

Biodiversity management in quarries and gravel pits

Putting Nature back together



HEIDELBERGCEMENT

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Contents

Preface.....	4
Greetings.....	6
Mineral extraction sites as hotspots of species richness.....	8
Maintaining an overview.....	14
Plan first – and then act!.....	16
Restoration of agricultural and silvicultural land	18
Flagship project: Reducing erosion in the Yongwa limestone quarry, Ghana	20
Natural forests – more than just a bunch of trees	22
Flagship project: Sowing a forest	26
Biodiversity management in quarries and gravel pits.....	28
The earlier the better ... begin biodiversity actions during active mining.....	30
Flagship project: Saving orchids at the Rheinstetten gravel pit.....	34
Water is life.....	36
Small but very important – shallow temporary waters.....	40
Flagship project: Creating and optimising spawning waters for amphibians	42
Still waters run deep – permanent waters	44
Flagship project: The Hanson-RSPB wetland project	46
Structural diversity – the icing on the cake for higher species-richness	50
Unconsolidated materials – harsh conditions where only pioneer species thrive.....	54
Dry semi-natural grasslands and heaths – species diversity on nutrient-poor soils	58
Flagship project: Semi-wild pasture in Schelklingen-Gerhausen	64
Flagship project: Sheep pasturing in the Geseke limestone quarries	68
Flagship project: Establishing new dry meadows using grass clippings in the Swabian Alb	70
Living structural elements in the open landscapes – hedges, copses, groves.....	72
Give free rein to nature by allowing natural vegetation to develop.....	74
How to deal with invasive plant and animal species.....	76
Species in the spotlight – targeted management programmes.....	80
Flagship project: Reintroduction of pasqueflower species	82
Flagship project: The HeidelbergCement sand martin project	84
Glossary.....	86
Literature.....	90



Preface

In the first four volumes of our book series we have presented the animals and plants which live in our mineral extraction sites, and explained the nature protection value of post-use quarries and gravel pits. The book in your hands represents something of a break with this tradition.

Many readers, as well as the management board of HeidelbergCement, have encouraged us to dedicate this fifth volume to the restoration and conservation of high value habitats in quarries and gravel pits. Its target groups are practitioners in mining rehabilitation, plant and quarry managers, environmental engineers, teachers, students, nature protection groups, and the many volunteers at our mineral extraction sites.

This book is intended to serve them as a concise, easily comprehensible and, as always, richly illustrated handbook. For this purpose we have consulted many guideline documents, books, and scientific papers; and we have double-checked their methods with our own vast knowledge of habitat restoration at our mineral extraction sites. Thus, I want to thank all HeidelbergCement plant managers, quarry managers, and biodiversity experts, whose knowhow contributed substantially to the high quality of this unique book. At the end of the book you will find a glossary and a short literature overview, which will help all those who want to dig deeper into this subject.

Alas, 96 pages are not enough to cover the complete array of habitat creation and management methods. Therefore, we have focused on what our long-time specialist experience tells us are the most effective methods for biodiversity, and the most practical for the people involved in the everyday work of managing active and post-use quarries and gravel pits. The creation of such habitats is one thing, but their management and long-term conservation is just as important. Only in this way can mineral extraction sites yield additional benefit for biodiversity after they are handed back to the community.

Readers of the previous volumes of our book series will be familiar with the fact that pioneer species depend particularly on the high site dynamics within active mineral extraction sites. We are well aware of the area of conflict between “conservative” nature protection approaches on the one hand, and the habitat destruction and re-creation necessary for the long-term protection of pioneer species on the other hand. We describe approaches that allow for the reconciliation of mining activities with protection for these species.

This can only work, however, when both governmental, private and third sector nature protection representatives are willing to abstain from the dogma of a strictly conservative nature protection strategy. Accepting dynamics means accepting partial destruction and redevelopment, trusting in the regenerative capacity of plant and animal populations. When this is understood, mineral extraction can continue to play a substantial role in the preservation of biodiversity.

And now – enjoy the book!

Prof. Dr. Michael Rademacher
Biodiversity & Natural Resources, Fachhochschule Bingen

Greetings

HeidelbergCement's corporate mission is not only to excel in terms of economic performance, but also to act in an ecologically and socially responsible way. Next to climate protection, the protection of nature and species is the focus of our sustainability strategy.

In practice, HeidelbergCement has been demonstrating for years that mineral extraction and the protection of biodiversity are not in conflict. Before we begin work at any new site, we carry out a study to assess the impact of our mining and production activities on the environment. Based on these studies, we either ensure that adverse environmental effects are avoided or, when avoidance is not feasible, minimise them from the project planning phase onwards. We compensate for the inevitable adverse effects with our highly developed technical environmental protection standards, as well with state-of-the-art ecological restoration of our quarries and gravel pits.

We were the first pit and quarry industry company to make a commitment to the sustainable ecological rehabilitation of our mineral extraction sites, and to adopt group-wide biodiversity guidelines. Since 2012 we have been cooperating with BirdLife International, one of the largest international conservation organisations. In addition to numerous joint projects in our mineral extraction sites around the globe, we have assessed the nature protection value of all of our quarries and gravel pits in Europe, Africa, and Asia. By 2030 we will have completed site-specific management plans aiming at the promotion of particularly valuable habitats and rare species for all our mineral extraction sites with high biodiversity value. We will also intensify our cooperation with our partner BirdLife in tackling other environmental issues such as climate protection.

The Quarry Life award, now in its third funding period, will once again encourage pupils and students in more than 20 countries to carry out biological studies at our mineral extraction sites. In this way, we will continue to contribute to the improvement of knowledge about the protection of biodiversity in quarries and gravel pits. The results of all studies are freely available to the scientific community and new findings are incorporated into the standard post-use site rehabilitation activities of our company.

We are also aware of the social dimension of our activities: protection of biodiversity and the common good go hand in hand. Numerous projects around the globe demonstrate the benefits for both nature and society.

This book series is one more part of our commitment to sustainability.

Dr. Bernd Scheifele
Chief Executive Officer HeidelbergCement AG





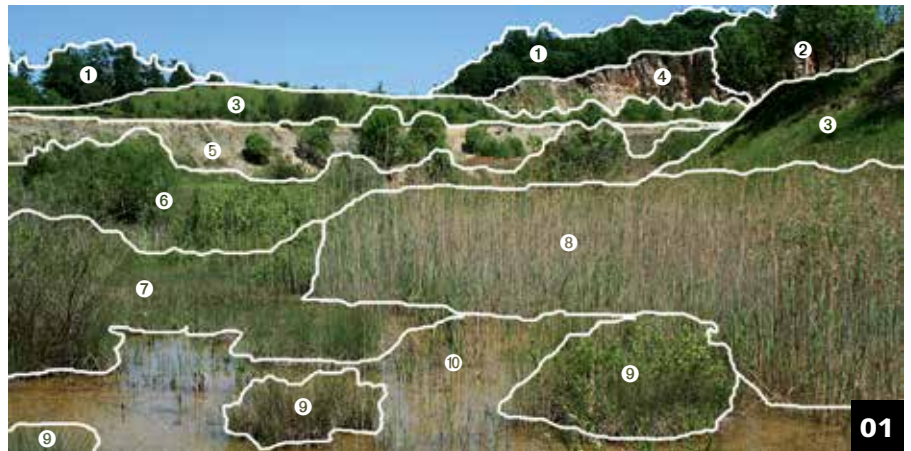
Mineral extraction sites as hotspots of species richness



Mineral extraction sites as hotspots of species richness – a contradiction?

The mining process changes landscapes profoundly – landscapes with their own soils, and plant and animal communities, which have developed over the course of millennia.

So how can quarries and gravel pits still be hotspots of species richness? The importance of active and former mineral extraction sites for biodiversity, especially in intensively-used agricultural landscapes, is due to the following three characteristics: the nutrient-poor soils at the sites, small-scale site diversity, and high site dynamics.



03



01 Small-scale site diversity in a quarry.

- 1 Forest
- 2 Grove
- 3 Dry grassland
- 4 Rock face
- 5 Scree
- 6 Willow scrub
- 7 Inundation zone
- 8 Reed
- 9 Sedges and rushes
- 10 Open water

02 High site dynamics in natural flood plains create a changing mosaic of features including braided channels and open gravel plains. This is the Drôme River in southern France.

03 The fly orchid (*Ophrys insectifera*) is confined to nutrient-poor sites.

Nutrient-poor soils: In many cultural (human-altered) landscapes, intensive agriculture involving the use of fertilisers and other agrochemicals has led to highly productive soils. Only a handful of unspecialised plants such as Common Nettle (*Urtica dioica*), Spear Thistle (*Cirsium vulgare*) and Broad-leaved Dock (*Rumex obtusifolius*) thrive on such soils, out-competing most other plant species, which grow less vigorously. Orchids, for example, can only grow at sites not shaded and overgrown by more rapidly-growing plants.

On nutrient-poor soils, sparse vegetation composed of many different plant species provides habitat for species-rich animal communities. Topsoil-stripping as a preparatory step for mineral extraction returns the substrate to a nutrient-poor condition, where less competitive plant species may establish themselves.

Site diversity: Mineral extraction creates a true jigsaw puzzle of habitats: water bodies of different sizes and depths, gravel plains, mine dumps (tailings), screens, slopes with different inclinations and exposures, rock ledges and faces, and many more. In addition, this site mosaic is covered by vegetation at different developmental stages depending on age, water supply, and intensity of use. The higher the site diversity, the more plant and animal species find suitable habitats – ecological niches.

Site dynamics: Mineral extraction activities lead to permanent remodelling and rearrangement of the site mosaic. This creates habitats for specialised pioneer species. Among plants, most pioneer species are annuals which depend for germination on patches of open soil created by disturbance. The original habitats of many of these species were within natural river plains, where flood dynamics created open sites periodically.



01

Natural landscape versus cultural landscape

In our century, no landscape on earth remains truly unaffected by human impact.

Climate change caused by human activities is affecting the entire planet, and industrial pollutants have reached even the remotest places. Disregarding such global effects, **natural landscapes** can be defined as landscapes (almost) unaffected by human beings in their appearance, natural dynamics, and plant and animal inhabitants. Such landscapes are often referred to as wilderness.

In contrast, **cultural landscapes** are permanently altered by human activities. The term encompasses settlements, agricultural land, and silvicultural (forestry) land. Traditional agricultural landscapes with small-scale, diverse patterns of land-use led to an increase in species richness. Large-scale intensive land use in modern times, however, has levelled and homogenised vast areas, leading to strong declines of biodiversity.

01 The greatest structural diversity and species richness is to be found in tropical rainforests (Puerto Maldonado / Peru).

02 A cultural landscape – Pian Piccolo di Castelluccio in central Italy – with high species and structural richness, characterised by stony fields, nutrient-poor meadows and pastures, and many natural structural elements.





Maintaining an overview...



Plan first – and then act!

Prerequisites such as the legal framework and higher level planning will determine the after-use of a mineral extraction site. It can be scheduled for agricultural, forestry, or other intensive human use, or the intention may be to unfold its potential for nature protection purposes. Even when nature protection goals prevail, the aims can be quite

different. In countries with a high proportion of natural landscapes or traditional cultural landscapes, the main purpose may be to re-establish species-rich forests, while in the intensive cultural landscapes of Europe and North America, for instance, the preservation of richly structured, nutrient-poor open habitats may be the priority.

A clear understanding of the kind of habitat to be created, together with a practical plan for achieving it, with specific targets at each stage, is essential before taking action.

Recultivation versus renaturalisation

Recultivation aims at putting mineral extraction sites back to economically productive use following exploitation. Originally this usually meant returning quarries to agricultural or silvicultural use by filling them with waste material and covering them with fertile topsoil. (Gravel pit lakes may also be used for recreational purposes, such as fishing, sailing and birdwatching, activities which can be combined with biodiversity conservation.)

Renaturalisation, on the other hand, means returning the site to as near a natural condition as possible. Nature protection targets and actions are the focus.

It is generally important to engage local people and decision-makers in any mineral site restoration project, including the decision on whether to renaturalise or recultivate.



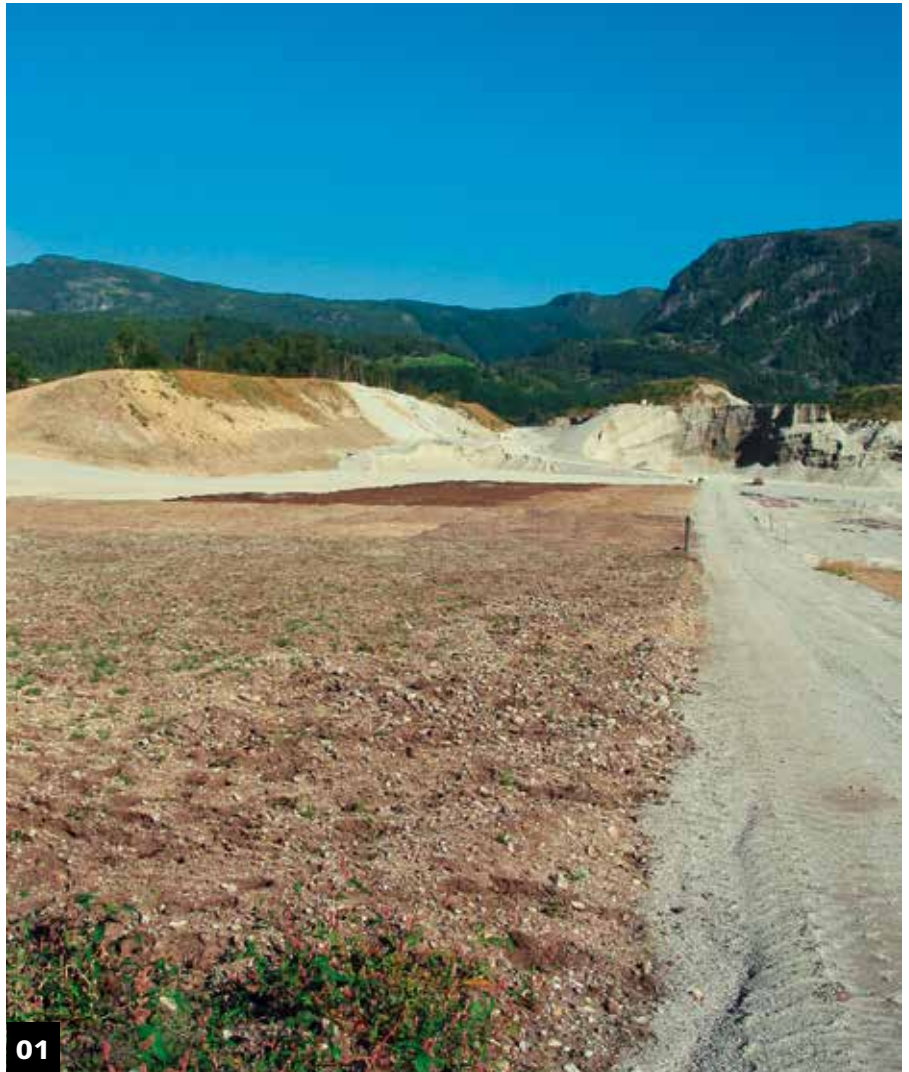
01 Mineral extraction that aims to go easy on nature needs thorough planning, including good communication between all people involved or affected.



Restoration of agricultural and silvicultural land

Gentle handling of topsoil is essential for the later restoration of agricultural or forest lands. Prior to mineral extraction, the soil must be removed carefully, and stored in heaps with a maximum height of two metres, at sites protected from erosion. Following extraction, the soil must be brought back and spread out without compacting it.

Particularly in tropical regions with abundant precipitation, special measures have to be taken to protect the fertile topsoil from erosion. In the tropics it may also be necessary to enrich the laterite remaining after mineral extraction by intermixing humus or compost, in order to obtain fertile soils.



In arid climates with low precipitation – and in extreme cases, such as desert areas – saving water is a prime environmental goal. Such areas are to be found in parts of North America, Africa, Australia, Southern Europe and other regions of the world. Several flagship projects in Australia gather and process rainwater in a system of basins, and reuse it within the mineral extraction site.

01 Humus-rich topsoil has already been worked into the gravelly lower soil at this Norwegian gravel pit. After seeding, nutrient-poor grasslands will establish at this site.

02 Temporary storage of topsoil in a limestone quarry in Togo. Gentle handling of the soil, especially the avoidance of compaction, plays a central role.

03 Basins for the collection of rainwater are an important contribution to groundwater protection, and to the avoidance of erosion. This is particularly important in dry areas, such as Australia. The basins can be designed in a near-natural fashion, and provide important plant and animal habitats.



Reducing erosion in the Yongwa limestone quarry, Ghana

Under tropical climate conditions with frequent heavy rains, topsoil erosion is a serious problem, especially on un-vegetated slopes. A team led by Paul K. Nsiah in Ghana developed an affordable way of reducing erosion to 30% using grass mats. What makes this Quarry Life Award project even more appealing is that the mats can be made by local people, using the abundant native elephant grass.





01 Massive erosion is a common phenomenon in mineral extraction sites in the tropics. In this picture, the task group led by Paul K. Nsiah is measuring the degree of erosion.

02 Elephant grass mats (*Pennisetum purpureum*) protect this slope from erosion and improve the success of revegetation efforts.



Natural forests – more than just a bunch of trees

The area of primeval forest is still declining massively on a global scale. In many old cultural landscapes, for instance in Europe, the primeval forests that once covered most of the land area are long gone, following hundreds or even thousands of years of overuse. In many regions of the world, forest is the final stage of vegetation development. Even when they are not primeval, richly-structured forests with high amounts of ancient trees and dead wood provide important habitats for many species. Post-use mineral extraction sites can be well-suited for the restoration of species-rich forests. This is particularly true for nutrient-poor and permeable unconsolidated materials, where trees do not grow well, so that enough light reaches the forest floor for the abundant growth of herbs and shrubs.



01 Near-natural central European deciduous forests, with well-developed shrub and herb layers, serve as habitats for a wide array of species.

02 The larvae of most longhorn beetles (Cerambycidae), such as this capricorn beetle (*Cerambyx scopolii*), develop in woody plants, especially old and dead trees.

03 Wood anemones (*Anemone nemorosa*) bloom in early spring in European forests.

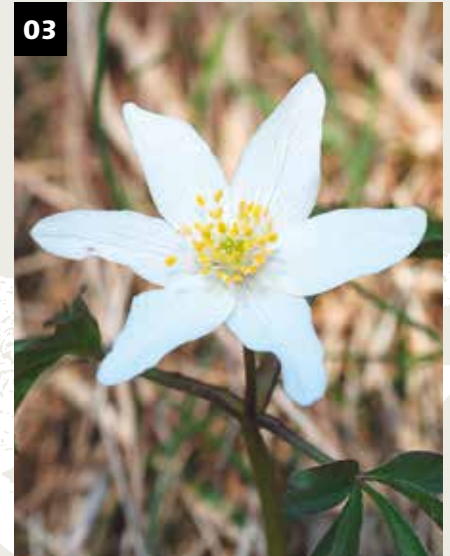
How to plant a forest

1. If forestry use rather than nature protection is the main purpose, the unconsolidated material should be covered with a topsoil layer of at least 30cm.
2. A forest can be initiated either by planting, sowing, or natural reforestation processes.
3. When planting, the saplings should not be planted in dense rows as in typical forestry plantations. They should be planted in a more natural, random fashion. Fences or spiral tree protectors are necessary to prevent damage by browsing deer and rabbits.
4. When planting and sowing slopes, appropriately trained forestry workers must be employed. Between 80 and 100 kg of seeds are necessary per hectare.
5. From a forester's point of view, the economic value of sown rather than planted forests is uncertain, because the development is much less predictable.
6. A third option is natural reforestation. This process takes much more time than planting or sowing.

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**02**

01 The Eurasian red squirrel (*Sciurus vulgaris*) is a characteristic and still abundant species of European forests. By burying tree seeds such as acorns and hazelnuts it plays an important role in the regeneration of forests.

02 Most longhorn beetles (Cerambycidae), such as this wasp beetle (*Clytus arietis*), live in forests.



Sowing a forest



01

The extraction of Upper White Jurassic limestone from the tree-covered Swabian Alb region of southwest Germany inevitably had a significant impact on forests. In most cases, the forests affected by quarrying were of European beech (*Fagus sylvatica*).

Mineral extraction also led to the replacement of the original soils with unconsolidated material. As the top-

soil layers in this region are thin, the post-use sites could only be covered with relatively small amounts of topsoil.

Permission to cut down forests for the purpose of mineral extraction is always tied to the obligation to restore the forests after use. A safe and simple method of re-establishing forests would be to allow natural succession. However, this natural process

takes too long to comply with the legal deadlines for reforestation. For this reason, the areas to be recultivated were first covered with a 0.5 metre layer of clay and marl to improve conditions for root growth, and then a mixture of different regional tree and shrub species were sown.



02



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01 A handful of seeds of various deciduous woody plants. The large, three-cornered beechnuts are quite conspicuous.

02 European beech forest in its autumn dress.

03 A young European beech forest some years after sowing.



**Biodiversity management in
quarries and gravel pits**



The earlier the better... begin biodiversity actions during active mining



Ideally, biodiversity management in quarries and gravel pits will begin during active mining. A significant proportion of the characteristic and threatened species occurring in mineral extraction sites have their origin in dynamic floodplains. This encompasses, among others, most European amphibian species.

Natural floodplains and mineral extraction sites have much in common. Both are characterised by abundant dynamics. The power of high waters in flood plains, and the forces of extraction activities in quarries and gravel pits, are continually remodelling the landscape, creating diverse habitat structures.

01 The small bluetail (*Ischnura pumilio*) depends on temporary shallow waters. This species can be promoted effectively by creating small pools during active mining.

The following options are available for the enhancement of biodiversity during active mineral extraction:

Alternating mineral extraction activities: If geological conditions and the amount of minerals present in a gravel pit or quarry allow for this, mineral extraction should alternate, and not be carried out everywhere at the same time. This allows for the periodical re-creation of habitats for pioneer species until the next large disturbance takes place.

Creation of undisturbed areas: Areas not needed for mineral extraction in the medium term should be left to natural development, to serve as habitats for sensitive species. Such undisturbed areas should not be entered, and not be used as storage spaces or parking lots. Areas with high nature protection value due to the presence of unconsolidated material, shallow inundation zones, rock faces or other favourable features should be preferred as designated undisturbed areas.

Creation of temporary biotopes: Undisturbed areas or alternating mineral extraction areas can be upgraded as temporary habitats. This can be achieved by, for instance, "inoculating" sites with seeding plant material taken from species-rich meadows in the form of hay or grass clippings, or by creating small water bodies, stone heaps and other valuable habitat elements.

Species-specific actions: Many species can be encouraged to use the site during active mineral extraction. For instance, steep slopes can be created or preserved for sand martins, kingfishers, and bee-eaters. Artificial nesting aids for birds and bats can be installed on buildings or trees, and spawning waters for amphibians can be scraped out in undisturbed areas.

Relocation / safeguarding of threatened species during active mineral extraction: If the destruction of areas with populations of threatened species or habitats cannot be avoided, they must, as a last resort, be relocated to suitable post-use areas. With semi-natural dry grasslands, heath or fen vegetation, this can be done by first preparing the prospective new site, and then transplanting single plants or turfs. If relocations are to succeed, experts must be consulted. Old trees colonised by threatened animal species, for instance longhorn beetles, should be safeguarded, or at least be stored as dead wood at suitable undisturbed sites.

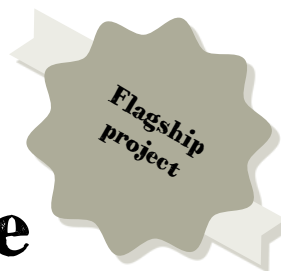
01 Natterjack toads (*Bufo calamita*) prefer unshaded shallow water bodies.

02 In undisturbed areas, annual herbs such as rue-leaved saxifrage, also known as nailwort (*Saxifraga tridactylites*), establish at an often rapid pace. They are an important food source for insects.

03 Undisturbed areas with temporary habitats can play an important role for sensitive species such as common cranes (*Grus grus*).







Saving orchids at the Rheinstetten gravel pit

In 2010, a former dredging material disposal site at a gravel pit south of Karlsruhe (Baden-Württemberg, Germany) had to be cleared, because sluiced sand threatened to slide down and block gravel deposits which had been approved for mining. An environmental audit, however, showed that several hundred specimens of two threatened orchid species had established at that site.

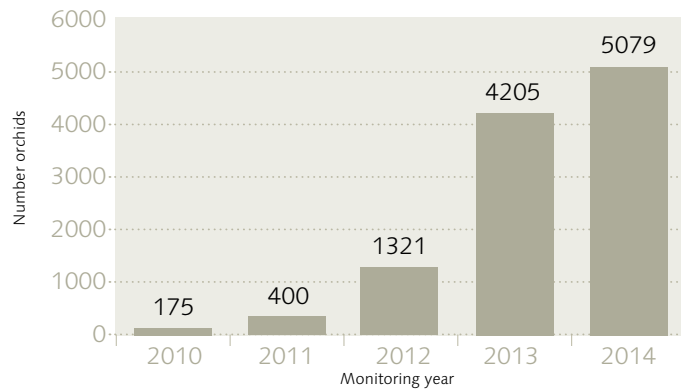
With the approval of the nature conservation authority, the orchids were relocated to a different site, which had previously been covered with goldenrods (*Solidago*, invasive plants from North America) and so was of low nature protection value. First, the designated new orchid site had to be prepared by stripping the topsoil and replacing it with sluiced sand. Following this, turfs from the original site, containing the orchid

rhizomes, were laid at the new site. In addition, a minimum of 175 specimens of marsh helleborines and 15 specimens of early marsh-orchids were dug out, stored temporarily and then replanted manually. Following annual care, the populations of both species have developed very favourably since their introduction.

01



Development of the marsh helleborine population at the new site:

**03**

01 A single flower of a marsh helleborine (*Epipactis palustris*).

02 Spreading the relocated soil material with orchid rhizomes at the new site.

03 Freshly transplanted group of marsh helleborines.

**02**

Water is life...



Standing waters are important habitats for many plant and animal species. Depending on the type of mineral extraction and the minerals themselves, different types of water bodies may develop spontaneously during the mining process. For example, wet gravel mining often creates large lakes. Because many gravel deposits are located in floodplains, dry mining in groundwater fluctuation zones sometimes creates smaller, shallower water bodies. In

depressions with compacted soil or bedrock, shallow waters fed by rainfall may develop. Sometimes small water bodies are created when large waters are filled up with excavation residues, leaving troughs and depressions in the new surface.

However, when setting out to create water bodies, it must first be considered which groups of animals they are to support. Large permanent lakes are important habitats for fish,

waterfowl, and also for numerous water insects, while small temporary ponds are favourable for amphibians and many small animal species.

01 Shallow water on the floor of a quarry. Shore vegetation has begun to develop, while the surroundings are still bare.

02 Standing water provides habitats for many plant and animal species. This male ruddy darter (*Sympetrum sanguineum*) prefers shallow, well-vegetated ponds and lakes, or marshy pools and ditches.

**02**

What has to be considered generally when creating water bodies?

1. Water bodies should be created preferably in surface depressions where either ground water feeds them, or precipitation collects from the largest possible catchment area.
2. The surroundings of newly-created waters must be kept free of nutrient-rich topsoil.
3. In most cases, no woody plants should be planted along the shoreline. They shade the water, and dead leaves decomposing in water lead to eutrophication.
4. Vegetation should be allowed to develop naturally, and no plants or animals should be introduced.



- 01** The rare fringed water-lily (*Nymphoides peltata*) occurs mainly in rather nutrient-rich waters.
- 02** Flowering spiked water-milfoil (*Myriophyllum spicatum*) in a gravel pit lake.



Small but very important – shallow temporary waters



It seems obvious that large, deep permanent waters, where, for instance, birds, fish and aquatic mammals can breed, would have a particularly high nature protection value. However, in agricultural landscapes, shallow ponds of different sizes which dry up periodically have become the rarest kind of standing water habitat. Such non-permanent waters are the nursery grounds of many water insects and other water-dwelling invertebrates, and most amphibian species. These temporary ponds are free of larger predators, such as fish, which would feast on the invertebrates and amphibian larvae

(tadpoles). But these dynamic habitats present other kinds of risk. If the water dries up too early, before the larval phase of its inhabitants is completed and the fully developed animals can take up the terrestrial phase of their life cycle, they are literally left stranded and die.

Full exposure to sunlight, and sparse water vegetation with sufficient areas of open water, are prerequisites for high species richness. In contrast, few species will be found in pools that are completely overgrown with dense reeds, or shaded by alders or willows.



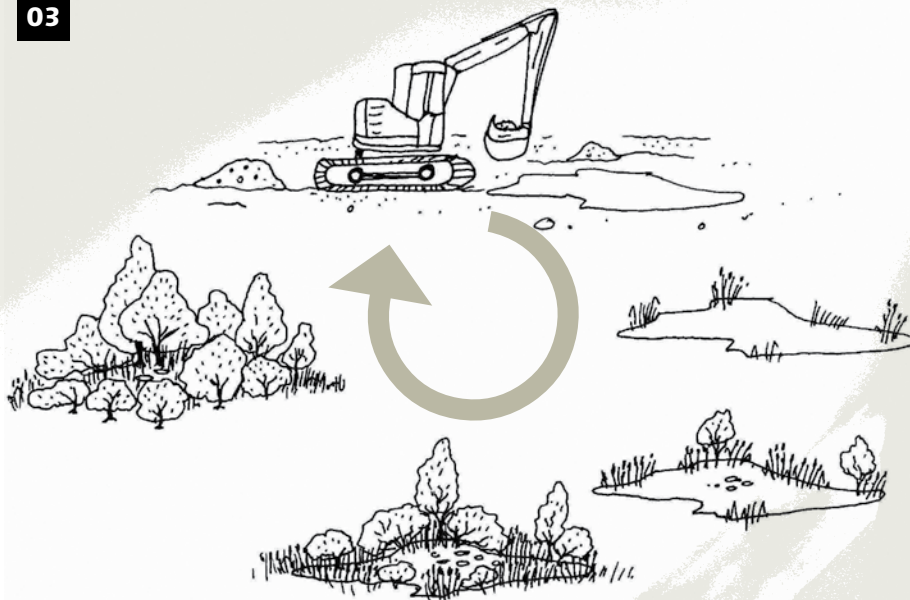
01 A tiny water body in a gravel pit. This insignificant-looking puddle is an important spawning site for amphibians, whose tadpoles can be seen as black dots in this picture.

02 Another puddle, this time with tadpoles of the European green toad (*Bufo viridis*). Circling above it, is an egg-laying female broad-bodied chaser (*Libellula depressa*).

What has to be considered when creating and managing temporary waters?

1. Pond edges (the shore zone) should be as shallow as possible.
2. Nothing should be planted, because the most characteristic species prefer open, sparsely vegetated habitats.
3. Under no circumstances should fish be introduced.
4. The waters can be kept open by mowing or grazing. If necessary, the shore zones can also be carefully dredged every few years.
5. The ideal is to create complexes of shallow waters of different sizes and depths. They can be kept open by dredging, following the rotation model (see sidebar).

03



What is the rotation model?

The rotation model is a habitat management strategy. Management actions are planned and taken in a rotational fashion over time and across the different areas of a site. The aim is to maintain a permanently high level of habitat diversity. For water bodies, this means that species with diverse ecological demands can always find suitable habitats at different stages of silting up and vegetation succession. The model can be transferred to many other habitat types.

03 The rotation model involves periodic management actions in order to restore sun-exposed pioneer habitats.

Creating and optimising spawning waters for amphibians

At one large HeidelbergCement gravel pit in north-eastern Germany, the gravel, extracted by wet mining, contains large amounts of sand. As only a small portion of the sand is in demand regionally, the remainder is used to fill up shallow lakes created during the mining process. In order to preserve the important amphibian populations present at the site, water-retaining depressions are being left among the landfill, where they provide fish-free spawning waters for threatened natterjack toads (*Epidalea* or *Bufo calamita*) and garlic toads (*Pelobates fuscus*).





01 When filling up gravel pit lakes with sand, shallow bays and small pools can be created to provide nursery grounds for threatened amphibian and insect species.

02 Garlic toad (*Pelobates fuscus*) in spawning waters.



02

Still waters run deep – permanent waters

Shallow shore zones, like those found in the most species-rich small ponds, are of particular value for most plant and animal species in large permanent lakes as well. Not only water and marsh plants, but also less specialised amphibian species and all kinds of small animals use these areas; they are also the nursery grounds of most fish species. Reed beds in shallow water offer nesting sites where waterfowl are hidden from predators.

Shore zones should therefore be as shallow as possible to allow for the development of extensive water and marsh plant vegetation. In some large mineral extraction sites, vast landscapes of alternating open water and marsh can be created. In their spacious reed zones, very demanding waterfowl species, such as the Eurasian bittern (*Botaurus stellaris*), may find suitable habitats (see flagship project).

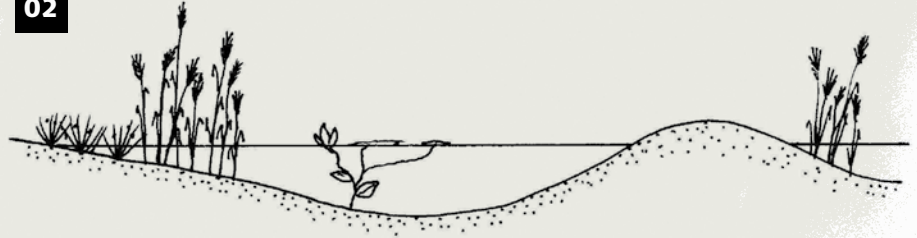
01



01 Gravel pit lakes with diversely structured, mostly shallow shores offer space for the development of reed zones.

02 Schematic for the design of a richly-structured shallow shore zone.

02



What has to be considered when creating and managing permanent waters?

1. The shoreline should be made as long and varied in shape as possible, in order to create extended transition zones – ecotones – between water and land.
2. Shallow shores and inundation zones with an angle of slope of about 1:10 increase the area that can be colonised by most fresh water organisms.
3. Among the mostly shallow edge zones, steep slopes for burrow-digging birds should be included.
4. In order to guarantee ice-free zones for animals overwintering in the water, permanent waters should include areas where the depth is at least 1 to 1.5 metres.
5. Encroaching woody plants should be cleared every few years, especially around smaller water bodies.
6. Structural diversity can be enhanced by bringing in dead wood, or nesting rafts for colonial breeders such as common terns (*Sterna hirundo*).





The Hanson-RSPB wetland project

The renaturalisation of a vast dry mining site at Needingworth Quarry in Cambridgeshire, south-eastern England, has raised the bar for what can be done in post-use mineral site habitat creation. The owner, the Hanson Company (HeidelbergCement Group), has been creating an extended wetland area of open water and large reed zones on formerly drained agri-

cultural land in the old flood plain of the River Great Ouse.

The project is carried out in close cooperation with the Royal Society for the Protection of Birds (RSPB), and with local people. The wetlands are created step by step, in sections of about 40 hectares. A system of ditches and water-gates (sluices) at the edges allows for the exact regulation of

water inflow and water levels. In order to accelerate the development of reed beds, reed seedlings are being planted in the renaturalised areas. Willow saplings are being removed, and the whole area is being flooded to a depth of 15 to 70 cm. The aim is a total area of 700 hectares of wetland which will offer habitats for rare waterfowl species such as Eurasian bitterns and western marsh harriers (*Circus aeruginosus*).

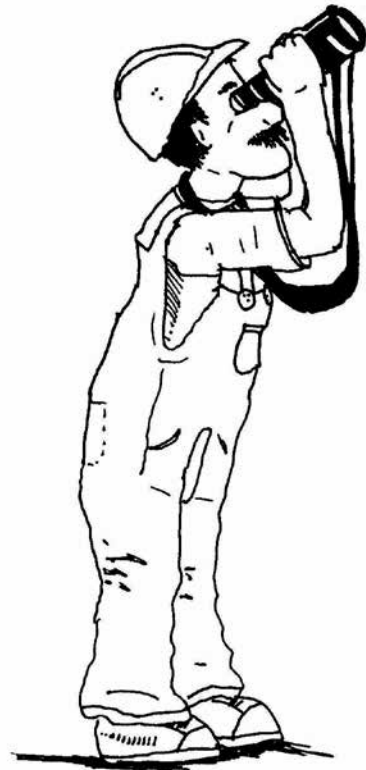


02



01 Vast reed zones at the Needingworth Quarry offer habitats for numerous threatened waterfowl and wader species.

02 The grey heron (*Ardea cinerea*) likes wet feet, and being screened from view by reeds.





01 Volunteers fencing an area with planted reeds.

02 The common reed bunting (*Emberiza schoeniclus*) profits from reeds in the Needingworth Quarry.



02

Structural diversity – the icing on the cake for higher species-richness

During and as a result of the extraction of gravel and rocks, an array of structural elements is created which are important habitat components for many plant and animal species. Examples are slopes and rock faces from different parent materials and the screes at their bases, sand and gravel heaps, overburden stockpiles, and heaps of dead wood. Such structural elements have become very rare in “tidied-up”

cultural landscapes, and are important prerequisites for the survival of many specialist species. Well-known examples are steep sand, loess or loam slopes where many solitary bee species, as well as birds like kingfishers, sand martins, and bee-eaters, dig burrows for breeding.

Sand and gravel heaps and overburden stockpiles are important habitats for many insects such as butterflies

and grasshoppers, which need warm, sunny, open sites. Lizards use them to lay their eggs, and for sunbathing. In addition, substrate that can be easily dug offers suitable hideaways and frost-free overwintering cavities for many reptile and amphibian species. Heaps of dead wood may serve the same function.



General recommendations for the design of specific structural elements

1. Do not cover these valuable bare "pioneer" habitats with topsoil, as this will speed up the succession to less desired stages of vegetation.
2. No planting.
3. Remove encroaching scrub every few years if necessary to reduce shade.
4. No management actions during the bird breeding season.

Creation and management of hard rock faces

1. Rocks and rock faces should be shaped in a manner inspired by nature.
2. Rocky ledges, projections and depressions should be promoted and kept.
3. Rock faces and rocky areas should be fenced to prevent disturbance and accidents.
4. Given sufficient stability, walls with a height of 30 metres and more offer ideal potential breeding sites for peregrine falcons (*Falco peregrinus*) and eagle owls.



03

01 Steep faces and slopes of loose material are used for breeding by hole-nesting bird and insect species.

02 The eagle owl (*Bubo bubo*) breeds on rock faces. This young owl is almost fully fledged.

03 A scree in a limestone quarry in early spring, with flowering coltsfoot (*Tussilago farfara*).

01 Hard rock face in a limestone quarry with screens at its base.

02 Richly-structured mineral extraction site with small ponds, open gravel plains, heaps of sand and large boulders.

Creation and management of soft rock and soil faces

1. Even small steep faces can play an important role, for example, in providing breeding sites for solitary bees.
2. The best opportunities for designing and creating rock and soil faces are during active mining.
3. Rock and soil faces must not be touched during the bird breeding season.
4. The nature potential of sites away from water should also be exploited. Steep slopes can be created at longer-term overburden stockpiles, for instance.
5. Before taking such actions, possible conflicts between different nature-protection aims have to be evaluated.



01

Creation and management of overburden stockpiles, screes, sand and stone heaps

1. Include holes at least 1 metre deep, filled with coarse stones with diameters of at least 10 cm, as frost-free overwintering habitats.
2. Overburden stockpiles should not be created next to exposed, sunny rock walls or waters because of negative shading effects.
3. Material of different grain sizes, such as sand and gravel, should be kept in separate layers.
4. Coarse materials should be piled up with a southern exposure in order to create pioneer sites.
5. Water bodies should be kept open by periodic dredging following a rotation model (see sidebar page 41).



Unconsolidated materials - harsh conditions where only pioneer species thrive

In post-use mineral extraction sites, unconsolidated materials are left in piles and screes and on the quarry floor. These are very young soils with no, or at least very little, organic matter, and low nutrient content. Unconsolidated materials in mineral extraction sites are often sandy-to-gravelly, and therefore very permeable. As there are hardly any nutrients, very low amounts of fine substrates for rooting, and little water, plants establish at a very low rate. Only specialist pioneer species, which cannot compete with more rapidly-growing plants on richer soils, can live under these extreme conditions. Typically, these species are either inconspicuous annuals, such as the spurge flax, or succulent species with adaptations to nutrient-poorness and drought, such as stonecrops (*Sedum* species).



Many animal specialists also occur at such sites, including tiger beetles (*Cicindela* species), blue-winged and red-winged grasshoppers (*Oedipoda coerulea*, *O. germanica*), and little ringed plovers (*Charadrius dubius*).

Design and management of unconsolidated materials

1. Unconsolidated materials are created spontaneously during mining.
2. They are typical **wanderbiotopes**, a word used in German ecological literature to describe temporary habitats created at different times and in different parts of a site during mineral extraction. Planning ensures that whenever one of these temporary habitats is destroyed by mineral extraction, a replacement site is available close by for disturbed species to move, or be moved to.
3. No topsoil distribution and no planting!
4. No actions during the bird breeding season.
5. Removing encroaching scrub every couple of years ensures full sun exposure, and prevents nutrient inputs from fallen leaves.
6. In post-use mineral extraction sites, unconsolidated materials can be maintained by grazing, or stripping the surface with graders when necessary, according to the rotation model. In the case of loose materials, tilling or ploughing can also be an option.

01 Unconsolidated materials – in this case in a gravel pit – are continually created during active mining.

02 Perfectly camouflaged: the slender blue-winged grasshopper (*Sphingonotus caeruleus*).

03 Basil thyme (*Acinos arvensis*) grows on young unconsolidated materials within quarries and gravel pits.

03



01 The unconsolidated materials left after mining are often sandy or gravelly, with little organic matter.

02 A rare inhabitant of unconsolidated materials: the yellow bugle (*Ajuga chamaepitys*).

03 The inconspicuous spurge flax (*Thymelaea passerina*) which occurs on unconsolidated materials in quarries has become rare in intensively farmed landscapes.

04 The green tiger beetle (*Cicindela campestris*) preys on other insects on sparsely vegetated soils.



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Dry semi-natural grasslands and heaths – species diversity on nutrient-poor soils

On dry, nutrient-poor unconsolidated materials, natural vegetation development leads to different types of dry semi-natural grasslands or, on acidic soils, heaths. Which type of grassland or heath develops is chiefly dependent on whether the unconsolidated materials are calcareous, i.e. rich in lime, or acidic. In mineral extraction sites with sandstone or other low-lime substrates and acidic soils, sandy

grasslands may develop. With ongoing succession, different dwarf shrubs may become more and more abundant, finally forming heathlands. On soils with high limestone content, calcareous dry grasslands develop. They are among the most species-rich vegetation types in Europe, celebrated for their rich orchid assemblages.

Since they offer abundant flowers,

insect species, which are in turn the main food source for reptiles, birds, and some mammals.

If suitable management actions are taken, species-rich semi-natural grasslands may develop spontaneously at sites with unconsolidated materials. However, there are ways of speeding up their development.





How to establish dry semi-natural grasslands

1. Sowing seeds or hay: Only seeds of local origin should be used. Hay from meadows nearby is the perfect solution.
2. Freshly cut grass (or green hay): Distributing grass clippings to "inoculate" a site with seeds works in the same way as using hay. At a time in early summer when ripe seeds of as many plant species as possible are present, the donor grassland is mowed in the early morning. The clippings, wet with morning dew, are immediately carried to and distributed at the prepared new site. The clippings taken from 1 m² of the donor site are enough for 2 to 5 m² of the new site. Apart from the guaranteed regional origin, another advantage of using green hay is that the seedlings are better protected from desiccation, and from being blown away by the wind.
3. Transplantation of turfs or individual plants: Larger areas of dry semi-natural grassland may develop from parent plants spaced at intervals. This method is also suitable for introducing rare species, or species that are difficult to establish via seeds.
4. Grasslands can also be relocated by stripping the vegetation with its roots with Caterpillars, and transferring the turfs to the target site.
5. The methods described here can also be used for other types of herbaceous vegetation.

01 Calcareous dry grassland in a quarry. The large purple flowers of Chiltern gentians (*Gentianella germanica*) and the pale ones of Carline thistles (*Carlina vulgaris*) are visible.

02 The dwarf everlast (*Helichrysum arenarium*) is a typical species of nutrient-poor, sparse sandy grasslands.



02

How to manage dry semi-natural grasslands and dry tall herb vegetation

1. With the exception of extremely dry sites, where no forest can establish under natural conditions, dry semi-natural grasslands are man-made, and can only be preserved in the long run by suitable use or management.
2. Grasslands on extremely shallow soils, and dry non-grass herbaceous (forb) vegetation, sometimes need only very extensive management, such as the occasional removal of encroaching scrub. The grass clippings and woody material must be taken away to prevent nutrient accumulation.
3. A classic management method is mowing, and removal of the hay. Well-developed dry grasslands need to be cut only once per year.
4. Alternatively, extensive grazing can be used to maintain semi-natural dry grasslands.





02

01 Dry heathland with common heather (*Calluna vulgaris*).

02 Calcareous dry grasslands are often rich in orchid species. This picture shows green-winged orchids (*Orchis morio*) and early spider orchids (*Ophrys sphegodes*).

Mowing versus grazing

There are pros and cons for both mowing and grazing, and the decision about which management type is best has to be taken for each individual case. The main difference is that a mower does not differentiate between species, but cuts all plants at the same height. In contrast, pasturing livestock forage preferentially on plants that are more tender and palatable than others. The consequence is that tasty species become rarer over time, while unpalatable species profit and become more abundant. If orchids are to be protected and promoted, grazing is usually not a good idea at all, because livestock tend to feast on them. On the other hand, spiny or bristly thistle species, as well as bitter plants such as gentians, are well-adapted to livestock, and are in fact promoted by grazing.

Another difference is that livestock – especially big species – cause trampling damage. Wallowing, pawing and similar behaviour also creates open patches in the soil. Such small-scale disturbances of the sward, however, do not usually have a negative impact. On the contrary, open spaces are of high importance for many animal species, and for the germination of some annual plant species.

After nature protection targets, practical aspects need to be considered. In order to be able to use standard agricultural machines safely, the ground has to be level and wide enough. For small, steep or uneven meadows, grazing is usually more practical and less costly too. However, for large meadows at least, mowing is usually cheaper than pasturing. Mowing also has the advantage that it can be scheduled at times when it will have the least impact on breeding animal and seeding plant species.





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How to manage heathlands

1. Dry heathlands are generally easier to maintain than dry semi-natural grasslands. In most cases, it is sufficient to remove encroaching bracken and scrub regularly.
2. Heathlands profit from extensive grazing. Moreover, small disturbed areas in the vegetation cover are created by the grazing animals' hooves. Such microsites are favourable for many plant and animal species.

01 Heathland with common heather (*Calluna vulgaris*) and European blueberries (*Vaccinium myrtillus*).


 Flagship
project

Semi-wild pasture in Schelklingen-Gerhausen

Until about 2000, the Schelklingen-Gerhausen quarry in the Swabian Alb (south-western Germany) was used to extract limestone for the cement industry. In the post-use quarry, an area of roughly 93 ha has been grazed by a mixed herd of 13 Taurus cattle and 14 Konik horses. The project is being carried out by a dedicated company, the Urzeit Weide GmbH. The shareholders of this company are HeidelbergCement and the Blautal Land-und-Forst GmbH & Co. KG.

The other partners are the industrial association ISTE, and the nature conservation organisation NABU, BirdLife International's representative organisation in Germany.

The semi-wild pasturing aims at preserving the habitats of the little ringed plover and the natterjack toad. These serve as “umbrella species”; in other words, actions to conserve these species and the conditions they require also protect other species and their habitat requirements.



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- 01** One of the main objectives of grazing at the former Schelklingen-Gerhausen quarry is to keep the habitat of the little ringed plover (*Charadrius dubius*) open.
- 02** Browsing Taurus cattle push back encroaching scrub from the quarry floor.

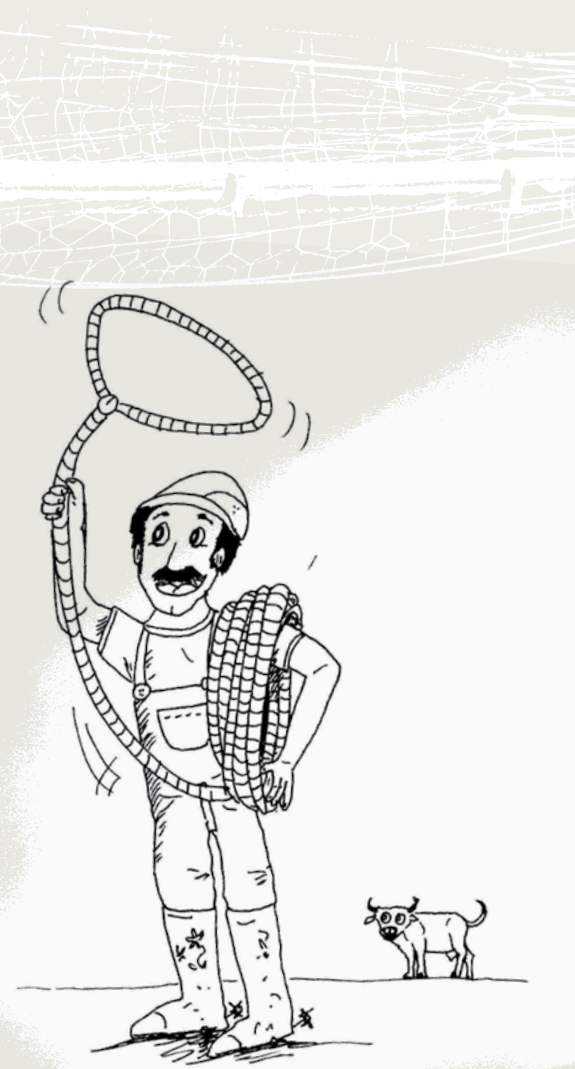


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01 The Taurus cattle's landscape work is backed up by a small herd of Konik horses. These breeds are attempts to recreate two of Europe's extinct big herbivores, the Aurochs and the Tarpan.



Flagship
project

Sheep pasturing in the Geseke limestone quarries

In order to protect and manage the semi-natural dry meadows within quarries, the association “VerBund e.V. Geseke” in northern Germany has been breeding its own kind of sheep. The emerging breed, the “Hellweg-Steinschaf” is robust, and undemanding, given the sparse diet available in the quarries, and not too heavy, so that it does not damage the delicate vegetation by trampling. It sheds its hair naturally so that no shearing is necessary. Pasturing with this sheep breed in three post-use quarries south of Geseke has already shown some success in maintaining the dry meadows. Scrub encroachment has been pushed back successfully, and herbs and grasses in the meadows are thriving.



01



01, 02 The "Hellweg Steinschaf" sheep breed is being bred specifically for extensive "conservation grazing" within quarries.



Establishing new dry meadows using grass clippings in the Swabian Alb



Since 1992, Dr. Ulrich Tränkle has been carrying out long-term experiments for the establishment of new dry calcareous meadows in quarries in the Swabian Alb. Using freshly cut clippings (green hay) from a species-rich meadow has proved to be a particularly effective method. Suitable donor meadows are identified in the local area, and the grass and wildflowers are cut in early summer, when most of them have ripe seeds. The clippings are transferred to the target sites in the quarry. It does not take long until typical plant species, such as upright brome (*Bromus erectus*) and common kidneyvetch, establish and begin to spread within the quarry. Insects and other animals soon visit and occupy the new meadow.

Flagship
project

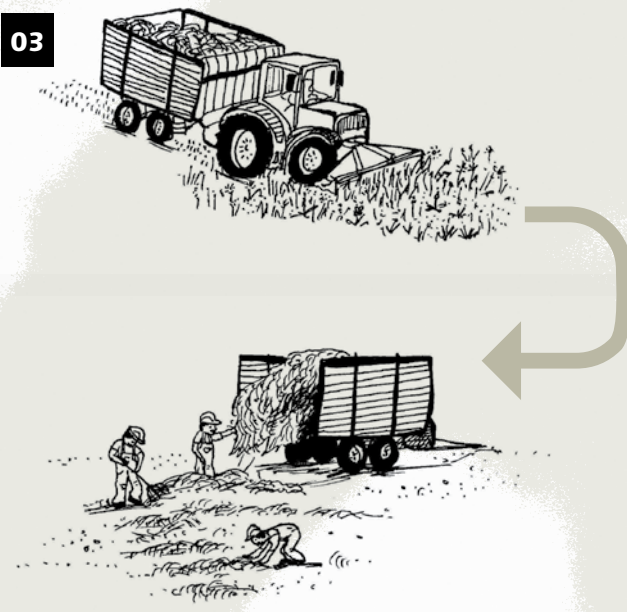


- 01** The grass clippings are transferred to the target site.
02, 03 Cutting and spreading the "green hay".
04 Flowering common kidneyvetch (*Anthyllis vulneraria*).

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Living structural elements in the open landscapes – hedges, copses, groves

Hedgerows, copses, thickets and groves are important structural elements within open cultural landscapes. Hedgerows are linear features composed mainly of shrubs with a few mature trees, while copses, thickets and groves are effectively small woodlands. The distinctions between these and other English terms for small wooded features in the landscape are not clear, but in general, copses are smaller, and thickets denser, while groves are larger and have

a higher proportion of fully-grown trees with little or no shrub-layer beneath them. Such areas dominated by trees and shrubs enhance species diversity in open landscapes significantly. They provide insects, such as certain butterflies, and especially many bird and mammal species, with hiding places, and breeding or roosting sites. The fruits of the shrubs and trees are an important food source for many animals, especially birds. Along the fringes of small woods and hedges

grow many light-demanding grasses and flowering tall herbs (forbs), which also provide habitat and food sources for many insects. Last but not least hedges, copses and groves increase species richness by subdividing the landscape into compartments, and increasing protection from the wind. This is of special importance for many insects. In many European landscapes hedges and trees have been planted to reduce the detrimental effects of wind erosion.

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How to design and manage stands of woody plants

1. Hedges, copses and other small woodland habitats can be created by planting, or by sowing or broadcasting seeds. The "Benjes hedge", devised in Germany, is a technique that takes advantage of natural seed dispersal mechanisms, and ensures that only local seeds are used. Brushwood bundles are piled up, then songbirds take care of the rest: they use the brushwood as perches and roost-sites, where they excrete seeds from fruits eaten at sites nearby. The brushwood also protects the developing seedlings from trampling, and from browsing by cattle and deer.
2. The cold season is best for tree and hedge planting.
3. It is crucial – and in some countries required by law – that only seeds or saplings of tree and shrub species that are native to the landscape are used.
4. Shrubs and some tree species can be rejuvenated by pruning or even cutting them back to the trunk when necessary (coppicing or pollarding).
5. Old trees and dead and decaying wood should be left in place, because they serve as important habitats for many species, including fungi, woodpeckers, and the larvae of wood-boring beetles.

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01 This copse in a gravel pit is composed of common sea-buckthorn (*Hippophae rhamnoides*) and common elder (*Sambucus nigra*). It plays an important role as a breeding site for birds. The berries of both these tree species are an important food source for birds in autumn and winter.

02 The red-backed shrike (*Lanius collurio*) is a typical bird of open landscapes interspersed with copses, scattered trees and scrub.

03 The common broom (*Cytisus scoparius*) is not only beautiful to look at; it also offers plenty of nectar and pollen for insects.

04 Different rose species – in this case a sweet briar (*Rosa rubiginosa*) – are frequently found in hedges and around copses.

Give free rein to nature by allowing natural vegetation to develop

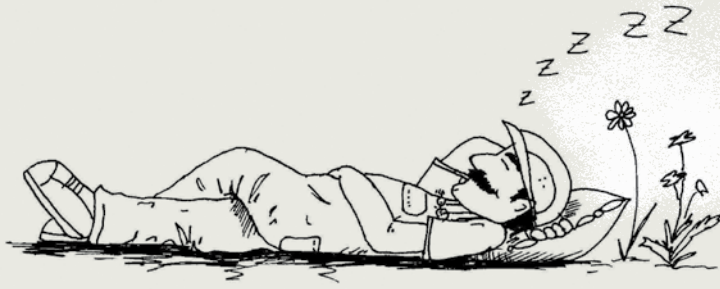
On nutrient-poor unconsolidated soils, species-rich vegetation with high value for nature conservation may develop all on its own.

In many regions of the world, forests are the final stage of vegetation

development. The process runs step by step via the following stages, each characterised by different communities of species: pioneer plants and animals – tall forb vegetation – scrub – pioneer forest – forest. Each stage offers habitats for certain plant and animal species. If it is not intended

to promote particular rare or threatened species that depend on a certain transient stage of vegetation development, parts of a mineral extraction site can be left to develop naturally.





Things to watch out for while you're doing nothing

1. As in general when renaturalising a site, the areas assigned for natural development must not be covered with nutrient-rich topsoil beforehand.
2. The sites should be protected from disturbance, trampling and use by vehicles.
3. Keep your hands in your pockets – and watch how things develop.
4. Only in the case of undesired developments, e.g. when non-native species move in, should interventions be made.

01 If post-use mineral extraction sites are simply left alone, pioneer forests, e.g. with silver birches (*Betula pendula*), may develop all by themselves.

02 Sparse birch pioneer forest in a quarry.

03 One-flowered wintergreen (*Moneses uniflora*) occurs in successional forests in post-use limestone quarries.



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How to deal with invasive plant and animal species

Globalisation is leading to an increasingly rapid spread of plants and animals from their original ranges to other parts of the planet. This may be deliberate, or may happen accidentally. If such alien species manage to establish themselves, they can crowd out native species. Climate change can make conditions less suitable for native plants, and more suitable for invasive species. For example, in regions with seasonal climates, invasive plants that would formerly have been killed by cold are now often able to survive the increasingly mild winters.

Well-known examples of invasive animal species are European rabbits in Australia or giant Indian pythons (*Python molurus*) and Burmese pythons (*Python bivittatus*) in the southern United States of America. In Europe,

aquatic organisms such as marbled goby (*Oxyeleotris marmorata*), zebra mussel (*Dreissena polymorpha*), killer shrimp (*Dikerogammarus villosus*) and several north American crayfish species are causing serious damage to habitats, and outcompeting native species.

Invasive alien plant species include tall “forbs”, such as Canadian and giant goldenrods (*Solidago canadensis*, *S. gigantea*), and Himalayan balsam (*Impatiens glandulifera*). The two goldenrod species are a particular threat to native dry meadow species, which they displace, while the Himalayan balsam thrives along shores, where it crowds out native species, but dies back in the winter, resulting in increased bank erosion. North-American black cherries (*Prunus serotina*) spread massively especially on sandy

soils, pushing back the original sand grasslands.

Barren sites dominated by unconsolidated materials are particularly prone to infestation by alien plant species. When topsoil is brought in during restoration, the seeds of alien plant species are often introduced involuntarily – a serious threat in mineral extraction sites! As soon as such undesired alien plant species are noticed, immediate management actions should be taken to remove them before they become established.

01 Beautiful indeed, but a threat to native plant communities: the north American black cherry (*Prunus serotina*).



01



01 Crayfish released into waters by anglers or aquaculturists pose a severe threat to native water organisms. This picture shows a calico crayfish (*Orconectes immunis*). Many crayfish species have a huge reproductive and dispersal potential – and an enormous appetite as well. They can carry diseases which are fatal to native crayfish, but to which they are themselves immune.

What to do against invasive species?

1. No general advice can be given, because each individual invasive plant or animal species requires specific management actions to control or eradicate it.
2. As soon as single specimens or small groups of invasive species are seen, immediate action must be taken. Once these species have established and colonised larger areas it is often almost impossible to tackle them successfully.
3. Management actions should aim to prevent successful seed development by the invasive species.
4. Many invasive plant species propagate vegetatively (via roots or above-ground plant parts). Therefore machines that are used in affected areas must be thoroughly examined and cleaned to prevent bits of root or stem being transferred to new places in soil sticking to tractor tyres or caterpillar tracks, or on trailers, mowers, and other equipment.
5. The same precautions must be taken when dredging vessels or other equipment used in water is moved to other sites. These are often covered with invasive animal species – especially mussels. They should be cleaned thoroughly and left to dry long enough for the invasive species and their eggs to die off.
6. Canadian and giant goldenrods can be controlled by cutting them shortly before flowering in June/July, and preferably a second time in autumn. However, cutting has to be repeated every year, and in most cases the goldenrods will never vanish completely. The same is true for an array of other species, for instance the American black cherry.
7. Stands of Japanese or giant knotweeds (*Fallopia spec.*) are extremely tenacious. Following cutting, they can be covered with thick black foil in order to kill the regrowth, but this, too, takes several years. Knotweeds are palatable to grazing animals, so another strategy might be repeated sheep pasturing.

Species in the spotlight – targeted management programmes

Peregrine falcons, common terns, kingfishers and many other species have very specific habitat demands. They can be especially picky when it comes to choosing a site to raise their offspring. There is often a significant lack of suitable nesting sites, especially for cavity breeders among birds and bats. This can be improved with relatively little effort, by offering artificial nesting sites.



Other species-specific management actions include the promotion of nectar plants required by specialist bee species, or of plant species that are the only food source of caterpillars of certain butterfly species. Highly threatened plant species can be introduced to suitable sites within quarries and gravel pits in order to stabilise their populations. Nature conservation authorities may need to give permission for projects involving threatened species.

01 A male Idas blue (*Lycaeides idas*) on common broom (*Cytisus scoparius*), the food plant of its caterpillars. Populations of this species can be stabilised by promoting its food plant.

02 Threatened plants of dry semi-natural meadows, such as the military orchid (*Orchis militaris*) in this picture, can be conserved by promoting dry meadows within post-use mineral extraction sites.

03 The peregrine falcon (*Falco peregrinus*) can be helped by installing special nest boxes.

How to carry out species-specific management actions

1. Planning and carrying out species-specific management actions requires cooperation with specialists and with nature conservation authorities.
2. However, nesting aids for birds and bees or artificial roosting sites for bats can be installed with little effort, at low cost and without specific planning. Specialists should still be contacted in these cases in order to pick the most suitable sites.
3. It makes sense to initiate targeted management actions during active mining. For instance, small water bodies can be created as spawning habitats for amphibians, or steep banks for the burrows of kingfishers, sand martins, or bee-eaters.

03



Flagship
project

Reintroduction of pasqueflower species



Pasqueflower species grow in open grasslands free of woody plants. In most countries where they occur, they are listed as threatened. Moreover, six pasqueflower species are listed as protected species in Annex II of the Habitats Directive, and thus of special interest in the nature protection legal framework of the European Union.

The project was carried out at three sites in accordance with the relevant nature conservancy authorities: Cementa AB Slite (Sweden), OJSC Doncement, Amvrosiyivka (Ukraine) and Schelklingen (Germany).

Seeds of the species Eastern pasqueflower (*Pulsatilla patens*) (Sweden), small pasqueflower (*Pulsatilla*

pratensis) (Ukraine), and common pasqueflower (*Pulsatilla vulgaris*) (Germany), were collected in the given regions, and the seedlings cultivated in pots, in the open or in greenhouses, for one to two years. The young plants were then planted at suitable sites within the renaturalised areas.



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01 Sowing pasqueflowers to produce seedlings for reintroduction.

02 Common pasqueflower (*Pulsatilla vulgaris*), Germany.

03 Eastern pasqueflower (*Pulsatilla patens*), Sweden.

04 Small pasqueflower (*Pulsatilla pratensis*), Ukraine.



The HeidelbergCement sand martin project

Sand martins breed regularly in HeidelbergCement gravel and sand pits. Breeding sites are steep slopes of sandy and loamy material that are continually created during the mining process.

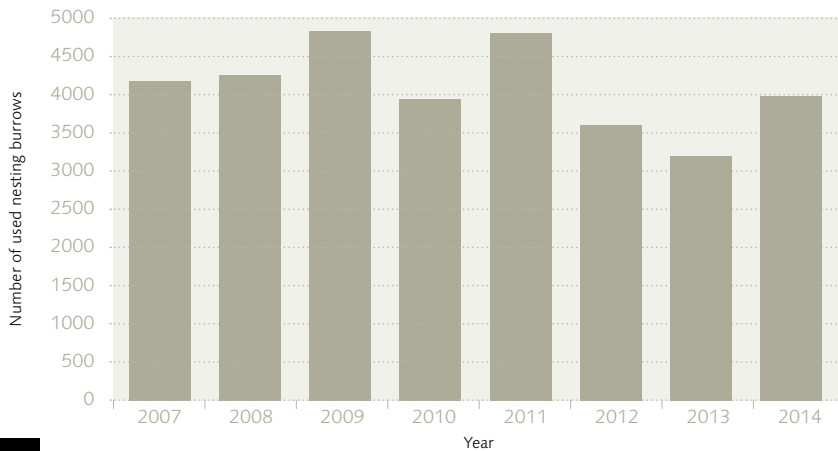
The aim of the project, which started in 2007, is to identify potential conflicts between mining interests on the one hand, and species protection and nature conservancy on the other. These conflicts can then be prevented

by tailored management actions. During the breeding season all nesting burrows in 42 German mineral extraction sites are monitored and mapped. During the winter, the site managers plan their mining activities for the months to come. If steep faces that are attractive to or actually used by sand martins are affected by scheduled mining during spring or summer, alternative steep faces are created for the birds. This is done by removing shrubs from disused steep

banks and cliffs, and creating new steep faces with excavator shovels in sandy-to-loamy topsoil deposits. At the same time, the former nest banks designated for mining are flattened, so that they can no longer be used by sand martins returning from their wintering grounds.

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01 A sand martin (*Riparia riparia*).

02 The total population of sand martins in 33 German gravel pits displayed a slightly negative trend – on a high level – in spite of the management actions taken since 2007.

03 A steep face with nesting burrows of sand martins.

**03**

Glossary

alien species / invasive species	Plant and animal species that have been either actively or involuntarily introduced to other parts of the world, where they spread aggressively.
amphibians	Collective name for frogs, toads, newts, and so on.
aspect	→ exposure
biocoenosis	Community of organisms of various species (animals, plants, fungi, etc.) within a definable → habitat.
biodiversity	Encompasses the diversity of species, genetic diversity, and the diversity of ecosystems.
bog	→ marsh
clay	Fine-grained natural rock or soil material (particle size < 0.002 mm). Clayey soils tend to hold water very well.
corridor	A wildlife corridor, habitat corridor or green corridor connects areas of habitat in the wider landscape, enabling species to disperse and find food or mates. Hedges, railway embankments and road verges can function as green corridors.
cultural landscape	Landscape that has been altered – to different degrees – by human activities. (This term is often used in a more specialised sense to describe landscapes of historic and cultural value.)
diversity	Variety of biotic systems; diversity in species, in structure, in function. Diversity can be measured at different spatial levels – from a square metre of grassland to an entire ecosystem or region – and over time.
dry mining	Mining minerals without touching the groundwater. Opposite: → wet mining.
ecological niche	The ecological role and space that an organism fills in an ecosystem. Sometimes referred to as the "profession" of a species.
ecosystem	Network of organisms interacting with each other and their → habitat.
ecotone	Transitional zone between different → habitats.
edge	The boundary between two habitats, such as woodland and grassland. Edge habitats can contain species from both adjoining habitats, but some species are edge specialists. Hedges are a kind of edge habitat, supporting many of the species typical of a woodland-grassland edge. Edge habitats can be species-rich, but too much edge is symptomatic of the fragmentation of a habitat such as forest, with the potential loss of species.
erosion	The breakdown and movement of materials such as soil or rock, often by water or wind, but also by ice, cycles of freezing and thawing, and chemical processes (for example, carbon dioxide in water forms carbonic acid, which dissolves limestone).
exposure (or aspect)	The direction a site faces. In the northern hemisphere, south- or west-facing slopes get the most sun. Aspect affects the local (micro-) climate, the humidity (the amount of water available), and therefore the plant and animal communities.

fallow	An area which is left uncultivated, as part either of a crop rotation, or an agro-ecological scheme to promote biodiversity on farmland.
fauna	The animal species of an area. Can be broken down by group, e.g. avifauna (birds).
flood plain	The lowland areas bounding a river or stream, which under natural conditions will be subject to seasonal or periodic flooding. Floodplains are dynamic, high-biodiversity environments. Regular flooding carries away and redeposits gravel and nutrient-rich silt, creating new habitats.
flora	The plant species of an area.
grassland	A vegetation type found where rainfall is insufficient for forest to develop, or where forest has been cleared and the ground kept open by mowing or grazing. Natural grassland is very rich in plant and animal species, but grassland "improved" with fertilisers supports only the most competitive plants ("weeds").
habitat	Place where an individual of a species or a community of species lives. A habitat consists of physical ("abiotic") factors such as soil, water and light, and "biotic" factors – other species, including predators, competitors and food species.
habitat network	Linked areas of the same or different kinds of habitat, enabling a species to disperse through the landscape and meet all its needs, including feeding, breeding and seasonal movements.
habitat tree	Big, old standing tree with cavities and crevices, and patches of dead and rotting wood or dead branches. These are of high value for nature, because they offer habitats for many species.
hay	Grass and other herbaceous plants cut (mown) in late spring or early summer and dried in the sun to provide fodder and bedding for livestock. Because the grasses and other plants will have reached the stage of bearing seeds by the time they are cut, hay from a wild flower meadow can be used to "inoculate" bare ground to create new grassland. "Green hay" has been mown but not dried, and is transferred to the new grassland site immediately after cutting, while still wet with dew.
heathland	Type of landscape and vegetation dominated by dwarf shrubs on well-drained, acidic, often sandy soil of low fertility.
hedge	A linear landscape feature of trees and shrubs prevented from growing to their full height by regular cutting. Periodic cutting also causes multiple stems and branches to form, creating a dense barrier.
invertebrates	All animals without a spinal column, such as insects, molluscs and worms.
laterite	Soil type rich in iron and aluminium, found in hot and wet tropical areas. May form a hard crust following desiccation and degradation.
loess	A kind of unconsolidated rock, made up of fine materials transported and deposited by the wind.
marl	Lime-rich mudstone which contains variable amounts of clays and silt.

Glossary

marsh	A habitat consisting of wet though not usually flooded soil, often found around lakes or along rivers. Sometimes used interchangeably with bog and swamp, though bogs (and mires) are dominated by peaty soil, and swamps have trees and other woody vegetation, while marshes are covered with sedges and herbaceous plants.
meadow	A field mown for hay to provide winter fodder. Grassland where animals graze is called pasture.
moor	The upland equivalent of heath, moorland is a habitat consisting of wet soils (often peat) on which dwarf shrubs and tussocky grasses grow.
mowing	Cutting the grass in meadows to make hay.
natural forest	Forest that has been allowed to develop spontaneously, without human interference.
natural landscape	Landscape that is largely unaffected by human activities. Opposite: → cultural landscape.
pasture	Grassland used for livestock grazing. → meadow.
pioneer forest	Early stages in the reforestation of a location characterised by more or less short-lived woody plants needing a lot of light. Pioneer tree species include birch, aspen, elder, alder and cherry.
pioneer habitat	In our context, habitats created during the mining process by stripping away topsoil and exposing unconsolidated materials.
plant community	Group of plant species sharing a habitat. They may interact by competing with (e.g. for light or nutrients), complementing (occupying different niches), or depending on one another.
primeval forest	Forest which has undergone no, or very little, interference by humans. Also known as old growth, virgin, or primary forest. In actual fact, very little forest in Europe and North America (and none at all in smaller, heavily developed countries like the UK) has been free from any human interference. The UK term "ancient woodland", for forest that has existed continuously at a location since before the 17th century, may be of more practical value.
recultivation	Restoring a mainly cultural landscape at post-use mineral extraction sites. The restored landscape may be used for farming, forestry or other economic purposes. Land restored for its biodiversity rather than economic value is described as → renaturalised.
reeds / reed beds	→ Plant communities in shallow waters at river banks or lake shores, consisting of tall perennial grasses with hollow slender stems, especially of the genera <i>Arundo</i> , <i>Typha</i> and <i>Phragmites</i> .
renaturalisation	Returning the site to as near a natural condition as possible, with or without targeted management actions. The aim is to optimize the site in the interests of biodiversity.
reptiles	Collective name for such species as turtles, tortoises, snakes, lizards etc.
rotation model of habitat management	The area to be managed is divided into parts, and these parts are managed in a regular sequence, with intermittent rest periods. The idea is to get a spatial and temporal mosaic of different successional stages.

sedge	Plants of the genus <i>Carex</i> which frequently occur in wet habitats such as → marshes and → moors.
semi-natural dry meadow	Unfertilised, sparse, low-productivity → grassland with high richness of herb species.
scrub	An intermediate habitat consisting of shrubs and young trees, which may develop on ungrazed and unmanaged grassland, and which if left undisturbed may mature into woodland.
stepping-stone habitat	Islands of habitat which enable a species to disperse (spread) into the landscape. → corridor, → habitat network.
stratification	The treatment of seeds, for example at low temperatures to simulate winter conditions, to promote germination.
subsoil	Layer of soil between → topsoil and parent material (underlying geology), mainly mineral and lacking organic content (humus).
succession	Progressive changes of plant (and animal) communities at a site over time, for example, from bare ground, via pioneer species, to grassland, scrub and eventually forest.
swamp	→ marsh
tall forb vegetation	→ Communities of herbaceous plants, among which grasses if present are not dominant. Found on deeper soils with higher levels of nutrients than dry meadows, and with sufficient moisture to permit growth throughout the warm seasons.
temporary waters	Water bodies which dry up completely for certain periods of time. Seasonal ponds, for example, may be present only from winter to early summer, but provide fish-free breeding habitat for amphibians.
topsoil	Upper layer of the soil containing organic matter such as humus and microorganisms.
umbrella species	A species providing a focus for conservation work which also benefits other species in a community or ecosystem.
unconsolidated materials	Unconsolidated materials are the initial stages of soil development, for instance gravel or sand plains. Sometimes also termed protosoil.
vegetation	Entirety of plant communities in an area.
vertebrates	All animals with a spinal column such as mammals, birds, amphibians, reptiles.
wanderbiotopes	New early succession zones are continually created in active mineral extraction sites, while older areas reach later stages of succession. Habitats at a similar stage of succession therefore "wander" across the mineral extraction site, in space and in time.
wet mining	Gravel mining – in most cases with dredging vessels – below the groundwater level. It leads to the creation of gravel pit lakes. Opposite: → dry mining.

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