

Using Twitter to communicate conservation science beyond professional conferences

Running Head: Communicating conservation using Twitter

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Abstract

Scientists are increasingly using Twitter as a tool for communicating science. Twitter can promote scholarly discussion, disseminate research rapidly, and extend and diversify the scope of audiences reached. However, scientists also caution that if Twitter does not accurately convey science due to the inherent brevity of this media, misinformation could cascade quickly through social media. Data on whether Twitter effectively communicates conservation science and the types of user groups receiving these tweets are lacking. To address these knowledge gaps, we examined live-tweeting as a means of communicating conservation science at the 2013 International Congress for Conservation Biology (ICCB). We quantified and compared the user groups sending and reading live-tweets. We also surveyed presenters to determine whether tweets about their presentations reached their intended audience groups, and we asked how effectively Twitter conveyed their research findings. We found that Twitter reached a more diverse audience relative to those attending and live-tweeting at ICCB. However, the groups reached through live-tweeting were mismatched with the presenters' intended audiences; policy-makers, government, and non-governmental organizations (NGOs) were rarely reached, despite the intent of the presenters. Plenary talks were tweeted about far more than other oral or poster presentations. Finally, over half of the presenters believed that the tweet about their talk was effective, and less effective tweets were perceived as vague or missing the presenters' main message. We recommend that presenters who want their science to be communicated accurately and broadly through Twitter should provide Twitter-friendly summaries that incorporate relevant hashtags and usernames. We also encourage speakers to capitalize on Twitter as an emerging tool for communicating conservation science – one that can be used to explicitly articulate the relevance of their findings to diverse target audiences beyond conference walls.

Introduction

Interest in Twitter as a tool for communicating science is gaining momentum globally (Darling et al. 2013; You 2014). As a free platform that is often accessed via mobile devices, Twitter disseminates information rapidly and broadly to diverse audiences including policy makers, the media, and the general public (Shiffman 2012; Federer 2013; Winkless 2013; Ferguson et al. 2014; Parsons et al. 2014). As of January 2015, Twitter has over 284 million monthly users, an estimated 77% of whom are outside of the United States (Duggan & Smith 2013; Twitter, Inc. 2014), and reaches a variety of socio-economic groups and age classes (Duggan & Smith 2013; Twitter, Inc. 2014). Given Twitter's global reach, a well-constructed tweet has the potential to reach an audience well beyond the scientific community. Twitter could thus overcome the limitations of more traditional means of communicating science, such as journal articles and conference presentations (Shiffman 2012; Ferguson et al. 2014).

Twitter is already being used as a tool to promote scholarly discussion and debate (Darling et al. 2013; Ferguson et al. 2014). Numerous scientists actively use Twitter for public engagement and outreach, most academic universities have their own Twitter account, and most major conferences have their own hashtags (Shiffman 2012; Darling et al. 2013; Winkless 2013; Parsons et al. 2014; You 2014). Darling et al. (2013) found that a diverse group of academic, government and non-governmental organization (NGO) scientists, students, and journalists used Twitter to discuss conservation science topics.

The increasing frequency of Twitter use in the scientific community, however, has raised concerns that Twitter may be an imperfect outlet for science communication. Some scientists worry that 140 characters prohibits the effective communication of complex scientific concepts, and misinterpreted tweets could be particularly detrimental to the time-sensitive and political nature of some conservation issues (Brossard 2013). Other scientists have suggested that important individual tweets often fall short of reaching people in

positions to make key conservation decisions. These scientists argue that Twitter remains relatively ineffective in changing conservation policy and practice, and is over-popularized by some scientists (Hall 2014; You 2014). Finally, the metric used to evaluate the number of people reached through Twitter is usually based on the total number of followers, rather than the identity of those individuals (Shiffman 2012; Darling et al. 2013; Winkless 2013; Ferguson et al. 2014; Parsons et al. 2014). The lack of data on whether Twitter effectively communicates conservation science, and the limited information on user groups receiving these tweets, inhibits rigorous assessment of if and how Twitter can help link research and action.

To address these knowledge gaps, we examined live-tweeting (Fig. 1) as a means of communicating scientific findings at the 2013 International Congress for Conservation Biology (ICCB) located in Baltimore, Maryland USA, on 21-25 July 2013. We quantified and compared the user groups sending and reading live-tweets, and used surveys to examine presenters' opinions on how effectively tweets conveyed their research and the extent to which tweets reached their intended audiences (refer to Table 1 for a glossary of terms). The goal of ICCB – a biennial international meeting hosted by the Society for Conservation Biology – is to address conservation challenges by presenting new research and developments in conservation science and practice. Participants are predominantly conservation scientists and practitioners from academic institutions, government agencies, and NGOs.

With the goal of determining whether Twitter's potential to communicate conservation science is being met through live-tweeting at conferences, we posed the following specific questions: Which user groups were reached through conference live-tweeting? How do these user groups compare to the intended audiences of the presenters? Do

presenters at ICCB 2013 believe their research was conveyed effectively through Twitter, and what were the most common reasons for any perceived lack of clarity or accuracy?

Methods

Data Collection

The 2013 International Congress for Conservation Biology had over 1500 attendees (Parsons et al. 2014). We selected ICCB 2013 to address our research questions because the participants and research topics were international in scope, Twitter was widely used by participants (Parsons et al. 2014), and the official conference hashtag (#ICCB2013) was well-promoted and is readily searchable using the Twitter search tool.

To identify the audiences being reached by conference live-tweeting, we used the search tool in Twitter to compile all tweets that included #ICCB2013. We included all tweets that used this hashtag in our dataset except: 1) tweets that were not directly relevant to presentations given at the conference (e.g., messages about social gatherings), 2) tweets that could not be clearly assigned to a presentation given at the conference, and 3) messages tweeted by the presenter promoting their upcoming talk.

We collected publicly available information related to each tweet and retweet using Twitter user profiles and other Internet sources. Specifically, we recorded information on the following: 1) the tweet (full text of tweet, date tweeted, and number of retweets), 2) the tweeters and retweeters (name, professional position or organization type, professional affiliation, location, and number of followers), and 3) the presenters (name, presentation title, presentation type [e.g., plenary, symposium, oral session], professional position or organization type, and professional affiliation) (Supporting Information). When professional positions and professional affiliations were not explicitly stated in Twitter user profiles, we acquired this information from the most recent Internet source related to the individual's

professional status (e.g. LinkedIn, professional webpages). We categorized professional positions, professional affiliations, and locations that could not be clearly identified from any source (e.g. users with pseudonyms) as unknown.

Identifying User Groups

To determine and analyze professional positions or organization types for each Twitter user, we created a list of all potential professional positions and organization types that we could identify in the dataset (Supporting Information). We then classified each user into these categories based on the most current position that we could identify using publicly available data from Internet searches.

Characterizing the Audience

We used the dataset described above to identify and characterize the audience reached through conference live-tweeting. We defined the audience as all of the retweeters in our dataset. We consider the retweeters rather than the total number of followers to represent the Twitter audience because we assumed that a retweeter viewed the original tweet in order to pass on the message as a retweet. In contrast, it seems likely that most Twitter followers are not reading every tweet that appears in their Twitter feed. Parsons et al. (2014) demonstrated that approximately 90% of the Twitter users that used the hashtag #ICCB2013 did not attend this conference; therefore we assumed that most retweeters were not physically present during the oral presentation that was the subject of their retweets. We used data on tweeters and retweeters to calculate and compare percentages of different professional positions or organization types, and tweets per session type (i.e., symposium, workshop, oral session, award speech, speed session, exhibitor booth, poster, and plenary). As one science-related presentation was given at an exhibitor's booth, we considered the sponsors and exhibitors to be a session in our data collection. Because there was a large disparity in the number of

presentations within different session types (e.g., 6 plenary talks vs. 400 oral session presentations), we adjusted the frequency of tweets per session type to account for the total number of presentations in each session type.

During the intended and actual audience classification process, we identified 30 retweeters that were research scientists or program directors/administrators. These individuals worked for organizations that were also considered audience categories (e.g., NGOs); therefore, they could simultaneously represent two different audience categories (e.g., research scientist and NGOs). Due to the nested nature of this classification, we chose post-hoc to include in our dataset both the research scientist or program director/administrator and the organization they worked for. We identified organizations for 9 program directors/administrators and 16 research scientists, and as a result, the “audience reached” categories for academia, NGOs, professional societies, and the private sector were 8%, 2%, 1%, and 1% higher, respectively, than if we listed the research scientists and directors/administrators independently of the organization they worked for in our intended audience dataset.

Survey Methods

We emailed a survey (Supporting Information), along with a brief definition of twitter, to each presenter who had his or her research shared via live-tweeting, and for whom we could obtain contact information. We sent a follow up reminder to all non-respondents within 2 weeks of initially sending the first survey. We sent the survey again to all non-respondents within 4-6 weeks of the initial survey. The survey included their presentation title and a randomly selected tweet about their presentation. We asked the presenters to identify three categories of audiences that they wanted to reach with their presentation. The original list of audience categories (Supporting Information) was pooled into the following categories: academia, policymakers, government agencies, NGOs, media, research scientists, resource

managers, K-12 education, private sector, and professional societies. Using these pooled categories, we compared the percentage of actual audience types reached through conference live-tweeting (obtained from our audience dataset) to the percentage of presenters' intended audience choices. We included all three audience choices for each presenter. To assess demographic bias in survey responses, we used a Fisher's Exact Test to determine whether the responses differed significantly by gender, age class, or social media use.

We also asked each presenter to evaluate the effectiveness of the tweet using the following choices: very ineffective, moderately ineffective, fair, moderately effective, and very effective. Here we use the term "effective" strictly to describe how well the tweet conveyed the presenter's intended message. If the presenter chose anything other than very effective, we asked them to describe why. We asked presenters to provide a written response and/or select one or more of the following explanations: 1) the tweet included an inaccurate fact about my research, 2) the tweet misinterpreted my research, 3) the tweet did not convey the main point of my talk, 4) the tweet did not mention the results of my research, 5) the tweet was too vague, 6) the tweet had spelling or grammatical errors that obscured the message, 7) the tweet did not include a link to further information about my research. We used these data to calculate and compare the percentage of different responses in each category.

Results

We compiled 774 tweets about ICCB presentations from 96 unique usernames, and 1711 retweets from 421 unique usernames. Ninety-two percent of tweets about ICCB presentations came from Twitter users with at least 100 followers. The mean number of followers of tweeters and retweeters were 2404 (SE 1218; median 371) and 1191 (SE 167; median 385), respectively. Nearly 40% of the tweets in our dataset were from users with

more than 10000 Twitter followers, and of that 40%, all but two of these tweets were generated by a single, highly active individual. All tweets originated from the conference location in Baltimore, Maryland, USA; however, retweeters spanned a diverse geographic area. Retweeters were primarily comprised of individuals located in North America (79%), including users from 34 U.S. states and 5 Canadian provinces, but there was also representation from 40 different countries worldwide.

Session Types

In our assessment of retweeter activity by session type, we found that 52% of retweets were about symposium presentations. The oral sessions and plenary talks were also frequently retweeted (22% and 18%, respectively), and workshops generated about 4% of all retweets. The remaining session types (speed sessions, posters, award speeches, exhibitor booths) each accounted for < 1% of retweets in our dataset. In addition, some retweets could not be associated with a session type (2%) or pertained to multiple session types (<1%). Plenary talks (n=6) were by far the most influential, each inspiring about 52 retweets/talk on average. Symposiums (n=315) and workshops (n=25) generated an average of 2.8 and 2.5 retweets per session, respectively. In contrast, the mean rates for other session types were all less than 1 retweet/session (Fig. 2).

User Groups and Affiliations

Individuals in academia were responsible for 67% of the tweets in our study, the majority of which were from graduate students (50%). Research scientists and program directors/administrators were also represented, producing 11% and 9% of total tweets, respectively (Supporting Information). Media sources (i.e., journalists, bloggers, news and media, and websites) were responsible for about 5% of all conference tweets.

Most retweets also came from individuals in academia (44%), a group comprised mainly of graduate students (23%) and professors (16%) (Supporting Information). Media

sources (19%), research scientists (10%) and program directors/administrators (5%) were also well-represented in retweets. Retweets sent by NGOs, teachers, members of the general public, and resource managers each accounted for about 2% of all retweets, while the private sector comprised 1% (Supporting Information). Other professionals contributed 5% of all retweets, while an additional 2% of retweets were generated by other types of organizations, such as professional societies and scientific journals. We could not reliably assign the remaining 8% of retweets to a particular profession or organization.

Intended and Actual Audiences Reached

Of the 142 presenters that were sent surveys, 59 individuals (42%) completed and returned the survey. Of all respondents, 42% were female, and 58% were male, which was roughly equivalent to the presenters that were contacted (39% female, 61% male).

Respondents between the ages of 20-40 comprised 42% of the total, 48% were between the ages of 40-60 and 10% were over the age of 60. Survey respondents reported a range of familiarity with social media: 19% had never used any form of social media to communicate their research, 81% communicate their research at least once per year using social media platforms, and 31% do so at least once per week. Our tests of whether survey responses varied with the self-reported age, gender and social media use of respondents indicated no significant differences (Fisher's Exact Test, $p = 0.644$, 0.522 , and 0.946 respectively).

Therefore, we pooled survey responses and analyzed them as a group. Six survey respondents did not provide information to link their responses to the original tweet, so we were unable to compare the intended and actual audience groups reached for these presenters.

Survey respondents selected three audience groups they wanted to reach with their presentation (Fig. 3). Academia was listed most frequently (25%), followed by government agencies (22%), policymakers (15%), NGOs (13%), media (8%), research scientists (6%), and members of the public (3%). K-12 education, members of the private sector, professional

societies, scientific journals, zoos and aquaria, program directors/administrators, political interest groups, and other professionals were selected least frequently, and each made up less than 3% of the respondents' choices.

The organizations and individuals that retweeted the live-tweets from the conference were notably different from the audience that presenters indicated that they would like to reach with their presentation (Fig. 3). Academia was reached almost twice as much as intended, and made up 41% of the actual audience reached by the tweets. Government agencies were reached less than one fourth as much as intended, and made up 4% of the audience reached by the tweets. There were no policymakers in the actual audience reached by the tweets. NGOs were reached a little more than half as much as they were intended, and made up 6% of the actual audience reached. Presenters reached members of the media more than twice as frequently as intended; media made up 17% of the actual audience reached. Research scientists were reached slightly more frequently than intended, and made up 9% of the actual audience reached. Zoos and aquaria were reached less often than intended, and made up 0.5% of the actual audience reached. Members of the public, K-12 education, the private sector, professional societies, scientific journals, program directors/administrators, and political interest groups were reached more frequently than intended, and made up 5%, 3%, 1%, 3%, and 0.5% of the actual audience, respectively.

Tweet Effectiveness

Most tweets were judged favorably by presenters. A majority of respondents (53%) believed that the tweet about their presentation was either moderately effective (29%) or very effective (24%) at communicating their intended message. While 15% of respondents considered the tweet about their presentation to be fair (neither effective nor ineffective), 24% found the tweet to be moderately ineffective, and a minority (9%) evaluated the tweet as very ineffective at communicating their intended message.

If tweets were judged to be less than very effective, presenters also gave one or more reasons why the tweet fell short (Fig. 4). The most frequent responses given by presenters were that the tweet did not convey the main point of the talk (40%), the tweet was too vague (25%), the tweet did not provide a link to another webpage with more information (9%), or the tweet did not provide the results of the research (8%). Less than 5% of respondents believed that the tweet lacked engaging qualities, misinterpreted their research, included an inaccurate fact, or had grammatical errors.

Discussion

Our study demonstrates that Twitter can effectively convey conservation science to a diverse and somewhat unexpected audience beyond a professional conference. Although live-tweets from ICCB reached a variety of groups, such as the media, educators and the private sector, tweets rarely reached policymakers, government agencies or NGOs, despite the intentions of the presenters. Importantly, according to conference presenters, live-tweets generally communicated scientific information effectively. As the scientific community discusses how to improve dissemination of science to broad or targeted audiences, our study provides novel insight into the outcomes of conference live-tweeting for conservation practitioners.

Effective communication has been a major critique of Twitter. Although information can be generated and shared quickly, not all of this information is accurate (Aosaki et al. 2010). Additionally, the social nature of Twitter and other online communication tools (e.g., retweets on Twitter or likes on Facebook) has the potential to affect the readers' interpretation through social pressures and group consciousness (Aosaki et al. 2010; Anderson et al. 2014). The ease of access and capability to post unfiltered content also raises concerns about the readers' ability to differentiate between facts and opinions (Brossard

2013). Contrary to these concerns, the majority of our survey respondents (53%) viewed tweets about their conference presentations favorably and described them as moderately or very effective. We did, however, find evidence that Twitter does not always convey messages perfectly; 76% of tweets were categorized as less than very effective. Missing the main point and vagueness were the two most common reasons cited (Fig. 4). These problems may be a persistent pitfall of Twitter, perhaps due to the limited number of characters permitted.

Conference tweets usually do not occur in isolation, however, and it is possible that the suite of Twitter activity in reference to a particular presentation may help mitigate these shortcomings. Surprisingly, only 3% of presenters judged the tweet about their presentation to be inaccurate, and only 3% suggested that the tweet misinterpreted their research.

Presenters may interpret critical tweets as inaccurate; however we did not have any tweets that were openly critical. Our findings should help alleviate concerns about whether or not Twitter can accurately convey information about conservation science from a conference. The 44% of tweets that were less than very effective, but not classified as ineffective, may still have value for communicating conservation science messages. These tweets can encourage conversations and debate about conservation topics, increase awareness about current issues and augment readership of published research (Darling et al. 2013).

An important purported advantage of Twitter is its ability to reach diverse audiences (Twitter, Inc. 2014). Ideally, the Twitter audiences reached would reflect the intentions of conservation scientists presenting their research, but we found substantial discrepancies between the two (Fig. 3). Members of academia, research scientists, and the media were all reached disproportionately more than intended. Other sought-after audiences such as government agencies, policymakers, and NGOs, were underrepresented. As many members of these intended audiences have Twitter accounts, there is potential to improve connections with these audiences using Twitter. It is noteworthy that many of the well-represented user

audiences, such as academia and research scientists, were the same groups doing the majority of the tweeting in our study (Supporting Information). Similarly, underrepresented intended user audiences like NGOs did not do much live-tweeting. These similarities between tweeters and retweeters suggest that Twitter users follow others that share similar areas of interest, professions or opinions. Darling et al. (2013) found comparable results in their analysis of scientists on Twitter, reporting that the majority (~55%) of people who follow scientists on Twitter are also scientists. This could explain why we found relatively high levels of similar occupational groups (i.e., academia) retweeting conservation messages (Supporting Information).

One of the strongest advantages of using Twitter in a conference setting is that messages are likely to reach user groups and audiences well beyond the confines of the conference. Our results indicated that the user groups receiving these messages were far more diverse in regard to professional positions compared to those of the original tweeters (Supporting Information). Importantly, the proportion of retweets by news and media affiliates far exceeded the proportion of original tweets from this group. This suggests Twitter is a promising avenue for quickly spreading conservation messages to the public, as the media can serve as a microphone to convey and amplify scientific findings. Other conferences (e.g., 2014 North American Congress for Conservation Biology) have emphasized developing in-person relationships with members of the media to publicize the results of conservation science, and simultaneously, to help reporters and writers develop quality stories on important topics. Twitter may foster these relationships online and offer an efficient mechanism for connecting remotely. Our results suggest the science presented at ICCB 2013 was shared far beyond the geographic location of the conference. Twitter users from 40 countries received and retweeted the messages. Over 90% of these messages had the potential to reach at least 100 Twitter users, based on the number of followers. As most

presenters can expect to have only a few dozen attendees present during their talk (with the exception of plenary talks), live-tweeting can reach orders of magnitude more people than physically present (Shiffman 2012).

Scope of Study

Our findings provide novel insight into tweet effectiveness, the audiences reached via live-tweeting and the number and type of followers, but there are several important limitations to this study. During data collection, we were restricted by the public availability of accurate contact information to reach presenters and request participation. However, out of the 155 total presenters who were the subject of tweets, we were able to email our survey to 142 (92%), with a 42% response rate; this response rate is only slightly lower than the average rate for other studies that used surveys to collect data from individuals (Baruch and Holtom 2008). Furthermore, our tweet search strategy only included the official conference hashtag #ICCB2013. Consequently, any relevant tweets or retweets about scientific content at ICCB that lacked the conference hashtag went undetected. Finally, because the rate of tweeting at ICCB conferences has been described as high compared to other academic meetings (Parsons et al. 2014), our results may not be generalizable to other scientific conferences.

Although many followers had the potential to receive conference tweets, we only considered a message to be read if it was retweeted. This conservative estimate of the audience ensured high certainty that a follower read a particular tweet. Enthusiastic followers who retweet messages from their favorite users without reading them are an exception. We also acknowledge that many more followers, perhaps from different professional arenas, may have read the message, yet did not retweet it. Importantly, government agencies may only retweet official information relevant to their organization, so our approach may have underestimated how many government agencies were reached. However, we found that

research scientists working for government agencies also rarely retweeted messages (0.06%; Supporting Information), which may indicate that this group was not well-reached overall. Yet, due to cuts in federal spending, the 2013 ICCB meeting had over 200 fewer federal employees attend than usual (Cigliano 2013), so our results may not be representative of typical government tweet and retweet rates. Lastly, some groups may frequently tweet under pseudonyms and would be categorized as unknown using our approach; thus tweet and retweet rates of groups that frequently use pseudonyms may have been underestimated.

Conferences are just one form of communicating science, and disseminating conservation information at a conference may be different from other forms of communication (e.g., scientific journals, webinars). Conference presentations are normally constructed with the audience in mind – they are brief and frequently allow direct interaction with presenters (e.g., during question and answer periods). These unique characteristics of conferences could influence the way live audiences interpret information or share it via Twitter. Moreover, Twitter is one resource in a vast array of social media tools (e.g., Facebook, Reddit and YouTube) that could be used to communicate conservation science. We predict that there are differences in the effectiveness, composition and extent of audiences reached by these social media outlets, based on their format requirements and user base. Therefore, we are cautious of extrapolating our results and recommendations to all forms of social media. Finally, our study was designed to measure the utility of using Twitter to communicate conservation science beyond a conference, but not whether live-tweeting leads to conservation success. Quantifying the extent that Twitter results in conservation action (e.g., change in knowledge or attitudes about conservation, hectares protected or restored, species listed, policies enacted) was beyond the scope of this study but should be a priority for future research.

Recommendations

Based on the results of our study, along with previously published literature, we provide the following recommendations for conservation practitioners who would like to incorporate Twitter into their communication toolbox. First, to overcome the major weaknesses of tweets (vagueness and missed main point) highlighted by presenters, we recommend that speakers provide social media statements in footnotes, or as a final slide, during presentations. These stock tweets allow for wide dissemination of a presenter's takeaway message(s) by providing accurate and unambiguous information (Parsons et al. 2014). Presenters and tweeters should remember that well-crafted tweets are concise, use one or two appropriate hashtags, avoid jargon and provide content beyond the talk title (Parsons et al. 2014). A shortcoming of presenters providing stock tweets is that Twitter is often viewed as a form of self-expression; live-tweeters may thus ignore stock tweets that prompt them to communicate specific content under their own username. Second, we suggest that presenters with Twitter accounts use Twitter tools (e.g. TweetDeck) to schedule automated sharing of their own tweets during their presentation. Third, presenters can facilitate the inclusion of links to websites, if desired, by providing search terms or a simple link that will help the Twitter user locate their work online.

Furthermore, if scientists aim to reach underrepresented groups of Twitter users, they may need to change how they network online. We propose that conservation scientists broaden their following on Twitter by connecting with more diverse groups of people from different disciplines. A direct way to reach out to these groups and extend networks might be to use specific hashtags or incorporate usernames of policymakers or NGOs into stock tweets during presentations. Presenters should also be aware of the most active live-tweeters in their field and make contact with these individuals. Several Twitter users at ICCB 2013 had a large number of followers (>10,000) and were very active (40% of all tweets). Encouraging

particularly active tweeters to attend your presentation could expand the reach of your conservation science.

Finally, our study also provides several insights for conference organizers. Our results indicated a marked disparity in the types of conference sessions that are subject to conference live-tweeting. Plenary talks had the most retweets per session (Fig. 2) and, presumably, the most influence beyond the conference. This is not surprising as plenary talks are often scheduled without competing presentations and most conference participants attend these sessions to hear from highly-regarded speakers. These data, however, provide conference organizers extra incentive to choose plenary speakers wisely to reflect not only the interests and concerns of the live audience, but also of a more diverse online community. Plenary speakers may want to be prepared for a live-tweeting audience with messages that are readily tweetable.

Conference organizers should also continue to create and promote official conference hashtags (Parsons et al. 2014) to encourage participation and enhance flow of information. When conference attendees know and use the official hashtag, it makes conference information easily searchable and accessible to all Twitter users (Ferguson et al. 2014). Official hashtags also help organizers disseminate conference updates, publicize new research (Winkless 2013), and promote social networking activities. Using hashtags can help facilitate a sense of community and allow for continued discussion of scientific progress after the conclusion of the conference (Parsons et al. 2014).

Today, Internet-based resources and social media are increasingly prevalent and people are relying on these sources for scientific information (National Science Board 2012). It has been suggested that science communication will be most successful if it is spread through channels that the public and other target audiences are already utilizing (Van Eperen & Marincola 2011). Therefore, it is critical that we understand the challenges and

opportunities associated with communicating science through social media. We measured the first stage of effective communication of conservation science through Twitter. Quantifying the extent that Twitter results in conservation action on the ground is a critical next step. Future research should investigate whether and under what circumstances Twitter contributes to science-based decision making. Due to the time-sensitive nature of environmental issues and the need to engage a diverse group of stakeholders, conservation biology may benefit from the ubiquity of Twitter. As Twitter becomes part of more conservation scientists' communication toolbox, it will be critical to avoid its pitfalls, while also harnessing its full potential.

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Supporting Information

The definitions of categories used to organize Twitter users into professional position or organization groups (Appendix S1), the survey sent to presenters (Appendix S2), and professional titles or organization types represented by users that tweeted or retweeted about ICCB 2013 presentations (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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Table 1. Glossary of terms used throughout the manuscript.

Term	Definition
<i>Twitter</i>	a free social media platform used to share messages with 140 characters or less
<i>Tweet</i>	a message including up to 140 characters of text that may also contain photos, videos, or links to websites
<i>Live-tweeting</i>	when a Twitter user tweets information from an event (e.g., scientific conference) in real-time
<i>Retweet</i>	a tweet that is forwarded. Retweeting is often used to pass along tweets of interest through Twitter. Retweets always retain original author attribution.
<i>Twitter user</i>	a person or organization that uses Twitter and has a username
<i>Tweeter</i>	a Twitter user that creates and sends a tweet
<i>Retweeter</i>	a Twitter user that retweets an original tweet
<i>Username</i>	also known as a Twitter handle, this is how Twitter users are identified on Twitter. A username is always preceded immediately by the @ symbol (e.g., @charlesdarwin)
<i>Hashtag</i>	any word or phrase immediately preceded by the # symbol. A word with a hashtag becomes a keyword or topic that is searchable through the Twitter search tool (e.g., #ICCB2013)
<i>Follower</i>	a Twitter user who has chosen to follow a username and receive tweets from that username in their Twitter feed
<i>Feed</i>	a real-time stream of tweets from followers
<i>Profile</i>	a short bio of a Twitter user (interests, location, etc.), as well as all of the tweets they have posted

Fig. 1. The flow of information from the presenter to the live-tweeter to the retweeters to their followers from a tweet about a presentation at the ICCB 2013 meeting.

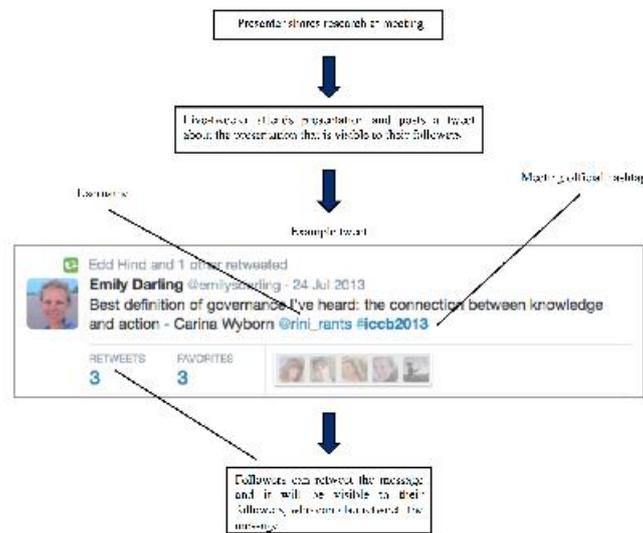


Fig. 2. A comparison of live-tweeting of session types at ICCB 2013, as measured by the total number of retweets / total number of presentations in a session type. The number of retweets/session type are listed above each bar and the total number of presentations (n) is shown below each session type on the x-axis.

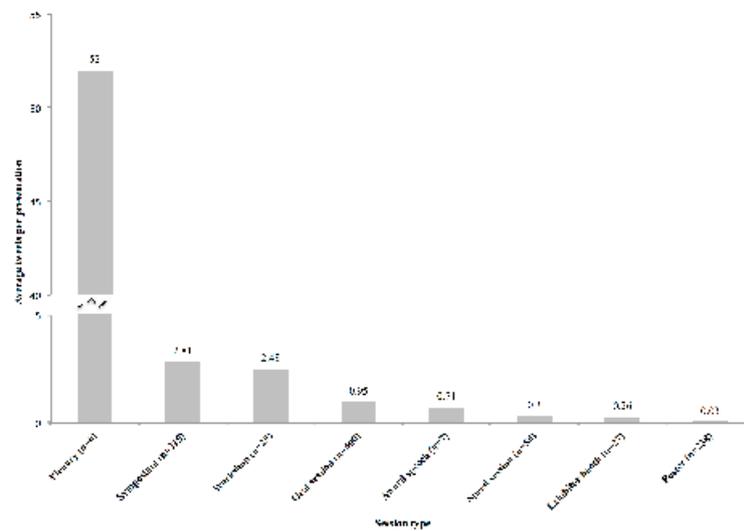


Fig. 3. The percentage of audience categories that presenters intended to reach with their research, compared with the actual proportion of audience categories reached through live-tweeting at ICCB 2013.

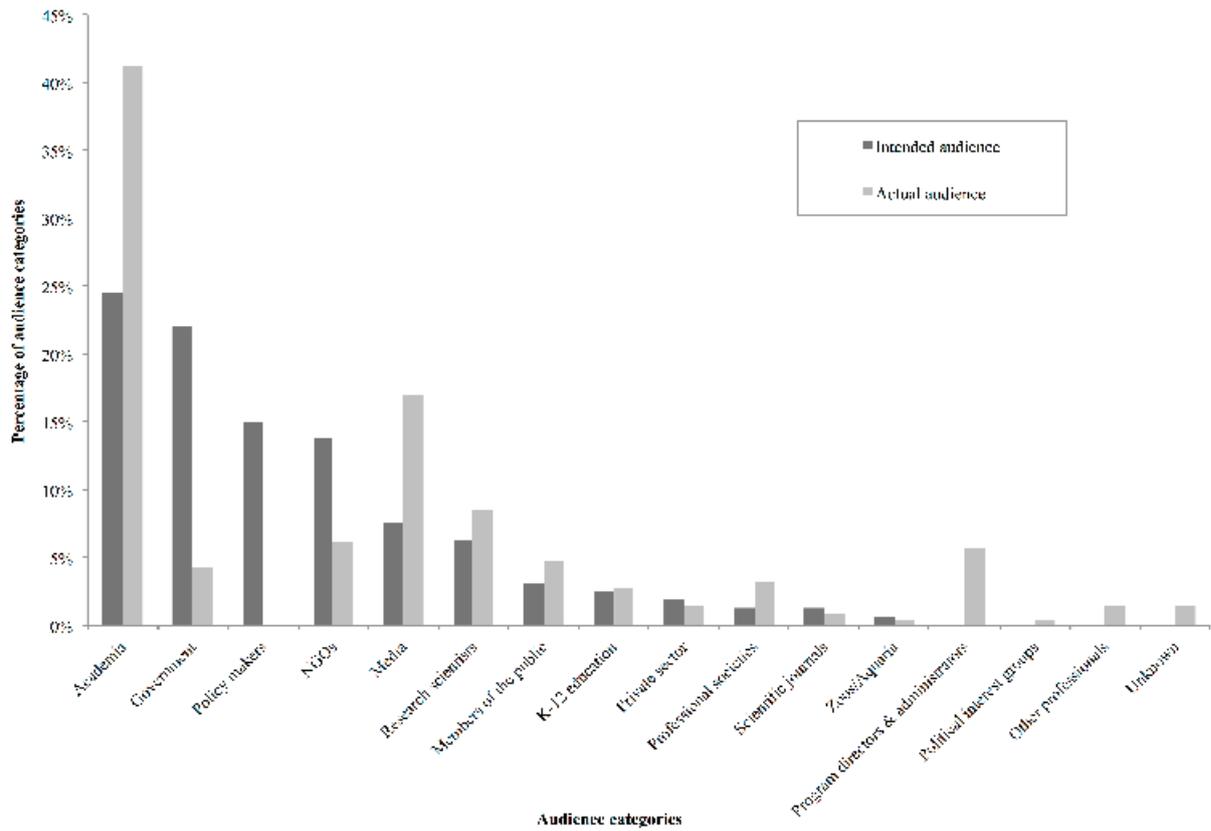


Fig. 4. Shortcomings listed by ICCB 2013 presenters that indicated why the randomly selected tweet about their presentation was less than very effective.

