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Action Plan for the Conservation of the Meadow Viper (V*ipera ursinii)* in Europe



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CONTENTS

A. MEADOW VIPER – SPECIES ACTION PLAN SUMMARY 3

1. Introduction 3

2. Rationale 3

3. Objectives 4

4. Recommended Actions 5

Figure 1: *Vipera ursinii rakosiensis* at the Last Remaining Site for this Subspecies in Romania 4

Table 1: Urgent Priority Actions for the Meadow Viper *Vipera ursinii* 5

B. MEADOW VIPER – SPECIES ACTION PLAN 8

1. INTRODUCTION AND ACKNOWLEDGEMENTS 8

2. BACKGROUND INFORMATION 9

2.1. Systematics 9
2.2. Description 11
2.3. Life History 11
2.4. Distribution and Conservation Status 14
2.5. Threats 21
2.6. Current Protection 24
2.7. Conservation Actions to Date 25

3. ACTION PLAN GOAL AND OBJECTIVES 26

3.1. Overall Goal 26
3.2. Objectives 26

4. ACTIONS REQUIRED 27

4.1 Habitat Protection 27
4.2 Habitat Management 28
4.3 Species Protection 29
4.4 Species Management 29
4.5 Distribution Surveys 30
4.6 Population and Conservation Status Monitoring 30
4.7 Scientific Research 31
4.8 Improved Liaison and Coordination 31
4.9. Public Awareness and Education 32

5. REFERENCES 32

Map 1: Distribution of the Meadow Viper *Vipera ursinii* in Europe 10

Table 2 Summary of Meadow Viper Conservation Status 15

PART A. MEADOW VIPER SPECIES ACTION PLAN SUMMARY

1. Introduction

The meadow viper, *Vipera ursinii*, has a relict, post-glacial distribution and occurs as a series of isolated populations in limited areas of southern and central Europe. Meadow vipers inhabit two distinct habitat types – three of the five currently recognised subspecies are only found in montane habitats, while the other two subspecies prefer lowland steppe grassland. All five subspecies have suffered such severe declines, which have been particularly catastrophic for the lowland taxa, that this species is now considered by herpetologists to be one of the most endangered snakes in Europe. This Species Action Plan has been commissioned by the Standing Committee of the Bern Convention in order to assess the extent of the problems faced by the meadow viper in Europe, and to make appropriate recommendations for specific actions to address these problems. This section, Part A, summarizes the need for this Species Action Plan and highlights the most urgent priority actions required, as well as the countries to which these are relevant. Further actions and much additional information can be found in Part B, the main body of the Species Action Plan.

2. Rationale

Vipera ursinii is a member of species complex of small, insect-eating vipers that has a long and complicated taxonomic history. The five subspecies currently recognised are:

- **Orsini's meadow viper** *Vipera ursinii ursinii* – alpine areas of southeast France and central Italy.
- **Balkan meadow viper** *Vipera ursinii macrops* – alpine areas of Croatia, Bosnia-Herzegovina, Serbia, Montenegro, the Former Yugoslav Republic of Macedonia and northern Albania. Unconfirmed reports from Slovenia. May also have reached western Bulgaria, where it is now considered to be extinct.
- **Greek meadow viper** *Vipera ursinii graeca* – endemic to the Pindos Mountains of Greece.
- **Hungarian meadow viper** *Vipera ursinii rakosiensis* – lowland steppe grasslands of eastern Austria (where it is now extinct), Hungary and western Romania. Possibly once also occurred in adjacent areas of northern Croatia (Slavonia) and Serbia (Vojvodina).
- **Moldavian meadow viper** *Vipera ursinii moldavica* – a few lowland areas of eastern Romania (Moldavia and the Danube Delta) and possibly still survives in the Republic of Moldova. Formerly found in northeast Bulgaria, where it is considered to be extinct.

Vipera ursinii is the smallest species of European viper, averaging 40 - 45 cm in total length (rarely exceeding 60 cm) and, although venomous, is virtually harmless to humans. The subspecies are all morphologically similar and have the typical viper-like appearance of a dorsal zigzag and other dark markings on a lighter ground colour. Meadow viper populations are very highly fragmented and are confined to two distinctly different habitat types. The Orsini's, Balkan and Greek meadow vipers inhabit alpine and subalpine meadows between 900 and 3000 m in altitude, whereas the Hungarian and Moldavian meadow vipers are found in lowland steppe grasslands well below 800 m. Both habitat types support a range of other rare flora and fauna and, with their traditional pastoral economies, form an important part of the cultural heritage of Europe.

Meadow vipers face a large number of threats, many of which may still be a factor even within protected areas. Past declines have largely been due to direct habitat destruction and fragmentation. Lowland populations in particular have suffered huge losses through agricultural reclamation of their steppe grassland habitats. Some small isolated populations now show evidence of loss of genetic diversity and severe inbreeding depression. These snakes are also known to suffer from inappropriate habitat management, illegal collection and outright persecution. Other threats include drainage, chemical pollution, indirect pressures from increased human activities (especially winter sports and other tourist developments, as well as in the vicinity of urban areas) and artificially high levels of predation due to burgeoning numbers of wild boar and introduced pheasants. It is not known how climate change will affect this species, although meadow vipers may be at particular risk in alpine habitats.

Hungarian and Moldavian meadow vipers are now on the verge of extinction and, with only 13 and 4 known populations respectively, are amongst the most endangered of all vertebrate taxa in the Council of Europe area. While the 40 or so populations of the three montane subspecies appear to be more secure, they are still undoubtedly very rare and continue to face numerous threats. The conservation status of this species in each of its range countries is either considered to be unfavourable or is simply unknown. Fortunately, *Vipera ursinii* receives high levels of legal protection and is listed in Appendix II of the Bern Convention, Annexes II and IV of the EU Habitats Directive and Appendix I of CITES. The IUCN Red List includes the Hungarian meadow viper as "Endangered" and the Moldavian meadow viper as "Critically Endangered". The meadow viper also receives national protection in all range countries for which information is available and many of its known sites are included in national or international protected areas, such as National Parks and Natura 2000 sites. However, there are still large parts of its range, especially in the Balkans, where little is known about its distribution – within protected areas or otherwise. The meadow viper has been subject to a variety of conservation actions in the past and work such as distribution surveys, habitat and species protection, habitat management and ecological research have been particularly intensive to date in countries such as France and Hungary. However, much remains to be done to secure the future of this species in Europe.

Figure 1: *Vipera ursinii rakosiensis* Photographed at the Last Remaining Site for this Subspecies in Romania. (Photograph by Ioan Ghira, Romanian Herpetological Society)



3. Objectives. The main reasons for producing this Species Action Plan are to ensure that:

i. The decline of all five meadow viper subspecies in Europe is reversed

ii. Viable populations are re-established and enlarged, and isolated populations are re-connected, throughout the European range

iii. All populations are subsequently maintained as a viable and integral part of the habitats and landscapes they occupy

Ten general objectives are proposed to help achieve these overall aims. These cover the protection and management of both species and habitat, additional distribution surveys, population and conservation status monitoring, scientific research, the improved coordination of conservation efforts and raising public awareness.

4. Recommended Actions

Conservation work is already underway in most range countries but it is important to expand on these successes to ensure the maintenance, and restoration where necessary, of viable meadow viper populations in Europe. Consequently, 42 specific actions are proposed in this Species Action Plan, 22 of which have been identified as being of the most urgent priority (see Table 1, below). These actions

should therefore be implemented as soon as possible. The remaining 20 actions are of a less immediate priority, or, as in the production of national recovery plans, will take time to realise, but are nonetheless still important for the recovery of meadow viper populations. Among the most vital elements of future conservation work for this species will be the effective liaison and coordination of these efforts (both within and between range countries) and, of course, adequate funding.

The overall goal of this action plan is to expand on these past successes and ensure the maintenance, and restoration where necessary, of viable populations of meadow vipers across Europe. A series of general objectives are outlined and specific actions proposed include the improvement of international liaison and coordination of conservation efforts for this species, additional distribution surveys and protection measures, habitat and species management recommendations, population and conservation status monitoring, scientific research, public awareness and education programmes.

Table 1: Urgent Priority Actions for the Meadow Viper *Vipera ursinii*

Area of Activity	Urgent Priority Actions	Relevant Countries
Habitat Protection	**Action 4.1.1.** Ensure that 100% of the habitat that supports known meadow viper populations, of all five alpine and lowland subspecies, are protected from any threats of further habitat loss by appropriate national designations and where possible, incorporated into the Natura 2000 and Emerald Network series.	France, Italy, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, FYR of Macedonia, Albania, Greece, Hungary, Romania, Moldova
Habitat Protection	**Action 4.1.2.** Specifically, and as a matter of extreme urgency, ensure that the habitat of the single, recently discovered population of *Vipera ursinii rakosiensis* in Romania receives full Government protection and, if necessary, is acquired by purchase. In particular, investigate ways of averting the threats posed to this site by planned agricultural intensification.	Romania
Habitat Protection	**Action 4.1.3.** Specifically, and as a matter of extreme urgency, ensure that the newly discovered populations of *Vipera ursinii moldavica* in the Ciritei/Holm area of Romanian Moldavia receive full Government protection and, if necessary, are acquired by purchase.	Romania
Habitat Management	**Action 4.2.1.** Prepare management plans for all known *Vipera ursinii* sites (or ensure existing plans are suitably modified) that map key areas and fully take into account the likely movements and particular ecological requirements of meadow vipers on that site. Traditional grassland management should be supported or re-instated whenever possible at both alpine and lowland meadow viper sites.	France, Italy, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, FYR of Macedonia, Albania, Greece, Hungary, Romania, Moldova
Habitat Management	**Action 4.2.2.** Control vegetation succession on key meadow viper sites by the regular removal of bushes and trees as necessary.	France, Italy, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, FYR of Macedonia, Albania, Greece, Hungary, Romania, Moldova
Habitat Management	**Action 4.2.3.** Avoid overstocking of grazing animals for purely commercial reasons at meadow viper sites, and maintain controlled, extensive grazing regimes using suitable, traditional livestock breeds.	France, Italy, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, FYR of Macedonia, Albania, Greece, Hungary, Romania, Moldova
Habitat Management	**Action 4.2.4.** Prohibit excessive levels of controlled burning, and also establish fire-fighting measures, at meadow viper sites. Protect key plant species such as dwarf juniper from deliberate eradication.	France, Italy, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, FYR of Macedonia, Albania, Greece, Hungary, Romania, Moldova

Habitat Management	**Action 4.2.5.** To preserve the structural diversity of vegetation (particularly tussocks), avoid any cutting of vegetation on at least 25 % of prime meadow viper habitat and ensure that no more than 33 % of the remaining area is ever cut in any one season. Promote hand cutting wherever possible, limiting any mechanical cutting to the autumn (November onwards), ensuring that cutting heights are set no lower than 15 cm, and completely prohibit the most damaging methods such as rotary cutting.	France, Italy, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, FYR of Macedonia, Albania, Greece, Hungary, Romania, Moldova
Habitat Management	**Action 4.2.6.** Avoid the use of pesticides and other chemicals on or within 500 m of all meadow viper sites.	France, Italy, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, FYR of Macedonia, Albania, Greece, Hungary, Romania, Moldova
Habitat Management	**Action 4.2.7.** Avoid the flooding of important lowland meadow viper habitats through the deliberate manipulation of water tables, especially all areas that represent known or potential hibernation sites for this species in the winter months.	Hungary, Romania, Moldova
Habitat Management	**Action 4.2.8.** Produce and implement habitat re-creation and restoration plans where appropriate, particularly where this would re-connect presently fragmented meadow viper populations and reverse the effects of agricultural reclamation, forestry, drainage or other past activities. As a priority, examine the opportunities for re-creating habitats in lowland areas of Hungary, Romania and the Republic of Moldova and, in preparation for any meadow viper re-introduction programme, in Austria (specifically at Moosbrunn, the National Park of Neusiedler See and within the extensive grasslands of Vienna's Schwechat Airport).	France, Italy, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, FYR of Macedonia, Albania, Greece, Hungary, Romania, Moldova (plus Austria)
Species Protection	**Action 4.3.1.** Whenever possible, ensure that key meadow viper sites under particular pressure from illegal activities such as collection and persecution are adequately wardened.	France, Italy, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, FYR of Macedonia, Albania, Greece, Hungary, Romania, Moldova
Species Management	**Action 4.4.1.** Investigate the potential for expanding the newly established captive breeding programme for *Vipera ursinii rakosiensis* in Hungary to include this subspecies, and also *Vipera ursinii moldavica*, in Romania and the Republic of Moldova. Only release genetically screened captive bred animals into sufficiently large areas of managed meadow viper habitat where known threats have been removed.	Hungary, Romania, Moldova
Species Management	**Action 4.4.2.** Investigate pathogens likely to increase and affect meadow vipers in any captive breeding programme. Ensure that, prior to release, all animals receive adequate health screening for any diseases or parasites that may compromise the survival of both this snake and other wildlife species.	France, Italy, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, FYR of Macedonia, Albania, Greece, Hungary, Romania, Moldova
Distribution Surveys	**Action 4.5.1.** Plan and conduct coordinated surveys and mapping of known and potential sites for *Vipera ursinii macrops* in the Dinaric Alps of Croatia, Bosnia-Herzegovina, Serbia, Montenegro, the Former Yugoslav Republic of Macedonia and northern Albania.	Croatia, Bosnia-Herzegovina, Serbia, Montenegro, FYR of Macedonia, Albania.
Distribution Surveys	**Action 4.5.2.** Carry out field surveys to determine the population status and conservation needs of the populations of *Vipera ursinii graeca* in the Pindos Mountains of Greece.	Greece

Distribution Surveys	**Action 4.5.3.** Conduct thorough field surveys in western Romania to locate any other possible surviving populations of *Vipera ursinii rakosiensis*, and in northeast Romania (Moldavia) for additional sites for *Vipera ursinii moldavica*. Also investigate the previously known meadow viper site at Mount Rarau in the Carpathian Mountains.	Romania
Distribution Surveys	**Action 4.5.4.** Initiate urgent field surveys for *Vipera ursinii moldavica* in the Republic of Moldova.	Moldova
Population and Conservation Status Monitoring	**Action 4.6.1.** Determine the current range of known meadow viper populations, as well as the historical range of this species (especially on lowland steppes), to assist with the development of specific targets for habitat restoration and re-creation strategies, as well as species re-introduction programmes.	France, Italy, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, FYR of Macedonia, Albania, Greece, Hungary, Romania, Moldova (plus Bulgaria)
Population and Conservation Status Monitoring	**Action 4.6.2.** Develop standardised GIS-based methods for the mapping and measuring of prime habitats specifically used by meadow vipers (as opposed to the broader habitat categories, above) to enable the future assessment of changes in the extent and quality of these habitats at all sites.	France, Italy, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, FYR of Macedonia, Albania, Greece, Hungary, Romania, Moldova
Improved Liaison and Coordination	**Action 4.8.1.** Ensure that the Governments and relevant conservation bodies of all currently known meadow viper range countries implement this Action Plan.	France, Italy, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, FYR of Macedonia, Albania, Greece, Hungary, Romania, Moldova
Improved Liaison and Coordination	**Action 4.8.2.** Where these do not already exist, encourage the production and implementation of national Meadow Viper Recovery Plans (in a standard format) for all countries where *Vipera ursinii* occurs. Ensure that these are formally adopted by the relevant Governments and are thus binding on all key players, e.g. relevant Ministries and National Park Administrations.	France, Italy, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, FYR of Macedonia, Albania, Greece, Hungary, Romania, Moldova
Public Awareness and Education	**Action 4.9.1.** Produce appropriate educational and public awareness material in all range countries, aimed at local people and stressing the conservation importance and docile nature of the meadow viper.	France, Italy, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, FYR of Macedonia, Albania, Greece, Hungary, Romania, Moldova

PART B. MEADOW VIPER – SPECIES ACTION PLAN

1. INTRODUCTION

The meadow viper, *Vipera ursinii*, has a restricted and highly fragmented distribution in Europe. Five subspecies of this snake are currently recognised. Three inhabit a handful of alpine and subalpine meadows in southern Europe, while two are found on central European lowland steppe grasslands – a habitat that has suffered from massive agricultural and urban expansion. Such habitat destruction and other human induced pressures have caused varying degrees of decline, particularly during the latter half of the 20th Century, in virtually every known meadow viper population. These losses have been so catastrophic for the two lowland subspecies that they have been lost from several countries, are now on the brink of extinction in Hungary and Romania and are amongst the most endangered vertebrate taxa in the whole of Europe.

Snakes, especially venomous ones, face particular pressures on top of the usual threats common to most wildlife. They often have very specific habitat requirements that are not always catered for by general habitat management. Their limited mobility and lack of any dormant phase (such as the seed bank of plants) means that snakes may not be able to avoid or survive inappropriate conservation management and this has sometimes been a direct cause of population declines. In addition, *Vipera ursinii* is unusual among European vipers in that it feeds heavily on insects and must therefore eat very frequently. Consequently, it is less capable than other snakes of avoiding adverse conditions by becoming inactive, even temporarily. The meadow viper has also been a victim of the craze for keeping reptiles that has swept Western Europe and is a species that is highly sought after by commercial and private collectors. As if these pressures were not enough, they are almost always killed on sight, even within strictly protected areas. Although the meadow viper is indeed venomous, outright persecution of this species is hardly justified since it is an extremely docile little snake and poses virtually no threat to humans.

There have been good reasons, therefore, to highlight the plight of the meadow viper in Europe. The Conservation Committee of the Societas Europaea Herpetologica has been particularly active in promoting conservation action for this species. Much has already been achieved under the auspices of the Bern Convention, and through the hard work of various national governments, conservation bodies and other organisations. These efforts, combined with the strict legal protection afforded to the meadow viper, have slowed many population declines. However, only limited reversals of these declines have been achieved to date and there are still also large gaps in our knowledge of the distribution and status of this species. To address the need for further conservation action for the meadow viper, therefore, the Standing Committee of the Bern Convention has commissioned the production of this Action Plan.

An attempt has been made to pull together and summarise the most pertinent information and published literature concerning meadow viper conservation. The ecology and complicated taxonomic history of this species are covered briefly, while more attention is given to its distribution, conservation status and protection and to the threats that it is known to face. A series of general objectives and specific conservation actions are recommended for adoption by the Bern Convention and relevant national governments. In particular, it is hoped that international liaison can be enhanced and that meadow viper conservation efforts become more coordinated. It should be noted that this Action Plan is not intended to be a static document. As additional information is obtained, and as conservation work and scientific research progress, subsequent versions should be produced that report on successes and submit amended and updated recommendations as required. In future years, the successful conservation of the meadow viper should be seen as an important measure of, and contribution towards, international efforts to maintain the biodiversity of Europe.

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2. BACKGROUND INFORMATION

2.1. Systematics

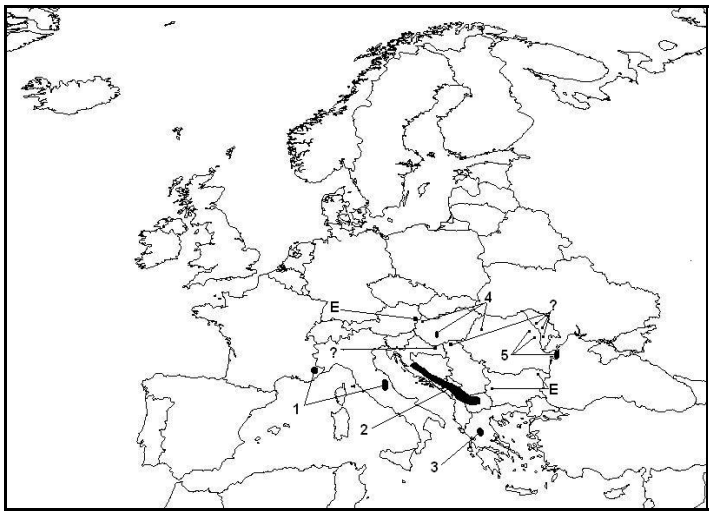
The European meadow viper was discovered by Count Orsini on the Apennine massif of Gran Sasso in central Italy, and was first formally described by Bonaparte (1835) as *Pelias ursinii*. Boulenger (1893) subsequently renamed the species *Vipera ursinii*. After the collection of further specimens in various parts of southern and central Europe, many years of taxonomic debate about the relationships of this species with the other European vipers then followed. To complicate matters further, *Vipera ursinii* is itself part of a species complex – the closely related meadow and steppe vipers of the *Vipera* subgenus *Acridophaga* – so its taxonomy has taken some time to resolve. For much of the 20th Century, while various authors continued to dispute the arrangement of species and subspecies boundaries, all populations of this complex were simply assigned to *Vipera ursinii*. A thorough revision of the systematics of the meadow and steppe viper complex was finally undertaken by Nilson and Andrén (2001). As a result, the following subspecies of *Vipera ursinii* are currently recognised:

Orsini's meadow viper *Vipera ursinii ursinii*
Balkan meadow viper *Vipera ursinii macrops*
Greek meadow viper *Vipera ursinii graeca*
Hungarian meadow viper *Vipera ursinii rakosiensis*
Moldavian meadow viper *Vipera ursinii moldavica*

The first three taxa listed are montane forms, generally occurring between 900 and 3000 m, while the last two are thought to be found mainly in lowland habitats below 800 m. The distribution in Europe of each is shown in Figure 1. The morphological differences between the subspecies are often subtle, and specimens may be difficult to classify without locality information. Although many aspects of their biology and ecology are also similar, these taxa may face quite different conservation problems and political situations in the various range countries and they are therefore treated separately here where appropriate. Many papers that predate Nilson and Andrén (2001) report the occurrence of *Vipera ursinii* in countries other than those listed above. However, such accounts refer to taxa that, although they are still part of the meadow and steppe viper species complex, are no longer assigned to *Vipera ursinii* itself. For example, the steppe viper *Vipera renardi*, which occurs from Eastern Europe to China, has been variously referred to in the literature as a full species, or as the subspecies *Vipera ursinii renardi*. The same is the case for *Vipera anatolica*, *V. ebneri*, *V.*

eriwanensis and *V. lotievi*, although all have now all been assigned full species status. Such species are therefore disregarded in this Species Action Plan, even if older references or maps indicate that they should have been included. Useful summaries of the taxonomic history of the meadow viper species complex are provided by Böhme (1993) and Mallow *et al* (2003). It should be noted that the status of *Vipera ursinii* is still not entirely clear and that further revisions can be expected.

Map 1: Distribution of the Meadow Viper *Vipera ursinii* in Europe



1. Orsini's meadow viper *Vipera ursinii ursinii* – alpine areas of southeast France (12 populations currently known) and central Italy (about 20 populations).

2. Balkan meadow viper *Vipera ursinii macrops* – recorded on various mountains in the Dinaric Alps, along the north west coast of the Balkan Peninsula, in Croatia, Bosnia-Herzegovina, Serbia, Montenegro, the Former Yugoslav Republic of Macedonia and northern Albania. About 20 known locations but more probably exist. May also have reached the mountains of western Bulgaria, where it is now considered to be extinct.

3. Greek meadow viper *Vipera ursinii graeca* – endemic to the southern Pindos Mountains of north-central Greece where it is has only been recorded from four sites.

4. Hungarian meadow viper *Vipera ursinii rakosiensis* – formerly occupied a huge lowland range in the Pannonian steppe region, from eastern Austria (where it is now extinct), across the Great Hungarian Plain to western Romania. Now reduced to 12 sites in Hungary and one in Romania. Possibly once found in adjacent lowland steppe areas of Croatia (Slavonia) and Serbia (Vojvodina).

5. Moldavian meadow viper *Vipera ursinii moldavica* – a few lowland areas of eastern Romania (one site in Moldavia and three in the Danube Delta) and possibly still survives in the Republic of Moldova. Recorded from lowland areas of northeast Bulgaria, where it is now thought to be extinct.

E – Meadow viper populations currently considered to be extinct

? – Continued survival of meadow viper populations unconfirmed

2.2. Description

2.2.1. Morphology. *Vipera ursinii* is the smallest European viper (Arnold 2002). Adults have short, moderately slender bodies and normally attain a total length of approximately 400-450 mm, occasionally reaching 550 mm. The record length is 630 mm for a Hungarian meadow viper, *Vipera ursinii rakosiensis* (Street 1979), although Gruber (1989) reports that this species can reach 800 mm. Females are generally larger than males (Bruno 1985) and were found to be significantly so in Italy (Filippi and Luiselli 2003) and Hungary (Újvári *et al* 2000). The tail is very short compared to many other snakes and is proportionally longer in males. The body scales are strongly keeled on the dorsum, although less so on the sides. The somewhat oval, obtusely pointed head of *Vipera ursinii*,

which is slightly narrower in males (Street 1979), is not particularly distinct from the neck and shows no evidence of a nose horn. The very small eyes have the typical vertical pupils of vipers.

2.2.2. Colouration. *Vipera ursinii* differs from many other vipers in that sexual dimorphism in its colouration is absent (L. Krecsák *pers. com.*), or is at least much less evident (Street 1979; Shine and Madsen 1994). The grey or brownish ground colour is usually lighter dorsally and there is also a dark wavy band along the back of most individuals. This is black, brown or reddish and often has a narrow black border down either side. However, this marking does not form such a pronounced dorsal zigzag as in many other *Vipera* species and, in some specimens, may even be broken up into a series of elliptical or rhomboidal patches along the back. There are dark spots along the sides of the body and dark stripes extend backwards from the eyes to the side of the neck. There is usually a dark **Λ**, **X** or even **H** shaped marking on the back of the head, along with a few symmetrical dark patches. The pale coloured lip scales may be marked with black or brown. The underside of meadow vipers can be either pale or dark, sometimes with contrasting speckling. Abnormally coloured or melanistic individuals occasionally occur (Janisch 1993).

2.3. Life History

2.3.1. Habitat Requirements. *Vipera ursinii* probably expanded into Western Europe from central Asia during past grassland expansions and separated from its basal viper lineage about 10 million years ago (Nilson and Andrén 2001; Nilson 2002). The range of this species has recently contracted following post-glacial climate changes, leaving a few populations isolated in areas where both suitable habitat and climatic conditions (i.e. cold winters and warm dry summers) have persisted to modern times. Two key habitat types (Street 1979; Corbett 1989; Gasc *et al* 1997; Mallow *et al* 2003) are inhabited by different subspecies of *Vipera ursinii*:

- Well-drained alpine and subalpine meadows between about 900 and 3,000 m in altitude.
- Dry lowland meadow-steppe grasslands, up to a maximum of 800 m but usually below 300 m.

Meadow viper populations occupying montane habitats are invariably found on warmer, south facing slopes, often on a limestone substrate. At or above the tree line, shelter from the wind is also important. An unshaded, structurally diverse cover of grasses and other low herbaceous plants is a crucial habitat component, as this provides both basking areas and adequate shelter in close proximity. In Italy (Filippi and Luiselli 2003) and other countries, healthy meadow viper populations have been particularly noted at alpine sites where dwarf juniper (*Juniperus nana*) occurs in abundance, with individual snakes showing a clear preference for the larger bushes of more than 6 m in diameter. This plant grows in low spreading mats, and thus provides excellent protection, although snakes may also inhabit more open grassland situations if conditions are appropriate.

Typical meadow viper habitats in the lowlands include parts of the central European or Pannonian steppe grassland system (known as puszta in Hungary), as well as dry sandy meadows in the Danube Delta. Again, these habitats need to be essentially open, i.e. unshaded by shrubs or trees, to be suitable for meadow vipers. The snakes also need a physically diverse vegetation structure and a particularly essential feature appears to be the presence of grass tussocks (Corbett *et al* 1985; Újvári *et al* 2000). Steppe grassland populations generally have two separate niche requirements:

- Marshy ground, dried out ditches and low-lying damp areas (often prone to winter flooding) that provide more humid, and therefore cooler habitats, and are mainly used by snakes in the summer.
- Higher areas, typically with dry, sandy substrates, that are required for successful hibernation.

Such areas must be found fairly close to each other, preferably within the same undulating meadow. A third biotope may also be locally important, namely the intermediate zone (ecotone) between dry and wet areas (Corbett *et al* 1985). Although an inhabitant of open habitats, *Vipera ursinii rakosiensis* in Hungary has also been recorded utilising wet willow mire during hot weather (Újvári and Korsós 1997).

In the past, natural grazing levels may have controlled succession, and maintained an open, structurally diverse vegetation sward, in both montane and lowland meadow viper habitats. Additional factors such as winter flooding of lowland steppes and exposure at alpine sites were no

doubt also important. In recent centuries, traditional forms of management by humans, such as livestock grazing and haymaking, have also had a considerable influence on both types of habitat. Such pastoral land uses have maintained habitats rich in plants and animals and have obviously been highly compatible with meadow viper survival as well. In both the montane and lowland parts of their range, therefore, meadow vipers inhabit European landscapes that possess a significant wildlife and cultural value.

2.3.2. Dietary Requirements. The feeding ecology of meadow vipers is atypical for the viper family, most members of which prey on lizards when young and small mammals as adults. A high proportion of the diet of meadow vipers, however, consists of insects. For example, *Vipera ursinii ursinii* in France was found to feed principally on Orthopterans, which represented 99% of the number of prey items identified and over 98% of the prey mass ingested Baron (1992). Small lizards (e.g. *Podarcis muralis*) and spiders are also occasionally eaten. In some areas, there is clearly a seasonal shift in prey types in response to food availability. Lizards and small mammals are eaten early in the season, followed by a shift to Orthopterans when these become more abundant later in the summer. Agrimi and Luiselli (1992), for example, found that invertebrates strongly predominate (97.5%) in the diet of Italian *Vipera ursinii ursinii*, but only between July and September. During the early part of year, the male snakes preyed heavily (66.6%) on lizards, while in late June small mammals represented 63.6% of the prey caught by females (Agrimi and Luiselli 1992). Snakes were found not to eat at all early in the active season in France (Baron 1992). Fledgling birds were occasionally eaten in Italy, especially those species that nest in dwarf juniper bushes.

The lowland subspecies *Vipera ursinii rakosiensis* also feeds heavily on Orthopterans, but lizards such as *Lacerta agilis*, *Podarcis taurica* and *Zootoca vivipara pannonica* form an important part of the diet at certain times of the year (Corbett *et al* 1985). This subspecies is also known to take small mammals, although this may be an incidental result of snakes using burrows for shelter rather than through direct hunting – for example, Brenner (1939) records nestling mice as one of the dietary items of this taxon. Boulenger (1913) includes shrews, small rodents, lizards, Orthopterans, beetles and other insects amongst their food items and frogs such as *Pelobates fuscus*, *Rana arvalis* and *Rana dalmatina* may also be eaten (A. Stumpel *pers. com.*; Corbett *et al* 1985).

Prey is eaten by meadow vipers in proportion to their size, i.e. larger snakes eat larger prey. Meadow vipers have weak venom, suited to immobilising small victims, and prey is held by the snake until consumed (Luiselli 1990). The frequency of feeding is much greater than that of other viper species and small meals, of only 3.0 to 7.2% of the snake's body weight, are consumed every two to four days (Baron 1992). Unlike many other snakes, gravid female meadow vipers continue to eat throughout gestation (Agrimi and Luiselli 1992; Baron *et al* 1996), as do individuals preparing to slough their skin, although males are not thought to eat prior to their first slough of the spring (L. Krecsák *pers. com.*). Meadow viper prey items typically represent an abundant food source in both montane and lowland habitats. In French alpine meadows, for example, the biomass of Orthopterans during August may exceed 4kg/ha (Baron 1992). Insects can also be extremely abundant in lowland steppes, as indeed are various species of lizard and small mammal. The former, natural abundance of meadow vipers on the Central European steppes is considered to reflect their semi-insectivorous position in the food chain (Corbett *et al* 1985).

2.3.3. Activity and Movements. Meadow vipers are almost exclusively diurnal and the strong insolation at high altitudes, and the hot daytime temperatures of the lowlands, means that the snakes heat up quickly in both habitats by basking. Active meadow vipers are generally very alert and unobtrusive snakes and so can be hard to detect, quite unlike other vipers that are less elusive and stand their ground more readily when approached (Corbett *et al* 1985). Although snakes in alpine habitats may bask in the middle of the day throughout the active season, lowland animals tend to primarily engage in this behaviour in the spring and late summer. Typical basking spots in central Hungary, always near readily available cover, include the tops of ant hills and the low, dry and often sandy spoil heaps produced by moles, *Talpa talpa*, rabbits, *Oryctolagus cuniculus*, hamsters, *Cricetus cricetus* or souslik, *Citellus citellus* (Corbett *et al* 1985). There is no evidence of collective basking areas being used by meadow vipers, as with many other vipers.

Once active, meadow vipers then spend much of the day foraging under cover or sheltering, particularly in grass tussocks and among low shrubs. The optimal body temperature of active *Vipera*

ursinii rakosiensis in Hungary is just below 35°C (Újvári and Korsós 1997). Average body temperatures of active *Vipera ursinii moldavica* measured in Romania, however, were less, at 29.67°C (Zamfirescu and Krecsák 2002). *Vipera ursinii ursinii* in France exhibit an even lower average body temperature of 28°C (Dreux & Saint Girons 1951). The maximum cloacal temperature recorded for a gravid female *Vipera ursinii macrops* in Montenegro was 32.1°C (Tomović *et al* 2004), which would be expected to be higher than for non-gravid snakes. At night, the body temperature of meadow vipers, like other reptiles, falls to that of the substrate where they are sheltering. This is usually too cold to permit normal activity, although anecdotal reports suggest that lowland populations sometimes exhibit nocturnal behaviour during very hot weather (Corbett *et al* 1985).

Montane taxa spend over half of the year (October to April) in hibernation. On Mont Ventoux in France, *Vipera ursinii ursinii* hibernates from mid-October. The adult males then emerge again around mid-April, as soon as the snow melts, while females do not appear until early May (Baron 1992; Baron *et al* 1996). Unusually among vipers, immature snakes in this population become active very late in the year, not emerging until the second half of June (when the adults begin feeding), more than two months after the first adult males (Baron 1992). In Italy and Hungary, however, males, females and juvenile all emerge from hibernation at the same time (Luiselli 1990; Újvári *et al* 2000). Emergence from hibernation is earlier in lowland populations, and usually occurs in March, and snakes may remain active until past the end of October (Corbett *et al* 1985). A radiotracked female *Vipera ursinii rakosiensis* was recorded entering hibernation in early November in Kiskunság National Park, Hungary (Újvári and Korsós 1999). Hibernation sites are often in existing mammal burrows (Újvári and Korsós 1999) and there are no reports of the communal hibernacula often used by other viper species. However, recent studies in Hungary, using artificial burrows that can be checked during the winter months, suggest that *Vipera ursinii rakosiensis* tends to prefer to hibernate in groups (H. Balint *pers. com.*).

Meadow vipers generally engage in limited movements and may remain for long periods in relatively small areas, of approximately 100 m^2 (Újvári and Korsós 1997), where they can be repeatedly observed. The apparently small and overlapping home ranges of this species can result in great abundance in prime areas, especially in the lowlands (Corbett *et al* 1985). Longer distance movements, of 200-300 m or more, have been recorded and these may be associated with searches for more sheltered habitats, either during the heat of summer or while moving to suitable hibernation sites (Újvári and Korsós 1997; 1999). Other possible reasons for these longer movements may include a reduction in food availability, increased competition, the natural flooding of low-lying parts of their habitat or other forms of habitat alteration or disturbance.

2.3.4. Reproduction. Like other members of the viper family, this species is ovoviviparous, i.e. the females retain their eggs throughout gestation and give birth to "live" young. Meadow vipers mate early in the active season. In montane French populations, mating occurs in late May, ovulation in early June and parturition in September (Baron *et al* 1996). In Italy, mating of *Vipera ursinii ursinii* takes place in May and gestation lasts about three and a half months, with three to eight young being born between the second half of August and the first week of September (Ferri and Marconi 2006). Gravid females may still sometimes be present at the end of September in Italy, which suggests that, when climatic conditions are unfavourable, gestation in this montane subspecies may be prolonged, with the young being born the following year (Ferri and Marconi 2006). In addition, only some females in populations in the Italian Gran Sasso massif reproduce every year – others are known to reproduce only every two to three years (V. Ferri *pers. obs.*). Mating of *Vipera ursinii rakosiensis* in lowland Hungary takes place earlier than for the montane subspecies, in March or April, and the young are born in late July or early August (Corbett *et al* 1985). Meadow vipers can produce between two and 18 young depending on the size, age and condition of the female concerned (Corbett *et al* 1985). Lowland snakes, however, tend to have larger litters than alpine animals (Újvári *et al* 2000) and Boulenger (1913) recorded an exceptionally large brood of 22 from an Austrian *Vipera ursinii rakosiensis*. The young average about 140-150 mm in length at birth (Baron *et al* 1996; Újvári *et al* 2000) and are born fully self sufficient and able to fend for themselves. Male meadow vipers in France become sexually mature in their fourth year and females in their fifth (Baron *et al* 1996). Like other vipers, the females of this species appear to require at least one season to rebuild their fat reserves, consequently only breeding in alternate years (Luiselli 1990; Baron *et al* 1996).

2.3.5. Natural Predators and Competitors. The small size and relatively weak venom of meadow vipers mean that these snakes, and especially the young, have many natural predators. Predominant among these are a large variety of birds, including raptors, corvids, storks and great bustards (*Otis tarda*), and mammals such as mustelids and wild cats (Corbett *et al* 1985). Meadow vipers are also known to be eaten by wild boar in Italy (Filippi & Luiselli 2003). Vásárhelyi (1965) reported that captive *Vipera ursinii* would cannibalise their own young if insufficient food is provided, although it is not known if this behaviour also occurs in the wild. Meadow vipers are almost certainly preyed on by smooth snakes, *Coronella austriaca*, where the two species occur together. In addition, smooth snakes consume lizards and small mammals, so may also be a direct competitor. Competition from other vipers does not seem to occur and Boulenger (1913) reported that *Vipera ursinii* was generally never present in areas inhabited by the adder, *Vipera berus*. Although Angel (1946) mentioned these two species occurring sympatrically on Mont Ventoux in the French Alps, this account is reported to be erroneous (P. Haffner *pers. com.*). However, *Vipera ursinii ursinii* is sympatric with *Vipera aspis* in the Duchessa Mountains of central Italy, even to the extent of basking together (Filippi and Luiselli 2003), as well as in the Montagne de Lure of southeast France (A. Stumpel *pers. com.*).

2.4. Distribution and Conservation Status

2.4.1. The Conservation Status of the Meadow Viper

The meadow viper is endemic to geographical Europe, although the current distribution of this species is both highly fragmented and extremely limited in total extent. The European Red List of Globally Threatened Animals and Plants (Economic Commission for Europe 1991) specifically lists the subspecies *Vipera ursinii rakosiensis* as "Endangered", while the species as a whole is considered to be "Endangered" (Category A1c+2c) in the Red Data Book of European Vertebrates (Council of Europe 1997). In addition, the IUCN (World Conservation Union) Red Data List includes *Vipera ursinii moldavica* as a "Critically Endangered" taxon and *Vipera ursinii rakosiensis* as "Endangered" (IUCN 1996), although the latter subspecies is now just as much in danger of imminent extinction as the former.

The three montane subspecies exhibit a relict, post-glacial distribution and naturally occur at relatively low densities in small patches of suitable habitat. Although all have suffered some often serious population declines, these taxa inhabit such remote and/or marginal land that human activities have not radically altered their overall distribution. In contrast, the lowland taxa were once considerably more widespread across vast areas of steppe grassland in central Europe, where they could also be extraordinarily abundant. The advent of modern agriculture, however, led to enormous destruction of this habitat and almost every population of the two lowland subspecies has now been exterminated. Their range and numbers have therefore been reduced to a fraction of their former size.

Article 1(i) of the European Union's Habitats and Species Directive states that the conservation status of a species will be taken as favourable when:

- population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and
- the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and
- there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

The monitoring of conservation status is a requirement for EU member states only, although this would be a useful and valuable measure to apply to meadow viper populations in all range countries. The overall conservation status of *Vipera ursinii* is only partially known at present, although is certainly unfavourable. The status of individual taxa should also be monitored separately. That of *Vipera ursinii ursinii* is probably still unfavourable, although some populations are now secure and thriving (P. Haffner *pers. com.*). The conservation status of *Vipera ursinii macrops* and *Vipera ursinii graeca* is largely unknown. The lowland subspecies *Vipera ursinii rakosiensis* and *Vipera ursinii moldavica* are now in a critical situation and their conservation status is obviously highly unfavourable.

Clearly, this concept needs to be further defined and quantified for this species and considerably greater monitoring effort will be required to clarify the situation for the meadow viper across its range. In the meantime, Table 1 attempts to summarise current understanding of the distribution and presumed conservation status of the five described meadow viper subspecies in fifteen European countries.

Table 2: Summary of Meadow Viper Conservation Status

Country	MEADOW VIPER TAXA	Threats Known?	Conservation Status	Population Trend
France	*Vipera ursinii ursinii*	Yes	Unfavourable	Recovering
Italy	*Vipera ursinii ursinii*	Yes	Unfavourable	Recovering
Croatia (only *V. u. macrops* is likely)	*Vipera ursinii macrops*	Yes	Unknown	Unknown
	Vipera ursinii rakosiensis	Unknown	Unknown	Present?
Bosnia-Herzegovina	*Vipera ursinii macrops*	Unknown	Unknown	Unknown
Serbia (only *V. u. macrops* is likely)	*Vipera ursinii macrops*	Unknown	Unknown	Unknown
	Vipera ursinii rakosiensis	Unknown	Unknown	Present?
Montenegro	*Vipera ursinii macrops*	Unknown	Unknown	Unknown
FYR of Macedonia	*Vipera ursinii macrops*	Unknown	Unknown	Unknown
Albania	*Vipera ursinii macrops*	Unknown	Unknown	Unknown
Greece	*Vipera ursinii graeca*	Yes	Unknown	Unknown
Austria	*Vipera ursinii rakosiensis*	-	Extinct	-
Hungary	*Vipera ursinii rakosiensis*	Yes	Unfavourable	Declining
Romania	*Vipera ursinii rakosiensis*	Yes	Unfavourable	Declining
	Vipera ursinii moldavica	Yes	Unfavourable	Declining
Bulgaria (unknown which taxa occurred)	*Vipera ursinii macrops*	-	Extinct?	-
	Vipera ursinii moldavica	-	Extinct?	-
Republic of Moldova	*Vipera ursinii moldavica*	Yes	Unknown	Unknown

2.4.2. Distribution and Conservation Status of Montane Populations

France (*Vipera ursinii ursinii*). The subspecies *Vipera ursinii ursinii* is restricted here to the Provence-Cote d'Azur region of southeast France, where it occupies a small number of pre-Alpine massifs in four departments - Vaucluse, Alpes-deHaute-Provence, Alpes-Maritimes and Var (Lyet *et al* 2005). Only nine populations of this taxon were known in the late 1980s (Corbett 1989; Stumpel *et al* 1992). However, a thorough survey was conducted from 1993 to 1998 (Penloup *et al* 1999), bringing the total of known populations in France to 12, plus two to be confirmed and one that is probably extinct (P. Haffner *pers. com.*). All occur in dry grasslands, between 900 and 2150 m in altitude, and these sites have a combined area of about 9,000 ha (Baron 1989; Penloup *et al* 1999). The total number of adult snakes in France was once estimated to be a mere 200-300 adults (Groombridge, undated; Corbett 1989), although this figure has since been revised upwards. Indeed, the French population has more recently been calculated at roughly 60,000 individuals (Lyet *et al* 2005). The 140 ha Mont Ventoux site alone, which is considered threatened but not endangered, is thought to support at least 1,000 adults (Baron 1987; Gasc *et al* 1997), although it now probably supports fewer individuals (P. Haffner *pers. com.*), while four other populations (Cheval Blanc, Caussols, Calern and Cheiron) are of even greater size (Lyet *et al* 2005). The distribution of these snakes is not homogenous, however, and further studies are required to obtain more accurate population figures. The density of adult snakes in prime habitat in France has been estimated to be as high as 20-30 adult snakes per ha (Gasc *et al* 1997), but is more typically around 10-17 per ha (Penloup *et al* 1999). Individual French populations of *Vipera ursinii ursinii* are considered to vary from secure to highly endangered (Gasc *et al* 1997; Penloup *et al* 1999). This taxon is listed as vulnerable in the French Red Data Book (Penloup *et al* 1999) since threats such as succession, overgrazing, illegal collecting and persecution still remain. While the French populations can still probably be classed as having ***Unfavourable Conservation Status*** overall, many key sites are now protected, and are included in the Natura 2000 series, and a National Action Plan for this species has now been produced. The future trend for the status of *Vipera ursinii ursinii* in France is likely to be recovering – that is, as long as the National Action Plan is implemented and conservation efforts are continued in the long term.

Italy (*Vipera ursinii ursinii*). About 20 separate populations of Orsini's meadow viper *Vipera ursinii ursinii* are currently known, scattered along a 150 km section of the Apennine uplands of central Italy (between 1,400 and 2,400 m in altitude), in the regions of Marche, Umbria and Abruzzo (Bruno 1967; 1973; Gasc *et al* 1997; Filippi and Luiselli 2003; Ferri and Marconi 2006; Groombridge undated). The approximate areas of potential viper habitat at the main known localities are:

- Monti Sibillini massif (4,375 ha)
- Monti della Laga massif (1,800 ha)
- Monti Velino massif (10,000 ha)
- Parco Nazionale d'Abruzzo (1,600 ha)
- Gran Sasso massif (8,500 ha, including the 6,000 ha Campo Imperatore)

There is also an isolated population in the Duchessa Mountains of Latium, which occurs between 1700 and 2000 m, although these snakes have always been reported as very rare here (Filippi & Luiselli 2003). The total potential area in Italy for this subspecies is therefore less than 27,000 ha. The situation for the known Italian populations is unclear - snakes are usually not distributed evenly at any of these sites and populations are undoubtedly restricted to much smaller areas of ideal habitat within them. The most important site in the country is Campo Imperatore, in the Gran Sasso, which at approximately 6,000 ha is probably the largest single area occupied by *Vipera ursinii* in Europe. This site forms a huge basin, with its entire northern slope forming 15 km of prime, south-facing meadow viper habitat. Estimates based on surveys conducted since 1995 in the Campo Imperatore area suggest that population density is high (V. Ferri, unpublished data). Little other information is available about numbers of individual snakes, although with densities in Italy estimated at anywhere between 1 and 20 snakes per ha (Groombridge, undated), the total population in Italy is likely to be as high as, or higher, than that of France. As in France, large areas of meadow viper habitat now receive protection although similar threats persist. The extreme habitats favoured by this snake in Italy afford a degree of protection as the presence of humans is limited (although collectors can still be a problem) and is largely concentrated around tourist accommodation and sports centres. The main threat in Italy is the intensive agricultural use of the land, which leads to the overgrazing and trampling of meadows and the elimination of the grasses on which the main Orthopteran prey (chiefly the *Acrididae* and *Tettigonidae*) feed (Ferri and Marconi 2006). The Italian populations of *Vipera ursinii ursinii* probably have a similar status to the French, i.e. ***Unfavourable Conservation Status***, but recovering.

The Western Balkans – Croatia, Bosnia-Herzegovina, Serbia, Montenegro, Former Yugoslav Republic of Macedonia, Albania (*Vipera ursinii macrops*). The Balkan meadow viper, *Vipera ursinii macrops*, has been reported from more than 20 localities in the northwest portion of the Balkan Peninsula (Gasc *et al* 1997). In this region it occurs on a number of mountains in the Dinaric Alps, including sites in Croatia, Bosnia-Herzegovina, Serbia, Montenegro, the FYR of Macedonia and northern Albania (Crnobrnja-Isailović and Džukić 1995; Gasc *et al* 1997; Crnobrnja-Isailović 2002; Crnobrnja-Isailović *et al* 2003; Tomović *et al* 2004). This taxon is not found below 1000 m (Méhely 1911) and has been recorded up to 2100 m (Werner 1897). The lack of detailed information about the distribution of the meadow viper in the Balkans creates a number of uncertainties that only further surveys will be able to resolve. A few accounts mention the presence of meadow vipers in Slovenia (Golay *et al* 1993; Groombridge, undated), although these are certainly erroneous (K. Poboljsaj *pers. com.*) and could have been misspelt references to the lowland region of Slavonia in northern Croatia (see Section 2.4.3.). *Vipera ursinii macrops* has also been reported from the Adriatic island of Krk, near the Istrian peninsula of Croatia (Knoepffler and Sochurek 1955; Bruno 1980; Gasc et al 1997), although it has also been suggested that this may have been a record of the Italian form of *Vipera ursinii ursinii* instead (Groombridge, undated). In any event, such an atypical lowland coastal locality (about 50 m above sea level) would represent a curious distribution anomaly for either of these montane subspecies and it appears that this record may actually have been based on an earlier misidentification of another viper species altogether.

Vipera ursinii macrops is said to be common in Bosnia-Herzegovina and Montenegro, rare in Croatia and Albania and very rare in Serbia and the Former Yugoslav Republic of Macedonia (Gasc *et al* 1997; Tomović *et al* 2004). A few new populations have recently been discovered in Croatia,

including within a minefield (which will create problems for management aimed at controlling vegetation succession), all being restricted to a small belt of the Dinaric Alps above 1200 m (E. Kletecki *pers. com.*). Otherwise, very little is known about the extent of habitats occupied, population sizes or the conservation status of *Vipera ursinii macrops* in the Balkans. Recent surveys have obviously been difficult or impossible to carry out in some areas and some potential meadow viper sites in the mountains are known to still be mined following the various wars of the 1990s. At present, *Vipera ursinii macrops* as a whole, and for each country within its range, has an ***Unknown Conservation Status***.

Greece (*Vipera ursinii graeca*). The presence of meadow vipers in the southern Pindos mountains of north-central Greece was established by two photographs of these snakes – one taken by a Swedish botanist in the 1970s (Nilson and Andrén 1987) and another published in a mountaineering magazine in 1980 (Dimitropoulos 1985). Originally considered to be a relict population of *Vipera ursinii ursinii*, although also showing some similarities to *Vipera ursinii macrops* (Dimitropoulos 1986), this taxon was formally described as the new and endemic subspecies *Vipera ursinii graeca* by Nilson and Andrén (1988). The Greek meadow viper has only been recorded from four alpine meadow sites, including Tzoumerka, Lakmos and Koziakis mountains in the Pindos range, at about 1800-2000 m (Dimitropoulos 1985; Gasc *et al* 1997).

A substantial area of habitat suitable for *Vipera ursinii graeca* is protected in the Pindos National Park and adjacent areas, although some problems, especially illegal collecting, probably remain a threat. Even though population densities have been reported as being high (Nilson and Andrén 1987), this did not stop considerable concern being expressed, and questions being asked in the European Parliament, about proposals in 2002 (fortunately since abandoned) to issue permits for the commercial collection of 600 specimens of this snake. More surveys are required in Greece to determine the exact distribution and status of *Vipera ursinii graeca* and, at present, this taxon therefore must be considered to have ***Unknown Conservation Status***.

2.4.3. Distribution and Conservation Status of Lowland Populations

Austria (*Vipera ursinii rakosiensis*). The Hungarian meadow viper, *Vipera ursinii rakosiensis*, was once widespread and extraordinarily abundant in the Vienna Basin of Austria (Korsós and Újvári 1998) and was found up to maximum altitude of 600 m (Tiedemann *et al* 2001). After many decades of bounty-led persecution and massive habitat destruction, and despite repeated warnings about the decline of this snake (e.g. Werner 1915; Sochurek 1952; Kramer 1961; Luttenberger 1971; Sochurek 1978; Honegger 1978; 1981; Corbett *et al* 1985), it was feared extinct in Austria by the mid-1980s (Tiedemann 1986). A subsequent search for relict populations of *Vipera ursinii rakosiensis* in southeast Lower Austria, in the vicinity of the villages of Himberg, Mitterndorf, Götzendorf an der Leitha and Enzersdorf an der Fischa, failed to locate any snakes (Kammel 1992). Moreover, it was considered that any potential habitat remaining in the provinces of Burgenland or Lower Austria was either suboptimal or, if it did appear to be structurally suitable for vipers, that the areas concerned were now too limited in extent to support viable populations. Therefore this taxon is now officially considered to be ***Extinct*** in Austria (Kammel 1992; Gasc *et al* 1997). However, despite management that is often inappropriate for this species, some potential, albeit degraded, habitat does survive and at least two unconfirmed reports of the continued presence of this subspecies in Austria were received in the 1990s (Cabela *et al* 2001; Kammel 2002).

Hungary (*Vipera ursinii rakosiensis*). This subspecies was formerly widespread on the Great Hungarian Plain. At least 30 populations were still in existence in the 1950s (Dely and Janisch 1959) but the distribution of this snake has since been reduced to 12 populations that are found in two main areas:

- **Hanság.** Much of this region of northwest Hungary, close to the Austrian border, has been converted to agriculture and forestry on an enormous scale. About 6,000 ha of mainly damp, low-lying peaty habitats have now been protected. The current distribution of the meadow viper within this area was originally thought to be confined to a single 9 ha site (Corbett *et al* 1985; Újvári *et al* 2000). This site was reported as supporting only a tiny population, of less than 50 snakes, which exhibited many signs of severe inbreeding depression (Újvári *et al* 2002). However, it is now known that there are two Hanság populations (Fülöp 1992) as an additional 39

ha fenced area, within a more extensive (around 150 ha) grassland site, has been recently rediscovered that supports a larger population. In fact, the Hanság populations are considered to be the best ones in Hungary by some experts (H. Balint *pers. com.*). It has also been disputed that inbreeding depression is actually a problem here at all (K. Corbett *pers. com.*), especially as all the samples studied were actually collected from Kiskunság (H. Balint *pers. com.*).

- **Kiskunság.** The remaining populations of *Vipera ursinii rakosiensis* in Hungary survive in this area of highly fragmented habitats in central Hungary, between the Danube and Tisza rivers (Corbett *et al* 1985; Újvári *et al* 2000). This region contains the Kiskunság National Park to the south. The Park, the northernmost point of which lies about 30 km south of Budapest, protects a range of lowland habitats in six separate blocks, totaling 30,628 ha, including the meadow-steppe grasslands (puszta) of the Bugac region occupied by *Vipera ursinii rakosiensis*. Meadow vipers, which often inhabit the remnants of post-glacial sand dune systems, survive in nine isolated populations in this area (H. Balint *pers. com.*). The sites occupied range from 100-400 ha in extent (averaging 200 ha) but only support an estimated combined total of approximately 450-950 individual snakes (Báldi *et al* 2001; Halpern & Péchy 2002). Regular population and habitat assessment studies carried out in the Kiskunság National Park since 1993 by BirdLife Hungary have shown rapidly decreasing population sizes and the apparent disappearance of juvenile and subadult snakes suggests a recruitment rate of close to zero at some sites (Halpern and Péchy 2002).

In an assessment of 379 Hungarian vertebrate taxa carried out by Báldi *et al* (2001), the meadow viper was considered to be by far the most endangered. With a total population of only a few hundred individuals restricted to just a dozen sites, many of which show signs of terminal decline (although others are now recovering), *Vipera ursinii rakosiensis* clearly has an ***Unfavourable Conservation Status*** in Hungary.

Croatia. *Vipera ursinii rakosiensis* is thought to have once occurred in Slavonia, in the northern lowlands of Croatia (Mertens and Wermuth 1960; Radovanović 1964; Dely 1986; Tomović and Džukić 2002). The grassland habitats in this region were once continuous with the steppe systems of adjacent Hungary so this may be possible but these old records are disputed (L. Krecsák *pers. com.*). Nothing further is known about the persistence of this second meadow viper subspecies in Croatia, if any populations still survive or, indeed, if it ever actually occurred here at all. Therefore this subspecies of meadow viper has an ***Unknown Conservation Status*** in Croatia. Surveys are currently underway in northern Croatia for this meadow viper taxon (E. Kletecki *pers. com.*).

Serbia. There are also reports of the former occurrence of meadow vipers in the autonomous region of Vojvodina in northern Serbia, adjacent to the Hungarian and Romanian borders (Corbett *et al* 1985; Stumpel 1995; Tomović and Džukić 2002). Although these records have never been verified, the taxon concerned is very likely to have been *Vipera ursinii rakosiensis*. Nothing more is known about the survival or present distribution of this subspecies in Serbia, and, as for Croatia, its former presence here is disputed (L. Krecsák *pers. com.*), so it has an ***Unknown Conservation Status***. While most potential habitat in Serbia has been destroyed by agricultural reclamation, grasslands supporting great bustards (*Otis tarda*), another characteristic member of the steppe fauna, still exist south of Novi Kneževac, near the Romanian border (Tomović and Džukić 2002), and would be well worth investigating for the potential presence of meadow vipers.

Romania (*Vipera ursinii rakosiensis* and *Vipera ursinii moldavica*). Two subspecies of meadow viper have been recorded in Romania – *Vipera ursinii rakosiensis*, on the Transylvanian Plain (in the Carpathian Basin) in the west of the country, and *Vipera ursinii moldavica*, in the province of Moldavia and the Danube Delta, in the east. A single specimen of a third subspecies, the Balkan meadow viper *Vipera ursinii macrops*, was also reported from the Bucegi Mountains of central Romania by Băcescu (1936), although this is now known to have been a misidentified adder, *Vipera berus* (Fuhn and Vancea 1961; Török 2002; L. Krecsák *pers. com.*).

The situation of *Vipera ursinii rakosiensis* in Romania is even more critical than it is in Hungary. One of the last, and certainly the best documented, Romanian populations of *Vipera ursinii rakosiensis* occurred in an isolated 1.5 ha hayfield, known as Fînaţele Clujului, in the vicinity of Cluj-Napoca (Stugren 1955; Vancea *et al* 1980; 1985). A relatively recent visit to Fînaţele Clujului by

Korsós *et al* (1997), however, failed to locate any snakes. The habitat has been heavily overgrazed (I. Ghira *pers. com.*) and the subspecies is now considered to be extinct at this location (Gasc *et al* 1997; Korsós and Újvári 1998;). A photograph of a meadow viper was taken in 1962 to the east of this site, between Sic and Bonțida, but surveys carried out between 1999 and 2001 by Babeş-Bólyai University at Cluj-Napoca failed to locate any snakes here (Török 2002). Although several other potential (Korsós and Újvári 1998) and historical sites (Krecsák and Korsós 2001; Török 2002) have been investigated, no further evidence of the survival of this taxon in Transylvania has been obtained. Until recently, therefore, *Vipera ursinii rakosiensis* was considered to be extinct in Romania.

However, a single, tiny population of *Vipera ursinii rakosiensis* was discovered in 2002 on the Transylvanian Plain (some distance from Cluj-Napoca) by members of the Romanian Herpetological Society. Although a reasonably high density of snakes appear to be present at this site, the entire area occupied by the viper population is confined to a tiny fragment, only about 30 ha in extent, of the once widespread mesic meadow-steppe habitat. This area is surrounded and isolated by agricultural land and, furthermore, was imminently threatened by planned ploughing for maize and, ironically, by an EU grant to instigate cattle grazing obtained by an absentee landowner from SAPARD (the EU's Special Accession Programme for Agriculture and Rural Development). The Romanian Herpetological Society were successful in their urgent attempts to safeguard the surviving population here and, fortunately, the SAPARD grant has now been stopped and an LIFE grant very recently approved instead (I. Ghira *pers. com.*).

The status of *Vipera ursinii moldavica* (Nilson *et al* 1993) in Romania is also precarious and only a few populations persist in the east of the country. In northeast Romania, enormous monocultural fields now cover most of the former range of this subspecies in the province of Moldavia (Nilson *et al* 1993; Gasc et al 1997; Krecsák *et al* 2003). At least seven known populations have probably been lost in recent years and the last remaining population in Moldavia was thought to be confined to the 46.36 ha Valea Lui David Natural Reserve, close to the border with the Republic of Moldova (Korsós *et al* 1997; Krecsák and Zamfirescu 2001; 2002; Török 2002). However, several meadow vipers have recently been found in an area around a valley known as Ciritei and a hill named Holm (Krecsák and Zamfirescu 2002; Krecsák *et al* 2003). This site occurs at an altitude of about 150 m near the villages of Românești, Avântul and Ursoaia. The steppe habitats remaining here are more extensive than those of the Valea Lui David Natural Reserve so these sites may consequently support larger viper populations. Two further populations have very recently been discovered in this area (L. Krecsák *pers. com.*)

Two specimens considered to be *Vipera ursinii moldavica* were also collected at 950 m just south of Mount Rarau in the Carpathian Mountains (Vancea *et al* 1985; Nilson *et al* 1993; Nilson and Andrén 2001), a geographical feature that separates the lowland distributions of the two Romanian meadow viper subspecies (Council of Europe 1994). These specimens have now been lost, which is unfortunate, as uncertainty exists about their taxonomic placement. There has also been some debate as to whether meadow vipers from the Danube Delta in southeast Romania should be assigned to *Vipera ursinii moldavica* or to *Vipera renardi*. The former placement (Nilson *et al* 1993; Nilson and Andrén 2001) is followed here – thus three important populations of *Vipera ursinii moldavica* survive on dry grassland among the wetlands of the Danube Delta Biosphere Reserve (Kotenko *et al* 1993; Korsós *et al* 1997; Török 1997; 1998; 2002). These sites are:

- **Grindul Perișor-Periteaşca.** Meadow vipers are found in an area of about 1,200 ha of sandy meadows in this region of the Black Sea coast, in the south of the Danube Delta (Kotenko and Oțel 1997; Török 2002). The population here is estimated to be approximately 1,800 snakes.
- **Grindul Sărături (Sfăntu Gheorghe).** About 1,000 ha of this area in the middle of the Danube Delta are inhabited by an estimated population of 800 snakes (Török 2002).
- **Grindul Letea.** Meadow vipers have been known at this site, in the north of the Delta and close to the border with Ukraine, since 1937 (Băcescu 1937). Approximately 300-400 ha is considered to be suitable habitat for *Vipera ursinii moldavica* but no population estimates are available (Török 2002).

Vipera ursinii rakosiensis is clearly close to extinction in Romania and its loss is inevitable in the very near future if present agricultural practices continue. Although *Vipera ursinii moldavica* is more abundant it is still an extremely rare snake and continues to face a number of threats, even within protected areas. Therefore both subspecies must be classified as having ***Unfavourable Conservation Status*** in Romania.

Bulgaria (Possibly *Vipera ursinii macrops* and *Vipera ursinii moldavica*). Only a few, very old museum specimens of *Vipera ursinii* are known from Bulgaria (Westerström 2002; Krecsák *et al* 2003). Two of these originated from the Lülin Mountains, west of Sofia, one caught in the vicinity of the village of Verdikal, at an altitude of about 650-680 m, and the other near the monastery of Sveti Kral at 950 m. Although variously reported as *Vipera ursinii ursinii* and *Vipera ursinii rakosiensis* (Beskov 1973; Dely and Stohl 1989), judging from the location and altitude they could well have been specimens of the Balkan meadow viper, *Vipera ursinii macrops*. Meadow viper populations are presumed to be extinct at this location (Groombridge, undated; Gasc *et al* 1997) although, since the habitat has reportedly been little altered, it is possible that this species still exists in the area. Some accounts also mention two specimens of *Vipera ursinii rakosiensis*, collected at about 350 m from Sumen (or Shumen) in northeast Bulgaria (Groombridge, undated; Westerström 2002). Recent taxonomic changes, and the locality and altitude involved, indicate that these specimens may be *Vipera ursinii moldavica* (Nilson and Andrén 2001), although this has been disputed by Krecsák *et al* (2003). Regardless of the taxonomic placement of any of these specimens, no definite records of *Vipera ursinii* have been verified for Bulgaria since the 19th Century (Gasc *et al* 1997). In recent years, however, a photograph of a meadow viper was claimed to have been taken in northeast Bulgaria by a group of Swiss ornithologists (Westerström 2002). This photograph has yet to be examined by a herpetologist, however, so the identity of this species cannot yet be confirmed. There are also reports that meadow vipers were found in Bulgaria in 2004 (V. Georgiev *pers. com.*) although again this has not been confirmed and it has been disputed that this record was in fact *Vipera ursinii*. It is therefore not known if either of the two *Vipera ursinii* subspecies that may have once occurred in Bulgaria still actually survive and the species as a whole is currently listed as ***Extinct*** in the Red Data Book of Bulgaria (Beschkov 1985).

Republic of Moldova (*Vipera ursinii moldavica*). Almost nothing is known about the current distribution and status of *Vipera ursinii moldavica* in the Republic of Moldova (Bessarabia). While this snake was fairly widespread in Moldova during the first half of the 20th Century, its continued existence is now doubtful (S. Drucioc; V. Turcanu; L. Krecsák *pers. com.*). The populations formerly known to occur between the Nistru and Prut Rivers are now extinct, as some 80% of their steppe habitat has been destroyed and the remainder is highly fragmented and overgrazed. However, it is thought that some vipers may survive in the steppe grassland that remains on the plain of the Middle Prut. This belief has been lent some credence by the rediscovery of the four-lined snake, *Elaphe quatuorlineata*, which is a species facing similar problems in Moldova, in this region (S. Drucioc; V. Turcanu *pers. com.*). Specimens of *Vipera ursinii moldavica* have been reported from Chişinău, Tighina, Ciucur-Minger, Benderei, Hînceşti, Balţi, Ialoveni, Secăreni, Oknița and Ikela (Krecsák and Zamfirescu 2002; Krecsák *et al* 2003). However, based on a 1997-1998 field survey to verify these records, which was only able to examine a few sites, these localities now appear to be questionable and the continued presence of this snake in the Republic of Moldova cannot be confirmed (Krecsák and Zamfirescu 2002; Krecsák *et al* 2003). This taxon therefore has an ***Unknown Conservation Status*** in the country. In addition, about 40 individuals of the steppe viper, *Vipera renardi*, were deliberately released in the Republic of Moldova at Trebujeni in 1993, but these snakes no longer appeared to be present in 1998 (Krecsák *et al* 2003).

2.5. Threats

2.5.1. Habitat Destruction. The physical destruction of their habitat has been the principal cause of meadow viper declines. This is especially the case in the lowlands and almost every population of *Vipera ursinii rakosiensis* and *Vipera ursinii moldavica* has now been eradicated in this way (Corbett 1989; Korsós and Újvári 1998; Krecsák and Zamfirescu 2001; Halpern and Péchy 2002). Most of the Pannonian steppe grasslands have been converted to monoculture agriculture or forestry plantations (Halpern and Péchy 2002), or lost to the various developments and roads associated with such land-use changes. Large monocultures of maize, sunflowers and mixed crops, plus orchards and vineyards,

have replaced many steppe grasslands in Hungary, Romania and Austria (Corbett *et al* 1985). Lowland habitats have also been lost to urban expansion and the suburbs of Budapest, for example, swallowed up a large part of the central Hungarian range of *Vipera ursinii rakosiensis*, including the type locality for this subspecies (Corbett *et al* 1985). Direct habitat destruction has been less severe in montane areas but the construction of tourist resorts, ski runs, radar stations, dams and mountain roads, plus other forms of development and conifer plantations, are all-important reasons for past losses of meadow viper habitat in alpine regions (Groombridge, undated; Corbett 1989; Gasc *et al* 1997; Penloup *et al* 1999).

2.5.2. Habitat Fragmentation and Loss of Genetic Diversity. Habitat destruction leads directly to habitat fragmentation, isolating surviving meadow viper populations from each other and preventing the dispersal and genetic interchange that occurs in natural metapopulations. The overall size of snake populations is obviously also reduced when less habitat is available. Such small, isolated populations are therefore not only vulnerable to extinction factors such as demographic and environmental stochastisy but also to the loss of genetic diversity. Genetic variability was found to be much lower in *Vipera ursinii rakosiensis* than in the far more abundant steppe viper *Vipera renardi* from Ukraine and there have also been reports of birth deformities, chromosomal abnormalities and low juvenile survival rates (Újvári *et al* 2002), although it has been disputed that inbreeding depression is actually a problem in the Hungarian meadow viper (K. Corbett *pers. com.*).

2.5.3. Habitat Management. Even the most significant surviving meadow viper populations, in fully protected areas, can be adversely affected by inappropriate habitat management. This may be due to changes in traditional management systems, but can also occur when unsuitable management techniques are introduced for nature conservation purposes. Overgrazing by free-ranging livestock, such as cattle and sheep, appears to be the most frequent cause of habitat damage. Heavy grazing can totally destroy the diverse vegetation structure required by the snakes, especially the all-important grass tussocks, within a matter of weeks. Since reptiles have very limited mobility and also possess no dormant stage (such as the seed bank of plants), this type of event can cause local extinctions or even the total loss of small populations. Overgrazing is a concern at a number of sites in southeast France (Penloup *et al* 1999) and in central Italy, and is especially acute in the vicinity of Duchessa Lake (Filippi and Luiselli 2003). The increasingly large numbers of domestic livestock that are turned out on Hungarian sites have caused severe damage to viper habitats, reducing both structural diversity and available cover (Halpern and Péchy 2002). To compound the effects of overgrazing in Hungary, geese and pigs here are both known to prey directly on meadow vipers, especially young snakes (Corbett *et al* 1985). Overgrazing by cattle and pigs is also considered by some experts (although not by others) to be a problem for *Vipera ursinii moldavica* in parts of the Danube Delta Biosphere Reserve (Török 2002).

Controlled burning is often practised in traditional pastoral systems to promote the growth of fresh vegetation and thereby improve available grazing land. Meadow vipers have survived such management for centuries, and indeed, along with grazing, this practice has helped to preserve both their montane and lowland habitats. However, where economic factors have encouraged the overstocking of grazing land, the perceived need is for more regular, and much larger, controlled burns to allow more animals to be grazed. Burning may also be carried out to control unwanted plants. For example, shepherds deliberately fire areas in Italy and France to discourage the growth of dwarf juniper and sometimes also grub out the bushes (Honegger 1981; Groombridge, undated). Although an extremely valuable habitat feature for the snakes, juniper is not consumed by sheep or horses and is therefore considered to be a nuisance. Excessive controlled burning is highly damaging to meadow viper microhabitats and further compounds the effects of overgrazing (Corbett 1989; Penloup *et al* 1999).

Hay cutting is another traditional use of meadow viper habitats that has been changing in recent years. Most is now carried out mechanically instead of by hand. When done too frequently and in the wrong way, mechanised cutting can be disastrous for meadow vipers – and this also applies to vegetation management carried out specifically for nature conservation reasons. If the vegetation is cut too often, especially if the cutting blades are set too close to the ground, the tussocky structure essential for the snakes is reduced, if not lost altogether. This instantly renders the habitat sup-optimal or completely unusable for meadow vipers (Corbett *et al* 1985; Halpern and Péchy 2002). Also, if

cutting takes place during their active season, the snakes are unable to move out of the way fast enough, or simply take refuge in grass tussocks that provide absolutely no protection, and many are killed as a consequence. The enforcement of "viper-friendly" management often requires compensatory payments to farmers for lost income from hay crops and funding for this may not always be available (Halpern and Péchy 2002).

Conversely, despite the problems that may be caused by the "over-management" of sites (i.e. too much grazing, burning or cutting), a lack of the same types of management can also be highly detrimental to meadow viper populations as this may allow the loss of open grasslands to succession (Webb 1995). In France, for example, shrubs such as *Genista cinerea* and trees such as *Pinus sylvestris* are no longer kept in check below the tree line and have become a serious threat to a number of alpine meadow viper sites. This is mostly due to the decline of traditional human activities, especially pastoral farming, in the French pre-Alps (Ministère de l'Environment 1998). In addition, seedlings from conifer plantations have added considerably to the problem of succession at many montane sites (Penloup *et al* 1999).

2.5.4. Illegal Collection. Despite the high levels of protection afforded to this species (Section 2.6), illegal collecting still poses a serious threat to the survival of many small *Vipera ursinii* populations (Corbett 1989; Gasc et al 1997; Halpern and Péchy 2002). Both commercial dealers and individual snake-keeping enthusiasts engage in this activity. Road construction and drainage in the lowlands, as well as new alpine roads, have made it easier to reach previously remote refuges for this snake and knowledgeable people can catch a large number of vipers in a short period. The trend for owning "hot herps" (i.e. venomous reptiles) has led to this species becoming highly sought after by amateur pet keepers. This is probably because, while undoubtedly venomous, the meadow viper is mild mannered and not particularly dangerous to keep. As the species has became rarer, so its value to the pet trade and private collectors, especially from Western Europe, has increased considerably. The conservation message seems to be irrelevant to such people, who openly discuss owning critically endangered taxa such as *Vipera ursinii moldavica* on the Internet. Most cases of *Vipera ursinii rakosiensis* bites in Hungary between 1970 and 1986 were inflicted on amateur keepers, showing the level of interest in keeping this snake, even though all were aware that this is a strictly protected snake (Takács *et al* 1987).

In the past, museums were also responsible for the collection of many meadow viper specimens – over 800 are lodged in the Natural History Museum in Vienna as a result of the former bounty system (Corbett *et al* 1985). In most cases, however, collecting for museums involves small numbers and does not pose a threat to populations and, indeed, is crucial for the scientific understanding of the taxonomy and distribution of species. However, some small populations may have been adversely affected in this way. For example, despite its rarity at least ten specimens of *Vipera ursinii rakosiensis* were removed from the remnant Cluj population, which is now extinct, in Romania (Corbett *et al* 1985).

A Population and Habitat Viability Assessment carried out for *Vipera ursinii rakosiensis* in Hungary showed that small populations were unable to sustain even moderate levels of harvesting (in this case for a planned conservation captive breeding programme). The removal of three adult females per annum for just three years from a population of 30 snakes was calculated to lead to an almost 70% risk of population extinction within 50 years (Kovács *et al* 2002). While bigger populations are more robust, commercial collectors may steal correspondingly larger numbers of snakes. Even well intentioned private collectors, who may only take a few snakes hoping that this will have no adverse effects, can easily contribute to population declines. Since these individuals may be unaware of the similar activities of others, the cumulative effects of illegal collection can decimate populations facing other pressures. For example, collectors are thought to have completed the process of extinction of *Vipera ursinii rakosiensis* at one of the last known sites for this species in Austria (Corbett *et al* 1985). Collecting is cited as a serious threat to some small populations of *Vipera ursinii ursinii* in France (Ministère de l'Environment 1998; Penloup *et al* 1999). The Campo Imperatore in central Italy is well known to collectors (Groombridge, undated), there have been unconfirmed reports of heavy collecting of *Vipera ursinii graeca* in Greece and this has long been a problem in Hungary (Halpern and Péchy 2002).

2.5.5. Persecution. With its typical viper-like markings and appearance this species resembles its more dangerous European relatives, such as *Vipera ammodytes*, *V. aspis* and *V. berus*. Not surprisingly, therefore, persecution by humans is often a threat to this species, although it actually has a mild venom and very docile temperament (Street 1976). Persecution of meadow vipers is hardly justified since very few cases of snakebite have ever been attributed to this species in the wild. Vásárhelyi (1965) cites just one case and Street (1979) records the known fatality of a single child. In addition, no reports of livestock injury or deaths are known (Corbett *et al* 1985). Nonetheless, wanton killing has been cited as a reason for the decline of meadow vipers in many areas (Honeggar 1978; Corbett 1989). Orsini's meadow vipers are often intentionally killed by hikers and hunters in France (Ministère de l'Environment 1998) and Italy (Filippi and Luiselli 2003). The illegal killing of *Vipera ursinii rakosiensis* can still be a problem in Hungary (Halpern and Péchy 2002) and the persecution of *Vipera ursinii moldavica*, by both local people and tourists, occurs within the Danube Delta Biosphere Reserve in Romania (Török 2002). Presumably this fate also frequently befalls the Balkan and Greek meadow viper subspecies whenever humans encounter them.

The construction of new roads, apart from the direct habitat destruction caused, brings more visitors to formerly remote alpine or lowland regions and increases the risk of snakes being killed through ignorance. Even within protected areas, tourism and increased public access can therefore be damaging to meadow viper populations in the absence of proper controls and restrictions. Positive publicity for venomous snakes is never easy to achieve, but appropriate legal frameworks can help mitigate against such problems. The small numbers of meadow vipers surviving in lowland and alpine regions today are unable to sustain high, persistent levels of persecution. The officially sanctioned killing of meadow vipers for bounty may have been a cause of local declines in the past, even in large, healthy populations, although the formerly vast areas of habitat available buffered some populations against these losses. For example, hundreds of these snakes were recorded as being killed annually around Laxenburg, Austria, in the late 19th and early 20th Centuries (Corbett 1989). In 1892 over 1,000 meadow vipers were killed in the grounds of Laxenburg Castle alone (Street 1979). However, Méhely (1911) considered meadow vipers to be still abundant in this area, presumably because extensive habitat remained intact at the time. Sochurek (1952) records that their extinction in Laxenburg was brought about by flooding, rather than by deliberate killing, although this theory is disputed. In any event, meadow vipers no longer exist at anything like their former densities and abundance, so persecution will always have a highly detrimental effect on populations of this species anywhere within its current range.

2.5.6. Other Threats

Drainage. Reclamation for agriculture is usually preceded by land drainage and much of the Danube flood plain has now been drained in this way. Surviving patches of natural habitat may therefore be subject to changes in their existing water tables, thus affecting the snakes (Corbett *et al* 1985; Halpern and Péchy 2002). Conversely, the reinstatement of water tables in these areas risks drowning snakes, or freezing them in hibernation, and is considered to be a very serious threat (K. Corbett. *pers. com.*).

Chemicals. Isolated habitat fragments, surrounded by intensive agriculture, are extremely vulnerable to run off or spray drift of pesticides, herbicides and fertilisers. Chemicals can destroy grassland plant communities and decimate invertebrate populations, and reptiles such as lizards and the meadow viper inevitably suffer as a result (Honegger 1978; Lambert 1987; Corbett 1989).

Urban Pressures. Urban development creates its own particular set of pressures on any meadow viper populations remaining in the vicinity, particularly through the inevitable increases in the frequency of persecution, opportunistic collection and predation by domestic cats. Damage to habitats by four-wheel drive vehicles and motorbikes is also much more common near urban areas. One of the most detrimental side effects of urbanisation is the massive increase in the numbers of accidental and deliberate fires that occurs on any nearby flammable habitats (such as lowland steppe grasslands). Such fires are far more damaging than controlled burns (section 2.5.3.), as there is no attempt at proper control at all and they often occur during dry summer weather, when the snakes are above ground and the fires can more rapidly spread.

Military Training. The ownership of land by the military, as in parts of the Kiskunság region of Hungary (Corbett *et al* 1985) or the French Alps (Penloup *et al* 1999), has often kept areas free from

agricultural reclamation and other pressures. However, serious habitat degradation can be caused by tracked vehicles and accidental fires started by flares. Significant damage was caused to a Hungarian meadow viper site when localised fires resulting from NATO military exercises were followed by a huge fire in 1997, caused by a family trying to light a shell (Újvári *et al* 2000). Despite this, the military are often willing to modify their activities to accommodate the conservation of rare species and may even incorporate particularly sensitive areas into training exercises – for example, by marking them on maps as "minefields" to be avoided by troops and vehicles.

Other Native Species. Obviously native predators are part of the same ecosystem inhabited by meadow vipers and are therefore an entirely natural pressure. However, when an imbalance occurs (almost always due to human activities) this can add to other pressures on small snake populations. The over-population of wild boar (*Sus scrofa*), for example, has been recorded as a cause of significant habitat damage in Hungary and central Italy (Péchy *et al* 1996; Filippi and Luiselli 2003). Wild boar are known to eat meadow vipers and also to reduce available habitat for snakes and their prey species, to the extent that recommendations have been made to protect critical areas of viper habitat with electric fencing.

Intensive Pheasant Rearing. The intensive rearing and release into the wild of artificially high numbers of pheasants (*Phasianus colchicus*) for shooting purposes is becoming more commonplace in parts of Europe. Pheasants have been recorded eating small reptiles in a number of countries and could consume juvenile meadow vipers with ease. The increasing numbers of this species are considered to be a threat to Moldavian meadow vipers in the Danube Delta Biosphere Reserve (Fuhn 1976; Török 2002).

Climate Change. The threat of a potentially warmer climate is clear for many alpine species, which have very little scope for migration, but it is not known how this will affect meadow vipers.

2.6. Current Protection

2.6.1. Species Protection.

International Protection. *Vipera ursinii* is listed in Appendix II of the Bern Convention (Council of Europe's Convention on the Conservation of European Wildlife and Natural Habitats, 1979), in Annexes II (*Priority Species) and IVa of the Habitats and Species Directive (European Union Directive on the Conservation of Natural Habitats and of Wild Flora and Fauna, Directive 92/43/EEC), and in Appendix I of CITES (Convention on International Trade in Endangered Species).

National Protection. European Union member states have drafted laws that specifically transpose the EU Habitats and Species Directive into national legislation and all therefore afford the meadow viper, as a species of community concern, with strict protection. Every other range state for which information was obtained has also given *Vipera ursinii* some degree of national protection. For example, national protection for *Vipera ursinii ursinii* in France is provided by Article 1 of the decree of the Ministry of Environment of 22 July 1993 (Penloup *et al* 1999). Similarly, both subspecies of *Vipera ursinii* that occur in Romania are protected under Governmental Acts No. 13/1993, No. 127/1994 and No. 462/2001 (Korsós and Újvári 1998; Török 2002) and, since 1982, *Vipera ursinii rakosiensis* has received the most rigorous national protection possible in Hungary (Halpern and Péchy 2002), equivalent to that afforded to the great bustard. Nonetheless, strict protection is meaningless without enforcement or suitable deterrents and only in Hungary is the physical guarding of some sites, plus the prospect of large fines, now starting to a have an effect on reducing illegal collecting and persecution.

2.6.2. Habitat Protection. EU member states are required to declare Special Areas of Conservation for the protection of Species of Community Interest that are listed on Annex II of the Habitats and Species Directive, with these sites then being incorporated into the Natura 2000 network. Non-EU states in Eastern Europe are preparing a similar series of protected sites, known as the Emerald Network. All countries also have various national and local designations of protected areas. Where information is available, many meadow viper sites have often been afforded the highest levels of protection.

Eight Natura 2000 sites support *Vipera ursinii ursinii* in France and these probably cover the majority of meadow viper sites in the country. The same appears to be the case for Natura 2000 sites

in Italy and Greece. Some 70% of the total *Vipera ursinii rakosiensis* habitat in Hungary is located in protected areas such as the Kiskunság National Park, established in 1975 (Janisch 1993) and the Hansag Nature Reserve. The remaining 30% is on military training land, which is now leased for conservation by BirdLife Hungary (Halpern and Péchy 2002). Although the recently discovered, and now the last known, *Vipera ursinii rakosiensis* site in Romania currently receives no protection, the 46.36 ha Valea Lui David Natural Reserve in the north eastern province of Moldavia, which supports a small population of *Vipera ursinii moldavica*, has been protected since 1969 and all 2,500 ha of habitat suitable for this subspecies in the Danube Delta is included within the Biosphere Reserve (Török 2002). Limited information exists for other countries about the proportion of *Vipera ursinii* habitat within protected areas, or indeed about the size or location of most of the national meadow viper populations themselves. As distribution surveys progress, it is hoped that all meadow viper habitat in Europe will ultimately receive protection. Of course, even on the most strictly protected sites it is also essential to ensure that management is not detrimental to the meadow vipers and that other pressures are controlled.

2.7. Conservation Actions to Date

The decline of meadow viper populations in Europe has long been recognised (Honegger 1978; 1981; Corbett et al 1985; Corbett 1989) and conservation efforts have been underway for some time. The Conservation Committee of the Societas Europaea Herpetologica (SEH) has been active for over 25 years, for example visiting sites in Hungary in 1985 and 1987, putting forward recommendations for habitat management and proposals for reserves (Corbett *et al* 1985; 1986; 1989) and, in 1996, financing the purchase of the important Orditó-rét meadow near Kunspeszar, Hungary, since incorporated into the Kiskunság National Park (Corbett 2002). The SEH has worked largely through the Bern Convention, which has played an enormous role in progressing the conservation of amphibians and reptiles in Europe (e.g. Corbett 1989; Council of Europe 1990; 1992; 1993; 1994; 1997; 1998; Edgar and Stumpel 2004). Meadow vipers are included in Recommendations Nos. 13, 23 and 26 (Council of Europe 1988; 1991a; 1991b) and the Bern Convention Standing Committee has also funded this Action Plan.

As a result of this political recognition and pressure, a great deal of attention has been focused on *Vipera ursinii*. Comprehensive surveys of *Vipera ursinii ursinii* populations and habitats were conducted in France from 1993 to 1998 (Penloup *et al* 1999) and a significant body of work has been done in Italy (Sindaco *et al* 2006). Distribution surveys have also been carried out in Hungary and Romania. Past surveys have been much more limited in the Republic of Moldova, although a small team has recently started work, with the support of the Ministry of Ecology and Natural Resources, to determine the distribution and status of *Vipera ursinii moldavica* in the country (S. Drucioc/V. Turcanu *pers. com.*). The Dinaric Alps Rare Habitats and Species Conservation Project will include the identification of habitats and localities of the Balkan meadow viper *Vipera ursinii macrops*. Appropriate habitat management for meadow vipers has been implemented, and scientific research carried out, at a number of sites in France, Italy and Montenegro (Tomović *et al* 2004).

The most intensive meadow viper conservation efforts have been undertaken for *Vipera ursinii rakosiensis* in Hungary. These actions have included the implementation of a national Recovery Programme (now succeeded by a national Species Action Plan), the establishment of a Viper Conservation Council, habitat protection and purchase, the guarding of important sites from collectors and fires, the implementation of viper-friendly management, the reinforcement of viper numbers through the captive overwintering and release of young snakes, population monitoring and detailed scientific research (Nechay and Péchy 1994; Péchy *et al* 1996; Liptói *et al* 1999; Ujvári and Korsós 1997; 1999; Halpern and Péchy 2002; H. Balint *pers. com.*). A Hungarian meadow viper Population and Habitat Viability Assessment (PHVA) workshop was also held in Hungary in November 2001 (Kovács *et al* 2002). In recent years, substantial funding has been obtained via two LIFE projects for the conservation of *Vipera ursinii moldavica* in Romania and *Vipera ursinii rakosiensis* in Hungary (and recent approval has been given in late 2005 for another project in Romania). These projects are:

"In situ" conservation of the Romanian Steppe Viper (*Vipera ursinii*), LIFE Project No. LIFE99 NAT/RO/006404. This provided €255,877 between October 1999 and January 2002 for the conservation of the meadow viper in the Danube Delta Biosphere Reserve. A management

plan for *Vipera ursinii moldavica* was prepared (Török 2002), although no further progress was made and the project unfortunately came to a premature end. Fortunately, however, a national Species Action Plan for the meadow viper in Romania (both subspecies) is now being implemented (A. Iftime *pers. com.*).

Establishing the background of saving the Hungarian meadow viper (*Vipera ursinii rakosiensis*) from extinction, LIFE Project No. LIFE04 NAT/HU/000116. Between January 2004 and December 2007, BirdLife Hungary, the Kiskunság National Park and the Ministry of the Environment Nature Conservation Authority will receive €649,000 for this project. This will be used for the conservation of 95% of the global population of this taxon. Principal aims include bringing all meadow viper sites into State ownership, re-creation of grassland habitats to create ecological corridors, a captive breeding programme, public awareness, education and the establishment of a "Viper Conservation and Recovery Centre".

Much more still needs to be done, however, before all meadow viper populations can be considered secure. The following sections therefore outline a series of objectives and actions aimed at consolidating past achievements and securing the long-term viability of this species in Europe.

3. ACTION PLAN OBJECTIVES

3.1. Overall Goal

The overall goal of this action plan is to ensure the maintenance, and restoration as necessary, of viable populations of meadow vipers as an integral part of ecosystems and landscapes they inhabit in Europe.

3.2. Objectives

In order to achieve this goal, it is necessary to identify and then remove (or mitigate for) any threats to meadow viper populations and their habitats. An immediate priority is to halt and reverse the deterioration of every small, isolated and declining meadow viper population in Europe. It is also essential to ensure that all other, presently viable, meadow viper populations, including any that may yet be discovered, are fully protected and that this species is given adequate priority in all relevant habitat management plans and programmes. The following objectives are integral to this process:

Objective 1. To plan and carry out field surveys, as an urgent priority, to fill all gaps in current knowledge about the distribution and status of *Vipera ursinii*.

Objective 2. To adequately map all habitats supporting meadow viper populations, combining these with existing information for various countries to produce a GIS-based site inventory for *Vipera ursinii*.

Objective 3. To ensure that any currently unprotected areas are safeguarded where possible by suitable national designations - and preferably incorporated into the Natura 2000 or Emerald Network series.

Objective 4. To define and quantify "Favourable Conservation Status" targets for the meadow viper, in all countries within its range, in order to plan monitoring programmes and provide an accurate measure of the success of future actions.

Objective 5. To produce management plans (or assist with the amendment of existing plans if necessary) for all known *Vipera ursinii* sites that take into account the particular ecological requirements of this species and give adequate priority to appropriate and sensitive management regimes.

Objective 6. To produce detailed Meadow Viper Recovery Plans for every range country, where this is still required, which are specifically targeted at increasing the range, numbers, genetic vigour and long-term viability of each population. Captive breeding and re-introduction programmes should be implemented if these are considered to be a necessary adjunct to individual Recovery Plans.

Objective 7. To encourage and support scientific research relevant to meadow viper conservation, which is seen as particularly important in informing habitat management and other initiatives.

Objective 8. To plan and cost out appropriate habitat purchase and re-creation strategies, especially in lowland steppe habitats, with a view to expanding and/or linking isolated meadow viper populations and re-establishing the natural metapopulation dynamics of this species.

Objective 9. To promote a positive public attitude towards meadow vipers and secure the support of all relevant governments, policy makers, organisations, institutions, landowners and individuals.

Objective 10. To improve international liaison and coordination between all those engaged in surveys, monitoring, habitat management and scientific research (to more effectively achieve Objectives 1-9).

4. ACTIONS REQUIRED

4.1. Habitat Protection

The endangered status of the meadow viper in Europe indicates that all occupied habitat should be as fully protected as possible, preferably within the Natura 2000 and Emerald Network series. This process is already well advanced in countries such as France, Italy and Hungary. The LIFE project in Hungary, for example, will secure nature protection designation for all surviving populations of *Vipera ursinii rakosiensis* in the country, ensuring adequate buffer zones are in place. In other countries, more surveys will be required to determine what proportion of meadow viper habitat is already protected and what else needs to be done.

A. Urgent Priority Actions

Action 4.1.1. Ensure that 100% of the habitat that supports known meadow viper populations, of all five alpine and lowland subspecies, are protected from any threats of further habitat loss by appropriate national designations and where possible, incorporated into the Natura 2000 and Emerald Network series.

Action 4.1.2. Specifically, and as a matter of extreme urgency, ensure that the habitat of the single, recently discovered population of *Vipera ursinii rakosiensis* in Romania receives full Government protection and, if necessary, is acquired by purchase. In particular, investigate ways of averting the threats posed to this site by planned agricultural intensification.

Action 4.1.3. Specifically, and as a matter of extreme urgency, ensure that the newly discovered populations of *Vipera ursinii moldavica* in the Ciritei/Holm area of Romanian Moldavia receive full Government protection and, if necessary, are acquired by purchase.

B. Medium Priority Actions

Action 4.1.4. Establish adequate buffer zones around meadow viper sites that are at risk from spray drift or the run-off of chemicals from adjacent agricultural land.

Action 4.1.5. If any new meadow viper locations are discovered through future distribution surveys, ensure that these are brought to the attention of the relevant governments and conservation bodies (while retaining confidentiality) and that they receive full protection at the earliest opportunity.

4.2. Habitat Management

In addition to the legal protection of sites, the specific habitats required by meadow vipers must be managed appropriately. The physical structure of both montane and lowland meadow viper habitats is generally a much more important factor, as far as survival of the snakes is concerned, than the actual plant species composition. Nonetheless, particular plant species may be more heavily utilised for shelter by meadow vipers than others, and may also be vital for certain prey species. In addition, meadow viper populations are seldom distributed uniformly, even within apparently suitable habitat, and the often highly localised nature of snake concentrations may have implications for conservation management plans. Although species-specific management should obviously not dominate across an entire site, a balance must be achieved with general ecosystem management in certain key areas to ensure the long-term viability of snake populations. Habitat re-creation will also be essential to prevent the loss of small lowland meadow viper populations. Extensive GIS mapping of the Hungarian and Romanian grasslands has already been carried out (Demeter and Veen 2001;

Anca *et al* 2004) and large datasets are therefore potentially available to assist with habitat re-creation plans for meadow viper sites.

A. Urgent Priority Actions

Action 4.2.1. Prepare management plans for all known *Vipera ursinii* sites (or ensure existing plans are suitably modified) that map key areas and fully take into account the likely movements and particular ecological requirements of meadow vipers on that site. Traditional grassland management should be supported or re-instated whenever possible at both alpine and lowland meadow viper sites. Specifically:

Action 4.2.2. Control vegetation succession on key meadow viper sites by the regular removal of bushes and trees as necessary.

Action 4.2.3. Avoid overstocking of grazing animals for purely commercial reasons at meadow viper sites, and maintain controlled, extensive grazing regimes using suitable, traditional livestock breeds.

Action 4.2.4. Prohibit excessive levels of controlled burning, and also establish fire-fighting measures, at meadow viper sites. Protect key plant species such as dwarf juniper from deliberate eradication.

Action 4.2.5. To preserve the structural diversity of vegetation (particularly tussocks), avoid any cutting of vegetation on at least 25 % of prime meadow viper habitat and ensure that no more than 33 % of the remaining area is ever cut in any one season. Promote hand cutting wherever possible, limiting any mechanical cutting to the autumn (November onwards), ensuring that cutting heights are set no lower than 15 cm, and completely prohibit the most damaging methods such as rotary cutting.

Action 4.2.6. Avoid the use of pesticides and other chemicals on or within 500 m of all meadow viper sites.

Action 4.2.7. Avoid the flooding of important lowland meadow viper habitats through the deliberate manipulation of water tables, especially all areas that represent known or potential hibernation sites for this species in the winter months.

Action 4.2.8. Produce and implement habitat re-creation and restoration plans where appropriate, particularly where this would re-connect presently fragmented meadow viper populations and reverse the effects of agricultural reclamation, forestry, drainage or other past activities. As a priority, examine the opportunities for re-creating habitats in lowland areas of Hungary, Romania and the Republic of Moldova and, in preparation for any meadow viper re-introduction programme, in Austria (specifically at Moosbrunn, the National Park of Neusiedler See and within the extensive grasslands of Vienna's Schwechat Airport).

B. Medium Priority Actions

Action 4.2.9. Reduce and control the numbers of species such as pheasants and wild boar where these are known or are thought to be causing problems for any meadow viper population.

Action 4.2.10. Where applicable on land under military control, negotiate agreements with the relevant authorities to alter or limit any damaging training activities on key meadow viper habitats.

4.3. Species Protection

The meadow viper already receives a high degree of protection across its range, although this has often failed to reduce illegal activities such as collection and deliberate killing. Improving public awareness (Section 4.9.) is of paramount importance in preventing persecution but, in many cases, only high financial penalties, and even the physical guarding of the most vulnerable populations, will deter the most persistent collectors.

A. Urgent Priority Actions

Action 4.3.1. Whenever possible, ensure that key meadow viper sites under particular pressure from illegal activities such as collection and persecution are adequately wardened.

B. Medium Priority Actions

Action 4.3.2. Carry out a review of the effectiveness of current legal protection for the meadow viper and its enforcement throughout the range of this species. Provide recommendations for improving the situation where necessary, for example through the imposition of higher penalties for infringements.

Action 4.3.3. Absolutely prohibit the issuing of any permits for the commercial collection or trading of meadow vipers.

Action 4.3.4. Investigate the potential for the indirect protection of meadow viper populations using other legal instruments, for example the use of fencing within National Parks to protect vegetation.

4.4. Species Management

Although suitable habitat management and re-creation schemes will be sufficient for most meadow viper populations to recover naturally, thus negating the need for species management, some lowland populations will undoubtedly require direct intervention to survive. Several options are available for increasing numbers and improving genetic diversity. Moving snakes between recently isolated sites has produced dramatic improvements for inbred populations of related species such as the adder, *Vipera berus* (Madsen *et al* 1999). This action is less likely to be appropriate for meadow vipers, however, since most populations have been isolated for long periods and are separated by considerable distances. In such cases, the within-population genetic diversity can be low while the variation between different populations can be significant. Therefore simply moving meadow vipers between populations runs the risk of outbreeding depression. In addition, population reinforcement, by retaining females and releasing young, was found to be ineffective over a three-year period in Hungary (Nechay and Péchy 1994; Újvari *et al* 2000). The only feasible option to increase genetic diversity and save some small populations from inevitable extinction, especially in Hungary and Romania, is to implement a captive breeding programme based on genetically screened animals (Újvári *et al* 2002), with viable animals then being released into areas of suitably restored and managed habitat. It should be noted, however, that captive breeding should always be seen as a last resort. This technique is very expensive and can also create a range of new problems of its own (spreading disease is a particular risk). Stringent criteria must therefore be met before a captive breeding programme can even be considered and strict husbandry, health and release protocols must always be adhered to whenever this technique is employed.

A. Urgent Priority Actions

Action 4.4.1. Investigate the potential for expanding the newly established captive breeding programme for *Vipera ursinii rakosiensis* in Hungary to include this subspecies, and also *Vipera ursinii moldavica*, in Romania and the Republic of Moldova. Only release genetically screened captive bred animals into sufficiently large areas of managed meadow viper habitat where known threats have been removed.

Action 4.4.2. Investigate pathogens likely to increase and affect meadow vipers in any captive breeding programme. Ensure that, prior to release, all animals receive adequate health screening for any diseases or parasites that may compromise the survival of both this snake and other wildlife species.

B. Medium Priority Actions

Action 4.4.3. Assess the current interest and ecological potential for re-introducing *Vipera ursinii rakosiensis* to parts of its previously well-documented range in Austria.

4.5. Distribution Surveys

The extent and status of all meadow viper populations must be established before the success of conservation efforts can be properly planned and implemented, let alone measured. However, distribution data for the meadow viper in Europe are incomplete, especially in the Balkan countries, and there is an obvious need to fill these gaps in our knowledge. Standardised survey methods and mapping techniques, particularly the use of Geographic Information Systems (GIS), will be essential. Countries where this exercise has already been undertaken, or is currently underway, may be able to provide valuable information and help to others. For example, the 1990s project to establish the

distribution and status of *Vipera ursinii ursinii* in France (Penloup *et al* 1999) would be an excellent model to follow. Whenever possible, and where this will be relevant and beneficial, support should also be sought from those coordinating wider conservation and mapping initiatives, such as the Dinaric Alps Rare Habitats and Species Conservation Project or the INTERREG III B Alpine Space Programme projects HABITALP and CADSES (Central European, Adriatic, Danubian, South-eastern European Space). Although information about Natura 2000 sites is publicly available, records of small vulnerable meadow viper populations should be remain confidential as far as possible due to the generally precarious status of many of these and, in particular, to the threat posed by illegal collection.

A. Urgent Priority Actions

Action 4.5.1. Plan and conduct coordinated surveys and mapping of known and potential sites for *Vipera ursinii macrops* in the Dinaric Alps of Croatia, Bosnia-Herzegovina, Serbia, Montenegro, the Former Yugoslav Republic of Macedonia and northern Albania.

Action 4.5.2. Carry out field surveys to determine the population status and conservation needs of the populations of *Vipera ursinii graeca* in the Pindos Mountains of Greece.

Action 4.5.3. Conduct thorough field surveys in western Romania to locate any other possible surviving populations of *Vipera ursinii rakosiensis*, and in northeast Romania (Moldavia) for additional sites for *Vipera ursinii moldavica*. Also investigate the previously known meadow viper site at Mount Rarau in the Carpathian Mountains.

Action 4.5.4. Initiate urgent field surveys for *Vipera ursinii moldavica* in the Republic of Moldova.

B. Medium Priority Actions

Action 4.5.5. Continue field surveys and the mapping of *Vipera ursinii ursinii* habitats in southeast France and central Italy.

Action 4.5.6. Investigate the possible continued presence of *Vipera ursinii rakosiensis* in eastern Austria, northern Croatia (Slavonia) and Serbia (Vojvodina).

Action 4.5.7. Investigate old reported sites for meadow vipers in both western and northeast Bulgaria.

4.6. Population and Conservation Status Monitoring

It is important to regularly monitor meadow viper populations to detect changes in status and to assess the effectiveness of any conservation actions taken. The results can also be used to refine and adjust conservation and habitat management techniques and to prioritise the allocation of available resources. Defining and quantifying "Favourable Conservation Status" for meadow vipers in the various range countries of Europe should be central to this process and will enable a clear set of goals, targets and funding requirements for conservation actions to be produced.

A. Urgent Priority Actions

Action 4.6.1. Determine the current range of known meadow viper populations, as well as the historical range of this species (especially on lowland steppes), to assist with the development of specific targets for habitat restoration and re-creation strategies, as well as species re-introduction programmes.

Action 4.6.2. Develop standardised GIS-based methods for the mapping and measuring of prime habitats specifically used by meadow vipers (as opposed to the broader habitat categories, above) to enable the future assessment of changes in the extent and quality of these habitats at all sites.

B. Medium Priority Actions

Action 4.6.3. Produce a standardised methodology for monitoring and calculating the condition of individual meadow viper populations and any future changes to their status.

Action 4.6.4. Using the above methods, establish an internationally coordinated population monitoring programme for the meadow viper to regularly determine conservation status. Inform

national governments, the Standing Committee of the Bern Convention and other relevant parties of the results.

4.7. Scientific Research

Appropriate scientific research is essential to inform and refine conservation management. Significant bodies of work have already been published about various aspects of meadow viper ecology but there is still a lot to learn about this species. In particular, radiotracking is one of the most useful techniques for elucidating habitat use by snakes and offers unparalleled opportunities to study meadow vipers in more detail (Fitch, 1987; Újvári and Korsós 1997; Kenward, 2001). As much support as possible should be given to academic institutions planning to conduct meadow viper research of this nature, or in any other areas that will be relevant to the objectives of this Action Plan.

B. Medium Priority Actions

Action 4.7.1. Encourage and support scientific research investigating the general ecology, behaviour and habitat use of the different meadow viper subspecies in the various range countries.

Action 4.7.2. With experienced scientists, develop a series of applied research goals that are relevant to the conservation of meadow vipers, especially empirical work investigating the response of the snakes to various forms of habitat management, such as grazing, controlled burning and vegetation cutting.

Action 4.7.3. Investigate the potential for research projects looking into the effects of climate change on alpine populations of meadow vipers, if possible collaborating with wider projects such as the INTERREG III B initiatives HABITALP and CADSES (see Section 4.2.).

4.8. Improved Liaison and Coordination

Conservation efforts to halt the decline of the meadow viper in Europe have progressed erratically in recent years and there is still much to be done to ensure the long-term viability of this species. Although conservation is always more effective when carried out by local workers, within their own country, international liaison has clearly been highly beneficial in the past and there is still a need to further improve cooperation in order to facilitate the exchange of information and ideas and to provide mutual support.

A. Urgent Priority Actions

Action 4.8.1. Ensure that the Governments and relevant conservation bodies of all currently known meadow viper range countries implement this Action Plan.

Action 4.8.2. Where these do not already exist, encourage the production and implementation of national Meadow Viper Recovery Plans (in a standard format) for all countries where *Vipera ursinii* occurs. Encourage the implementation of these plans by the relevant Governments and all key players, e.g. relevant Ministries and National Park Administrations.

B. Medium Priority Actions

Action 4.8.3. Establish a "European Meadow Viper Group" responsible for collating all existing data on distribution and for setting up a central Internet-based database for survey and monitoring records and for other important information (including habitat management guidelines) relevant to this species.

Action 4.8.4. Develop common, agreed protocols to standardise further distribution surveys and habitat mapping in Europe (see Section 4.2.), plus the effective population and conservation status monitoring of meadow vipers (see Section 4.7.).

Action 4.8.5. An international symposium on *Vipera ursinii* should be organized by a suitable pan-European conservation body to promote collaboration and discussion, with all those involved in the conservation of this species invited to present the results of their efforts and research. Publish the proceedings in the appropriate format and languages.

4.9. Public Awareness and Education

The widespread belief that meadow viper conservation efforts in southeast France involved the mass release of venomous snakes led to a lack of support and increased persecution (Ministère de l'Environment 1998). Clearly it is often difficult to obtain public sympathy and support for the conservation of snakes. It is therefore imperative that well planned public awareness and education programmes are an integral part of meadow viper conservation projects and these should preferably be locally run. It may pay to stress the importance of the other species of flora and fauna found in a particular area, rather than the snakes, although imaginative ways of promoting meadow vipers can sometimes pay off, and also help to influence other target audiences such as Governments and policy makers. For example, stamps and phone cards depicting *Vipera ursinii macrops*, issued with WWF support, proved to be very popular in Croatia.

A. Urgent Priority Actions

Action 4.9.1. Produce appropriate educational and public awareness material in all range countries, aimed at local people and stressing the conservation importance and docile nature of the meadow viper.

B. Medium Priority Actions

Action 4.9.2. Co-ordinate fund-raising support for public awareness, where needed, via a central body.

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