

1 **The untapped potential of conservation journals to promote freshwater**
2 **biodiversity**

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13

14 **Abstract**

15 Freshwater ecosystems are amongst the most diverse ecosystems on the planet. They
16 are subject to intense and increasing threats and have a higher proportion of threatened
17 and extinct species than terrestrial or marine realms. Concurrently, freshwater
18 ecosystems are largely underrepresented in both conservation research and actions
19 arguably as a consequence of less popularity and promotion. To test this assumption,
20 we used cover images as a proxy of exposure and promotion opportunities provided by
21 conservation journals. We collected information on cover images of 18 conservation
22 journals from 1997 to 2016 and data on citations and Altmetric scores of papers
23 published in them. We found that freshwater ecosystems (10.4%) were featured less
24 often than marine (15.2%) or terrestrial (74.4%) ecosystems on covers of these journals.
25 All 15 most featured species are from terrestrial or marine ecosystems, with 14 of them
26 being large vertebrates such as elephants, big cats, rhinos, polar bears, and marine
27 turtles. None of the 95 species featured more than once on the covers of conservation
28 journals spend their whole life history in fresh waters, i.e. they are at least partly
29 associated with terrestrial or marine ecosystems. Our results indicated that cover-
30 featured studies received more attention from academia and the general public, i.e.
31 showed higher citations and Altmetric scores, than non-featured ones within the same
32 issue. By featuring freshwater species and habitats on covers, therewith providing more
33 exposure opportunities, conservation journals hold the potential to promote biodiversity
34 conservation in fresh waters. Scientists can help that endeavour by submitting
35 freshwater-related photos together with their manuscripts for review, therewith

36 providing more options for editors to portray freshwater species and habitats and to
37 ultimately raise awareness and appreciation of freshwater life.

38

39 **Keywords**

40 altmetric, citation, cover image, flagship species, public awareness, social media

41

42 **INTRODUCTION**

43 Freshwater habitats including rivers, lakes, and wetlands cover less than 3% of Earth's
44 surface but support approximately 9.5% of all described animals and one-third of
45 vertebrates (Balian et al., 2008). Meanwhile, freshwater ecosystems are subject to
46 tremendous and increasing pressures due to a growing demand for water, energy, and
47 food, leading to overexploitation of freshwater and organisms (Dudgeon et al., 2006;
48 Vörösmarty et al., 2010; Reid et al., 2019), and to the loss of important habitats such as
49 wetlands and free-flowing rivers (Reis et al., 2017; Grill et al., 2019). Consequently,
50 27% of all assessed freshwater species are considered as threatened with extinction on
51 the International Union for Conservation of Nature (IUCN) Red List of Threatened
52 Species (Tickner et al., 2020), while global freshwater vertebrate populations have
53 declined by 83% from 1970 to 2014 (WWF, 2018).

54 Although the proportions of threatened and extinct species and the decline rate
55 of vertebrate populations are much higher in fresh waters than those in terrestrial or
56 marine ecosystems (Costello, 2015; McRae et al., 2017), freshwater ecosystems are
57 largely underrepresented in biodiversity research and conservation actions (Kalinkat et

58 al., 2017; Jucker et al., 2018; Mazor et al., 2018; Tydecks et al., 2018). Even more
59 worryingly, gaps in conservation actions could be worse than those in research (Clark
60 & May, 2002). Indeed, globally 89% of seasonal freshwater wetlands are not covered
61 by protected areas (Reis et al., 2017), and most of the world's largest rivers have less
62 than 10% of their basins targeted by integrated protection, which falls short of the target
63 (i.e. 17%) of the Convention on Biological Diversity (Abell et al., 2017). Even within
64 protected areas, stressors to freshwater biodiversity often exist. For example, over 1200
65 large dams and 500 proposed hydropower dams are located within protected areas,
66 which affects the effectiveness of the protection of freshwater ecosystems (Thieme et
67 al., 2020).

68 Research and conservation actions to safeguard freshwater biodiversity are
69 likely inadequate as a consequence of low popularity among the general public (Monroe
70 et al., 2009; Cooke et al., 2013). Unlike terrestrial and marine ecosystems represented
71 by popular species such as the big cats, elephants, rhinos, polar bears, and cetaceans,
72 freshwater life remains inconspicuous to the public eye and consequently out of sight
73 and out of mind (Monroe et al., 2009; Darwall et al., 2018; He & Jähnig, 2019). Indeed,
74 public perception and knowledge on biodiversity, including its status and importance,
75 are influenced by available information (Papworth et al., 2015; Kochalski et al., 2019),
76 which is currently biased towards certain species and ecosystems (Clark & May, 2002;
77 Jucker et al., 2018; Mazor et al., 2018; Tydecks et al., 2018).

78 One of the common practices to increase public awareness on biodiversity is
79 featuring species or habitats that are in need of conservation (Clucas et al., 2008).

80 Within the scientific community this is commonly done by conservation journal using
81 species or habitat images as journal covers to promote content, relating the cover image
82 to one of the articles published in the same issue (e.g. Conservation Biology, Diversity
83 and Distributions, and Ecography). These featured species and habitats and related
84 articles are often promoted by journals on social media, which has become an important
85 platform for communicating science and promoting biodiversity conservation (Parsons
86 et al., 2014; Bombaci et al., 2016; Lamb et al., 2018). More and more scientists,
87 conservation journals (e.g. Conservation Biology, Conservation Letters, Animal
88 Conservation, and Ecography) and conservation organizations (IUCN, WWF,
89 Conservation International, and The Nature Conservancy) are active on social media
90 platforms such as Twitter and Facebook, and frequently interact with the general public
91 through these channels (Parsons et al., 2014).

92 Here we explored the idea that there is an untapped potential of conservation
93 journals to promote freshwater biodiversity by providing more exposure opportunities.
94 Since previous studies have suggested that freshwater ecosystems received less
95 attention from biodiversity research and conservation efforts than terrestrial or marine
96 ecosystems (Jucker et al., 2018; Mazor et al., 2018; Tydecks et al., 2018), we, first,
97 hypothesized that freshwater species and habitats are featured less often on covers than
98 terrestrial or marine ones. Second, we hypothesized that cover-featured articles can
99 reach a broader audience and, therefore, receive more attention in the scientific
100 community as well as generally in society than the non-featured articles within the same
101 issue. If these two hypotheses hold true, freshwater biodiversity could benefit from

102 more exposure opportunities for freshwater studies and related cover images, with
103 likely further-reaching benefits for their protection.

104 **METHODS**

105 To test our hypotheses, information on cover images of conservation journals from 1997
106 to 2016 was collected. There are 56 academic journals listed under the category of
107 “biodiversity conservation” in Web of Science database. Among these journals, 18
108 journals were selected as they regularly changed their covers between 1997 and 2016
109 and had information on their covers available online or in the printed copies (Table S1).
110 For each cover image, information on the species or habitats featured on cover images
111 was collected. In total, 1043 images with a clear focus on species or habitats and
112 associated ecosystems were included in our analysis. In addition, information on
113 locations (i.e. country or region where photos were taken) was gathered, if it was
114 indicated. When a species was assessed by the IUCN Red List (IUCN, 2018), its
115 associated ecosystems were assigned following the IUCN Red List. For species which
116 are not on the IUCN Red List, a single ecosystem (i.e. freshwater, marine, or terrestrial)
117 or a combination of ecosystems (e.g. marine and terrestrial) was assigned, according to
118 their life history. Similarly, covers that featured habitats only (without species) were
119 either assigned to a single ecosystem or a combination of ecosystems. In case of
120 multiple ecosystems featured on the same cover, the cover count was split
121 proportionally (e.g. 0.5 points for the terrestrial and the freshwater ecosystem count, if
122 both are shown on the cover).

123 Citation was used as a proxy to measure attention received by published articles

124 from academia. In addition, the Altmetric score was chosen as an indicator of attention
125 from both scientists and the general public. The Altmetric score is a web-driven metric
126 capturing coverage and mentionings on web-based media including news, blogs, social
127 media, and policy documents (Costas et al., 2015). It is considered as a complementary
128 metric to citations, as it can capture broader attention from both scientists and the
129 general public (Piwowar et al., 2013; Bornmann et al., 2014).

130 For nine journals including *Animal Conservation*, *Conservation Biology*,
131 *Conservation Letters*, *Diversity and Distributions*, *Ecography*, *Global Change Biology*,
132 *Journal of Applied Ecology*, *Oryx*, and *Systematic and Biodiversity*, cover images are
133 usually related to articles within the same issue. Citations and Altmetric scores of
134 articles (excluding editorials and book reviews) published in these nine journals
135 between 2014 and 2016 was collated. The citations of articles were derived from Web
136 of Science on October 27th, 2017. The Altmetric scores were collected from journal
137 websites. Considering the fact that Altmetric scores could change over time, Altmetric
138 scores of articles published in the same issue were collected on the same day. Then the
139 percentiles of cover-featured articles within the same issue were calculated, for both
140 citations and Altmetric scores. Wilcoxon signed-rank test was used to test if the
141 percentiles of cover-featured articles are higher than the median (i.e. Q₅₀).

142 **RESULTS**

143 In total, 74.4% of all cover images were related to terrestrial ecosystems, outnumbering
144 the sum of cover images featuring marine (15.2%) or freshwater (10.4%) ecosystems.
145 From 1997 to 2016, terrestrial species and habitats constantly dominated covers of

146 conservation journals (Figure 1), contributing at least 70% to all cover images in each
147 year except for 2010 (64.2%). Since 2007, freshwater ecosystems have been portrayed
148 the fewest in each year. Species and habitats in the USA contributed the highest number
149 (210) of cover images (Figure 2), followed by Canada (26), Brazil (18), Australia (15),
150 and South Africa (15).

151 In terms of individual species (Figure 3), the African elephant (*Loxodonta Africana*;
152 18 times) was featured most often on journals' covers, followed by the tiger (*Panthera*
153 *tigris*; 8), the black rhinoceros (*Diceros bicornis*; 8), the polar bear (*Ursus maritimus*;
154 7), the puma (*Puma concolor*; 7), the gray wolf (*Canis lupus*; 6), and the American
155 black bear (*Ursus americanus*; 6). All 15 most featured species (i.e. featured on journal
156 covers at least 4 times) were from terrestrial or marine ecosystems. Fourteen of them
157 are large vertebrate species with the monarch butterfly (*Danaus plexippus*) being the
158 only invertebrate species.

159 Among the 34 species that were featured at least 3 times on journal covers, only 3
160 species were associated with fresh waters (i.e. *Alligator mississippiensis*, *Ambystoma*
161 *maculatum*, and *Oncorhynchus nerka*), while 6 species were associated with marine
162 and 32 species with terrestrial ecosystems. None of the 95 species featured more than
163 once was solely associated with fresh waters. Meanwhile, 6 of them were only
164 associated with marine ecosystems and 62 species were only associated with terrestrial
165 ecosystems.

166 The median percentiles of citations and Altmetric scores of cover-featured articles
167 were 0.63 and 0.76, respectively (Figure 4). The Wilcoxon signed-rank test showed that

168 featured articles had significantly higher citations ($p < 0.001$, effect size = 0.34) and
169 Altmetric scores ($p < 0.001$, effect size = 0.60) than non-featured ones within the same
170 issue.

171 **DISCUSSION**

172 Our results showed that the distribution of cover images and the related, featured studies
173 were skewed in terms of geographical region and ecosystem. Regions harboring a high
174 amount of biodiversity such as Central Africa, Central America, and South and
175 Southeast Asia are currently vastly underrepresented on journal covers. This supports
176 previous findings that most research and conservation efforts have not focused on the
177 regions where they are most needed (Wilson et al., 2016; Tydecks et al., 2018). In
178 addition, we found freshwater species and habitats being largely underrepresented on
179 covers of conservation journals. Our results are consistent with the findings of Clucas
180 et al. (2008) who found big cats, bears, primates, and large birds are often featured on
181 covers of popular conservation and nature magazines in the USA, while freshwater
182 species such as fish and amphibians were rarely featured. Hence, the covers of
183 conservation journals reflect the current research landscape of biodiversity
184 conservation; so far, most research and conservation efforts have focused on terrestrial
185 and marine ecosystems, particularly on large vertebrates (Clucas et al., 2008; Mazor et
186 al., 2018; Tydecks et al., 2018), while only 18% of all biodiversity studies published
187 from 1945 to 2014 are associated with freshwater ecosystems (Tydecks et al., 2018).
188 This is despite that an urgent need for the conservation of freshwater ecosystems has
189 been addressed over 15 years ago (Abell 2002) and a large body of research shows that

190 threats to freshwater habitats and species are intense and increasing over the last few
191 decades (Dudgeon et al., 2006; Vörösmarty et al., 2010; Reid et al., 2019; He et al.,
192 2018; Grill et al., 2019). Terrestrial and marine megafauna species, which are frequently
193 featured on covers of conservation journals (Figure 3) and popular conservation and
194 nature magazines (Clucas et al., 2008), are the ones that receive most of research and
195 conservation efforts (Donaldson et al., 2016; Ford et al., 2017). These species are also
196 the ones on the list of the 10 most charismatic animals perceived by the general public
197 (Courchamp et al., 2018), while freshwater megafauna are often overlooked (Cooke et
198 al., 2013; Carrizo et al., 2017; He & Jähnig, 2019). Tellingly, no freshwater species has
199 made it onto this list.

200 Three factors may have contributed to the underrepresentation of freshwater
201 species and habitats on the covers of conservation journals: First, fresh waters are often
202 regarded as a resource rather than as important ecosystems. This is despite the fact that
203 they harbor a high level of biodiversity (e.g. 126, 000 animal species), while providing
204 vital ecosystem services (Postel & Carpenter 1997; Balian et al., 2008). Second,
205 compared to terrestrial species, photographers less often portray freshwater species in
206 their natural habitats, but instead display them as “fish out of the water” (i.e. fish species
207 as food or trophy of angling games; Monroe et al., 2009). In addition, large rivers are
208 often turbid, which makes it challenging to photograph freshwater life and underwater
209 habitats compared to marine species and environments. Third, there are generally fewer
210 freshwater studies published in biodiversity and conservation journals than studies
211 focusing on terrestrial or marine ecosystems (Mazor et al., 2018; Tydecks et al., 2018),

212 which therefore limits the choices for editors to display freshwater-related cover images.

213 Popularity of species or ecosystems can also be generated through global initiatives,
214 such as the Census of Marine Life, which has major positive effects on both public
215 perception and conservation actions (Williams et al., 2010; Vermeulen 2013). So far
216 such prominent, large-scale projects are lacking for fresh waters. In addition,
217 charismatic flagship species are much less promoted in fresh waters in comparison with
218 marine ecosystems that are well represented by popular taxa such as whales, dolphins,
219 sharks, and polar bear (Cooke et al., 2013; Kalinkat et al., 2017; Carrizo et al., 2017;
220 He et al., 2018).

221 Within the same journal issue, we found that cover-featured articles have higher
222 citations and Altmetric scores than non-featured ones. This indicates that articles
223 featured on covers received more attention from scientists and the general public. On
224 the one hand, such a correlation does not necessarily imply a causation, i.e. the high
225 citations and Altmetric scores of cover-featured articles may not solely be a result of
226 being promoted on journal covers. It is possible that these cover-featured articles
227 received more attention just because they are more interesting and attractive to
228 scientists and the general public than non-featured ones. As experienced scientists,
229 editors often have a good instinct in selecting potentially popular studies that resonate
230 well in academia and the society. In this case, our results only verified good decisions
231 of editors but not the power of cover images. To this argument adds that nowadays the
232 majority of journal readers access research articles through online portals rather than
233 reading the printed copy, and therefore do not come across the journals' covers. On the

234 other hand, being featured on journal covers can offer more opportunities of exposure
235 to potential readers. For example, cover images are often displayed in prominent
236 positions on websites of conservation journals (e.g. Diversity and Distribution, Animal
237 Conservation, and Journal of Applied Ecology) and are specially mentioned by the
238 journals' accounts on social media platforms together with the featured study. Cover-
239 featured articles are more likely to be noticed, spread through the internet, and picked
240 up by media outlets, and are, in turn, exposed to a more diverse, non-scientific audience
241 than non-featured articles (Lamb et al., 2018). Hence, the selection of cover images and
242 related featured research by conservation journals entails the potential to facilitate and
243 balance the development of conservation actions.

244 Editors may be limited in their options when it comes to the selection of a cover
245 image. For example, many papers only show figures of data and model results which
246 do not provide attractive journal covers. In addition, fewer freshwater studies are
247 accepted in biodiversity and conservation journals than marine or terrestrial ecosystems
248 (Mazor et al., 2018; Tydecks et al., 2018), which makes it challenging for editors to
249 balance the journal covers among ecosystems. By submitting appealing images of
250 freshwater species and habitats to journals as potential cover images along with their
251 freshwater-related articles, scientists can play an active role to support editors in
252 promoting freshwater research. Such images can also be used by journals to promote
253 articles on social media platforms. By doing so, scientists and editors can form an
254 alliance to create momentum in society for fresh waters to be experienced as essential
255 ecosystems harboring charismatic species and providing important ecosystem services.

256 Moreover, scientists can directly enhance their communications with decision makers,
257 media, and the general public to inform them about the need of biodiversity
258 conservation in fresh waters. Such direct interaction has been suggested to influence
259 conservation actions (Parsons et al., 2014; Papworth et al., 2015) and lead to better
260 uptake of science in policy (King et al., 2017).

261 Studies that make it into one of the conservation journals are all significant and
262 novel and have, therefore, a certain potential to be featured on covers. Thus,
263 conservation journals could work towards balancing their choice, inviting more
264 freshwater scientists as editors and providing more exposure opportunities for
265 freshwater-related studies, whenever such an opportunity arises. To support
266 conservation journals in this endeavor, we encourage scientists to include their favorite
267 freshwater photos in future manuscript submissions. We also call for scientists,
268 conservation organizations, and photographers to work together to portray more
269 freshwater species and habitats, raising public awareness and appreciation of freshwater
270 life. In addition, more studies are needed to explore the roles of conservation journals
271 and their social media accounts in promoting biodiversity conservation. For example,
272 it would be interesting to examine the proportion of scientists versus non-scientists in
273 their followers and what makes a post to be retweeted, liked and commented on by
274 these followers. Hence, this study allows formulating specific hypotheses to be tested
275 in future studies, which is a necessary step in solving the major task of safeguarding
276 freshwater ecosystems and its biodiversity that lies ahead of us.

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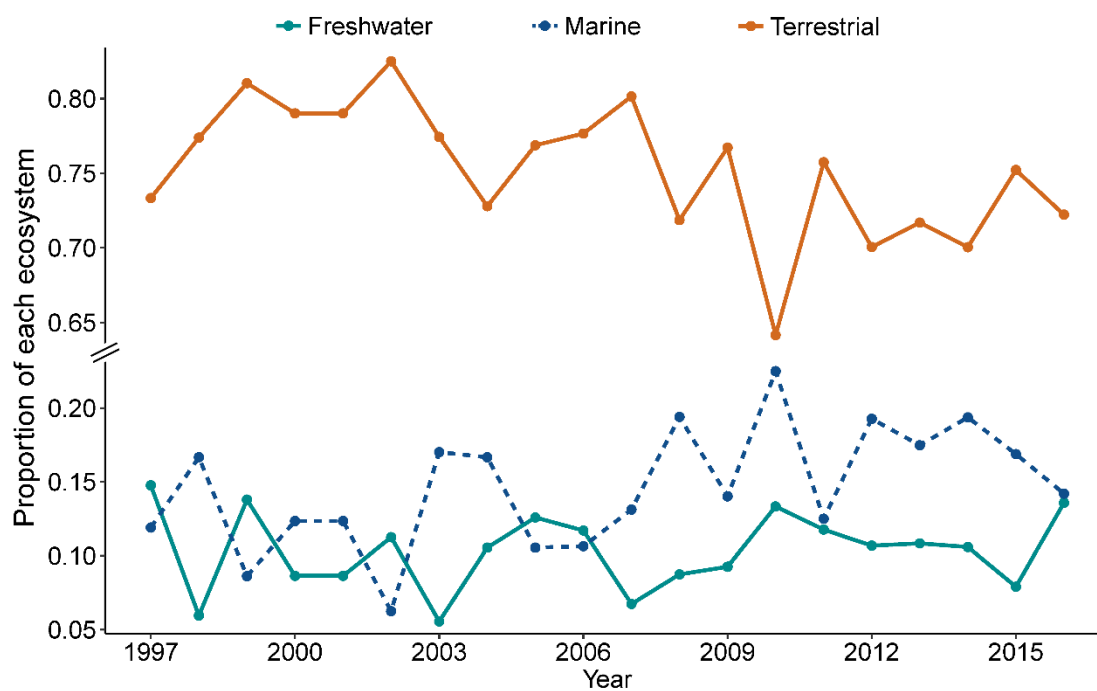
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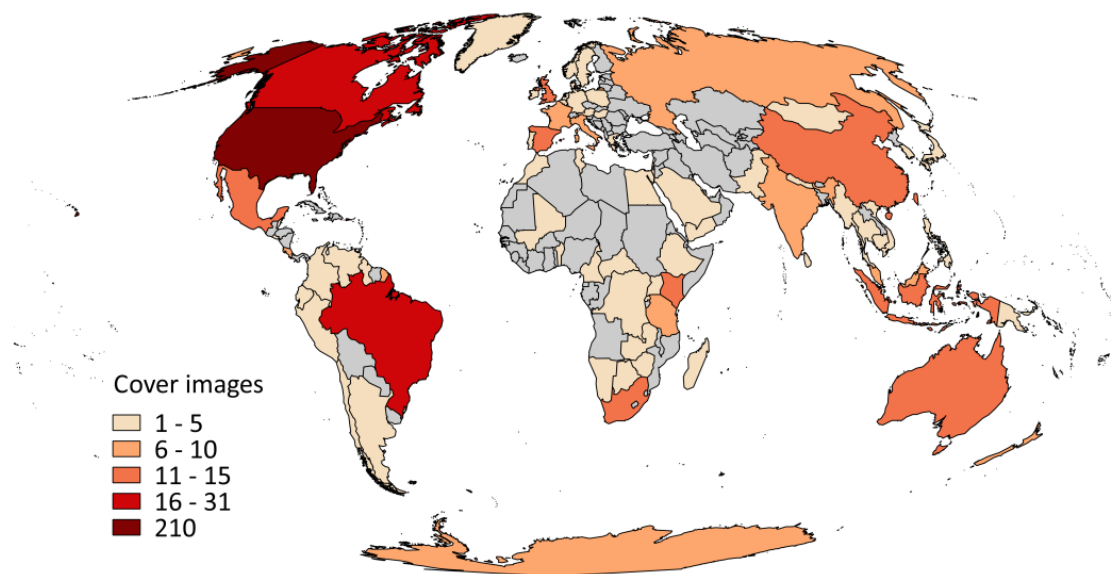
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417 Figure 1 Proportion of species and habitats from each ecosystem on the covers of 18

418 conservation journals between 1997 and 2016.

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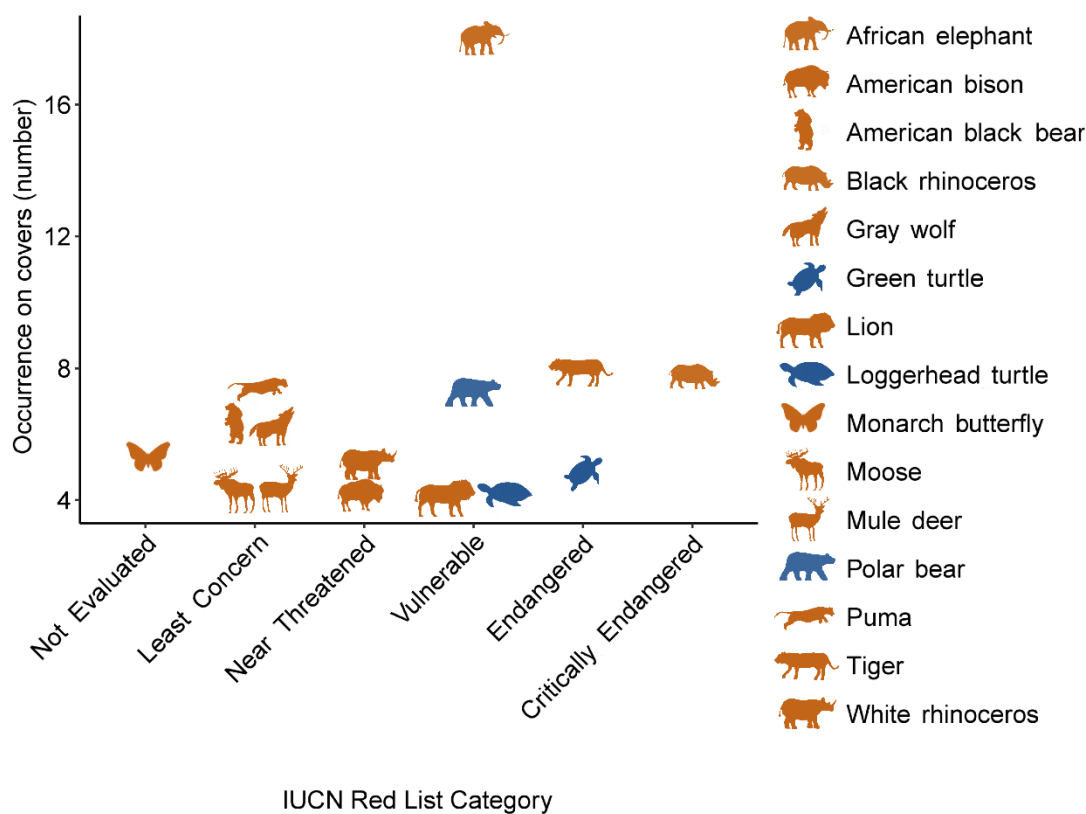


421

422 Figure 2 Number of cover images of 18 conservation journals taken in different

423 countries/regions between 1997 and 2016.

424



425

IUCN Red List Category

426

Figure 3 The 15 most featured species and their IUCN Red List categories on covers of

427

18 conservation journals between 1997 and 2016 (IUCN, 2018; brown-colored animals

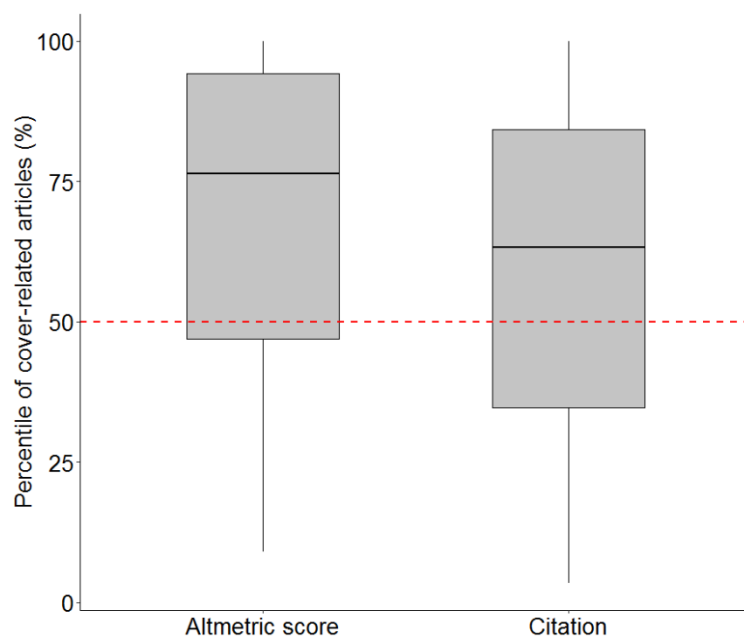
428

are from terrestrial ecosystem while blue-colored animals are associated with both

429

marine and terrestrial ecosystems).

430



431

432 Figure 4 Percentiles of cover-related articles in terms of Altmetric scores and citations

433 within respective issues (N = 168). Red dash line shows the median percentile (i.e. Q50)

434 of all articles within the same issue.

435

436 Table S1 Summary of cover images collected from biodiversity and conservation journals

Journal	Period of data collection	Publication frequency	Twitter account
Animal Conservation [†]	2003-2016 [‡]	Quarterly (2003-2007) Bi-monthly (2008-2016)	Yes
Biodiversity and Conservation	1997-2012 [‡]	Monthly	No
Conservation Biology [†]	1997-2016	Bi-monthly	Yes
Conservation Letters [†]	1998-2016 [‡]	Bi-monthly	Yes
Diversity and Distributions [†]	2016 [‡]	Monthly	Yes
Ecography [†]	2014-2016 [‡]	Monthly	Yes
Global Change Biology [†]	1998-2016	8 issues per year (1997-2001) Monthly (2002-2016)	Yes
Journal for Nature Conservation	2002-2016 [‡]	Quarterly (2002-2010) Bi-monthly (2011-2016)	No
Journal of Applied Ecology [†]	1997-2016	Bi-monthly	Yes
Journal of Fish and Wildlife Management	2010-2016 [‡]	Biannual	No
Northeastern Naturalist	1997-2016	Quarterly	No
Oryx [†]	2007-2016	Quarterly	Yes
Pachyderm	1997-2016	Biannual (1997-2013) Annual (2014-2016)	No
Southeastern Naturalist	2002-2016 [‡]	Quarterly	No
Systematics and Biodiversity [†]	2003-2016 [‡]	Quarterly (2003-2014) Bi-monthly (2015-2016)	No
The Southwestern Naturalist	1997-2016	Quarterly	No
Tropical Conservation Science	2008-2016 [‡]	Quarterly (Bi-monthly in 2013)	No
Wildlife Society Bulletin	1997-2006; 2011-2016 [‡]	Quarterly	No

437 [†]These journals show Altmetric scores for each article on their websites.

438 [‡]These journals started changing cover images regularly after 1997. All cover images have been
439 included. Wildlife Society Bulletin has been paused between 2007-2010.

440