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Status of Conservation and Decline of Amphibians: Eastern Hemisphere

Part 5

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Cover image: The natterjack toad *Epidalea calamita* is a European endemic. The image shows a calling male in the city of Jena, Thuringia, Germany. In highly industrialized countries with a dense human population, the species often colonizes secondary habitats like quarry pits or wasteland within large cities. Photo: Andreas & Christel Nöllert.

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61 Conservation status of amphibians in Norway

Leif Yngve Gjerde

Abbreviations and acronyms used in the text and list of references

DN	*Directorate for Nature Management*
EEA	*European Economic Area*
EFTA	*European Free Trade Association*
EIA	*Environmental Impact Assessments*
EU	*European Union*
NFHF	*Fieldherpetological Forum 2016*
NGO	*Non-governmental Organization*
NINA	*Norwegian Institute for Nature Research*
NIVA	*Norwegian Institute for Water Research*
NØBI	*Nordre Øyeren Biological Station*
NTNU	*Norwegian University of Science and Technology*

I. Introduction

A. Geography, landscape and climate

Norway covers an area of 323,895 square kilometres and stretches 1,752 kilometres from Lindesnes (57°59'N) in the south to Kinnarodden (71°08'N) in the north (Gjessing and Ouren 1983; Anonymous 1990, 1991). Within this area there are low strandflats, extensive fjords, high mountains (highest 2,469 m), hill lands, valleys and lowlands (Wallen 1970). Five of Köppen's climatic types occur within this area. A small area along the southern coast belongs to the Nemoral Zonobiome. Larger parts of southern Norway, east of the northeast-southwest orientated Caledonian mountain chain,

belong to the Boreal Zonobiome and Boreonemoral Zonoecotone. An Interzonal Orobiome covers a larger part of southern Norway, while the Tundra Zonobiome is present in northern Norway. The western coast of Norway has high precipitation with mild winters and cool summers (Oceanic and Suboceanic sections). The Svalbard Islands have a costal tundra climate and glaciers cover large areas. The archipelago covers an area of 62,700 square kilometres.

B. Previous research

The first review of the Norwegian amphibian fauna was probably carried out in 1878 by Robert Collett, when he lectured at the Science Academy in Oslo, and was later published by him (Collett, 1879). Later reviews include Collett (1918), Johnsen (1935), Ruud (1949), Støp-Bowitz (1950), and Johnsson and Semb-Johansson (1992). Surveys of spawning sites were first carried out by Enger (1970) in the Fredrikstad area. Later surveys include the areas of Kongsrudmyra (Gjerde 1984, 1992), the Øyeren delta (Gjerde 1989a, 1991b, 1996), Kløfta (Rygg 1989), Romerike (Fossen *et al.* 1989) and Stange municipality (Aaseth *et al.* 1993).

Professor Arne Semb-Johansson studied *Bufo bufo* on three islands on the Hvaler archipelago every summer for 27 years beginning in 1966. In addition to monitoring the populations he also made notes on their morphology, and suggested their reduced body size constituted an insular adaptation (Semb-Johansson 1989). Dag Dolmen at the NTNU University Science Museum in Trondheim carried out his work on newts in central Norway from 1971 until he retired in 2014 (e.g. Dolmen 1982). Leif Gjerde from the Nordre Øyeren Biological Station initiated a survey and monitoring project on brown frogs at the Øyeren delta in 1988, which is still in progress (Gjerde 1989, 1996, in prep. b). During more recent years a number of theses on the occurrence of *Triturus cristatus* at Geitaknottane has been produced by students at the University of Bergen (Gjerde, in prep. a).

In Norway there have traditionally been only a few people working with amphibians. A *Norwegian Fieldherpetological Forum* was established as a network in 1991, and formalized into an organization in 2016 (see web page: www.nfhf.info/norway). Further information about amphibians in Norway is also available from www.herptiler.no.

C. Current status of amphibians

Norway has a relatively poor diversity of amphibian species. Norway and Sweden combined constitute the Scandinavian Peninsula, which has a land bridge to Finland/Russia only north of the Arctic Circle. There were connections to continental Europe (Denmark/Germany) during postglacial periods (7,500–6,000 B.C.) when the Baltic Sea was a lake (Lake Ancylus), but the land bridge disappeared before all species were able to disperse to the north. Since then, Norway has had a number of warm and cold climatic periods, and it is believed that the small Norwegian population of *Rana lessonae* is a relict from such a warm period. Seven amphibian species occur in Norway: two newts *Triturus cristatus* (Laurenti, 1768) and *Triturus vulgaris* (L., 1758); one toad *Bufo bufo* (L., 1758); and four frogs *Rana temporaria* L., 1758, *Rana arvalis* Nilsson, 1842 (Figure 61.1), *Rana lessonae* Camerano, 1882, and *Rana esculenta* L., 1758 (not native). No amphibian species are known from the Svalbard Islands, Bear Island or Jan Mayen.

Fog (1995) suggested that three colour varieties of *Rana* arvalis from Denmark (*striata*, *maculata*, *nigromaculata*) are in part geographic variations linked to habitat and with interspecific competition with *R. temporaria*. Furthermore, he described morphological variations linked to their distribution. For Eastern Europe he mentioned *unicolor* and *punctata* as additional examples of colour morphs. However, the ventral side was not described. In Norway only the colour morph *maculata* has been recorded. However, Gjerde (1993) mentioned a characteristic white stripe on the throat (but not on the belly), which is formed by the lack of blue colouration (100% of the males) (Figure 61.2 left) or marbled surface (94% of the females) (Figure 61.2 right), described as *oeyereniensis*. This feature

Fig. 61.1 A male *Rana arvalis* forma *oeyereniensis* from the Øyeren delta in 2011. Note its blue lek colouration. Photograph by Leif Yngve Gjerde.

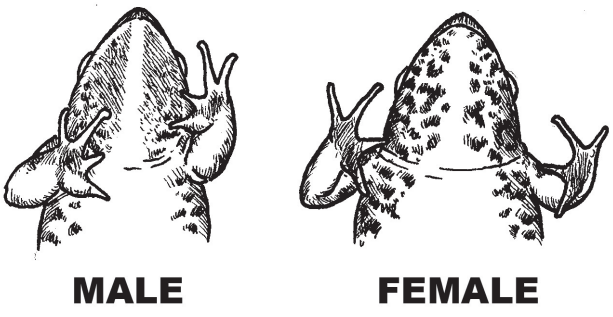

Fig. 61.2 *Rana arvalis* forma *oeyereniensis* from the Øyeren delta showing the characteristic stripe on the throat in the majority of individuals. The stripe is formed by lack of the blue colouration in males and by lack of marbling in females. Illustrations by Petter Bøckman.

also has been described by Elmberg (1978) from Umeå and Gotland (both in Sweden) (Nilson and Andrén 1981). However, the sample from Umeå included only one individual, and on the individuals from Gotland the entire belly was marbled as well. Forma *oeyereniensis* has been reported from Denmark, West Germany, Poland and mainland Sweden (13–35%), but the colouration of the belly has not been described for specimens from these regions. The status of the variety found in the Øyeren delta has yet to be assessed.

II. Status and distribution

A. Surveys

Dolmen (1982) published a temporary atlas based on work he initiated in 1973. It was mainly about newts in central Norway, but was expanded to include all amphibians throughout Norway. A number of other preliminary publications have appeared since. Beginning at the end of the 1980s interest in amphibians has increased, and a number of local and regional surveys have been carried out (e.g. Strand 1994; Gjerde 1997a, b, 2002; Spikkeland 1998; Hansen 1999).

B. Mapping biological diversity

In the Parliamentary instructions of 1997 (Anonymous 1997) it was required that all municipalities should carry out mapping and evaluate the biological diversity within each municipality boundary by 2003. The Regional Environmental Agencies provided 50% of the finances, and the municipalities were expected to provide the rest. However, implementation varied from place to place; some municipalities initiated their own surveys, but most only compiled existing knowledge into a report. These reports also included data, if available, on the status of amphibians within the specific geographic scope of the municipality. Some municipalities only provided databases.

III. Threats

None of the Norwegian amphibian species, except for *R. lessonae* (Anonymous 2006), are threatened by extirpation on a national scale. Most landscape features remain intact and are ecologically sustainable. This includes coastal, montane and forested areas. On a regional basis, amphibian populations are threatened in the agricultural landscape by loss of habitat, industrialized agriculture and destruction of ponds.

Within the boreal forests of eastern and central Norway, forestry management has a large impact on amphibian habitats by drainage of peat bogs. The introduction of fish to small bodies of water is also a general but extensive threat.

NØBI produced in 1994 some simple guidelines for management of amphibian populations (Gjerde 1994a).

A. Habitat and occurrence

Due to the earlier glaciations of Norway, a number of lakes and peat bogs, of all sizes, exist (Figure 61.3). Both in mountainous and boreal regions, there are a number of natural habitats still intact. In addition to these, the wetlands are connected to rivers and their flood plains.

Fig. 61.3 Annual spring flood at Årnestangen (the Øyeren delta). A typical spawning habitat (*Carex* swamp) for *Rana arvalis*. Photograph by Leif Yngve Gjerde.

In rural areas, amphibians are traditionally found in artificial ponds on farm estates. Usually a farm had one or two ponds functioning as a source of water for use by people and animals, and in case of fire. A new law came into effect in 1958 (Schei and Zimmer 1996: LOV-1957-05-31-1) which required all farmers to fence their ponds for security reasons. This, in combination with a change from production of milk and meat to the raising of cereals in the agricultural industry, resulted in the filling in of most ponds.

B. Red List

The concept of the Red List was developed and placed in use by the IUCN as early as 1964. Subsequently, it was adapted by a number of NGOs throughout the world. In Norway the first Red List was published in 1974 by the World Wildlife Fund (Hagen *et al.* 1974). The first governmental Red List was produced in 1978 by the Nature Conservation Inspector for South Norway and *Statens Naturvernråd* (the Governmental Nature Conservation Council) published a Red List in 1984 (Anonymous 1984). In 1988 the *Directorate for Nature Management* (DN) published a Red List (Christensen and Eldøy 1988). The Red List of 1992 attracted some controversy since it was published both by Sandlund and Størkersen, resulting in two separate lists from the same authorities. In 1999 the Red List was updated by Størkersen.

In 2005 the *Norwegian Biodiversity Information Center* was established by the *Directorate for Nature Management*. Today it is a part of the *Ministry of Education and Research*. It revised the status of the Norwegian amphibian species twice (Kålås *et al.* 2006, 2010) (Table 61.1). It is important to be aware that Red Lists made by management authorities often have political objectives influencing the choice of categories. This becomes especially apparent when NGOs and independent scientists have not been asked for advice. In Sweden this problem is solved by using scientists who have no connection with the management authorities (Ahlén and Tjernberg 1996).

C. Agricultural landscapes

Typical agricultural landscapes of Norway, where crops are grown, lie below the late-glacial marine limit. They are old sea beds with deposited clay. These areas are located at Jæren (southwestern Norway), Ringerike and Vestfold (southwest of Oslo), Romerike/Østfold (southeast to northeast of Oslo), and around Norway's largest lake, Lake Mjøsa (in the Hamar and Gjøvik regions), as well as in areas around Trondhjem Fjord. The landscapes in these areas have been altered by intensive industrial agriculture with extensive levelling of ground in ravine valleys.

Before 1940, agriculture was mainly conducted by manual labour, and included a variety of animals. It was common to have a pond as a source for drinking water and in case of fire. Furthermore, a number of ponds in grazing areas supplied horses, cattle, sheep and goats with drinking water.

Table 61.1 Status of threatened Norwegian amphibians. **CR** = Critically endangered; **NT** = Near threatened; **VU** = Vulnerable

Species	Kålås *et al.* (2010)	Status NFHF [1]	Threats
Rana arvalis	NT	VU	Drainage of peat bogs; ploughing of floodplains and wetlands; road constructions isolating populations.
Rana lessonae	CR	CR	Only one metapopulation of 100–500 adults.
Triturus cristatus	VU	VU	Destruction of ponds on farmland; drainage of peat bogs; ploughing of floodplains and wetlands; road constructions isolating populations.
Triturus vulgaris	NT	VU	Destruction of ponds on farmland; drainage of peat bogs; ploughing of floodplains and wetlands; road constructions isolating populations.

[1] Norwegian Fieldherpetological Forum, 2016.

In 1957 a law was introduced to prevent children from drowning. It required that all ponds be reported to the police, and be secured by fencing (Schei and Zimmer 1996: LOV-1957-05-31-1). Since farming in Norway was gradually changing from animal production to the growing of crops, and with the access of water through pipes, ponds became less important. Accordingly, an increasing number of ponds were filled in during the following decades and the space they had occupied used for other purposes. This law was cancelled in 1995, and integrated into the Norwegian Planning and Building Act. Now a pool was defined as any open water with a depth of over 20 centimetres, and the municipality (not the police) became responsible for inspection.

Today most areas have few remaining ponds, e.g. in Fet municipality only two remained by the year 2000 (Gjerde 2002), while a school project in Ullensaker municipality located 122 ponds on recent maps, only 83 of which still persist (Rygg 1989). Spydeberg municipality had over 200 ponds on 300 farms in the 1930s. By 1984 there remained only 30–50% of them, and ten years later most of those were gone.

D. Forested regions

Most of the mountain chain in southern Norway consists of the Paleic Peneplain. As most of this area is relatively flat, the density of variably sized bodies of water is very high. Also peat bogs are quite frequent. Most regions east of the Caledonian mountain chain also have a high density of pools and lakes of various sizes. Except for residential and agricultural regions, this area is mostly covered with boreal forest of mountain birch (*Betula pubescens tortuosa*), birch (*Betula pubescens pubescens*), pine (*Pinus sylvestris*) and spruce (*Picea abies abies*).

Recreational fishing is a popular hobby in Norway, and the *Norwegian Association of Hunters and Anglers* is a strong organization promoting angling. Fish (mostly trout, *Salmo trutta*) are artificially introduced and cultivated in most lakes (e.g. Ingierd 2006). This includes small bodies of water down to 80 x 80 m. Newts are sensitive to predation by fish and, consequently, few localities remain suitable for these salamanders.

E. Introduced species

In 2003, Petter Bøckmann told the author that he had received rumours of a new frog species on the western coast of Norway. It transpired that it was a botanist, Svein Imsland, who first discovered the frogs. Subsequently, Mikaelsen (2008a, b) published the information that *R. esculenta* and *R. lessonae* had been introduced to the island Finnøy, just outside Stavanger. A Norwegian family had brought 20–30 individuals of mixed species from their vacation in Poland during the spring of 2003. Since then, the frogs have spread to a number of ponds on the island. In 2008 the species had established themselves at 4 of 7 lakes and 5 of 18 ponds (Dolmen, 2009). Potential threats of introduced species of amphibians to native ones are predation, competition and transfer of disease.

IV. Current law and protection

A. Protection of species

The law on hunting and capture of wild game came into effect in 1982 (Anonymous 2014b: LOV-1981-05-29-38). Until then, plant or animal species needed to be protected specifically if they were under threat. With this new law it widened the definition of "game" to include all species of amphibians, reptiles, birds and mammals, prohibiting general hunting, unless a designated hunting season was specified for the species. This reversed the hunting philosophy in favour of the species – the "mirror prinsipp". Similar laws came into effect in a number of European countries at this time. In essence, these gave a wide protection to all amphibian species, but not to their habitats.

B. Protection of biological diversity

In 2009 an additional law was introduced, the biodiversity act (Naturmangfoldloven). The aim of this law was to protect biological diversity and ecological processes by sustainable management, and for the benefit of human activity, culture, health and wellbeing, both at present and in the future. The objective for the conservation of each species is the long-term protection of its genetic variation, and that the species exist in sustainable populations within their natural geographic range. To obtain this objective the entire environment needs to be protected to allow all the species' ecological functions to proceed. This law came into effect on 1 July 2009 (Anonymous 2014c: LOV-2009-06-19-100).

C. Environmental impact assessments (EIA)

Regulations on environmental impact assessments have existed since 1990, but have been revised a number of times since. New regulations pursuant to the *Norwegian Planning and Building Act* came into effect on 1 January 2015. The objectives of these regulations are to ensure that consideration for the environment and society is included during preparation of measures/changes, and to decide if, and on what terms, those measures/changes are implemented.

It is usually the municipality's case worker who assesses the need for any environmental impact assessment (screening). If found necessary, usually a general biological study is carried out, usually based on existing knowledge. In most cases, however, current knowledge is too poor, fragmented and accidental to give any correct picture of the specific amphibian fauna at a given area. This leads to wrong and misguided conclusions. A field study is usually required.

The implementation of environmental laws integrated into construction work like road building and construction of wind turbines is relatively new, and no tradition has been developed for good planning and mitigation in the interest of environmental conservation.

The forest industry has developed guidelines and ethical standards that accompany the law, but nothing includes amphibians. The road authorities, however, have developed standards for environmental impact assessments and mitigations through guidelines like "Roads and Wildlife" (Iuell 2005). The implementation and integration of wildlife laws into the management of projects has become increasingly common (although the laws require full compliance from when the laws came into effect). This is a process that takes time. Most projects today consider environmental laws during the planning phase, but a field evaluation of the effects of any mitigation is still rare.

D. Mitigation

Although regulations on environmental impact assessments have existed for 28 years, implementation by authorities of sectors (e.g. municipalities, road authorities) has gradually become adopted over time. Even today, however, the importance of EIA is still trivialized. The change does not depend on regulations alone, but follows the knowledge, practice and respect every project coordinator has for the value of nature. What is essential is that mitigation proposals need to be included in the EIA. This includes mitigation both during construction and post-construction. Even if the law provides clear recommendations to post-construction EIA in which the effect of mitigation is tested, and even improved, such measures will never happen unless included in the EIA and in the budget for the construction work.

EIA has become relatively common in most sectors, but mitigation for amphibian populations is still relatively new. Only four mitigations have been carried out on amphibian passages under roads, and all during the past 12 years (Strand and Stornes 2007; Strand *et al.* 2009). Unfortunately, these have not been completely successful owing to lack of experience and neglect of effective designs from other countries, so all require post-construction improvements.

Table 61.2 Reviews of amphibian tunnel projects in Norway.

Locality	Mitigation	Reference	Faults
Volda	1997/2010	Strand *et al.* (2009)	Experimenting with untested designs for tunnel
Nesodden	2006	Strand (2001b); Strand and Stornes (2007)	Experimenting with untested designs for tunnel
Merkja, Nordre Øyeren	2015	Strand (in preparation)	Experimenting with untested designs for tunnel. The effect of tunnels not evaluated.

An overview of all Norwegian mitigation projects for amphibians is almost impossible owing to the numerous sector authorities involved. No central database or library on the topic exists. We know replacement ponds have been used for road projects and in connection with farming (e.g. Heggland 2010). However, it is the amphibian tunnels that receive the eye of the media, making it possible to get a proper overview of most projects (see Table 61.2). The latest and most extensive mitigation for amphibian populations was carried out in Merkja (Figure 61.4; Nordre Øyeren Nature Reserve) during 2014. This project is used as an example of obvious mistakes that have been made (Gjerde 2009, in prep. c):

- Recommendations ignored: noise screening, stone deposits along road for hibernation, creating additional ponds
- No dialogue between EIA scientists and mitigation
- Lack of replacement habitats (both terrestrial and aquatic)
- Concrete not coated, resulting in excessively high pH

Fig. 61.4 Amphibian tunnel at Merkja (Nordre Øyeren Nature Reserve) illustrating extensive foraging areas out of reach for amphibians. The prevention of communication between researchers from the EIA and mitigation stages of the road resulted in unnecessary mistakes. Also, there was a lack of a buffer zone between the terrestrial and aquatic habitats. The fence and tunnel should have been placed higher up on the slope. Mitigation failed to include replacement habitats. Photograph by Leif Yngve Gjerde.

- Entrances to tunnels on one side below ground level
- Poor drainage of tunnels
- No post-construction study of the success of the tunnel

The biggest mistake was that during EIA the scientists hired for construction work and post-construction testing were different individuals with no exchange of information. This resulted in important information being lost during the process. The second mistake was that details and information concerning the mitigation should have been included in the EIA. Failure to do so resulted in information being lost and ignored later in the building process.

V. Monitoring programmes and conservation measures

The Parliament has given instructions on monitoring biological diversity in Norway (Anonymous 1997). The Directorate for Nature Management wish to include amphibians in a national monitoring programme and they have charged the Norwegian Institute for Nature Research (NINA) with assessing the possibility for such a scheme. NINA published their recommendations in 2000 (Hårsaker *et al.* 2000). Such a program has still to be initiated, however, and the ongoing non-governmental bodies have not been consulted.

A. Population Monitoring

The first monitoring of amphibians in Norway was carried out by Professor Arne Semb-Johansson on three islands of Hvaler (outer Oslo Fjord) over a 24-year period (Semb-Johansen 1989). It started in 1966 and included a 2.2-km walking transect repeated 10–20 times each summer (Semb-Johansson 1992).

A monitoring project on brown frogs (Figure 61.5) was initiated by Nordre Øyeren Biological Station in 1988 (see Figure 61.6). The objective was to monitor population sizes of *R. temporaria*

Fig. 61.5 Individuals of *Rana arvalis* from the Årnestangen metapopulation in the Øyeren delta during April 2011 showing their blue lek colouration. The spawning period lasts only for a few days and the blue colouration takes 1–2 days to develop after initiation of calling at the spawning site, during which the blue colour may be only partially developed or lacking (Gjerde 1993). Photograph by Leif Yngve Gjerde.

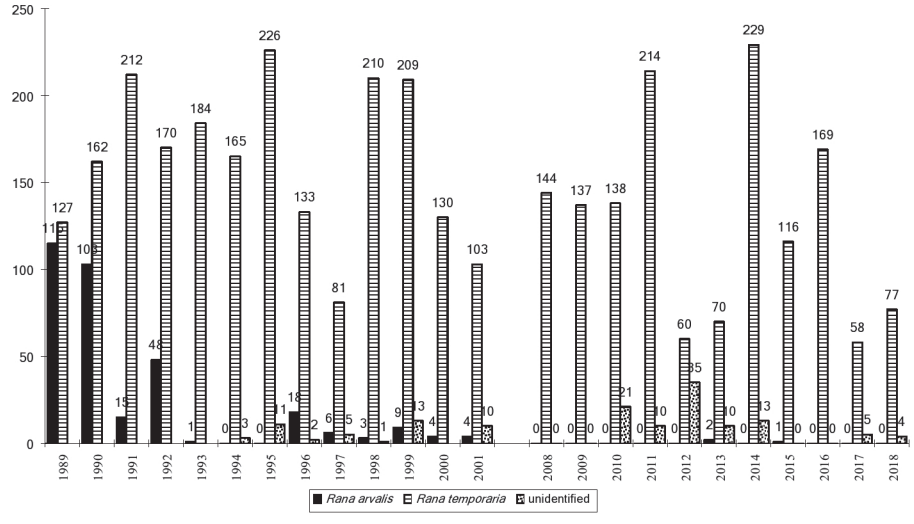

Fig. 61.6 Number of reproducing females at pond No. 20 in Nordre Øyeren Nature Reserve, monitored by the author. The work began in 1989, and is still being carried out by Nordre Øyeren Biological Station (NØBI). The project was discontinued from 2002–2007. Today we know that data from single ponds give limited information owing to short-term fluctuations in the population. For this reason, the project was gradually extended to include a number of spawning sites within the same metapopulation. Monitoring changes in habitat and general status of the breeding population (sink, medium, source) in relation to distances between suitable surrounding habitats (spawning and foraging sites) have been shown to be much more relevant in the author's experience.

and *R. arvalis* by registering the number of egg clusters in the Øyeren delta just 20 km east of Oslo. Since each female lays only one cluster of eggs, the numbers represent the population size of reproducing females (Figure 61.6). This is an accurate and effective way of monitoring populations. The 1988 season started as a trial, but the number of localities has increased to allow for monitoring three metapopulations, not individual ponds (Gjerde 1994b, in prep. b).

B. Phenology

In connection with the monitoring of metapopulations of brown frogs in Nordre Øyeren, data on timing of spring activity (phenology) were also collected, especially the date of the first cluster of eggs. Minimum and maximum ambient temperatures are compared with rainfall to assess the beginning of each spawning season (Gjerde 1996c, in prep. b). These data are important when assessing short-term climatic changes.

C. Repeated surveys

Except at Nordre Øyeren, there is no real monitoring going on in Norway. A program has been suggested by the authorities, but lack of funding and cooperation so far has prevented its implementation. However, a number of distributional surveys have been carried out by measuring the occurrence/absence of species at spawning localities. Such studies have been repeated to measure changes of occurrence and distribution through time (e.g. Gjerde 2008a, b; Strand 2001a).

D. Protected areas

The Danish conservation law protects all natural bodies of water of 100 m^2 or larger. In Norway, however, there is no general law specifically protecting amphibian habitats. Norway is not a member of the EU, but has cooperation and obligations as an EFTA (European Free Trade Association) country, through the EEA agreement. This implies that most legislation within the EU, is usually integrated into Norwegian law. However, the EU Habitats Directive has never been legally

integrated into Norwegian law, and it has not been implemented in Norway. From 2001 onwards, however, a new water-resource law came into effect (Anonymous 2014a), protecting all natural waterways. The definition of a waterway includes semi-terrestrial areas covered by flood water at some time during a 10-year period (maximum 10-year average flood level). This covers areas/habitats potentially important for *R. arvalis*. However, implementation of the law has proved ineffective and has been ignored by local authorities such as Fet municipality in the Nordre Øyeren Nature Reserve (Figures 61.7, 61.8). Thus, the only real protection of areas important to amphibian populations is carried out by the creation of Nature Reserves where entities other than amphibians are important aspects of the protection process.

So far, two areas in which amphibian populations have been a crucial argument for the legal process have been protected. They are Kongsrudmyra and Geitaknottane.

Kongsrudmyra (Figure 61.9) is located just 30 km east of Oslo and consists of a valley 2 km long and surrounded by agriculture to the north and east, and boreal forest to the south and west. The entire length of the valley's floor is covered with peat bogs, with a small lake in the centre. Buffer areas surrounding the bog include swamp forests of birch (*Betula pubescens pubescens*) and spruce (*Picea abies*). Three small lakes surrounded by small bogs are located in the boreal forest to the west of the ridge above the valley. The first studies on amphibians were carried out during spring and summer of 1983 (Gjerde 1984). A follow up study was carried out in 1990 and 1992 (Gjerde 1992) and revealed the occurrence of all five Norwegian amphibian species. Furthermore, the population of *T. cristatus*, *R. arvalis* and *R. temporaria* were relatively high. This led to a number of organizations getting involved to protect the area. The area was temporarily protected on

Fig. 61.7 The picture is from construction work during 2014 in Merkja (Nordre Øyeren Nature Reserve), illustrating the loss of wetland. The road authorities ignored the water-resource law of 2001, and mitigation did not include the replacement of lost wetlands. Photograph by Leif Yngve Gjerde.

Fig. 61.8 A pond within the Nordre Øyeren Nature Reserve (Ramsar site). It has the largest population of *Rana temporaria* within the reserve, but has been threatened a number of times by road construction, digging of ditches, run-off from agriculture and the ploughing of wetlands. The picture shows a normal spring flood in an area that since 2001 has been protected by the water-resource law. The picture is from 2006 and illustrates the landowners ploughing below the defined wetland boundary. Poor management and violations of the law resulted in the extirpation of *Rana arvalis* in the 1990s, although in some subsequent years a few individuals have reappeared and reproduced. Photograph by Leif Yngve Gjerde.

Fig. 61.9 Kongsrudmyra (viewed from north to south). This area is known for its many habitats within a small area, thus resulting in a high species diversity of plants, insects, amphibians and birds. Photograph by Leif Yngve Gjerde.

16 February 1996, and permanently protected on 13 December 2002 as a forest reserve with its special qualities of valuable amphibians.

Geitaknottane is located on a peninsula between the Hardanger and Bjørna Fjords, 30 km southeast of Bergen. The landscape is rocky and includes areas below and above the tree line. The area was first mentioned by Dolmen (1993). Torstein Solhøy and Anders Hobæk at the University of Bergen have since supervised over eight theses and students' reports from this area (Myklebust 1998; Hage 1999; Hobæk *et al.* 2000; Gutiérrez 2002; Berge 2005; Strømme 2005; Paulsen 2006; Paulsen *et al.* 2009), making it the most extensively studied area in Norway. The metapopulation of *T. cristatus* is large and included 1,680 individuals in 180 ponds surveyed in 2008 (Paulsen *et al.* 2009). An estimate for the total area suggests a population of 3,000–10,000 individuals (Myklebust 1998; Hage 1999; Gutiérrez 2002; Paulsen 2006). These populations are considered to be some of the largest in the world (Steinvåg 2010) and are certainly the largest in Norway. An area 13.7 km^2 in size at Geitaknottane was protected as a Nature Reserve on 19 December 1997.

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