# Identification of areas of very high biodiversity value to achieve the EU Biodiversity Strategy for 2030 key commitments

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## Abstract

**Background**

The European Union strives to increase protected areas of the EU terrestrial surface to 30% by year 2030, of which one third should be strictly protected. Designation of the Natura 2000 network, the backbone of nature protection in the EU, was mostly an expert-opinion process with little systematic conservation planning. The designation of the Natura 2000 network in Romania followed the same non-systematic approach, resulting in a suboptimal representation of invertebrates and plants. To help identify areas with very high biodiversity without repeating past planning missteps, we present a reproducible example of spatial prioritization using Romania's current terrestrial Natura 2000 network and coarse-scale terrestrial species occurrence.

**Methods**

We used 371 terrestrial Natura 2000 Sites of Community Importance (Natura 2000 SCI), designated to protect 164 terrestrial species listed under Annex II of Habitats Directive in Romania in our spatial prioritization analyses (marine Natura 2000 sites and species were excluded). Species occurrences in terrestrial Natura 2000 sites were aggregated at a Universal Traverse Mercator spatial resolution of 1 km$^2$. To identify priority terrestrial Natura 2000 sites for species conservation, and to explore if the Romanian Natura 2000 network sufficiently represents species included in Annex II of Habitats Directive, we used Zonation v4, a decision support software tool for spatial conservation planning. We carried out the analyses nationwide (all Natura 2000 sites) as well as separately for each biogeographic region (i.e., Alpine, Continental, Pannonian, Steppic and Black Sea).

**Results**

The results of spatial prioritization of terrestrial Natura 2000 vary greatly by planning scenario. The performance of national-level planning of top priorities is minimal. On average, when 33% of the landscape of Natura 2000 sites is protected, only 20% of the distribution of species listed in Annex II of Habitats Directive are protected. As a consequence, the representation of species by priority terrestrial Natura 2000 sites is lessened when compared to the initial set of species. When planning by taxonomic group, the top-priority areas include only 10% of invertebrate distribution in Natura 2000. When selecting top-priority areas by biogeographical region, there are significantly fewer gap species than in the national level and by taxa scenarios; thusly, the scenario outperforms the national-level prioritization. The designation of strictly protected areas

49  as required by the EU Biodiversity Strategy for 2030 should be followed by setting clear

50  objectives, including a good representation of species and habitats at the biogeographical region

51  level.

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## Introduction

54  Protected areas, a critical tool for nature conservation strategies, are intended to ensure the long-

55  term persistence and viability of biodiversity. These areas should support many rare, threatened,

56  or endemic taxa, particularly those with low mobility and high sensitivity to environmental

57  alterations as possible (Geldmann et al. 2013; Gray et al. 2016; Possingham et al. 2006;

58  Rodrigues et al. 2004). When planning protected areas, states around the world are guided by

59  supranational policies such as Convention on Biological Diversity and EU Biodiversity Strategy

60  for 2030, which issue ambitious objectives to increase the extent of protected areas. For example,

61  Convention on Biological Diversity (CDB) Aichi Target on Protected Areas calls for the

62  protection of 17% of the world's terrestrial and inland water areas in key regions for biodiversity

63  and ecosystem services (UNEP 2011), while the EU Member States seek to increase by 2030 the

64  Natura 2000 network to 30% of which one third should be under strict protection as areas of very

65  high biodiversity and climate value (European Commission 2020).

66  A promising tool to help build an ecologically-sound network of protected areas meeting the

67  CDB or EU targets is systematic conservation planning (Margules & Pressey 2000). Systematic

68  conservation planning maximizes conservation benefits while minimizing impacts on other

69  resources, such as the availability of productive land. Spatial conservation prioritization, as a part

70  of systematic conservation planning, customarily  relies on the complementarity concept (i.e.,

71  selection of complementary areas to avoid duplication of conservation effort) and is considered

72  an efficient instrument for identifying spatial priorities and achieving conservation goals

73  (Margules & Pressey 2000; Pressey et al. 2007).

74  One of the most extensive networks of conservation areas in the world is the Natura 2000

75  network, which has been created to operationalize EU Birds (Directive 2009/147/EC) and

76  Habitats Directives (Council Directive 92/43/EEC). To date, Natura 2000 encompasses 18% of

77  EU terrestrial area, thus meeting the CDB Aichi Target on Protected Areas (UNEP 2011). The

78  effectiveness and representativity of Natura 2000 were evaluated for different taxonomic groups

79  and geographic areas, and the conclusions tended to highlight suboptimal planning (D'Amen et

80  al. 2013; Dimitrakopoulos et al. 2004; Kukkala et al. 2016; Lisón et al. 2013; Müller et al. 2018;

81  Müller et al. 2020; Votsi et al. 2016). The suboptimal planning of Natura 2000 at the EU and at

82  Member States levels originates from an uncoordinated process (Apostolopoulou & Pantis 2009;

83  Iojă et al. 2010; Lisón et al. 2017; Orlikowska et al. 2016), which was partially resolved by

84  selecting new sites after expert-opinion evaluations during the Natura 2000 biogeographical

85  seminars (Kenig-Witkowska 2017; Manolache et al. 2017). Furthermore, the efficacy of the

86  Natura 2000 network was extensively re-evaluated from other perspectives, for example, for

87  understanding the effect of climate change on representativity (Araújo et al. 2011; Popescu et al.

88  2013) and for coordinating conservation investments (Hermoso et al. 2017; Nita et al. 2016).

89  The designation of the Natura 2000 network in Romania followed the same non-systematic

90  approach. The process started in 2007 with designating 273 Sites of Community Importance

91  covering Habitats Directive. This process continues in the present; nowadays, there are 606

92  designated Natura 2000 sites (Sites of Community Importance and Special Protection Areas) that

93  encompass 23% of the total country's land area (54214 km$^2$) (DG Environment 2020; Manolache

94  et al. 2017). Of these, 426 are terrestrial Natura 2000 Sites of Community Importance, covering

95  40310 km$^2$ (17% of Romania's terrestrial surface) (DG Environment 2020; EIONET 2020).

96  During the first two designation stages, the process was highly biased towards overlapping

97  existing national protected areas (Iojă et al. 2010; Manolache et al. 2017), and thus, even if the

98  CBD 17% target is met, the effectiveness of Natura 2000 in representing habitats and species is

99  questionable. For example, Iojă et al. (2010) confirmed that overlapping existing national

100  protected areas resulted in a suboptimal representation of plants and invertebrates; Miu et al.

101  (2018) highlighted underrepresentation of agricultural landscape in Dobrogea, while Mânzu et al.

102  (2013) and Popescu et al. (2013) concluded that the Natura 2000 network would not protect

103  plants, reptiles, or amphibians if species ranges shift under climate change scenarios.

104  With the latest extensions, the Romanian Natura 2000 network encompasses all species and

105  habitats listed in Habitats and Birds Directives (DG Environment 2020; Manolache et al. 2017);

106  however, the new EU Biodiversity Strategy for 2030 requires an increase from 23% to 30% of

107  the total terrestrial country's area of which one third should be under strict protection as areas of

108  very high biodiversity and climate value (European Commission 2020). To help identify areas

109  with very high biodiversity and to provide an example of systematic planning of a protected area

110  network, we present a reproducible spatial prioritization case study using Romania's current

111  terrestrial Natura 2000 network and coarse-scale terrestrial species occurrence (marine Natura

112  2000 sites and species were excluded). The objectives of this study are (1) to identify candidate

113  sites for designation as areas of very high biodiversity within the Romanian terrestrial Natura

114  2000 network in national, taxa-specific and biogeographical levels spatial prioritization scenarios

115  and (2) to investigate the extent to which the areas of very high biodiversity within terrestrial

116  Natura 2000 network cover the species listed in Annex II of Habitats Directive in national, taxa-

117  specific and biogeographical levels spatial prioritization scenarios. The European Union assesses

118  the effectiveness of Natura 2000 network in protecting species and habitats listed in Birds and

119  Habitats Directives at the Member State level but also at the biogeographic level (Evans 2012);

120  thus, we performed the analyses at both administrative levels.

## Methods

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### Natura 2000 sites and species

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123  The dataset used in our planning analysis included 371 terrestrial Natura 2000 Sites of

124  Community Importance (Natura 2000 SCI), designated to protect 164 terrestrial species listed

125  under Annex II of Habitats Directive in Romania. The initial database included 426 Natura 2000

126  SCI and 166 species (EIONET 2020), from which we excluded 7 sites with a small area ($<1$ km$^2$,

127  the spatial resolution of our data), 48 terrestrial sites designed only for habitat protection, and 2

128  marine species (the common bottlenose dolphin - *Tursiops truncatus*, and the harbor porpoise -

129  *Phocena phocena*) (Data S1). We used only terrestrial sites and species to match the EU

130  commitment to designate by 2030 as strictly protected of one-third of protected areas separately

131  on land and at sea (DG Environment 2020). Of the 164 species protected by this terrestrial

132  Natura 2000 network, 26 are mammals, 6 are reptiles, 6 are amphibians, 26 are fish, 54 are

133  invertebrates, and 46 are plants. The number of species protected within a Natura 2000 site

134  varies between 1 (46 sites protect only one species) and 62 (Iron Gates). The terrestrial sites with

135  the largest number of protected species ($>40$ species) are Iron Gates, Domogled - Valea Cernei,

136  Calimani - Gurghiu, Danube Delta, Cheile Nerei – Beusnita, Fagaras Mountains, and Tur River.

137  The largest Natura 2000 sites in terms of surface area ($>1200$ km$^2$) are Danube Delta, Fagaras

138  Mountains, Frumoasa, Calimani – Gurghiu, and Iron Gates (Rozylowicz et al. 2019).

139 To map species occurrences in terrestrial Natura 2000, we used site-level occurrence data
140 included in the Natura 2000 Standard Data Forms (EIONET 2020). Site-level occurrence records
141 were aggregated at a Universal Traverse Mercator spatial resolution of 1 km$^2$ (UTM 1 × 1 km).
142 Thus, if a species was included in the Standard Data Form (recorded for the respective Natura
143 2000 site), each cell of that site was considered as having that species present. We followed this
144 approach due to the absence of finer scale species distribution data in Romania for Natura 2000
145 taxa, which makes species distribution modelling impractical for all Natura 2000 taxa. While the
146 coarse spatial resolution likely overestimates the distribution of several range-restricted taxa,
147 data at protected area level, rather than within protected areas, is currently used for official
148 biogeographical assessments of conservation status of species and habitats in Romania under
149 Article 17 of the Habitats Directive (EIONET 2020). The likely outcome of overestimating the
150 distribution of some species for this prioritization study, which focuses on species-rich areas
151 (Additive Benefit Function algorithm, see section *Priority ranking of terrestrial Natura 2000*
152 *sites*), is that some protected areas may emerge as top priorities despite the fact that some species
153 are occurring only within a relatively small area within those respective protected areas. Thus,
154 the prioritization results should be interpreted as a Natura 2000 site with a certain proportion to
155 be designated as strictly protected areas and not as the exact position of top priority grid cells. As
156 such, this approach closely matches the approach to conservation planning in Romania, which
157 uses species lists to establish protected areas of various sizes and acknowledges that species may
158 only occur in discrete units within a given protected area (EIONET 2020).

159 The Natura 2000 sites and species considered here were further sorted by biogeographic region.
160 Because Romania lies at the geographic center of Europe (Rey et al. 2007), Natura 2000 network
161 overlaps five terrestrial biogeographical regions, out of the nine regions recognized by the
162 European Union, i.e., Alpine, Continental, Pannonian, Steppic and Black Sea (Rozylowicz et al.
163 2019). Due to its small size, the terrestrial part of Black Sea region was merged with the Steppic
164 biogeographic region (Steppic and Black Sea region in our analysis). Of the 164 terrestrial
165 species, 110 are found in the Alpine Biogeographic Region, 143 in the Continental
166 Biogeographic Region, 76 in the Pannonian Biogeographic Region, and 78 in the Steppic and
167 Black Sea Biogeographic Region. Several species were found in 2 or 3 biogeographic regions
168 due to their wide geographic range (e.g., *Bombina bombina, Bombina variegata, Emys*
169 *orbicularis)* or because they inhabit a greater range of habitats (e.g., *Lutra lutra*) (Data S1).

**Priority ranking of terrestrial Natura 2000 sites**

To identify priority terrestrial Natura 2000 sites for species conservation and to explore these areas adequately representing species included in Annex II of Habitats Directive, we used Zonation v4, a decision-support software tool for spatial conservation planning with Natura 2000 sites as planning units (Lehtomäki & Moilanen 2013; Moilanen 2007). We analyzed three priority ranking scenarios: (1) nationwide, (2) nationwide for several taxonomic groups separately (amphibians, reptiles, mammals, fish, invertebrates and plants), and (3) separately for each biogeographic region across all taxonomic groups (Alpine, Continental, Pannonian, Steppic and the Black Sea biogeographic regions) (Fig. 1). Zonation produces a priority ranking by iteratively removing planning units (Natura 2000 sites in our case) with the lowest total marginal loss of conservation value while accounting for total and remaining distributions of protected species (Moilanen et al. 2014). Priority ranking starts from the full Natura 2000 network, and the planning units are iteratively removed until there are none remaining. Least valuable sites (e.g., low species richness) are removed first, while the valuable sites (e.g., high species richness) are kept until the end (Di Minin et al. 2014).
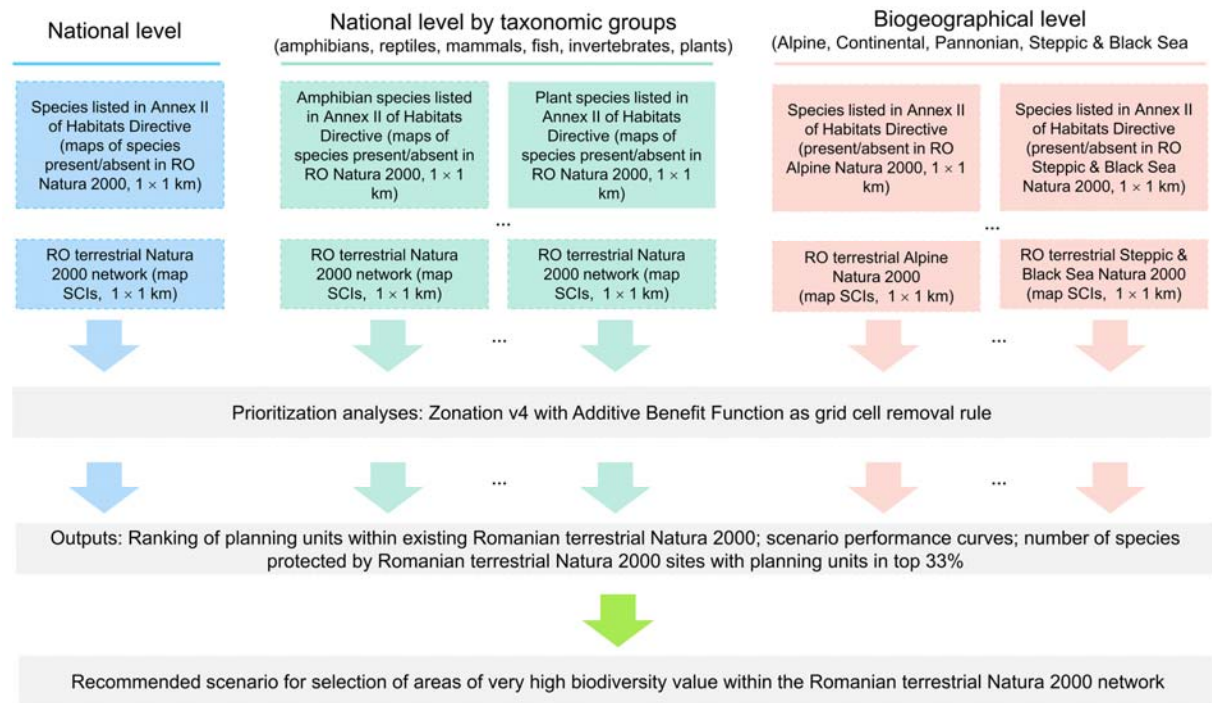


Figure 1 Flowchart illustrating the spatial prioritization process (national, taxa-specific and biogeographical levels spatial prioritization scenarios).

188  Zonation provides four cell removal rules (Core-area Zonation, Additive benefit function,
189  Target-based planning and Generalized benefit function). For our case study, we used additive
190  benefit function with exponent $z = 0.25$ (the default value for species sensitivity to habitat loss), a
191  cell removal rule with a summation structure (Moilanen et al. 2014; Moilanen 2007; Moilanen et
192  al. 2005), which gives higher priority to planning units with a higher number of species present
193  and tended to remove biodiversity-poor cells even if they include rare species. Thus, planning
194  with additive benefit function may result in a selection of top priority areas that have higher
195  performance on average, but retains a lower minimum proportion of original distributions for
196  rare species (Arponen et al. 2005; Moilanen et al. 2014). The additive benefit function fits well
197  to our prioritization objective – identification of high biodiversity value protected areas within
198  the Romanian terrestrial Natura 2000 network.

199  The outputs of the priority analyses provide the ranking of grid cells within Natura 2000 sites
200  according to their contribution in covering protected species (0 = cells with the lowest priority; 1
201  = cells with the highest priority). The ranking scores exhibit a uniform distribution; thus, the top
202  spatial conservation priorities (e.g., top 33% of the Natura 2000 network) have a Zonation
203  ranking of ≥0.67. The ranking maps are paired with the performance curves that describe the
204  extent to which each species is retained in any given high-priority or low-priority fraction of the
205  Natura 2000 network (Moilanen et al. 2005; Moilanen et al. 2011). Because we used Natura
206  2000 as a planning unit layer, our analysis can be used to infer how much of a Natura 2000 site
207  should be designated as strictly protected in order to reach one third objective at network level.

## Results

### Prioritization of Natura 2000 sites at the national level

210  Terrestrial Natura 2000 sites represented as $1 \times 1$ km grid cells cover 48954 cells (20.24% of
211  Romanian territory), of which 4920 overlaps less than 5% with the respective protected area. The
212  Natura 2000 sites with high priority grid cells extend over the Carpathians and Transylvania
213  (Fig. 2). Outside of Carpathians (Eastern and Southern Romania), the top-priority Natura 2000
214  sites were principally located along river corridors. The sites with the largest number of grid cells
215  labeled as priority for conservation ( $> 400$ km$^2$) are Sighisoara Tarnava Mare, Muntii Ciucului,
216  Trascau, Valea Izei si Dealul Solovan, Muntele Ses, Retezat, Podisul Lipovei Poiana Rusca,

217    Dealurile Tarnavei Mici Biches, Semenic Cheile Carasului. A notable exception is the Natura

218    2000 overlapping the lower course of Ialomita river in Eastern Romania (Fig. 2, Data S2).
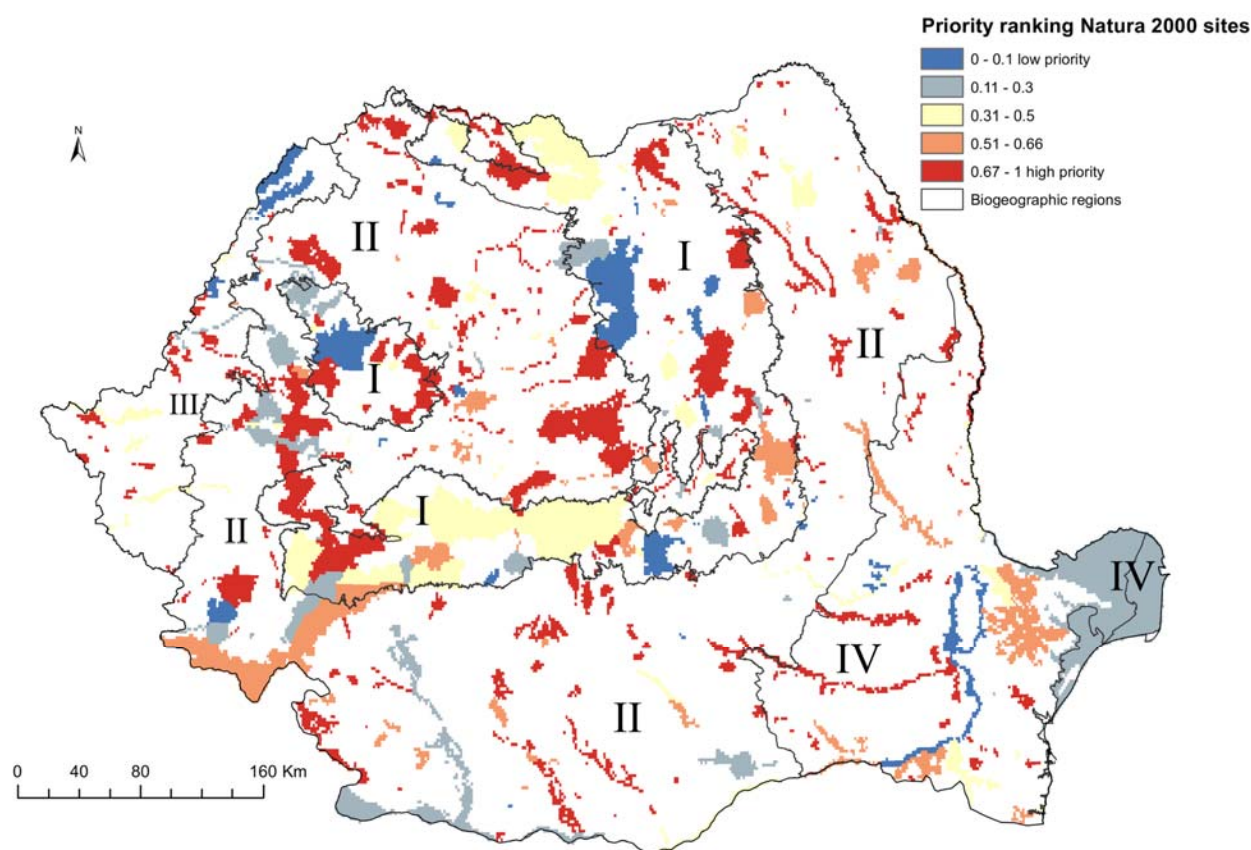


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Figure 2 High priority sites for designation as areas under strict protection (national level prioritization scenario). Grid cells within the Romanian terrestrial Natura 2000 network have been graded according to their priority, with the highest-priority sites (top 33%) shown in red. Biogeographic regions are numbered as follows: I (Alpine), II (Continental), III (Pannonian), IV (Steppic and terrestrial Black Sea).

224    Top-priority sites in national level scenario cover 37% of Natura 2000 protected grid cells in

225    Alpine biogeographic region, 28% of protected grid cells in Continental biogeographic region,

226    22% in Pannonian biogeographic region, and 12% Natura 2000 protected grid cells in the

227    Steppic and the Black Sea biogeographic region (Fig. 2, Data S2).

228    The performance of national-level planning of top priorities is minimal. On average, when 33%

229    of landscape of Natura 2000 sites is protected, only 20% of distribution of species listed in

230    Annex II of Habitats Directive are protected (Fig. S1). As a consequence, the representation of

231    species by priority terrestrial Natura 2000 sites is lessened when compared to the initial set of

232    species, with 20 species (12%) not covered by the top 33% of protected grid cells. The missed

233     species include plants (12 species), invertebrates (4 species), fish (2 species) and mammals (2

234     species) (Table 1, Data S3).

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*Table 1 Representation of protected species by Natura 2000 sites with grid cells selected as high priority in national level prioritization scenario (gap and most represented species).*

| Taxonomic group | Species | Number of top 33 % Natura 2000 sites covering the species |
|---|---|---|
| Plants | *Centaurea jankae, Potentilla emilii-popii, Centaurea pontica, Dracocephalum austriacum, Ferula sadleriana, Gladiolus palustris, Stipa danubialis, Thlaspi jankae, Tulipa hungarica, Paeonia officinalis* subsp. *banatica, Colchicum arenarium, Saxifraga hirculus* | 0 |
| | *Ligularia sibirica* | 17 |
| Invertebrates | *Graphoderus bilineatus, Stenobothrus eurasius, Isophya harzi, Vertigo moulinsiana* | 0 |
| | *Lucanus cervus* | 41 |
| Fish | *Cobitis elongata, Rutilus pigus* | 0 |
| | *Barbus meridionalis* | 62 |
| Amphibians | - | 0 |
| | *Bombina variegata* | 108 |
| Reptiles | - | 0 |
| | *Emys orbicularis* | 24 |
| Mammals | *Mustela lutreola, Rhinolophus mehelyi* | 0 |
| | *Lutra lutra* | 110 |

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**Prioritization of Natura 2000 sites at national level by taxonomic group**

239     When priority ranking maps are organized by taxonomic group, the top-priority sites are

240     dissimilar to the results of national level prioritization (Fig. 3). For amphibians, the ranking map

241     (Fig. 3B) indicates that sites with high priority grid cells for conservation are spatially grouped in

242     the western and central parts of Romania, while for reptiles, the sites were clustered in the

243     southwestern and southeastern part of Romania (Fig. 3B). For mammals and plants, most of the

244     high-priority sites are spatially grouped in the Carpathians and Dobrogea areas, regions with

245     large protected areas and high species richness. High priority Natura 2000 sites for invertebrates

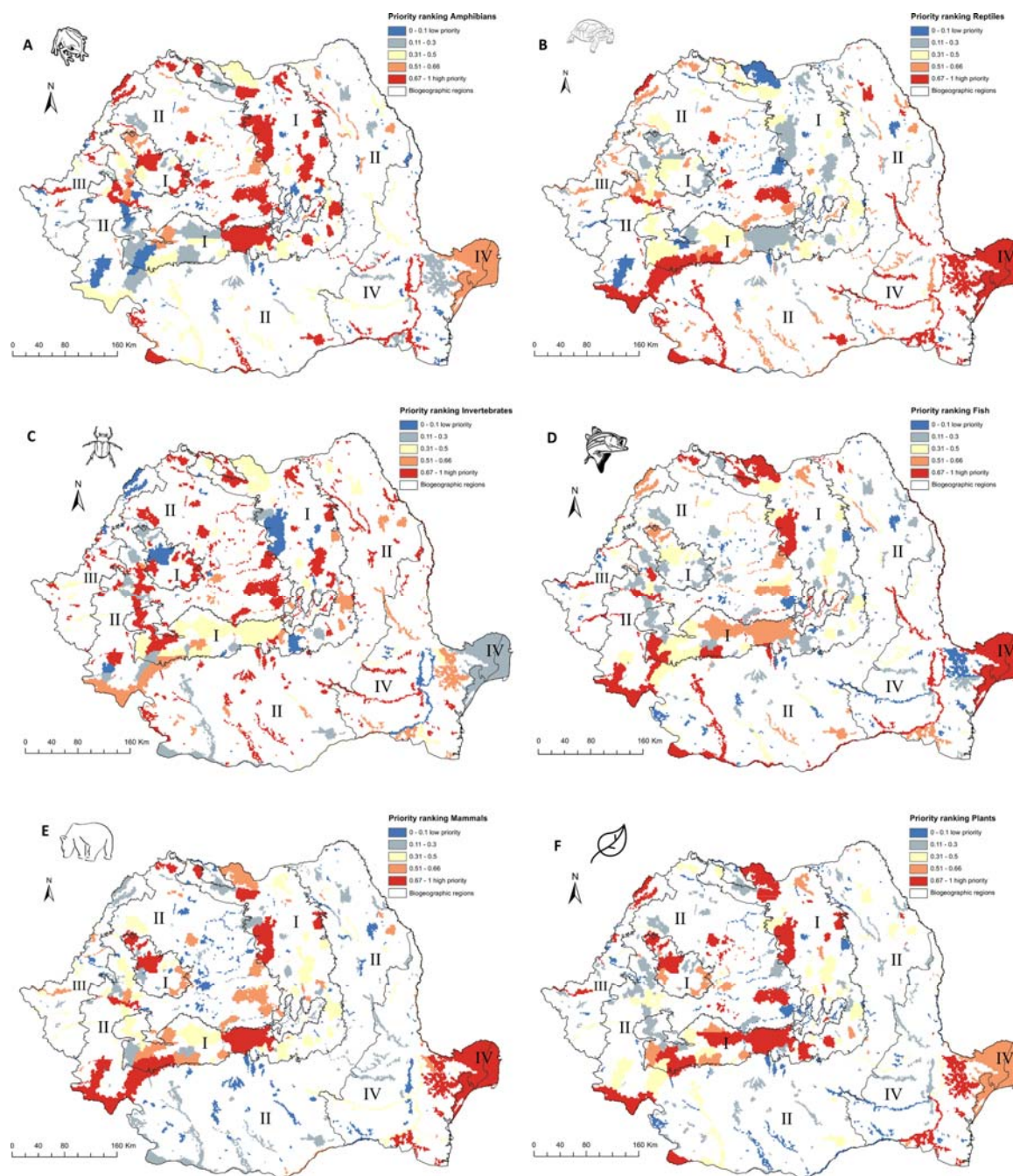246     and fish are dispersed within the country (Fig. 3C-F).

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*Figure 3 High priority sites for designation as areas under strict protection (taxonomic level prioritization scenario). Grid cells within the Romanian terrestrial Natura 2000 network have been graded according to their priority, with the highest-priority sites (top 33%) shown in red. Biogeographic regions are numbered as follows: I (Alpine), II (Continental), III (Pannonian), IV (Steppic and terrestrial Black Sea). (A) Amphibians. (B) Reptiles. (C) Invertebrates. (D) Fish. (E) Mammals. (F) Plants.*

The performance of top-priority Natura 2000 sites in representing species distribution varies by taxonomic group (Fig. S2). For invertebrates, the prioritization ranking indicates that if the top 33% of the landscape included in Natura 2000 sites is strictly protected, on average only 20% of

257   the invertebrate distributions in Natura 2000 are also protected; this is followed by the amphibian

258   group, with over 50% of the amphibian distribution in Natura 2000 protected. For reptiles,

259   Natura 2000 performs better, with over 90% of the distribution of reptiles in strictly protected

260   areas. For mammals, fish, and plants, the Romanian Natura 2000 network performs very well,

261   with more than 75% of distribution of the respective species strictly protected when the

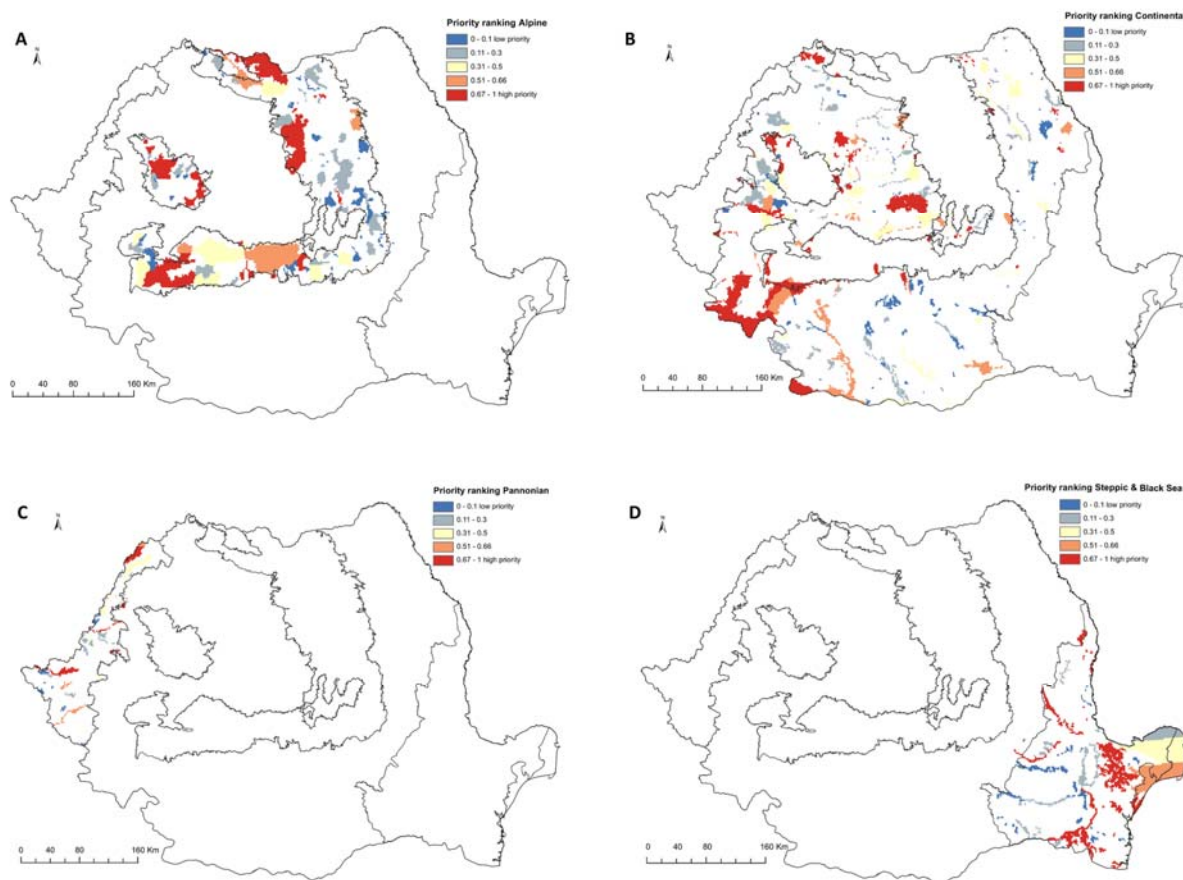262   identified top priority 33% of Natura 2000 area is protected.



263

264   *Figure 4 High priority sites for designation as areas under strict protection (biogeographical level prioritization scenario). Grid*
265   *cells within the Romanian terrestrial Natura 2000 network have been graded according to their priority, with the highest-priority*
266   *sites (top 33%) shown in red. (A) Alpine biogeographic region. (B) Continental biogeographic region. (C) Pannonian*
267   *biogeographic region. (D) Steppic and terrestrial Black Sea biogeographic region.*

268   The biogeographic level planning scenario produced fewer gap species (i.e., not covered within

269   the strictly protected area network) than the national level scenario when selecting top priorities

270   (Fig. 5, Data S3). Out of 118 species included in Alpine biogeographic region, 9 are gap species

271   if planning is done at the national level and 3 if planning is done at the biogeographical level. Of

272   149 species in Continental biogeographic region, 37 are gap species when prioritization is done

273    at the national level and 6 when it is done at the biogeographical level. Furthermore, out of 75

274    species represented in Pannonian biogeographic region, 27 are gap species in national-level

275    scenarios and only 3 in biogeographical level scenarios. Also, the number of gap species is

276    reduced when planning is done at the Steppic and Black Sea biogeographic region level, with no

277    gap species out of 38 in national-level scenarios and only 12 species in biogeographical level
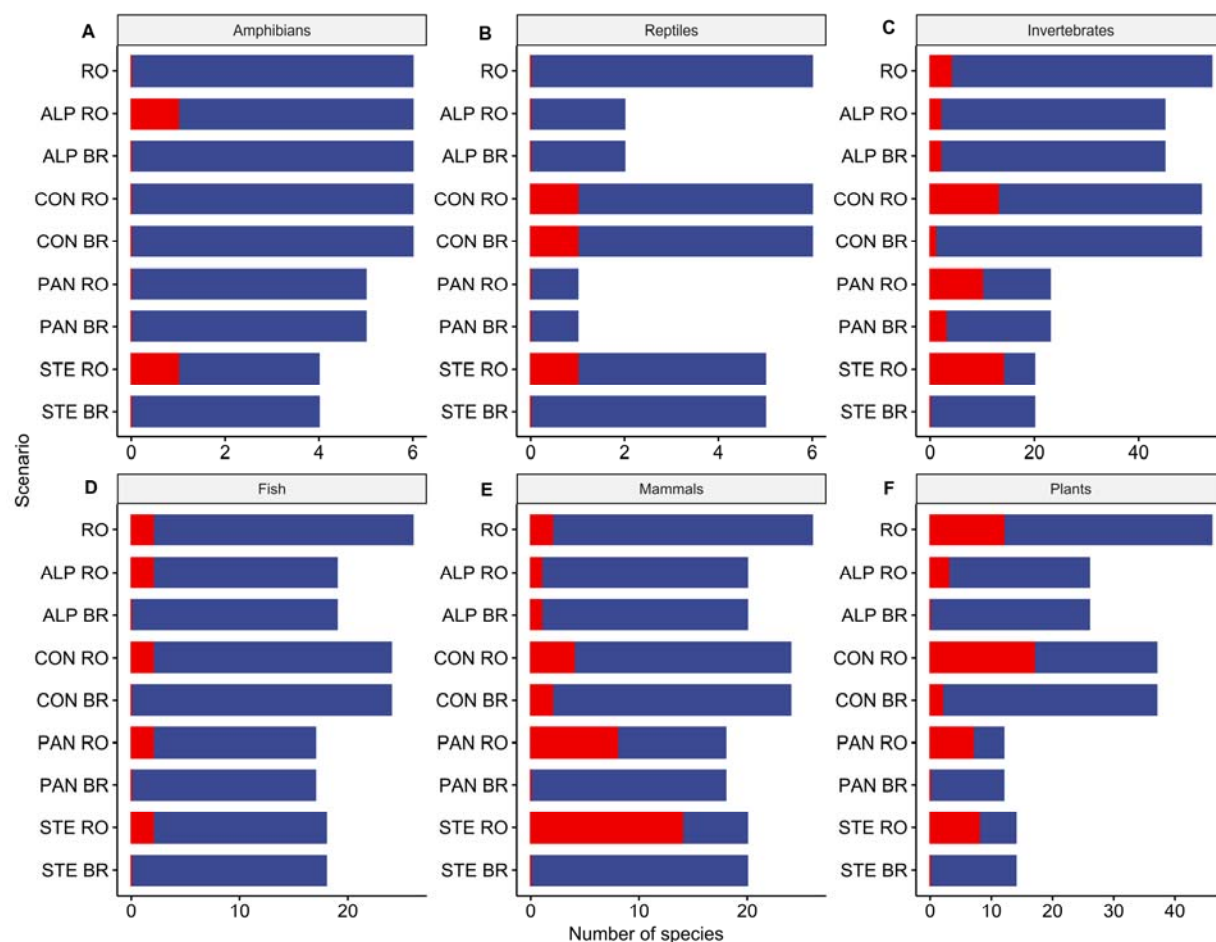
278    scenarios.



279

*Figure 5 Species representation in the top 33% planning units by prioritization scenarios. Red = gap species (never included in Natura 2000 sites with high priority grid cells in the respective scenario), Blue = covered species (included in Natura 2000 sites with high priority grid cells in the respective scenario). RO = national level scenario. ALP RO = Alpine EBR in national level scenario. ALP BR = Alpine EBR in biogeographical level scenario; CON RO = Continental EBR in national level scenario. CON BR = Continental EBR in biogeographical level scenario; PAN RO = Pannonian EBR in national level scenario. PAN BR = Pannonian EBR in biogeographical level scenario; STE RO = Steppic and terrestrial Black Sea EBR in national level scenario. STE BR = Steppic and terrestrial Black Sea EBR in biogeographical level scenario.*

## Discussion

288  The EU Biodiversity Strategy for 2030 acknowledges that the current network of protected areas,

289  including those under strict protection, is not sufficiently large to safeguard Europe's biodiversity

290  in the face of multiple stressors. To overcome this issue, the European Commission set ambitious

291  conservation objectives for Member States, such as the enlargement of protected areas to at least

292  30% of terrestrial national territory in Europe, of which one-third should be strictly protected

293  (European Commission 2020). To support policymakers in establishing criteria and guidance for

294  meeting the objective of one-third of protected areas under strict protection, we tested three

295  spatial conservation prioritization scenarios using the Romanian terrestrial Natura 2000 network

296  as a case study. Our analyses suggest that selecting strictly protected areas at the European

297  Biogeographical Region level performs better than nationwide or taxa-specific planning

298  scenarios in terms of species representation and spatial evenness of selected sites.

299  The EU Biodiversity Strategy for 2030 outlines key principles designation of areas of very high

300  biodiversity value, such as including carbon-rich ecosystems (old-growth forests, peatlands) or

301  outermost regions. The strategy also stipulates potential planning scenarios, e.g., at EU bio-

302  geographical regions, national level (European Commission 2020). Because the backbone of

303  strictly protected areas will be within the Natura 2000 network, which already covers over 17%

304  of EU land, these areas with high biodiversity value should also ensure the long-term survival of

305  species and habitats listed in Birds and Habitats Directives (Evans 2012), therefore contributing

306  to the implementation of the two Directives by the EU Member States.

307  In the case of Romanian terrestrial protected areas, when spatial conservation prioritization is

308  done at the national level, the top 33% protected grid cells cover, on average, less than 18% of

309  Habitats Directive-listed species occurrences within the existing Natura 2000 (see Fig. 2, Data

310  S2). The limited coverage of most species indicates that prioritization at a national level is

311  insufficient to ensure that the favorable conservation status is maintained for most species listed

312  in Habitats Directive. Most species that would not be represented in strictly protected areas are

313  plants; 46 plant species will be strictly protected in areas of less than 10 km$^2$, which may be

314  sufficient only for some range-restricted species since efficient management requires specific

315  measures such as fencing or manual mowing (Heywood 2019). National-level prioritization will

316  also lead to a lack of representation of endangered mammals, such as the European mink *Mustela*

317  *lutreola* and the marbled polecat *Vormela peregusna*. Under the national level prioritization,

318  most of Natura 2000 sites are located within the Continental biogeographic region (51% of

319    priority areas and 48% of the region). The Alpine biogeographic region, which harbors most of

320    the remaining old-growth forests in the Carpathian Mountains (Veen et al. 2010), had a relatively

321    low contribution to high-value priority areas (27% of Alpine region) (see Data S1). The

322    Continental region, which in this scenario would constitute the backbone of strictly protected

323    areas, include many common species when compared to other biogeographic regions (Gruber et

324    al. 2012; Rozylowicz et al. 2019); thus, rare species inhabiting Alpine, Steppic and the Black Sea

325    regions would not be represented in strictly protected areas without a significant expansion of

326    protected areas network. This finding corroborates previous work that found that more than 50%

327    of sites from Alpine, Steppic, and the Black Sea regions are important for the cohesion of the

328    Natura 2000 network at the national level (Rozylowicz et al. 2019).

329    The limited contribution of the national-level prioritization scenario may be due to the

330    prioritization algorithm selected for this analysis (Additive Benefit Function), which favors

331    Natura 2000 sites with high species richness (Di Minin et al. 2014). Using other removal rules,

332    such as Core-Area Zonation, which strives to provide the best representation for each individual

333    species, would result in better representation of range-restricted species; as a result, Natura 2000

334    sites with a high number of endemic species would be retained as areas of high biodiversity

335    value (Kukkala et al. 2016); however, forests and other important carbon-rich ecosystems would

336    be missed, thus limiting more their contribution to achieve the EU Biodiversity Strategy for 2030

337    of one-third under strict protection objective.

338    Spatial conservation prioritization relies on the quality of species distribution data (Wiersma and

339    Sleep, 2016). Studies typically opt to limit planning exercises to the best available species data

340    set (e.g., Kukkala et al. 2016; D'Amen M et al. 2013); however, drawing conclusions on data-

341    rich taxa likely limits the application of systematic conservation planning at a continental level

342    that consider species across all taxonomic groups (see Jung et. 2020 for a comprehensive global

343    analysis). Our analysis, while coarse, does explore several taxonomic groups (amphibians,

344    reptiles, fish, mammals, invertebrates, plants), thus providing a national-level perspective on

345    protecting many levels of biodiversity.  For example, we found a limited value of applying

346    spatial conservation prioritization algorithms at national level by taxonomic group (see Fig. 3,

347    Fig. S2, Data S2). In our taxa specific scenarios, the top 33% priority areas overlap 295 Natura

348    2000 sites, of which 222 sites include priority areas for invertebrates, 92 sites for amphibians, 73

349    sites for plants, 63 sites for fish species, 58 sites for reptiles, and 42 sites for mammals.

350 Achieving the EU Biodiversity Strategy 203 targets will result in overshooting the one-third

351 strictly protected target, and will require significant land availability and funding to implement,

352 neither being a feasible and efficient prerequisite to conservation in Romania and the EU

353 (Hermoso et al. 2019). Despite their limited value for the EU biodiversity targets, the taxonomic

354 group-based scenarios can be used to identify key areas for a specific taxon and could be used to

355 complement the more realistic, biogeographic regional-based scenarios. This type of

356 prioritization can also be used to understand the data gaps across taxonomic groups. For

357 example, in our case, the top 33% planning units for 53 invertebrate species include 222 Natura

358 2000 sites out of 371, while for 46 plant species, the prioritization algorithm will select planning

359 units for 73 Natura 2000 sites. The large number of sites selected in the top 33% for invertebrates

360 is a direct result of insufficient monitoring efforts for these species, and a lack of taxonomists

361 (Brodie et al. 2019; Cardoso et al. 2011; D'Amen et al. 2013). Data gaps likely resulted in a

362 lower than expected species per site, thus affecting the outcomes of our prioritization exercise.

363 The biogeographical region level prioritization resulted in a balanced distribution of top-priority

364 planning units across the country. This is an expected result, as prioritization using biologically-

365 significant administrative borders will reduce the lower coverage of areas with many range-

366 restricted species (Kukkala et al. 2016). The biogeographic region level planning scenarios also

367 resulted in a smaller number of sites with planning units in top 33%, with 104 Natura 2000 sites

368 when planning region by region (19 sites belong to more than a region) compared to 222 sites

369 under the national level scenario (see Fig. 4, Data S2). Most sites with top-priority grid cells

370 occur in the Continental region (56 sites) and the Alpine region (38 sites), followed by the

371 Steppic and terrestrial Black Sea (23 sites), and the Pannonian regions (8 sites). Biogeographic-

372 focused planning scenarios also performs better in terms of species representation, with only 12

373 species not covered by top-priority planning units (see Data S3, Fig. 5). Only one species is

374 missed by all biogeographic regions - European bison, *Bison bonasus*) - which would require

375 only one new Natura 2000 site for complete representation (e.g., Tarcu Mountains in SW

376 Romania is on of them, and there are ongoing efforts to reintroduce bison in the Southern

377 Carpathians, Fagaras Mountains).

378 Our prioritization is constrained by the limited availability of occurrence data for most of the

379 Annex II Habitats Directive species. With few exceptions, such as reptiles, amphibians,

380 mammals in the Dobrogea region, large carnivores (Bîrsan et al. 2017; Cogălniceanu et al.

381    2013a; Cogălniceanu et al. 2013b; Cristescu et al. 2019; Miu et al. 2018) species distribution data

382    are available as extent of occurrence, rather than specific locations or modeled species

383    distributions (EIONET 2020). Also, other sources extensively used in prioritization research,

384    such as GBIF (e.g., Guo et al. 2020), include low numbers of occurrence data for Romania. To

385    overcome this shortcoming we used Natura 2000 Standard Data Form, the technical

386    documentation of a Natura 2000 which includes species for which it was designated (Lisón et al.

387    2017), and the spatial resolution of data reported by the Romanian authorities for

388    biogeographical assessments of the conservation status of species and habitats under Article 17

389    of the Habitats Directive (EIONET 2020). While this is less than ideal for systematic

390    conservation planning, it showcases the real-world decision-making process in Eastern European

391    conservation. This is why we support the existing calls for obtaining robust species distribution

392    data prior to establishing and planning strictly protected areas, especially for overlooked species

393    such as invertebrates (Cardoso et al. 2011).

## Conclusions

395    The EU Biodiversity Strategy for 2030 requires an expansion of protected areas network in

396    Europe, of which one third should be under strict protection as areas of very high biodiversity

397    and climate value. The strategy outlines key principles for designation of strictly protected areas

398    but without providing clear guidelines. To support policymakers in establishing criteria and

399    guidance for meeting the target of one-third of protected areas under strict protection, we provide

400    here a reproducible spatial prioritization case study using Romania's current terrestrial Natura

401    2000 network and coarse-scale terrestrial species occurrence. Our results indicate that

402    designation of strictly protected areas using a systematic conservation planning approach at

403    biogeographic region-level would result not only in a good representation of all species protected

404    by EU legislation in a country but also in spatial evenness of selected sites. The species-specific

405    approach used in our example may be easily expanded to include other dimensions of

406    biodiversity, such as carbon-rich areas and old-growth forests, ecological corridors, etc.

407    However, because the results are dependent no only on setting clear targets but also on data

408    quality, we urge policymakers to invest in producing high-quality biodiversity data before

409    proceeding to the designation of new areas of strict protection.

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413 **Data**

414 The data underpinning the prioritization analyses reported in this article are available at this

415 Zenodo repository: Miu, Iulia V, Rozylowicz, Laurentiu, Popescu, Dan V, & Anastasiu, Paulina.

416 (2020). Data from: Identification of top-priority areas to achieve EU Biodiversity Strategy for

417 2030 key commitments [Data set]. Zenodo. http://doi.org/10.5281/zenodo.3931433.

# References

419 Apostolopoulou E, and Pantis JD. 2009. Conceptual gaps in the national strategy for the
420      implementation of the European Natura 2000 conservation policy in Greece. *Biological*
421      *Conservation* 142:221-237. 10.1016/j.biocon.2008.10.021

422 Araújo MB, Alagador D, Cabeza M, Nogués-Bravo D, and Thuiller W. 2011. Climate change
423      threatens European conservation areas. *Ecology Letters* 14:484-492. 10.1111/j.1461-
424      0248.2011.01610.x

425 Arponen A, Heikkinen RK, Thomas CD, and Moilanen A. 2005. The value of biodiversity in
426      reserve selection: Representation, species weighting, and benefit functions. *Conservation*
427      *Biology* 19:2009-2014. 10.1111/j.1523-1739.2005.00218.x

428 Bîrsan C, Iosif R, Szekely P, and Cogălniceanu D. 2017. Spatio-temporal Bias in the Perceived
429      Distribution of the European Pond Turtle, Emys orbicularis (Linnaeus, 1758), in
430      Romania. *Acta Zoologica Bulgarica* 10:37–41.

431 Brodie BS, Popescu VD, Iosif R, Ciocanea C, Manolache S, Vanau G, Gavrilidis AA, Serafim R,
432      and Rozylowicz L. 2019. Non-lethal monitoring of longicorn beetle communities using
433      generic pheromone lures and occupancy models. *Ecological Indicators* 101:330-340.
434      10.1016/j.ecolind.2019.01.038

435 Cardoso P, Erwin TL, Borges PA, and New TR. 2011. The seven impediments in invertebrate
436      conservation and how to overcome them. *Biological Conservation* 144:2647-2655 DOI:
437      10.1016/j.biocon.2011.07.024

438 Cogălniceanu D, Rozylowicz L, Székely P, Samoilă C, Stănescu F, Tudor M, Székely D, and
439      Iosif R. 2013a. Diversity and distribution of reptiles in Romania. *ZooKeys* 341:49-76
440      DOI: 10.3897/zookeys.341.5502

441    Cogălniceanu D, Székely P, Samoilă C, Iosif R, Tudor M, Plăiaşu R, Stănescu F, and
442        Rozylowicz L. 2013b. Diversity and distribution of amphibians in Romania. *ZooKeys*
443        296:35-57 DOI: 10.3897/zookeys.296.4872

444    Council Directive 92/43/EEC. Council Directive 92/43/EEC of 21 May 1992 on the conservation
445        of natural habitats and of wild fauna and flora. Available at https://eur-
446        lex.europa.eu/legal-content/EN/TXT/?uri=celex:31992L0043 (accessed 24 August 2020).

447    Cristescu B, Domokos C, Teichman KJ, and Nielsen SE. 2019. Large carnivore habitat
448        suitability modelling for Romania and associated predictions for protected areas. *PeerJ*
449        7:e6549 DOI: 10.7717/peerj.6549

450    D'Amen M, Bombi P, Campanaro A, Zapponi L, Bologna MA, and Mason F. 2013. Protected
451        areas and insect conservation: Questioning the effectiveness of Natura 2000 network for
452        saproxylic beetles in italy. *Animal Conservation* 16:370-378 DOI: 10.1111/acv.12016

453    DG Environment. 2020. Natura 2000 barometer. *Natura 2000 Nature and biodiversity newsletter*
454        47:8-9.

455    Di Minin E, Veach V, Lehtomäki J, Pouzols FP and Moilanen A. 2014. A quick introduction to
456        Zonation. Version 1 (for Zv4). University of Helsinki

457    Dimitrakopoulos PG, Memtsas D, and Troumbis AY. 2004. Questioning the effectiveness of the
458        Natura 2000 Special Areas of Conservation strategy: The case of Crete. *Global Ecology*
459        *and Biogeography* 13:199-207 DOI: 10.1111/j.1466-822X.2004.00086.x

460    Directive 2009/147/EC. Directive 2009/147/EC of the European Parliament and of the Council
461        of 30 November 2009 on the conservation of wild birds. *Available at https://eur-*
462        *lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02009L0147-20190626* (accessed 24
463        August 2020)

464    EIONET. 2020. Central Data Repository. Natura 2000 network (Birds Directive and Habitats
465        Directive). Natura 2000 updating 2019. *Available at*
466        *https://cdr.eionet.europa.eu/ro/eu/n2000/envxdvb_a/* (accessed March, 5 2020).

467    European Commission. 2020. EU Biodiversity Strategy for 2030. Bringing nature back into our
468        lives. Communication from the Commission to the European Parliament, the Council, the
469        European Economic and Social Committee and the Committee of the Regions. *Available*
470        *at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0380*
471        (accessed 24 August 2020).

472    Evans D. 2012. Building the European Union's Natura 2000 network. *Nature conservation* 1:11
473         DOI: 10.3897/natureconservation.1.1808

474    Geldmann J, Barnes M, Coad L, Craigie ID, Hockings M, and Burgess ND. 2013. Effectiveness
475         of terrestrial protected areas in reducing habitat loss and population declines. *Biological*
476         *Conservation* 161:230-238 DOI: 10.1016/j.biocon.2013.02.018

477    Gray CL, Hill SLL, Newbold T, Hudson LN, Börger L, Contu S, Hoskins AJ, Ferrier S, Purvis
478         A, and Scharlemann JPW. 2016. Local biodiversity is higher inside than outside
479         terrestrial protected areas worldwide. *Nature Communications* 7:12306 DOI:
480         10.1038/ncomms12306

481    Gruber B, Evans D, Henle K, Bauch B, Schmeller D, Dziock F, Henry P-Y, Lengyel S, Margules
482         C, and Dormann C. 2012. "Mind the gap!"–How well does Natura 2000 cover species of
483         European interest? *Nature conservation* 3:45 DOI: 10.3897/natureconservation.3.3732

484    Guo W-Y, Serra-Diaz JM, Schrodt F, Eiserhardt WL, Maitner BS, Merow C, Violle C, Anand
485         M, Belluau M, Bruun HH, Byun C, Catford JA, Cerabolini BEL, Chacón-Madrigal E,
486         Ciccarelli D, Cornelissen JHC, Dang-Le AT, de Frutos A, Dias AS, Giroldo AB, Guo K,
487         Gutiérrez AG, Hattingh W, He T, Hietz P, Hough-Snee N, Jansen S, Kattge J, Klein T,
488         Komac B, Kraft N, Kramer K, Lavorel S, Lusk CH, Martin AR, Mencuccini M,
489         Michaletz ST, Minden V, Mori AS, Niinemets Ü, Onoda Y, Onstein RE, Peñuelas J,
490         Pillar VD, Pisek J, Robroek BJM, Schamp B, Slot M, Sosinski Ê, Soudzilovskaia NA,
491         Thiffault N, van Bodegom P, van der Plas F, Wright IJ, Xu W-B, Zheng J, Enquist BJ,
492         Svenning J-C. 2020. Half of the world's tree biodiversity is unprotected and is
493         increasingly threatened by human activities. bioRxiv DOI: 10.1101/2020.04.21.052464.

494    Hermoso V, Clavero M, Villero D, and Brotons L. 2017. EU's Conservation Efforts Need More
495         Strategic Investment to Meet Continental Commitments. *Conservation Letters* 10 231-
496         237 DOI: 10.1111/conl.12248

497    Hermoso V, Morán-Ordóñez A, Canessa S, Brotons L. 2019. Realising the potential of Natura
498         2000 to achieve EU conservation goals as 2020 approaches. Scientific Reports 9. DOI:
499         10.1038/s41598-019-52625-4.

500    Heywood VH. 2019. Conserving plants within and beyond protected areas – still problematic
501         and future uncertain. Plant Diversity 41:36–49. DOI: 10.1016/j.pld.2018.10.001.

502    Iojă CI, Pătroescu M, Rozylowicz L, Popescu VD, Vergheleț M, Zotta M, and Felciuc M. 2010.
503        The efficacy of Romania's protected areas network in conserving biodiversity. *Biological*
504        *Conservation* 143:2468-2476 DOI: 10.1016/j.biocon.2010.06.013

505    Jung M, Arnell A, de Lamo X, García-Rangel S, Lewis M, Mark J, Merow C, Miles L, Ondo I,
506        Pironon S, Ravilious C, Rivers M, Schepashenko D, Tallowin O, van Soesbergen A,
507        Govaerts R, Boyle BL, Enquist BJ, Feng X, Gallagher RV, Maitner B, Meiri S, Mulligan
508        M, Ofer G, Hanson JO, Jetz W, Di Marco M, McGowan J, Rinnan DS, Sachs JD, Lesiv
509        M, Adams V, Andrew SC, Burger JR, Hannah L, Marquet PA, McCarthy JK, Morueta-
510        Holme N, Newman EA, Park DS, Roehrdanz PR, Svenning JC, Violle C, Wieringa JJ,
511        Wynne G, Fritz S, Strassburg BBN, Obersteiner M, Kapos V, Burgess N, Schmidt-Traub
512        G and Visconti P. 2020. Areas of global importance for terrestrial biodiversity, carbon,
513        and water. bioRxiv. DOI: 10.1101/2020.04.16.021444.

514    Kenig-Witkowska MM. 2017. Natura 2000-The European Union Mechanism for Nature
515        Conservation: Some Legal Issues. *Journal of Comparative Urban Law and Policy* 2:198-
516        214.

517    Kukkala AS, Arponen A, Maiorano L, Moilanen A, Thuiller W, Toivonen T, Zupan L, Brotons
518        L, and Cabeza M. 2016. Matches and mismatches between national and EU-wide
519        priorities: Examining the Natura 2000 network in vertebrate species conservation.
520        *Biological Conservation* 198:193-201 DOI: 10.1016/j.biocon.2016.04.016

521    Lehtomäki J, and Moilanen A. 2013. Methods and workflow for spatial conservation
522        prioritization using Zonation. *Environmental Modelling and Software* 47:128-137 DOI:
523        10.1016/j.envsoft.2013.05.001

524    Lisón F, Altamirano A, Field R, and Jones G. 2017. Conservation on the blink: Deficient
525        technical reports threaten conservation in the Natura 2000 network. *Biological*
526        *Conservation* 209:11-16 DOI: 10.1016/j.biocon.2017.02.003

527    Lisón F, Palazón JA, and Calvo JF. 2013. Effectiveness of the Natura 2000 Network for the
528        conservation of cave-dwelling bats in a Mediterranean region. *Animal Conservation*
529        16:528-537 DOI: 10.1111/acv.12025

530    Manolache S, Ciocanea CM, Rozylowicz L, and Nita A. 2017. Natura 2000 in Romania–a
531        decade of governance challenges. *European Journal of Geography* 8:24-34.

532     Mânzu C, Gherghel I, Zamfirescu Ş, Zamfirescu O, Roşca I, and Strugariu A. 2013. Current and
533         future potential distribution of glacial relict Ligularia sibirica (Asteraceae) in Romania
534         and temporal contribution of Natura 2000 to protect the species in light of global change.
535         *Carpathian Journal of Earth and Environmental Sciences* 8:77-87.

536     Margules CR, and Pressey RL. 2000. Systematic conservation planning. *Nature* 405:243-253
537         DOI: 10.1038/35012251

538     Mikkonen N, and Moilanen A. 2013. Identification of top priority areas and management
539         landscapes from a national Natura 2000 network. *Environmental science & policy* 27:11-
540         20 DOI: 10.1016/j.envsci.2012.10.022

541     Miu IV, Chisamera GB, Popescu VD, Iosif R, Nita A, Manolache S, Gavril VD, Cobzaru I, and
542         Rozylowicz L. 2018. Conservation priorities for terrestrial mammals in Dobrogea
543         Region, Romania. *ZooKeys* 158:133-158 DOI: 10.3897/zookeys.792.25314

544     Moilanen A, Franco AMA, Early RI, Fox R, Wintle B, and Thomas CD. 2005. Prioritizing
545         multiple-use landscapes for conservation : methods for large multi-species planning
546         problems. 57:1885-1891 DOI: 10.1098/rspb.2005.3164

547     Moilanen A, Leathwick JR, and Quinn JM. 2011. Spatial prioritization of conservation
548         management. *Conservation Letters* 4:383-393 DOI: 10.1111/j.1755-263X.2011.00190.x

549     Moilanen A, Pouzols FM, Meller L, Veach V, Arponen A, Leppänen J, and Kujala H. 2014.
550         Spatial conservation planning methods and software ZONATION. User Manual.
551         DOI:10.1017/CBO9781107415324.004

552     Moilanen A. 2007. Landscape Zonation, benefit functions and target-based planning: Unifying
553         reserve selection strategies. *Biological Conservation* 134:571-579 DOI:
554         10.1016/j.biocon.2006.09.008

555     Müller A, Schneider UA, and Jantke K. 2018. Is large good enough? Evaluating and improving
556         representation of ecoregions and habitat types in the European Union's protected area
557         network Natura 2000. *Biological Conservation* 227:292-300 DOI:
558         10.1016/j.biocon.2018.09.024

559     Müller A, Schneider UA, and Jantke K. 2020. Evaluating and expanding the European Union's
560         protected-area network toward potential post-2020 coverage targets. *Conservation
561         Biology* 34:654-665 DOI: 10.1111/cobi.13479

562    Nita A, Rozylowicz L, Manolache S, Ciocănea MC, Miu VI, and Popescu DV. 2016.
563         Collaboration Networks in Applied Conservation Projects across Europe. *Plos One* 11:
564         e0164503:1-16 DOI: 10.1371/journal.pone.0164503

565    Orlikowska EH, Roberge JM, Blicharska M, and Mikusiński G. 2016. Gaps in ecological
566         research on the world's largest internationally coordinated network of protected areas: A
567         review of Natura 2000. *Biological Conservation* 200:216-227 DOI:
568         10.1016/j.biocon.2016.06.015

569    Popescu VD, Rozylowicz L, Cogălniceanu D, Niculae IM, and Cucu AL. 2013. Moving into
570         Protected Areas? Setting Conservation Priorities for Romanian Reptiles and Amphibians
571         at Risk from Climate Change. *PLoS ONE* 8:e79330. DOI: 10.1371/journal.pone.0079330

572    Possingham HP, Wilson KA, Andelman SJ, and Vynme CH. 2006. Protected Areas: Goals,
573         Limitations, and Design. In: Groom MJ, Meffe GK, Carroll RC ed. Principles of
574         Conservation Biology. Boston: Sinauer Associates, 509-533.

575    Pressey RL, Cabeza M, Watts ME, Cowling RM, and Wilson KA. 2007. Conservation planning
576         in a changing world. *Trends in ecology & evolution* 22:583-592. DOI:
577         10.1016/j.tree.2007.10.001

578    Rey V, Ianos I, Groza O, and Patroescu M. 2007. *Atlas de la Roumanie. Nouvelle edition*.
579         Montpellier: Reclus.

580    Rodrigues ASL, Andelman SJ, Bakarr MI, Boitani L, Brooks TM, Cowling RM, Fishpool LDC,
581         Da Fonseca GAB, Gaston KJ, Hoffmann M, Long JS, Marquet PA, Pilgrim JD, Pressey
582         RL, Schipper J, Sechrest W, Stuart SN, Underhill LG, Waller RW, Watts MEJ, and Yan
583         X. 2004. Effectiveness of the global protected area network in representing species
584         diversity. *Nature* 428:640-643. DOI: 10.1038/nature02422

585    Rozylowicz L, Nita A, Manolache S, Popescu VD, and Hartel T. 2019. Navigating protected
586         areas networks for improving diffusion of conservation practices. *Journal of
587         Environmental Management* 230:413-421. DOI: 10.1016/j.jenvman.2018.09.088

588    UNEP. 2011. Strategic Plan for Biodiversity 2011–2020: Further Information Related to the
589         Technical Rationale for the Aichi Biodiversity Targets, Including Potential Indicators and
590         Milestones. New York: UNEP.

591    Veen P, Fanta J, Raev I, Biriş I-A, de Smidt J, Maes B. 2010. Virgin forests in Romania and
592        Bulgaria: results of two national inventory projects and their implications for protection.
593        Biodiversity and Conservation 19:1805–1819. DOI: 10.1007/s10531-010-9804-2.

594    Votsi NEP, Zomeni MS, and Pantis JD. 2016. Evaluating the Effectiveness of Natura 2000
595        Network for Wolf Conservation: A Case-Study in Greece. *Environmental Management*
596        57:257-270. DOI: 10.1007/s00267-015-0621-y

597    Wiersma YF, Sleep DJH. 2016. A review of applications of the six-step method of systematic
598        conservation planning. The Forestry Chronicle 92:322–335. DOI: 10.5558/tfc2016-059.

599

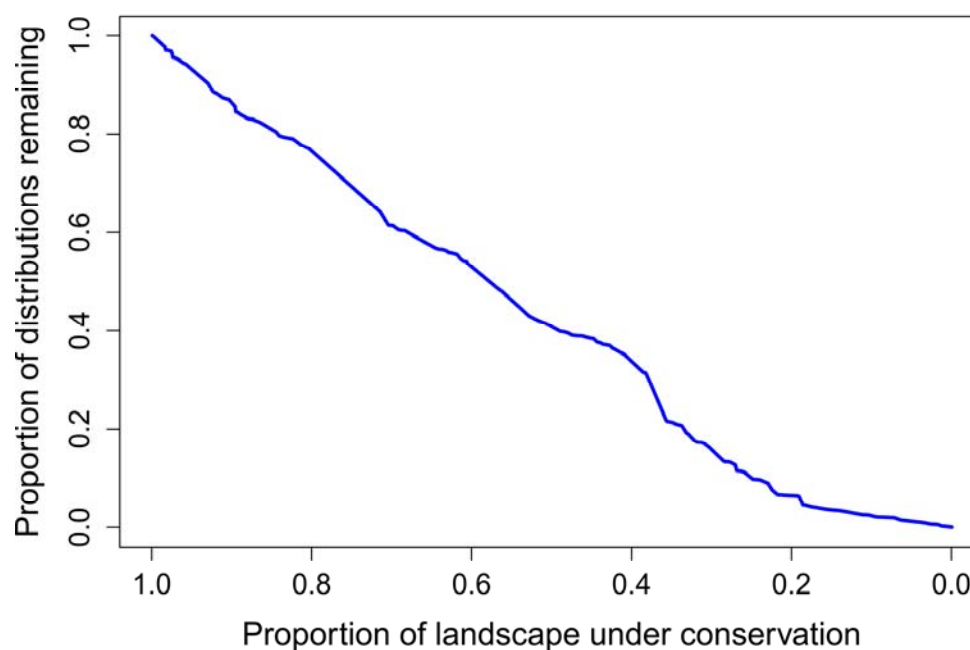600    **Supplementary figures**



601

602    *Figure S 1 Coverage of species distribution within Romanian terrestrial Natura 2000 network at various proportions of strictly*
603    *protected landscape. National level prioritization scenario. The curve represent mean coverage achieved across all species.*
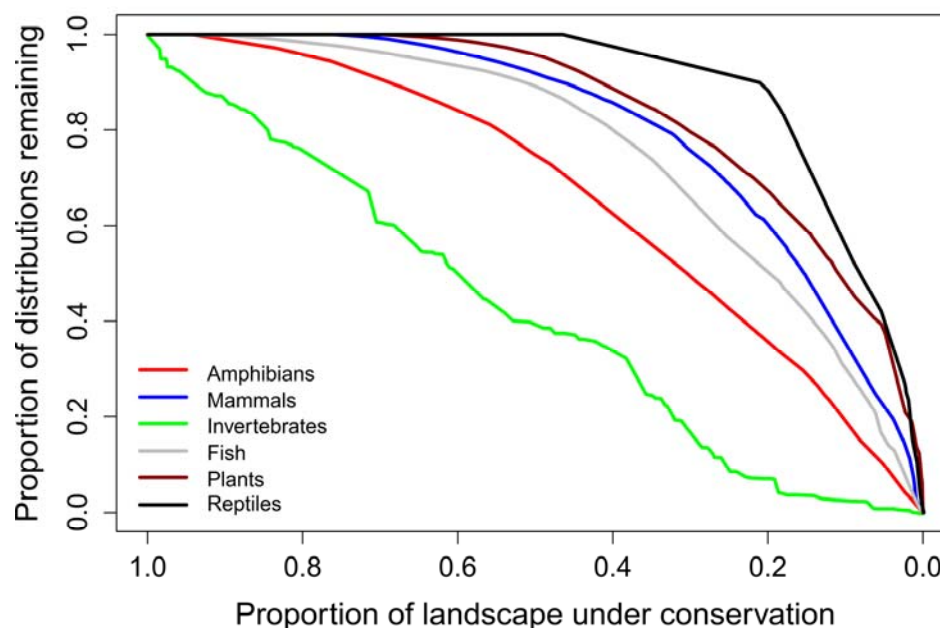
604

*Figure S 2 Coverage of taxonomic group distribution within Romanian terrestrial Natura 2000 network at various proportions of strictly protected landscape. Taxonomic group level prioritization scenario. The curves represent mean coverage achieved across all species of the respective taxonomic group.*
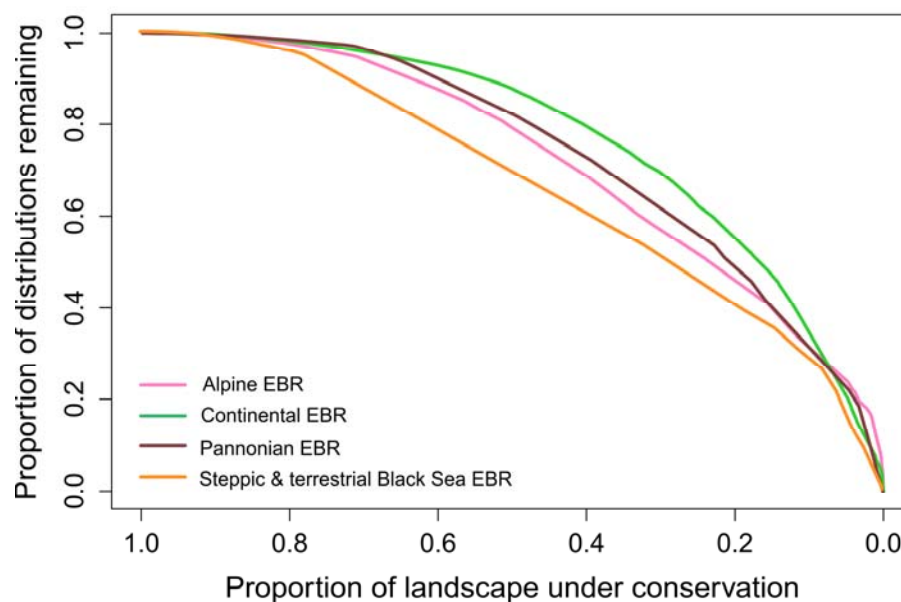


608

*Figure S 3 Coverage of species distribution within biogeographical regions overlapping Romanian terrestrial Natura 2000 network at various proportions of strictly protected landscape. Biogeographical level prioritization scenario. The curves represent mean coverage achieved across all species.*