



# Quantifying the role of online news in linking conservation research to Facebook and Twitter

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**Abstract:** Conservation science needs to engage the general public to ensure successful conservation interventions. Although online technologies such as Twitter and Facebook offer new opportunities to accelerate communication between conservation scientists and the online public, factors influencing the spread of conservation news in online media are not well understood. We explored transmission of conservation research through online news articles with generalized linear mixed-effects models and an information theoretic approach. In particular, we assessed differences in the frequency conservation research is featured on online news sites and the impact of online conservation news content and delivery on Facebook likes and shares and Twitter tweets. Five percent of articles in conservation journals are reported in online news, and the probability of reporting depended on the journal. There was weak evidence that articles on climate change and mammals were more likely to be featured. Online news articles about charismatic mammals with illustrations were more likely to be shared or liked on Facebook and Twitter, but the effect of news sites was much larger. These results suggest journals have the greatest impact on which conservation research is featured and that news site has the greatest impact on how popular an online article will be on Facebook and Twitter.

**Keywords:** Almetric.com, Facebook, online news, science communication, social media, Twitter

Cuantificación del Papel de las Noticias En Línea en el Enlazamiento de la Investigación para la Conservación con Facebook y Twitter

**Resumen:** La ciencia de la conservación necesita involucrar al público en general para asegurar intervenciones exitosas de conservación. Aunque tecnologías en línea como Twitter y Facebook ofrecen nuevas oportunidades para acelerar la comunicación entre los científicos de la conservación y el público en línea, los factores que influyen sobre el esparcimiento de las noticias de conservación en los medios en línea no están bien entendidos. Exploramos la transmisión de la investigación de la conservación a través de artículos en línea con modelos lineales generalizados de efectos mixtos y un enfoque teórico de información. En particular, evaluamos las diferencias en la frecuencia con la que la investigación de la conservación es incluida en sitios en línea de noticias y el impacto del contenido y la forma de comunicarse de las noticias de conservación sobre los "likes" y número de veces que se comparte en Facebook y sobre los tuits en Twitter. El 5% de los artículos de las revistas de conservación se reportan en noticias en línea y la probabilidad de reportar dependió de la revista. Hubo evidencias débiles de que los artículos sobre el cambio climático y los mamíferos tuvieron mayor probabilidad de ser incluidos. Las noticias en línea sobre mamíferos carismáticos con ilustraciones fueron más probables de ser compartidas o que obtuvieran "likes" en Facebook y Twitter, pero el efecto de los sitios de noticias fue mucho mayor. Estos resultados sugieren que las revistas tienen el mayor impacto sobre

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*cuál investigación se incluye y que los sitios de noticias tienen el mayor impacto sobre cuán popular será un artículo en Facebook o Twitter.*

**Palabras Clave:** Almetric.com, ciencia de la comunicación, Facebook, medios sociales, noticias en línea, Twitter

## Introduction

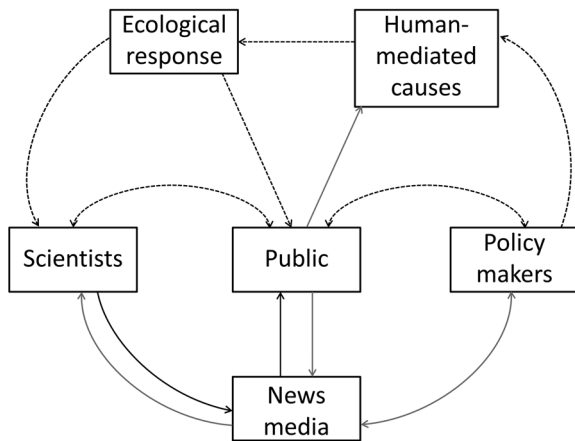
The conservation process has been conceptualized as involving 3 main sectors of society—scientists, the public, and policy makers (Baron 2010). Although this conceptualization of interactions suggests one-way reactionary pathways, where information on specific issues moves from scientists, to the public, and then policy makers, the conservation process is far more complex and involves multiple interactions among diverse actors in these sectors (Phillis et al. 2013). Public awareness is often a crucial first step toward policy change and resolution of conservation issues because societal values determine whether initiatives and interventions gain support (Novacek 2008; Brown et al. 2010). Thus, scientists are encouraged to increase their communication with the public (e.g., Pace et al. 2010; Bickford et al. 2012). In addition to outreach and direct communication between scientists and the public, news media (e.g., print, broadcasts, and websites dedicated to current news) are a common venue for presentation of science topics to nonexperts (Brossard & Lewenstein 2010). News coverage of conservation issues is an important pathway to transfer information to large audiences because it can translate academic research and policy for general audiences (Smith et al. 2010; Verissimo et al. 2014). There is evidence that public engagement with the news positively influences civic participation (Livingstone & Markham 2008), and news media has played a role in promoting beneficial behaviors (Abroms & Maibach 2008).

The role of news media in public awareness and interpretation of societal issues is not straightforward (Berkowitz 1992). On one hand, coverage of environmental issues is considered a reflection of public interest (e.g., Phillis et al. 2013). Yet agenda-setting theory, which examines how the salience of everything from politicians to climate change can be transmitted from the press to the public (Berkowitz 1992; McCombs 2005; Anderson 2009), demonstrates the influence of news coverage in framing public perceptions (McCombs 2004; Uscinski 2009). Consequently, news articles may not be a good reflection of public interest. News coverage can also polarize and exacerbate existing environmental conflicts (Webb & Raffaelli 2008; Muter et al. 2013). News media should therefore be considered a fourth sector in the conservation process—one that does not passively transmit information between scientists, policy makers, and the public, but rather is an additional sector whose actors have their own motivations (Fig. 1). When these motivations align with those of conservation scientists,

news media offers opportunities to rapidly disseminate research to potentially large audiences. Sectors within the conservation process represent (to some extent) tools and actors. Whereas scientific or news media tools (e.g., primary research and news articles, respectively) remain within their sector, individual actors can transcend sectors and fulfil various roles. The distinctions between sectors in the conservation process are further complicated because individual actors may play dual roles and represent different sectors in different contexts.

Lack of public engagement with the conservation process is predominantly ascribed to insufficient communication efforts by scientists and policy makers, yet information transfer alone does not necessarily increase engagement, and knowledge of specific issues does not necessarily correlate with proconservation behavior (e.g., Lo et al. 2012). In traditional information deficit and contextual models of science communication, information transfer from scientists to the public (Brossard & Lewenstein 2010) is usually assumed to lead to better public support (Bubela et al. 2009; Irwin 2009). Newer science communication models, such as the lay expertise and public engagement models, emphasize interactions between scientific and public actors and aim to engage, rather than inform, the public (Brossard & Lewenstein 2010). The internet creates provides communication methods that complement and parallel traditional print and broadcast news (Brossard & Scheufele 2013). Internet technologies that emphasize networking and interactivity have transformed how information is distributed and consumed by the public. Although limited to the computer literate, the internet and new media (i.e., media that requires a computer for distribution and exhibition [Manovich 2001]) have the potential to reach geographically and temporally wider audiences than traditional channels and allow greater reader participation (Gerhards & Schäfer 2010). Long-established news institutions now disseminate content through websites, and many digital only news producers have emerged as more people acquire news over the internet. Online news articles (written reports viewed on the internet) that can be commented on and linked to through various social media and blogging platforms can be used to increase public engagement (Brossard & Scheufele 2013) and thus better align with contemporary understanding of the conservation process.

We investigated 2 aspects of communication pathways between scientists, news media, and the online public through online news. We assessed differences between scientific journals in the frequency that research



**Figure 1.** The conservation process conceptualized as reactionary pathways that include news media as a fourth sector (dashed lines, pathways suggested by Phillis et al. [2013]; black lines, pathways assessed here; gray, other possible pathways).

articles are featured in online news sites and investigated research article characteristics associated with increased news coverage. We focused on the link between online news articles and public interest on social networking sites by assessing the impact of content and delivery on Facebook likes and shares and Twitter tweets about online conservation news articles. We sought to explore potential links between scientists and the public through news media and to inform scientists of the potential of online news to communicate with and engage the public.

## Methods

### Coverage of Academic Articles Online

We estimated the proportion of conservation research articles covered by online news sites (websites dedicated to providing news, whether or not these sites are associated with offline news media such as a newspaper) with Altmetric.com (<http://www.altmetric.com/>), a measure that complements conventional impact factors of scholarly publications. Altmetric.com uses the digital object identifier number of an academic article to quantify its appearance in online sources, including news sites, social media, microblogs, and academic services such as Mendeley (Robinson-García et al. 2014). We sampled research articles published from 2011 to 2013 in the 8 journals with the highest impact factor in the biodiversity conservation category on Web of Science: *Global Change Biology*, *Diversity and Distributions*, *Ecography*, *Conservation Letters*, *Conservation Biology*, *Biological Conservation*, *Animal Conservation*, and *Biological Invasions*. We sampled open-access journals that publish research on conservation: *Conservation and Society*, *Ecology and Society*, *Environmental Research Letters*,

*PLOS ONE*, and *Ecology and Evolution*. We also selected conservation articles in the highest impact multidisciplinary journals: *Science* and *Nature*.

Articles were chosen by generating 50 random numbers between 1 and the total number of research articles published by the journal in each year. We used these numbers to select the  $n$ th research article published in the journal in that year. We sampled all articles if a journal published fewer than 50 conservation research articles in a year. For interdisciplinary journals (*Science*, *Nature*, *PLOS ONE*, *Global Change Biology*, *Diversity and Distributions*, *Ecography*, *Ecology and Evolution*, and *Environmental Research Letters*), we restricted articles to those that included *conservation* and *ecolog\**, *endangered*, *marine*, *biodivers\**, *management*, *climat\**, *threatened*, *invasive*, or *ecosystem services* in either the title or abstract. These search terms excluded most articles on energy, soil, or gene conservation, but when the abstract indicated these topics were the subject, articles (total = 61) were excluded from the final data set. Most of the 1519 articles in the final data set were not covered by online news sites. To assess whether this was due to subject, we used article abstracts to determine whether an article presented data on mammals, birds, plants, or aquatic habitats; was a local (1 country), regional (continent or group of countries), or global study; or focused on climate change; or human activities (e.g., economics of conservation, resource extraction, human-wildlife conflicts, management tools).

We used generalized linear mixed-effects models to assess the effect of article content on the frequency with which articles were covered by online news sites; journal was a random effect. We used package lme4 in the R environment (R Development Core Team 2014) to quantify the relative importance of each variable and obtain averaged parameter estimates with model averaging and Akaike's information criterion (AIC), where AICc denotes a correction for finite sample sizes. Following an information theoretic approach (Burnham & Anderson 2002),  $\Delta AICc$  for each model was derived by subtracting the AICc of the best model from the AICc of all other models. All models with  $\Delta AICc < 4$  were considered because models with  $\Delta AICc > 4$  have considerably less support (Burnham & Anderson 2002). Model averaging uses relative AICc weights of all models to calculate the relative importance of each variable. Variable weights vary from 1.00 to 0.00. When a variable weight is 1.00, it is included in all the models in the model set (i.e., those models with  $\Delta AICc < 4$ ). When variable weight is 0.00, it is included in none of these models. We checked for potential problems of multicollinearity with generalized variance inflation factors, but all were  $< 4$  (Zuur et al. 2009). To assess the relative contribution of fixed and random effects in explaining variance, we calculated marginal and conditional  $R^2$  for the model with the highest AICc weight with Nakagawa and Schielzeth's (2013)

method. Marginal  $R^2$  describes variance explained by fixed effects, whereas conditional  $R^2$  yields the variance explained by both fixed and random effects.

### Factors Affecting Social Media Popularity

User activities on the 2 most popular English-language social media providers—Facebook and Twitter—were used to assess the influence of conservation news content and delivery on reader interest. In April 2014, we recorded the cumulative number of Facebook likes and shares and Twitter tweets for 517 conservation news articles published between June and November 2013 on the websites of Mongabay, National Geographic (animal news section), *The Scientist* (with a conservation tag), and *The Guardian* (conservation section). We also searched for these articles on the Facebook page and Twitter accounts of the news site because not all metrics (tweets, likes, shares) were available on the uniform resource locator of the article. For example, Mongabay does not show number of Facebook shares. We excluded interviews of individuals and articles that displayed wildlife pictures or videos without informative text. Although we were unable to obtain information on all 3 metrics for all 517 articles, we collected Facebook shares, Facebook likes, and Twitter tweets for 407, 401, and 494 articles, respectively. We excluded *The New York Times*, *Washington Post*, *USA Today*, and BBC news sites because they either do not report conservation news or do not report social media popularity statistics (number of Facebook shares and likes or Twitter tweets) for news articles. Preliminary analysis suggested the number of shares, likes, and tweets increased sharply in the first week after online publication and cumulated shares, likes and tweets plateaued within 30 days. We therefore assumed that the number of tweets and likes for these 517 news articles had plateaued when data were collected more than 30 days after article appearance.

For each news article we recorded characteristics of content and delivery. For news article content, we determined whether the article discussed charismatic species (i.e., popular species symbolic of conservation initiatives). All mammals discussed in the sampled news that were categorized as vulnerable, endangered or critically endangered by the International Union for Conservation of Nature (IUCN 2014) were included. Species were mostly bears, cats, and primates, but elephants, giant pandas (*Ailuropoda melanoleuca*), rhinoceroses, whales, dolphins, wolves, and koalas were also included. Whales, dolphins, and wolves were not identified to the species level in the articles and thus had no IUCN classification. Koalas are least concern or near threatened, but we included them because they are attractive and thought of as charismatic (e.g., Tisdell & Nantha 2007). We did not consider plants and other animal groups (e.g., insects, reptiles, amphibians, birds) as charismatic species. However, we did include sharks and sea turtles because

these groups are the focus of substantial public interest and are regarded as charismatic species (Bowen-Jones & Entwistle 2002; Campbell & Smith 2006).

We determined whether news articles discussed disputes that involved legal measures, such as lawsuits, legal proceedings against perpetrators of crimes against wildlife, and unresolved conflicts between a local community and a company over access to natural resources that escalates to a lawsuit.

We also determined whether the news article conveyed a positive or happy mood (e.g., species discovery or rediscovery, population recovery, effective conservation results) or a negative or sad mood (e.g., species extinction, habitat degradation, policies that negatively affect conservation, illegal logging). News that was considered neither positive nor negative mood was classified as neutral. Finally, we determined whether a news article contained local (one country), regional (continent or group of countries), or global news (levels of geographic scope were compared to laboratory or modeling based studies which had no geographic dimension) and whether it discussed a paper published in a scientific journal.

We hypothesized that news featuring charismatic animals, legal interventions in conflicts, positive news, and news with a broader geographic scope are more popular (more likes, shares, and tweets) than negative news. We hypothesized that news articles based on academic papers are more popular than articles not based on academic papers. We realize, however, that articles based on academic papers may be considered more technical by readers and thus be less popular. To investigate the impact of delivery, we recorded total number of words, number of words in the title, and number of illustrations. We hypothesized that shorter articles with briefer titles are more popular with readers, as are articles with more illustrations.

We used the same model building, checking, and selection process as detailed in the previous section; news site and time of publication (by month) were random effects. Text length was log transformed to normalize its distribution. Separate analyses were conducted for the number of Facebook likes, Facebook shares, and tweets due to the different audiences of the 2 social media and connotations of liking versus tweeting or sharing. For example, Facebook users may be less willing to like negative news stories due to the positive emotional feeling suggested by the word like, an emotional context that is not present when tweeting or sharing.

## Results

### Online Coverage of Academic Articles

Of journal articles sampled, 7% were featured on online news sites. The proportion of research articles covered by the news media varied per journal. *Nature* and

**Table 1. Percentage of conservation articles published in 2013 in multidisciplinary journals and conservation journals reported on by online news site.**

Access* and journal	Conservation articles reported by online media (%)	Journal impact factor (5 year)
Closed access		
<i>Nature</i>	61.5	38.159
<i>Science</i>	80.0	33.587
<i>Global Change Biology</i>	17.3	7.819
<i>Ecography</i>	1.3	5.791
<i>Diversity and Distributions</i>	2.7	5.743
<i>Conservation Biology</i>	8.1	5.462
<i>Conservation Letters</i>	11.8	4.717
<i>Biological Conservation</i>	7.4	4.241
<i>Animal Conservation</i>	5.3	3.221
<i>Biological Invasions</i>	2.0	3.027
Open access		
<i>Environmental Research Letters</i>	23.1	4.280
<i>PLOS ONE</i>	11.3	4.244
<i>Ecology and Society</i>	0.0	3.680
<i>Ecology and Evolution</i>	1.4	1.658
<i>Conservation and Society</i>	1.1	NA

\*Closed access means articles can be accessed only through institutional or personal subscription. Open access means articles are freely available to all.

*Science* had higher proportions of coverage (80% and 62%, respectively & Table 1). Articles that featured climate change or mammals were more frequently covered (variable importance = 1.0), and the model with the highest AICc weight included all variables except the presence or absence of plants as an explanatory variable (weight = 0.12; Supporting Information). However, most of the variance in this best model was explained by the random effects (i.e., journal strongly affected the probability that the article would be picked up by the news media) (Table 2 & marginal  $R^2 < 0.01$ , conditional  $R^2 = 0.39$ ). Variable importance for articles focused on humans, birds, aquatic habitats, and plants species were 0.89, 0.47, 0.60, and 0.30, respectively. Relative variable importance for geographic scope was 0.65.

### Factors Affecting Social Media Popularity

The article with the most Facebook likes was in *National Geographic* (36,000) and was based on a paper published in *Molecular Ecology* (Mendez et al. 2013) announcing the discovery of a new dolphin species in northern Australia. The most shared (13,459) and tweeted (1,766) news article was in *The Guardian* and discussed the cruelty in which common palm civets (*Paraxorus hermaphroditus*) are kept to produce civet cat coffee and launched a social media campaign to ban its sale worldwide (Wild 2013).

The model with the highest AICc weight for Facebook likes included number of illustrations, mood, and news on charismatic mammals. The weight for this model was very low (0.08; Supporting Information), but both number of illustrations and news on charismatic mammals

**Table 2. Results of generalized linear mixed-effects models of the relationships between conservation journal articles featured by online news sites (number of media sources featuring the article) and the characteristics of the article.**

Parameter	Value (SE) <sup>a</sup>
Fixed effect, article topic	
climate change	1.37 (0.36)
aquatic habitats	0.44 (0.26)
human focused	0.68 (0.30)
bird species	0.45 (0.32)
mammal species	0.86 (0.27)
plant species	-0.22 (0.32)
geographic scope <sup>b</sup>	
national	-0.29 (0.48)
regional	0.58 (0.53)
global	0.11 (0.53)
Random effect, journal	2.84 (1.68)
$R^2$ <sup>c</sup>	
marginal	<0.01
conditional	0.39

<sup>a</sup>Fixed effects parameter estimates are based on model averaged parameters of all models where  $\Delta AICc < 4$ .

<sup>b</sup>Levels of geographic scope were compared with laboratory or modeling based studies which had no geographic dimension.

<sup>c</sup> $R^2$  values and variance and standard error are taken from the most parsimonious model which included only whether the article was about climate change as a fixed effect.

had relative variable weights of 1.00 because they were included in all models where  $\Delta AICc < 4$  (Supporting Information). The model with highest AICc weight for Facebook shares included only number of illustrations and news on charismatic mammals. The weight for this model was relatively low (0.13; Supporting Information), but both number of illustrations and news on charismatic

**Table 3.** Results of generalized linear mixed-effects models (variance and SE) of relationships between social media popularity (Facebook likes and shares and Twitter tweets) and the characteristics of the conservation news piece.<sup>a</sup>

Variable	Facebook likes (n = 401)	Facebook shares (n = 407)	Twitter tweets (n = 494)
<b>Fixed effects</b>			
charismatic mammals	1.09 (0.19)	0.53 (0.16)	0.33 (0.09)
disputes involving legal measures	0.23 (0.25)	0.24 (0.20)	-0.05 (0.12)
negative news <sup>b</sup>	-0.22 (0.19)	-0.21 (0.17)	0.13 (0.10)
positive news	0.26 (0.17)	0.17 (0.16)	0.11 (0.09)
regional news <sup>c</sup>	0.16 (0.17)	0.07 (0.15)	0.17 (0.08)
global news	0.08 (0.17)	0.13 (0.16)	0.39 (0.09)
journal article	-0.16 (0.16)	-0.15 (0.16)	-0.09 (0.08)
length of the article	0.12 (0.15)	0.02 (0.14)	-0.04 (0.08)
length of the article title	-0.04 (0.03)	0.02 (0.02)	0.01 (0.01)
number of illustrations	0.20 (0.04)	0.11 (0.04)	0.09 (0.02)
<b>Random effects</b>			
time of publication (month)	0.00 (0.00)	0.01 (0.11)	0.01 (0.12)
news site	2.42 (1.56)	2.89 (1.70)	0.37 (0.61)
<b>Mean and SE for each news site</b>			
Mongabay	360 (55)	21 (5)	84 (5)
National Geographic	7563 (1172)	NA	332 (29)
The Guardian	NA	880 (163)	189 (22)
The Scientist	122 (33)	NA	NA
Marginal $R^2$	0.07	0.02	0.06
Conditional $R^2$	0.61	0.67	0.43

<sup>a</sup>Fixed effects parameter estimates are based on model averaged parameters of all models where  $\Delta AICc < 4$ . The  $R^2$  values, variance, standard error are taken from the models with highest AICc weights.

<sup>b</sup>Neutral news was used as a baseline to assess the effects of positive and negative news.

<sup>c</sup>Local news was used as a baseline to assess the effects of regional and global news.

mammals were included in all models where  $\Delta AICc < 4$  (Supporting Information). The model with the highest AICc weight for tweets included number of illustrations, geographic scope, and news on charismatic mammals. The weight for this model was also relatively low (0.15; Supporting Information), but all 3 variables were included in all models where  $\Delta AICc < 4$  (Supporting Information). As expected, the number of likes, shares, and tweets was higher for news on charismatic mammals and articles with more illustrations than for articles on other types of animals and without illustrations (Table 3).

There were more tweets about regional and global news than about local news, but little evidence of changes in Facebook shares and likes with geographic extent. Facebook users were more likely to like positive news than negative news relative to neutral news (relative variable weight = 0.67). Although 33% of articles were about published research, the weight of this variable was  $< 0.39$  for all 3 response variables (Supporting Information). Nevertheless, these results should be treated with caution because the fixed effects accounted for little variance in the models with highest AICc weights for Facebook likes, Facebook shares, and tweets (marginal  $R^2 = 0.07$ , 0.02, and 0.06, respectively). The majority of the variance in Facebook likes, Facebook shares, and tweets was explained by the random effects and particularly by the news site (Table 3 & conditional  $R^2 = 0.61$ , 0.67, and 0.43, respectively).

## Discussion

Internet communication offers opportunities to augment dialogue between scientists and the public. Although conservation scientists can communicate directly with the online public through blogs or social media (Bik & Goldstein 2013), online news also offers opportunities to reach new and broader audiences. Sectors in the conservation process include scientists, policy makers, and the public. We argue that news media is a fourth sector in the conservation process—it is not just a passive conduit through which scientists can transmit information to the public. The most tweeted and shared conservation news article on civet cat coffee demonstrates this point. The article was written by Tony Wild, who first introduced civet cat coffee to the United Kingdom (Wild 2013). Although the article argues animal cruelty as the prime reason change is needed, this is a case of news media being used as a tool in a call for public advocacy (through social media) aimed at changing policy on civet cat coffee. This case (an example from animal welfare rather than biodiversity conservation), demonstrates a possible pathway where the online public could drive policy change and perhaps motivate scientific research on a particular conservation issue.

Although incentives for conservation scholars to use blogs or Twitter could contribute to science dissemination and increase the proximity of conservation scientists

and the online public, such outlets may attract few readers or only be preaching to the choir (Nadkarni 2004). Linking online news articles about research articles to online platforms where readers can interact directly with authors through Twitter messages or by commenting on blogs could encourage greater interaction between scientists and the public than online news articles alone (Gerhards & Schäfer 2010). One possible way to increase Twitter usage by scholars is by using tweets to submit questions during conservation conferences. This method was successfully used at plenaries during the 2013 INTECOL (International Congress of Ecology) conference in London (Parsons et al. 2014) and encourages scholars to sign up for Twitter. Questions were necessarily succinct (under 140 characters), and younger attendees were less reluctant to ask questions.

Our exploratory analysis suggests strategies for conservation scientists to communicate their findings through news media. Previous research suggests press coverage of climate change is increasing (Verissimo et al. 2014), and we found that articles about climate change were more likely to be featured in news articles. Overall, however, our results suggest the journal in which an article is published has a greater impact than article content on whether a research article is featured in online news articles, as assessed by simple dichotomous variables. We found research articles in *Science* and *Nature* were most likely to be featured by online news sites, followed by articles in *PLOS ONE*. This may be because high impact journals with general readership are more likely to employ press officers and produce information subsidies such as press releases or because journalists are more likely to search these journals for newsworthy articles. However, we focused on broad-scale patterns of conservation science in news media and thus cannot account for personal relationships. The work of particular scientists could be frequently featured in news media if they are already relatively well known or have a long-standing relationship with one or more journalists. This reinforces the key role of news sources in providing journalists with items to report (Berkowitz 1992). Conservation journals and scientists could proactively increase coverage of their research by providing press releases or developing working relationships with journalists (Novacek 2008). Press releases may be particularly effective for increasing online news reporting on conservation because text modification by journalists may be minimal (Murcott & Williams 2013), thus the key message of research as framed by the researcher is present. The generation of online content is not, however, sufficient to engage online publics, as demonstrated by the variation in number of tweets and Facebook likes and shares of online news articles we found. Furthermore, noncritical and scientist-sourced news content may erode trust between online news sites and their audiences, violating audience expectations

for investigative and critical news reporting (Murcott & Williams 2013).

Including specialist news sites such as Mongabay may have biased our results, but the inclusion of news site as a random effect was intended to capture the differences between news sites in aspects such as target audience and readership size. We found that although research published in high-profile interdisciplinary journals was more likely to be reported, research in specialist journals was also covered by the news. We also found that articles on charismatic species which included images were more popular on Facebook and Twitter, which could help scientists write more effective press releases to send to journalists or more effectively present conservation science in their own blogs or social media profiles. The greatest percentage of the variance in likes, shares, and tweets was explained by news sites rather than the characteristics of news articles. More news articles covered articles from scholarly journals than the approximately 20% reported by Smith et al. (2010), although this may have been due to differences in sampling method. Although conservation news articles that discuss research articles published in scholarly journals had negative parameter estimates, suggesting they are less likely to be tweeted, liked, or shared, these estimates had large standard errors and relatively low variable importance, so these results are not conclusive.

At the simplest level, illustrations and news about charismatic species increase popularity. In an attempt to address the possible influence of charismatic species on news readers at a global scale, we adopted a subjective definition of the term. There is some confusion over its definition, and it is possible that a different definition of *charismatic species* at a finer geographical scale would have captured different trends of interest among the public. For example, badgers (*Meles meles*) could be considered a charismatic species in the United Kingdom (Cassidy 2012), but we did not consider it charismatic here. Not all conservation research is about such species, but provision of relevant high quality images to accompany text on almost any communication piece featuring conservation may increase popularity in social media. For example, the news article based on scientific research that had the most Facebook shares looked at the role of climate change on marine species, including plankton and ocean plants (Poloczanska et al. 2013). *The Guardian* news article featured a high quality image of phytoplankton blooms in Norway.

Other results of our analyses may be relevant for specific conservation issues, depending on their content. For instance, Facebook likes for a particular story were usually far higher than the number of tweets or shares, Facebook users were less likely to share or like negative news, and Twitter users were more likely to tweet about negative news relative to neutral news. Likewise, popularity on Twitter increased for news with wider geographic

scope. Rather than using these insights to change the research they conduct, conservation scientists can use this information to choose appropriate social media channels to communicate with the online public.

This said, the nature of our analysis was exploratory. There are many aspects of the news that cannot be analyzed with simple dichotomous variables and categories of mood. For instance, news super-spreaders (e.g., celebrities advocating behavioral change) could pass news articles to multiple social media contacts, but we did not quantify this. For individual news articles, our methods also could not completely elucidate writing quality or effectiveness at grabbing public attention. Characteristics such as use of resonating language or humor may substantially affect popularity. Our results could be extended by conducting an in-depth analysis of individual articles, investigating the role of these characteristics, and identifying whether the article follows traditional science journalism models of information delivery or new models that emphasize public engagement (Secko et al. 2013). These classifications could then be linked to both the simple measures of popularity we used and more detailed analyses. (See Muter et al. [2013] for an example of news article content analysis on representations of sharks in U.S. and Australian news). Our use of Facebook likes, shares, and Twitter tweets may not perfectly correlate with other possible measures of online popularity, such as number of page views or analysis of comments on individual news articles. Nevertheless, tweets, shares, and likes demonstrate greater engagement with the article content than page views, and spread news content to possible additional readers. Analyses of the text associated with tweets, shares, and likes or comments on news articles could provide information on how readers engage with an article. Nekaris et al. (2013) conducted such an analysis by examining comments on a single Youtube video to determine whether commenters perceived slow loris (*Nycticebus* spp.) as pets or as endangered animals.

The trend in science communication is toward increased public participation and the democratization of the scientific process (Brossard & Lewenstein 2010). These trends are also visible in conservation, with increased emphasis on community support and stakeholder involvement (Reed 2008). We examined one part of the conservation process, and our results demonstrate the potential of online news to enhance public engagement and reduce the gap between scientists, the public, and policy makers (Novacek 2008; Brossard & Scheufele 2013).

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## Supporting Information

Models of the number of mass media outlets that feature conservation articles (Appendix S1), models of the number of Facebook likes and shares, Twitter tweets (Appendixes S2, S4, S5), and relative variable importance (Appendix S3) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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