THE CURRENT DISTRIBUTION OF HERPETOFAUNA IN THE MARAMUREŞ COUNTY AND THE MARAMUREŞ MOUNTAINS NATURE PARK, (MARAMUREŞ, ROMANIA)

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ABSTRACT

We documented and then updated the geographic range of herpetofauna from the Maramureş County based on historical and present data and on our own inventory data. A total of 25 species (14 amphibians and 11 reptiles) were recorded in the area. We further examined the species conservation status by applying three cartographic measures and a relative area of occupancy index. The species were roughly ranked in a similar way according to all indices. We found that the most rare and potentially threatened species were *Rana arvalis*, *Coronella austriaca* and *Natrix tessellata*. We suspect that the lack of suitable habitats and ecological specialization are the causes of their increased vulnerability. The indices tested by us proved adequate for detecting vulnerable amphibian and reptile species, and could serve as a simple but effective tool in species conservation.

RESUME La distribution de l'herpetofaune du département de Maramureş et du Parc Naturel Montagnes de Maramureş (Maramureş, Roumanie).

Les données sur la distribution de l'herpetofaune du département de Maramureş et du Parc Naturel Montagnes de Maramureş proviennent de la littérature et notre inventaire. En total 25 espèces sont présentes dans la région, dont 14 amphibiens et 11 reptiles. Nous avons estime le statut de conservation en appliquant trois mesures cartographiques et un indice relatif de l'aire occupe. Les espèces ont été hiérarchise similairement par rapport a tout les indices utilises. Les plus rares et possiblement menaces espèces sont *Rana arvalis*, *Coronella austriaca* et *Natrix tessellata*, probablement a cause due manqué des habitats propice. Les indices utilises sont utiles pour identifier les espèces vulnérables et peuvent servir comme instruments simples et efficaces pour décider les priorités en conservation.

REZUMAT: Distribuţia actuală a herpetofaunei în judeţul Maramureş şi Parcul Natural Munţii Maramureşului (Maramureş, România).

Datele referitoare la distribuţia herpetofaunei din judeţul Maramureş şi din Parcul Natural Munţii Maramureşului au fost preluate din literatura de specialitate şi completate cu date personale. În total au fost inventariate 25 de specii în zonă (14 de amfibieni şi 11 de reptile). În continuare, am estimat statutul speciilor, aplicând trei indici cartografici şi un indice al habitatului ocupat. Speciile au fost ierarhizate într-un mod similar în raport cu toţi indicii testaţi. Cele mai rare şi potenţial periclitate specii au fost *Rana arvalis*, *Coronella austriaca* şi *Natrix tessellata*, probabil datorită ponderii scăzute a habitatelor prielnice. Indicii testaţi s-au dovedit utili în detectarea speciilor vulnerabile de amfibieni şi reptile şi pot servi ca instrumente simple şi eficiente în stabilirea priorităţilor în conservare.

INTRODUCTION

Understanding and managing species diversity requires knowledge about their geographical distribution and patterns. A key component to understanding shifts in species diversity is the availability of detailed maps of species distribution based on historical and present data. Amphibians and reptiles are excellent indicator taxa of global changes since they are undergoing a worldwide decline according to recent global studies (Whitfield et al., 2000; Beebee and Griffiths, 2005). Reliable and updated distribution data are essential for understanding the impact of human-induced disturbances and propose mitigating activities of their effects.

The Maramureş Mountains Nature Park was established in 2004 (H. G. 2151 / 2004). Few historical records on herpetofauna were available here (Frivaldszky, 1871), partly due of its isolation and past access restrictions due to the vicinity of the border with Ukraine (ex Soviet Union). In 2007 we inventoried the herpetofauna of the area in order to update and check the presence of protected species within the park (Cogălniceanu et al., 2007).

In this paper we aim to (1) update the species list and document the geographic range of herpetofauna from the Maramureş County and compare it with the Maramureş Mountains Nature Park, and (2) evaluate the species conservation status in the area based on changes over time of the distribution records and the area of occupancy.

MATERIAL AND METHODS

The Maramureş County is located in the northeast part of Romania and covers a surface of 621,500 ha (latitude N 47°35'5" - 47°58'20"; longitude E 24°8'12" - 25°2'38"). The Maramureş Mountains Nature Park is located between the Vişeu Valley and the Romanian - Ukrainian border and covers approximately 150,000 ha out of which 9,050 ha are nature reserves (IV IUCN category) and 139,800 ha are protected landscapes (V IUCN category). The altitude varies between 300 and 1970 m a. s. l. and the area receives an average 900 mm of rainfall annually and has an average annual temperature of 6 ^{o}C.

We compiled the available amphibian and reptile distribution data from Maramureş County based on bibliography and museum collections. In 2007 we carried out a herpetofauna inventory in the Maramureş Mountains Nature Park (Cogălniceanu et al., 2007) and we added our field data. Garmin handheld GPS units with 3 - 5 m horizontal accuracy, set to WGS84 geographic coordinate system, were used to record point locations for each station in the field. The collected GPS data was imported into a GIS environment using ArcGIS Desktop 9.3. There, the data was converted to the national Stereographic 70 coordinate system in order to match the basemap layers' coordinate system, and each point location was associated with its corresponding field data attributes in order to build a geodatabase comprising the whole field inventory.

Early records of the Maramureş County herpetofauna, go back to 1871 (Frivaldszky, 1871). Since then, over 17 publications provided distribution data for amphibians and reptiles in the Maramureş County, of which six were published before 1990 (Fuhn, 1960; Fuhn and Vancea, 1961; Stugren and Popovici, 1961; Micluţă, 1969, 1970; Borcea, 1983) while eleven were published during 1996 - 2002 (Andrei, 1997; Ardelean and Bereş, 2000; Bereş, 1996, 1997; Dehelean and Ardelean, 2000; Ghira et al., 2002; Török, 1997 a, 1997 b, 1998, 1999, 2000).

The distribution data from bibliography and collections were analyzed as historical data (records before 1990), recent data (records only after 1990), and 2007 field data. We used the UTM grid system with cells of 100 km^2 (10 × 10 km), each cell being identified with a biogeographical code (Lehrer and Lehrer, 1990), as mapping units since most literature records are based on localities and offer no information on the area covered within a location. When more localities were located in the same UTM grid cell they were counted as a single record. While this method has certain limits, it allows for a quantification of the area covered, providing an equal value for each record and thus an estimate of the area of occupancy.

In order to identify changes in the area of occupancy we computed three distribution indices: (i) the relative change in species distribution, $Rc = V / (C + N)$, (ii) the continuity index, $Ci = C \times 100 / (V + C)$, and (iii) the relative degree of knowledge $K = (C + N) \times 100 / T$, where V = number of records before 1990, C = number of constant records (before and after 1990 records), N = number of records after 1990 and T = total number of records. Values of the relative change in species distribution ratio higher than one indicate a reduction of the distribution range of one species. The continuity index is a measure of the constant record of the species at a particular site. Higher values of this index correspond to an increasing continuity. The relative degree of knowledge index has high values when most records are recent (i. e. after 1990), and lower values when more records are old (i. e. before 1990).

The area of occupancy is an indicator of the extent of unsuitable or unoccupied habitats. Since we did not have distribution records from all 104 grid cells we computed a relative area of occupancy for each species (number of UTM grid cells where a species is present / total number of quadrates from which at least one species was recorded - i. e. 53 from our data). This index allowed us to estimate the range of favourable and unsuitable habitats in the studied region.

In the recent years a number of taxonomical changes were proposed but never considered in the national legislation (especially in the national annexes of the Habitats Directive OUG 57 / 2007). Our present paper uses the old, still widely used scientific names to avoid confusion (Tab. 1).

Table 1: Taxonomic changes involving amphibian and reptile species present in the Maramureş County.

Old species name	New species name
Amphibians	
Triturus alpestris	*Mesotriton alpestris*
Triturus montandoni	*Lissotriton montandoni*
Triturus vulgaris	*Lissotriton vulgaris*
Rana esculenta	*Pelophylax esculentus*
Rana ridibunda	*Pelophylax ridibundus*
Bufo viridis	*Pseudepidalea viridis*
Reptiles	
Lacerta vivipara	*Zootoca vivipara*
Elaphe longissima	*Zamenis longissimus*

RESULTS

Distribution data for amphibians and reptiles is available for only 50.96 % of the area of the Maramureş County and 42.10 % of the area of the Maramureş Mountains Nature Park. 14 amphibian and 11 reptile species were recorded in the Maramureş County. The most widely distributed amphibian species are *Bombina variegata* and *Rana temporaria* whereas for reptile species are *Lacerta agilis* and *Natrix natrix* (Fig. 1). From a total numbers of 1133 records (841 from bibliographic sources, 4 from collections and 288 field records), 90.64% are records after 1990 and only 9.36 % records before 1990. From the Maramureş Mountains Nature Park there are only 47 herpetofauna records before our 2007 inventory (24 records are after 1990).

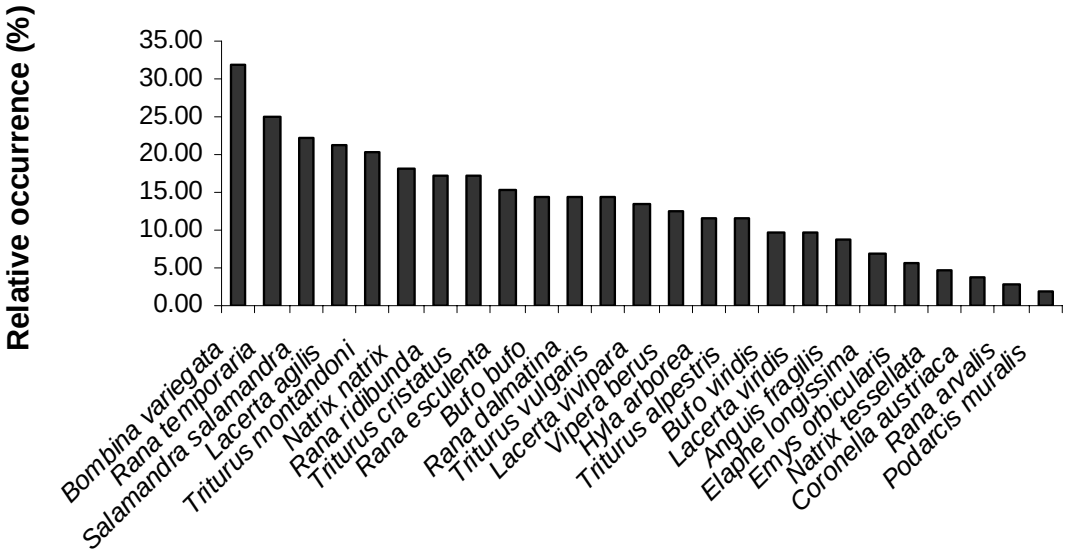

Figure 1: The relative occurrence of amphibian and reptile species calculated as total number of records (T) for a species on the total number of grid cells from the Maramureş County.

The known distribution records for herpetofauna available at county level are presented in the figure 2. Figures 3 - 8 shows the distribution data for the most common species. The maps include both published and collection data assigned to the UTM grid cell centroid and our own GPS - based inventory represented as high resolution point data. The available data type and the values of calculated indices for each species are presented in the table 2.

The analysis of the new distribution data (records after 1990) indicated that one amphibian species (*Rana temporaria*) and three reptile species (*Emys orbicularis*, *Natrix tessellata* and *Podarcis muralis*) were not previously reported from the Maramureş County. A considerable increase in the number of records was found for *Triturus montandoni*, *Rana dalmatina*, *Rana esculenta* and *Lacerta agilis*. *Rana arvalis* suffered the highest reduction area as suggested by the values of the Rc and Ci indices. Five amphibian species (*Bombina variegata*, *Hyla arborea*, *Triturus montandoni*, *Rana dalmatina* and *Rana esculenta*) and two reptile species (*Lacerta agilis* and *Coronella austriaca*) show the highest values for the Ci and also the K index. *Rana temporaria*, *Natrix tessellata*, *Emys orbicularis* and *Vipera berus* also present a high value of the K index since they either have a restricted distribution or all records are recent.

Table 2: The distribution of records according to the species investigated and to the date of observation. Four indices are proposed as ratios between the different record types (see text for details).

Species	Records before 1990 (V)	Continuous records (C)	Records after 1990 (N)	Total number of records (T)	Relative area of occupancy	Relative change in species distribution (Rc) V / (C + N)	Continuity index (Ci) C × 100 / (V + C)	Relative degree of knowledge (K) (C + N) × 100 / T
Amphibia								
Triturus alpestris	2	3	7	12	0.23	0.20	60.00	83.33
Triturus cristatus	5	0	13	18	0.34	0.38	0.00	72.22
Triturus montandoni	0	5	16	21	0.40	0.00	100.00	100.00
Triturus vulgaris	3	1	11	15	0.28	0.25	25.00	80.00
Salamandra salamandra	7	12	4	23	0.43	0.44	63.16	69.57
Bombina variegata	0	4	29	33	0.62	0.00	100.00	100.00
Bufo bufo	1	2	12	15	0.28	0.07	66.67	93.33
Bufo viridis	1	2	7	10	0.19	0.11	66.67	90.00
Hyla arborea	0	3	9	12	0.23	0.00	100.00	100.00
Rana arvalis	2	1	0	3	0.06	2.00	33.33	33.33
Rana dalmatina	0	2	13	15	0.28	0.00	100.00	100.00
Rana esculenta	0	1	15	16	0.30	0.00	100.00	100.00
Rana ridibunda	1	1	16	18	0.34	0.06	50.00	94.44
Rana temporaria	0	0	26	26	0.49	0.00		100.00
Reptilia								
Emys orbicularis	0	0	6	6	0.11	0.00	100.00	
Anguis fragilis	1	2	6	9	0.17	0.13	66.67	88.89
Podarcis muralis	0	0	2	2	0.04	0.00		100.00
Lacerta agilis	0	2	20	22	0.42	0.00	100.00	100.00
Lacerta viridis	1	3	6	10	0.19	0.11	75.00	90.00
Lacerta vivipara	2	1	11	14	0.26	0.17	33.33	85.71
Coronella austriaca	0	2	2	4	0.08	0.00	100.00	100.00
Elaphe longissima	1	1	5	7	0.13	0.17	50.00	85.71
Natrix natrix	3	1	15	19	0.36	0.19	25.00	84.21
Natrix tessellata	0	0	5	5	0.09	0.00		100.00
Vipera berus	2	4	7	13	0.25	0.18	66.67	84.62

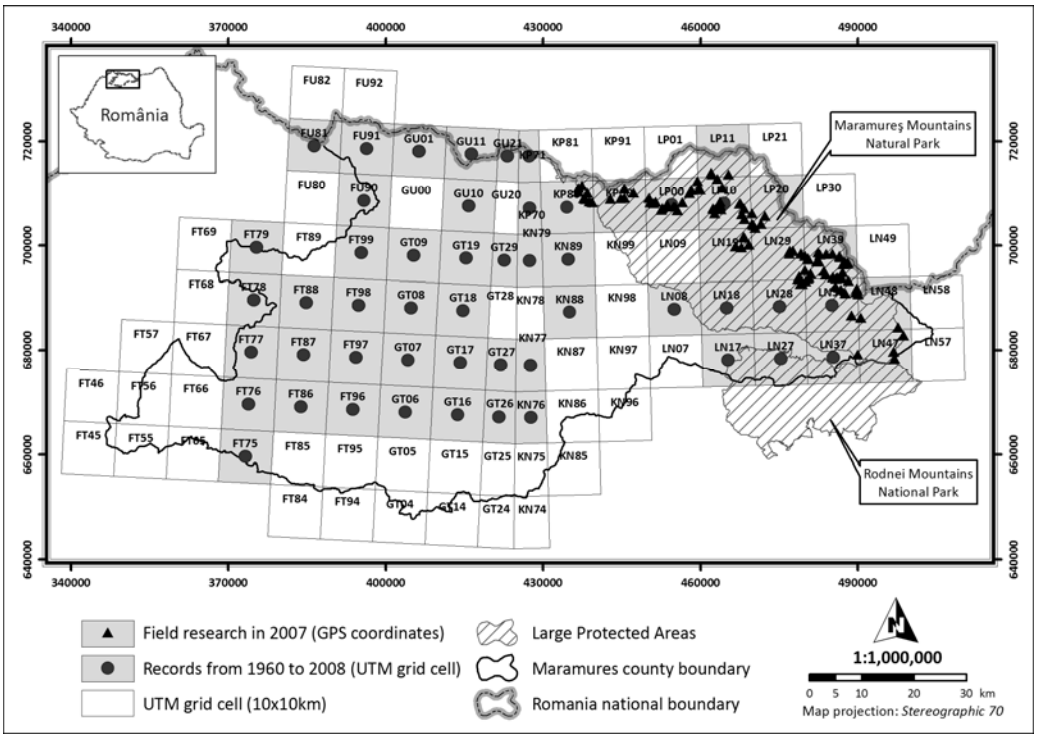

Figure 2: Cover of geographic records of amphibians and reptiles from the Maramureş County

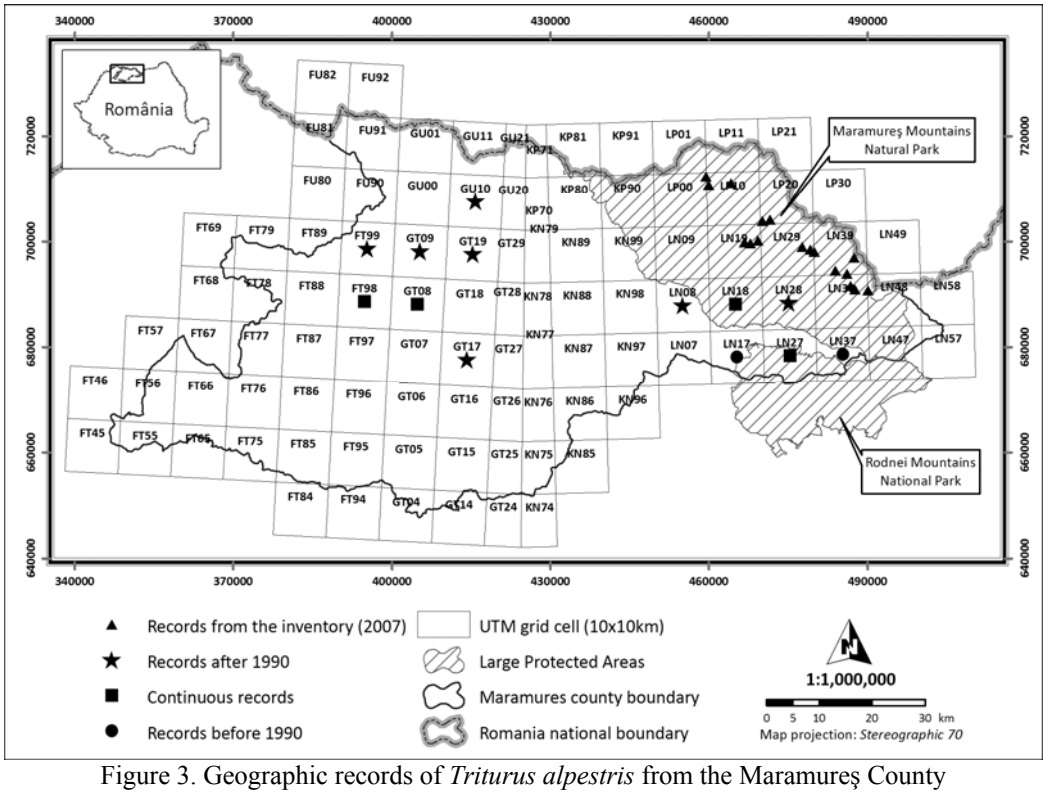

Figure 3. Geographic records of *Triturus alpestris* from the Maramureş County

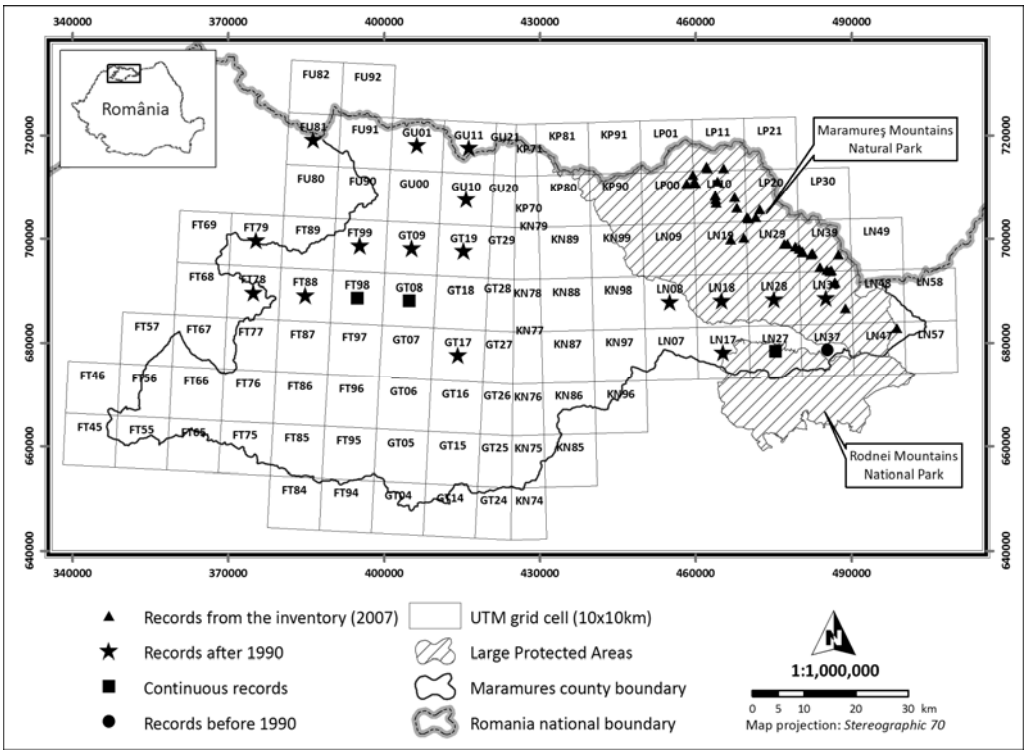

Figure 4: Geographic records of *Triturus montandoni* from the Maramureş County.

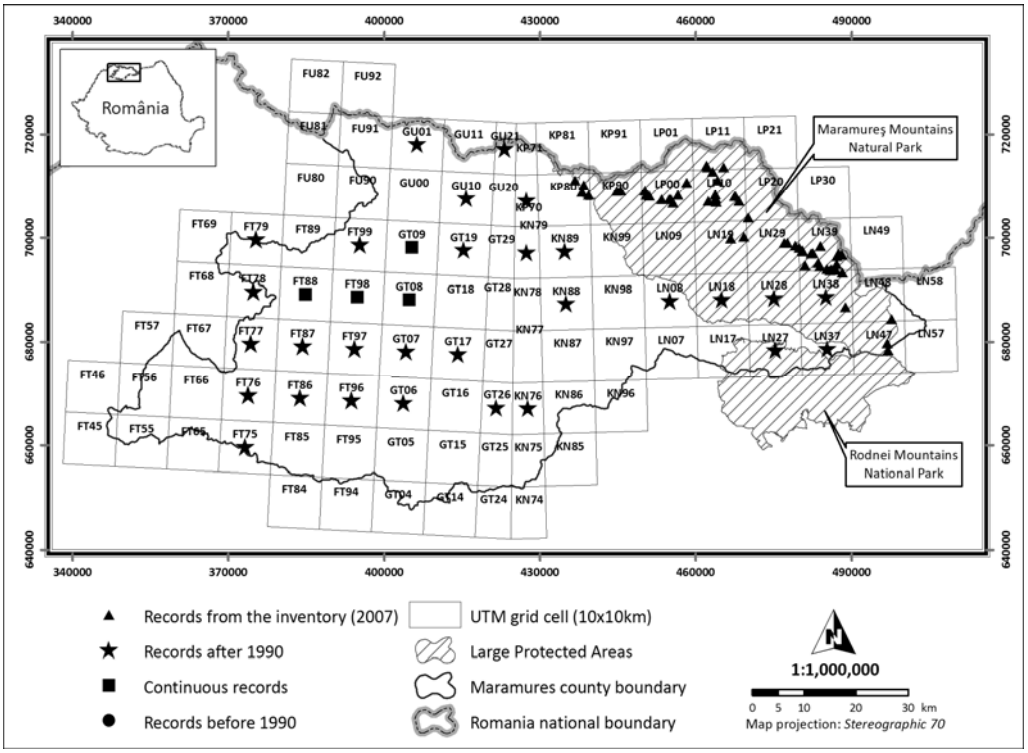

Figure 5: Geographic records of *Bombina variegata* from the Maramureş County.

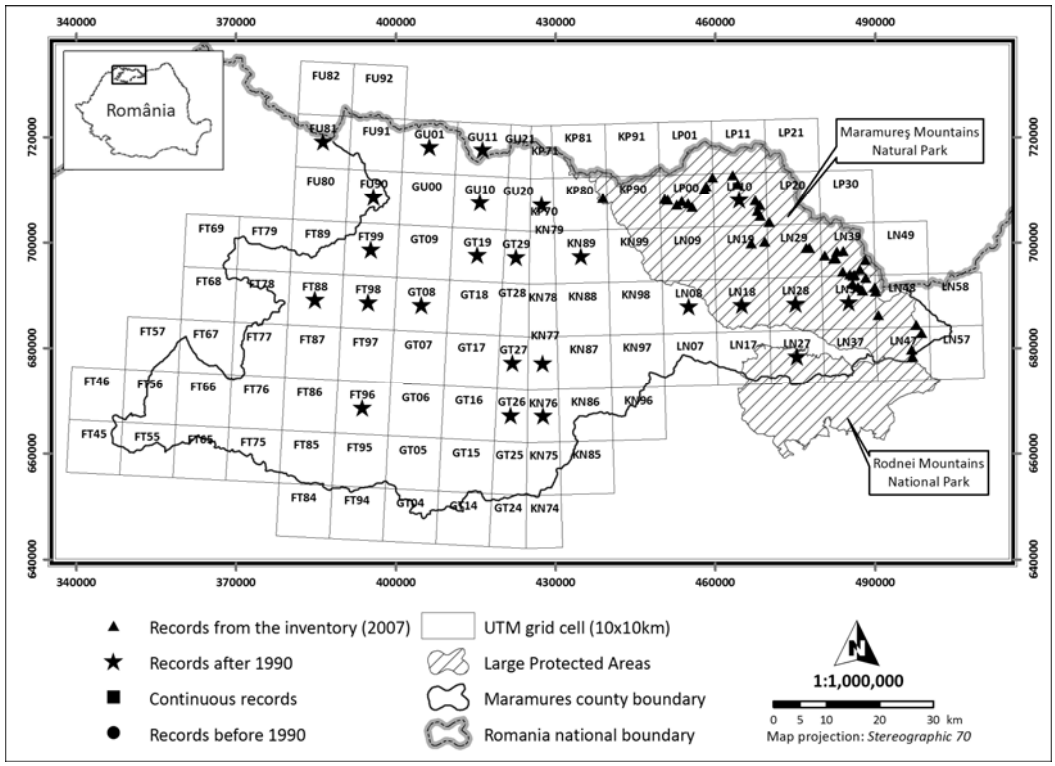

Figure 6: Geographic records of *Rana temporaria* from the Maramureş County.

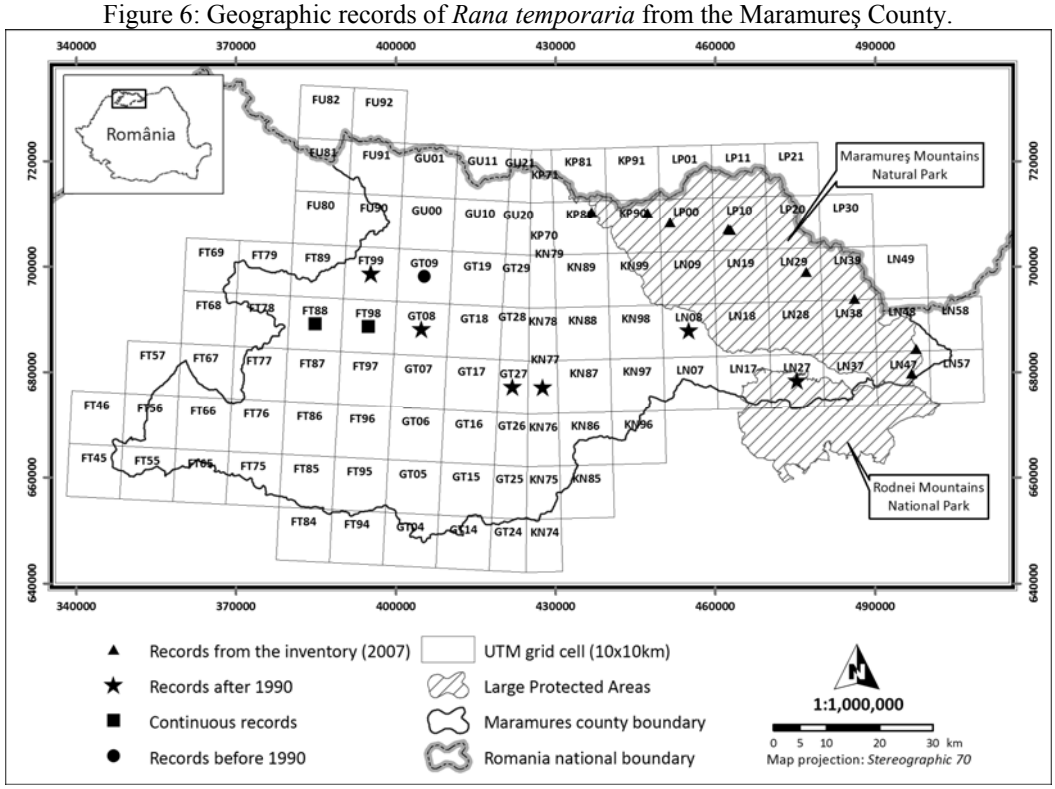

Figure 7: Geographic records of *Anguis fragilis* from the Maramureş County.

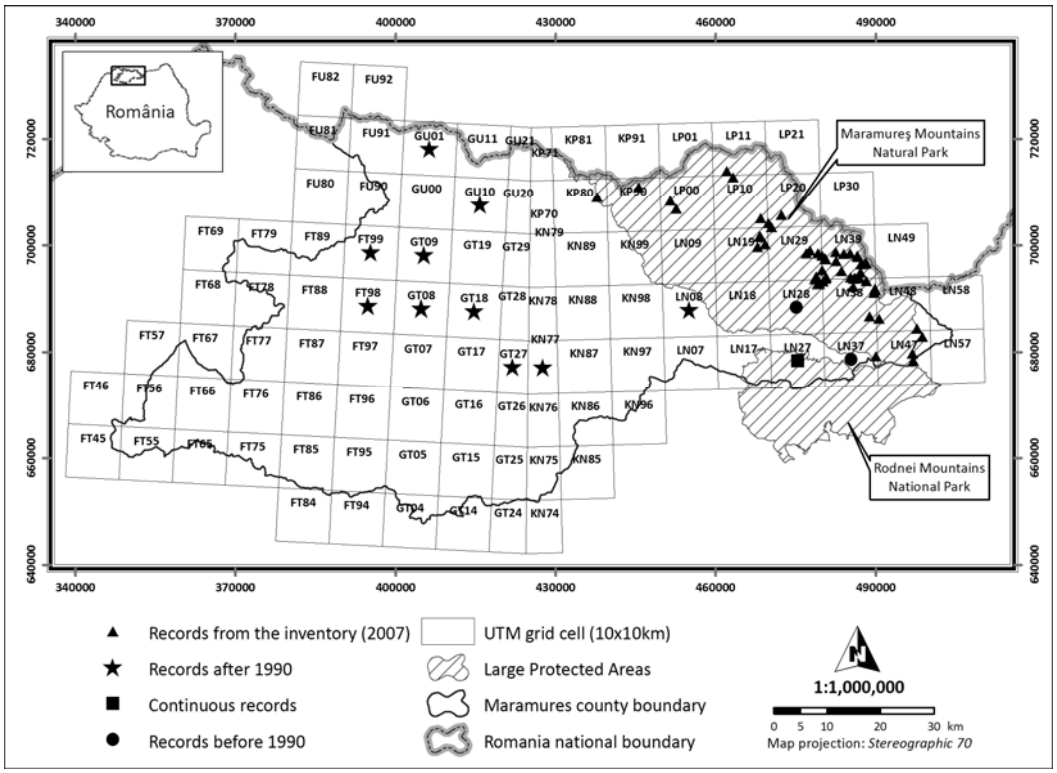

Figure 8: Geographic records of *Lacerta vivipara* from the Maramureş County.

DISCUSSION

Developing a proper conservation strategy for amphibian and reptile species is often a daunting task due to the absence of reliable estimates of biophysical, genetic, social, behavioural, demographic, and habitat parameters (Dodd, 1993). One of the most useful criteria to determine vulnerability in reptiles is the geographic range (criterion B of the 2001 IUCN Red List Categories and Criteria version 3.1, IUCN, 2005), as researchers normally start their study by recording species distribution (Pleguezuelos et al., 2002). Santos et al. (2007) used with good results the percentage of grid cells with both old and new citations to determine the conservation status of Iberian snakes. We used this index and two indices from the cartographic method together with a relative area of occupancy index to identify the amphibian and reptile species undergoing decline. Species were roughly ranked in the same way by the cartographic method and relative area of occupancy index. Species with the highest value for relative change in distribution range were in most cases the same with the lowest value of relative area of occupancy.

Some amphibian and reptile species can be easily overlooked due to elusive behaviour and secretive habitats resulting in low detectability. This might explain the lack of any increase of distributional records for *Rana arvalis*, *Coronella austriaca*, and up to a certain extent for *Podarcis muralis*. For other species as *Rana temporaria*, *Triturus montandoni*, *Rana dalmatina*, *Rana esculenta* and *Lacerta agilis* there was a considerable improvement in their distributional records. *Rana arvalis* had the highest score by relative distribution area index and the lowest scores by relative area of occupancy index. No new reports of *Rana arvalis* were made during the last eighteen years. Lack of suitable habitats due to habitat reduction and deterioration are probable the main causes for the increased vulnerability of this species.

Coronela austriaca is another species with a low relative area of occupancy score. Studies carried out in different populations of this species in Europe show that it is generally present in relatively low abundance; it has small home range and a sedentary life, large juvenile mortality, the late maturation of females (Spellerberg and Phelps, 1977; Goddard, 1984; Gent and Spellerberg, 1993). The detection probability of this species is generally moderate to low (Kéry, 2002) and the number of visits to confirm with 95 % confidence that the species is absent may vary between six and up to 35, depending on the habitat type, season and local population densities (Kéry, 2002; Hartel et al., unpublished results). Low relative area of occupancy scores were found also for *Natrix tessellata*. Aquatic and semi-aquatic species and feeding specialists are expected to suffer more severe population declines as suitable habitats disappear, and *Natrix tessellata* is an aquatic colubrid snake that is known for having a basically fish-based diet (Luiselli and Capizzi, 2007).

There were several limitations of our study that should be considered in evaluating our results. First we cannot control for false absences. False absences may complicate distribution studies in cryptic species especially if the detection probability is not incorporated in the study design and data analysis (Kéry, 2002). Second, the size of the UTM grid cells used by us is large (10 × 10 km), but using smaller cells is not supported by the available data, although this would increase efficiency (Pressey and Logan, 1998). Third, our analysis does not control for the habitat variables. Quantifying the ecological conditions using various habitat and landscape parameters can be used to construct predictive models regarding the importance of habitat features for amphibians and reptiles. Also this type of analysis will benefit from adding human threats such as land use or land cover change, as well as land ownership and planned infrastructures.

The indices based on cartographic data proposed by us proved adequate for detecting vulnerable amphibian and reptile species and are relatively easy to compute. They represent a simple tool for detecting trends in area of occupancy that can be used by protected areas managers.

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