand sustainability to be a constant effort for improvements in the field of nature and environment protection. We do our best to keep the impact on the environment as low as possible through good management at our locations.

This Group guideline manifests the basic parameters for the promotion of biodiversity at our mineral extraction sites. This guideline aims at defining consistent standards for restoration and renaturation. These standards are to be deployed in all our business lines. Every after-use plan will take into account the economic, ecological and social needs of the respective community. All intended forms of after-use will support the preservation of species diversity and contribute to raising the variety of plants and animals.

When extracting minerals, we change the landscape and make use of mineral resources which have developed over millions of years. Only if we manage to safeguard these resources and handle them carefully, we will be able to meet our own demands and those of future generations. We have set ourselves the goal of sustainable and long-term economic growth. We will contribute to this goal significantly by implementing this Group guideline consistently.

The Managing Board

2 Introduction

2.1 Biodiversity through targeted management

In roughly 40 countries around the world, the name HeidelbergCement stands for competence and quality. The international character of the company implies a worldwide responsibility for all of our activities. HeidelbergCement has a tradition of commitment to sustainability, and builds on the three pillars: ecology, economy and social responsibility. Our sustainable management is centred around clients, employees, shareholders and local partners at all locations.
The quarries and gravel pits from which we extract our raw materials are valuable habitats for a variety of animal and plant species. The dynamic nature of quarrying attracts a wide range of rare species. During and after the quarrying activities, our mineral extraction sites are professionally restored and returned to a natural state, or prepared for agricultural use or forestry. Our emphasis on natural succession has consistently increased over time, benefiting the development of broad biodiversity, adjusted to the native habitat.

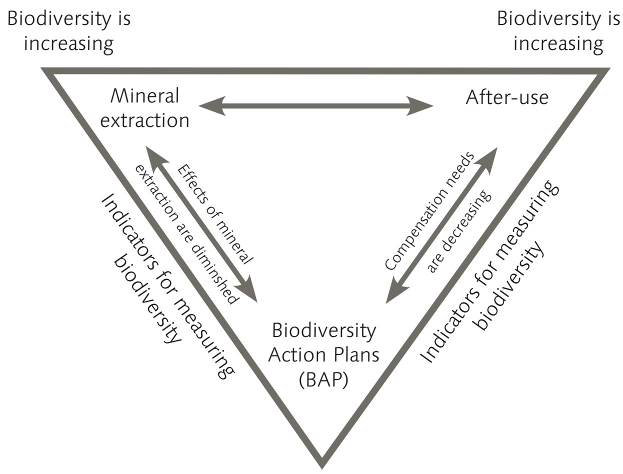
Our ambition is to strategically promote and conserve biodiversity at our mineral extraction sites worldwide. To meet this goal, HeidelbergCement is the first company in the industry to adopt a Group guideline for the promotion of biodiversity at mineral extraction sites. This guideline is valid at all our locations throughout Europe. It is the basis for systematic implementation of consistent measures, as well as the realisation of our biodiversity ambitions.
The core of the guideline comprises ten principles geared towards promoting dialogue with key stakeholders, as well as increasing biological diversity during and after quarrying, in order to protect the native landscape and ecology. In addition, the guideline defines ambitious targets HeidelbergCement aims to successively achieve by 2020. It also sets out decisive principles for modern, professional restoration, which significantly contribute to the promotion of biodiversity.

2.2 Availability and goals of this guideline

This guideline, as well as many good practice examples as PDF-documents in the internet and intranet of HeidelbergCement, provides an all-embracing introduction to the specific new orientation of the company regarding "extraction sites and biological diversity" for employees and the public. This guideline is to be effective at our locations in Europe. Its worldwide implementation is currently being prepared.
For internal use there is an elaborate long version describing the restoration of distinct habitats.
The general advice in this guideline cannot be implemented completely in each and every extraction site. Thus it needs to be implemented using concerted action, taking mining needs as well as economic factors into account according to the specific conditions on location.

The future orientation of after-use planning is based on the following goals:

- This guideline aims at defining Group-wide global minimum standards for the restoration of mineral extraction sites, encompassing cement and aggregates as business lines.
- All forms of after-use ought to contribute to the preservation of biological diversity and to increase biodiversity where possible. Furthermore, they ought to be sustainable, long-lasting and efficiently usable for human beings.
- The global goal of after-use planning for each mineral extraction site is to reach a balance between economic, ecological and social requirements.
- In order to take into account the distinctive biological diversity features of the individual countries and continents, the guideline will successively become more detailed and will be adapted to the specific demands of various geographic areas.



3 HeidelbergCement and biodiversity

3.1 The impact of mineral extraction sites on biodiversity

Nature and landscapes have become increasingly exposed to a rapidly growing world population and an increasing utilisation impact over the last decades. This has lead to a considerable and ever increasing loss of animal and plant species worldwide as habitats are either chopped up or lost completely. Mineral extraction sites in particular are frequently regarded as destructive to the environment and therefore still present a predominantly negative image for the public and nature conservation organisations and authorities. Despite massive efforts of the industry to restore mineral extraction sites, the resentment remains unbroken to a large extent and poses serious problems for the provision of raw materials and future mineral extraction planning.

Scientific data

This general disapproval is opposed by an understanding which has arisen since the end of the 1970s, namely that mineral extraction sites which have been closed down may take on important functions in the environment of intensely utilised land cultivated by man. Closed down mineral extraction sites which have not been restored by topsoil application, sowing and plantation, contribute to sustainably increase and safeguard biodiversity just through the existence of habitats significant within a habitat network system. They also stabilise the surrounding ecosystems. Closed down quarries contain high numbers of species with a high share of endangered animal and plant species. Various manifestations of habitat types appear meshed there, many of which are endangered, rare or threatened. This diversity is caused by long periods of development hardly ever influenced or disturbed by man. Thus a great variety of locations and structures have developed.

Research in the last two decades has proven convincingly, with a broad specialist foundation, that this insight also applies to operating extraction sites. They are characterised by a high number of animal and plant species, many of which are endangered (Figure 1). The findings are frequently comparable

Biological diversity

Biological diversity – or biodiversity – is one of the keywords in nature conservation. It refers to the "abundance of life and its manifold structures" (European Commission).

The term biological diversity stands for more than the diversity of species, however. According to the Convention on Biological Diversity (CBD), biodiversity encompasses

- the diversity of species on earth (organism level),
- genetic diversity (diversity of genes within a species),
- diversity of habitats (ecosystem level).

Figure 1: Young initial vegetation at quarrying level

or even higher than in most habitats of the surroundings. This is due to the extreme environmental conditions in the extraction sites and their great habitat conditions. Characteristic habitats are e. g. rock faces (Figure 2), perennial bodies of water, temporary bodies of water as for instance in tracks and the refuse and spoil heaps (Figure 3, Figure 4).

Comparison of the factors accounting for the nature conservation significance of closed down and operating quarries:

Operating quarries
high diversity of structures and locations
rare habitat conditions at the location
very high numbers of species
number of endangered species almost always higher than that of most habitats in the surroundings
rare and endangered vegetation types, predominantly protosoil and pioneer locations

Closed down quarries
high diversity of structures and locations
rare habitat conditions at the location
high numbers of species
number of endangered species very high, partly higher than in the surroundings
rare and endangered vegetation types in various forms

Figure 2: Colony of sand martins in old riverbed sediments in a steep face of an extraction site

Figure 3: The areas are colonised quickly

Figure 4: Young body of water as habitat for specialised animals and plants


Figure 5: Variegated coexistence of wanderbiotopes close to ongoing extraction


Figure 6: Near-natural rock face


Figure 7: Temporary water bodies at quarrying level

Wanderbiotopes

Extraction sites are very important for the protection of species and habitats due to the variety of sub-habitats interlocked at small-scale or the development areas for animals and plants of different ages within spatial and temporal interrelations (Figure 5). The combination of sometimes extreme contrasts in habitat conditions, which can hardly be found or not be found at all in the surrounding cultivated landscape, have developed into a great structural variety that is a prerequisite for the establishment of numerous plant and animal species (Figure 6).
The bare shallow temporary water bodies in the tracks of heavy duty lorries, which can appear within a very short time during the extraction process, are typical wanderbiotopes for amphibians such as the yellow-bellied toad (*Bombina variegata*) or the green toad (*Bufo calamita*) (Figure 7, Figure 8). The little ringed plover (*Charadrius dubius*) likes to settle on almost bare spacious stone leas, pebble leas or protosoil leas, but only during ongoing extraction and with temporary water bodies close by. Numerous cliff breeders such as the eagle owl (*Bubo bubo*) or the peregrine falcon (*Falco peregrinus*) use the quarry faces for breeding as long as there are suitable alcoves and as long as the walls do not erode too quickly due to soft rock material such as marl. Whenever the mining works move away from a freshly carved out quarry face, the birds settle fairly quickly, if the structure is suitable. They may even hatch only a few dozen metres away from ongoing extraction works.
The differences in flora are similarly obvious. Wetland habitats and topsoil or spoil dumps are specious-rich wanderbiotopes for many plant species and are settled very quickly (Figure 9, Figure 10), while dry or temporarily dry clay habitats need more

time until they become settled to a relevant extent due to the more extreme habitat conditions (Figure 11, Figure 12).
The extraction sites are characterised by pronounced dynamics. A comparison of old photographs to the current state proves how fast these presumably nutrient-poor protosoil locations are settled by specialised species (Figure 8, Figure 9). Modern extraction planning regards these results as an opportunity for new restoration and renaturation concepts. Dynamic processes get integrated and the after-use is adapted accordingly. Existing species populations are taken into account and habitats are optimised. The following chapters provide directions on how the various interests for the after-use can be balanced, while biodiversity is promoted at the same time.

Figure 8: Temporary body of water – photographed in 1992

Figure 9: The same body of water in 2006

Further reading

Davis (1977; 1979; 1981a; b); Tränkle 1997; 2000; Böhmer & Rahmann (1997); Gilcher & Bruns 1999; Rademacher (2001); BDZ/VDZ (2001; 2003).

Wanderbiotopes

Spatial changes within the extraction areas may create areas predestined for the development of animals and plants. They are of various ages, show different structures and are closely connected to one another (succession zones). Whenever minerals are extracted once again from one of these areas, a substitute has already developed elsewhere. These habitats thus “wander”, as the plants and animals wander from one end of the extraction site to the other. These succession zones which are continually renewed are called wanderbiotopes.

Figure 10: Settlement of a sedimentation basin

Figure 12: Succession areas on spoil dumps

Figure 13: Initial reeds in wetland area

Figure 11: Near-naturally settled belay

3.2 Principles for the promotion of biodiversity

Encouraging dialogue

- HeidelbergCement promotes the increase of biodiversity in the planning and implementation of restoration through a structured approach, in dialogue with all stakeholders.
- The forms of after-use are to be discussed with environmental authorities, nature conservation organisations and other interested parties.

Increasing biodiversity

- Each mineral extraction site should maximise the land area with ecological value.
- The ecological and economic value of land after-use need to be fully considered as they both can forward the promotion of biodiversity.
- The planning and implementation of subsequent after-use will be carried out by specialists.
- HeidelbergCement promotes a high degree of biodiversity even in working quarries. Areas temporarily out of use should be managed to maximise ecological benefit.
- Certain areas of each quarry should be left to develop naturally.

Protecting nature and environment

- Indigenous and regionally typical plant species will be favoured.
- It is imperative to protect the topsoil and subsoil. Soil resources need to be safeguarded, protected from erosion and to be either reused as soon as possible on restoration areas or to be stored for a transitional period to avoid damage or loss.
- Ground water and surface water must not be contaminated either during work or after-use.

3.3 Biodiversity ambitions

Follow up on biodiversity indicators and achievements of our ambitions can be found in the Sustainability Report or on www.heidelbergcement.com > Sustainability

Ambitions 2010

- Integration of the guideline into the environmental management system.
- Inclusion of further mineral extraction sites in the monitoring system for biodiversity and implementation of action plans.
- Increase the percentage of mineral extraction sites with effective restoration plans to 85%.

Ambitions 2012

- Inclusion of further mineral extraction sites in the monitoring system for biodiversity and implementation of action plans.
- Increase the percentage of mineral extraction sites with effective restoration plans to 90%.

Ambitions 2020

- Increase the percentage of mineral extraction sites with effective restoration plans to 100%.
- Biodiversity management plans will be implemented in at least 50% of mining sites of the cement business line that are located within or adjacent to areas designated for their high biodiversity value.

4 After-use

4.1 Basics

The extraction of minerals always leaves hollow moulds all of kinds, be they in the shape of a funnel or a box-hole, in the form of offsetting mountainsides or expanding valleys, no matter if with or without water, steep rock faces, flat dumps or terraced with excavation beds. These artificial forms should be integrated into the landscape after the quarrying ends. They ought to be utilisable and left to natural resettlement. And so they are, already today. The resettlement of nature and landscapes is the last step of mining work. The term restoration points out the reference to the surrounding landscape – the extraction site needs to be fitted into the surrounding landscape and nature so that it will be integrated completely. Therefore, restoration requires focused landscape analysis. Then there are the varied wishes of the population for the after-use. All these actualities, wishes and demands, including taking into account the call for more biodiversity, need to be integrated in a reasonable after-use concept. The overall goal is the recreation of rare, near-natural habitats typical for the kind of excavation and ecologically significant. This encompasses establishing agricultural or forestry areas and settlement plots wherever reasonable. Fields, meadows, commercial forests and settlements will be located in the places best suitable, meaning the flat areas. Near-natural habitats will conquer the steep parts of the landscape, which are less apt for human usage. The conceptual aims and the planning of the restoration measures have to meet these demands as well as possible and with as little conflict as possible.

The priority of our conceptual aims is the maintenance and promotion of biological diversity. Depending on the specific surroundings of each extraction site, the restoration or the renaturation areas will prevail. It is on the agenda of Heidelberg-Cement to integrate areas within each extraction site, which contribute to biodiversity. Their share is supposed to increase gradually depending on the local conditions.

Succession

In ecology, succession denotes the chronology of plant and animal communities at one location in the progress of time. During a succession process, an ecosystem goes through a climax from an initial state containing only few species up to a nearly stable final species-rich stage. The areas change quickly in a kaleidoscopic way.

Free succession is the settlement of areas without any human supporting measures.

Controlled succession means that human support only takes place in the beginning in order to accelerate the first settlements by introducing initial species.

4.2 Definitions

The way we define restoration and other terms used in this context is already predetermined by the measures and ambitions we decided to put into practice. There are however considerable differences in the way different countries understand certain terms. Because the practical usage of terms on site locally differs from the scientific terminology, we would like to explain the most important terms briefly in this chapter.

Restoration

Restoration means reestablishing the original ecosystem, the habitat or their functions in the undisturbed way in which they originally existed, including biological, chemical and physical elements.

Reclamation

Reclamation is the reconditioning for agricultural ends or the reestablishing of the natural scenery. In most cases, the original soil as well as the original vegetation do not exist any more, but have to be reconditioned through soil application, fertilisation and sowing.
The term recultivation is predominantly used in Europe and mostly in connection with extraction sites.

Recreation

Recreation implies that it is not necessary to reestablish the exact same ecosystem as existed before the extraction work. It means that it is enough to create an ecological system of any kind. It is important however, that this ecosystem is ecologically significant.

Renaturation

Renaturation means the resettlement of man-made locations as, for instance, extraction sites (or of ecosystems influenced by men) through plants and animals. This leads to habitats autochthonous for the location and its climate. Renaturation is closely connected to reaching a high level of biological diversity.
Three forms can be distinguished on the basis of the intensity of human influence:

- Renaturation goes on without initiation or human regulation. We call this independent process natural succession.
- Renaturation is initiated by strategic planning and practical measures, which accelerate the process at least in the beginning. This process can be categorised as natural succession as well.
- The course of renaturation is systematically changed and controlled through planning, planting and subsequent maintenance. Controlled renaturation is very similar to restoration.

Autochthonous species

Domestic species have or used to have a natural range extending partly over a whole nation. Species which were introduced by man and returned to the wild do not belong in this category.

We speak of indigenous or autochthonous species if they form genetically adapted tribes in one biogeographic region. Such species are well-adapted to the regional environmental conditions.

We speak of autochthonous species if they have settled at a certain location due only to ecological principles – uninfluenced by man. In most cases the term autochthonous is used as a synonym of the term indigenous.

Rehabilitation, reintroduction, reestablishing and habitat improvement

The following terms differ inherently in their quality, but have distinct intersections in common. They all aim at improving a habitat type. The first three terms are aspects of restoration.

Rehabilitation: Rehabilitation is the restoration or improvement of certain aspects or functions of an ecosystem or habitat. It does not necessarily imply the complete restoration of an ecosystem or habitat.

Reintroduction: Reintroduction implies that only small parts of an ecosystem are substituted and not the whole ecosystem. Certain species are introduced into an existing, established, i.e. functioning ecosystem.

Reestablishing: Reestablishing comprises only the targeted reintroduction of plants and animals, for instance through sowing or planting or through catching and releasing in order to increase biological diversity.

Habitat improvement: The improvement of habitat factors such as hydrological, physical or chemical conditions for instance by targeted fertilisation can enhance the quality of a habitat.

Further reading

Bradshaw (1977); Cairns & Cairns Jr. (1995); Gore (1985); Kangas (2004); Kauffman et al. (1997); National Research Council (1992); Pfadenhauer & Maas (1991); Pfadenhauer (1990); Rana (1998); Roni et al. (2005); Tränkle et al. (1992).

In order to standardise terminology, the following terms will be used in this guideline:

- Restoration:
  If reestablishing an original habitat or at least a similar one is the goal, we call this process restoration.
- Recultivation/Reclamation:
  If the focus is on the economic after-use, we call the process recultivation.
- Renaturation:
  If a natural resettlement (with or without supporting measures) is the target for the after-use, we call this process renaturation. The emphasis lies on reaching a high biodiversity level.

→ If a clear-cut categorisation is impossible, the term restoration shall be favoured.

4.3 Best practice for project and restoration planning

The operation and extension of extraction sites inevitably leads to using up landscape areas. The emissions and immissions resulting from quarrying affect nature and the environment. Therefore, HeidelbergCement aims at following good professional practice all around the world for all processes, be they planning, quarrying or restoring. It is essential at planning stages to always check environmental compatibility. Employing a framework concept for after-use (UVU, EIA) is a minimal requirement.
Good professional practice needs to contain the following four essential steps:

- Detailed project planning in the run-up; all relevant natural and environmental factors need to be regarded including human beings.
- Analysing and examining the environmental compatibility; the impact on the environment needs to be avoided or minimised at best.
- The extraction phase.
- Restoration concentrating on a high level of biological diversity in all areas exploited.

The last point, the actual restoration of habitat types, contains the following basic steps:

- Choice of location.
- Developing a framework restoration plan under regional sustainability aspects (text and map).
- Developing a detailed restoration plan (text and map).
- Providing adequate habitat conditions.
- Maintenance.
- Monitoring.

It is essential to keep the public adequately informed during the whole process.
In numerous countries there are already legal regulations regarding restoration, but only some provide additional guidelines or directives on how to handle the whole planning process. Thus we list the most important documents to be consulted here:

- COP 6 Decisions, The Hague, 7 - 19 April 2002: Decision IV/7: Identification, monitoring, indicators and assessments
- IAIA Headquarter (1998): Environmental Methods Review: Retooling Impact Assessment for the New Century. Edited by Alan L. Porter and John J. Fittipaldi. Fargo, North Dakota, USA: The Press Club. March 1998. 309p.
- Council Directive (27 June 1985) on the assessment of the effects of certain public and private projects on the environment (85/337/EEC). The Council of the European Communities (as ammended from time to time).
- Vanclay, F.; Bronstein, D. A. (1995): Environmental and Social Impact Assessment. John Wiley and Sons Ltd. Hrsg.: Vanclay, F.; Bronstein, D. A. ISBN-10: 047195764X, ISBN-13: 978-0471957645. 352p.
- World Business Council for Sustainable Development (WBCSD) (2005): Environmental and social impact assessment (ESIA) guidelines. Land and communities. Version 1.0. April 2005. wbcsd@earthprint.com. 52p.

4.4 Soil and protection of soil

The development of vegetation, i.e. sowing and planting in the after-use phase, requires adequate soil as a basis. If there is no suitable soil available on location in the beginning of the restoration workings, soil will be quite a substantial expense factor in the after-use planning. Therefore it is imperative to store the soil in order to reduce costs considerably.

➜ Principle: No soil leaves the quarry area, which may be used or needed in the future.

Protection of soil has top priority

The utilisation of the soil after the cessation of quarrying requires careful and professional treatment to make sure the soil is usable in the future.

The volume of topsoil and subsoil consists of about 50 % voids (pores) and 50 % solid materials. If the soil is compressed, it loses its ability to absorb and store water as well as to provide vitally important oxygen for soil microorganisms and roots. Compressed soil is not useable for after-use any more as figure 14 shows. The sensitive loess got compressed here because it was removed in wet weather. On top of this, it was exposed to drizzle over several weeks, with the wrong kinds of drainage. Even after deep scarifying twice, the maize is a lot harder to grow on this area. The area will not recover for several years.

Such compressions of soil cause additional costs for the after-use, although they can be avoided by following these rules:

- The mechanical load should be kept as low as possible when removing and reapplying soil.
- Dry soil can bear loads better and is more resistant. The topsoil and the subsoil should therefore always be dry enough (Figure 15).
- Employing soil-conserving machinery and methods avoids long-term damage. Only machines with little gross weight and low surface pressure should be deployed. Tracked vehicles such as bulldozers are suitable.
- No vehicles with wheels should ever be used on the soil (Figure 16).
- Earthwork should only be carried out in as few work steps as possible. Therefore soil layers have to be removed in one work step at a time.

Soil

Soil is the topmost, unsealed, animate border zone of the earth's surface. It consists of humus topsoil (up to a thickness of 0.5 m), densely pervaded by roots and the weathered subsoil (predominantly 0.3-2 m thick), not densely pervaded by roots. It is a transformation product, made of stone, dead plants and animals, water and air. Soil is living space for fungi, algae and plants and consequentially for animals and human beings.

Figure 14: Compressed soil results in bad crop yields


Figure 15: The humidity of this loess is ideal – the topsoil is loose and not compressed by handling


Figure 16: Strong compression through heavy lorry traffic


Figure 17: The soil material can barely be separated any more

- No mixing with any materials that are allochthonous (i.e. alien materials such as gravel, pebbles, refuse). Too high a percentage of stones in the soil leads to poor growth in the after-use.
- Planting protects the soil. Soil with plants on top and many roots under the surface dries quicker and is much more resistant.

Soil management

The long-term protection of the soil for after-use requires careful planning on the extraction site. The following questions need to be answered before extraction and work begin:

- Is the soil utilisable? Of which quality is it? Professional consultants may help with the assessment, which may also determine the possibilities for later after-use.
- Is the material at hand suitable for an agricultural after-use or not?
- Can the area be used as a commercial forest?
- Or does the nutrient-deficient shallow quality of the soil only allow nature protection as after-use?
- How much topsoil and subsoil is there? The estimated and selectively measured thickness of the layers is the basis for calculating the resulting bulk and amounts.
- What amounts of topsoil and subsoil are required? The kind of after-use projected and the subsequent demands determine the total demand for topsoil and subsoil. These amounts have to be stored for a transitional period.

Transitional storage

- The soil bulk needs enough space for the transitional storage. It should be moved as little as possible. Thus, sufficient storage space needs to be included in the planning.

- Topsoil and subsoil must be stored separately and not get mixed up. They should be stored in different places at best and protected against vehicles passing over by blocks of stone. Storage spaces, in which e. g. black earth, loess and subsoil are barely distinguishable heaps, cannot be the basis of a professional and qualified after-use (Figure 17).
- The animate topsoil must not be stored any higher than 2 m, since it would suffer long-term damage otherwise. Subsoil may be stored up to 4 m high, but it should not be compressed. The storage space can be set up along the edge of the extraction site (Figure 18) or dumped flat on suitable ground (Figure 20).
- To protect the store grounds from wetness they have to have flat surfaces and steep slopes (Figure 19). Drainage of the storage space is essential in order to prevent the soil from damage through water-logging. The storage space ought to be on a slightly inclined slope, never in a hollow.
- The storage space must not be passed over. Passing over stored heaps leads to compression of the soil underneath. The effects can be seen in the bad growth of field crops in the aftermath (Figure 21).
- At an ideal point in time the heaps are sown loosely or allowed to develop vegetation independently. Vegetated soil is less prone to erosion, whether caused by wind or water. If the topsoil and the subsoil heaps are settled by wild species, they can be classified as wanderbiotopes (Figure 22).
- Topsoil heaps and excavation ground dumps should not be located near waterbodies because they could wash away components that are nutrient-rich or rich in humus. This kind of erosion

Figure 18: Stone mill for the preparation of soil

Figure 19: Freshly smoothened, oblong soil heap in typical trapezium shape

Figure 20: Spacious soil heap with young plant cover


Figure 21: Loss of crop yields through only little usage of lorries on the soil heap. The soil underneath got compressed


Figure 22: Independently vegetated soil heap about 6 months after tipping


Figure 23: Light bulldozer at a recultivation of loess fields

would also result in an accumulation of nutrients in otherwise nutrient-deficient waterbodies. This would lead to rapid growth in these waterbodies and decrease the biological diversity in them.

Restoration measures

The soil can only be processed when the weather is fine. The soil must neither be too dry nor clumped together, neither too wet nor sludgy. All this would ruin the soil structure in the long run and lead to considerable losses in earnings in a commercial after-use. Should there be any doubt, professional soil specialists need to be consulted on location. They can assist in questions of soil protection and clashes.

When preparing the location, you should proceed as follows:

- The area needs to be prepared with unpolluted excavation material. Then apply the subsoil between 0.3 m and 2.0 m in thickness. There should be absolutely no levelling with heavy bulldozers, as this leads to soil compression and losses in crop yield. Just tip the materials and smooth the surface slightly. Irregularities are perfectly alright, since they allow topsoil and subsoil to better interlock.
- Then apply topsoil of a thickness of between 0.05 m and 0.4 m on top of the subsoil (Figure 23). Vegetation will take place immediately afterwards.
- The new areas should be used extensively for the first 2-3 years to allow the soil structures to stabilise. After that they may be used as regular agricultural farmland.
- There should be absolutely no passing over those new areas. The quarrying traffic must stick to the already existing roads and alignments.

4.5 Commercially used forests

4.5.1 Habitats worldwide

Commercially used forests can and should only be planted in climatic zones, which allow for tree growth on a larger scale. Depending on the climatic zones of the earth there are the following forest types spread worldwide: deciduous forests in the temperate zones, laurel forests, sclerophyllic forests in the winter-rain zone, taiga with deciduous and coniferous forests, rain forests and dry forests.

4.5.2 General characteristics

Commercial forests are marked-off areas on which trees grow. They are cultivated and used for the withdrawal of timber in regular turns. The main purpose of this kind of forest management is the realisation of profits.

These large tree populations are characterised by withdrawal of timber, elimination of unwanted species and harvesting by machinery. Most of them were planted at the same time, frequently with high-yield but non-autochthonous species. The age of the trees is roughly the same (Figure 24), leading to a mosaic of different age-group forests with little structural variety. The deciduous trees are only allowed a little time until they get cut down – giant trees appear very rarely or hardly at all.

The tree plantations are arranged in rows, which are still visible after decades. Tree upgrowth and shrub layer are normally removed from young plantations in order to prevent losses in earnings through biological competition during the years in which the young trees grow most rapidly. The timber is brought in by clear-felling large areas, which are then reforested anew.

For a long time, the objective has been a management in the form of monocultures. In the last few decades a more considerate forestry has developed, still employing machinery but working on a much smaller scale and preferring deciduous forests with autochthonous tree species well adapted to the soil conditions and the climate. These trees are also less vulnerable to pests. This kind of forestry allows natural regeneration and puts an emphasis on the timber quality, not only on the amount of timber derived.

Sustainable forestry

Sustainable management of forests limits their commercial utilisation. The emphasis clearly lies on biological diversity and the vitality of the forest stands. Productivity and regenerative potential remain important benchmark figures of sustainable forestry however, in which large-scale implementation of biocides is beyond all question in order to protect beneficial organisms.

Forests are to take over important ecological, economic and social functions on local, national and global level at present and in the future – without harming other ecosystems.

Figure 24: Mixed forest with trees all the same age

4.5.3 Significance for biodiversity

Even forests with a low diversity of tree species may host rare animals and plants. In most cases however, they only provide good habitat conditions to a few specialists for some years. Their diversity in species and structures is far from reaching that of a near-natural or primeval forest.

The further a forest develops away from intensely managed cultures with only one or a few tree species (Figure 26) in dense stands, and the more differentiated the tree-species and their ages, and the more vegetation layers there are in a forest, the higher its diversity in species and structures and the higher its value for biological diversity.

4.5.4 Value-defining habitat structures and their qualities

Recently thinned areas and dense plantations have almost no ecological significance. If there are however old trees, if deadwood remains untouched and the periods between thinnings are long, the ecological value rises. This encompasses a high share of spontaneously upgrowing tree and shrub species or a pronounced forest skirt with varied shrub species and a broad fringe of herbs and grasses.

4.5.5 Protection and promotion of biodiversity

The biodiversity of such areas can even be raised by commercially oriented forestry through sowing, establishing endemic species, enhancing the diversity of structures and through protecting and preserving some older trees. Noticeable economic losses are not necessarily involved. The felling of trees should be restricted to comparatively small areas in a mosaic way, large clear-fellings need to be avoided.

4.5.6 Proceeding

Topographical features

The final configuration of the extraction site must be included in the renaturation planning, especially when it comes to yields because all forests in the temperate and cold zones are frost-susceptible and in warmer areas susceptible to drought. A water runoff should however be granted and cold airstreams need to be directed. Partial backfilling

Figure 25: Monoculture with spruce after thinning

Figure 26: Beech tree succession in a clear-felling

makes it possible to shape a suitable basic form, which helps to avoid the above mentioned dangers to a large extent.

The following preconditions need to be fulfilled:

- Flat to slightly inclined areas are suitable. They tolerate forest management with machines. The areas also need to have access roads. Large-scale slopes should have a proportion of 1:3 (height : width) or even planer than that.
- Steep areas only have some value if they provide economically interesting tree-species or if only small parts are steep.

Preparation of the areas

Trees generally need:

- a deeply rooted soil layer of 1-2 m,
- with good water supplies,
- a high water capacity,
- good drainage without water-logging at the same time,
- a mixture of sands and gravel with a high degree of clay soil may be used.

The materials used as subsoil and as topsoil need to be processed with utmost care. Good aeration is mandatory. Figure 27 shows the opposite: a mixture of topsoil and subsoil has been applied up to ca. 0.8 m on an extremely rocky quarrying sole. The softwood trees planted there are not able to tolerate such habitat conditions. While the young trees still grow to some extent, the older ones wither.

After the area has been sufficiently prepared, the next steps are:

- If the ground is suitable, scarify compressed parts up to a depth of 0.8 m. Then apply the topsoil about 0.3 m thick.

Figure 27: Minimum requirements for tree plantations are not fulfilled

Figure 28: Two year old forest recultivation of a dry slope forest

Figure 29: Young pine succession on a spoil dump. Barely suitable conifer types all of the same age grow in the foreground

- If the ground is not suitable, apply a 2 m tick layer of subsoil in one work step. Do not compress it.
- Next, apply the topsoil to a thickness of about 0.3 m. You may use topsoil stemming from the forests that have only recently been cleared. It already contains the regionally typical seed and thus vegetates faster.
- Afterwards, the new soil is now sown with a mixture of agricultural green manure species or autochthonous annual or perennial species. The resulting vegetation will benefit the development of the young soil by shading, aerating and invigorating it.

Choice and introduction of tree-species

A commercial forest can be developed in three different ways:

- by natural succession,
- by sowing,
- by planting.

Free succession will be the most improbable start restoring commercial forests, since commercial forestry focuses on yield. The controlled introduction of desirable tree species can thus only be realised on a long-term basis.

From an economic perspective, even sowing is rather incalculable when it comes to controlling the development of the future commercial forest. Sowing on forest areas, which have an unfavourable climate may nevertheless prove to be the most important method and lead to the designated results. It may well be the only way to grow trees perfectly adapted to the climate.

Planting forests is therefore the most frequently used method of reforestation (Figure 28). Reforestation of technically recultivated soil means planting only robust and easily growing species. In order to protect the plantations, quickly growing tree species should be planted as windbreak and shelter-belt as well as for the positive effects of the shade they provide.

- Wherever forests have been planted and established, the development of pioneer forests has proven most useful.

The fast-growing pioneer tree species with a high light demand have a positive effect on soil development because they develop dense root systems, produce beneficial humus and activate micro-organisms. The resulting climate of the stands is advantageous for the development of target forest types (it lowers high temperature amplitudes, increases humidity and shades the target forest seedlings).

A forest which is reasonably useful from an economic point of view can only develop where the macroclimate allows it. Reforestations in climatic steppe areas for instance can only be achieved at high financial expenditure, which is not reasonable at all.

Yet, the position of the future forest areas in the extraction sites and the resulting microclimate have to be taken into account as well. The species which grow on sunny dumps and slope-edges are different from those growing in planes, on shadowy slopes and dumps with sufficient supply of water. Species-rich deciduous forest can even be developed on coarse spoil dumps and block fields with permeable substrate below rock faces. They are similar to the block fields in mountain areas.

A staged forest edge made up of shrub and tree species always needs to be established at the forest skirts. It constitutes a near-natural transition zone to the surrounding open spaces. When choosing the tree species, the regionally typical sustainable

forestry has to be considered and consulted (Figure 30).
The tree species are to be planted in the regionally specific way onto the designated areas. The soil surfaces not yet vegetated are to be sown loosely in order to prevent soil erosion.
A recultivation of a forest should be at least 20 to 30 m away from the foot of rock faces and rocks.

Maintenance
The areas are to be incorporated into the regionally specific kind of sustainable utilisation after the plantation has been accomplished.
It is essential however to reach a high degree of structural diversity, which is typical for natural forests. Nowadays, this is one of the central features of modern sustainable forestry. Large clear-fellings have to be avoided. Instead, biodiversity is being promoted through withdrawal of single tree trunks, leaving deadwood and structured forest mantles.

4.5.7 Summary

- Commercial forests have quite some importance for specialised animal and plant species because in most cases the wood stands are rather extensive and remain undisturbed over several years.
- If all woody species are to grow at an adequate rate, 1-2 m of loose, uncompressed subsoil or forest gravel needs to be applied or the existing soil needs to be deeply scarified. Then 0.3-0.4 m topsoil is to be applied.
- Autochthonous woody species should be reforested in mixed stands in order to promote biodiversity. Such mixed forests are less prone to damage than monocultures with only one tree species.
- Harvesting the timber needs to be done on a small-scale, resulting in a vegetation mosaic. Such changes in structure create a species-rich biocoenosis.
- Sustainable forestry takes priority over a forest management only concentrating on high yields.

4.6 Natural forests, forests with low level use and pioneer forests

4.6.1 Habitats worldwide

We already introduced the distribution of natural forest areas in the previous chapter. Even natural forests and forests with low level use can and should only be planted in climatic zones, which allow for tree growth or the growth of small woods to a larger extent.
The ecosystems worldwide do not fundamentally differ in their demands when compared to commercially used forests.

4.6.2 General characteristics

Each mineral extraction site within the forest belts in the temperate zone of the tropics and the subtropics shows spontaneous growth of forests on unused areas (Figure 30, Figure 31). The species growing here are well adapted to the climate and soil conditions. They are successful in crowding out woody plants with less competitive ability. The forest stands are first patchy with an undergrowth of grasses and herbs rich in species. Such early colonisers need much light. Most of them belong to the smaller tree species. The shade-tolerant forest trees succeed in their shade as the canopy gradually closes. They form the final species composition of the natural forest with its typical structure made up of several layers of trees, shrubs and herbs. If wood is only withdrawn on a small scale, we speak of near-natural forests.

4.6.3 Significance for biodiversity

Pioneer forests display a great variety of structures, especially of animal species. Invertebrate animals such as beetles quickly colonise all existing ecological niches. The vertebrates follow their food basis.

- This phase in the development of forests must be included in planning in order to take advantage of the positive effects of dynamic development processes on biological diversity.

Natural forests and primeval forests

Natural forests: The basis for the small-sized, but often famous natural forests of industrialised countries such as the Rothwald in the lime alps of Lower Austria or the woodland complex of Bialowieza in North-Eastern Poland often display long standing traditions of utilisation as hunting forests for the feudal lords, which ruled out other kinds of utilisation e. g. as woodland pastures or forests used for logging at least for some time. These forests come closest to the primeval forests without human utilisation, which were prevalent all over the world in the past. Most of them were however utilised forests several centuries ago.

Primeval forests: Primeval forests are forests which have undergone no or only little interference by humans. They have developed according to the abiotic conditions (climate, soil, water, insulation). Such primeval forests are very rare in Europe (the Dinaric Alps forests, the Carpathians, the Mediterranean Orjen mountains and forests at the edge of the Scandinavian Mountain ridge). The largest primeval forests can be found in Siberia and Canada, in tropical primeval forests in the Amazonas delta, in the Congo delta and in South-East Asia.

All in all, the targeted forests are poorer in species than their earlier stages. There are however many animal and plant species, which require forests and especially old trees. These species have less and less chance to survive in man-made landscapes or commercially used forests.

- The goal in a natural forest is to preserve the natural processes, such as clearings arising as a result of old trees falling down (Figure 32), wind breakage areas and various age stages in confined spaces in order to grant the specialists among the animals and plants adequate habitats.

Figure 30: Independently grown small wood at the foot of a hillside on a lime slope

4.6.4 Value-defining habitat structures and their qualities

Natural forests have special significance for biodiversity. This is particularly the case if the soil conditions are not uniform, if there is sufficient humidity and the projected areas are rather large. The larger a forest area, the more stable the composition of species. Areas with special structures such as stone tips and rocks increase the qualities of the natural wood habitats significantly (Figure 33). The high degree of structural diversity characteristic for natural forests is increasingly transferred to modern forestry. Thus, sustainable forestry avoids large clear-fellings and promotes biodiversity through withdrawal of single tree trunks, leaving deadwood and structured forest mantles. Damage, as for instance pest attack, can be reduced through ecological management, which also increases the economic yield.

Figure 31: Grove succession on lime rubble protosoil

4.6.5 Protection and promotion of biodiversity

Natural forests should be exempted from commercial utilisation and entirely left to natural development.

Figure 32: Clearing with woody litter and young wood

4.6.6 Proceeding

Topographical features
The final configuration of the forests must be included in renaturation planning because all forests in temperate and cold zones are frost-susceptible and in warmer areas susceptible to drought. Partial backfilling makes it possible to shape the suitable basic form, which helps to avoid the above mentioned dangers to a large extent.

Suitable areas
Flat to steeply inclined areas in inaccessible parts of the former mineral extraction site are suitable.

Preparation of the areas
Trees need a cropped soil layer of between 1 and 2 m with good water supply, high water capacity and good drainage without risk of water-logging at the same time. Stony ground may prove difficult for planting, but it can be sowed after application of topsoil. If a slower progress is required, the soil needs to be applied more shallowly. Such areas are suitable for free succession.

After the area is prepared, the protosoil – pebbly or with few stones and with a sufficient proportion of fine earth – is left unchanged or covered with topsoil of up to 0.3 m in thickness, if desired. The areas have to be sowed or planted immediately after the preparation of the protosoil.

Introduction of the species
A natural forest can come into existence in three different ways:

- by planting,
- by sowing,
- by natural succession.

Planting: A natural forest can be planted if the subsoil only contains few stones. The choice of species depends on the targeted forest. The procedure is the same as in a forest restoration for commercial use. The yield is of no importance when choosing the tree species. Planting of dense rows as in typical forest plantations should, however, be avoided in favour of near-naturally defined partial areas. Development via pioneer forests has proven most efficient.

Figure 33: Stone setting to increase structures in a young hardwood forest

Sowing: The economic value of sown areas is unclear from a commercial point of view, since it is hard to predict their development over many decades. In natural forests economic aspects are of less importance.
In particular in locations which are not suitable for planting target tree species from a soil and water management point of view, reforestation can be initiated through sowing shrubs at no great expenditure.
A tree and shrub mixture of seed is sown in the protosoil or the areas covered by soil. In most cases this will have to be done by hand, in plane areas machinery may be used.

- Between 80 and 100 kilograms of seed should be used per hectare, since shrubs with light as well as ones with heavy fruit are to be sown.
- If necessary, the seed will be prepared, i.e. stratified. If the sowing is to be carried out in spring, the seed needs to be prepared, i.e. stratified in order to receive better germination rates.
- The percentage of rapidly growing shrubs should be small, since they are extremely competitive. Large fruits such as those of oak or beech trees are to be dug into the upper layers of the substrate.
- Solitary trees of the umbraticole species can be planted into the stand in order to help the target tree species (e.g. beech trees) grow.

Free succession: For a free succession the areas need to be protected from use by vehicles or pedestrians to allow natural reforestation. The existence of tree species in the surroundings is a prerequisite for they provide the designated seeds. It is advantageous that the reforestation proceeds very slowly in this way, but enables many diverse and species-rich

Stratification

In biology we call the treatment of seed which stimulates it to germinate more easily stratification. It increases the natural germination rate in less time. Almost all kinds of seed ripen at the parent plant in a dormancy of seeds. The dormancy has to be outlasted before germination because it protects the plant from germinating within the fruit. Certain environmental conditions also need to be fulfilled before the seed can germinate: a certain humidity and temperature or even predigestion in animal organisms if the seed coats are extremely hard. This avoids germination at an inopportune time, such as in the beginning of winter or after too short periods of rain in arid regions. Stratification is the artificial subjection to natural-like conditions.


Figure 34: Near-natural light alluvial forest

habitats to develop. If there is no time pressure, at least some part of the natural forest areas should be left to develop in free succession.
When planting natural forests, free succession of smaller areas should always be taken into consideration, even if planting or sowing is the prevalent method used. Planted areas will only cover the smallest part of the future natural forests.

Choice of tree species
There are similar preconditions for planting and sowing. It is imperative to observe the following rules:
- Robust types of preliminary forest need to be chosen.
- Light-demanding tree species as well as half shade-demanding tree species should be used.
- Shrub species need to be integrated.
- These shrub species need to be sown at the edges of the forests.

The position and exposition, the water supplies and the substratum determine the possible tree species of these forest areas. Dry forests, mixed hardwood forests, boreal softwood forests and alluvial forests (Figure 34) can be started and developed in a regionally characteristic way.

Maintenance of habitats
- No or almost no cultivation measures should be carried out in a natural forest.
- In the first few years, planted natural forests should be mown between the trees, but then left completely to free succession.
- If there is a high density of game, the very young areas need to be protected against browsing.

4.6.7 Summary
- Natural forests are species-rich at every stage. Its species mixture is balanced and extremely complex. The older these habitats get, the more forest specialists conquer their own habitats.
- Biodiversity benefits from natural processes such as wind throw or lightning stroke, since they enable vegetation mosaics to develop. Species living in deadwood and decomposing it benefit the most.
- If all woody species are to grow at an adequate rate from the start, between 1 and 2 m of loose, uncompressed subsoil or forest gravel needs to be applied or the existing soil needs to be scarified deeply. Then 0.3-0.4 m of topsoil needs to be applied. Shallow soil only allows slow growth.
- Initialisation requires sowing autochthonous, but also rare tree and shrub species.
- Parts of the areas will be left to free succession. Natural forests should only be planted in exceptional cases.
- Extensive use is possible. In the beginning, cultivation measures may be necessary. If there is a lot of game, protection of young trees is imperative.

4.7 Shrubs and groves

4.7.1 Habitats worldwide

Shrubs and groves consisting of bushes, low-height trees or field trees grow in areas outside the forest belts of the earth. They can be established even in the dry regions of the earth, in extensive savannahs, subtropical grasslands or steppes as small-scale plantations, if enough protection and favourable water conditions are available. As a matter of course they can also be established in the climate zones mentioned in the previous chapters.
Shrubs and groves are typical elements of old widespread forms of land use. They either indicate dynamic succession processes in the ecosystem (reforestations) or they are final stages, if the climatic or edaphic conditions do not allow for tree growth (as in the African thornbush savannah or the subpolar tundra).

4.7.2 General characteristics

The term grove habitat sums up hedges, shrubs, field trees, lines of trees. They were planted in the open landscape or grew spontaneously. The bordering users tolerated them or even made use of them. Examples are shelter-belt plantations between fields as well as bush fruit hedges and orchards or pollard trees of the rural agricultural landscape.
If a climate becomes increasingly unfavourable for the development of forests, only small shrubs will grow on micro-climatic advantageous areas. They will however grow extremely slowly on the extensive grassland or tundra.
Shrubs and field trees function as a disaggregation and rearrangement of the scenery within man-made landscape. They are important for the compound of habitats as well as for the protection of the species and the habitats. Grove habitats can also serve as erosion control. Such areas can be designed first of all in after-use planning and then successfully implemented as a screen and/or a device for navigating human beings through the landscape.

Shrubs and groves

A **hedge** is a kind of upright young wood (uniserial or multi-serial). The shrubs or bushes stand closely and densely together and are branchy. Hedges can frequently be found as protective plantation or emerge through the abandonment of field boundary or rock edges between agricultural areas. They serve as foliage food and as bush fruit areas.

Shrubs are irregular areas grown with bushes. They can be found in agricultural landscapes and have developed through a low degree of utilisation or through abandonment of single small lots of land.

Copse are typical small woods in between agricultural areas. In most cases they have developed long ago out of woods used as Christmas tree plantations, tree nurseries, orchards or gardens.

Field trees and lines of trees are also old elements of traditional man-made landscapes. They used to shade paths, served as resting places for animals and human beings. As pasture trees they protected cattle, as large outstanding deciduous trees they marked intersections and communal or district borders.


Figure 35: Bush-fruit hedge as the border of a meadow


Figure 36: Pasture landscape in Georgia

Significance for biodiversity

Grove habitats within an agricultural landscape or large open wood-free areas increase biodiversity significantly (Figure 35). Many rare species such as butterflies and birds need groves as safe nesting sites, while predators among the mammals need them as a raised hide where they can lie in ambush. The fruits of the bushes are important food for many species. Grasses and herbs found at the edges and in the undergrowth are home to many insects, which are again food for other animals. Even small-scale grove habitats thus feature high numbers of species.

4.7.3 Value-defining habitat structures and their qualities

When developing a grove habitat, the emphasis should always be on woods which are rather rare in the surrounding landscape. In temperate zones these are thorny scrubs of the sun-exposed dry and warm hillsides, whereas shaded places at the foot of rocks are preferable in dry areas. Autochthonous species which occur in comparable places in comparable kinds of use should always be preferred when planting or sowing.

4.7.4 Protection and promotion of biodiversity

Only autochthonous woody plants and typical rural shrub and orchard trees, which need very little care should be planted.

Low-growing shrubs especially benefit from rejuventation pruning to be conducted from time to time every 5-25 years, depending on the growth. The grove edges should be guaranteed enough distance from the next farmland or effective area (fields or paths), in order to secure the designated diversity of species. These edges may be mown every 1-2 years or grazed briefly to keep them from growing too fast (Figure 36).

4.7.5 Proceeding

Topographical features

The grove habitats occur in open country and frequently demarcate different types of use. Gaps or elevations in the relief can be safeguarded by hedges or groves.
Similar preconditions as those for forests are to be regarded, generally, although most of the shrub species are not as susceptible to drought or frost as forest trees.

Suitable areas

Plane to steeply inclined areas are suitable even in parts of the former extraction site.

Preparation of the areas

As long as the groves are located in free succession areas, those areas should be prepared according to the method described in the paragraphs on forest restoration and sowing forests (cf. forests, natural forests).
If the area is sufficiently prepared, the protosoil (which is stony or contains only few stones) will need to be mixed with fines, left as it is if desired, or covered by topsoil of up to 0.3 m in thickness. The areas will need to be sown or planted immediately afterwards.
If the groves stand on agricultural grounds, the whole area will need to be prepared according to the demands of agriculture (cf. meadows/fields). The shrubs are then planted in this ideal soil. The same applies to field trees and lines of trees.

Introduction of the species

Grove habitats are populated by the typical autochthonous species and light-demanding tree species.

- The area may be sown or planted, depending on the underground.
- Already existing woody plant individuals, that have grown independently, need to be integrated (Figure 37).
- The edge of the grove is to be planted completely in order to protect the area.

Bush fruit or wild fruit

Bush fruit or **wild fruit** are trees or shrubs of various plant families, which produce edible berries, fruits, nuts or leaves. These plants have never been used much by mankind and have only rarely been cultivated. In the temperate zones they are for instance: *Amelanchier*, *Berberis*, *Castanea*, *Cornus mas*, *Crataegus*, *Cydonia*, *Hippophaë*, *Mespilus*, *Prunus*, *Rosa* and *Rubus*.

Genera only autochthonous to the tropics and subtropics are for instance: *Adansonia*, *Tamarindus*, *Grewia*, *Ziziphus, Annona*, *Aegle* or *Choerospondias*.

Figure 37: Spontaneous grove upgrowth on an artificial slope. Such areas may be integrated into the detailed planning

- The inner area is sown. Narrow hedges should be planted. Sowing the area is only possible if it is covered by chunky clippings or thorny branches. Only in this way can the seed develop undisturbed.

The goal is a varied species mixture of the wild species used with many different blossoms, fruits and growth types. This provides the settling animals a habitat with diverse food sources.
In agricultural landscapes fruit-trees and bush fruit scrubs need to be integrated into the species list. They may be harvested by both man and animals. Wild fruit species are also an interesting option for the after-use. They have qualities such as robustness, little need of care, commercial usability in combination with natural growth forms. Most wild fruit species are an important food source for many insect species during bloom. They offer protection and nesting sites for many birds. These habitats also promote faunistic biodiversity. When choosing the species, the traditionally used wild fruit species need to be picked.
Species with large blossoms or many blossoms are especially suitable for agriculturally effective groves. All others should produce blossoms or fruit for as long a period each year as possible in order to provide a broad source of food for many animals.

Maintenance of habitats

- Hedges and shrubs need to be cut back every 5-25 years, in order to preserve their dense, comparatively low-growing shape.
- Groves should always be surrounded by a ring of hedge plants protecting the trees in the middle. These species as well as the groves must not be cut or trimmed.
- In the case of field trees and lines of trees, the planted species determine the maintenance efforts: fruit trees require regular pruning, typical alley trees must not endanger traffic. Here, it is best to go by the general standards for the tree types.

4.7.6 Summary

- Grove habitats in agriculture are species-rich, serve as strip corridor along which animals and plants migrate and host many useful animals. Each planning ought to devise such grove habitats right from the beginning.
- Even small areas can be highly effective retreat areas, as they provide high structural diversity and long edge lines. Their positive effect on biodiversity is substantial. This kind of habitat is used intensely by wildlife throughout the whole year.
- If all woody species are to grow at an adequate rate from the start, between 1 and 2 m of loose, uncompressed subsoil or forest gravel needs to be applied or the existing soil needs to be deeply scarified. Then 0.3-0.4 m of topsoil needs to be applied.
- Hedges and groves need to be planted. This can be done at random to allow spontaneous settlings of other woody plants. Sown areas need to be protected from trespassing or passing over through clippings and branches.
- Grove habitats normally remain unused. Hedges and field trees need to be trimmed occasionally if required.

4.8 Grassland

4.8.1 Habitats worldwide

Open landscapes covered with grasses occur in all climate zones. They cover about a fifth of the mainland, which is quite a substantial part of the earth's surface. The tropical summer-rain regions (savannahs) and the steppes and prairies of temperate zones with cold winters display the largest grassland areas. Nowadays there are only a few remains of near-natural grasslands left. The original grasslands are used as agricultural farmland or have been destroyed by overuse.

Typical near-natural grasslands are prairie, tussock grasslands, tropical (Figure 38) and neotropical savannahs including the Llanos plains of Venezuela, the Gran Chaco of Argentina and Brazil and the Argentinian Pampa. The steppes of South America as well as the steppes in Eastern Europe and Northern Asia belong to the grasslands. The most extreme of the grassland habitats are the subpolar grassland zones and grass tundra.

4.8.2 General characteristics

Grassland is a habitat characterised by grasses, free of woody plants or with only sparse woody plants. Meadows and pastures are grasslands, just like the large natural grasslands.

Human intervention in the forest regions of the earth are the most significant reason for the formation of grasslands. Mankind has created huge new growing areas through livestock farming (i.e. cattle breeding). Within the forest belts man cut forests down and transformed this land into pastures. Man-made grasslands are alpine pastures, hay-meadows which are mown at regular intervals, pastures, forest-meadows, heat hand orchards (Figure 40). On those grasslands a variety of turf and meadow communities, consisting of various, often specialised grasses and herbs grow.

Water and lack of warmth promote open grasslands as much as flooding. Herds of wild animals repress woody plants. Meagre, shallow soils or regular fires provide an advantage to grasses over the not so drought-resistant woody plants (Figure 39).

4.8.3 Significance for biodiversity

Grasslands are home to manifold herbaceous plant species, whose floweriness attracts and nourishes insects. This combination of grasses and herbs is

Figure 38: African savannah landscape in the Namibia Highlands

Figure 39: Grassland in arid regions


Figure 40: Alpine meadow in the central European Alps


Figure 41: Bioturbation in black earth (Ukraine). Light and dark soil material was shifted by rodents. This has resulted in striking patches


Figure 42: Meagre grassland on top of a hill (Georgia)

especially significant for biological diversity where growth conditions are wet to moist or rather dry because these types of habitats are becoming increasingly rare in man-made landscape, due to intensification of utilisation, drainage or abandonment of utilisation. Numerous rare animal and plant species depend on these open types of vegetation and form highly complex and interference-prone relationship networks (Figure 41).

4.8.4 Value-defining habitat structures and their qualities

Species-rich grasslands only appear to be monotonous. They possess a close mosaic of spare vegetated and dense vegetated spots. They are between dry and moist to water-logged. Shallow soils and extreme soil parameters promote the specialists of flora and fauna.
Grasslands with nature conservation value are species-rich and cover large areas (preferably over 20 ha) or lie in mosaic shape on soil types not very suitable for agriculture (Figure 42) embedded in the agrarian landscape.

4.8.5 Protection and promotion of biodiversity

The control of mowing to the point of extensive utilisation including targeted and ecologically compatible fertilisation is essential.

- The areas should not be mown too often and not too early.

Grassland

This type of landscape and vegetation consists of vegetation cover of grasses and herbs which is more or less completely closed. Trees and shrubs are missing or are very infrequent.

Figure 43: Hay making with machines

Figure 44: Large-scale grassland restoration in an operating extraction site

- Rotational grazing should be preferred to all-year grazing.
- No fertilisation as a rule. If fertiliser is used, it is mandatory to use as little as possible and only after an analysis of the nutrient constituents present.
- Seasonal flooding is useful, as long as it allows utilisation to be kept up. Drainage trenches should be avoided.

Undulating forms are the first step when projecting grassland habitats to initiate this vegetation mosaic. In this way a species-rich, diversely flowering grassland habitat is created instead of monoculture grassland. Exempted are however the desirable and typical one-species grassland stands as made up of reed or bamboo.

4.8.6 Proceeding

Topographical features

The topographical features of the future grassland area have to be adapted to the regionally specific characteristics of the commercial meadows.
This means, for instance, that whether a good drainage or an irrigation system is necessary has to be clarified. Meadow areas can be established at quarrying level as well as on the backfilled or partially backfilled slopes. Knoll locations are also possible. Continuous shade as well as hollows with no water outlets are inappropriate. If machinery is used in farming, the fact that the habitat is trafficable (Figure 43) has to be ensured.

Suitable areas

The areas for hay meadows should be predominantly flat or slightly inclined. This has to be taken into account at the point of initial levelling. If steeper fall off ground has to be overcome, terracing with road and path network needs to be included into the planning. Pastures with characteristics of dry meadows may also be established on steeper slopes. It is essential however that the regionally specific vegetation elements be found in the extraction site as well.

Preparation of the areas

Agricultural utilisation of grasslands on after-use areas requires professional soil restoration in order to secure the yield hoped for. All areas need be machinable and easily accessible.

- Make sure that the weather is fine when you start the work (Figure 44).
- Make sure the underground is suitable. After the area has been prepared, scarify compressed areas to a depth of 0.8 m and then apply topsoil of 0.3 m in thickness.
- If the underground is not suitable, scarify it superficially. Then tip a 1-2 m subsoil layer on the area. Further compression is not necessary. Afterwards apply topsoil of about 0.3 m in thickness with light equipment – without compressing it.

Introduction of the species

The areas are to be sown with the designated grass and herb mixtures directly after finishing the application of soil. Prepared seeds can be used as well as freshly mown grass from sufficiently mature meadows and heath lands. Both kinds of establishing are efficient and quickly produce the designated vegetation types. The following points have to be taken into consideration:

- In the case of meadows which are predominantly grown for their agricultural yield, the usual commercial seed should be used – but it should be guaranteed that it is species-rich,


Figure 45: Sowing of a meadow by distribution of cut grass on shallow soil


Figure 46: Species-rich hay meadow before the first mowing


Figure 47: Meagre hay meadow in Central Europe

contains endemic species and that it is sown professionally.

- Meagre meadow areas can be covered by freshly mown grass, cut in mature grasslands, loaded up and spread on the new area immediately afterwards. This ensures that the most important species of the proximate surroundings get planted on the new areas. The development of these stands will then take a targeted course (Figure 45).

Maintenance of habitats

The grassland is to be integrated into utilisation after ca. 1-3 years. The utilisation needs to promote biodiversity as well. In areas with a high density of game their browsing alone may be enough to preserve the grassland stands. The areas should be used extensively as hay meadows or maybe as pastures. An intensive utilisation should always be an exemption (Figure 46, Figure 47). In the steppe and savannah zones of the earth the grasslands may only provide ecological after-use. In this case they have to be left alone.

4.8.7 Summary

- Grasslands as main habitats or as slim stripes within groves are species-rich and floriferous. They are inhabited by many animal species, scoured for food or used by human beings.
- Biodiversity is extremely high in such areas – unless they are used intensely. Specialised species form complex communities there.
- At least 1 m of subsoil and 0.3-0.4 m of topsoil serve as the underground for sowing.
- Either agricultural grassland with endemic
- species is sown directly or freshly mown grass from the surroundings is used as seed provider, depending on the kind of after-use.

- At least a part of the areas should remain species-rich. Therefore utilisation within the natural forest zones may only be extensive. Within the natural grassland zones some parts should remain completely unused.

4.9 Fields

4.9.1 Habitats worldwide

Field areas have been shaping the face of the earth for thousands of years. The earth's climate zones are as varied as the cultivated lands of agriculture. The corn growing in the Great Plains of the Middle West of the USA or on the black earth from Hungary to Kazakhstan marks the landscape nowadays, where earlier on prairies and *Stipa* steppes used to be. Dryland farming produces harvests even if precipitation is low, irrigated fields yield good returns. In South Asia and Latin America landscapes are shaped by artful terracing. Currently, corn growing is being spurred on, most of all in china, the U.S. and India (Figure 48).

4.9.2 General characteristics

Fields are agriculturally used areas in which field crops are grown and whose surface gets worked regularly. Fields provide food and fodder and they are shaped and used according to agricultural management principles.

4.9.3 Significance for biodiversity

The extension of field crop farming has lead to the adaption of many plant and animal species to life in the field. Field weeds, typical field inhabiting birds and insects need to be mentioned here. Maturity of seed or breeding time and the mode of life have been adapted to agricultural utilisation so that enough offspring is procured. The fields with 1-2 harvests per year, which lie fallow for a certain time or only grow patchily are especially species-rich. The small, parcelled out, field forms with marges, shrubs, trees and hedges are also much richer in species than the huge fields worked with machines (Figure 49). The fewer herbicides are used the more species-rich the beneficial wildlife will be. The rule is: high structural diversity generates biodiversity.

Figure 48: Sprouting corn seed

4.9.4 Value-defining habitat structures and their qualities

Agricultural landscapes that are valuable ecosystems are interspersed with marges, small groves and trees. They are parcelled out in small to medium-sized subdivisions, but can still be worked with machines. Short periods of lying fallow allow for retreat areas. Fallow stripes created purposefully are ideal. Beneficial organisms rank higher than large-scale crop-spraying. It is imperative to place selective fertilisation over over-fertilisation and shallow scarification over deep ploughing. Stone cairns and stone ridges increase biological diversity at the edges of fields. This may serve as a guideline for species-rich farmland in sustainable agriculture.

4.9.5 Protection and promotion of biodiversity

Well-directed planning of terraced farmland landscapes with marges, small slopes and hedges is mandatory. The network of roads and paths needs to be designed effectively in planning, meaning the routes have to be as short as possible. Regionally specific orchards and bush fruit stripes with extensive utilisation and care are to be integrated. If they are sold or let, the land should preferably be given to farmers or agricultural production collectives working sustainably. In areas of intensive farming, biodiversity can be increased enormously by establishing fallow stripes between the fields. These steps need to be carried out right in the beginning.

4.9.6 Proceeding

Topographical features

Farmland areas can be developed at quarrying level.

Suitable areas

Professional soil restoration is a precondition of obtaining the designated yield. All areas need to be workable by machines and easily accessible. Intensive as well as extensive farming are both optional. The areas should be plane to slightly inclined. This needs to be provided during the initial levelling work. If steeper fall off ground has to be overcome, terracing with road and path network needs to be included into the planning.

Figure 49: Marge as a structural element

Sustainable agriculture

This kind of agricultural management employs methods and procedures, which maximise productivity of the soil while preserving resources at the same time. Any harmful effects on soil, water, air and biodiversity as well as on human health are minimised in this kind of agricultural management. Sustainable agriculture thus is ecologically and economically positive in its effects, it is socially responsible and forms the basis for future generations.

Preparation of the areas

Profitable farmlands require well-drained soil and deep rooting. The foundation should be 2 m of subsoil loosely tipped and containing only few stones. Shallow subsoil should be the exemption. Apply 0.3-0.4 m of topsoil on the subsoil with light equipment in order to prevent compression right from the start (Figure 50). Make sure the weather is fine when you start the work – it should neither be too dry nor too moist. Only this can grant high yields in future farming. When in doubt, consult professionals who can provide essential information and include regionally specific features.

Introduction of the species

The new farmland areas need to be sown immediately after preparing the ground. This protects the soil and helps develop the required soil structure. Undesirable herbs are suppressed all the same. Field crops can only be sown or planted after two years (Figure 51).
This kind of preparation is also ideal for peripheral structures such as marges or hedges. The areas need to be sown immediately and have to be planted at the best time of the year. Narrow fallow stripes or meadows should be sown with species-rich seed from regional meadows or with freshly mown grass from surrounding meadows after the green manuring period. It is also useful to include some food crops into the mixture.

Maintenance of habitats

Fields need to be integrated into regular utilisation. Peripheral areas and marges should only be mown at long intervals. Production of green manure is possible as long as mowing is rarely carried out.

4.9.7 Summary

- Fields provide the means of existence for mankind in the first place. A species-rich farmland scenery is nevertheless mandatory.
- Biodiversity is not very high in such areas. But even agricultural intensive crop areas still provide habitats for highly specialised animal and plant species well adapted to farming. It is imperative to support them.

Figure 50: Completed field recultivation on loess soil

Figure 51: This shows how profitable new farmlands are developed

- Farmland areas usually have 2 m of subsoil and 0.3-0.4 m of topsoil as loose ground foundation.
- The new fields are sown with green manure seed for the first two years. Then they can be used as regular farmland.
- Intermediary structures such as hedges, trees and grassland field boundaries are to be included in planning. They enhance the scenery, protect from erosion and promote biodiversity.

4.10 Flowing waters

4.10.1 Habitats worldwide

Flowing waters are part of the global water cycle and are spread all over the world. The only exceptions are the polar regions and the precipitation-free extremely arid regions. Depending on size and flow conditions they occur as springs, rivulets, brooks, rivers or streams (Figure 52). Flowing waters in extraction sites are generally runlets or rivulets.

4.10.2 General characteristics

Flowing waters are water bodies with a somewhat strong current. Flowing waters in excavation sites frequently originate in springs and seepage areas and run into other water bodies (brooks or rivers, lakes etc.).

Different kinds of biocoenosis develop according to catchment, age, size and morphology, to the amount of water, the aquatic chemism and the degree of disturbance (Figure 53).

4.10.3 Significance for biodiversity

The impact of flowing waters on biological diversity is grounded in the specific qualities of flowing water ecosystems and the accompanying specialisation of the plant and animal species living in this habitat.

Flowing water bodies form important habitats e. g. for rare or endangered dragonflies, which make use of all sections from the spring unto the brook with specialised species.

Flowing waters are also significant for biodiversity in their function as strip corridor for manifold plant and tree species.

Figure 52: Large river systems shape a landscape – and have been shaped by man

Figure 53: Dynamic mountain rivers are changing their appearance all the time

Figure 54: Tree trunks structure and enrich the course of a brook

Figure 55: Near natural flood plain

Figure 56: Near natural course of a brook with woody plants

Figure 57: Brook in a meadow after renaturation

4.10.4 Value-defining habitat structures and their qualities

The central value-defining qualities of flowing waters are the following:

- High level of diversity in water structures.
- Near natural water morphology with winding course, profiled bed with deep and shallow water areas, unspoilt riverbanks with undercut slopes, steep slopes and bordering floodplains (Figure 55).
- Varied location-specific and regionally typical mosaics of sediments with bedrock, coarse stone chippings, pebbles, sand and clay components. Other habitats here are tree trunks, root plates, lumps of rock (Figure 56).
- Possibilities for flowing waters to pass without traverse obstacles such as retaining dams.

4.10.5 Protection and promotion of biodiversity

The measures focus on the protection and promotion of biodiversity in flowing waters and concentrate on a near-natural formation with high structural diversity (Figure 55).

- All flowing water structures present need to be included in the master plan.
- The sensitive spring areas need first rate protection.
- All existing valuable animal and plant species in the extraction site or its surroundings need to be included in the planning.

4.10.6 Proceeding

Topographical features and suitable areas

Typical flowing waters run along an inclination in gulleys. Locations on slopes with variable decline are ideal. It allows for slow and quick running water sections.

Flowing waters either develop independently in extraction sites or under control or in a combination of the two. Building trenches is, for instance, a targeted measure for leading water out of the quarrying area (Figure 57).

Preparation of the areas
The goal when preparing the area is a near-natural formation of the flowing water habitat and the flow conditions. Structures already present need to be included in the water body to be created. The structural diversity of the habitats is to be increased by shallow and deep water zones and different grain size of the sediment. In order to liven up the water body dynamics, other structural elements such as rocks or tree trunks should be implemented.
When the area is sufficiently prepared, the protosoil with enough fines containing little or even many stones can be left untouched. Only if groves are to be planted, the areas in question may be covered with topsoil of up to 0.3 m in thickness.

Introduction of the species
The area of the flowing waters and its banks does not normally need planting. Plants will grow here by and by (e. g. through wind or water birds transporting seed). The goal for a flowing water habitat is a half-open area with protosoil, herbaceous vegetation and single wetland groves. Regionally specific shrub species may be planted purposefully to protect single parts of the bank areas.
Step by step an accompanying forest may be developed along the flowing waters. The tree species need to be chosen according to the regional conditions and then be planted along the flowing waters.

Maintenance of habitats
The flowing water habitats develop independently. Maintenance of the habitat is not necessary in most cases.
Larger flowing waters may be used for instance for fishing. The main objective has to be the quality of the water in any case. Fishing and recreational use are subordinate to it.

4.10.7 Summary

- Flowing waters are highly important habitats and serve as strip corridors for various plant and animal species.
- The morphological formation of near-natural flowing waters aims at a high degree of structural diversity. Good water quality and the possibility for water bodies to pass unhindered increase the biological diversity.
- Application of topsoil of up to 0.3 m in thickness is limited to the areas with grove plantations.
- The area of the flowing waters does not need planting. Typical plants will crop up here by and by.
- A forest accompanying the flowing waters can be developed by planting woody plants along the banks.
- The flowing waters are to be left to free development. Utilisation of substantial flowing waters needs to be in accordance with sustainability principles. The protection of water quality always has top priority.

4.11 Standing waters

Standing waters are habitat types frequently found in extraction sites. They can be categorised according to size into large perennial standing waters (larger than 1 ha), small perennial standing waters and temporary bodies or small standing fresh waters (smaller than 1 ha).

4.11.1 Large perennial standing waters

4.11.1.1 Habitats worldwide

Just like flowing waters, large standing waters can be found worldwide. Large perennial standing waters are usually called "lake" or "pond". They are predominantly located in flood plain landscapes (e. g. gravel-pits), next to severed mighty aquifers or in regions with high precipitation.

4.11.1.2 General characteristics

Large perennial standing waters are characterised by the morphology of their beds as well as by their aquatic chemistry.
The morphology, size and depth of the lake beds are directly related to the extraction works. The sheer number of extraction sites implies that there is a huge variety of standing waters in them. Gravel pits for instance feature other forms of standing waters than quarry lakes in limestone or granite rock. An important criterion for the future development of large perennial standing waters is their depth. Lakes can possess a characteristic depth zoning along the temperature gradient. The aquatic chemistry is in essence defined by the catchment area.
Different kinds of biocoenosis develop according to catchment, age, size and morphology, the amount of water, the aquatic chemism and the degree of interference. The dominant habitats of a lake for plants and trees are the following three:

Lake

Deep lakes possess characteristic zoning.

The free water body is called Pelagial zone. It can be subdivided into a metabolic and a catabolic zone. The metabolic zone is the layer penetrated by light where photosynthesis is still possible. The catabolic zone contains the lightless deep waters, where only decomposition and consumption are possible. The plankton (predominantly microscopically small suspended organisms) and fish live in the Pelagial zone.

The lowest zone of a lake is the Benthic zone. It is subdivided in the littoral zone and the profundal zone. The littoral zone contains the shore area of the water body with its characteristic vegetation. Groves, reeds, aquatic plants and stoneworts are found here. This zone borders the profundal zone, the plant free bottom of the lake where there is no light.

- The shores of the water body with a characteristic vegetation zoning.
- The upper layer of water penetrated by light.
- The deep water zone on the bottom of the lake.

The highest biodiversity is to be found in the shallow waters and in the littoral zone because this is where land and water habitats adjoin.

4.11.1.3 Significance for biodiversity

Standing waters are an important habitat for numerous specialised plant and animal species. They range from rare nutrient-poor waters with a species-poor vegetation of stoneworts to the common nutrient-rich waters with a species-rich vegetation of herbs and woody plants, featuring manifold structures. The shallow water zone and the shoreline of large perennial standing waters are most species-rich. Correspondingly, the fauna is also very varied there. Large perennial standing waters serve as important habitats for water birds and their breeding, resting and feeding (Figure 58, Figure 59). Many fish species, amphibians and dragonflies also depend on standing waters as a habitat.

4.11.1.4 Value-defining habitat structures and their qualities

Large perennial standing waters possess the highest biological diversity along the shoreline. Several value-defining water body structures can be distinguished:

- Extensive shallow water zones with open areas, reeds and wetland groves.
- Shorelines with small-scale structures and varied slope forms, bays, peninsulas and detached small water bodies.
- Open protosoil locations.

Figure 58: Large water body in operating extraction site

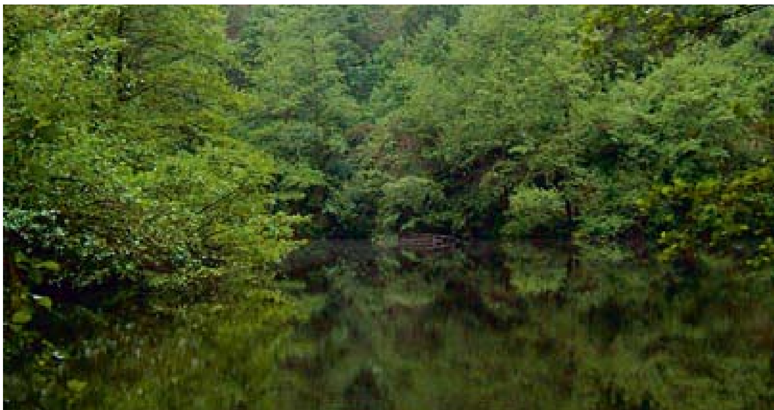


Figure 59: Middle and bottom: Old extraction sites that can hardly be recognized as such

Figure 60: Lakes in dredging areas

- High structural diversity made up of woody litter and large lumps of rock in the shallow water and on the shore.

4.11.1.5 Protection and promotion of biodiversity

Each large perennial standing water is an individual ecosystem with characteristic features that can be improved. The goal is to establish a habitat, which complies with the regionally typical forms and possesses near-natural morphology, vegetation and dynamics. Water bodies already existing have to be integrated into the master plan. Value-defining plant and animal species within the extraction site area or in the surroundings have to be included as well.
It is generally possible to allow utilisation of large perennial standing waters for human beings, e. g. for fishing or recreational purposes. Individually adapted utilisation concepts have to be developed, however, for these purposes in order to avoid disturbances or damage to the flora and fauna. The guiding principle has to be a sustainable development and utilisation of the respective standing water body.

4.11.1.6 Proceeding

Topographical features

Large perennial standing waters result from quarrying in the form of hollows filled with water (Figure 60). If practicable, the development of such value-defining habitat structures should be integrated into the planning of the ongoing quarrying already. This encompasses the formation of shallow water zones and shore slopes.

Preparation of the areas

The morphological shaping of the water body needs to focus on the shallow water zone and the shoreline. As described above, the development of these two zones with diverse structural features is of particular importance. It should be included in the concluding phase of quarrying.

Introduction of the species

A mosaic of open succession areas with light wetland groves is to be established in the shore zone and the shallow water zone.

- The goal is a half open area with gravel, mud and rock areas, pioneer vegetation and single wetland groves.
- Planting is not necessary. A vegetation of reeds, tall forbs and initial willow shrubs will develop independently by and by. The succession process will depend on seasonal changes in the water level, on the development of the soil and on seed carried in from the diaspore by wind and water birds. Young open succession stages also offer favourable habitat structures to a wide range of plant and animal species. Specialised species (amphibians, reptiles and dragonflies among others) need open shallow waters for reproduction (Figure 61).
- The deeper layers of the water are reserved for floating leaf and underwater plant communities in free succession. They are a species-rich habitat for manifold plant and animal species. A settlement by transported seed from the standing waters in the surroundings via water birds can be expected here as well.
- Structurally diverse shallow water zones with numerous hiding places are the main habitat for young fish.

- The fish and crustacean fauna develop independently. Stocking with non-endemic species often leads to the predominance of that species and the extinction of others. This has to be avoided.

Maintenance of habitats

The standing water bodies undergo free development. It is not necessary to control the succession in this kind of habitat.

- If the standing water bodies are used by man, it is essential to develop a sustainable utilisation management.
- It is strictly forbidden to discharge or pollute the water bodies.
- The water quality has top priority. All recreational activities as well as fishing have to succumb to this goal.

4.11.1.7 Summary

- Standing waters are an important habitat for numerous specialised plant and animal species. Large perennial standing waters are significant habitats for the breeding, feeding and resting of water birds. Manifold other species such as fish, amphibians and dragonflies also depend on standing water habitats.
- The water bodies predominantly need to be morphologically shaped in the shallow water zone and along the shoreline. It is most important to develop the shallow water zone and to form a structurally diverse shoreline. This should be integrated in the concluding phase of the quarrying already.
- It is not necessary to apply topsoil.
- Planting is not necessary. A vegetation of reeds, tall forbs and initial willow shrubs will develop independently by and by.
- Biodiversity and water quality have top priority. All recreational activities as well as fishing have to succumb to this goal.

4.11.2 Perennial and temporary small standing waters

4.11.2.1 Habitats worldwide

Small standing waters are characteristic parts of larger wetlands and spread all over the world. They are often called "pool“, "tarn“ or "pond“, in Spanish "pozo“ or "charca“.

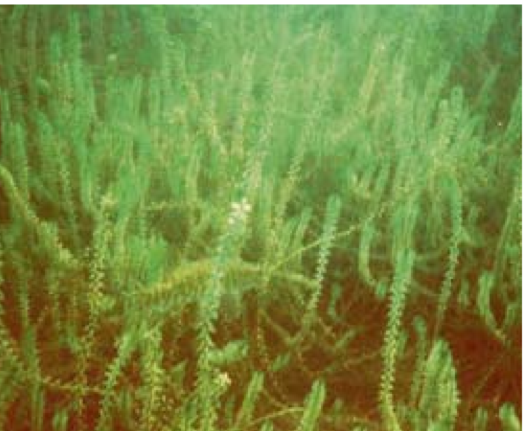


Figure 61: Shallow water zone with manifold structures

Perennial and temporary small water bodies can be found in many extraction sites (Figure 62, Figure 63).

4.11.2.2 General characteristics

Small standing waters are influenced by many factors such as the form and shape of the water body, the amount of water and the quality of the sediments, the bottom of the water body, the nutrient composition and availability and thus the productivity. Small standing waters within one quarrying site all show a distributional pattern depending on the rock, the quarrying technique and the amount of water available. Small standing waters feed from precipitation, from surface water that runs down from surrounding areas and from seepage and springs.
Small bodies of water can generally be distinguished into perennial standing waters and temporary standing waters. The perennial, small standing waters permanently hold water. The temporary, small standing waters however undergo various periods of drought. According to these habitat conditions there is a specialised flora and fauna in the small standing waters.

Without interference the vegetation will develop in a way that the water body will slowly get filled up by sedimentation. The water area decreases and the vegetation zones get compressed (Figure 63).

4.11.2.3 Significance for biodiversity

In natural landscapes, perennial and temporary small standing waters can frequently be found in the neighbourhood of flood plains next to rivers. They reappear time and again and display a varied vegetation cover with well adapted plant and animal species. The small standing waters in quarrying sites provide a habitat for these partially highly specialised plant and animal species (Figure 64).

4.11.2.4 Value-defining habitat structures and their qualities

The value-defining parameters of small standing water bodies are the following:

- Existence of small standing waters of various extensions and depth. They supply the precondition for the development of perennial and temporary standing waters and all transitional forms.

Figure 62: Perennial water body with young reeds (old gravel pit)

Figure 63: Near-natural overgrown old gravel pit

- The preservation of small standing waters originating in quarrying provides locations of different ages.
- The existence of small open waters is an important prerequisite for specialised plant and animal species of early succession stages.

4.11.2.5 Protection and promotion of biodiversity

Most small standing waters appear while quarrying is still going on. They immediately take over important functions for biological diversity. These small standing waters ought to be protected and developed further by the quarry management. All plant and animal species within the extraction site area or in the surroundings have to be included in the planning.

4.11.2.6 Proceeding

Topographical features

Suitable topographical features for perennial and temporary small standing waters in extraction sites are almost plane areas with little cavities lined with material impermeable to water, so that rain water can accrue.

Suitable areas

Suitable areas can be found in quarries on all mining levels, in gravel pits under groundwater level and at the foot of dumps as well as on planed dumps. A connection to the surroundings is convenient, especially with other standing waters, but not essential. Existing water bodies may be enlarged (Figure 66).

Preparation of the areas

First, cavities are dug out in the designated areas and lined with cohesive stone-free material (clay or silt). The extension and the depth of the projected small standing waters should be varied to the extent usual in the region. A backfilling of small standing waters is not necessary if the location is apt. The required amount of water typical for the location will be reached autonomously through precipitation and surface water. Small standing waters already present are to be integrated into the master plan.

Figure 64: Perennial shallow pond in a 10 year old quarry restoration

Figure 65: The European Green Toad is a typical settler of vegetation-free small standing waters

Figure 66: Lake landscape during mining still in operation

Figure 67: Edge zone of an upland moor

Introduction of the species

The small standing waters do not need planting. Experience proves that e. g. reed species settle them relatively quickly through wind and water birds. Young open development stages offer particularly advantageous habitat structures for a number of plant and animal species (e. g. amphibians, Figure 65).

Maintenance of habitats

Controlled maintenance of the habitat is not necessary. If the habitat is settled successfully by plant and animal species (such as certain dragonflies), a part of the vegetation can be removed after 10-15 years in order to create young vegetation-free stages.

4.11.2.7 Summary

- Small standing waters form an important habitat for numerous specialised plant and animal species. Different communities develop there according to the amount of water and the vegetation cover.
- Cavities are dug out on the designated areas and lined with cohesive stone-free material. The extension and the depth of the projected small standing waters should be varied as usual in the region. It is not necessary to fill up small standing waters with water.
- Application of topsoil is not necessary.
- Planting is not needed. Vegetation such as reeds will develop independently by and by.
- Small standing waters are left to free development. If the habitat is settled successfully by ecologically significant plant and animal species, a part of the vegetation can be removed after 10-15 years in order to create young vegetation-free stages.

4.12 Wetland habitats

4.12.1 Habitats worldwide

Wetland habitats such as swamps and moors are globally wide-spread habitat types (Figure 67). Large swamp areas are, for instance, the "Sudd" in the White Nile flood plain in Southern Sudan, the "Pantanal" in South America, the "Urmanij" in South Siberia and the "Everglades" in Southern Florida. Moors are characteristic habitats of the Northern Regions, especially in the taiga. The Central European wetlands have predominantly been drained except for some protected remains.
Wetland habitats can normally develop without disturbances in wet extraction site locations over the years.

4.12.2 General characteristics

The predominant feature of the wetlands ranging between land and water habitats is the constant surplus of water in the ground. All locations are characterised by either a constantly high groundwater level or inundation. They often form a mosaic with the above described flowing and standing waters.

Defining factors of wetlands are the availability of water (water level and temporal influences), the aquatic chemism, age and surface form.
In extraction sites swamps frequently develop in apt locations. Moors only appear individually since the conditions and the long time span they need to develop is predominantly not given.

4.12.3 Significance for biodiversity

Swamps in extraction sites often possess a species-poor yet productive vegetation. These wetland habitats are characterised by few reeds, sedges and tall perennial herbs. Wetland groves add to these regularly.
Wetland habitats have a high significance for animals. They provide important breeding and feeding habitats for specialised bird species as well as for snails, spiders and insects.

4.12.4 Value-defining habitat structures and their qualities

Wetland habitats in extraction sites display a great variety of habitats due to the often intensely varying small-scale relief of the surface. The close inter-

Moor and swamp

A **moor** is a wetland habitat, in which the decomposition of plant remnants has been incompletely accomplished due to the constant surplus of water. High-carbon decomposition products accrue in moors over long periods of time. The product is called peat. There are two main types of peat from an ecological point of view. Bogs are only influenced by rainwater containing little minerals, fens have got additional water containing lots of minerals available (e. g. slope water or seawater).

A **swamp** contains no peat in its intermittently extremely wet soil, in contrast to moors. It may not have developed yet due to the young age of the swamp or drought phases and springwater rich in oxygen may prevent its development permanently.

Moors and swamps can both be covered by wet meadows.

connection to the bordering land and water habitats heightens the biodiversity of such locations significantly (Figure 68).

4.12.5 Protection and promotion of biodiversity

Just like small standing waters, wetland habitats appear already during quarrying if the preconditions are fulfilled. Thus they can take over important functions for biodiversity at an early stage. Wetland habitats should be spared if in anyway possible during the ongoing quarrying and be developed further. All plant and animal species within the extraction site area or in the surroundings have to be included in the planning.

4.12.6 Proceeding

Topographical features

Suitable topographical features for wetland habitats in extraction sites are predominantly plane areas with small cavities. These cavities have to be lined with material impermeable to water so that water can accrue. Wetland habitats automatically appear at the edges of standing and flowing waters.

Suitable areas

Generally, the whole extraction site is suitable. If the water supply is too small for large expanses of water, little wetland habitats can at least survive in hollows.

Preparation of the areas

In most cases, the preparation of the areas for wetland habitats is connected to the establishment of water habitats. Thus, the same requirements as described for water habitats apply. The provision of a retaining soil layer is crucial for the accrual of water. Wetland habitats already existing need to be integrated into the master plan and have to be protected from damage until it gets implemented (Figure 69).

Introduction of the species

Wetland habitats do not need planting. Experience proves that e. g. reed species settle them relatively quickly through wind and water birds. Young open development stages offer particularly advantageous habitat structures for a number of plant and animal species (e. g. birds). If vegetation is to be established faster, it can be initiated with freshly mown grass from mature wet meadows.

Figure 68: Reed stands as vegetation mosaic

Figure 69: Rocks or ramparts protect habitats from passing over and destruction

Maintenance of habitats

Control of the development is not necessary.

4.12.7 Summary

- Wetland habitats provide significant habitats for numerous plant and animal species. They have a high significance for animals. They provide important breeding and feeding habitats for specialised bird species as well as for snails, spiders and insects.
- The preparation of the areas for wetland habitats is normally connected to the establishment of water habitats. Thus, the same requirements as described for water habitats apply. The provision of a retaining soil layer is crucial for the accrual of water.
- Application of topsoil is not necessary.
- Planting is not necessary. Vegetation such as reeds will develop independently by and by.
- The wetland habitats are left to free development.

4.13 Rocks, steep faces and protosoils

4.13.1 Habitats worldwide

Rocks, steep faces and protosoils are globally widespread habitat types which can be found wherever there is no or just a thin soil cover. They reach the largest extension in all high mountains of the earth. They are also located near ocean cliffs, in river valleys and gorges, at the edges of low mountain ranges, the "rock outcrop" of Australia and the "Tepui" of South America (Figure 70).
Rocks, steep faces and protosoils are typical habitat elements in extraction sites which often intermingle (Figure 71 to Figure 73).

4.13.2 General characteristics

Rocks are solid rock fragments, which are characterised by a lack of soil or a very thin soil layer and extreme habitat conditions. In these habitats there is normally hardly any water supply and the variation in temperature is high. Other important habitat conditions are the parent material, the exposition and the age since formation.

Figure 70: Ridge at Mt. Ventoux with steep faces

Figure 71: Old quarry steep face

Figure 72: Weathering dumps at the foot of a steep face

Figure 73: Face in a gravel pit with incumbent top soil layer

Rock areas can be distinguished in typical sub-habitats such as rock face, face top and scree (Figure 72). These sub-habitats display characteristic vegetations. Rock areas can span very large dimensions, far in excess of 100 m in height.
Steep faces can be found in areas of soft rock such as gravel, loess or clay. Due to the unconsolidated structure steep faces are not very stable (Figure 73). The chemo-physical conditions vary intensely depending on the parent material.
Protosoils can be found at numerous plane to steeply inclined locations in extraction sites due to quarrying. The missing soil layer makes the habitat conditions similarly extreme as in rock or steep faces.
The settlement of rock areas, steep faces and protosoils depends on the qualities of the parent material, the age and the morphological features of these habitats. The settlement of solid rock often begins with algae, lichen and moss. The first flowering plants and ferns follow later. Herbs and shrubs can establish themselves in unconsolidated rock early on, whereas the intense erosion continually creates new open spaces.

4.13.3 Significance for biodiversity

Due to the extreme habitat conditions, rock areas, steep faces and protosoils provide habitats for highly specialised plant and animal species. Such natural habitats have become rare in today's landscapes. Therefore they define the ecological significance and value of an extraction site. Scarcely overgrown open locations are the precondition for their development. Steep faces made of soft rock are important breeding habitats for hole-nesting bird species and wild bees (Figure 74). Hard rock faces, however, offer nesting opportunities for birds specialised in rock breeding on cliff edges and in cavities. Rare and endangered plant species can often be found on face edges and screes. Open protosoil grounds are a vital habitat for numerous pioneer species such as birds, reptiles, grasshoppers, ground beetles, spiders and hymenoptera.

4.13.4 Value-defining habitat structures and their qualities

The diversity of different structures such as rocks, steep faces and protosoil makes these habitats ecologically significant. These are:

- Existence of larger and small rock areas, steep faces and protosoils with different ages within a quarrying site.
- Variable expositions; rock and steep faces with deposits, cavities and fissures.
- Existence of open screes underneath steep faces (Figure 75).
- Topographical proximity of dry to wet protosoil with water bodies promotes numerous ecologically significant plant and animal species such as birds and amphibians.
- Diversity of substrates between sand-gravel and clay-silt further enhances the diversity of habitats.

4.13.5 Protection and promotion of biodiversity

Rock areas, steep faces and protosoils result from quarrying in all extraction sites. This habitat type can take over important functions for nature conservation (Figure 76, Figure 77). Rock faces, steep faces and protosoils should be protected and developed further if this conforms with quarrying and safety. All plant and animal species within the extraction site area or in the surroundings have to be included in the planning.

Figure 74: Lose rock faces with sand martin colonies (above) and bee-eaters (middle).

Figure 75: Extensive limestone scree

Figure 76: Vegetation mosaic on former dumps: woody plants predominate at the foot of dumps, drought tolerant grasslands prevail on the knoll

Figure 77: Scarcely vegetated protosoil on former mining level

Figure 78: Habitat conglomerate made up of quarry face, scree and protosoil

4.13.6 Proceeding

Topographical features

Suitable topographical features are rocks, steep faces and protosoils normally created during quarrying in extractions sites.

Suitable areas

Suitable areas can be found in all expositions and inclinations. The existence of open locations with uncovered bedrocks is essential (Figure 78).

Preparation of the areas

Rocks, steep faces and protosoils normally created during quarrying have to be formed in a morphologically near-natural way. The provision of sufficiently large areas is essential. The size of an area has to be in accordance with the locally specific conditions.

If there are rock and steep faces in extractions sites, safety for human beings comes first. There must neither be easy access from the top (due to fall hazard) nor easy trespassing from below (due to rockfall hazard) close to the steep face. Safety should be safeguarded through fences. Rock face edges which are rounded off or screes overgrown with woody plants keep visitors off. Dense thorny hedges are also very useful.

Introduction of the species

- Rocks, steep faces and protosoils do not need planting, but are left to free succession. During succession plant and animal species typical for the habitat there will immigrate independently.
- Adapting to the local habitat conditions, a marginal vegetation of woody plants will develop in the transition zone to bordering habitats.

- Forest restoration should be at least 20-30 m away from rock faces.
- Extensive protosoil areas can be sown flimsily and in a mosaic with suitable endemic species. Apply a thin layer of straw as a protection for the seed and the sprouts after sowing. (Figure 79).

Maintenance of habitats

Control of the development in the habitat is not necessary (Figure 80). Therefore, maintenance of the habitat is dispensable.

4.13.7 Summary

- Rocks, steep faces and protosoils are an important habitat for numerous specialised plant and animal species. The extreme habitat conditions are essential.
- Rocks, steep faces and protosoils created during quarrying are to be formed in a morphologically near-natural way. The provision of sufficiently large areas is what counts here.
- If there are steep faces in extraction sites, safety for human beings comes first. This can be guaranteed by fences, adequate formation of the site and by suitable habitat elements such as dense thorny hedges.
- Application of topsoil is not necessary.
- Planting is not necessary. A suitable vegetation will develop independently by and by.
- Rocks, steep faces and protosoils are to be left to free development.

4.14 Human settlement areas (incl. recreational areas)

Although human settlement areas are rarely planned in quarries, the most important aspects will be explained in the following paragraphs.

4.14.1 Habitats worldwide

Contrary to accepted opinion saying there has been little biodiversity in human settlement areas, there are many structures to be found in human settlements, which are used as a habitat even by rare species. Raptors can be found on high buildings (instead of rock faces) and reptiles underneath

Erosion

Processes of destruction and transportation of rock and soil is called erosion (from the Latin: erodere = gnaw off). Erosion levels out relief differences of the earth's surface. Erosion can take place linearly, e.g. through flowing waters or laminarly, e.g. through wind. The deepest possible erosion basis are the oceans while a lake can be a local erosion basis.

Figure 79: Sowing attempts on protosoil

Figure 80: Even protosoil habitats are species-rich –butterflies ingest minerals

Figure 81: Spontaneous green in a backyard

Figure 82: Green predominates in a residential street

terraces (instead of in stone claims and brushwood undergrowth), while bats inhabit attics and cellars (instead of tree-holes or cavities in rock).
Yet, human settlements are predominantly habitats for humans and tailored to human demands. Biodiversity can still be promoted by easy additional measures. This should be kept in sight.

4.14.2 General characteristics

Each human settlement contains shaped green spaces and woody plants (Figure 81) for the improvement of human communities and for the enhancement of biodiversity in cities in addition to spontaneous growth (Figure 82). Green spaces cool down the areas covered with buildings, balance the extreme city climate and provide recreational spaces for human beings. Such greens contain care-intensive playgrounds and so-called wild areas. Building development is planned and restricted. Densely populated spaces alternate with spaces covered only loosely by buildings. The general principles of sustainable settling development need to be followed.

4.14.3 Significance for biodiversity

The spatially compact variations in human settlement areas result in habitats characterised by construction works, abandonment and demolition, which are rather similar to natural habitats.
Abandoned industrial storage sites resemble gravel banks, buildings resemble rocks, parks equal grasslands and forests. Each and every crack or gap in a wall or in the pavement and every puddle is used as a habitat (Figure 83). Areas suitable as habitats can easily be promoted without disadvantages for human beings. Biodiversity can be enhanced in cities without much effort.

Figure 83: A storage site for rock provides a habitat for endangered wild bees and grass hoppers

Figure 84: A small park in the neighbourhood of conglomerate buildings

4.14.4 Value-defining habitat structures and their qualities

The most species-rich city areas are normally the oldest ones. Old parks, buildings with old cellars, pavements and gravel roads, well-aired attics are potential settlement areas for wide-spread plant and animal species living in areas developed by man, but also for rare specialists. Hermetically closed buildings, jointless coatings and walls without greens however delimit biodiversity and the quality of habitats substantially.

4.14.5 Protection and promotion of biodiversity

A great variety of construction materials, pavement materials and variable greens ensure manifold habitat structures. Enclosing and supporting walls are to be erected without joints. Meadow corridors lined with shrubs can run in between houses and should only be used by pedestrians. They could form strip corridors for the fauna. The streetlights should have insect-friendly illuminants such as sodium-vapour lamps. Carefree green roof covers may create habitats for densely populated areas.

4.14.6 Proceeding

Topographical features

Human settlement areas are to be established on the scarcely backfilled quarrying levels or the completely backfilled extraction area with considerable distance to near-natural areas.

Suitable areas

The areas need to be large enough to create a human settlement. Plains and slightly inclined slopes are suitable. Terracing is also apt. Hazardous areas of the former extraction site should be equipped with safety-devices early on.

Preparation of the areas

- The planning of these areas should start, when the quarrying is still going on. After it has come to an end and the backfilling is completed, the only areas that need to be covered by soil are the ones which shall be covered by green spaces later on.
- Backfilled areas need to ensure the long-term stability of buildings. Therefore they have to be fully compressed.
- The after-use "human settlement area" or "recreational area" can only be completed successfully if all parties concerned exchange their wishes and demands and work on a solution in dialogue (Figure 84).

Introduction of the species

Wild species are not normally introduced into human settlement areas. The habitat conditions can nevertheless be improved through the sowing and planting of endemic species in parks and greens. This should be preferred to the wide-spread and globally rather similar ornamental plants.

Maintenance of habitats

The maintenance of such habitats has to take human beings into account first of all.

4.14.7 Summary

- Even human settlement areas can be the home of many plant and animal species. Utilisation by man has priority, however.
- Small-scale variation between buildings and green spaces promotes biodiversity. Autochthonous species with little requirements for care should

be preferred to ornamental plants. Green roof covers have a positive effect in densely populated areas.
- Human safety has top priority. Potentially hazardous areas need to be abolished or guarded. The focus is not so much on adults, but on children playing, who cannot fully assess the dangers yet.
- Application of topsoil is only necessary where greens are to be created.
- Planting has to be geared to human demands. Autochthonous species should always be preferred to ornamental plants.
- Maintenance of the habitats needs to be in accordance with human demands.

4.15 Renaturation techniques

Renaturation techniques aim at the purposeful establishment or initiation of ecologically significant habitats, which are important for the protection and promotion of biodiversity.
While plants or their communities can be used for renaturation without any difficulty, it is virtually impossible to establish animal communities. Certain animal species can be relocated or returned to the wild in exceptional cases. Yet, this is rather dangerous and difficult. Each animal species needs different specialised conditions. The best way to promote animal species is to establish and provide habitats with the necessary structures and plants for them. It is mandatory to use only autochthonous plant material.
The most important techniques for a successful renaturation shall briefly be explained in the following paragraphs with their advantages and disadvantages.
Due to long years of experience, the most successful technique so far has proved to be the distribution of freshly mown grass.

4.15.1 Distribution of freshly mown grass

Freshly mown grass containing autochthonous species typical for the region is derived from the surroundings and then distributed in the extraction site. Frequently synonymously used terms are mulch-seed and chaff-seed. Species-rich meadows

Sustainable settling development

Sustainable settling development emphasises reduced land consumption, preserves and develops landscape and moderately takes care of it. It pays attention to fresh and cold air currents and makes use of regenerative energies wherever possible. It promotes energy-efficient construction methods, channels traffic or avoids it by creating short routes. This improves the air quality sustainably. Noise is reduced, water is saved, waste is recycled or reduced at the source. The principles of soil protection are respected. All planning, measures and implementations incorporate economic institutions just as much as the citizens concerned.

Solutions result from dialogue.

are most suitable. Freshly cut grass has to be loaded up immediately after mowing and has to be distributed in the designated areas at once. Mowing can be carried out once or several times at the time when the respective seeds reach maturity. The ratio should be between 1:2 and 1:5, depending on the growth of the donator areas (donator : renaturation area) (Figure 85 to Figure 88).

Advantages:	Disadvantages:
The area will be settled by plants which can adapt well to the environment; the costs are low; the maintenance of the habitat can have a positive effect on the surroundings; many variation possibilities through choosing well where the freshly cut grass is derived from; variably adaptable to different habitat conditions.	If the originating areas used are unfavourable, other steps need to be taken (e. g. additional sowing of important species); it is essential to work fast.

Figure 85: Distribution of the freshly cut grass

Figure 86: Large area in a quarry with freshly mown grass

Figure 87: The technique may also be used on steep faces


Figure 88: Distribution of freshly cut grass after 4 years of development – all target species have grown

4.15.2 Sowing of wild species

Wild seed material can be collected by hand on location. It is, however, easier to buy autochthonous wild seed mixtures. The species are to be sown individually or as a mixture. This technique is the ideal one, if ecologically significant plant species are to be introduced purposefully into the extraction site.

Advantages:	Disadvantages:
The designated species can be chosen specifically; rare species can be introduced in sufficient abundance; only autochthonous material gets used or at least it is apt for the location.	A high expense of time and money; collecting by hand is only practicable if the area is rather small; it is very complicated to produce the right mixture of seeds – professional knowledge is needed.

4.15.3 Returning wild animals to the wild

For this technique wild animals or their young stages (such as caterpillars of butterflies) need to be collected by hand and returned to the wild in the new habitat. Certain animal species (such as fish, reptiles, insects, birds) are bred in certain projects. They can be bought and returned to the wild as young animals.

Advantages:	Disadvantages:
The designated species can be chosen specifically; larger numbers of rare species can be provided without putting a strain on the natural populations.	High expense of time and money; not always successful.

4.15.4 Planting wild plant species

The designated wild plant species can be dug out and relocated, if they are available at the extraction site.
It is, however, much better to breed them in nurseries from collected seed. They are then to be reintroduced into the renaturation areas. In some specialised shops there are already numerous autochthonous woody plants and many grasses and herbs available.

Advantages:	Disadvantages:
The designated species can be chosen specifically; rare species can be introduced or preserved purposefully; vegetation develops very quickly.	High expense of time and money if the material cannot be bought; rather high maintenance efforts if climate and weather are unfavourable; can only be used well in smaller areas.

4.15.5 Enrichment of existing plant communities

This technique can be used parallel to the planting of wild species. It is reasonable only if special, i.e. highly endangered species are to be reintroduced or introduced anew.

Advantages:	Disadvantages:
The designated species can be chosen specifically; rare species can be introduced or preserved purposefully.	High expense of time and money if the material cannot be bought; rather high maintenance efforts (e.g. watering), if climate and weather are unfavourable; can only be used properly in smaller areas.

4.15.6 Turf transplantation

Complete components of plant communities are dug out with the soil and then relocated and put together again some place else. Another term used frequently here is relocation of habitat.

Advantages:	Disadvantages:
Conservation of existing stands may be possible; parts of the fauna are relocated as well.	High expense of time and money; possibly high maintenance efforts, depending on the type of the stand; probably only successful with certain types of vegetation.

4.15.7 Turf impoundment

In this technique the soil with the plant communities is not relocated in chunks as in turf transplantation, but more or less chopped up as in normal removal with bulldozers. In this way it is possible to compensate for the unwanted release of nutrients by creating unsettled germination beds.

Advantages:	Disadvantages:
Conservation of existing stands may be possible; parts of the fauna are relocated as well; plant cover remains patchy for a longer time than in the case of turf transplantation; can be carried out by own machinery.	High expense of time and money; possibly high maintenance efforts, depending on the type of the stand; probably only successful with certain types of vegetation; more animals are lost than is the case with turf transplantation.

4.15.8 Application of topsoil from the extraction site

Topsoil always contains a certain amount of diaspores, i.e. seed, bulbs and sprouts of the original vegetation. These diaspores can germinate and grow when applied to new areas. It is favourable for shallow grounds.

Advantages:	Disadvantages:
Settlement by autochthonous plant material; the whole habitat community on a certain soil can "move"; it is advisable not to store the soil; reasonable in combination with planting or sowing of the same vegetation types.	Not always successful; if the soil is stored for a longer period of time, numerous, undesignated species will have intermingled; high maintenance efforts through habitat initiation measures (e.g. shading of forest soil), thus involving high monetary expense.

4.15.9 Relocation of shrubs and trees

Field trees and woody plants are relocated with the roots by bucket excavator onto protosoil locations. It is mandatory to transfer as much of the root system as possible.

Advantages:	Disadvantages:
High structural diversity is implemented very quickly on protosoil locations; parts of the fauna are relocated as well; the transplantation can be carried out using your own machinery and can thus be cost-efficient.	Not always successful; relocation is only possible if donator and protosoil areas can be worked simultaneously.

5 Management measures in operating extraction sites

Many extraction sites possess species-rich communities with numerous rare plants and animals without anyone's help even during the ongoing quarrying. The biodiversity is considerable. It is possible, however, to further enhance and preserve biological diversity by comparatively simple measures without disturbing the mining activity. In this way HeidelbergCement's ambitions for sustainability are supported throughout the Group.
The following general advice cannot be implemented completely in each and every extraction site. Thus it needs to be implemented using concerted action, taking mining needs as well as economic factors into account according to the specific conditions on location.

Alternating operation of extraction sites
An alternating operation of the extraction work is especially favourable for biodiversity. It will generally only be realistic in bigger extraction sites. It means that the extraction should alternate in location – not everywhere at the same time, unless geological factors prevent this or the storing of the raw materials is problematic. In an alternating exploitation site, wanderbiotopes can develop (long-term pacified areas) with their highly specialised habitats and numerous rare plant and animal species.
If habitats with endangered species have developed within an extraction site and these areas are needed for further extraction, they may be relocated.

Temporary establishment of habitats
Autochthonous species can be sown or the development concept "distribution of freshly cut grass" can be implemented on parts of areas not used for a longer period of time. The establishment of a temporary habitat will result in the immigration of parts of the species into the succession areas of the quarry. This will enhance the biological diversity in the whole extraction site. Only autochthonous seed from specialised commercial plant centres ought to be used for sowing, however.

Establishment of rest zones
Areas, which are presumably not operated any longer, should be outsourced at an early point of time. This means that these areas neither get passed over nor used as storage areas or rack. In these

rest zones the first species immigrate, which can settle the other areas after the complete closure of the quarry. It is advisory to mark shallow dry areas or areas with temporary waters as rest zones. Rocks and steep faces may even be excluded from quarrying for a while. The separation of such rest zones from areas still active is achieved by ramparts made of spoil, by large rocks or linearly stapled wood clippings. This allows specialised habitat communities to develop slowly.

Selective promotion of species

The more cavities and holes in the plant buildings where birds can slip in, the more animal species can benefit. Animals such as bats or birds, and with some exceptions also reptiles and insects, should always be tolerated unless they provide any kind of danger for the staff. Special nesting aids on buildings, rock faces or in woods may lure in designated species.

Soil management

Advice on soil management before, during and after quarrying is provided in section 4.4.

After-use planning

Inflexible prescription and implementation of after-use planning needs to be replaced by a more flexible handling of after-use concepts. This makes it possible to take spontaneous development of biological diversity into account on site after the cessation of quarrying and when it comes to reclamation.

Further reading

BDZ/VDZ (2002); Davis (ed.) (1981); Tränkle & Beisswenger (1999).

6 Indicators for measuring and controlling biodiversity

6.1 Biodiversity – a core topic for HeidelbergCement

Conservation, promotion and reconstitution of biodiversity has become the most important goal of sustainable development world-wide. This was emphasised by the results of the UN World Summit on Sustainable Development in Johannesburg in August/September 2002. From the point of view of leading biodiversity experts, the global target to significantly reduce the loss of biodiversity by 2010 will not be achieved.

What is biodiversity?
Biodiversity is the abundance of life and the factors that account for it.
Biodiversity encompasses for instance:

- The number of plants and animals per area, per ecosystem, per habitat, per vegetation unit, per biocoenosis, per phytocoenosis, per zoocoenosis.
- The number of vegetation units and types, of habitat types, of phytocoenosis and zoocoenosis per spatial unit.
- The genetic diversity: the number of eco-breeds and eco-clines and the number of morpho-breeds.
- The number and length of structural elements and units (stepping-stone habitats) per spatial unit (this was the basis for the development of the habitat network concept).
- The number and the amount of eco-tone effects.

HeidelbergCement makes biodiversity measurable
Numerous studies within the last two decades have shown that not only extraction sites which have closed down but also those which are still operating and show a high degree of biodiversity. Extraction sites are thus centres of biodiversity despite the undisputable negative effects on nature and environment. Therefore extraction sites have to be preserved while they are still operating, as well as in the after-use period in the sense of global efforts.
So-called indicators, especially biodiversity indicators are the appropriate instruments to make the development in the extraction sites qualitatively and quantitatively measurable, rateable and controllable with regard to sustainability.
Sustainable Development Indicators (SDI) for measuring biodiversity are also called Biodiversity Indicators (BI).
The term" indicator" derives from the Latin verb "indicare" which can be translated as "to show" or "to betray". The call for implementing sustainability indicators is based on chapter 40 of "Agenda 21" (UNCED, Rio de Janeiro 1992).

Further reading
CBD (Convention on Biological Diversity); Malahide Conference 2004; SEBI 2010 (Streamlining European 2010 Biodiversity Indicators); World Summit on Sustainable Development 2002.

6.2 Indicator systems

There are three indicator systems available at present. They shall be presented briefly in the following passage. HeidelbergCement strives for the implementation of its own indicators.

6.2.1 HeidelbergCement indicators

HeidelbergCement AG was involved in the development of biodiversity indicators especially adapted for operating extraction sites and their after-use within the framework of a long-term research and development project. 56 biodiversity indicators were generated in this project. 10 indicators were finally chosen from this choice (cf. Tab. 1).
Three of these indicators deal with the issue of habitats in extraction sites, one indicator with "habitats" in general, one with "after-use" and one with "wanderbiotopes". The diversity of species is recorded by seven indicators, four of which belong to the sub-category "numbers of species" and three to the subcategory "ecologically significant species".
The project results can be looked up on the company homepage, where they are available in a long and a short text version.

Tab. 1: List of HeidelbergCement's own indicators for the representation of successful reconstruction measures and for the measuring of biodiversity

Indicator	Computation
Set of indicators "habitats"	
Subcategory habitats	
Habitats	Number of habitats per extraction site / area of the extraction site (ha)
Subcategory after-use	
After-use	Area of the extraction site with after-use nature conservation (ha) / area of the extraction site (ha) / area of the extraction site with after-use cultivated landscape (ha) / area of the extraction site (ha)
Subcategory wanderbiotopes	
Wanderbiotopes	Area of the wanderbiotopes in an extraction site (ha) / area of the extraction site (ha)
Set of indicators "number of species"	
Subcategory number of species	
Number of species plants A	Number of plant species in the extraction site / area of the extraction site (ha)
Number of species plants B	Number of plant species in the extraction site / number of plant species in the surroundings
Number of species animals A	Number of selected animal groups in the extraction site / area of the extraction site (ha)
Number of species animals B	Number of selected animal groups in the extraction site / number of selected animal groups in the surroundings
Subcategory ecologically significant species	
Endangered species A	Number of species in a given taxocoenosis based list of species / total number of species on the same given taxocoenosis based list of species
Endangered species B	Number of endangered species in an extraction site / number of endangered species in the surroundings
Species of the Species Action Plans	Occurrence and/or number of individuals of the species of the Species Action Plans

6.2.2 Global Reporting Initiative

From the 4th - 6th October 2006 the International Conference of the Global Reporting Initiative (GRI) was held in Amsterdam, in which globally applicable quality indicators for the reporting on sustainability were developed involving a broad selection of stakeholders.

- Among the numerous GRI-indicators there are 30 so-called ecological performance indicators altogether, of which only five (EN 11 to EN 15) deal with biodiversity.
- These indicators are, however, hardly suitable for the representation of successful restoration measures and for the measuring and control of biodiversity in operating extraction sites.

6.2.3 Cement Sustainability Initiative

The Cement Sustainability Initiative (CSI) is a consortium of cement companies. This consortium has set itself the target of combining the challenges of sustainable development and of developing an agenda on sustainability.

So-called key performance indicators (KPIs) were developed for five different fields within the framework of the CSI. In the sub-field local impacts on land and communities, there are currently only two indicators acknowledged by the members of the Initiative:

- KPI 1: Number of active quarries within, containing or adjacent to areas designated for their high biodiversity value, as defined by GRI 1.
- KPI 2: Percentage of sites with high biodiversity value (according to KPI 1) where biodiversity management plans are actively implemented.

The second indicator is apt to represent the activities in the context of reconstruction measures. These indicators are, however, not suitable for measuring or controlling biodiversity in operating extraction sites. We therefore apply our own indicators.

Further reading

GRI (2000-2006); Tränkle et al. (2008); WBCSD (2005a; b).

7 Stakeholder dialogue

Quarries and gravel pits are part of modern cultivated landscape and can be further utilised by man. The restoration and renaturation objectives should therefore be developed using dialogue with municipalities, local authorities and lobbies. An open dialogue with all persons concerned is necessary and recommended. This is the only way HeidelbergCement can be a vital part of society.

- Supporting the culture of open dialogue on all levels by hosting events and delivering presentations regularly is mandatory. Furthermore, offering guided tours through the extraction sites can be prudent. HeidelbergCement also participates actively in environmental education through lectures and publications.
- As members of a forward-looking concern, numerous plants within HeidelbergCement have already established close cooperation between industry and schools. Quarries and gravel pits are to be promoted as open classrooms. In order to allow interested persons insights into our extraction works, it is crucial to develop nature trails and films on nature conservation, mineral extraction and its history and make them available to a large audience.
- More and more extraction sites show interested citizens on presentation boards and viewing platforms how the workplace and the habitat quarry and gravel pit function. A quarry nature trail has been established in the Nussloch quarry near the German city of Heidelberg. In cooperation with specialised and qualified rangers of a Geopark, we offer regular guided tours there.
- HeidelbergCement intends its commitment to provide an active contribution to sustainable extraction of raw materials and it will thus also promote projects of this kind in the future.


Rules of conduct on excursions in extraction sites

- Do not leave the paths.
- Stay away from technical assets.
- Fall hazard, rock fall hazard, risk of stumbling at any time.
- Use picnic areas outside the quarry.
- Take all refuse with you.
- Dogs are prohibited. In justified exceptions dogs have to be kept on a leash.
- Do neither pick or dig out plants, nor catch animals.
- Sudden traffic hazard at any time.
- Watch your children all the time.
- No swimming in any waters on site.
- No guided tours at dusk or even night.
- Sturdy shoes, rain and sun protection are mandatory.
- Take drinking water with you.

Emergency directions

- All rangers need to carry a functional mobile phone.
- In case of emergency, contact the control centre immediately.
- The control centre will inform the fire brigade, the police and the paramedics. It will direct the rescue vehicles.
- The control centre will inform the on-call service immediately.
- Always report trespassers in the quarry.
- Report all damage to the fence or the installations.

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9 Glossary

abiotic factors	All physical and chemical influences in the inanimate environment such as climate, soil, relief.
all-year grazing	A grazing method: the cattle stays on the same pasture throughout the whole grazing period.
amphibians	Collective name for frogs, toads, newts and so on.
autochthonous	Indigenous, i.e. originating from the same area or habitat.
belay	Plane or slightly inclined upside of rock.
biocoenosis	Community of organisms of various species (animals, plants, fungi, etc.) within a definable → habitat.
biodiversity	Encompasses the diversity of species, the genetic diversity and the diversity of ecosystems.
Biodiversity Action Plan	The Biodiversity Action Plan is an internationally acknowledged instrument for the protection, promotion and development of species and habitats.
bioturbation	Relocation of soil layers by small-size organisms such as earthworms, gophers etc.
browsing	Food intake of wild animals such as deer, fallow deer etc.
bush fruit	Shrubs and trees of various genera producing edible berries, fruit, nuts or leaves.
cold air current	Cold air directed towards the valley or down a slope, streaming close to the ground; it forms especially at night in light wind situations and predominantly under high pressure weather conditions.
depth zoning	Characteristic layering of deep lakes with free water body, called Pelagial and bottom zone called Benthal. The bottom zone encompasses the shore (called Littoral) and the lightless area at the very bottom of the lake, called Profundal.
diaspore	Distributional units of plants such as seed, spores, fruit, tubers, bulbs etc.
diversity	Variety of biotic systems; diversity in species, in structure, in function may be distinguished in spatial and temporal coordinates.
domestic	Species which occur naturally only or, to a certain extent, in one state or at least used to do so.
drainage	The subterranean removal of water through tubes or hoses with holes in order to make agricultural land workable.
eco-race, eco-type	Different ecological conditions result in different populations of one species within a larger location, having genetically adapted to a certain environmental influence (e. g. heavy metal).
ecosystem	Network of organisms interacting with each other and their → habitat.

eco-tone	Transitional zone between different → habitats or landscapes.
edges	Linear plant stands connecting open lands and woody plant stands.
erosion	Abrasion of the earth's surface caused by water or wind.
exposition	Position of a location with regard to the direction; relevant for the energy balance, the climate balance and the water balance of an area.
fallow	An area which is temporarily, or for a longer period, not cultivated.
fauna	Entirety of all animal species of an area.
flood plain	Area along flowing water bodies characterised by alternating flooding and low water.
flora	Entirety of all plant species of an area.
grain size	Size of solid particles in → sediments.
grassland	Type of landscape and vegetation with a more or less closed cover of grasses and herbs; shrubs and trees are missing completely or are at least very rare.
green manuring	Supply with nutrients and organic material in soil by planting and ploughing in cultivated plants.
grove	Small wood dominated by tree species in between agricultural areas.
habitat	Place where an individual or a population lives.
habitat network	A network of → habitats and functional, ecological interrelations in a landscape in order to ensure the survival of species and → biocoenosis.
hedge	A kind of upright young wood (uniserial or pluiserial). The shrubs or bushes stand closely and densely together and are branchy.
indicator	An indicator shows the change or the achievement of a state, for instance indicators for measuring → biodiversity.
initial levelling work	Preparing the shaping of the → morphology of an area.
invertebrates	All animals without a spinal column such as insects, molluscs and worms.
loess	A kind of unconsolidated rock, made up of fine materials, originating in the ice-age, when it was transported and sedimented by the wind.
marge	Little used, linear edge or borderline in field areas, often with steps in the terrain
meadow	→ Grassland, mown as farmland (→ mowing/swath).
monoculture	An agricultural area that may also be used as a commercial forest on which only species of crop plants is cultivated for instance a heat or rice field, a spruce forest, a eucalyptus plantation.

moor	A wetland habitat, in which decomposition of plant remnants functions incompletely because of a constant surplus of water, leading to an accumulation of carbon-rich decomposition products (peat).
morphology	Description of the surface forms of an area.
mowing	Cuttings of meadows used as fodder or litter or bedding.
natural forest	Forest areas that are not utilised any longer but left to a natural development uninfluenced by man.
pasture	→ Grassland used as farmland for the grazing of domestic animals (→ all-year grazing → rotational grazing).
phytocoenosis	Symbiotic community of plants within a defined area (→ habitat).
pioneer forest	Succession stages in the reforestation of a location characterised by more or less short-lived woody plants needing a lot of light. Pioneer forests are substituted by and by as a consequence of → succession by species of the overmature forest.
plant community	Number of plant species occuring in a large area in similar composition (e. g. beech forests, semi-arid grassland).
pollard trees	Pollard trees possess a thick trunk branching out into lots of twigs so as to from a dense head of foliage. This typical form is a result of cutting back the tree to the trunk over many generations. The branches of poplars, ash trees or hornbeam were used to feed cattle earlier on, willows were used to make baskets and the like.
population	Entirety of all individuals of one species within a certain habitat.
primeval forest	Forests which have undergone no or only little interference by humans, having developed according to the → abiotic conditions.
protosoil	Protosoil is an initial stage of soil development with a small degree of humus and a high degree of not weathered original material.
reeds	→ Plant communities in shallow waters at river banks or lake shores, consisting of tall perennial grasses with hollow slender stems especially of the genera *Arundo, Typha and Phragmites.*
regenerative energies	Energy types such as wind energy, water power, solar power, biomass energy.
reproduction	Synonymous term for progeny of organisms.
reptiles	Collective name for such species as turtles, snakes, lizards etc.
rotational grazing	A grazing method: the pasture is divided up in parts, which are grazed in a regular rhythm with intermediate rest-periods for the unused parts.
sealing	Cover of the soil during construction works of streets, paths and building with asphalt (tarmac), concrete, pavement stones etc.

sedge	Plant which frequently occurs in wet habitats such as → swamps and → moors of the genus *Carex.*
sediment	Accumulation of materials in layers: we distinguish clastic s. (material such as sand and clay removed and transported by → erosion), chemical s. (material such as calcium carbonate, deposited by chemical processes in the water) and biogene s. (deposits of organic remnants such as corals).
shrubbery	Plane, irregular copses formed by shrubs in agricultural landscapes.
stepping-stone habitat	Insular habitats functioning as intermediate stages in the spreading of species (→ habitat network).
stoneworts	Characeae, small group of about 200 species of green alga, frequently embed calcium carbonate, predominantly in sweet water.
stratification	The treatment of seed e. g. by deep temperatures to promote or even enable germination.
subsoil	Lower layer of the soil, predominantly poor of humus; part of the ground between → topsoil and parent material.
succession	The change of plant and animal communities in the course of time in one location. → free succession is the uncontrolled development of nature at a location.
swamp	A wetland habitat with periodically very wet soil, which contains no peat contrary to → moors (e. g. because of the young age, due to droughts or oxygen-rich springwater).
tall forb vegetation	→ Plant communities on wet, nutrient-high soil, formed by high growing, perennial herbal plant species.
temporary waters	Water bodies which dry up completely for certain periods of time; opposite: perennial waters holding water all year round.
topsoil	Upper part of the soil containing a characteristic percentage of humus and microorganisms and thus darker than the → subsoil.
vegetation	Entirety of plant communities in an area.
vertebrates	All animals with a spinal column such as mammals, birds, amphibians, reptiles.
wanderbiotopes	Constantly new emerging succession zones in operating extraction sites due to the spatial and temporal change of quarrying sections.
water capacity	Maximum amount of water soil can hold if the water can run through freely.
wet meadow	A type of meadow in wetlands (→ swamps and → moors), grown with grasses, juncales, sedges and other herb-species, free of woody plants.
zoocoenosis	Symbiotic community of animals within a defined → habitat.

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