

The Life-project Sand Life



LAYMAN'S REPORT for Sand Life
Restoration of sandy habitats in Southern Sweden

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Sandy habitats

Sand is found along our coastal dunes, on extensive plains or in rolling inland hills. The sandy habitats have mainly been used for grazing, and for many people, the fight against the drifting sand remains in memory. On the other hand, for the plants, fungi and wildlife, the sandy environments form an eldorado with heat, drought and soils that are easy to dig.

The sandy soils through history

The sandy soils were formed when the latest ice left southern Sweden more than 10,000 years ago. Left was the virgin sand that was colonized by plants, animals and humans. Slowly, the sandy fields began to encroach, but were partly kept open by water, wind and wild grazing animals. First there were hunters and the forests consisted of oaks and pines, but from about 6,000 years ago, humans began to keep domestic animals for breeding and started early to farm the sandy soils.

Cultivation, grazing and utilization of the forests opened the landscape little by little. The lean sandy soils were mainly used for grazing and for collecting firewood and timber. Temporary fields were farmed during a couple of years and were then left to recover.

The sandy soils of southern Sweden began to be used more intensively during periods of population increase and turbulent times. Large harvesting of woods and fire woods were devastating the forests. In the absence of wood, grass and heather peat was broken to fences, rooftops, fuel and the building of defense facilities during the wars. In the early 1700s the problems with drifting sand culminated. Early in the process man were stopping the drifting sand, but it was not until the beginning of the 19th century when the state prohibited grazing, logging, collection of peat and seaweed on the arid sandy fields. Large-scale plantations in state administration with *Ammophila arenaria*, *Leymus arenarius* and pine trees began in southern Sweden. The sand became productive woodland with, among other things, alien species like mountain pines. It was first in 1936, the state regarded the sand being stabilized, but the plantations were still classified as protection forests.

The unique plant and wildlife

The blossoms of the open sandy fields and their high value as grazing and arable land were already noted by Carl von Linné on his Scanish journey and from Halland by his disciples Lars Montin and Pehr Osbeck, but

the species richness spans 18,000 years back. Different species have migrated for thousands of years and the diversity has increased thereafter. The plants, animals and fungi that have migrated to Sweden have been adapted to different environments, due to differences in climate and other conditions that have varied throughout the ages. For a maximum degree of species richness, all stages of encroachment are needed. Therefore, there is also need for a constant presence of bare sand in the landscape where everything can start over again.

The threats to the sandy habitats

The largest threat to the sandy habitats came through centuries of tree plantations. Since the beginning of the 20th century, the tourism and leisure increased along the coasts. A new era of protecting the sand took off by covering the sand with seaweed, putting up protection fences and prohibition to access the dunes to stop wear and erosion. The coastal nature reserves that were formed during this time had the purpose for favouring outdoor activities and prohibited, among other things, "jumping in the dunes".

Protective measures, together with the effects of nitrogen deposition and acidification, accelerated the rate of encroachment. In the 21st century, the nature conservationists became more aware of the critical situation for the biodiversity in open sandy soils. Above all, there were the negative trends for the rare bird, *Anthus campestris*, in Sweden and the insects in the sandy habitats of Halland, which became an eye opener. The sandy soils gained increased attention through Sweden's entry into the EU-community with commitment to protect nature and also by the expanded work with national action programs for endangered species.





An image of a restored sandy landscape in the 21st century with a mosaic of open dunes, sparse wooded dunes and inland open fields, all with bare sand. Illustration by Nils Forshed.

Sand Life

When it was clear that the sandy habitats had an extremely high species richness, the threats became obvious and the increasing need for restoration was seen, then the idea of a major restoration project was born and Sand Life became a reality.

Through Sand Life, the conditions for a thriving plant, fungi and wildlife in southern Sweden's sandy fields have been recreated. These environments have always been dynamic where different stages of encroachment (succession) have replaced each other. The purpose of the project was therefore to turn the clock back when restoring the first stages of the succession and then let the development takes its course. The objective was to create a landscape with a mosaic of different environments with bare sand, flowering vegetation, shrubs and trees.

For 6 years, between 2012 and 2018, 32 different activities have been carried out in 23 Natura 2000 sites in Skåne, Halland and on Öland. The activities that were

most visible in the landscape are the restorations that includes clearing of trees and shrubs, creation patches of bare sand, prescribed burnings or introduced grazing. How these activities have affected plant and animal life have been followed up by inventory of species and environments. To increase understanding of the natural values and needs for management of the sandy habitats, information and dialogue with stakeholders and the public have been prioritized.

Project partners

Sand Life has been a cooperation project between the three County Administrative Boards in Skåne, Halland and Kalmar County, Lund University and the Municipality of Kristianstad. Skåne County Administrative Board has been the coordinating part. The counties have been responsible for restoration and information, Lund University has monitored the effects on plants and animals and the municipality of Kristianstad has developed outdoor museums.



Natura 2000-areas included in the Sand Life project distributed in the three counties of Skåne, Halland and Kalmar.

Financing

The project was funded by the EU's Life + Nature program and had a budget of 7,8 million EUR. The EU accounts for half of the funding and the other half shares partners together with the co-financiers the Swedish Environmental Protection Agency and the Scania Landscape Foundation.

The restored sites

The project has been implemented in 23 Natura 2000-sites distributed in the three southern counties of Sweden; Skåne, Halland and Kalmar. The restored envi-

ronments include, partly, the coastal dune landscape from the exposed white dunes closest to the sea to the wooded dunes inland, and inland's large sandy fields, which may be more or less lime-rich.

After Life

When Sand Life ends, it is important that the sandy habitats are managed to maintain the open structures. All areas of the project are part of the Natura 2000-network and the county administrative boards are responsible for the continued management with funds from the Swedish Environmental Protection Agency.

Restoration actions in Sand Life from August 2012 to 2017 (2018 areas not included).

Action	Amounts
Clearing of trees and pulling stumps (hectar)	465
Clearing encroachment (hectar)	196
Removal of <i>Rosa rugosa</i> (hectar)	38
Creating areas with bare sand (hectar)	205
Prescribed burnings (number)	79
Fencing (meter)	11 511





Wide open coastal dunes at Friseboda, Skåne

Open coastal dunes

The open coastline with sandy beaches is popular for sunbathing and outdoor activities. There is also a unique vegetation, a rich insect fauna and the rare bird, *Anthus campestris*.

Description

The sand dunes along our coasts are dynamic environments. The coastal dunes are in constant transformation from the flat sandy beach that crumbles inland and slowly build the white dune with its sparse vegetation without mosses and lichens. When the vegetation stabilizes, a gray dune forms with a rich variety of flowering herbs and a certain amount of mosses and lichens. Furthermore, heath and small low-grown shrubs comes in and finally, bushes and trees. New sand is constantly added to the dune system from the sea, new dunes arise and wetlands are formed between the dunes.

Depending on how exposed the dunes are to winds and waves, lime and grazing, the dunes develop their special character and species richness. On the sandy beach, seaweed is accumulated, that favour a special vegetation. Perennial dune-grasses and the rare plant *Eryngium maritimum* are found in the white dunes and in early spring, the beetle *Apalus bimaculatus* can be seen flying in search of the bee *Colletes cunicularius* to parasitize. The gray dunes have a rich herbal flora with, for example, *Lotus corniculatus* and *Jasione montana*, and there is also a large variety of *Hymenopterans*. It is also in the open dunes that *Anthus campestris* seek food and lay their eggs.

Threats

During periods of over-exploitation of the coastal dunes, the sand was blowing in over the landscape inside the dune areas. Historical efforts to bind the sand have resulted in that only fragments of the former open dunes are left today. In these dunes, there is hardly any bare sand. During a couple of centuries, seaweed have been laid out in the dunes to benefit the vegetation and fence have been put up to catch the drifting sand. Grass, bushes and trees have been planted systematically. Information campaigns have effectively learned the visitor not to walk in the dunes. Today, the invasive alien species *Rosa rugosa* spreads in the dunes, effectively covering all other vegetation.

Actions and results

The project included 14 Natura 2000-sites with open coastal sand-dunes. Pine forests have been cleared in these areas. Alien species such as *Rosa rugosa* and *Populus balsamifera* have been cleared or excavated. The sand has been exposed when stumps or litter have been buried and nutrient-poor sand has been added to the top. The dunes have been burned off early in the spring to remove old grass, ancient, mosses and lichens. Sand has also been exposed when the fire breakers have been excavated. One of the most important actions has been to dig up *Rosa rugosa* in the dunes. This action was shown to be both costlier and more complicated than estimated.



Eryngium maritimum



Anthus campestris

Future management

It is a challenge to keep the coastal dunes open. The surfaces that have been opened up and the sand that have been exposed in Sand Life has let the encroachment (succession) start from the beginning. In the future, efforts will be necessary to keep the sand open, but to a lesser extent. The growth of shrubs and bushes will need to be cleared before it becomes too extensive. Recurring conservation burnings can hold back the accumulation of litter and the fire breakers created within the project provide a permanent element of exposed sand. The shrubs of *Rosa rugosa* has been removed, but in future it is important that all new spreads are immediately picked up. Recurring excavations will be required to maintain bare sand in the sites. Patches of bare sand is necessary to maintain the unique vegetation, the rich insect life and the rare bird, *Anthus campestris*.



Wooded dunes with glades at Bökakustens nature reserve, Öland

Wooded dunes

The open coastal dunes encroach slowly, trees establish and a wooded dune has been created. A mosaic of grass and herb in glades, bare sand, sunlit trees and dead wood create a warm and dry climate with a unique wildlife.

Description

The sand dunes along our coasts are in constant transformation and the dune system is constantly being built from the ocean. As various plants, mosses and lichens settle, the white dunes turn into gray dunes, heath and shrub-dunes, and finally into tree-covered, wooded dunes. The original dune forest consisted of pine- and oak-trees. Today, there are hardly any naturally occurring dune forests left along the southern Swedish coasts. During the past centuries, the wooded dunes were kept open by grazing and many were completely devastated for fire-wood and timber. Today's wooded dunes originate mainly from the plantations of pine in the last 200 years to stop the drifting sand or as an at-

tempt to gain economies on these fields. From these plantations, pine have spread into the open dunes and formed semi-natural forests. Today, the wooded dunes mainly consist of dense pine plantations with mosses and lichens in the field layer.

In pine forests with a variety of old, coarser trees, dead woods and open sand, a species richness thrives in both the open sand and on the sunlit trees. Here, *Chimaphila umbellata* and *Epipactis helleborine* can flourish and the larvae, ant-lions, lives in the bare sand. The openness of the wooded dunes, depends on how close it is located to the coast.

Threats

The biodiversity of the wooded dunes is dependent on the sun's rays warming up the sand, the trees trunks or the dead wood. Many of today's planted pine forests are of the same age without dead woods, shrubs or glades. In most sites, there are also elements of alien tree species. One example is *Pinus mugo*, which form impermeable dense stands, which in turn impedes both species richness and outdoor life.

Actions and results

In Sand Life 12 Natura 2000-sites with wooded dunes were included. In these sites, pine-trees, *Pinus mugo*, and *Populus balsamifera* have been eliminated. The open coastal heath has been broadened and a system of glades has been created inside the wooded dunes. Stumps have been pulled up to reduce the amount of nutrients in the ground. Much of the timber has gone to wood chippings and some stumps and litter have been buried, while light, nutrient-poor sand has been excavated and laid on the surface. Some of the encroachment and litter have also been burned.



Small pits in the sand with the larvae of ant lions. A larva can be seen on the inserted image.

Future management

It is a challenge to maintain the wooded dunes opened so that the sun can reach both the ground and the trees. The surfaces that have been cleared from trees and shrubs and the sand exposed in Sand Life has let the encroachment (succession) start from the beginning again. In the future, less effort will be necessary in the same areas. However, new glades may need to be created, but to a lesser extent. Some dead and dying woods should be stored in sunlit locations. Encroachment needs to be cleared regularly before it becomes too rough. Mechanical disturbance can be done in the glades that have been opened up so that there continuously will be exposed sand in the wooded dunes.



Open sandy fields at Revingefället, Skåne

Inland dunes

The sandy fields in the inland covered with grasses or heaths and bare sand harboring the country's richest insect life. Several of these areas have been cultivated, but are kept open today by extensive grassing. Since the 20th century, the military has been present in some areas which, through its driving, create the necessary disturbance.

Description

The sandy fields in the inland was formed when the ice sheet from the last inland ice melted and material that the ice carried, sedimented. The wind has then constantly rearranged the sand during periods of sparse vegetation. These sandy fields were easy to use and also the earliest to farm in the ancient landscape.

Inland sandy fields are found in Vombsänkan, on the plains at Ljungbyhed, on Kristianstadslätten and in the southeastern hilly landscape of Linderödsåsen. Inland sandy fields have been considered unproductive and

planted with forest or taken over by the military. Today, large parts of these sandy fields are covered by grass, herbs and heath. The vegetation is species poor, but with flowering herbs and an extremely rich insect life. Some of the country's most important sandy inland dunes are located in the military training fields at Revinge and Ravlunda. On grazed sandy fields, there is also a high species richness of dung-beetles, with many rare species such the *Copris lunaris* and *Aphodius quadriguttatus*.

Threats

The rich insect life in the inland sandy fields is entirely dependent on bare sand and flowering plants. Since the historical use with alternately cultivation, fallowing and grassing have ceased, these fields have encroached. Only grassing results in a denser grass-cover and abandoned fields encroached with bushes and shrubs. In the military fields, a change in activity with fewer military trolleys has reduced the level of mechanical disturbance. Earlier cultivation along with atmospheric nitrogen mean that many of these fields are nutritional influenced, favoring fast growing plant species. Today, there are also threats from planting, cultivation and exploitation.

Actions and results

The project included five Natura 2000-sites with inland sandy fields. The most significant restoration activity has been mechanical disturbance and bare sand has been created by digging, excavating, plowing and harrowing. Since the nutritional content can be relatively high at the ground level, the best method in the long-term has been to dig up nutrient-poor sand from deeper layers. On ungrassed surfaces, litter and mosses have been burned. New open sandy areas have also been created by clearing of pine plantations and encroachment of shrubs and bushes.



Future management

The inland sandy fields need constant soil disturbance to maintain the conditions for their rich insect life. The disturbances made in Sand Life have let the encroachment (succession) start from the beginning, and these surfaces will to some extent, slowly re-encroach. Some surfaces might be plowed after a few years to keep the sand open. In future, it will be necessary to repeat the diggings, excavations and plowings carried out within the project, but on a smaller scale.



Flowering xeric sand calcareous grasslands at Vitemölla strandbackar, Skåne

Xeric sand calcareous grasslands

The xeric sand calcareous grasslands are one of Sweden's most rare habitats with a very limited spread in the country. Extreme climate and special geology are important conditions. Calcium-rich sand in warm, sunny places where it falls extremely little rain are the crucial conditions.

Description

Heat, drought, sun, sand and lime provides the conditions for a special vegetation with many annuals and flowering herbs, the unique habitat xeric sand calcareous grasslands (sandsteppe). The sandsteppe needs recurring disturbance to let the calcareous sand reach the surface. In Sweden, only eastern Skåne and Öland have suitable climate and geology for sandsteppe. The sandsteppe can be divided into three different stages; initial phase with more than 60 percent exposed sand, optimal phase rich in flowering plants and annuals, as well as the encroachment phase with perennials, mosses and unique fungi. A mosaic of these three phases results in a sandsteppe in favorable conservation status. The richness of flowering herbs consists of the characteristic species of *Koeleria glauca*, *Dianthus arenarius*, *Astragalus*

arenarius and *Holosteum umbellatum*. The fungi are unique with several species in the genera *Geastrum*, *Tulostoma* and *Disciseda*.

Threats

Encroachment and no disturbance are the two largest threats to the sandsteppe. Leakage of lime results in a more acidic soil (lower pH-value), which changes the species composition of both plants and fungi. Nutritional impact favor fast-growing plant species that compete out the sandsteppe vegetation. The encroachment begins with a denser grass-cover of mosses that pass into heath, shrubs and bushes. There are also threats from planting, cultivation and exploitation.



Test-drilling after calcareous, nutrient-poor sand.



Dianthus arenarius ssp. arenarius

Actions and results

The project included 11 Natura 2000-sites with sandsteppe. New surfaces with the habitat have been created by clearing of pine plantations and encroachment of shrubs and bushes. On Öland, the heath was harvested and the hay was vacuumed to avoid accumulation of litter. Old vegetation and mosses have been burned in the sandsteppe. Most importantly, a new initial phase with bare, nutrient-poor sand has been created and the stirring has brought calcium-rich sand to the surface.



Tulostoma melanocephalum



Anthericum liliago



Koeleria glauca



Phleum arenarium

Future management

Sandsteppe requires constant management, but can with simple efforts be found or created in most south-facing slopes containing calcareous sand. The restorations made in Sand Life has let the sandsteppe start over again in a new initial phase. The succession now takes its course, and at appropriate intervals the sand will be stirred again so that the lime-rich and nutrient-poor sand returns to the surface.

Species richness in sandy habitats

The sand provides a warm microclimate, but are also dry and poor in nutrients that affect plants, animals and fungi. These species have developed special adaptations and strategies for their survival.

Plants

Plants in sandy habitats may have rolled or thick leaves to reduce evaporation, early flowering to avoid the summer drought or slow-growth to handle the low amount of nutrition. In the sandy heaths, *Helichrysum arenarium* and *Corynephorus canescens* grows, while *Dianthus arenarius*, *Holosteum umbellatum* and *Koeleria glauca* are found in the more calcareous soils.

Hymenoptera

The sandy habitats are rich in Hymenopterans, with many red-listed species. The sandy soils are easy to dig for insects that build their larva chambers below the ground. The Hymenopterans can be digging solitary bees, cleptoparasitic bees, so-called cuckoo bees, or species parasitical directly on the bees.

Beetles

The characteristic tiger beetles fly rapidly over the open sand, the ground beetles are looking for oil rich seeds in the sparse vegetation and in the dung of grazing animals the dung beetles put their eggs. In the dunes, *Apalus bimaculatus* can be seen flying around looking for the nests of the bee *Colletes cunicularius*, where it puts its eggs.

Butterflies

Many sandy habitats are rich in flowers that attracts butterflies like blue wings, gold wings and the shining *Adscita statices*. Less visible are the night-active small butterflies, where many live on *Genista*, such as *Agonopterix atomella* and *Coleophora genistae*. On *Dianthus arenarius* lives the extremely rare moth, *Caryocolum schleichi*.

Birds

The characteristic bird of southern Sweden's open sandy habitats is *Anthus campestris*, which now only occurs in eastern Skåne. In the mosaic-shaped landscape, with a mixture of open and woody/shrubby fields, the *Lullula arborea* and *Caprimulgus europaeus* can be found.

Gastroid fungi

In the low vegetation, small unique fungi thrive. These so-called Gastroid fungi include species in the genera's *Geastrum*, *Tulostoma* and *Disciseda*. In the lime-rich dry meadows and sandy grasslands most of the Gastroids is found.



Thymus serpyllum



Dasyroda hirtipes



Copris lunaris



Argynnis niobe



Anthus campestris



Geastrum

Particularly protective species

On the sandy areas of southern Sweden there are several species, that have been designated as special protection according to the EU, which are included in the Species and Habitats Directive or the Birds Directive. Through the restorations carried out in Sand Life, the habitats of these species have improved considerably.

Dianthus arenarius ssp. arenarius

The sandy pink (*Dianthus arenarius ssp. arenarius*) grows mainly on the dry, calcareous sandy grasslands in eastern Skåne. The unique subspecies are endemic to Skåne, Sweden. Sand Life has dug up calcareous sand and cleared encroachment to favour the species.



Maculinea arion

The large blue (*Maculinea arion*) occurs rarely on sandy grasslands in central and eastern Skåne and in open dry fields on Öland. Sand Life has cleared encroachment and exposed the sand to benefit the growth of its host, *Thymus serpyllum*.



Lacerta agilis

The sand lizard (*Lacerta agilis*) is found throughout southern Sweden except on the islands of Öland and Gotland. Sand Life has cleared encroachment and exposed sand to make way for the sand lizard to dig down its eggs that then hatch in the warm sand.



Anthus campestris

The tawny pipit (*Anthus campestris*) is found only in the southern Swedish sandy fields. Today the species has disappeared from Halland and is only available in eastern Skåne. In the project, forests have been cleared and large areas of sand have been exposed to benefit the tawny pipit.



Lullula arborea

The tree larch (*Lullula arborea*) is found on sandy fields with a mosaic of open sandy surfaces, shrubs and trees. Dense re-growth has been cleared and forests have been opened that has benefited the species.



Caprimulgus europaeus

The night jar (*Caprimulgus europaeus*) is a night-active bird that is well-camouflaged daytime. It is found in similar mosaic environments as the tree larch and benefits from the landscape being opened and the sand exposed.





Open glade after removing *Pinus mugo* and excavation of the litter in Gropahålet, Skåne

Harvest, pull and clear

Sand dunes, encroached by trees and shrubs, may need to be opened to be available for the species that thrives in the sun-warm sand. Dense tree plantations with predominantly alien tree species, such as *Pinus mugo*, and the semi-natural forests that spread across the open coastal sand dunes needs to be cleared. Through the pulling of stumps and up-rooting smaller trees, the fertilization from decaying plant material is avoided. Left barrels and litter are removed or burned off and nutrient-poor sand is dug up to the ground surface.

Within the project, almost 500 hectares of forest have been cleared. Larger trees have been cut and stumps excavated, while smaller trees have been pulled up with the roots. The timber has been removed from the areas and smaller amounts have been burned at site. Some dead wood has been left sunlit to favor insects and fungi living in the wood. In some cases, stumps and litter have been dug down and sand exposed. The result has become considerably more bare sand and wider, open coastal dunes and a sparse tree-covered wooded dune with more open glades.



Pulling up roots of *Pinus mugo* at Hökafältet, Halland



Flowering *Rosa rugosa*, Japanese rose

Remove *Rosa rugosa*

In the coastal dunes, *Rosa rugosa*, a shrub that originates from East Asia, is found. Some of the first findings of wild-growing *Rosa rugosa* in Sweden were in Halland in the 1920s and since then it has been planted to stabilize the sand and then spread with birds and water in the open dunes. The roots of *Rosa rugosa* go deep down to the groundwater, making it sustainable for sanding over by the moving dunes.

Rosa rugosa effectively covers the ground and prevent the growth of any other vegetation. The ground becomes dark, moist and cool. The plants, animals and fungi that naturally occur in the dunes are effectively outcompeted.

In the project, about 40 hectares of *Rosa rugosa* have been excavated from the dunes, in particular, in Halland

and western Skåne. The most effective method of removing the rose bushes is to dig up the entire root system. At the same time, light nutrient-poor sand can be dug up and laid on the surface. All root pieces of the roses are sorted in sorting plants and run to landfill or burned up. The clean sand is then placed at the bottom of the pit. It is easy to miss root pieces and therefore, it is important to go over the areas annually and pull up remaining plants that are coming up.

Digging *Rosa rugosa* turned out to be both complicated and expensive. It is almost impossible to know in advance how deep the roots are going and how much it needs to be excavated, sorted, and removed from the site. On the other hand, we know that *Rosa rugosa* grows fast and it becomes more expensive to wait.



Rosa rugosa at Flommen, Skåne



Removal of *Rosa rugosa* at Haverdal, Halland



Creating bare sand at Åby sandbackar, Öland

Expose the sand

Bare, sunlit sand and lime that reduce acidification in the soil (giving a higher pH-value) are key words for plants, animals and fungi to thrive in the open sandy habitats. Regular disturbance that recreates an early phase in the growth (succession) is therefore necessary. Before restoration work is started, consideration should be given to the objective of the actions and the species to be favored. It is also important to consider where in the landscape a patch of bare sand will benefit the biodiversity most.

Within the project, over 200 hectares of sand have been exposed by direct actions, depending on the degree of encroachment. On fields with large restoration needs, excavations or deep digging has been necessary. Deep digging has given the best results where light, nutrient-poor sand has been dug up to the surface. Excavating and plowing has worked best when the vegetation is already relatively sparse. In the military shooting fields, excavation has not been possible with conventional excavators because unexploded ammunitions can remain in the ground, and therefore, splitter-protected machines have been required on these fields. On the leanest fields with a low-grown vegetation, rough harrowing can also provide enough bare sand.

For many plants and fungi, the lime content of the sand is of great importance and it is crucial when restoring sandsteppe. In eastern Skåne and on Öland, the excavation needs to be done to the depths of the lime-rich sand. This sand is then placed at the top of the new patch of bare sand. In order to know at what depth the calcareous sand is found, soil samples have been taken to a meter in the project to document the level of lime, phosphorus, nitrogen and the pH-value.



Harrowing at Gårdby sandhed, Öland



Prescribed burnings, Skåne

Prescribed burnings

The un-grazed sandy fields are likely to encroach with grasses, mosses, lichens and heath as well as remaining dead material from previous years growths. The soil will be covered and the environment becomes moist and cooler. An effective way to remove this gathering is to burn off the vegetation. So-called prescribed burnings can be used as restoration of the field before grazing, as well as annual management to replace grazing and mowing.

The most appropriate time to burn is during March-April when the soil dried up, but before the vegetation started to grow. The weather on the day of the fires should be sunny with moderate wind in an appropriate direction. Preparations with fire breakers should already have been done. A fire breaker can be excavated, cut and/or irrigated.

In Sand Life, more than 80 different prescribed burnings have been carried out in the sandy habitats with grass- or heathlands. In addition, the fire breakers excavated before the burnings have increased the amount of exposed sand in the areas. The excavated fire breakers can easily be ploughed and facilitate for future burnings.

Repeated prescribed burnings, will result in a sparse vegetation where digging insects can find patches with bare sand to dig their nests in while the richness of herbs increase, which in turn provides both Hymenoptera and butterflies with nectar and pollen.



Demonstration of fire equipment on a course about prescribed burning in Hagestad, Skåne.



Grazing cattle at Öland

Grazing and mowing

Many of the sandy grasslands and heaths are grazed that effectively prevent encroachment in the landscape. The grazing animals can maintain some bare sand through their trampling in steep slopes. The animal's dung also provides food and living for a variety of rare beetles and other insects. A low vegetation benefits the fungi of the sandy fields with, among others, the Gasteroid fungi. On the other hand, grazing animals can graze the flowering herbs that is a vital source of food for the insects. In a too well-grazed field, neither terrestrial birds can find tufts to put their nests under. One of the actions in the project has therefore been to fence the grazing animals out from smaller areas until flowering and seed set has passed.

New pastures have been created within the project where more than 15 000 meter fencing with gates and stiles has been set up. In Halland and Skåne there are now pastures where pine forests were formerly grown, and on Öland, encroached areas have been herded for grazing.

In the sandsteppe area of Öland, the heath has increased and within the project, 23 hectares of heath has been

harvested and the remains have been vacuum cleaned.

The difficulty has not been to find grazing animals to the sandy areas, but rather, the regulations for the environmental subsidies have limited to what extent and where patches of bare sand have been created in pastures. During the project, a surface area of up to 500 square meters has been achieved, and the area with environmental subsidies must have a minimum of 90 percentage grass-cover.



Fencing at Skedeås, Öland



A guided tour during "The day of the sand" in Haverdal, Halland.



Outdoor museum at Friseboda, Skåne.

Information

Restoration of sandy habitats on a larger scale raises many questions and the work with information, knowledge dissemination and dialogue have been important in the project. The objective has been to raise awareness about the unique nature in our sandy habitats and how they should be managed to keep their values even to the next generation.

Information in situ

Dialogues with the close residents and the interested public about sandy habitats and the need of management has been important. On over 200 guided field-tours, experts have shown exciting animals and plants living in the sandy habitats while discussing the project's actions. Knowledge of the sandy fields has been necessary and spread through workshops, networking and through lectures.

In all project-sites there are information signs that inform about sandy habitats, about Sand Life and the actions to be implemented. A total of 141 signs have been set up within the project, of which 80 are site-specific signs. Prior to each action, temporary signs have been set up to inform visitors about ongoing actions.

To answer questions and thoughts when standing in the middle of the thriving sandy fields, one can visit one of the 12 outdoor museums created within the project. On these information can be provided about the site, about the sandy habitats in general and about Sand Life. Today outdoor museums are available at Friseboda, Rinkaby shooting range, Revingefältet, Hagestad (Sandhammaren), Falsterbo shooting range and Äng-

elholms strandskog in Skåne, in Laholmsbuktens sanddynsreservat and Haverdal in Halland and in Bödakusten Nature Reserve on northern Öland.

Leaflets and reports

A folder containing general information about the project has been developed and for some of the sites there are site-specific folders. Eight different thematic leaflets provides information about the habitats sandsteppe, sand dunes and sandy grasslands, the organisms of vascular plants, wild bees and Gasteroid fungi, the invasive alien species, and how to create diversity on your own sandy land. For eastern Skåne, there is a map leaflet that guides you into the sandy landscape.

A guide for how to handle sandy habitats in the future has been compiled in the project entitled "*Restoration and Management of Sandy Habitats in Southern Sweden*" and can be downloaded from the project's website.

Finally, reports from the follow-up of the project's actions have been compiled and a plan for how to manage the sandy habitats in the future (After-life plan).

Digital information

Those who want to read more can visit the project website www.sandlife.se or follow us on **Instagram** (@sandlife_sweden with hashtag #sandlife_sweden). In Halland, four digital site-specific folders were compiled that are also available for mobile phones. Through permanent photo points in Hagestad (Sandhammaren) the public can help to follow the succession after the restoration actions.



Monitoring the effects of the restorations made in Sand Life, Öland

Monitoring

The objectives of Sand Life were to restore, maintain and improve biodiversity in sandy habitats. The methods of restoration that have been used have been best practice. The development of the plants and animals expected to be benefited from the actions has been followed up partly to evaluate the choice of methods and partly to communicate the results. During the course of the project, Lund University has documented changes of structures, vegetation and different target species of the sandy habitats. Project areas have been investigated both before and after restoration and, in addition, treated areas have been compared with nearby control areas.

Vegetation and structures

The results show that the most important structure, the amount of exposed sand, has doubled in the project areas, while the presence of grasses, mosses and lichens has been halved. In the dune habitats, *Pinus mugo* and *Rosa rugosa* have almost completely been removed, and encroachment has been strongly pushed back in favor of characteristic sandy species such as *Lathyrus japonicus* and *Eryngium maritimum*.

Birds

The most positive result is that the, since decades, on-going decline of *Anthus campestris* has been halted and the number of birds has begun to increase. Since the 1980s, the species has dropped drastically throughout the country, but between 2013 and 2017, the number of territorial defending males increased from 33 to 42. Even the *Caprimulgus europeus*, living in semi-open sandy fields, has increased by over 20 percent when dense pine forests have been opened.

Insects

Sandy fields have a large variety of insects and the groups followed up in the project are Hymenoptera, beetles, butterflies and moths. The numbers of Hymenoptera and beetles that are favoured by open sand increase where the sand is exposed. Even the moths increase in the pine forests that were opened up and where glades were created. Nectar and pollen-eating insects such as butterflies and some Hymenoptera have not been affected by the restoration measures at this early stage.



An opener dune after Sand Life, Tönnersa (Laholmsbukstens sanddynsreservat), Halland

After Sand Life

The restoration efforts made in Sand Life have improved the sandy habitats and the conditions for its species. The desired environments are a mosaic of bare sand, vegetation with flowering herbs, bushes and trees. The conditions for long-term sustainability of the sandy species have improved and the resilience of ecosystems for future climate change has hopefully increased in the restored environments.

Now the challenges for the future management of the sandy habitats and its species begin, and it is the County Administrative Boards that have the responsibility. Restorations in Sand Life has recreated the previous successive stages and now, hopefully, it is regrowth slowly. How fast this regrowth is, is due to factors such as nutritional impact and climate changes with mild winters and wet summers. The invasive *Rosa rugosa* can come back in the areas because it is still cultivated or dispersed in the surroundings.

The knowledge about the sandy habitats and their need of management has increased through Sand Life. More

than 40,000 people have been reached by the information disseminated through the project. Through the project, knowledge about the sandy habitats has increased and acceptance for future restorations and management is higher. Our hope is that smaller efforts need to be put on information in the future.

In Sand Life, the major restoration efforts needed for the sandy habitats have been made. The new patches of bare sand should be allowed to encroach, but some of them may be ploughed or harrowed to maintain the exposed sand. There will be need for creation of new small-scale patches with bare sand. Ungrazed surfaces may need to be burned with 3-5 years interval. Spreads of shrubs in the more open wooded dunes has to be removed and new glades open. Regrowth of *Rosa rugosa* needs to be constantly pulled up. In the future, fewer resources will hopefully be needed for maintaining a mosaic structure in the sandy landscape, but the need for management will always remain.

Partners



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Life+ Nature

Sand Life has been funded through LIFE + Nature, which is part of the EU's funding for major environmental and nature conservation projects in Europe. The purpose of Life + Nature is to implement the EU Birds Directive and the Habitats Directive mainly within the Natura 2000 European Network. The measures to be implemented in the area of LIFE + Nature should be well-proven and ensure that species and habitats achieve favorable conservation status.

Natura 2000

The sites included in Sand Life do all consists of Natura 2000, which is a network with valuable nature within the EU. The purpose of the network is to eliminate the eradication of animals and plants and to improve their habitats. In Sweden, there are just over 3 500 Natura 2000 sites, which are the most valuable natural areas in the country. Most of the sites are protected as a national park or nature reserve.

Read more about Life + and Natura 2000 on the website of the Swedish Environmental Protection Agency and the EU Commission.

www.sandlife.se