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Distribution, status and conservation of the moor frog (*Rana arvalis*) in the Netherlands

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Verbreitung, Status und Schutz des Moorfrosches (*Rana arvalis*) in den Niederlanden

Die westliche Verbreitungsgrenze des Moorfrosches (*Rana arvalis*) verläuft teilweise durch die Niederlande, die eine der westlichsten Populationen dieser Art beherbergt. Der Moorfrosch lebt in einer Vielfalt von Lebensräumen, mit Schwerpunkten auf sandigen und moorigen Böden. In der 1996 erschienenen Roten Liste war die Art als gefährdet eingestuft. In der neuen Roten Liste gilt sie als nicht bedroht, weil in der Zwischenzeit viele Vorkommen neu entdeckt worden sind. Trotzdem wird von einem Rückgang um 28,7 % in dem Zeitraum von 1950 bis 2006 ausgegangen. Vor allem die Kultivierung der Heiden und Mooren, die Absenkung des Grundwasserstandes und eine Intensivierung der Landwirtschaft haben den Rückgang des Moorfrosches verursacht. Schutzmaßnahmen für verschiedene Lebensräume werden dargestellt. Das Anlegen von Kleingewässern in Naturreservaten und in der extensiven Agrarlandschaft erwies sich in den Niederlanden für den Moorfrosch als wenig effektive Naturschutzmaßnahme.

Schlüsselbegriffe: Amphibia, Anura, Ranidae, *Rana arvalis*, Moorfrosch, Niederlande, Verbreitung, Status, Rote Liste, Gefährdungen, Schutzmaßnahmen.

Abstract

The western distribution border of *Rana arvalis* runs through the Netherlands, where one of the westernmost populations of the species occurs. The moor frog has been found in all provinces and occupies a wide variety of habitats, with concentrations on inland sand and peat. In the Netherlands Red List of 1996 the species was listed as vulnerable. In the new Red List it is listed as least concern, because recent inventories brought many new locations to light. Nevertheless, there is a decrease of 28.7 % between 1950 and 2006. Especially the cultivation of heathland and raised bogs as well as the lowering of ground water levels and intensification of agricultural practices account for the decrease of *R. arvalis*. Conservation measures for different habitat types are presented. The construction of new ponds is hardly an effective protective measure for *Rana arvalis* in the Netherlands.

Key words: Amphibia, Anura, Ranidae, *Rana arvalis*, moor frog, the Netherlands, distribution, status, Red List, threats, conservation measures

Introduction

Data on amphibians and reptiles in the Netherlands are collected on a larger scale since approximately 1900. The RAVON foundation (Reptile, Amphibian & Fish Con-

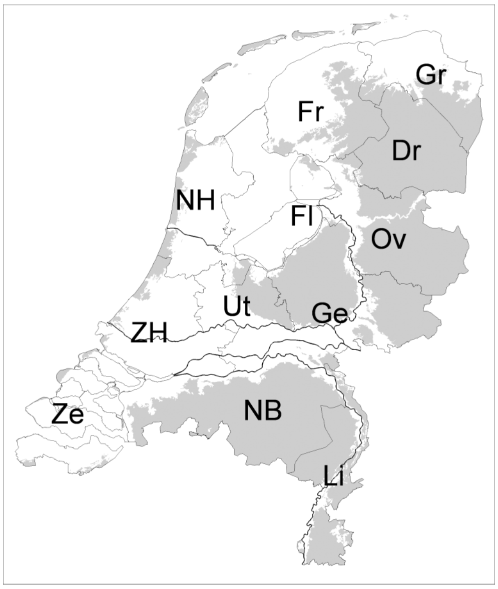


Fig. 1: Geography of the Netherlands; location of the 12 provinces. The grey colour indicates the higher, sandy soils and the marl/löss soils in southern Limburg. Fr = Friesland, Gr = Groningen, Dr = Drenthe, Ov = Overijssel, Fl = Flevoland, Ge = Gelderland, Ut = Utrecht, NH = Noord-Holland, ZH = Zuid-Holland, Ze = Zeeland, NB = Noord-Brabant, Li = Limburg.
Die Niederlande mit ihren 12 Provinzen. Graue Flächen geben höher gelegene, sandige Böden (z. B. Veluwe) an sowie mergelige Böden und Löss in Südlimburg.

servation the Netherlands) co-ordinates the data collection by hundreds of volunteers associated with RAVON, as well as their validation (CREEMERS & VAN DELFT 2001, CREEMERS & VAN DELFT in prep.). The last distribution atlas (BERGMANS & ZUIDERWIJK 1986) was based on 35 000 records. Since then, the database of RAVON has grown up to 389 285 validated records, of which 68.8 % were collected recently (1991–2005). 14 098 of these records (3.6 %) concern *Rana arvalis*, data which are used in the new herpetological distribution atlas (CREEMERS & VAN DELFT in prep.).

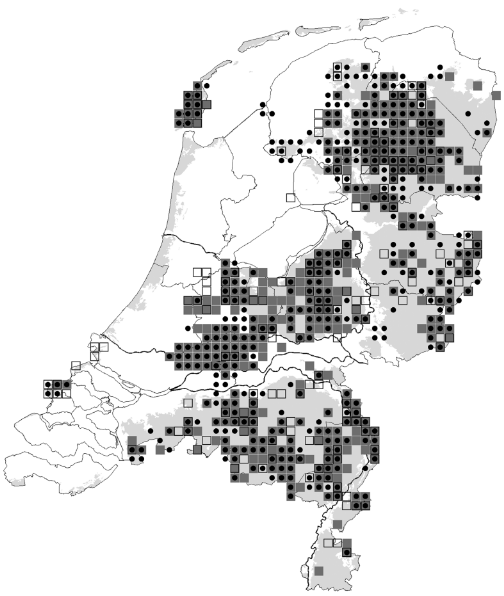
This text is largely based on the maps, analyses and the species specific chapter for the atlas (DE JONG & VOS in prep.), as well as the new Red List of threatened amphibians (CREEMERS et al. in prep.). For orientation, figure 1 shows a map with the 12 Dutch provinces.

Distribution of *Rana arvalis* in the Netherlands

Rana arvalis was recorded in the Netherlands for the first time by the famous Dutch Naturalist E. HEIMANS in 1897. Subsequent surveys revealed that the moor frog is commonplace. From 1991 to 2005, for example, it was recorded in 1 901 grid cells of 1 km^2.

The moor frog has been found in all 12 Dutch provinces (fig. 2), and it is locally abundant. However there is only a single, unconfirmed record from the province of Flevoland on the small former island of Urk (1945), where this frog is now considered to be extinct.

In the Netherlands, *R. arvalis* occurs from around sea level up to around 100 m a. s. l. in the centre (Veluwe area, Province of Gelderland) and south of the country (Berg en Terblijt (†) and Brunssummerheide, Province of Limburg). Many populations along



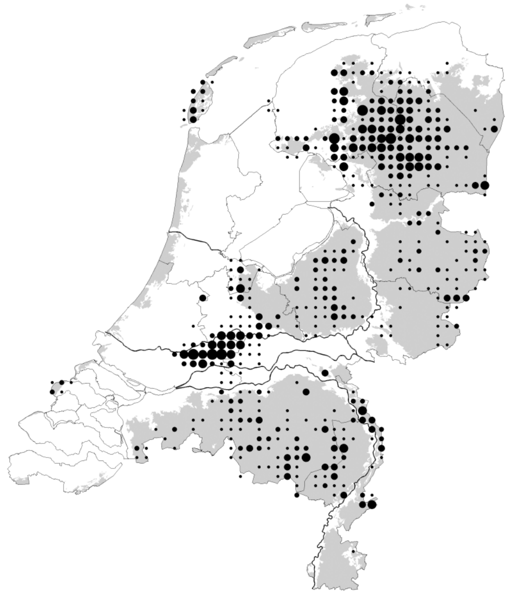


Fig. 2 (left): Recorded distribution of *Rana arvalis* in the Netherlands (5 X 5 kilometre grid) in three periods. □ = before and including 1970, ■ = 1971 to 1990, ● = 1991 to 2005.
Links: Nachweise von *Rana arvalis* in den Niederlanden (5 x 5 Kilometer-Raster) in drei Zeitperioden. □ = vor und einschließlich 1970, ■ = 1971 bis 1990, ● = 1991 bis 2005.

Fig. 3 (right): Distribution of *Rana arvalis* in the Netherlands between 1991 and 2005, expressed as the number of occupied square kilometres per grid of 5 x 5 kilometres. • = 1–2 sq. km, • = 3–5 sq. km, ● = 6–10 sq. km, ● = 11–15 sq. km, ● = 16 or more sq. km.
Rechts: Verbreitung von *Rana arvalis* in den Niederlanden zwischen 1991 und 2005, ausgedrückt als Anzahl belegter Quadratkilometer pro 5 x 5 km-Rasterfeld.

the Southern and Eastern border are in contact with Belgian (BAUWENS & CLAUS 1996) and German (GÜNTHER & NABROWSKY 1996) populations.

On a scale of 5 X 5 kilometres, the moor frog seems to be fairly abundant (fig. 2). In large parts of the country, however, it is found in small nature reserves and inhabits only one or a few square kilometres (fig. 3).

Hotspots for occurrence (fig. 2, tab. 1) are the sandy soils in the north, east, centre and south, the raised bogs in these sandy areas (Provinces of Friesland, Drenthe, Overijssel, Gelderland, Utrecht, Noord-Brabant and Limburg; fig. 4), and the peat bogs and polders in the northern and western parts of the Netherlands (Provinces of Friesland, Overijssel, Utrecht and Zuid-Holland). Raised bogs (mires) are originally ombrotrophic and dominated by *Sphagnum*, whereas peat bogs (fens) are in their top layer strongly influenced by the influx of mineral-rich ground or surface water (GORE 1983, WHEELER & PROCTOR 2000).

High densities of moor frogs are present particularly in the Northern provinces of Friesland and Drenthe, in parts of the province of Zuid-Holland, and the adjoining areas of the provinces of Utrecht and Gelderland (fig. 3). In most other provinces the species is relatively widespread, however many populations are isolated.

Tab. 1: Number of occupied square kilometre grid cells per province in the Netherlands between 1991 and 2005. Occupied grid cells on the border of two or three provinces have been added to all provinces involved.

Anzahl belegter Ein-Quadratkilometer-Rasterfelder je Provinz in den Niederlanden zwischen 1991 und 2005. Belegte Rasterfelder auf der Grenze von zwei oder drei Provinzen sind bei allen betroffenen Provinzen eingerechnet.

Province	Number of occupied square kilometre grid cells
Drenthe	447
Friesland	369
Noord-Brabant	247
Zuid-Holland	230
Gelderland	217
Limburg	166
Overijssel	159
Utrecht	104
Noord-Holland	63
Groningen	38
Zeeland	14
Flevoland	0

Rana arvalis is present in almost all suitable areas throughout Drenthe. Important large nature reserves in this province are for example Bargerveen, Dwingelderveld, Drents-Friese Wold and Fochteloërveen. In Friesland, high densities of occupied grid cells center around the border with the provinces of Overijssel and Drenthe. Important sites are, amongst others, Fochteloërveen, Drents-Friese Wold, Alde Feanen and Rottige Meenthe. Peculiar sites in Friesland are outer dike areas in the IJsselmeer region (former Southern Sea) (VAN DEN BOGERT 2005). In Zuid-Holland the species is widespread and fairly abundant in polders in the southeastern part of the province, especially in the region Vijfheerenlanden (PRIESTER & VAN DER VELDE 1973, VAN EEKELEN et al. 2006), a distribution which continues into Utrecht and Gelderland. The coastal populations of Goeree-Overflakkee and Voorne have gone extinct (DE JONG & VOS in prep.).

From the less densely populated provinces, Noord-Brabant harbours the largest number of occupied square kilometre grid cells. The most important reserves are situated in the southeast, for example Groote Heide, Strabrechtse Heide, Groote Peel and Deurnesepeel (VAN ERVE 2005). The last two reserves connect the populations in Noord-Brabant to those in Limburg, as they are situated exactly on the border between these provinces. Other important reserves in Limburg are Meinweg in the eastern centre and Maasduinen in the north. A peculiar location in Limburg was a hillside heathland in the extreme south (Berg en Terblijt near Maastricht), where the species was found in 1974 (H. STRIJBOSCH pers. comm.). The heathland is now completely overgrown, and no further sightings of moor frogs in this region occurred since then. This was the only record in the hilly, marl landscape of southern Limburg.

Besides the already mentioned localities, Gelderland harbours populations on the large forest and heathland areas of Veluwe in the centre of this province. The Veluwe is an area with a large number of grid cells lacking recent observations, from many of which *R. arvalis* has most probably disappeared. In the region Achterhoek, in Gelderland east of the large river IJssel, the species can only be found in some small reserves mostly situated close to Overijssel and the German border (SPITZEN-VAN DER SLUIJS 2007). The moor frog is present throughout Overijssel, but densities seem low. This might however been an artefact caused by lower inventorial activities (CREEMERS & VAN DELFT 2001). The species is, as well as in Gelderland, absent from the clay areas bordering the river IJssel.

In Utrecht a smaller albeit important area is situated along the large river Lower-Rhine (also called Lek) near the core area of Zuid-Holland. The species can also be

Fig. 4: Fochteloërveen, remnant of a raised bog in the provinces Friesland and Drenthe, habitat of *Rana arvalis*. Photo: RICHARD STRUIJK.
Fochteloërvenn, der Rest eines Hochmoores in den Provinzen Friesland und Drenthe, Habitat von *Rana arvalis.*

found near the border with Noord-Holland. *Rana arvalis* has disappeared from the largest part of the high sandy soils of the Utrechtse Heuvelrug and many areas of the Eempolders and Gelderse Vallei near the border with Gelderland. Also some grid cells at the western edge of Utrecht are lacking recent observations.

In Groningen, Noord-Holland and Zeeland, the distribution is limited to small parts of the provinces. In the northern province of Groningen, *R. arvalis* is known from Westerkwartier, Gorecht, Westerwolde and the surroundings of lake Schildmeer. Only in the southeastern region of Westerwolde larger numbers of adults were found (LUIJ-

Fig. 5: Grassland overgrown with *Juncus effusus* near ditches (aquatic habitat) in the province of Groningen: important terrestrial habitat for *Rana arvalis*. Photo: A. VAN RIJSEWIJK.
Flatterbinsenbestand (*Juncus effusus*) nahe einem Graben (aquatischer Lebensraum) in der Provinz Groningen, ein wichtiger Landlebensraum von *Rana arvalis.*

Fig. 6: Ditch on peaty soil in the province of Utrecht. At the right side cows trample the bank by which suitable, marshy habitat for *Rana arvalis* is formed. Cows are kept away from the left side of the ditch by a fence. The bank is steep, because of no trampling, and no moor frogs are present at that side. Photo: R. VAN EEKELEN.

Graben auf torfigem Untergrund in der Provinz Utrecht. An der rechten Seite Trittspuren von Rindern, durch die geeignete Bereiche für *Rana arvalis* entstehen. An der linken Seite werden die Rinder durch einen Zaun vom Ufer ferngehalten. Das Ufer ist steil, da kein Viehtritt stattfindet, und hier finden sich keine Moorfrösche.

TEN 2004). In Noord-Holland, smaller populations exist in coastal dunes and ditches of the West Frisian island of Texel (VAN LAAR 2005). The species can also be found in the southeastern part of this province, for example at the lakes Naardermeer and Oostelijke Vechtplassen. Zeeland only harbours one population, which is present at the island of Schouwen-Duiveland. This was the westernmost population of this species until CABY et al. (2000) described an isolated population in the Départment du Nord in France.

Concerning soil types, the peaty (11.4 %) and sandy (7.6 %) parts of the country show a relatively high occupation, without considering the sandy coastal dunes (tab. 2). Sandy soils are much more common in the Netherlands than peaty soils, and therefore account for most of the occupied grid cells (70.9 %) (tab. 2). Areas with river clay are

Tab. 2: Presence of *Rana arvalis* from 1991 until/including 2005 in relation to soil types in the Netherlands on a scale of 1 X 1 kilometre grid cells.

Vorkommen von *Rana arvalis* von 1991 bis einschließlich 2005 in Bezug auf Bodentypen in den Niederlanden auf der Grundlage von Ein-Quadratkilometer-Rasterfeldern.

Soil type	Number of grid cells (per soil type)	Number and percentage of grid cells that contain *Rana arvalis* (per soil type)	Contribution per soil type to total Netherlands population
Inland sand	17781	1348 (7.6 %)	70.9 %
Peat	2989	342 (11.4 %)	18.0 %
River clay	2647	139 (5.3 %)	7.3 %
Coastal sand (dunes)	1352	44 (3.3 %)	2.3 %
Sea clay	11265	28 (0.2 %)	1.5 %
Marl/loess	535	0 (0 %)	0.0 %
Total	36569	1901	100 %

Fig. 7: Acid heathland pool dominated by *Molinia caerulea* in Drenthe, breeding habitat of *Rana arvalis*. Photo: J. HERDER.
Saurer Heideweiher mit *Molinia caerulea* in Drenthe, Laichgewässer des Moorfrosches.

less occupied. On the heavy sea clay deposits and the marl and loess soils in the southern part of the province of Limburg, the species is practically absent (CREEMERS & VAN DELFT in prep.).

Status

In the first official Dutch Red List (HOM et al. 1996), the moor frog is listed as vulnerable, because of a decrease of 32 % during the period 1986–1995 compared to »before 1950«, and an occurrence in only 21.6 % of the Dutch 5 x 5 kilometre grid cells.

In 2007 the Red List has been revised, and the moor frog is now considered »not threatened« in the Netherlands, applying Dutch criteria (CREEMERS et al. in prep.). In recent years, intensive inventories have been carried out in which many previous locations could be reconfirmed and new locations were discovered, especially in the north-eastern part of the country. The decrease of the species, expressed as the number of occupied 5 x 5 km grid cells, is now (1997–2006) 28.7 % compared to the situation »around 1950«, and *Rana arvalis* is present in 25.5 % of the Dutch 5 x 5 kilometre grid cells. This combination lists the moor frog as »not threatened«, although a small change in presence (from 25.5 % to less than 25 %) would qualify the species as »vulnerable«. Applying the IUCN-criteria, the moor frog is listed as »least concern« (CREEMERS et al. in prep.). The trend within the Dutch amphibian monitoring scheme is »stable« (GOVERSE 2007).

Threats

The moor frog has been especially affected by large cultivations of heathland and raised bogs in the first five decades of the 20th century. Combined with the intensifica-

Fig. 8: A mesotrophic heathland pool in the province of Noord-Brabant. *Rana arvalis* is present together with *Mesotriton alpestris, Triturus cristatus, Lissotriton vulgaris, Pelobates fuscus, Bufo bufo, Rana temporaria, Rana lessonae*, and *Rana esculenta*. Photo: W. BOSMAN.
Mesotropher Heideweiher in der Provinz Noord-Brabant. *Rana arvalis* kommt hier zusammen mit *Mesotriton alpestris, Triturus cristatus, Lissotriton vulgaris, Pelobates fuscus, Bufo bufo, Rana temporaria, Rana lessonae* und *Rana esculenta* vor.

tion of agricultural practices and lowering of ground water levels in particularly brook valleys, fen meadows and polders, this confined the species to the current nature reserves. VAN GELDER & OOMEN (1970) report a heavy decrease of numbers caused by drought, which indicates that this species is indeed susceptible to desiccation.

The decline of heathland and raised bogs has been enormous. In 1833 there were 600 000 hectares of heathland, covering 20 % of the Netherlands territory. Sheep have always played an important role in maintaining the Netherlands heathlands. At the

Fig. 9: Habitat of *Rana arvalis* in the dunes of island Schouwen-Duiveland (province of Zeeland). Photo: J. JANSE.
Habitat von *Rana arvalis* in den Dünen der Insel Schouwen-Duiveland (Provinz Zeeland).

end of the 19th century sheep-breeding decreased because of decreasing wool-prices caused by the imports of cheap Australian wool. Thereupon the application of artificial fertilizers made sheep-breeding for their dung fall into disuse. In 1907 450 000 hectares remained. Especially during the economical depression of the 1930's, vast areas have been claimed for agriculture and forestry. In 1940 there were 100 000 hectares left and in 1990 only 36 000 hectares, drift-sands and raised bogs not included. Between 1983 and 2000, still 8 000 hectares of heathland changed into forests, mainly by natural succession, or were converted into arable land, or infrastructure (VAN DELFT & KUENEN 1998, MILIEU- EN NATUURCOMPENDIUM 2007).

The raised bogs share a similar history. In 1900 about 90 000 hectares were covered with this ecosystem, of which 5 200 were left in 1990. Of this area only 15 hectares are considered living raised bog nowadays (SCHOUWENAARS et al. 2002, MILIEU- EN NATUURCOMPENDIUM 2007).

However not only the number of suitable habitats decreased, also their quality was subject to deterioration. Many aquatic habitats of *R. arvalis* in the Netherlands, especially moorland and heathland pools, are characterised by a low buffering capacity and therefore a low pH. Because of acidification caused by atmospheric pollution, many pools became too acid for reproduction especially in the eighties and nineties. When pH drops below 4.5, reproduction is rarely reported (LEUVEN et al. 1986, BELLEMAKERS et al. 1991, BELLEMAKERS & VAN DAM 1992). For this reason the moor frog disappeared from many heathland pools (STUMPEL 2004). Further acidification occurred because of the removal of vegetation and the organic layer. This is a common nature conservation measure taken in heathland pools, which may lower the buffering capacity of the water. If no buffered surface or groundwater can reach the pool, acidification may take place (ROELOFS et al. 2002).

In peat bogs in the northern and western part of the country, suitable habitats consist of marshy vegetations. However, these succession stages are rare nowadays and their formation is counteracted by several reasons. Although hardly any research on the status and threats of *R. arvalis* in these areas has been conducted, we assume that this might affect the species to a large degree, as is the case for typical dragonflies of these same peat bog succession stages (NEDERLANDSE VERENIGING VOOR LIBELLENSTUDIE 2002). One important cause is bad water quality caused by desiccation and declining iron containing seepage due to agricultural activities and water extraction. This is even enhanced by the inlet of Rhine water to compensate for the lack of water in nature reserves and farm land. This Rhine water is alkaline, rich in sulphates and poor in iron. This directly results in external eutrophication. But by a series of chemical processes initiated by the inlet of this water, nutrients present in the ecosystem are released in an unnaturally fast way (internal eutrophication). These processes have most probably let to the decline of the marshy vegetations in peat bogs (ROELOFS 1991, SMOLDERS & ROELOFS 1995, LAMERS et al. 2002, SMOLDERS et al. 2006) used by *R. arvalis*.

Genetic studies in the Netherlands show a significant correlation between genetic and geographical distances of moor frog populations. However, even more than geographical distance itself, the number of roads and railways was able to explain genetic differentiation (VOS et al. 2001, ARENS et al. 2007). Fragmentation is thus still a serious threat, even in the province of Drenthe where, in contrast to most other provinces, many and large populations do occur and serious fragmentation started not earlier than around 1930.

Even conservation measures can be a threat when sod cutting, mowing and grazing are carried out on a large scale or too intensively (JONKERS 1995, STUMPEL 2004).

Conservation measures

Whereas the construction of new ponds in nature reserves and extensively used agricultural landscapes is a good protective measure for most Dutch amphibians, this is not the case for *R. arvalis*. In large Dutch inventories of new ponds, hardly any moor frogs were found (STUMPEL & VAN DER VOET 1998, CREEMERS et al. 2000, VAN DER SLUIS & BUGTER 2000, LENDERS 2005). However, older ponds near core populations may be colonised, when vegetation succession is tolerated and marshy situations including vegetation like *Juncus*, *Molinia*, *Carex* or *Phragmites* can develop (LENDERS 2005, J. VAN DELFT pers. obs.).

An important measure for preserving moor frog populations in soft waters, especially heathland pools, is restoring the water quality (pH). Adding chalk to acidified heathland pools (liming) may increase the pH and can decrease the lethality rate of eggs from 95 % to 5 % (BELLEMAKERS & VAN DAM 1992). However, this can also cause severe eutrophication due to the accelerated breakdown of organic material, when this material is not removed (ROELOFS et al. 2002), and soft water organisms might disappear as a result of direct liming. Adding chalk after removal of the sediment can only raise the pH over a short period of time (ROELOFS et al. 2002), after which rapid re-acidification will take place. Therefore, direct liming of pools is now discouraged, and catchment liming is seen as more promising (ROELOFS et al. 2002, DORLAND et al. 2005). After sod cutting in heathlands doses varying between 2 and 6 tons of Dolokal were applied per hectare on the highest parts of the terrain. This resulted in an increase of pH in these highest parts as well as in the lower, non-limed heath and in the pools. The increase lasted during the whole study period (6 years) (DORLAND et al. 2005).

The recent increase of pH and water quality in heathland pools caused by environmental measures (VAN DAM et al. 2003, VAN DAM & MERTENS 2004, GRONTMIJ/AQUA SENSE & ALTERRA 2005) combined with rewetting will most probably be favourable for the moor frog. *Rana arvalis* benefits from a small scale (heathland) management carried out in phases. Intense grazing should be avoided, because the damp microclimate in the vegetation will be lost (STUMPEL 2004).

Occupied waters near rivers should remain little influenced by river dynamics. Conservation measures should be carried out in phases. Damp and fen meadows are especially important if they are old, more or less neglected and part of a mosaic containing ditches, shallow waters and turf pits. An extensive management with sufficient space for higher terrestrial and aquatic vegetation is essential (LUIJTEN 2004, VAN DEN BOGERT 2005). It is important to realise that botanically species-poor grasslands dominated by *Juncus effuses* can be of high importance to *R. arvalis* (LUIJTEN 2004, VAN UCHELEN 2006). They have a moist microclimate and are richly structured, offering refuges and food.

Tab. 3: The most important Natura 2000 sites were *Rana arvalis* is present. The province(s) were the sites are situated are given as well as their surfaces. The abbreviations of the names of provinces are given in figure 1.
Die wichtigsten Gebiete von Natura 2000, in denen *Rana arvalis* vorkommt. Genannt werden die Provinzen, in denen die Flächen liegen sowie deren Ausdehnung. Die Abkürzungen der Provinznamen entsprechen denen in Abbildung 1.

Natura 2000 site	Province	Surface (hectares)
Bargerveen	Dr	2096
Drentsche Aa-gebied	Dr	3966
Dwingelderveld	Dr	3823
Havelte-Oost	Dr	1782
Mantingerzand	Dr	788
Drents-Friese Wold and Leggelderveld	Dr/Fr	7359
Fochteloërveen	Dr/Fr	2599
Alde Feanen	Fr	2142
Rottige Meenthe and Brandemeer	Fr	1396
Veluwe	Ge	91200
Zuider Lingedijk and Diefdijk-Zuid	Ge	483
Maasduinen	Li	5325
Meinweg	Li	1809
Groote Peel	Li/NB	1410
Deurnsche Peel and Mariapeel	Li/NB	2736
Leenderbos, Groote Heide and De Plateaux	NB	4356
Kampina and Oisterwijkse Vennen	NB	2294
Kempenland-West	NB	1957
Strabrechtse Heide and Beuven	NB	1859
Duinen en Lage Land Texel	NH	4615
Naardermeer	NH	1169
Oostelijke Vechtplassen	NH/Ut	6988
Buurserzand and Haaksbergerveen	Ov	1249
Weerribben	Ov	3346
Wieden	Ov	9260
Witte Veen	Ov	294
Kop van Schouwen	Ze	2250
Nieuwkoopse Plassen and De Haeck	ZH	2078
Zouweboezem	ZH	258

For more favourable vegetation (water dominated by hydrophytes, helophytes and floating fens) in peat bog waters, radical measures such as the restoration of natural seepage and the conservation of system characteristic water would be required. Atypical water, being let in, should be purged to avoid eutrophication (LAMERS et al. 2001, 2002). The digging of waters and smaller shallow ditches and depressions in peat bogs with a good water quality is promising (CREEMERS & VAN DELFT in prep.). Large amounts of eggs have been found in shallow waters, which appeared shortly after sod cutting in *Phragmites* stands in several peat bogs (T. VAN DEN BROEK pers. comm.).

To counteract the ascertained effect of isolation, the connection and enlargement of nature reserves as part of the National Ecological Network (strongly related with

Habitats Directive/Natura 2000), are important for genetic exchange. A vegetation which creates a moist microclimate such as moist heaths, *Molinia* vegetations, damp meadows, well vegetated sides of ditches and to a lesser extent deciduous forests (LOMAN 1978, STRIJBOSCH 1980, DE JONG 1988, HARTUNG 1991, DE JONG 2001) could be suitable for migration and can interconnect occupied areas.

The moor frog has limited dispersion capacities with distances estimated between 1 and 3 kilometres (HARTUNG 1991, VOS & CHARDON 1998, VOS et al. 2001). Therefore zones which are meant to connect different populations and that are longer than 1 kilometre, should contain suitable breeding waters, to enable the exchange of individuals between populations.

In table 3 the most important Natura 2000 sites are given. For each province the sites with relatively high densities of *R. arvalis* were chosen. Only sites larger than 100 hectares are taken into account.

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