SemiAquatic Life

Recreating habitat complexity for semi-aquatic fauna Layman's report









Authors: Hauke Drews, Niels Damm, Kristian Nilsson, Marzenna Rasmussen, Lars Briggs and Ekoll AB Layout: Ekoll AB

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About the project

The project has been running between 2016 and 2021. Total budget of the project has been approximately 5,8 milion € whereas the contribution from EU Life has been about 60%. The title "SemiAquaticLife", refers to the project's focus on amphibians and insects with a semi-aquatic life-cycle. This means that they, during a part of their life, are dependent on water, in this case stagnant freshwater, for e.g., breeding. In addition to aquatic habitats, they also need suitable terrestrial habitats for foraging, hibernation, and shelter.

Since the semi-aquatic species are completely dependent on both land and water for survival, they are particularly sensitive to environmental changes. Many of these species have drastically declined due to human impact and are therefore dependent on protected areas such as Natura 2000 sites. Amphibians, dragonflies, and some diving beetles are examples of species that have a semi-aquatic life-cycle.

The main goal of the project has been to restore and increase the number of aquatic and terrestrial habitats for herptiles and aquatic insects at 37 Natura 2000 sites in Denmark, Germany, and Sweden.

The goal has been to ensure viable populations of species listed in the EU's Habitats Directive. Another objective was to increase the public awareness and understanding of the need for restoration measures for semi-aquatic species.



The focus has been on improving both aquatic and terrestrial environments for the focus species. To achieve this, we have carried out the following actions:

- construction and restoration of wetlands
- creation of hiding places and hibernation spots
- removal of unwanted trees and bushes as well as invasive flora
- reintroduction of spadefoot toads, natterjack toads, fire-bellied toads, green toads, European tree frogs and sand lizard where they have gone locally extinct
- production of information materials
- organize public excursions

The Layman's report is focusing on lessons learned for actions made for some of the focus species of the project:

- Green Toad, Bufotes viridis
- Natterjack Toad, Epidalea calamita
- Spadefoot Toad, Pelobates fuscus
- European Tree Frog, Hyla arborea
- Fire-bellied Toad, Bombina bombina
- Sand Lizard, Lacerta agilis
- The diving beetle Dytiscus latissimus
- The diving beetle Graphoderus bilineatus

In this report we have also focused on management of habitats for wetland species on military exercise fields.







Introduction of Spadefoot toad. Photo: Marika Stenberg



Project results

Habitat improvements

The project has been working in 37 Natura 2000-sites with actions for improving reproduction areas (wetlands) and surrounding foraging and hibernation areas. All actions have been carried out with a meta-population concept in mind, i.e., several wetlands within dispersal range and suitable terrestrial habitats. Following actions have been done within the project:

- 243 constructed wetlands
- 228 restored wetlands
- 109 hibernation spots at 16 sites
- clearing of 376 hectares with trees and bushes (mainly invasive species)
- 14 065 meters of fence for grazing at 5 sites
- reintroductions and supportive breeding at 16 sites
 - Fire-bellied toad (DK, GER)
 - Spadefoot toad (GER, SWE)
 - Green toad (GER, DK)
 - European tree frog (DK)
 - Natterjack toad (DK, SWE)



Monitoring in all countries show that several reintroductions and supportive breeding have been successful. Newly created wetlands have, in several cases, been successfully colonized by target species. Some sites still need time for succession until our targeted species will use them. This is typically for species that needs submersed water vegetation, e.g., Tree frog and Fire-bellied toad.

Water beetle and dragonfly monitoring has been carried out in all countries. The conservation status of the targeted water beetles is poor/ non favourable in northern Germany, Denmark, and southern Sweden. National monitoring of the species in Sweden have given the result that the species range is moving up in the country. This might be due to climate change.









Public awareness

The project outcome can also be calculated in the number of involved people. Several excursions for the public and meetings with stakeholders have increased the public awareness and understanding of the need for restoration measures for semi-aquatic species. In the future the projects outdoor museum, table, and benches with the information of the projects actions on information signs will continue to let people to sit down, take a break and learn more about amphibians.

Större vattensalamander - dammens drake

Socioeconomic effects

The project has provided alterations in the long-term management of the involved Natura 2000-areas to e.g., prevent created wetlands from unwanted succession by vegetation. Conducted actions have also contributed with work hours and practical experiences among involved staff. Furthermore, the project has given rise to increased interest among the local public through excursions, information meetings and demonstrations for preschools. Also, created wetlands have contributed to increased nutrient retention and water holding capacity.



Håll utkik efter o

Ecosystem services

The project has had a positive effect on several ecosystem services. For regulating services, increased nutrient retention and reduced risk of flooding due to establishment of new wetlands are the most important services. For cultural services, increased human well-being and increased appreciation of local biodiversity are important results.

Green toad - the heat loving toad

Fun facts

- The green toad is well camouflaged with numerous green spots on a grey background
- Lives in open, stony, sandy and, disturbed habitats. It has followed humans into e.g., farms, villages and lime pits. They hide in stonewalls, piles of materials or stones or other "messy" places and old drift on the upper beach.
- At night, the green toad catches insects around their hiding places. In coastal areas they catch sand hoppers and drift flies.
- The toad is salt tolerant and can spread between islands in the Baltic Sea.

Green toads live in warm and quite open landscapes with rocks, stones, or sand and where the vegetation is very short or only scattered. They are pioneers in dynamic and disturbed habitats. They are very good at finding and colonizing new habitats but do not thrive on sites with other amphibian species. Stony, and sandy habitats are quite poor in nutrients which slows down growth of the vegetation. The habitat must be dynamic or disturbed to keep it open and most important unhostile to competing amphibian species. Without dynamic open habitats transform into denser vegetated and the green toad disappears searching for a new habitat.



Apart from Europe, the green toad can be found in Central Asia and in the Middle East. The green toad is adapted to breed in waters where other amphibians do not occur or breed. A common feature is a disturbed or special acuatic habitat - the unusual is the usual. Along the Baltic coast, common breeding waters are most often temporary, brackish ponds or flooded depressions. Green toads can also breed in permanent ponds, new dug ponds, watering holes with trampling of cattle, concrete basins, ponds in sand pits or stone quarries. The ponds must be without fish.

Actions and lessons learned

The main threats to the green toad today are:

- Drainage and overgrowth leading to a lack of open or short vegetated breeding waters.
- Overgrowth leading to a lack of open sandy or stony habitats.
- Lack of dynamics leading to competition and predation from more common amphibian species.
- Many populations face a high risk of extinction because of few adults remaining.

To mitigate these threats the following actions in the project can be used as examples:



Vestamager

The project site Vestamager south of Copenhagen has been a shallow coastal area with a few smaller islands but in the 1940's it was diked in to serve as a military training ground for artillery. The site was left without management but in the 1950's it was still an open landscape with a large population of the green toad which seemingly thrived very well in this sandy and open landscape.

Due to lack of management natural succession with long grass, willows and birch trees changed the habitat, and it became unfavourable for the green toad. However, today the site is well grazed, and some of the trees and bushes have been cleared. Because of succession, species such as the common toad and green frogs have colonized the site. They breed in deep ditches and permanent lakes and ponds and spread out through the vast network of overgrown ditches. There are no other suitable habitats for the green toad along the coast. So, the management of the site must fit the needs of the green toad to pre-



Vestamager, 2020 with restored habitats within the project, marked in red. vent local extinction. Therefore, several new shallow depressions were dug at Vestamager to offer suitable breeding sites for the green toad and at the same time the ditches were converted from habitats of the common amphibian species into habitats suitable for the green toad.

The result was a complete transformation from deep, overgrown and permanently waterfilled ditches with a thick layer of organic sediments to shallow depressions flooded during spring. More than 15 ha of new habitats for the green toad were made this way. And as a very positive side effect the new shallow water bodies are perfect feeding grounds for wader birds and their chicks during spring and summer. The plan is to carry on this work to modify all ditches at Vestamager to further diminish the populations of the common amphibian species and at the same time create new habitats for the green toad.



Ditch modified to habitat of the green toad and wader birds . Photo: Niels Damm



Pantener Moorweiher

In Schleswig-Holstein, Germany, at the nature reserve "Pantener Moorweiher" reintroduction of the green toad was made on an inland. Initially, ponds were dug and hiding places created. The green toad was reintroduced by release of tadpoles (6.800) and metamorphs (27.300) in the period 2016-2020.

At least one out of seven newly created ponds was

colonized by the green toad since successful reproduction (tadpoles) was observed for at least two consecutive years. The pond had very little vegetation with turbid water due to trampling by cattle. These habitat features attract the green toad, and the unclear water protect the tadpoles from predators. In 2021, 39 calling males and 4 females were observed.



Habitat component	Biological function
Open stony, rocky, or sandy pioneer landscapes	Open ground makes it easy for the toads to find beetles
with bare ground, low or scattered vegetation.	and spiders at night. Sand and stones are hiding places.
Salt meadows, beaches, dunes, old type of farms	Unhostile to other amphibian species – the green toad is
and villages.	strongly adapted to live without competition.
Stone walls, old buildings, piles of stones or	Places for hiding during daytime and hibernation
"mess"	
Unusual – dynamic breeding waters with no or	Adapted to breed without predation and competition.
little vegetation, sandy or stony bottom. Tempo-	The tadpoles live on algae growing on stones and sand.
rary or permanent waters in an early successional	Temporary, brackish, and dynamic waters disfavour com-
stage, also brackish water.	petitive/predatory amphibian species as well as predato-
No drainage, no ditches.	ry invertebrates and fish.
No fish, no other amphibians, few insect larvae	Waters unattractive to others = attractive to green toads
_	

Natterjack toad - the nocturnal sand runner

Fun facts

- The natterjack toad has short hind legs, and thus a characteristic movement, a bit like a mouse, fast-running instead of hopping.
- It has a distinct yellow line on the back and yellow-green eyes.
- Compared to other amphibians in Europe, the tadpoles have the shortest developmental period, and the young toadlets are the smallest of our European species.



The natterjack toad lives only in Europe and the populations in Schleswig-Holstein, Denmark, and Sweden along with the population in Estonia are the northernmost found. It is a true pioneer species living in quite open landscapes that are so dynamic that only bare ground or no more than low and stressed vegetation without trees or shrubs are found. It lives in sandy or stony habitats. Physical disturbance is important to create a dynamic landscape by preventing natural succession of vegetation and creating open sandy areas. Dunes and coastal areas are optimal habitats with the loose, ever drifting sand because the toads can easily make burrows and find food such as flies and sand hoppers during night. The natterjack toad has a large potential for migration in search for new pioneer landscapes to colonize.

Historically, salt meadows have been a very important habitat for the natterjack toad where the regular flooding by the sea and summer grazing cattle or horses keep the landscape open and the vegetation short without trees or shrubs. In earlier days, the unregulated rivers produced very good habitats for the toad because of flooding of the meadows around the river, creating an open landscape with sandy and stony banks. Also, the historical mowing and grazing regimes on meadows in river valleys favoured the natterjack toad along with many other species.





Rocky landscape offers many excellent hiding places, breeding waters and foraging grounds. Photo: Niels Damm.



Actions and lessons learned

The main threats to the natterjack toad today are:

- Lack of dynamic leading to a lack of open sandy or stony habitats.
- Lack of dynamics leading to competition and predation from more common amphibian species.
- Drainage and lack of dynamic leading to a lack of open breeding waters.
- Many populations face a high risk of extinction because of few adults remaining.

To mitigate these threats the following actions in the project can be used as examples:

Flensburger Förde

In Germany, at the coastal habitat at Geltinger Birk a reintroduction of the natterjack toad was carried out. Several temporary wetlands were created and restored. Some of the wetlands were also influenced by brackish water. In parallel to these actions, dense vegetation was removed by introducing grazing and by removing the invasive shrub, Rosa rugosa using an excavator. Furthermore, several hibernations spots were created at the site. These actions recreated a landscape consisting of several ha of semi-open dunes next to the beach. In 2018 and 2019, about 2 000 young toads were released. Since the spring of 2020 was too dry natterjack toads did not breed in the area. In 2021, about 3 000 tadpoles and 500 small toads were released at the newly created wetlands. In one of these wetlands, being influenced by brackish water, three calling males were heard in 2021. The calling males did not attract any females and nor eggs neither tadpoles were found. This result is not surprising since it usually takes about 4 years before the females become sexually mature.

It is in general easier to rescue a small population from extinction than to re-establish an extinct. That is if the genetic variation in the population is still large enough to make it viable. So, a lesson could be that, if possible, then try to save existing, threatened populations in time.

Since the natterjack toad is a true pioneer species it responds rapidly to habitat improvements. Subsequently, if habitats are restored before a population goes extinct there is a good chance that a rescue operation will be successful.

Ravlunda skjutfält

Ravlunda skjutfält (a military field in Sweden) is a good example of a successful rescue operation during this project. Before the project started only a couple of calling males were heard outside the Natura 2000site. In early 2017, eight new temporary ponds were made for the toad, but no other habitat restorations were needed, the terrestrial habitats were optimal in this sandy and heavily grazed coastal area.

During the project excursion to Ravlunda skjutfält in June 2017, about 30 males were heard calling at the new ponds, including observations of several egg strings. During a survey in 2019, more than 280 adults were counted within the area, and successful reproduction was confirmed in most ponds. A good example of a true rescue story.



Habitat component	Biological function
Dynamic, open, and large landscape of sand and	Keeps other amphibian species away – the toad is strongly
stones. No or short vegetation (max. 5 cm high).	adapted to live as a pioneer species without competition.
Dunes, salt meadows, beaches, sand pits, military	Easy for the toads to feed on beetles and spiders at night.
areas	_
Temporary flooding with clean, fresh or brack-	Adapted to breed without predation and competition.
ish water, low and semi open vegetation (in salt	Temporary and brackish waters exclude most other am-
meadows) or no vegetation (inland). Large flood-	phibians and predators. Waters too shallow for other =
ing in large dynamic landscape.	attractive to natterjack toads.
No drainage, no ditches.	The tadpoles live on algae growing on grass and sand.
No fish, no other amphibians, few insect larvae	
Fully sun exposed, open mudflats around the	On warm mudflats collembolans develop in very large
breeding water with low scattered vegetation	numbers and, being the only food of newly metamor-
	phosed toadlets

Spadefoot toad - the elusive amhibian

Fun facts

- The common spadefoot toad is like a ninja, hardly ever seen. The toad is only night active and well camouflaged. During daytime it is resting, buried in the soil and during the breeding season it stays hidden under water.
- Common spadefoot toads were earlier often found in potato fields and got in Denmark the pet name "potato troll".

The spadefoot toad lives in open, sandy landscapes as dunes, heathlands, and tough grazed sandy grasslands. It avoids forests and shrubs and is attracted to pioneer landscapes as sand pits and military areas.

For many hundreds of years, it came quite well along in the farmed landscape with large areas set aside for grazing or mowing and a much less intense treatment of the soil than today. Since modern farming practice has introduced intense soil treatment, pesticides, and artificial fertilizers, the spadefoot toad has become quite rare or extinct in many regions.

The pesticides are killing insects and other invertebrates in and on the soil, which are the food resource of the toad. The fertilizers affect the water quality in



ponds negatively and cause eutrophication and kills the amphibians under migration. Today the best populations of the common spadefoot toad live on military training fields, nature reserves with extensive organic farming or in large pasture landscapes.

The species is one of few amphibians in Europe where the males are calling under water. Above the water the gentle "ogg-ogg... ogg-ogg" call can be difficult to hear for humans, only in silent nights without other noises from e.g., wind, roads, or the sound from European tree frogs. When the males are sitting in deeper waters, their calling can only be registered with under water microphone.





Actions and lessons learned

During the project spade-foot toads have been reintroduced to sites where it had gone extinct, or populations had declined seriously.

In Germany eggs of the spadefoot toad were collected from populations in the vicinity of the newly restored habitat The eggs were hatched in a rearing station and the tadpoles were reared till metamorphosis and 4-legged young spade-foot toads were released. In Sweden eggs were placed in cages in newly created ponds. When the tadpoles were approximately 3 cm in length, and free swimming, they were released into the pond.

At two German sites 3100 and 5600 reared toads were released in newly created or restored habitats (3 years at each site) resulting in 60 and 37 calling males, respectively. At two sites in Sweden 12 500 eggs were introduced to each site during the project (4 times at each site) resulting in none and 12 calling males, respectively, during final monitoring.



Spadefoot toad tadpoles. ready to be released from the cage into the newly created wetland. Photo: Per Nyström



Habitat component	Biological function
Open landscapes with sand or sandy soil	The toad can hide in the ground during day and hiberna-
	tion. It can hunt spiders and beetles at night.
	Newts are attracted to landscapes with trees and shrubs
	and they avoid pioneer landscapes. Newts are serious
	predators on eggs and tadpoles of the toad.
No use of artificial fertilizer or pesticides	Fertilizer leads to eutrophication of breeding waters.
	Contact to fertilizer grain is deadly for amphibians.
	Pesticides kill the invertebrates that the toad prey upon.
Large shallow flooding or permanent pond	Eggs and tadpoles only develop in good water quality.
Good water quality	Diverse vegetation supports a diverse fauna and regulates
Diverse vegetation with vertical stems	water quality. Tadpoles feed upon algae growing on plants.
No fish	Vertical stems for attaching egg strings.
No or very few newts	Fish and newts are serious predators on eggs and tadpoles
	of the toad. Large fish can also eat the toad.
No evening/night traffic	The toads like to forage or migrate on roads because the
	surface is unvegetated. High mortality even with only very
	little traffic.

European tree frog - the climbing frog

Fun facts

- For no obvious reason, males can be heard after the breeding season calling from the top of trees. This behaviour can be triggered by mimicking their calling sound even during the day.
- Tree frog tadpoles in rearing stations love to forage on banana slices, which float at the surface, maybe an "expression of their tropical family genes"

Photo: Hauke Drews

The European tree frog belongs to the family Hylidae (tree frogs) which includes many species mainly occurring in the tropics. During daytime, the European tree frog climbs hedges, shrubs, and trees to find shelter and at the same time regulate their body temperature. They prefer sun exposed edges of broadleaved forests and hedges with bramble in pastures and fields. In the breeding season, the tree frogs try to find larger, shallow, flooded areas or smaller sun exposed ponds where the development of eggs and larvae benefit from the warm water. At night, males are calling to attracts females. The male calling sound (a fast epp-epp-epp-epp...) can be heard from up to one kilometer away. In ponds located in pasture with slightly turbid water caused by trampling animals but with vegetation, the tadpoles face reduced risk of being preyed upon.

Newly metamorphosed froglets forage for insects near the ponds. When they are fit and able to climb, they join the adults in the summer habitats in trees and hedges. In landscapes with many hedges, shrubs, and wetlands, such in Schleswig-Holstein, tree frogs can colonise new wetlands at a distance up to 10 km.





Actions and lessons learned

During last 70 years tree frogs have gone extinct in most of Eastern Denmark, the whole of Funen and on Zealand the tree frog only survived in 3 ponds, on 3 sites on Zealand: Rone Klint, Stensved and Rejnstrup

The population at Stensved was saved by one of the first supportive rearing projects in Denmark on the remaining about 10 tree frogs in the 1980'es. Pond digging around Stensved and the nearly 400 ha military area "Kulsbjerge" have boosted the population, so, it can be used in today's rearing projects to further spread tree frogs to new localities on Zealand. Inspired by projects as LIFE SemiAquatic the military has initiated whole year grazing, which keeps the ponds in a perfect condition with low vegetation.

The population on Rone Klint was also reduced to about 10 adults when it was supported by several new ponds. Also further south at Kragevig ponds were dug and reared tree frogs were released at both sites. At the end of the project Rone Klint and Kragevig both host a viable population being maintained by grazing.

At Rejnstup only one calling male was left at the beginning of the project. Reared tree frogs from the other sites were released at Rejnstrup. Combined with pond digging there again is a future for the tree frog at Rejnstrup.

We have learned that a good rearing program with release of large numbers of tree frogs in combination with digging of ponds in good habitats have resulted in several strong populations.

It is possible to save even very small populations of tree frogs with supportive rearing and thus one should never give up on conservation of even very small populations.







Habitat component	Biological function
Sun exposed shrubs, hedges, brambles, and trees	Bramble attracts many insects and function as both habitat
	and shelter for the bright green tree frogs because of their
	camouflage and the presence of thorns. The tree frogs can
	also regulate their body temperature by moving in and out
	of shade.
Deciduous forest with plenty of dead wood	Suitable habitat for hibernation.
No use of artificial fertilizers or pesticides	Fertilizer grains are deadly for migrating amphibians and
	leads to eutrophication of ponds.
	Pesticides harm or kill the flora and fauna in the ponds and
	surroundings that the tree frog depends upon.
Large shallow waters or permanent ponds	Eggs and tadpoles of tree frogs need warm water. The sub-
Good water quality	merse vegetation gives structure for egg laying and shelter
Fully sun exposed	for tadpoles.
Well-developed submerse vegetation like white	for the toad. Tadpoles feed upon algae growing on plants.
water-crowfoot	Fish and newts are serious predators on eggs and tadpoles
No fish	of the frog.
No or very few newts	

Fire-bellied toad - the ancient frog

Fun facts

- Fire-bellied toads cannot extend their tongue well beyond the opening of the mouth to catch prey. Instead, they move the whole body.
- When threatened, they present the orange pattern on the belly to the predator as a warning signal of being poisonous.
- Fire-bellied toads have a low reproductive rate, but instead can become quite old. In Denmark, an 18-year-old toad was captured.

The fire-bellied toad is one of the most ancient amphibian species. Fossils are known from the Pliocene epoch, 2 to 5 million years ago. The characteristic orange coloration on its belly justifies its name. The coloration signals to predators that the toad is poisonous. Upon danger, the adults can excrete a poisonous mucus, which is as potent as tear gas.

Fire-bellied toads are "water living" amphibians and spend the whole summer in wetlands. The fire-bellied toad needs a dense network of many different types of ponds - a "pond-scape": shallow clear-water ponds for breeding and deeper species rich ponds for foraging. All fully sun exposed and preferably in pasture. Before draining pipes were invented the landscape looked like that with flooded depressions and deeper ponds everywhere.

The ponds must have a well-developed submerse vegetation which is an ideal habitat for egg laying, and for the tadpoles to find food and shelter. Grazing cows



or horses prevent out shading the submerse vegetation by dense vegetation such as reeds.

The fire-bellied toad has a soft, melodious calling resembling church bells from a distance or the cuckoo singing. The males can be heard during warm, calm days and evenings in May and June and on the same days the fire-bellied toad lay small egg clusters of 20 to 60 eggs each, wrapped around thin stems of submerse vegetation. A population of fire-bellied toads build up choruses of calling males in selected ponds and during the season the frogs migrate between ponds in an area as the temperature and vegetation changes during the season.

Newly metamorphosed fire-bellied toads can be found during warm days in August at the edge of a breeding pond. The toadlets leave the water only for hibernation and they hibernate in mammal dens, stone piles, in thick layers of litter or under large old stumps.





Actions and lessons learned

On Avernakø in the Archipelago of South Funen a strong population of the fire-bellied toad is living. During the 1990'ies the situation for the population was very difficult because the ponds had deteriorated a lot during decades of modern farming around the few remaining ponds. Since then, three LIFE projects plus local projects have focused on safeguarding the population that today is much larger. The tool has in all projects been to convert farmed fields in to permanent grasslands without fertilizer, pesticides, or soil treatment and then initiate grazing with robust cattle. Drainage has been broken, old ponds have been restored, and even more have been dug. Grazing with robust cattle offers the farmers an alternative economy on the small island. For the fire-bellied toad the change from farming to grazing and from drained soil to numerous ponds have been a great success. This is the only realistic long-term approach to keep the fire-bellied toad alive in our landscapes.





Habitat components	Biological function
Open or semi open grazed grasslands with dense	The frog is adapted to live in waters when not hibernating.
network of numerous flooded depressions and	It migrates between waters during the season, so distance
ponds	should be short and migration safe without threats from
	farming. Grazing keeps vegetation short and open.
No use of artificial fertilizer or pesticides.	Fertilizer leads to eutrophication of waters and
	monotonizes flora and fauna around.
	Fertilizer grains are deadly for migrating amphibians
	Pesticides harm or kill the flora and fauna in the water that
	the toad depend upon.
Large shallow waters or permanent ponds	Eggs and tadpoles only develop in very good water quality.
Best water quality	Diverse vegetation and a diverse fauna are fundamental
Fully sun exposed	for the toad. Tadpoles feed upon algae growing on plants.
Diverse semi-open vegetation with vertical stems	Vertical stems for attaching egg clutches. Only thrive in
No fish	the warmest ponds.
No or very few newts	Fish and newts are serious predators on eggs and tadpoles
No drainage	of the toad. Large fish can also eat the toad.
	Natural spring flooding of depressions/ponds is essential.

Sand lizard

Fun facts

- The English and Swedish names of the lizard refer to that there is always sand where it lives.
- The Danish and German names refer to field and fence since it used to live in sandy fields and probably especially was found at the fences where it could hide.
- The males are beautiful in spring with their green colour. On some Danish islands the colour gave them the pet name "cliff sculpin".



The sand lizard lives in Europe and Asia. Denmark and Southern Sweden have some of the northern most habitats of the warmth-loving lizard. They live only where there is sand and where the sun can heat up the bare soil so the lizard can bask. A cold sand lizard is slow and has no chances against its predators. But by lying in the sun, it can raise its temperature to about the same level as us humans and then it becomes very fast. They live in dunes, on coastal cliffs and inland they are found on slopes at roads and railways, old sand pits and heath lands. The slopes are turning East, West or South to allow the sun to warm the ground.

In spring the sand lizards breed and the females bask to mature the eggs. In June the female as the only reptile in Northern Europe digs a burrow and lays eggs in the ground on slopes where the sun can warm the sandy soil. The eggs can only develop in the ground if there is full sun on a bare ground, thus the lizard avoids shade from dense grass, bushes, or trees. When the new young lizards appear in the end of summer, they, as the adults, need bare ground with sand where they can bask as well as flowering plants that attract grasshoppers, beetles, and spiders they can eat. Also, they need scattered thorny shrubs and old dry grass where they can hide when a predator approaches. An optimal habitat is patchy like a chess board, and it is especially the edges between the warm bare ground and the safer denser vegetation that is important.



Actions and lessons learned

The sand lizard has become rare in Northern Europe since so many of their former open, bare ground habitats have become overgrown. They are very poor in migrating in the modern landscape, so once a population disappears it does not come back. Many dunes both at the coast and inland have been transformed into dense plantations. Coastal areas are overgrowing with invasive species like Rosa rogusa. Earlier the sand lizard lived in the farmed landscape but the level of nutrients and homogenization of today no longer offers niches for the lizard. In general humans are in favor of homogenic management of slopes along roads and rail roads. But the lizard needs the opposite – a heterogenic environment.

What can we do to keep the sand lizard in our landscape? A very effective tool would be to bring the dunes back to life by removing plantations. Another way is to manage slopes along roads and railroads in a lizard-friendly manner by leaving and maintaining patches of bare ground and thorny bushes. This will also benefit many plants and insects. To remove invasive plant species from coastal areas would also be very beneficial for the sand lizard. Grazing with cows or horses can be positive as it slows down succession of trees and bushes. But ungrazed slopes and edges must be left.

In Schleswig-Holstein a rearing program has been initiated to reintroduce sand lizard to restored habitats. Males and females live and breed in a rearing station and the offspring is used to found new populations. On one of the sites the reintroduced lizards have started breeding.



Rearing station with outdoor enclosures for sand lizard in Germany. Photo: Patrick Pohlmann



Hatching eggs of sand lizard. Photo: Inken Neugebohren





Habitat component	Biological function
Sandy landscapes, slopes with patches of bare	Sand is easy to dig burrows in and lays eggs underground.
ground, flowering plants, thorny bushes, stumps,	Bare ground is needed for basking, hunting and egg laying.
and stones	Thorny bushes, stumps and stones are hiding places.
Dunes, heathlands, coastal cliffs, abandoned sand	Flowers attract insects and spiders which the lizard eats.
pits	
Nutrient poor and dynamic habitat	Fertilizer monotonizes flora and fauna. and causes dense
	vegetation.
	Dynamic keeps patches of ground open and thus warm in
	the sun.
Unfarmed heterogenic landscape.	The monoculture landscapes created by modern farming
	leaves no habitats for lizards.
	The more heterogenic, the more habitat. The lizard pri-
	marily lives on the edges between bare ground and denser
	vegetation.

Dytiscus latissimus and Graphoderus

Fun facts

The larvae of the diving beetle *Dytiscus latissimus* only eats caddis fly larvae which live protected in a "house" they build of plant materials around themselves. If the beetle larva cannot bite through the "house" - then it places itself on it with its jaws at the entrance ready to bite. It then makes a series of jerks with its hind pair of legs. The caddis fly larva then sticks its head and torso out to see who is knocking... And that was the end of it.

There is over 4.000 species of diving beetles known. Some of the species have become very rare and *Dytiscus latissimus* and *Graphoderus bilineatus* are among these. Therefore, the project has focused on improving habitats of the two endangered species. They are very different in size but live in the same habitats.

They live in both smaller and larger lakes, but the lakes must have clear water and a rather low level of nutrients. The shore of the lake should be sun exposed and have an open vegetation of water plants thriving under low levels of nutrients like sedge grasses, mosses as well as marsh cinquefoil and water lobelia. The lakes are normally situated in well protected nature areas surrounded by poor bogs and high moors thus not being directly influenced by farming.

A diving beetle is living in water throughout its entire life. It has no gills and therefore must go to the surface to breathe by trapping air underneath its wing case using it as a "diving tank". It then takes up oxygen from the trapped air and can stay underwater for quite some minutes depending on water temperature. The trapped air acts as a physical gill which can take up oxygen from the water and thus give the beetle extra diving time. A streamlined body and a pair of rear legs that have evolved into oars give it maneuverability underwater. It can fly but rarely does so — only to spread to new habitats.

The adult beetle of both species has a good sense of smell which it uses to find prey. But they are not the



fastest swimmers. In spring the beetles lay eggs underwater in stems of sedges and buckbean. The larva lives in shallow water for one month as a predator. *Dytiscus latissimus* is specialized in eating caddis fly larvae and eats at least 200 larvae during this time. *Graphoderus bilineatus* is specialized in eating daphnia. When large enough the larva pupates on land and after a month reappears as the adult diving beetle.



The larva of *Dytiscus latissimus* is a magnificent and agile predator. It feeds only on caddis fly larvae which might be one possible reason of why it has become so rare. Photo: Mogens Holmen

s bilineatus – the beautiful beasts









Shallow lakes with time become overgrown with marsh vegetation excluding the sun and the diving beetles. Removing the mud and some of the vegetation restores the lake as a habitat. Photo: Niels Damm

Habitat component	Biological function
Sun exposed lake surrounded by high moor, bog, or forest	Avoids direct influence of nutrients from farming.
Good water quality, non-eutrophic	Assures diverse flora and fauna and clear water.
Shallow water with semi open and diverse vegetation of	Eggs are laid in stems of sedges.
sedges, mosses and other submerse plants	Semi open vegetation provides warmer water.
	Diverse vegetation provides substrate for the prey.
Large density of caddis fly larvae	Only known food of the specialized larva of Dytiscus latis-
No or few non-predatory fish	simus.
	Fish eat daphnia which the larva of Graphoderus bilineatus
	depend upon.

General guidelines - for amphibian restorations

Preferred by amphibians

- Most amphibians thrive well in a mosaic landscape with multiple wetlands, pastures, and deciduous forests.
- Some amphibian species can only live in a pioneer landscape with no or low vegetation.
- Generally, it is not possible to favor all species in one site. This is often mistaken by site managers. The management should be targeted towards which habitats are realistic to achieve and maintain concerning landscape, soil type, size, and dynamics.
- For populations to be viable both aquatic and terrestrial habitats must be suitable to assure the whole life cycle of a species.
- Breeding waters for amphibians shall not contain any species of fish, be eutrophic or acidified.
- For populations to be viable in the long run, it must consist of at least 1000 adults.
- If a terrestrial habitat is good, then the breeding success from wetlands sets the limit for the population size. Some species need five or more breeding waters within 500 m from each other. In long term, the offspring from these breeding waters can migrate to neighbouring sites and counteract local extinction and inbreeding. By this process the populations are much more resilient towards changing environmental conditions.
- Ensure the quality and abundance of both terrestrial and aquatic habitats before reintroducing species that have gone extinct or are in severe decline.







General threats to amphibians

- Climate change may result in rising sea levels which inevitably will flood larger parts of the present salt meadows. This may result in a loss of freshwater habitats. The probability for colonization by predatory sticklebacks may increase.
- Populations of breeding and resting geese on salt meadows have increased over the last decade. Geese forage heavily on grass decreasing the possibilities for amphibians to find shelter. In addition, through their faeces, geese may significantly eutrophicate flooding and ponds. A major part of the nutrients of the eaten grass pass straight through the geese.
- Today most meadows are overgrowing due to lack of grazing or harvest of hay. In by far most areas, intensive agriculture and forestry have converted the landscape into large monocultures that are unsuitable for amphibians.
- Grazing by live-stock is positive for amphibians and necessary to prevent the landscape from overgrowing. Enough ponds and waters must be assured to avoid that the grazing live-stock trample and eutrophicate breeding sites of amphibians.
- Intense traffic is a problem in many areas causing populations to be fragmented and declining.
- There are several infectious diseases that are potentially threatening some population and species. The most well-known disease is caused by a water bourn fungus called chytrid.



Risk of increased salinity due to rising sea level. Photo: Per Nyström





Project on military grounds

Military Forces in Denmark and Sweden were important partners and stakeholders in the SemiAquaticLife project.

The five project sites in Denmark (Oksbøl, Søgårdlejeren, Aflandshage, Stold, Jægerspris) and three project sites in Sweden (Falsterbo skjutfält, Revingefältet, Ravlunda skjutfält) were managed by relevant Military administration.

Almost all project actions were implemented in the mentioned above sites. Over 85 ponds were dug and restored together with construction of hibernation places for amphibians. Unwanted vegetation of invasive species as *Rosa rugosa* and *Cytisus scoparius* were removed on more than 290 hectares improving terrestrial habitats especially for natterjack toad. In Sweden, canadian waterweed, *Elodea canadensis*, were removed from ponds at Ravlunda skjutfält and Revingefältet. Furthermore, reintroductions of spadefoot toad was made at Revingefältet.

Denmark is a thoroughly cultivated country, where only limited space is left for nature. Since historically the military grounds were laid out in sparsely populated areas with extensive land use as well as have been kept free of agriculture and infrastructure development, today they contain a wide range of well-preserved and valuable Danish nature. Similar situation is in Southern Sweden where the project was implemented.

The Ministry of Defense in Denmark manages approx. 33,000 ha altogether, corresponding to almost one percent of the Danish land area. About half of the areas have been designated as Natura 2000 sites, and more than half of these have been mapped as habitats protected by EU Habitat Directive. The natural values are especially linked to open, nutrient-poor habitats (as dunes or coastal meadows) and associated plant and animal communities. The main threat for those habitats is overgrowth with woody plants (many of which are invasive), perennials and tall grasses, accelerated by nutrient supply from surrounding production landscapes.

The Armed Forces' physical disturbances in the form of wear and tear when driving with heavy equipment and fires ignited by explosions, together with an active nature conservation effort have a positive effect on the biodiversity.

Given the size of the areas and their significance for endangered nature, priority management of the Armed Forces' areas is a very significant contribution to preserving and developing biodiversity in Denmark, Sweden, and Europe.

Depressions caused by military vehicles, suitable for natterjack toad at Oxbøl military ground,Denmark. Photo: Peer Ravn







Removal of *Elodea canadensis* by covering the wetland with biodegradeable geotextile and adding sand. Photo: Per Nyström

Beneficiaries, co-financiers and important participants



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