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HABITAT SUITABILITY FOR REPTILES IN THE GORAVAN SANDS SANCTUARY, ARMENIA

TIGRAN L. TADEVOSYAN

The Center for Ecological-Noosphere Studies. The National Academy of Sciences,
68 Abovyan St., Yerevan, Republic of Armenia,
e-mail: ttadevosyan76@yahoo.com

***Abstract.*—The Goravan Sands Sanctuary is an important Armenian wildlife conservation area. The objectives of my study were to assess habitat suitability for reptiles within the sanctuary by comparing species richness, total abundance and species diversity across 35 random quadrats. I present the mean abundance data of 5 reptiles: *Phrynocephalus persicus*, *Eremais pleskei*, *Eremias strauchi*, *Lacerta strigata* and *Testudo graeca*. Maps of the relatively uncommon lizard *P. persicus* reflect species richness patterns whereas maps of the most abundant lizard *E. pleskei* more accurately reflect total reptile abundance and species diversity. About 71 % of the area of the patches is covered with regions of high and moderate species diversity – suitable for reptile inhabitation. Fourteen percent of the area is covered with patches of low diversity. The moderate and highly suitable patches are recommended for intensive conservation management planning.**

Key Words.—abundance; Armenia; habitat suitability; species diversity; interpolation maps; reptiles

INTRODUCTION

Previous herpetological surveys performed in Armenia were generally focused on a wide range of questions encompassing the country's fauna, including the morphology, systematics, natural history, and general ecology of reptiles (Chernov 1939; Darevsky 1957; Aghasyan 1996; Aslanyan 2004). However, there is a critical need for the acquisition of currently lacking detailed reptile distribution information for Goravan Sands Sanctuary. Previous assessments were presented without details of the methodology used (Aghasyan 1985; Danyelyan 1989). The need for accurate information to perform monitoring stimulated the need for this study.

The Goravan Sands Sanctuary is a sandy, semi-desert site in the Ararat region of Armenia (Fig 1). This site supports two reptile taxa of local and global conservation priority, the Persian Toad-headed Lizard (*Phrynocephalus persicus*, Fig. 2a) and the Mediterranean Tortoise (*Testudo gracea*, Fig. 2b) (Danielyan 1987; Baillie et al. 2004); as well as, a few common taxa such as Pleske’s and Shtraukh’s Racerunners (*Eremias pleskei* and *Eremias strauchi*, respectively, Fig. 2c, d), Striped Lizard *(Lacerta strigata*, Fig. 2e), and Montpellier Snake (*Malpolon*

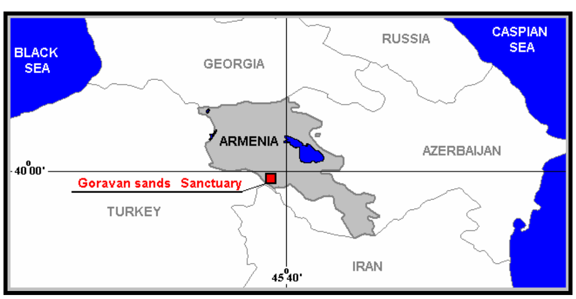

FIGURE 1. Geographic location of The Goravan Sands Sanctuary in Armenia.

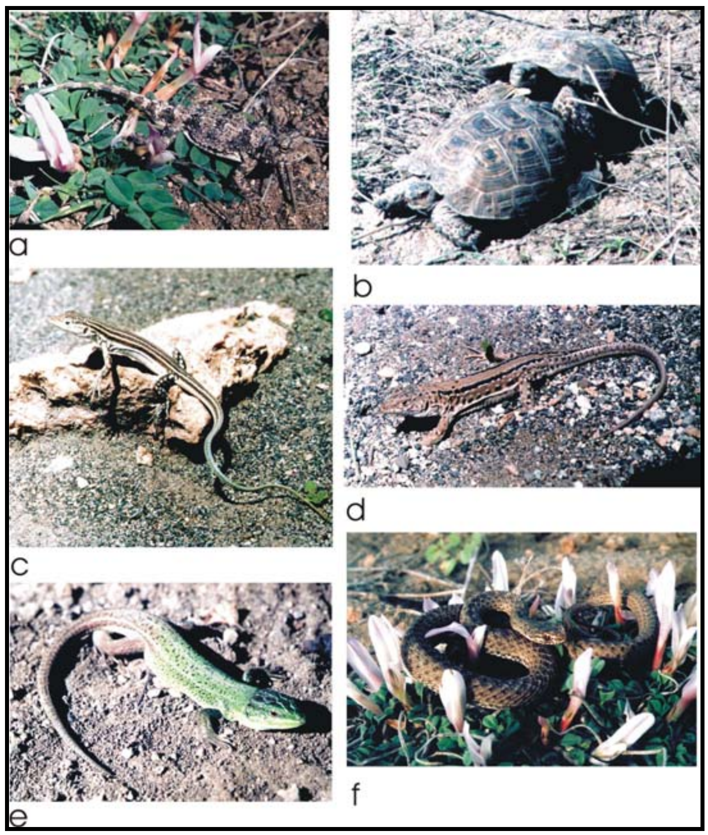

FIGURE 2. Representative photographs of reptiles from the Goravan Sands Sanctuary, Armenia: (a) Persian Toad-headed Lizard *Phrynocephalus persicus*; (b) Mediterranean Tortoise *Testudo graeca*; (c) Pleske's Racerunner *Eremias pleskei*; (d) Shtraukh's Racerunner *Eremias strauchi*; (e) Striped Lizard *Lacerta strigata*; and (f) Montpellier snake *Malpolon monspessulanus*. Photographed by Tigran L. Tadevosyan.

TABLE 1. Species diversity and densities of reptiles in 35 quadrats located in the Goravan Sands Sanctuary. Table includes numbers and coordinates of 35 sampling quadrats in decimal degrees, abundance per species, Calculated Hill's index (*N_2*), and relative abundance of species (%). E = *East;* N = *North;* N_2 = *Hill's species diversity index.*

Quadrats			Species Diversity and Density (Specimens/Quadrat)					
N/N	**E (d.ddddd)**	**N (d.ddddd)**	***P. persicus***	***E. strauchi***	***E. pleskei***	***L. strigata***	***T. graeca***	***(N_2)***
1	39.88825084	44.73345295	0	3	0	0	0	0.11
2	39.89191068	44.71955300	0	6	0	0	0	0.03
3	39.89224085	44.73402286	0	2	0	0	0	0.25
4	39.89395067	44.71841297	1	0	0	0	0	1.00
5	39.89259065	44.71697301	0	0	5	0	0	0.04
6	39.89013065	44.71682306	0	1	2	0	0	0.11
7	39.89673067	44.71835292	0	0	6	0	0	0.03
8	39.89227063	44.71555303	0	0	2	0	0	0.25
9	39.89348087	44.73554282	0	0	4	0	0	0.06
10	39.89195075	44.72559295	0	0	3	0	0	0.11
11	39.89190062	44.71445305	1	3	0	0	0	0.06
12	39.89226063	44.71554303	0	3	0	0	0	0.11
13	39.89775068	44.71928289	0	0	0	1	0	1.00
14	39.89490072	44.72325291	0	0	6	0	0	0.03
15	39.89194077	44.72717293	0	0	2	0	1	0.1
16	39.89426073	44.72416291	0	4	0	0	0	0.06
17	39.89433081	44.73069285	2	0	5	0	0	0.02
18	39.89134059	44.71158309	1	0	7	0	0	0.02
19	39.89112054	44.70803312	0	0	1	0	0	1.00
20	39.89423066	44.71764297	1	0	0	0	0	1.00
21	39.89263671	44.71141518	2	0	0	0	0	0.25
22	39.89400063	44.71494300	1	1	0	0	0	0.25
23	39.89572069	44.72029292	0	1	0	0	0	1.00
24	39.89537063	44.71533297	0	0	0	0	0	-
25	39.88797087	44.73573293	1	0	1	0	0	0.25
26	39.89136064	44.71615304	0	1	4	0	0	0.04
27	39.89182079	44.72881292	4	0	1	0	0	0.04
28	39.89657064	44.71623294	0	0	0	0	0	-
29	39.89254077	44.72693292	1	1	8	0	0	0.01
30	39.89244082	44.73141288	0	0	7	0	0	0.02
31	39.88870085	44.73401293	0	0	4	0	0	0.06
32	39.89378081	44.73042287	0	0	2	0	0	0.25
33	39.89677066	44.71743293	0	0	0	0	0	-
34	39.89521080	44.73002284	1	0	0	0	0	1.00
35	39.89117056	44.70953311	0	0	0	0	0	-
Specimens/Relative abundance (%)			16/<14	26/<23	70 /<61	1/<1	1/<1	
Total			114 (100%) of individuals					

monspessulanus, Fig. 2f).

The following objectives were targeted to justify future management planning: (1) determine the abundance, species richness, overall density and species diversity of reptiles in the study area; (2) produce interpolation maps to collate the reflection abilities; and (3) evaluate habitat suitability and delineate reptile distribution within the sanctuary.

MATERIALS AND METHODS

Study area.—According to remote sensing data, the Goravan Sands Sanctuary is composed of nearly 10 islets of sandy semi-desert habitat with a total area of nearly 175 ha. The dominant plants of the sandy habitats include semishrubs of *Noaea mucronata*, *Kochia prostrata* and *Achillea tenuifolia* (pers. obs.). The north sands are bordered by reclaimed land, and the other sides by dry limestone rocks covered with sparse shrubby vegetation called phryganoids (Takhtajyan and Fedorov 1972; Tadevosyan 2001). The boundaries of Goravan Sands Sanctuary are poorly defined. I conducted my study within the two largest plots of sands: main and eastern massifs (~136 ha, 894-965 m above sea level) that earlier investigators identified as part of the sanctuary (Tadevosyan 2001; Khanjyan 2004; A.V. Aslanyan's, pers. comm.).

Sampling.—We observed reptiles in 35 randomly selected 20 x 20 m quadrats using visual encounter surveys (Shenbrot and Krasnov 1997; Crump and Scott 2003; Heyek 2003a). Quadrat positions were determined using a digital map of the Goravan Sands Sanctuary produced using Arc View GIS v. 3.2.a (ESRI Inc., Redlands, California, USA). Relief and land cover data were obtained through vector analysis of a 1:25 000 topographic map (Anonymous 1979) and satellite image LandSat 7 ca. 2000 (NASA ES Ent., USA). The map and satellite image were geo-referenced in WGS-84, UTM (zone 38 N) coordinate system. I used Random Point Generator software (Jenniss 2005) to randomly generate 35 sampling plots. Point coordinates were uploaded into an Etrex GPS unit with accuracy averaging 5 m (Garmin Intern. Inc., Olathe, Kansas, USA) with DNR Garmin software (Minnesota Department of Natural Resources, Minnesota, USA).

We surveyed quadrats once in randomized order between 1000-1800 hrs in March-June 2005. I recorded the point coordinates of the search areas using the GPS unit. Capture was used to identify individuals. Specimens were captured and individually marked on the ventrum with a felt tip marker and then released at the capture site.

Statistical treatment.—I calculated the mean abundance of each species per quadrat, total abundance of reptiles, simple species richness (species per quadrat), and Hill's (N_2) index of species diversity (reciprocal of Simpson's Index):

$$N_2 = \frac{1}{\sum p_i^2}$$

where p_i is a proportion of individuals belonging to species collected (Hill, 1973; Schenbrot and Krasnov 1997). Mean (M), standard error (SE) and variation range (R) of abundance per species were calculated. Interspecific differences in abundance were analyzed using a single factor Kruskal-Wallis test, with the Fisher's LSD post hoc testing. Associations among total abundance of reptiles, species richness, and (N_2) index of species diversity and the abundance of each species were analyzed using Spearman's Rank correlation analysis (R_{sp}). Significance level for all tests was $P < 0.05$.

Visual analysis.—To perform visual analysis of spatial distribution diversity measures were interpolated once into values on the grid maps using Inverse Distance Weighted (IDW) interpolation (grid cell size = 20; neighbors = 12; power = 2), in Arc View GIS 3.2a and Arc View Spatial Analyst 2.0. I used the several classifications for grid mapping: three classes (one class for each additional species) for species richness; six classes (one class for every two additional specimens) for total reptile abundance, and six classes (one class for each 0.2 increase of the N_2 index) for species diversity. I manually converted grid patches from each class to vectors to measure and compare their areas. I used N_2 diversity index to finalize comparisons of the areas of patches because this index is a derivative of species richness and abundance. I used a standardized taxonomic nomenclature for the region (Ananjeva et al. 2004).

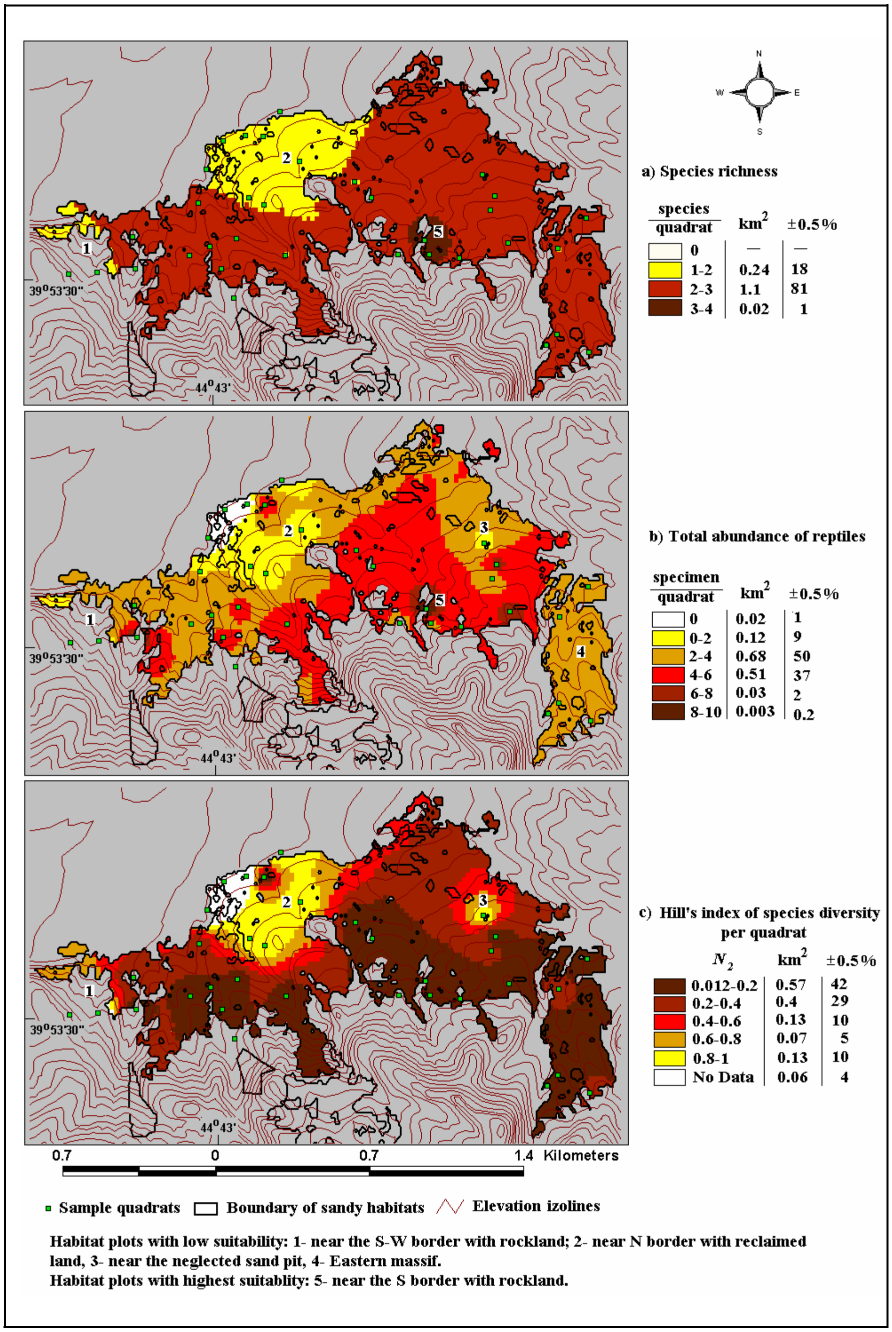

FIGURE 3. Interpolated maps a) Species richness, b) Total abundance of reptiles, c) Hill's (N_2) index of species diversity. (Fig. 1).

RESULTS

I mapped quadrat locations (Fig. 3) and specific locations are referenced by decimal degrees. The list of species, measured density values, and calculated N_2 per quadrat are given in Table 1. There were significant differences among species abundance detected ($n = 35$; $H = 37.04$; df = 4; $p < 0.001$). The data and particular differences between mean abundance of taxa are shown in Table 2.

There was no significant correlation among species for abundance (Table 3). However, species richness was correlated with abundance of *P. persicus* and *E. pleskey* and with total reptile abundance and N_2 index. These variables were correlated with abundance of *E. pleskey* and with each other. We found no *M. monspessulanus* in studied quadrats. Interpolated grid maps of density per species are available at The Center for Ecological - Noosphere Studies, The National Academy of Sciences (CENS NAS RA) in Yerevan, Armenia.

TABLE 2. Significance of Differences Among Mean Abundance of Species. Significant *p*-levels of Fisher's LSD test are bolded.

Taxon (mean abundance)	*E. pleskei*	*E. strauchi*	*P. persicus*	*L. strigata*	*T. graeca*
E. pleskei (n = 35; $M \pm SE$ = 2 ± 0.144; R – 0-8)	-	**<0.001**	**<0.001**	**<0.001**	**<0.001**
E. strauchi (n = 35; $M \pm SE$ = 0.743 ± 0.24; R – 0-6)	**<0.001**	-	0.38	**<0.001**	**<0.001**
P. persicus (n = 35; $M \pm SE$ = 0.457 ± 0.14; R – 0-4)	**<0.001**	0.38	-	0.19	0.19
L. strigata (n = 35; $M \pm SE$ = 0.0286 ± 0.029; R – 0-1)	**<0.001**	**<0.03**	0.19	-	1.00
T. graeca (n = 35; $M \pm SE$ = 0.0286 ± 0.029; R – 0-1)	**<0.001**	**<0.03**	0.19	1.00	-

Maps of species richness (Fig. 3a), total reptile abundance (Fig. 3b) and Hill's (N_2) diversity index (Fig. 3c) show similarly spread patches with low, moderate and high levels of corresponding variables. According to the species richness value, quadrats were unified within 4 classes of patches while for total reptile abundance and diversity index (N_2), 6 classes of values were delineated. Hence, the map of species richness is less clear as it indicates two plots (1-2; Fig. 3a) of low richness and one plot with the highest richness (5a; Fig. 3a). In contrast, the map of total reptile abundance (Fig. 3b) shows the three plots with the lowest abundance of reptiles, relatively low abundance for the Eastern massifs of sandy habitats (Fig. 3b: 4) and the plot with highest abundance (Fig. 3b: 5). The map of N_2 (Fig. 3c) illustrates the three plots with low species diversity, excluding plot 5, which had the highest diversity.

DISCUSSION

This survey reveals that the three most abundant lizard species, *E. pleskei*, *E. strauchi*, and *P. persicus*, are distributed throughout the study area of the Goravan Sands Sanctuary; whereas, *L. strigata* and *T. graeca* are probably characteristic of neighboring reclaimed land and rocky habitat, respectively. Darevsky (1957), Tadevosyan (2001) and Aslanyan (2004) also drew the same conclusions regarding habitat requirements of these species. Moreover, the low abundance of *T. graeca*, and absence of *M. monspessulanus* in samples may be due to my sampling methodology, because these species are sparsely distributed into dense aggregations. The snake *M. monspessulanus* occurs in microhabitats like open rocks, and with colonies of rodents (*Meriones* ssp.), which rarely coincide with random quadrats. Hence, the maps generally reflect habitat suitability for the three most common lizards.

The absence of significant correlations among the abundances of these taxa makes their use as indicator species for predicting the density of any other taxa of doubtful utility. In this respect, maps of generalized diversity measures like richness, total abundance and diversity may provide important information for conservation decision making. Using actual values of species abundance, richness, and diversity provided habitat suitability classifications that are more objective than most *a priori* classification schemes (Schenbrot and Krasnov 1997). More research is needed to clarify the roles of other microhabitat variables that were not used in this study.

Abundance of *P. persicus* was correlated with species richness, whereas abundance of *E. pleskei* was correlated with total abundance of lizards and N_2. This suggests that maps of species richness may best reflect the presence of relatively less abundant species, whereas the two other measures better illustrate the most

TABLE 3. Spearman rank correlation matrix for measured variables: densities of *P. persicus*, *E. strauchi*, *E. pleskei*, *L. strigata* and calculated variables: Numbers of species, Total abundance of reptiles, and Hill's species diversity index (N_2) at the Gorvan Sands Sanctuary, Armenia.

Variables	*P. persicus*	*E. strauchi*	*E. pleskei*	*L. strigata*	*T. graeca*	Numbers of Species	Total abundance	Hill's N_2 index
P. persicus	1.00	-0.11; p = 0.5 n = 35	-0.04; p = 0.82	-0.11; p = 0.51 n = 35	-0.11; p = 0.51 n = 35	**0.53; p<0.01**	0.13; p = 0.45	-0.002; p = 0.99
E. strauchi	-0.11; p = 0.5 n = 35	1.00	-0.33 p = 0.5	-0.11 p = 0.52 n = 35	-0.11 p = 0.52 n = 35	0.26 p = 0.14 n = 35	0.22 p = 0.21 n = 35	-0.11 p = 0.57 n = 31
E. pleskei	-0.04; p = 0.82 n = 35	-0.33 p = 0.56 n = 35	1.00	-0.16 p = 0.35 n = 35	0.08 p = 0.64 n = 35	**0.42 p < 0.05 n = 35**	**0.73 p < 0.0001 n = 35**	**-0.71 p < 0.0001 n = 31**
L. strigata	-0.11; p = 0.51 n = 35	-0.11 p = 0.52 n = 35	-0.16 p = 0.35	1.00	-0.03 p = 0.87 n = 35	-0.06 p = 0.74 n = 35	-0.18 p = 0.3 n = 35	0.26 p = 0.16 n = 31
T. graeca	-0.11; p = 0.51 n = 35	-0.11 p = 0.52 n = 35	0.08 p = 0.64	-0.03 p = 0.87 n = 35	1.00	0.23 p = 0.18 n = 35	0.02 p = 0.92 n = 35	0.02 p = 0.91 n = 31
Species Richness	**0.53; p < 0.01 n = 35**	0.26 p = 0.14 n = 35	**0.42 p < 0.05 n = 35**	-0.06 p = 0.74 n = 35	0.23 p = 0.18 n = 35	1.00	**0.59 p < 0.001 n = 35**	**-0.37 p < 0.05 n = 31**
Total abundance	0.13; p = 0.45 n = 35	0.22 p = 0.21 n = 35	**0.73 p < 0.0001 n = 35**	-0.18 p = 0.3 n = 35	0.02 p = 0.92 n = 35	**0.59 p < 0.001 n = 35**	1.00	**-1.00 n = 31**
N_2 index	-0.002; p = 0.99 n = 31	-0.11 p = 0.57 n = 31	**-0.71 p < 0.0001 n = 31**	0.26 p = 0.16 n = 31	0.02 p = 0.91 n = 31	**-0.37 p < 0.05 n = 31**	**-1.00 n = 31**	1.00

abundant taxa. Conversely, maps of species diversity and total reptile abundance appear to better reflect details of spatial distribution of habitat suitability than does the map of species richness. Significant correlations among species richness, total abundance and diversity suggest that the three measures can be equally useful for mapping habitat. However, using all three variables may incorporate multicolinearity in to analyses and confound regression analysis. In general, patches of high and moderate diversity (N_2; 0.12-0.4) comprise about 71% of the sanctuary (Fig. 3c). These patches also represent locations with moderate to high species richness and total reptile abundance (Fig. 3a, b). Relatively low diversity (0.8-1) is characteristic of three patches covering about 14% of the area. Low total abundance is also characteristic of these patches, while species richness is lowest only in two of them. The largest patch of low diversity is located in the north-central part of the main sandy massif, in the zone down the clayey hill. Until the early 1990s, this area was forested with mulberry trees (*Malus* sp.) (local residents, pers. comm.). Two other patches are situated near the SW and NE boundaries of sandy habitats, close to active and neglected sand pits, respectively. Soil quality in these areas may partially explain the low abundance of lizards found in these zones. Further research will be required to evaluate the role of soil quality in determining lizard abundance at these sites. Previous studies demonstrate that reptile abundance may be suppressed by cattle grazing (Busack and Bury 1974; Berry 1978). Relatively low reptile abundance within eastern sandy massifs (Fig. 3b, #4) may be associated with extensive grazing within this site.

There were no quadrats with diversity level of 0.4-0.8; hence, the corresponding patches on the map (Fig. 3c) should be considered as undetermined. Whereas maps of species richness and total reptile abundance (Fig. 3a, b) only reflect actual indices. Patches of merged and single quadrats with the lowest levels of richness (0-2), total abundance (0-2) and diversity (0.6-1) are presumably characteristic of poorly suitable habitat (1-3; Fig. 3a-c). Quadrats with moderate levels of richness (2-3), total abundance (2-4) and N_2 (0.2-0.6) presumably form habitat patches with moderate suitability whereas quadrats with the highest levels of richness (3-4), total abundance (4-6) and diversity (0.012-0.2,) presumably represent highly suitable habitat patches. (Fig. 3a-c, #1-3).

Sites with low diversity and other measured variables (i.e., low suitable sites) should be preliminarily excluded from planned conservation management actions (i.e., translocations of *P. persicus* and *T. graeca*). However, after determining low suitability of these sites, it may be useful to perform experimental habitat recovery actions (Moulton and Korbett, 1999; Kingsbury and Gibson 2002). Sites with moderate and high species diversity, richness and total abundance should be targeted for implementation of strong and flexible conservation management plans including, protection, monitoring, and public awareness. More extensive inventory activities may be needed at all sites to validate the results of this study.

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Tigran L. Tadevosyan earned his Ph.D. in Biology in 2001 from the Institute of Botany, National Academy of Sciences of the Republic of Armenia. Tigran currently works as a Senior Staff Scientists in the Laboratory of Thematic Mapping and GIS Technologies of the Center, Ecological-Noosphere Studies, National Academy of Science of The Republic of Armenia. His scientific interests include conservation biology, captive breeding, behavior and biogeography of amphibians and reptiles. Photographed by: Sergey Arevshatyan.