

 Open access • Journal Article • DOI:10.1038/S41559-017-0332-2

## The global distribution of tetrapods reveals a need for targeted reptile conservation

— [Source link](#) 

Uri Roll, Uri Roll, Anat Feldman, Maria Novosolov ...+37 more authors

**Institutions:** University of Oxford, Ben-Gurion University of the Negev, Tel Aviv University, Bishop Museum ...+21 more institutions

**Published on:** 09 Oct 2017 - Nature Ecology and Evolution (Nature Publishing Group)

**Topics:** Conservation biology, Species richness, Biodiversity, Global biodiversity and Vertebrate

Related papers:

- [Fully-sampled phylogenies of squamates reveal evolutionary patterns in threat status](#)
- [Body sizes and diversification rates of lizards, snakes, amphisbaenians and the tuatara](#)
- [The conservation status of the world's reptiles](#)
- [Traits of lizards of the world: Variation around a successful evolutionary design](#)
- [R: A language and environment for statistical computing.](#)

Share this paper:    

View more about this paper here: <https://typeset.io/papers/the-global-distribution-of-tetrapods-reveals-a-need-for-3fzyccvp9l>

**The global distribution of tetrapods reveals a need for targeted reptile conservation**

Uri Roll<sup>#1,2</sup>, Anat Feldman<sup>#3</sup>, Maria Novosolov<sup>#3</sup>, Allen Allison<sup>4</sup>, Aaron M. Bauer<sup>5</sup>, Rodolphe Bernard<sup>6</sup>, Monika Böhm<sup>7</sup>, Fernando Castro-Herrera<sup>8</sup>, Laurent Chirio<sup>9</sup>, Ben Collen<sup>10</sup>, Guarino R. Colli<sup>11</sup>, Lital Dabool<sup>12</sup>, Indraneil Das<sup>13</sup>, Tiffany M. Doan<sup>14</sup>, Lee L. Grismer<sup>15</sup>, Marinus Hoogmoed<sup>16</sup>, Yuval Itescu<sup>3</sup>, Fred Kraus<sup>17</sup>, Matthew LeBreton<sup>18</sup>, Amir Lewin<sup>3</sup>, Marcio Martins<sup>19</sup>, Erez Maza<sup>3</sup>, Danny Meirte<sup>20</sup>, Zoltán T. Nagy<sup>21</sup>, Cristiano de C. Nogueira<sup>19</sup>, Olivier S.G. Pauwels<sup>22</sup>, Daniel Pincheira-Donoso<sup>23</sup>, Gary D. Powney<sup>24</sup>, Roberto Sindaco<sup>25</sup>, Oliver Tallowin<sup>3</sup>, Omar Torres-Carvajal<sup>26</sup>, Jean-François Trape<sup>27</sup>, Enav Vidan<sup>3</sup>, Peter Uetz<sup>28</sup>, Philipp Wagner<sup>5,29</sup>, Yuezhaio Wang<sup>30</sup>, C David L Orme<sup>6</sup>, Richard Grenyer<sup>†1</sup> and Shai Meiri<sup>†\*3</sup>

<sup>#</sup> Contributed equally to the paper

<sup>†</sup> Contributed equally to the paper

<sup>\*</sup> Corresponding author

Affiliations:

<sup>1</sup> School of Geography and the Environment, University of Oxford, Oxford, OX13QY, UK.

<sup>2</sup> Mitrani Department of Desert Ecology, The Jacob Blaustein Institutes for Desert Research, Ben-Gurion University, Midreshet Ben-Gurion 8499000, Israel. (Current address)

<sup>3</sup> Department of Zoology, Tel-Aviv University, Tel-Aviv 6997801, Israel.

- 22 <sup>4</sup> Hawaii Biological Survey, 4 Bishop Museum, Honolulu, HI 96817, USA.
- 23 <sup>5</sup> Department of Biology, Villanova University, Villanova, PA 19085, USA.
- 24 <sup>6</sup> Department of Life Sciences, Imperial College London, Silwood Park Campus Silwood Park,  
25 Ascot, Berkshire, SL5 7PY, UK
- 26 <sup>7</sup> Institute of Zoology, Zoological Society of London, London NW1 4RY, UK.
- 27 <sup>8</sup> School of Basic Sciences, Physiology Sciences Department, Universidad del Valle, Colombia.
- 28 <sup>9</sup> 14, rue des roses - 06130 Grasse, France.
- 29 <sup>10</sup> Centre for Biodiversity & Environment Research, University College London, London WC1E  
30 6BT, UK.
- 31 <sup>11</sup> Departamento de Zoologia, Universidade de Brasília, 70910-900, Brasília, Distrito Federal,  
32 Brazil.
- 33 <sup>12</sup> Department of Genetics and Developmental Biology, The Rappaport Family Institute for  
34 Research in the Medical Sciences, Faculty of Medicine, Technion – Israel Institute of  
35 Technology, Haifa 31096, Israel.
- 36 <sup>13</sup> Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak,  
37 94300 Kota Samarahan, Sarawak, Malaysia.
- 38 <sup>14</sup> Department of Biology, University of Central Florida, Orlando, FL 32816, USA.
- 39 <sup>15</sup> Department of Biology, La Sierra University, Riverside, CA 92505, USA.
- 40 <sup>16</sup> Museu Paraense Emílio Goeldi/CZO, Caixa Postal 399, 66017–970 Belém, Pará, Brazil.
- 41 <sup>17</sup> Department of Ecology and Evolutionary Biology, University of Michigan, Ann-Arbor, MI  
42 48109-1048, USA.
- 43 <sup>18</sup> Mosaic, (Environment, Health, Data, Technology), Yaoundé, Cameroon.
- 44 <sup>19</sup> Departamento de Ecologia, Instituto de Biociências, Universidade de São Paulo, 05508-090  
45 São Paulo, São Paulo, Brasil.
- 46 <sup>20</sup> Royal Museum for Central Africa, Leuvensesteenweg 13, 3080 Tervuren, Belgium.
- 47 <sup>21</sup> Joint Experimental Molecular Unit, Royal Belgian Institute of Natural Sciences, B-1000  
48 Brussels, Belgium.
- 49 <sup>22</sup> Département des Vertébrés Récents, Royal Belgian Institute of Natural Sciences, B-1000  
50 Brussels, Belgium.
- 51 <sup>23</sup> School of Life Sciences, Joseph Banks Laboratories, University of Lincoln, Brayford Campus,  
52 Lincoln, LN6 7DL, UK.

- 53 <sup>24</sup> NERC Centre for Ecology and Hydrology, Maclean Building, Crowmarsh Gifford,  
54 Wallingford, OX10 8BB, UK.
- 55 <sup>25</sup> Museo Civico di Storia Naturale, I-10022 Carmagnola (TO), Italy.
- 56 <sup>26</sup> Museo de Zoología, Escuela de Ciencias Biológicas, Pontificia Universidad Católica del  
57 Ecuador, Apartado 17-01-2184, Quito, Ecuador.
- 58 <sup>27</sup> Institut de Recherche pour le Développement, Laboratoire de Paludologie et Zoologie  
59 Médicale, UMR MIVEGEC, Dakar, Senegal.
- 60 <sup>28</sup> Center for the Study of Biological Complexity, Virginia Commonwealth University,  
61 Richmond, VA 23284, USA.
- 62 <sup>29</sup> Zoologische Staatssammlung München, D-81247 München, Germany.
- 63 <sup>30</sup> Chengdu Institute of Biology, Chinese Academy of Sciences, Chengdu 610041, China.

## 64    **Abstract**

65    The distributions of amphibians, birds and mammals have underpinned global and local  
66    conservation priorities, and have been fundamental to our understanding of the determinants of  
67    global biodiversity. In contrast, the global distributions of reptiles, representing a third of  
68    terrestrial vertebrate diversity, have been unavailable. This prevented reptiles' incorporation into  
69    conservation planning and biased our understanding of the underlying processes governing  
70    global vertebrate biodiversity. Here, we present and analyse the global distribution of 10,064  
71    reptile species (99% of extant terrestrial species). We show that richness patterns of the other  
72    three tetrapod classes are good spatial surrogates for species richness of all reptiles combined and  
73    of snakes, but characterize diversity patterns of lizards and turtles poorly. Hotspots of total and  
74    endemic lizard richness overlap very little with those of other taxa. Moreover, existing protected  
75    areas, sites of biodiversity significance and global conservation schemes, represent birds and  
76    mammals better than reptiles. We show that additional conservation actions are needed to  
77    effectively protect reptiles, particularly lizards and turtles. Adding reptile knowledge to a global  
78    complementarity conservation priority scheme, identifies many locations that consequently  
79    become important. Notably, investing resources in some of the world's arid, grassland, and  
80    savannah habitats might be necessary to represent all terrestrial vertebrates efficiently.

## Introduction

Our knowledge of the distributions of a broad variety of organisms has improved greatly in the past decade<sup>1-3</sup>. This has greatly aided our efforts to conserve biodiversity<sup>4-6</sup> and significantly enhanced our grasp of broad scale evolutionary and ecological processes<sup>7-12</sup>. Nevertheless, despite comprising one third of terrestrial vertebrate species, knowledge of reptile distributions remained poor and unsystematic. This represented a major gap in our understanding of the global structure of biodiversity and our ability to conserve nature. Historically, broad-scale efforts towards the protection of land vertebrates (and thus also of reptiles) have been based predominantly on data from plants, birds, mammals and to a lesser degree amphibians<sup>13-15</sup>. Here we present complete species-level global distributions of nearly all reptiles: 10,064 known, extant, terrestrial species for which we could identify precise distribution information. These distributions cover the Sauria (lizards, 6110 species), Serpentes (snakes, 3414 species), Testudines (turtles, 322 species), Amphisbaenia ('worm lizards', 193 species), Crocodylia (crocodiles, 24 species) and Rhynchocephalia (the tuatara, one species).

This dataset completes the global distribution mapping of all described, extant, terrestrial vertebrates (Fig. 1a), providing information that has been missing from much of the global conservation planning and prioritization schemes constructed over the last twenty years<sup>4</sup>. We use our reptile distribution data to: a) examine the congruence in general, hotspot, and endemism richness patterns across all tetrapod classes and among reptile groups; b) explore how current conservation networks and priorities represent reptiles; and c) suggest regions in need of additional conservation attention to target full terrestrial vertebrate representation and highlight current surrogacy gaps, using a formal conservation prioritisation technique.

## Results and Discussion

### *Species richness of reptiles compared to other tetrapods*

The global pattern of reptile species richness (Fig. 1b) is largely congruent with that of all other terrestrial vertebrates combined ( $r = 0.824$ , e.d.f. = 31.2,  $p < 0.0001$ ; Figs. 2a, S1, Table S1). However, the major reptile groups (Figs. 1c-e, 2b-c, S1, Table S1) show differing degrees of congruence with the other tetrapod taxa. The richness distribution of snakes (Fig. 1d) is very similar to that of other tetrapods (Fig. 2c) in showing pan-tropical dominance ( $r = 0.873$ , e.d.f. = 30.2,  $p < 0.0001$ ). Lizard richness is much less similar to non-reptilian tetrapod richness ( $r = 0.501$ , e.d.f. = 38.3,  $p < 0.001$ , Fig. 2b). It is high in both tropical and arid regions, and notably in Australia (Figs. 1c, S1). Turtle richness is also less congruent with diversity patterns of the other tetrapods ( $r = 0.673$ , e.d.f. = 55.2,  $p < 0.001$ ), and peaks in the south-eastern USA, the Ganges Delta, and Southeast Asia (Fig. 1e).

Snakes dominate reptile richness patterns due to their much larger range sizes compared to lizards, even though lizards are about twice as speciose (median ranges size for 3414 snake species: 62,646 km<sup>2</sup>; for 6415 lizard species: 11,502 km<sup>2</sup>; Fig. S2). Therefore snakes, disproportionately influence global reptile richness patterns<sup>16,17</sup> (Table S1, Fig. S1).

### *Hotspots of richness and range-restricted species*

As with overall richness patterns, hotspots of richness (the richest 2.5%, 5%, 7.5% and 10% of grid-cells) for all reptiles combined, and of snakes, are largely congruent with those of other tetrapod classes. However they are incongruent with hotspots of lizard or turtle richness (Figs. 3; S3).

Congruence in the richness of range-restricted species (those species with the smallest 25% or 10% ranges in each group) between tetrapod groups is lower than the congruence across all species<sup>1</sup> (Table S1). Endemic lizard and turtle distributions are least congruent with the endemics in other tetrapod classes (Table S1). Global hotspots of relative endemism (or range-size weighted richness, see Methods) for reptiles differ from those of non-reptilian tetrapods (Fig. S4). Island faunas in places such as Socotra, New Caledonia and the Antilles are highlighted for reptiles, while hotspots of endemism for non-reptilian tetrapods are more often continental.

### ***The utility of protected areas and current priority schemes in capturing reptile richness***

Reptiles, like amphibians, are poorly represented in the global network of protected areas (Table S2; Figs. S5, S6). Only 3.5% of reptile and 3.4% of amphibian species distributions are contained in protected areas (median species range overlap per class, with IUCN categories I-IV), compared with 6.5% for birds and 6% for mammals. Within reptile groups, strict protected areas (IUCN Category I) overlap less with lizard ranges than with other reptile groups but there are no important differences between taxa for the more permissive protected area types (Table S2; Fig. S5). Amphibians have the highest proportion of species whose ranges lie completely outside protected areas, when compared to the other tetrapod groups. Lizards, also fare poorly and have the highest proportion of species outside protected areas when compared to the other reptile groups (Fig. S6a). Turtles have the lowest proportion of species with at least 10% of their range covered by protected areas (Fig. S6b). We suggest that these low overlaps may have been caused by the inability to consider reptile diversity for direct protection, probably arising from ignorance of their distributions.

We explored the coverage of all tetrapods in three global prioritisation schemes<sup>13,14,18</sup> and a global designation of sites for biodiversity significance<sup>15</sup> that have recently used distribution data



to highlight regions for targeted conservation. These four global prioritisations/designations cover 6.8%-37.4% of the Earth's land surface with 34-11,815 unique sites. Terrestrial vertebrate groups have 68%-98% of their species with at least some range covered by these schemes (Fig. S6c). However, reptiles and amphibians are sampled least well by these global schemes, and within reptiles lizards have the lowest representation (Fig. S6c).

Fortunately, reptiles seem better situated in terms of conservation costs compared to other tetrapods. The median conservation opportunity cost<sup>19</sup> (using the loss of agricultural revenue as a proxy for land-cost) for reptiles is lower than that for other tetrapods ( $F_{3, 31850} = 17.4$ ,  $p < 0.001$ ; Fig. S7). Within reptiles, the opportunity cost is lowest for lizards, and highest for turtles and crocodiles, which could reflect their greater dependence on fresh-water habitats ( $F_{3, 10060} = 88.4$ ,  $p < 0.001$ ; Fig. S7b).

#### ***Conservation priorities for all tetrapods, incorporating reptile distributions***

Our results suggest that reptiles, and particularly lizards and turtles, need to be better incorporated into conservation schemes. We used relative endemism within a complementarity analysis<sup>20</sup> to identify broad areas within which international and local conservation action should reduce reptile extinction risk (Figs. 4, S8), and repeated this analysis to also incorporate conservation opportunity costs<sup>19</sup> (Fig. S8d,e). Many previously identified priority regions<sup>13,14</sup>, have been retained with the addition of reptile distributions. These include northern and western Australia; central southern USA and the gulf coast of Mexico; the Brazilian Cerrado; Southeast Asia, and many islands.

Nevertheless, our analyses also reveal many regions, not currently perceived as biodiversity conservation priorities for tetrapods. These priority areas are predominantly arid and semi-arid

habitats (see also Fig. S8f for mean rank change per biome, for prioritisation with and without reptiles). They include parts of northern Africa through the Arabian Peninsula and the Levant; around Lake Chad; in inland arid southern Africa; central Asian arid highlands and steppes; central Australia; the Brazilian Caatinga, and the southern Andes. These regions have been previously neglected as their non-reptile vertebrate biotas were more efficiently represented in other locations. Our analyses show that those locations were poor spatial surrogates for reptile distributions and that conservation efforts in our suggested locations may afford better protection for reptiles while maintaining efficient representation of other vertebrates. We note that many of these locations have low conservation opportunity costs so may be especially attractive for conservation. Furthermore, the location of these areas is not primarily driven by conservation opportunity costs. When these costs are incorporated into the analyses, very similar regions are highlighted for special attention due to the inclusion of reptile distributions (Fig. S8d,e).

## ***Summation***

The complete map of tetrapod species richness presented here reveals important and unique properties of reptile diversity, particularly of lizards and turtles (Figs. 1-3). At a regional scale reptiles have previously been shown to be unusually diverse in arid and semi-arid habitats<sup>21-23</sup>. Here we reveal that this pattern is global, and further show reptile prominence in island faunas (Figs. 2d, S4). Furthermore, we show that reptiles' unique diversity patterns have important implications for their conservation. Targeted reptile conservation lags behind that of other tetrapod classes, probably through ignorance<sup>24-26</sup>. The distributions provided here could make a vital contribution to bridging this gap. Concentrations of rare species in unexpected locations (Fig. 4) require explicit consideration when planning conservation actions. Highlighting such locations for new taxa could be especially beneficial for resource-constrained planning,

especially where land costs are low. The lower global congruence with recognized diversity patterns for reptiles should also serve as a warning sign, contrary to some recent suggestions<sup>27</sup>, for our ability to use distributions of well-studied groups in order to predict diversity patterns of poorly known taxa. The distinctive distribution of reptiles, and especially of lizards, suggests that it is driven by different ecological and evolutionary processes to those in other vertebrate taxa<sup>23,28</sup>. The complete distributions of terrestrial tetrapods we now possess could greatly enhance our ability to study, understand and protect nature.

## **Methods**

Data collection and assembly was carried out by members of the Global Assessment of Reptile Distributions (GARD) group, which includes all the authors of this paper. Regional specialist group members supervised the integration of geographic data for all species from field guides and books covering the terrestrial reptilian fauna of various regions, as well as revised museum specimen databases, online meta-databases (including the IUCN, GBIF and Vertnet), our own observations and the primary literature. We followed the taxonomy of the March 2015 edition of the Reptile Database<sup>29</sup>. Source maps were split or joined on that basis. We used the newest sources available to us. Polygonal maps - representing species extent of occurrence - were preferred over other map types, as such distribution representations are those available for the other classes that were compared to reptiles. Point locality data were modelled to create polygons representing the extent of occurrence using hull geometries (see supplement). Gaps in reptile distribution knowledge for particular locations or taxa were filled using *de novo* polygon and gridded maps created by GARD members specializing in the fauna of particular regions and taxa. These maps and all data obtained from online databases and the primary literature were

then internally vetted, in a manner analogous to the IUCN Specialist Group process. Further details on data collection and curation, modelling of point localities and a full list of data sources per species are available in the supplement. Overall we analysed distribution maps for 10,064 extant species, which represent 99% of the species found in the Reptile Database of March 2015. For all analytical purposes we contrasted snakes with the paraphyletic ‘lizards’ (here defined as lepidosaurs exclusive of snakes).

Polygonal representations of the extent of species' occurrences, such as we assembled and use in our analyses, are fundamentally important to contemporary conservation planning<sup>30</sup>. The IUCN's assessment of the extinction risk of individual species requires (and produces) such data, and both they and many other organisations and researchers have used such data in aggregate and at regional-to-global scales for several decades<sup>31</sup>. Like any representation of species distributions, polygonal range maps can include errors both of omission and commission. Both kinds of inaccuracy can lead to erroneous conclusions by unwary users and this has led to some controversy over the use of polygonal range maps. Of course, all biogeographic representations - specimen localities, SDM outputs, atlas data, polygonal maps and explorers' narratives - lie along this omission: commission spectrum, and can equally be misused or found useless<sup>32</sup>. For global prioritisation, we follow a comprehensive recent study<sup>33</sup> demonstrating the effectiveness of polygonal range maps in highlighting priority areas, despite errors at the level of individual species. We do, however, recognise that specimen data, if collected, curated and made available (at a suitable scale) remains a gold standard for some uses<sup>34</sup>.

Our grid-cell analyses were conducted in a Behrmann Equal Area projection of 48.25 km grid-cells ( $\sim 0.5^\circ$  at  $30^\circ\text{N/S}$ ). All analyses were repeated at a grid size of 96.5 km ( $\sim 1^\circ$  at  $30^\circ\text{N/S}$ ) and

238 results were qualitatively unchanged. GIS and statistical analyses were carried out in R and  
239 PostGIS.

240 Range size weighted richness (rswr) was calculated, for each cell, using the following formula:

241  $rswr_i = \sum_j q_{ij}$  where  $q_{ij}$  is the fraction of the distribution of the species  $j$  in the cell  $i$ .

242 We used ‘Zonation’<sup>20</sup> to produce a ranked prioritisation amongst cells, assuming equal weight to  
243 all species and assuming an equal cost for all cells. Cell value was the maximum proportion of  
244 any species range represented in it. Cell priority was calculated by iteratively removing the least  
245 valuable cell and updating cell values<sup>20</sup>. We analysed all tetrapod species combined and  
246 tetrapods without reptiles separately, to reveal the change in rank importance induced by adding  
247 reptile distributions (See supplement, Fig. S8). We repeated our prioritisation using per-cell  
248 agricultural opportunity costs<sup>19</sup>, and found via rank correlation that our priority regions are fairly  
249 insensitive to the use of land costs (Figs. 4, S8).

## Acknowledgments

We thank Tamsin Burbidge, Tom Dowe, Shan Huang, Sonia Khela, Hsin-Ying Lee, Karin Tamar, Jonathan Usherwood, Meirion Hopkins and Snir Halle, for help in digitizing reptile ranges. We thank librarians and colleagues for help in obtaining relevant literature, Gill Bunting and Mark Balman for providing IBA polygons and bird species distribution maps from BirdLife International and Stuart Butchart and four anonymous referees for insightful comments. AB thanks the Gerald M. Lemole endowed Chair funds. GRC thanks CAPES - Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq and Fundação de Apoio à Pesquisa do Distrito Federal – FAPDF for financial support. ID was supported by a Niche Research Grant Scheme, NRGS/1087/2–13(01). CN and MM were supported by São Paulo Research Foundation (FAPESP #2011/50206-9, #2012/19858-2 to CN). MM acknowledges a research fellowship from CNPq. OTC acknowledges support from SENESCYT. RG acknowledges the John Fell Fund of the University of Oxford for support. AA and SM acknowledge support from a BSF grant # 2012143.

## Author contributions

AMB, RG, SM, UR conceived the study. RG, CDLO, UR designed the analyses. UR conducted the analyses. AF, SM, MN, UR complied, designed, and curated the dataset. RG, SM, UR wrote the paper. AA, AMB, MB, RB, BC, FCH, LC, GRC, LD, ID, TMD, AF, LLG, MH, YI, FK, AL, ML, EM, DM, MM, SM, CCN, MN, ZTN, GP, OSGP, DPD, UR, RS, OT, OTC, JFT, EV, PU, PW, YW provided, collated, and verified underlying data. All authors read and commented on the manuscript.

272 UR, AF and MN contributed equally to the paper. RG and SM contributed equally to the paper.

### 273 **Competing interests**

274 All authors declare no competing interests.

### 275 **Materials & Correspondence**

276 Corresponding author – Shai Meiri, Department of Zoology, Tel-Aviv University, Tel-Aviv  
277 6997801, Israel. [uncshai@post.tau.ac.il](mailto:uncshai@post.tau.ac.il)

### 278 **Data availability**

279 The reptile distribution data used in this study are available from Dryad (doi TBA)

280

### 281 **References:**

282 <sup>1</sup> Grenyer, R. *et al.*, Global distribution and conservation of rare and threatened vertebrates.  
283 *Nature* 444 (7115), 93-96 (2006).

284 <sup>2</sup> Orme, C.D.L. *et al.*, Global hotspots of species richness are not congruent with endemism  
285 or threat. *Nature* 436 (7053), 1016-1019 (2005).

286 <sup>3</sup> Stuart, S.N. *et al.*, Status and trends of amphibian declines and extinctions worldwide.  
287 *Science* 306 (5702), 1783-1786 (2004).

288 <sup>4</sup> Brooks, T.M. *et al.*, Global biodiversity conservation priorities. *Science* 313 (5783), 58-  
289 61 (2006).

290 <sup>5</sup> Kremen, C. *et al.*, Aligning conservation priorities across taxa in Madagascar with high-  
291 resolution planning tools. *Science* 320 (5873), 222-226 (2008).

292     <sup>6</sup>     Wilson, K.A., McBride, M.F., Bode, M., & Possingham, H.P., Prioritizing global  
293     conservation efforts. *Nature* 440 (7082), 337-340 (2006).

294     <sup>7</sup>     Holt, B.G. *et al.*, An update of Wallace's zoogeographic regions of the world. *Science*  
295     339 (6115), 74-78 (2013).

296     <sup>8</sup>     Schipper, J. *et al.*, The status of the world's land and marine mammals: Diversity, threat,  
297     and knowledge. *Science* 322 (5899), 225-230 (2008).

298     <sup>9</sup>     Bates, S.T. *et al.*, Examining the global distribution of dominant archaeal populations in  
299     soil. *ISME Journal* 5 (5), 908-917 (2011).

300     <sup>10</sup>    Morueta-Holme, N. *et al.*, Habitat area and climate stability determine geographical  
301     variation in plant species range sizes. *Ecology Letters* 16 (12), 1446-1454 (2013).

302     <sup>11</sup>    Stuart-Smith, R.D. *et al.*, Integrating abundance and functional traits reveals new global  
303     hotspots of fish diversity. *Nature* 501 (7468), 539-542 (2013).

304     <sup>12</sup>    Tittensor, D.P. *et al.*, Global patterns and predictors of marine biodiversity across taxa.  
305     *Nature* 466 (7310), 1098-1101 (2010).

306     <sup>13</sup>    Mittermeier, R.A. *et al.*, *Hotspots Revisited: Earth's Biologically Richest and Most*  
307     *Endangered Ecoregions*. (CEMEX, Mexico City, Mexico, 2004).

308     <sup>14</sup>    Olson, D.M. & Dinerstein, E., The global 200: A representation approach to conserving  
309     the Earth's most biologically valuable ecoregions. *Conservation Biology* 12 (3), 502-515  
310     (1998).

311     <sup>15</sup>    BirdLife International, Important Bird and Biodiversity Area (IBA) digital boundaries.  
312     Version 2015 2 (BirdLife International, Cambridge, UK, 2015).

313     <sup>16</sup>    Jetz, W. & Rahbek, C., Geographic range size and determinants of avian species  
314     Richness. *Science* 297 (5586), 1548-1551 (2002).



315    <sup>17</sup>    Lennon, J.J., Koleff, P., Greenwood, J.J.D., & Gaston, K.J., Contribution of rarity and  
316        commonness to patterns of species richness. *Ecology Letters* 7 (2), 81-87 (2004).

317    <sup>18</sup>    Joppa, L.N., Visconti, P., Jenkins, C.N., & Pimm, S.L., Achieving the Convention on  
318        Biological Diversity's goals for plant conservation. *Science* 341 (6150), 1100-1103  
319        (2013).

320    <sup>19</sup>    Naidoo, R. & Iwamura, T., Global-scale mapping of economic benefits from agricultural  
321        lands: implications for conservation priorities. *Biological Conservation* 140 (1), 40-49  
322        (2007).

323    <sup>20</sup>    Moilanen, A. *et al.*, Prioritizing multiple-use landscapes for conservation: methods for  
324        large multi-species planning problems. *Proceedings of the Royal Society of London B:*  
325        *Biological Sciences* 272 (1575), 1885-1891 (2005).

326    <sup>21</sup>    Pianka, E.R., The many dimensions of a lizard's ecological niche in *Lacertids of the*  
327        *Mediterranean region*, edited by E.D. Valakos, W. Böhme, V. Pérez-Mellado, & P.  
328        Maragou (Hellenic Zoological Society, University of Athens, Greece, 1993).

329    <sup>22</sup>    Lewin, A. *et al.*, Patterns of species richness, endemism and environmental gradients of  
330        African reptiles. *Journal of Biogeography* (2016), doi: 10.1111/jbi.12848.

331    <sup>23</sup>    Powney, G.D., Grenyer, R., Orme, C.D.L., Owens, I.P.F., & Meiri, S., Hot, dry and  
332        different: Australian lizard richness is unlike that of mammals, amphibians and birds.  
333        *Global Ecology and Biogeography* 19 (3), 386-396 (2010).

334    <sup>24</sup>    Böhm, M. *et al.*, The conservation status of the world's reptiles. *Biological Conservation*  
335        157 (0), 372-385 (2013).

336    <sup>25</sup>    Meiri, S. & Chapple, D.G., Biases in the current knowledge of threat status in lizards, and  
337        bridging the 'assessment gap'. *Biological Conservation* 2014A, 6-15 (2016).

338 <sup>26</sup> Roll, U. *et al.*, Using Wikipedia page views to explore the cultural importance of global  
339 reptiles. *Biological Conservation* 204A, 42-50 (2016).

340 <sup>27</sup> Bode, M. *et al.*, Cost-effective global conservation spending is robust to taxonomic  
341 group. *Proceedings of the National Academy of Sciences of the United States of America*  
342 105 (17), 6498-6501 (2008).

343 <sup>28</sup> Hawkins, B.A. *et al.*, Energy, water, and broad-scale geographic patterns of species  
344 richness. *Ecology* 84 (12), 3105-3117 (2003).

345 <sup>29</sup> Uetz, P. & Hošek, J., The Reptile Database, Available at [http://www.reptile-](http://www.reptile-database.org/)  
346 [database.org/](http://www.reptile-database.org/), (April 2015).

347 <sup>30</sup> Pouzols, F.M. *et al.*, Global protected area expansion is compromised by projected land-  
348 use and parochialism. *Nature* 516: 383–386 (2014).

349 <sup>31</sup> Scott, J.M. *et al.*, Gap Analysis: a geographic approach to protection of biological  
350 diversity. *Wildlife Monographs*, 123: 3-41 (1993).

351 <sup>32</sup> Maldonado, C. *et al.*, Estimating species diversity and distribution in the era of Big Data:  
352 to what extent can we trust public databases? *Global Ecology and Biogeography*, 24:  
353 973–984 (2015).

354 <sup>33</sup> Maréchaux, I., Rodrigues, A.S.L. & Charpentier, A., The value of coarse species range  
355 maps to inform local biodiversity conservation in a global context. *Ecography*, doi:  
356 10.1111/ecog.02598 (2017).

357 <sup>34</sup> Cantú-Salazar, L. & Gaston, K.J., Species richness and representation in protected areas  
358 of the Western hemisphere: discrepancies between checklists and range maps. *Diversity*  
359 *& Distributions* 19: 782–793 (2013).

360

361     <sup>35</sup>     Anselin, L., Local indicators of spatial association - LISA. *Geographical analysis* 27 (2),  
362             93-115 (1995).

## Figure captions

Figure 1 – Species richness maps of terrestrial tetrapods a) Richness of all tetrapods (reptiles, amphibians, birds and mammals). b-e: species richness of reptile groups b) all reptiles, c) ‘lizards’ d) snakes, e) turtles. Grey areas denote terrestrial regions devoid of species in a particular group. Blue colours denote regions with few species and red ones denote regions with many species (note that the scale differs between panels). All maps in an equal area, Behrmann projection at a 48.25 \*48.25 km grid-cell resolution).

Figure 2 – Comparing reptile richness to other tetrapods. Hexagon scatter plots comparing species richness values per grid-cell with binning (black line indicates a loess fit,  $\alpha=0.6$ ) of tetrapods without reptiles, to a) all reptiles, b) ‘lizards’ and c) snakes. d) a map of the ratio of reptile richness to non-reptilian tetrapod richness per grid cell (note the wide range of values for the top category). Hatched regions designate areas where this proportion in the top 5% (black) and 25% (grey).

Figure 3 –Species richness hotspots of reptiles and reptile groups. In each panel the lightest colour denote the 10% of 48.25\*48.25 km grid-cells with the highest numbers of species, and as the colours get darker they represent the top 7.5%, 5% and richest 2.5% cells respectively. a) all reptiles, b) lizards, c) snakes, and d) turtles.

Figure 4 – Key areas for tetrapod conservation, highlighting regions that rise in importance for conservation due to inclusion of reptiles. Cells were ranked in a formal prioritisation scheme<sup>20</sup>, based on complementarity when ranking cells in an iterative manner. Cells were ranked twice, I- with all tetrapods, II- with all tetrapods excluding reptiles. a) Patterns per 0.5 degree grid-cell where colours represent the priority ranks for the scheme which included all tetrapods (blue =

low, red = high). The cells that are highlighted with the bold foreground colours are those that pinpoint those regions that gain in conservation importance due to the inclusion of the reptile data. These cells were selected following these two rules (i) they were in the top 10% of increase in rank, when subtracting the ranks of the analysis with reptiles from the ranks of the analysis without them; and (ii) were part of statistically significant spatial clusters of rank changes (using local Moran's  $I^{35}$ ). b) The mean change in rank between prioritizations with and without reptiles (using the above method), per ecoregion (red- ecoregions that become more important due to the inclusion of reptile information; blue – ecoregions becoming less important).