

Does legal site protection lead to improved conservation of ponds with fire-bellied toads *Bombina bombina* in Denmark?

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SUMMARY

In Denmark, nature conservation in the middle of the twentieth century mainly involved protecting areas by legal declarations forbidding the destruction or degradation of the protected area. During the period 1946 to 1969, 22 sites with fire-bellied toads *Bombina bombina* were protected as single ponds, and 40 ponds with *Bombina* were protected as a part of larger protected landscapes. We evaluate the survival of *Bombina* populations in these protected ponds compared to 51 control ponds where *Bombina* was recorded in 1940-1955, but which were not protected. In all cases, survival of *Bombina* was low, and although protection may have delayed extinction, there is no clear evidence that it prevented extinction. There was a trend for better outcomes in the larger protected landscapes, but this may have been due to other causes, such as more cattle grazing. It is concluded that passive protection (legal protection without active management) is not effective, whereas the type of active approach that has been used increasingly since 1982 is more promising.

BACKGROUND

In the 1940s Danish naturalists were greatly concerned about the drastic decline of amphibians, especially the rarest species like the fire-bellied toad *Bombina bombina* (Pfaff 1943, Hass 1944). Pfaff (1943), who had gathered all available information on the distribution of the amphibian species in Denmark, wrote about the rapid rate of decline of *Bombina bombina*. This decline led him to write (in translation): “There is then all possible reason to treat the last *Bombina* localities with the utmost care. Even if the disaster may not be avoided, it may possibly be postponed. It would of course be best to protect the animal and the localities totally.”

Hass (1944) wrote an article with the title: “The tree frog and the fire-bellied toad should be protected.” He writes especially about some ponds on the island of Møn where the occurrence of *Bombina* was precarious; he argued that they should be protected, and that the situation was urgent. But nothing happened, and *Bombina* went extinct there some years later when fish were released into the main pond.

At this time, naturalists thought that the main threat to amphibians was the destruction of the ponds i.e. that they were filled in, used to dump garbage, or dried out due to drainage of the surroundings. In order to prevent this, some ponds were protected by declaration, according to the conservation law (Danish Law of Nature Conservation dating from 1917 and amended several times). In the period 1945 – 1955 much work was done to assess the status and provide protection for *Bombina*. Conservationists searched systematically for the remaining localities, negotiated with farmers to persuade them not to destroy the ponds, and sought to have ponds legally protected. In most cases, they failed. However, in a number of places, they managed to convince the conservation tribunal that *Bombina* ponds should be protected by declaration. Here we examine whether these protected ponds were effective in conserving *Bombina* populations, based on censuses of protected and unprotected sites.

ACTION

Some ponds were protected as single ponds, with few restrictions on the use of the surrounding areas, which were mostly cultivated or grazed fields (Table 1).

The regulations for each site were written in the land register and varied. For example, the regulations for the 12 ponds on Avernakø were as follows:

- It is not allowed to dig in or around the pond.
- It is not allowed to fill in or dump garbage of any kind.
- The only allowed use of the water is for cattle watering.
- No inlets or outlets may be established; the water level may not be lowered by drainage in the vicinity of the pond.
- The area around the pond must in continuation be used for grazing or arable land up to a distance of at least 100 m from the pond, and may not be built upon, planted with trees or included in a garden.
- No poultry or ducks, musk rats or similar may be kept in or near the pond.
- Adult fire-bellied toads, eggs or tadpoles may not be collected, and no other action which could harm the toads is allowed.

In other cases, whole landscapes were protected by declaration under the Danish Law for Nature Conservation, for example for their landscape value, and the survival of *Bombina* was only one aspect out of many in the declaration (Table 2). Here, regulations on the use of ponds was often less specific than in the cases above.

The ponds from which population data were recorded are all those where *Bombina* was known to occur around 1940-1955 or at the time when the site was protected. Except for Ulvshale, all sites referred to were on private property. The largest number of ponds is on Knudshoved Odde. Out of 24 ponds there, *Bombina* was recorded in 18 in 1946, and these 18 ponds have been censused.

We have evaluated in how many ponds *Bombina* has survived at several points of time. To do this, all recorded *Bombina* localities were investigated. One of us (EW) investigated the majority of localities in Denmark where it was

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Table 1. Date and location of ponds protected as individual ponds.

Year protected	Number of ponds	Location
1946	1	Junkergården NW of Nysted, Lolland
1949	1	Tranderup Mark, Ærø
1951	6	One on each of the following islands south of Funen: Drejø, Skarø, Hjelmshoved, Hjortø, Birkholm, Strynø Kalv
1956	12	Island of Avernakø south of Funen
1966	1	Cypresvænget on Enø near Næstved
1969	1	Tårup Strand south of Nyborg, Funen

suspected that *Bombina* might still live in 1976-1977. The few remaining localities were investigated by other surveyors in the years up to 1982. From about 1983, some persisting *Bombina* populations were monitored on a yearly basis, and from 1988 all extant populations have been monitored at least every third year. This has been done by a large number of experienced herpetologists, partially with and partially without pay. As a control, we include comparative data for ponds that were not protected by legal declaration. We include those ponds where *Bombina* was reliably recorded between 1940 and 1955 by naturalists (unpublished data from P. Holm Andersen, F. H. Møller, and many others).

Fisher's exact tests were used to compare whether there were significant differences in the proportion of ponds that originally contained *Bombina* in 1940-1955 which retained the species under different levels of protection.

CONSEQUENCES

By 1980, *Bombina* had disappeared from more than half of the ponds where it had been present between 1940-1955, especially from those that were protected only as single ponds or not protected at all (Table 3). *Bombina* persisted in significantly more ponds protected as single ponds ($p = 0.023$) or as part of protected areas ($p < 0.0001$) than unprotected ponds. The difference in the proportion of ponds where *Bombina* persisted between ponds protected singly and those that were part of a protected area over this time period was just significant ($p = 0.048$).

By 1988-1992 the number of ponds that still contained *Bombina* had fallen further in all three levels of protection (Table 3). Over this time period, significantly more ponds protected as part of a large protected area retained *Bombina* compared to ponds that were protected in isolation ($p = 0.019$), and there was no significant difference in the persistence of *Bombina* between singly protected ponds and unprotected ponds

Table 2. Date and location of protected landscapes containing *Bombina*.

Year protected	Location
1936	Holsteinborg, southwest Zealand
1947	Ulvshale on the island of Møn
1951	Nekselø, island off NW Zealand
1951	Hesselø, island north of Zealand (declared a scientific reserve)*
1952	Knudshoved Odde, SW Zealand
1953	Enø Overdrev, Enø island, SW Zealand
1955	Romsø, island off NE Funen*
1956	Holckenhavn, east Funen

*island sites where ponds were not distinctly protected

($p = 0.21$). Again there was a highly significant difference in the persistence of *Bombina* between ponds in protected landscapes and unprotected ponds ($p < 0.0001$). By that time, modern active methods of conservation, with dredging of ponds, removal of fish, and artificial rearing had begun to be carried out in several places (e.g. Briggs 1997), so the situation was no longer affected simply by legal protection versus no legal protection. There were many sites where active management was undertaken, and where the population would most likely have died out if protection by declaration had been the only measure taken. Thus the right hand column in Table 3 illustrates what could have been the results if legal protection had been the only measure taken and no other actions had been carried out.

DISCUSSION

For the fire-bellied toad, as well as for other amphibians in Denmark, disappearance of the breeding ponds is unlikely to be the main cause of decline. For example, for tree frogs *Hyla arborea* on the island of Bornholm, the cause of extinction of the populations during the period 1950-1990 was total disappearance of ponds in only 10% of cases; eutrophication and introduction of fishes were the main causes (Fog 1988).

Therefore, simple protection of ponds by declaration does not remove the main drivers of decline and, in accordance with this, the positive effects of such declarations on *Bombina bombina* in Denmark have been limited. Of 62 ponds protected by declaration up to 1969, only nine had surviving *Bombina* populations without any additional measures taken, as seen in the right hand column of Table 3.

The rate of loss of *Bombina* was significantly faster in unprotected ponds compared to protected ponds and the rate of loss was slowest for ponds that are parts of a generally protected landscape. The localities where *Bombina* survived in several of the protected ponds were mostly grazed areas, whereas most ponds where *Bombina* became extinct were places that have not been grazed for many years. Therefore these effects might be confounded by the effects of grazing versus no grazing. In any case, until recently it was not possible to prevent cessation of

Table 3. No. of ponds where *Bombina* has survived up to the indicated time.

Protection status of ponds	Original no. of ponds with <i>Bombina</i> in 1940-1955 or at time of protection	Still <i>Bombina</i> present 1977-1982	Still <i>Bombina</i> present 1988-1992	<i>Bombina</i> still present, and no specific management carried out
Part of large protected area	40	19	15	9
Protected as single ponds	22	5	2	0
No special protection	51	2	1	1

grazing by the declarations, so the conclusion still holds true that protection by declaration has been a rather ineffective intervention.

Although protection has rarely prevented extinction, it appears that it may have delayed extinction in some cases, and this has been important. Thus the first attempt to rescue a *Bombina* population by removing fish was carried out in 1982, and by about 1988, dredging of ponds, artificial rearing and other active measures had become standard. Where *Bombina* managed to survive until after 1988, these methods were implemented, and no population has gone completely extinct since then, although some have gone extinct in the wild and have survived only in captivity. One population went extinct in the wild as late as 2009.

In conclusion, the positive effect of protection alone as a conservation tool is weak and doubtful. On the other hand, the positive effects of active approaches (dredging, removal of fish etc.) are well documented. *Bombina* has survived for at least five years in 93% of actively managed ponds, but only 36% of ponds which were not managed (Fog 1997). The same is true for rare Danish amphibians in general (survival five years after the first recording was 92% in nearly 300 managed ponds with rare amphibians, but only 40% in nearly 500 unmanaged ponds) (Fog 1997). Since 1992, the Danish Law of Nature Conservation states that all ponds with an area of at least 100 m² are automatically protected, so there is no longer a need to protect ponds specifically against destruction; active management is what is now called for.

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