

1 **Phylogenetic patterns of extinction risk: the need for critical application**
2 **of appropriate datasets**

3
4 Roy E. Gereau^{1*}, Neil D. Burgess^{2,3}, Jon Fjeldså⁴, Jaclyn Hall⁵, Andreas Hemp⁶, Alistair
5 S. Jump⁷, Asukile R. Kajuni⁸, Robert A. Marchant⁹, Andrew R. Marshall^{10,11}, Philip J.
6 Platts⁹, Charlotte M. Taylor¹, Flora I. Tibazarwa¹²
7
8

9 ¹Missouri Botanical Garden, P.O. Box 299, St. Louis, MO 63166-0299, U.S.A.

10
11 ²Conservation Science Group, Zoology Department, University of Cambridge,
12 Cambridge, CB2 3EJ, UK

13
14 ³WWF-US Conservation Science Program, 1250 24th Street NW, Washington DC 20037,
15 U.S.A.

16
17 ⁴Center for Macroecology, Evolution and Climate, Natural History Museum of Denmark,
18 University of Copenhagen, DENMARK

19
20 ⁵Department of Geography, University of Florida, 3141 Turlington Hall, Gainesville, FL
21 32611-7315, U.S.A.

22
23 ⁶Department of Plant Systematics, University of Bayreuth, Universitaetsstr. 30-31, 95440
24 Bayreuth, GERMANY

25
26 ⁷Biological and Environmental Sciences, School of Natural Sciences, University of
27 Stirling, Stirling FK9 4LA, UK

28
29 ⁸WWF Tanzania Country Office, Plot 350, Regent Estate Mikocheni, P.O. Box 63117,
30 Dar es Salaam, TANZANIA

31
32 ⁹York Institute for Tropical Ecosystems, Environment Department, University of York,
33 York, YO10 5DD, UK

34
35 ¹⁰Centre for Integration of Research, Conservation and Learning (CIRCLE), Environment
36 Department, University of York, York, YO10 5DD, UK

37
38 ¹¹Flamingo Land Ltd., North Yorkshire, YO17 6UX, UK

39
40 ¹²Tanzania Commission for Science and Technology, P.O. Box 4302, Dar es Salaam,
41 TANZANIA

42
43
44 *Correspondence: telephone +1 (314) 577-9574; e-mail roy.gereau@mobot.org

1 **Abstract**

2

3 In order to conduct a replicable analysis of the possible phylogenetic patterns of
4 extinction risk, one must first formulate a clear set of definitions of ecosystem boundaries
5 and risk categories. Subsequently, a robust and internally consistent dataset that includes
6 all the available information on species distributions and risk assessments must be
7 assembled. Here, we review the dataset and methodology of a recent paper focused on
8 phylogenetic patterns of plant extinction risk in the Eastern Arc Mountains of Kenya and
9 Tanzania and point out some of the limitations of inferring such patterns from inadequate
10 and biased data. We show that bias in the dataset is probably responsible for the
11 conclusion that Vulnerable species are more closely related than expected by chance, and
12 provide guidelines for the construction of an appropriate dataset for such an analysis.

1 **Introduction**

2

3 Natural habitats are changing at a rate unprecedented in human history, as a result of both
4 direct and indirect human disturbance. It is thus essential to understand the extinction risk
5 facing species in ecosystems worldwide (Butchart et al., 2010). Yessoufou, Daru &
6 Davies (2012) present an approach that aims to elucidate phylogenetic factors that have a
7 role in determining the extinction risk of plant species in diverse tropical ecosystems, and
8 suggest that their results may be used to guide conservation management. We are
9 concerned, however, that their study suffers from several methodological flaws that
10 undermine the reliability of their conclusions and have the potential to misdirect
11 conservation efforts. Our principal criticisms of the paper are: 1) inadequate knowledge
12 of the study area, its flora, and relevant literature; 2) lack of transparent or repeatable
13 methods for data selection, compounded by inadequate sample size; and 3) compilation
14 and analysis of an inconsistent dataset containing non-equivalent Red List assessments
15 performed under different criteria and at different times.

16

17 **Characterization and delimitation of study area**

18

19 The study by Yessoufou, Daru & Davies (2012) focuses on selected plants of Tanzania,
20 with particular reference to part of the Eastern Arc Mountains of Kenya and Tanzania.
21 Despite the authors' claim to have made "a thorough literature survey", they cite no
22 recent literature characterizing the area's ecosystems and vegetation (e.g. Critical
23 Ecosystem Partnership Fund, 2003; Conservation International, 2008) or detailing its
24 flora and plant endemism (e.g. Gereau, Taylor & Luke, 2006), conservation assessments
25 and priorities (e.g. Newmark, 2002; Doggart et al., 2006; Gereau et al., 2009; Platts et al.,
26 2010; Ahrends et al., 2011), elevational distribution of extinction risk (e.g. Hall et al.,
27 2009), ecological and environmental history (e.g. Finch, Leng & Marchant, 2009; Finch
28 & Marchant, 2011), or physiographic delimitation (e.g. Platts et al., 2011). This lack of
29 adequate context is reflected in the authors' characterization of the Eastern Arc
30 Mountains as "woefully-understudied", and crucially undermines their ability to interpret
31 their findings accurately and objectively.

1 Yessoufou, Daru & Davies (2012) present a general description of the physical and
2 biological properties of the Eastern Arc Mountains, yet they do not provide a rigorous
3 delimitation of the study area's geographic boundaries, altitudinal limits, or other
4 parameters (cf. Platts et al., 2011). Thus the criteria for selection of their list of 230
5 Eastern Arc plant species with data on threat status (presented in their Table S2) are
6 unclear, so that the list cannot be tested nor a comparable list compiled from other data or
7 by other researchers. Furthermore, the authors leave out of their analysis the flora of an
8 important part of the Eastern Arc, the Taita Hills of Kenya, although they include the
9 Taita Hills in their description of the study area. The entire Eastern Arc has long been
10 identified as a single area for conservation and phytogeographic analysis (Lovett, 1990,
11 1993; Burgess et al., 2007). Thus the inclusion of the entire area is important to achieve
12 the stated goals of the study, and at a minimum the exclusion of the Taita Hills from the
13 study should be justified.

14

15 **Limitations and bias of the dataset**

16

17 For their analysis of conservation status and phylogeny, the authors downloaded
18 assessment details from the IUCN Red List website (www.iucnredlist.org) for the 581
19 Tanzanian flowering plant species that had been posted as of May 2012. By the authors'
20 own statement, this constitutes about 5% of the total country flora. This sample is not
21 adequate or representative, either phylogenetically or phytogeographically, to address
22 patterns of extinction risk across any regional flora. For these 581 species, 249
23 assessments were performed between 1998 and 2000 using the IUCN Categories and
24 Criteria version 2.3 (IUCN, 1994), and 332 were performed between 2003 and 2011
25 using the Categories and Criteria version 3.1 (IUCN, 2001). Because of marked
26 methodological differences between versions 2.3 and 3.1, these two sets of assessments
27 are not comparable and should at the least be analyzed separately. Indeed, it is doubtful
28 that assessments using version 2.3 should be analyzed at all before reassessment under
29 version 3.1 (http://www.iucnredlist.org/documents/RL_Criteria_1994_versus_2001.pdf).

1 Although the authors examine the possibility of taxonomic bias in the assessed species,
2 the bias in species selection for Red List assessment is not primarily taxonomic. Species
3 are selected for assessment primarily due to other factors including rarity, restricted
4 distribution, extreme habitat specialization, and human exploitation (Gereau et al., 2009).
5 This creates an *a priori* bias toward inclusion on the Red List in the threatened categories,
6 independent of taxonomy. Assessments performed under Red List Criteria version 2.3
7 were also strongly biased toward woody species, with almost no herbaceous taxa
8 assessed during this period, even though herbaceous species comprise ca. 60-70% of the
9 East African flora and the Eastern Arc Mountains consist not only of forests but also
10 significant areas of grassland, woodland, and other habitats with a high diversity of
11 herbaceous species. Both East Africa as a whole and the Eastern Arc in particular have
12 given rise to major species radiations of herbaceous families and genera of significant
13 management concern (e.g. Orchidaceae [orchids], 207 species in Eastern Arc; *Impatiens*
14 ['Busy Lizzie'], 42 species; *Saintpaulia* ['African Violet'], 8 species with 9 mostly very
15 localized subspecies, i.e. all species in the genus, with 7 species and 8 subspecies
16 endemic to the Eastern Arc), which are significant for understanding the extinction
17 dynamics of this flora, yet none of these are represented in the analysis.

18
19 A principal conclusion of Yessoufou, Daru & Davies (2012) is that “Vulnerable species
20 are more closely related than expected by chance, whereas endangered and critically
21 endangered species are not significantly clustered on the phylogeny.” However, the
22 assessments performed under Red List Criteria version 2.3 were strongly operationally
23 biased toward the Vulnerable category. In a series of seven Red List workshops
24 conducted between 2006 and 2013, the Eastern African Plant Red List Authority
25 (EAPRLA) has reassessed many of these species under version 3.1 and has moved many
26 of them into higher threat categories or downgraded them to Near Threatened or Least
27 Concern. The results of these Red List workshops are currently being processed by the
28 IUCN and are expected to be accessible on the Red List website (www.iucnredlist.org)
29 before the end of 2013 (W.R.Q. Luke pers. comm., 2013).

1 **Improvement of the dataset**

2

3 Using the mountain bloc boundaries as delimited by Platts et al. (2011) and a
4 comprehensive checklist of the Eastern Arc flora downloaded from www.tropicos.org,
5 we find that 1142 Eastern Arc plant taxa (949 species, 193 subspecies and varieties) have
6 information on threat status (www.iucnredlist.org, accessed April 2013; W.R.Q. Luke
7 pers. comm., 2013). Of these, 1031 taxa have been assessed under Red List criteria
8 version 3.1. Of the 111 taxa assessed under version 2.3 and still pending reassessment, 92
9 (82.9%) are in the Vulnerable category, demonstrating the above-described bias toward
10 this category in early assessments. In contrast, of the 1031 taxa assessed under version
11 3.1, almost half (486 taxa) are in non-threatened categories and, of those in threatened
12 categories, the distribution across threat categories is relatively balanced (14% CR, 45%
13 EN, 41% VU). We conclude that any statistical groupings of families based on the
14 admixture of assessments performed under versions 2.3 and 3.1 are unlikely to have
15 phylogenetic relevance.

16

17 **Conclusion**

18

19 In conclusion, we emphasize that the analytical methods suggested by Yessoufou, Daru
20 & Davies (2012) may potentially have significant value for analysis of phylogenetic
21 patterns of extinction risk, in the Eastern Arc Mountains and elsewhere, but that this can
22 only be realized through critical application of appropriate datasets, underpinned by a
23 thorough review of current knowledge of a region and its flora.

1 **References**

2

3 Ahrends, A., N.D. Burgess, R.E. Gereau, R. Marchant, M.T. Bulling, J.C. Lovett, P.J.
4 Platts, V.W. Kindemba, N. Owen, E. Fanning & C. Rahbek. 2011. Funding begets
5 biodiversity. *Diversity and Distributions* 17: 191-200.

6 Burgess, N.D., T.M. Butynski, N.J. Cordeiro, N.H. Doggart, J. Fjeldså, K.M. Howell,
7 F.B. Kilahama, S.P. Loader, J.C. Lovett, B. Mbilinyi, M. Menegon, D.C. Moyer, E.
8 Nashanda, A. Perkin, F. Rovero, W.T. Stanley & S.N. Stuart. 2007. The biological
9 importance of the Eastern Arc Mountains of Tanzania and Kenya. *Biological*
10 *Conservation* 134: 209-231.

11 Butchart, S.H.M., M. Walpole, B. Collen, A. van Strien, J.P.W. Scharlemann, R.E.A.
12 Almond, J.E.M. Baillie, B. Bomhard, C. Brown, J. Bruno, K.E. Carpenter, G.M. Carr,
13 J. Chanson, A.M. Chenery, J. Csirke, N.C. Davidson, F. Dentener, M. Foster, A. Galli,
14 J.N. Galloway, P. Genovesi, R.D. Gregory, M. Hockings, V. Kapos, J.-F. Lamarque,
15 F. Leverington, J. Loh, M.A. McGeoch, L. McRae, A. Minasyan, M.H. Morcillo,
16 T.E.E. Oldfield, D. Pauly, S. Quader, C. Revenga, J.R. Sauer, B. Skolnik, D. Spear, D.
17 Stanwell-Smith, S.N. Stuart, A. Symes, M. Tierney, T.D. Tyrrell, J.-C. Vié & R.
18 Watson. 2010. Global biodiversity: indicators of recent declines. *Science* 328: 1164-
19 1168.

20 Conservation International. 2008. Forest cover and change in Eastern Arc mountain and
21 coastal forests, 1990–2000 [www document]. URL

22 http://www.cepf.net/where_we_work/regions/africa/eastern_arc_coastal_forests/

23 Critical Ecosystem Partnership Fund. 2003. *Ecosystem Profile: Eastern Arc Mountains &*
24 *Coastal Forests of Tanzania & Kenya Biodiversity Hotspot*. Conservation
25 International, Washington DC.

26 Doggart, N., A. Perkin, J. Kiure, J. Fjeldså, J. Poynton & N. Burgess. 2006. Changing
27 places: how the results of new field work in the Rubeho Mountains influence
28 conservation priorities in the Eastern Arc Mountains of Tanzania. *African Journal of*
29 *Ecology* 44: 134-144.

30 Finch, J.M., M.J. Leng & R.A. Marchant. 2009. Vegetation history of a biodiversity
31 hotspot, the Eastern Arc Mountains of Tanzania. *Quaternary Research* 72: 111-122.

- 1 Finch, J.M. & R.A. Marchant. 2011. A palaeoecological investigation into the role of fire
2 and human activity in the development of montane grasslands in East Africa.
3 *Vegetation History and Archaeobotany* 20: 109-124.
- 4 Gereau, R.E., C.M. Taylor & W.R.Q. Luke. 2006. Endemic plant species of the Eastern
5 Arc Mountains of Kenya and Tanzania: analysis and refinement of distribution
6 patterns. Pp. 267-277 in: S.A. Ghazanfar & H.J. Beentje (editors), *Taxonomy and*
7 *Ecology of African Plants, their Conservation and Sustainable Use. Proceedings of*
8 *the 17th AETFAT Congress, Addis Ababa, Ethiopia*. Royal Botanic Gardens, Kew.
- 9 Gereau, R.E., W.R.Q. Luke, W. Kindeketa, S. Bodine & G.E. Schatz. 2009. Plant
10 conservation assessment in East Africa: procedures and first results. Pp. 469-473 in:
11 X. van der Burgt, J. van der Maesen & J.-M. Onana (editors), *Systematics and*
12 *Conservation of African Plants. Proceedings of the 18th AETFAT Congress, Yaoundé,*
13 *Cameroon*. Royal Botanic Gardens, Kew.
- 14 Hall, J., N.D. Burgess, J. Lovett, B. Mbilinyi & R.E. Gereau. 2009. Conservation
15 implications of deforestation across an elevational gradient in the Eastern Arc
16 Mountains, Tanzania. *Biological Conservation* 142: 2510-2521.
- 17 IUCN. 1994. *IUCN Red List Categories*. Prepared by the IUCN Species Survival
18 Commission. IUCN, Gland, Switzerland.
- 19 IUCN. 2001. *IUCN Red List Categories and Criteria : Version 3.1*. IUCN Species
20 Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.
- 21 Lovett, J.C. 1990. Classification and status of the moist forests of Tanzania. *Mitteilungen*
22 *aus dem Institut für allgemeine Botanik in Hamburg* 23a: 287-300.
- 23 Lovett, J.C. 1993. Temperate and tropical floras in the mountains of eastern Tanzania.
24 *Opera Botanica* 121: 217-227.
- 25 Newmark, W.D. 2002. *Conserving Biodiversity in East African Forests: a Study of the*
26 *Eastern Arc Mountains*. Berlin, Germany: Springer.
- 27 Platts, P.J., A. Ahrends, R.E. Gereau, C.J. McClean, J.C. Lovett, A.R. Marshall, P.K.E.
28 Pellikka, E. Fanning & R. Marchant. 2010. Can distribution models help refine
29 inventory-based estimates of conservation priority? A case study in the Eastern Arc
30 forests of Tanzania and Kenya. *Diversity and Distributions* 16: 628-642.

- 1 Platts, P.J., N.D. Burgess, R.E. Gereau, J.C. Lovett, A.R. Marshall, C.J. McClean, P.K.E.
2 Pellikka, R.D. Swetnam & R. Marchant. 2011. Delimiting tropical mountain
3 ecoregions for conservation. *Environmental Conservation* 38: 312-324.
4 Yessoufou, K., B.H. Daru & T. J. Davies. 2012. Phylogenetic patters of extinction risk in
5 the Eastern Arc ecosystems, an African biodiversity hotspot. *PLoS ONE* 7(10):
6 e47082. doi:10.1371/journal.pone.0047082