Evaluating the benefits and risks of social media for wildlife conservation

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Abstract

Given its extensive volume and reach, social media has the potential to widely spread conservation messaging and be a powerful tool to mobilize social change for conserving biodiversity. We synthesized gray and primary academic literature to investigate the effects of social media on wildlife conservation, revealing several overarching benefits and risks. We found that social media can increase pro-conservation behaviours among the public, increase conservation funding, and incite policy changes. Conversely, social media can contribute to species exploitation and illegal trade, cause unprecedented increases in tourism in protected areas, and perpetuate anti-conservation behaviours via misinformation. In most cases, we found that content sharing on social media did not result in a detectable impact on conservation; in this paper, however, we focus on providing examples where conservation impact was achieved. We relate these positive and negative outcomes of social media to psychological phenomena that may influence conservation efforts and discuss limitations of our findings. We conclude with recommendations of best practices to social media administrators, public social media users, nongovernmental organizations, and governing agencies to minimize conservation risks while maximizing beneficial outcomes. By improving messaging, policing online misconduct, and providing guidance for action, social media can help achieve wildlife conservation goals.

Key words: endangered species, Facebook, Instagram, invasive species, internet, Twitter

Introduction

Despite growing global conservation efforts, the rate of species extinctions continues to accelerate (Pimm et al. 2014). Combatting biodiversity loss is a "wicked" problem (Rittel and Webber 1973) that is difficult to solve as it is often complex and requires collaborative, transdisciplinary solutions. Conservation disciplines have never been more challenged than they are today by the wickedness of interacting and sometimes synergistic drivers of biodiversity loss (Bradshaw 2020); Game et al. (2014) went so far as to state "conservation is not rocket science; it is far more complex". Conservation practitioners must adopt multidisciplinary approaches that bridge not only academic disciplines but will also reach political and social realms (Dick et al. 2016). In the era of information

technology, where more than half of the global population is online (Kemp 2021), social media (e.g., Facebook, Twitter, Instagram, YouTube; Kaplan and Haenlin 2010) has the potential to widely spread conservation messaging and play a pivotal role in transformative societal changes. Thus, social media could offer an opportunity to explore innovative strategies to facilitate social change and stem biodiversity loss (Díaz et al. 2019). Importantly, social media can change peoples' behaviours (Lenda et al. 2020; Lenda et al. 2021); harnessing its unparalleled reach and influence could better facilitate conservation efforts and mobilize pro-environmental behaviours for nature conservation at large scales.

Social media can reach large and diverse sociodemographic groups of people. There are 4.48 billion social media users worldwide today, with users relatively evenly spread across genders, ages, and all continents including developed and developing countries (Korda and Itani 2013; Pearson et al. 2016; Kemp 2021). Conservation scientists are increasingly recognizing social media as a unique and large-scale source of data (Di Minin et al. 2015), as social media users generate real-time content and share information in the form of images, videos, and text that can be used to support a myriad of conservation-focused research (Kaplan and Haenlein 2010). This includes monitoring invasive species (Daume 2016), analyzing animal behaviours (Dylewski et al. 2017), determining tourist motivations in protected areas (Hausmann et al. 2017), and informing decisions for threatened species conservation (Sullivan et al. 2019). Additionally, geotagged posts (i.e., posts with geographic information) can be used to map ecosystem services (Casalegno et al. 2013), human visitors in protected areas (Tenkanen et al. 2017), and species distributions (El Qadi et al. 2017). However, the utility of social media as a tool for societal change that directly translates into positive conservation outcomes is unclear.

We investigated how social media can impact species-specific conservation, with a focus on threatened species conservation and invasive species management. Any conservation status provided (e.g., Vulnerable, Critically Endangered) is based on The International Union for Conservation of Nature's (IUCN) Red List of Threatened Species (see iucnredlist.org/) unless otherwise indicated. To describe how social media can influence wildlife conservation, we present a conceptual model (Fig. 1). Here, "wildlife" includes all nonhuman, nondomesticated, and nonintroduced species of plants, animals, and microbes (Wyatt 2013); "wildlife conservation" is therefore the practice of protecting those organisms and their associated habitats. Social media can be used as a source of evidence (i.e., data; Fig. 1B) or as a tool to increase public awareness (Fig. 1C). Increased awareness can lead to enhanced environmental knowledge, which may change people's current attitudes or behaviours, or initiate new ones, potentially resulting in various positive (benefits) and (or) negative (risks) outcomes for wildlife conservation (Fig. 1D). Owing to its capacity for rapid and far-reaching diffusion of information (King et al. 2014), social media can effectively spread messages across broad audiences, either initiating conservation actions or amplifying existing conservation messages. The examples and case studies we provide throughout the paper generally substantiate our conceptual model; interestingly, most of our examples support the otherwise largely debunked "knowledge-deficit model" of behaviour change. The knowledge-deficit model assumes that increased knowledge will result in specific behavioural responses—though some studies show a clear relationship between environmental knowledge and corresponding attitudes (Sturgis and Allum 2004; Allum et al. 2008)—the knowledge-deficit model in general oversimplifies the complex relationship between knowledge, attitudes, and associated behavioural responses (Schultz 2011; Moss et al. 2016). With this in mind, we have attempted to showcase examples that do offer clear links between increased knowledge or awareness from social media and a corresponding effect.

To synthesize and discuss examples of the different ways in which social media influences wildlife conservation, our transdisciplinary team performed a literature review and informal online search.
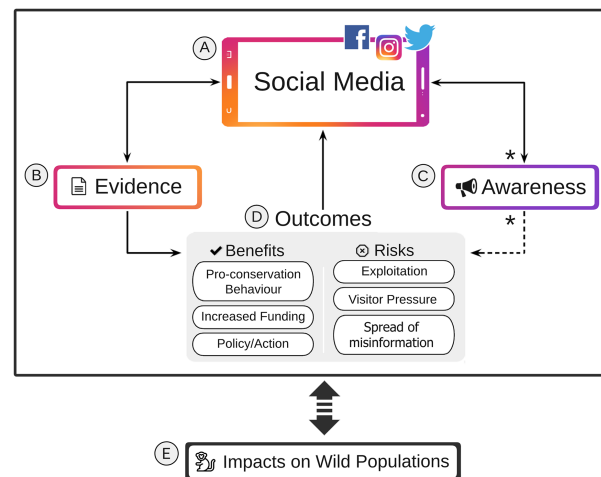
Fig. 1. Conceptual framework outlining the interactions between social media and wildlife. Posts on social media (A), which may include photos, videos, or text, can be used as a source of evidence (B) or as a tool to increase public awareness (C). A variety of potential outcomes exist (D) that may result in a benefit or risk to wildlife conservation. Social media can lead to beneficial outcomes by increasing pro-conservation human behaviour changes, increasing conservation funding, and inciting conservation policy action or governmental actions. Social media also poses several risks to wildlife, and may contribute to wildlife exploitation, increase visitor pressure to protected areas, and other anti-conservation behaviour due to the spread and influence of misinformation. Social media may simply result in further content sharing (A), or it may have detectable impacts on wildlife populations (E). *The detailed relationships between social media posts and human behaviour with potential psychological effects can be found in **Supplementary Material 6**.

We conducted a literature review using a series of filters in Web of Science (**Supplementary Material 1**) yielding a total of 547 articles (**Supplementary Material 2**). We used Web of Science as it is the world's leading multidisciplinary scientific citation search engine (Li et al. 2018) instead of a search engine like Google Scholar, which has known limitations (e.g., it is unavailable or restricted in some countries; see Gusenbauer and Haddaway (2020)). We screened the title and abstract for each of the 547 articles to identify literature that examined an interaction between social media and conservation (hereafter "relevant articles"). Of the 212 relevant articles we found, 129 used social media as a source of data for research (**Fig. 1B**), 40 used social media as an agent for outreach and awareness (**Fig. 1C**), and 32 used social media both as a source of data and for outreach, while the remaining 11 articles broadly discussed social media and conservation (**Supplementary Material 2**). Of the articles that provided a specific case of how social media impacted wildlife conservation ($N = 72$), 34 offered an example of a benefit and 38 an example of a risk (**Supplementary Material 2** and **3**). Finally, through informal online searches, we discovered 36 additional examples from gray literature sources (e.g., news articles) describing the influence of social media on wildlife conservation (**Supplementary Material 3**). Despite finding 212 relevant articles, with 72 providing a specific benefit or risk of social media to conservation, the results of our synthesis showed that there is generally a lack of studies quantifying the causal relationship between social media and measurable impacts in human environmental behaviours or wildlife conservation. This, however, is not unusual given conservation interventions targeting human behavioural change have been documented to often lack meaningful evaluation (Veríssimo 2013).

Our synthesis revealed several overarching positive and negative themes. We found that the benefits of using social media include: pro-conservation human behaviour changes, increases in conservation funding, and new conservation-based legislation or governmental actions. The main risks we

identified include: increases in species exploitation and illegal trade, increases in visitor pressure to protected areas, and the perpetuation of misinformation and other anti-conservation behaviours. Although in most cases content sharing (**Fig. 1A**) on social media will not result in a discernible effect on conservation, in some cases it can have direct or indirect impacts on wildlife (**Fig. 1E**). We present examples describing the relationship between social media attention and wildlife conservation, including a detailed description of a case where there is a clear impact of social media (**Box 1**) and another case where the link is likely but less clear (**Box 2**). In some cases, discerning the causal relationship between a post on social media (i.e., output) and a corresponding human behaviour effect (i.e., outcome) was unclear. As mentioned earlier, this was an overall key issue we found in our synthesis, so we have acknowledged cases where the output versus outcome was not evident. We then outline key socio-psychological phenomena to better understand the potential influence of social media on users to guide more effective use of social media and encourage pro-conservation behaviours (see **Table 1** for details). We discuss limitations of our findings and conclude with recommendations of best practices to social media administrators, public social media users, nongovernmental organizations (NGOs), and governing agencies to promote the responsible, conservation-minded use of social media.

Box 1. Case Study: How social media amplified efforts to control invasive Indo-Pacific lionfish in the Western Atlantic and Caribbean

The Indo-Pacific lionfish (*Pterois volitans* and *P. miles*) is an invasive, predatory fish that negatively affects coral reef ecosystems in the Western Atlantic and Caribbean (Côté et al. 2013). Derbies (i.e., organized culling events) are frequently advertised on various social media platforms to engage the public in conservation efforts and raise funding for invasive species removal events. In 2019 alone, 15 derbies were held (myfwc.com/fishing/saltwater/recreational/lionfish/events/) across the state of Florida, United States, through collaborations among governing agencies (e.g., Florida Fish and Wildlife Conservation Commission) and NGOs (e.g., REEF, Lionfish University), resulting in the removal of 24,571 individual lionfish. Derby organizers use social media as an effective mechanism to share information about upcoming events or tournaments (Alexander Fogg, Okaloosa County Board of County Commissioners, personal communication, 2021); when other users share derby posts, they further spread the message and increase public awareness. Social media was recognized as a key reason for the success of the "world's largest (lionfish) tournament," the 2019 Emerald Coast Open (ECO), which raised more prize money (USD$87,600; 10 times more compared to 2018), resulted in more individual lionfish removed (19,167; 1.5 times more compared to 2018), and received more participants than any other tournament to date (189; 2 times more compared to 2018). Though no official ECO tournament occurred in 2020 due to the COVID-19 pandemic, the 2021 tournament was again successful, raising USD$95,000 in prize money, registering 146 participants, and removing 10,250 lionfish (**Box 1 Fig. 1**). When conducted regularly, large-scale derbies like the Emerald Coast Open can provide native fish communities the chance to recover and mitigate the adverse impacts lionfish incur on local ecosystems (Green et al. 2017). In this case, the use of social media not only increased public awareness of invasive species impacts, but also increased funding, changed people's behaviour (e.g., increased participation in derbies), and reduced the abundance of invasive species in the wild.

Box 1. Fig. 1. Lionfish on artificial reef off the coast of Florida, United States (left). ECO tournament organizer Alexander Q. Fogg displaying a culled lionfish on spear (right). Photos used with permission by Mark Miller (see primofish.com).

Box 2. Case Study: Mass social media attention likely supported the exploitation and deterioration of the conservation status of Asian otters (subfamily: Lutrinae)

We highlight the case of Asian otter exploitation in Japan as it exemplifies the difficulty in teasing apart the interactive effects of traditional media, social media, and the relationship between attitudes and consumer demands. The perception of otters as suitable companion animals has been perpetuated by successive mass media (e.g., the Japanese television show "Tensai! Shimura Dobutsuen" which ran from 2007 to 2014) and public establishments (e.g., otter cafés), amplified by YouTube videos (Kitade and Naruse 2018; Harrington et al. 2019). YouTube has been suggested as a key platform responsible for amplifying the popularity of pet otters (Kitade and Naruse, 2018), so we conducted a search on YouTube to investigate these effects. We searched for the five most popular videos depicting Asian otters as pets and manually screened the top 500 comments for each video (2500 total) to evaluate viewers' responses. Comment analysis did indeed reveal that post-viewing, many viewers desired owning an Asian otter as a pet (e.g., "wow! i want one!!! WHERE can I get a pet otto!!!!!"; **Supplementary Material 7**). YouTube received its first (Japanese) video post of a pet otter in 2012, coinciding with the beginning of increased searchers for otters on Google (in Japanese, カワウソ) (**Box 2 Fig. 1**). The number of users on YouTube drastically increased from 20 million to 800 million from 2008 to 2012, respectively (see backlinko.com/youtube-users), corresponding with more people searching for otters on Google. Google searches peaked in 2017 and remained high until 2020—according to Harrington et al. 2019, although Japanese pet otter videos started being posted in 2012, it was not until 2017 that video posting began considerably increasing. Thus, there appears to be a relationship between increased engagement (users searching for otters on Google) and more videos being posted to social media. What is less clear, however, is how increased social media engagement impacted consumer demand and illegal imports of live otters. The number of live otters illegally imported into Japan increased comparably with Google searches in 2016–2019, lagging slightly by ∼1 year. As a result of the boom in demand for otters as pets in Japan, and online pet trade emerging as a pressing threat, CITES approved highest trade protections in 2019 (denoted by the green star on the x-axis **Box 2 Fig. 1**) for two Asian otter species (small-clawed (*Aonyx cinereus*) and smooth-coated (*Lutrogale perspicillata*)), acknowledging these species are threatened with extinction and banning commercial international trade (Kitade and Naruse, 2018; Senior and Thomas, 2018; Thomas, 2019). Note that the highest number of

Box 2. (*concluded*)

imported otters was in 2019, and following this ban, only one (live) otter was confiscated by CITES in 2020. Banning live imports does not necessarily mean otter trades are not occurring; it could simply mean illegal trades are not being discovered. It would be useful to know if otters continue to be illegally transported for the online pet trade and to what extent social media drives demand. Although many people who commented on the YouTube videos expressed a desire to own an Asian otter as a pet, 2% of viewers "disliked" the videos. Additionally, some responded to comments, explaining why owning an endangered species can negatively impact wild populations. Given millions of people view these online videos, comments explaining how owning and trading endangered animals is problematic may be able to pivot reactions from wanting to own to wanting to protect these species.
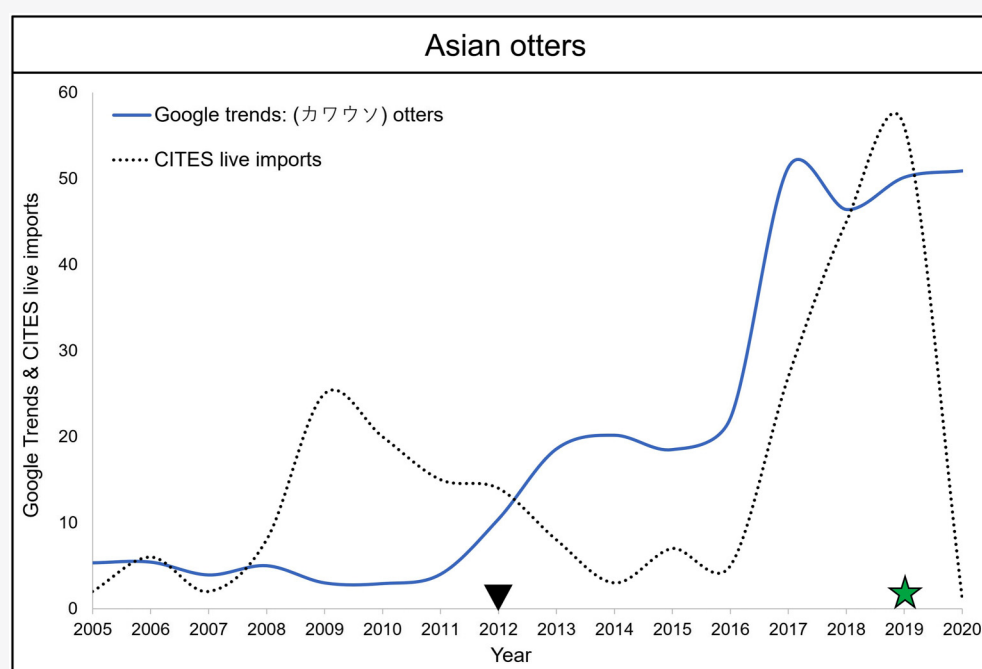
Box 2. Fig. 1. The mean annual Google Trends search interest (solid blue line) and number of live imported trades by CITES (dotted line). Google Trends search interest is relative to the highest peak in the time series, whereby "100" is the peak popularity for the term. We averaged values by year, resulting in a maximum Google Trends search interest of 51.33 in 2017. Google Trends and CITES data were downloaded 11 November 2021. The first Japanese pet otter videos were posted to YouTube in 2012 (denoted by inverted black triangle on *x*-axis). The number of otters imported and searched for on Google simultaneously peak in correlation with mass social media attention via YouTube in 2016–2020. Google Trends search data and CITES data shown is from 2005–2020 and averaged by year. The search term for otters was in Japanese (カワウソ). Number of live trades from CITES were calculated as gross, live imports. The green star denotes the year (2019) CITES prohibited all commercial trade of smooth-coated and small-clawed otters.

Table 1. Examples linking psychological phenomena and social media.

Psychological phenomena	Definition	Social media example	References
Cognitive dissonance	Cognitive dissonance occurs when a situation arises that involves conflicting attitudes, beliefs, or behaviours. The feeling of discomfort can lead to an alteration in ones' attitudes, beliefs, or behaviours to reduce said discomfort.	A video of a straw extraction from the nostril a sea turtle went viral and appeared to drive increased awareness of plastic pollution impacts on marine ecosystems. Google Trends illustrated a subsequent correlation between increased plastic pollution awareness and a new consumer desire for plastic alternatives (**Figure S1**). Seeing the turtle (a charismatic species) undergo a seemingly painful plastic-removal procedure resulted in viewers experiencing negative emotions and discomfort, and corresponded with pro-conservation behaviour changes.	Robinson and Figgener, (2015); Akpan et al. (2018); Figgener, (2018)
Humouristic persuasion	Humour-oriented approaches can be an effective method for promoting public interest and support for unappealing ("ugly") threatened species.	In instances where the threatened species of focus is not charismatic, researchers can use humour instead to engage audiences on social media. For example, amusing memes of the endangered, and ugly, proboscis monkey gained attention levels equal to, or even higher in some cases, memes with charismatic species. The amusing memes successfully raised awareness about an unappealing threatened species, and positively correlated with viewers' decision to donate to conservation.	Strick et al. (2009); Borden and Suggs, (2019); Lenda et al. (2020)
Streisand effect	The Streisand effect is an example of a psychological reaction whereby the suppression or censorship of information has the unintended consequence of stimulating a greater demand for that information.	On Instagram, if you search for a hashtag that has been associated with harmful behaviour to animals or the environment (e.g., #elephantride), an automated warning message is delivered to inform users of wildlife exploitation and negative interactions with wild animals. Though the policy aims to educate the public and reduce risks to wildlife, criticizing or banning these interactions may instead further perpetuate peoples' desire to seek out harmful wildlife selfies or interactions.	Parkinson (2014); Jansen and Martin, (2015); Ohlheiser (2020)
Consumer's doppelganger effect (conscious mimicry)	Consumer's doppelganger effect describes the phenomenon whereby individuals consciously mimic others' consumption behaviour to look or behave like those they admire. If the consumers' preferences or beliefs are not (well) formed yet, they are especially likely to select options based on what other people are choosing.	A YouTube video of a pet slow loris being tickled went viral and correlated with a global increase in Google Trends searches for slow lorises (**Figure S2**). Here, the large numbers of people "liking" content of slow lorises' as pets, and leaving comments suggesting a craving to own a slow loris, may inspire others to have such an animal as a pet. When other people purchase wild animals and claim their appropriateness as pets, it encourages others to do the same. In this instance, mimicry may be contributing negatively to wildlife conservation via species exploitation and, in some cases, illegal trade.	Nekaris et al. (2013); Ruvio et al. (2013); Nijman et al. (2017); see **Box 2**
Endorsement of public figures and celebrities	Most celebrities that have social media accounts have significantly more followers compared to the noncelebrity individual. Thus, the posts on a celebrity's account can reach considerably more viewers. Additionally, many public users idolize celebrities and mimic their behaviour (see conscious mimicry example above). As a result, public figures are frequently used in conservation marketing to raise awareness, generate funding, and influence behaviour changes.	In support of a WWF campaign, Leonardo DiCaprio called on his 19.5 million Twitter followers to directly contact and request the Mexican President take action to protect its critically endangered vaquita porpoise. More than 200,000 people emailed the Mexican President and, consequently, the Mexican government announced new conservation measures to protect the vaquita. It should also be noted however that celebrities can perpetuate misinformation and other anti-conservation behaviours. For example, if celebrities post images on social media holding or cuddling exotic (and usually endangered) animals, this can perpetuate the false conception that wild animals make suitable pets and lead to exploitation (see section 4.1).	Tanaka et al. (2015); Duthie et al. (2017); Olmedo et al. (2020); Nekaris et al. (2013); Noik, (2017); Albert et al. (2018); Spee et al. (2019); see section 3.3

(continued)

Table 1. (*concluded*)

Psychological phenomena	Definition	Social media example	References
Social proof	Social proof is the phenomenon in which people copy the actions of others because they assume this action is "acceptable" if other people are doing it. Related to social media, the number of followers, likes, views, or positive comments on a given post can play a role in influencing user perceptions.	Social media provides a simple but effective way to spread information about invasive species effects on ecosystems and associated management actions that the public can aid in. For example, Facebook has been used to draw attention to invasive species removal events and job prospects (e.g., lionfish derbies; culling positions), and opportunities to donate to conservation efforts. By sharing evidence-based information about invasive species and removal events via posts, and when others "like" and comment in approval, it shows other viewers that these events are "acceptable" because many are in support and can influence people to engage in those same conservation actions.	Schnuerch and Gibbons (2015); Fong et al. (2020); see **Box 1**
Effect of visual content	The use of imagery can condense complex information, convey powerful messages, and has been shown to have cognitive advantages over verbal messaging. Images can touch the "emotional side" of people and form a connection to what the image is depicting.	Powerful imagery shared on social media has engaged audiences—including both public and government—to take rapid conservation actions. Researchers shared high resolution images depicting proboscis monkey critical habitat being cleared, which alone threatens their population, but also revealed that the forest clearing illegally extended to a river's edge. The images raised significant public response, and the local government acted quickly, ordering an immediate halt to further clearing.	Nicholson-Cole (2005); Sheppard (2005); Kees et al. (2006); Wu et al. (2018); examples provided in text
Confirmation bias	Confirmation bias is the inclination of people to give preference to information that confirms their existing belief(s). Confirmation bias can result in people undervaluing or rejecting evidence that could disprove them, and unsurprisingly, it is usually stronger for emotionally-charged issues and for deeply entrenched beliefs.	The issue of managing outdoor, domestic cats (free-roaming pets or feral) is a concern that has been ongoing for 15+ years. Though the large-scale negative impacts cats impose on wildlife and biodiversity is well known, pro-outdoor cat groups on social media still portray cats as having little impact on local wildlife. Most (outdoor) cat colony caretakers (CCCs) hold false beliefs about the impacts of cats on wildlife, and even when evidence is provided to CCCs regarding cats' harmful impacts, they can seek confirmation by visiting other pro-outdoor-cat social media pages to reinforce their pre-existing beliefs. Here, confirmation bias results in people seeking out information (even if it is false) to support their existing beliefs, perpetuating misinformation, and anti-conservation behaviours.	Nickerson (1998); Peterson et al. (2012); Loss et al. (2013); Wald and Jacobson, (2014); Watson et al. (2018); Trouwborst et al. (2020)

Note: We provide examples of and define psychological phenomena linked with social media effects on wildlife conservation. Select examples are provided from the text that highlight the benefits and (or) risks linked with cognitive dissonance, humouristic persuasion, the Streisand effect, consumer's doppelganger effect, endorsement of public figures, social proof, the effect of visual content, and confirmation bias. The provided examples show how psychology can be an important lens through which these phenomena can be understood.

FACETS

Benefits of social media for wildlife conservation

Pro-conservation human behaviour changes

A powerful aspect of social media is its ability to influence consumer behaviour through digital advertising, product reviews, and online word of mouth (Stephen 2016). Consumer behaviours drive market demand; if social media can spread awareness about the impacts of unsustainable or environmentally harmful products, and people change their consumer behaviours to minimize these harmful effects accordingly, the gains could be considerable. In August 2015, a video was posted to YouTube of an olive ridley sea turtle (*Lepidochelys olivacea,* listed as Vulnerable; **Fig. 2A**) undergoing a seemingly painful plastic straw removal from its nostril (youtube.com/watch?v=4wH878t78bwandt=79s; Robinson and Figgener 2015). The video was credited as instrumental in spreading awareness (i.e., Effect of visual content, **Table 1**) about the global marine plastic crisis and is believed to have strongly supported an "anti-plastic straw movement" (Figgener 2018). The "strawless ocean" initiative
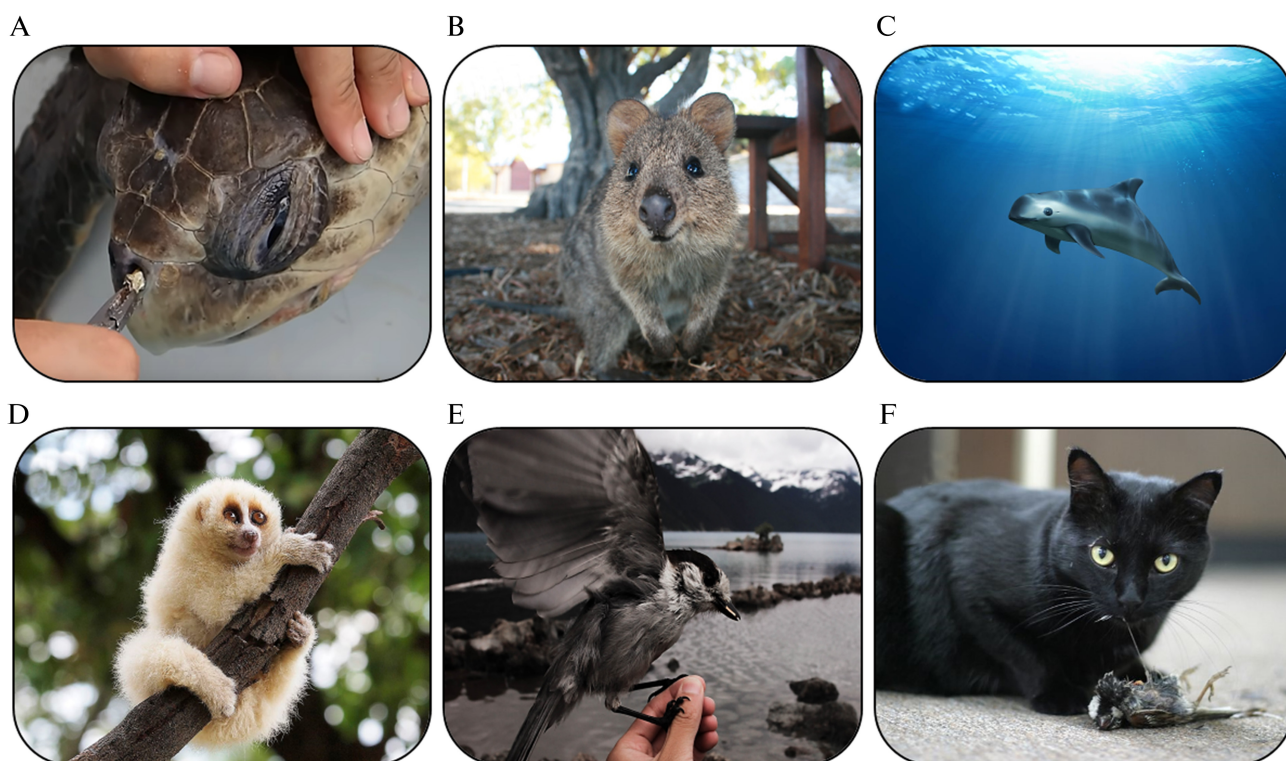
Fig. 2. Photo mosaic representing examples of potential benefits and risks of social media for wildlife conservation. Examples of benefits include (A) pro-conservation human behaviours: a viral video of an olive ridley sea turtle (*Lepidochelys olivacea*) with a plastic straw lodged in its nostril contributed to an anti-plastic straw movement; (B) increased conservation funding: the quokka (*Setonix brachyurus*), dubbed "the happiest animal in the world," inspired an online selfie craze (#quokkaselfie) resulting in increased tourism to Rottnest Island, Australia, and more funding for conservation research of the endemic population; (C) conservation-based changes to policy: a WWF social media campaign, bolstered by supportive Instagram and Twitter posts from Leonardo DiCaprio, garnered responses from 200,000 citizens worldwide and resulted in the Mexican government changing legislation to protect the sole remaining vaquita (*Phocoena sinus*) population. Social media also incurs several risks to wildlife, such as (D) increases in species exploitation: YouTube videos and celebrity selfies can drive illegal trades of Endangered slow lorises (*Nycticebus* spp.); (E) increases in visitor pressure to protected areas: geotagged social media posts led to unprecedented tourism at Joffre Lakes, British Columbia, Canada that altered normal foraging behaviour of Canada jays (*Perisoreus canadensis*); (F) misinformation perpetuation: free-roaming, outdoor cat (*Felis catus*) advocacy groups spread misinformation on social media platforms about the role of cats as an invasive species. Photo credits: (A) Christine Figgener and Nathan Robinson; (B) Adrien Lamotte; (C) Greenpeace/Marcelo Otero; (D) Aprisonsan, Wikimedia Commons; (E) Trevor Wongg, Wikimedia Commons; (F) Mark Marek, Wikimedia Commons. All photos used with permission.

gained momentum in mid-2017, corresponding with a considerable increase in Google search interest for reusable alternatives (**Supplementary Material 4**). According to the Ocean Conservancy (2018), plastic straws were among the most common waste items found along coasts during an international cleanup event, but only accounted for 5%–7.5% of all collected materials. Searches for plastic alternatives (e.g., beeswax wrap, reusable straw) increased in the ensuing months (**Supplementary Material 4**) and, in addition, we noted a considerable spike in searches for the term "single-use plastic" after mid-2017 suggesting an overall increased awareness about plastic effects. It is critical for campaign managers to (start or) continue crafting messages that guide users to rethink their relationship with single-use plastics as a whole, as plastic straws are just a small part of the plastic pollution problem.

There are also instances where social media spread knowledge and awareness of invasive species that inspired community members to take conservation actions (see **Box 1**; **Supplementary Material 3**). Since 2011, The Black Bass Conservation Committee (BBCC) has used social media to connect the public and anglers with conservation messages in a relatable (i.e., jargon-free language) and engaging way. Using clear, direct messaging to ensure stakeholder support is not a new concept and indeed is valued by consumers (McLeish 2010; Lyes et al. 2012). In response to a post on the BBCC Facebook page (facebook.com/afs.black.bass) about hybridization between native and non-native *Micropterus* (bass) spp. in the Chattahoochee River, United States, a local angling group organized a tournament—without any prompting from researchers, the government, or academics—to harvest as many non-native bass as legally possible to enact positive change for the native fishery (Andrew Taylor, University of Central Oklahoma, personal communication, 2021; Taylor and Sammons 2018). In this single event, anglers removed hundreds of non-native bass from an area, bringing much-needed attention to the growing issue of non-native bass introductions and their ecological impacts on native congeners (Taylor et al. 2018). The event was held the year after, and the BBCC expects the anglers to hold the tournament annually (Taylor and Sammons 2018). Although it is unclear if angler efforts will effectively suppress invader populations below levels that cause deleterious ecological effects (i.e., functional eradication; Green and Grosholz 2021), this case clearly illustrates how conservation messages shared on social media inspired stewardship in community members and resulted in pro-conservation behaviours.

Social media can unify people of diverse backgrounds across the globe to facilitate activism (Valenzuela 2013). Social movements can spread rapidly on social media owing to the easy means of organizing protests and demonstrations, lobbying support, and sharing e-petitions (Valenzuela 2013). In 2010, the environmental NGO Greenpeace launched several short emotional films, each with linked e-petitions, about the ecological impacts of palm oil production, specifically related to deforestation effects (Vijay et al. 2016) on Critically Endangered orangutans (*Pongo* spp.; see (1) youtube.com/watch?v=1BCA8dQfGi0 and (2) youtube.com/watch?v=TQQXstNh45g). Prior to 2010, Nestlé purchased palm oil from an Indonesian conglomerate (Sinar Mas) responsible for illegal forest and peatland clearing. Greenpeace created and disseminated a disturbing video (link (1)), targeting Nestlé and bringing awareness to their destruction of orangutan critical habitat, that went viral on social media. Nestlé attempted to have the video banned from YouTube, citing a breach of copyright; however. this censorship only encouraged conservation activists (i.e., the Streisand Effect, **Table 1**) who subsequently posted videos to other social media sites and flooded Nestlé's Facebook page with scorning comments. The story eventually made mainstream headlines (e.g., The New York Times, NBC), damaging Nestlé's reputation and causing stock prices to fall (Matharu-Daley and Hopp 2020). After Greenpeace's campaign—which was credited with raising considerable awareness concerning unsustainable palm oil (Zoller and Dray 2016; Chua et al. 2021) and further augmented by mainstream media—Nestlé broke off its relations with Sinar Mas (Shreeves 2010) and announced they would only source palm oil from suppliers who protect forests and peatlands,

support Indigenous and local communities, and do not break regional laws (Chaudhari 2011). These emotionally charged videos provide a clear example of how a message on YouTube helped with information diffusion (Stieglitz and Dang-Xuan 2014) and resulted in people actively pressuring the world's largest food and beverage company (Lee et al. 2020) to change their behaviours and policies to minimize environmental damage.

Increases in conservation funding

Inadequate funding is a major impediment to stemming global biodiversity loss (Martin et al. 2018). By using strategic marketing strategies (e.g., carefully considering each social media platform's demographics (Olafson and Tran 2021) and the best times to reach key audiences (Arens 2020)), social media can serve as an effective platform to generate funding for conservation. To garner financial support from broad audiences, NGOs commonly use social media as a platform to market conservation campaigns. For instance, in April 2016, the World Wide Fund for Nature (WWF) teamed up with Apple on Apps for Earth for a 10-day campaign to raise awareness about global conservation issues and generate funding for their work in connection to Earth Day. WWF credits the campaign as "extraordinarily successful": it resulted in three billion impressions on Twitter alone, was downloaded by 400,000 new viewers, and generated more than US$8 million in total proceeds (WWF-US Annual Report 2016). WWF's total revenues in 2016 was roughly US$305.2 million; although the US$8 million generated from the Apps for Earth campaign may have been a "drop in the bucket," the organization nonetheless achieved their goals of spreading awareness globally and raised millions of dollars for conservation work. WWF has held other social media based campaigns, like their #EndangeredEmoji fundraising campaign on Twitter (**Supplementary Material 3**). To participate, users first retweeted the WWF campaign tweet, and any subsequent tweets with an endangered emoji icon resulted in a suggested amount to donate. The #EndangeredEmoji campaign was also successful in garnering attention: within the first two months of the campaign, they received 59,618 signups and 559,000 mentions on Twitter (Hootsuite and WWF 2019). We were unable to determine how much money was directly raised as a result of this campaign (i.e., an issue of output versus outcome); however, WWF still credits the #EndangeredEmoji campaign as successful, because it did indeed increase awareness and spread information about endangered species.

Humans often show a positive attitude towards wildlife species that look similar to human infants (i.e., those with a large head in relation to its body, a small nose, and big eyes; Estren 2012; de Pinho et al. 2014) and large, charismatic megafauna (Skibins et al. 2013; Albert et al. 2018). NGOs and governments will strategically use these charismatic, flagship species to generate conservation funding in social media campaigns, and can generate spillover benefits for lesser-known or unappealing species and (or) ecological processes (Bennett et al. 2015). Reversing the current rate of biodiversity loss will depend on raising funds and support for a wider range of species outside the usual charismatic ones (Bennett et al. 2015; Veríssimo et al. 2017). To determine ways in which conservationists can bring awareness to threatened but unappealing species, Lenda et al. (2020) took an interesting approach by investigating whether humour could be used to generate equal engagement. They found that when humour was integrated into social media marketing strategies like "memes" (digital images, usually containing text, created for online communication), as much interest was garnered for an unappealing species, the Endangered proboscis monkey (*Nasalis larvatus*), as charismatic ones (e.g., koala (*Phascolarctos cinereus*), panda (*Ailuropoda melanoleuca*), orangutan, Lenda et al. 2020; i.e., Humouristic persuasion, **Table 1**). Importantly, the interest in humourous memes positively correlated with individuals' decisions to donate to conservation efforts (Lenda et al. 2020), suggesting that humorous social media strategies may provide a valuable complement to traditional campaigns when attempting to raise awareness and funding for less popular, noncharismatic species.

Similar to spillover benefits for noncharismatic species, ecotourism—one of the fastest growing tourism industries (Ballantyne and Packer 2013)—can also provide broad spillover financial conservation benefits. Bolstered by social media attention, the funding it generates can play a critical role in supporting management and achieving conservation goals (Steven and Castley 2013; Balmford et al. 2015). Ecotourism may however be a "double-edged sword" as it can have both favourable and unfavourable impacts on wildlife (see "Increases in visitor pressure to protected areas" section). In this section, however, we demonstrate how tourism can positively impact conservation. Rottnest Island, Australia, exemplifies one of the best-known cases of social media-related increases in ecotourism and associated conservation funding becasue of the viral hashtags #quokkaselfie (>36,000 Instagram posts) and #quokkaselfies (>31,000 Instagram posts). Home to the quokka (*Setonix brachyurus*; Fig. 2B), a charismatic, Threatened marsupial dubbed "the happiest animal in the world," Rottnest Island has experienced increased tourism and associated revenue due to more visitors seeking quokka selfies (Gretzel 2019). Since the initial #quokkaselfie post in 2015, the Rottnest Island Authority (RIA; a statutory body that maintains the island under Western Australia's government) has seen increases in total revenue (increase in annual revenue by 29% from 2015 to 2019 versus 11% from 2010 to 2014) and total visitors (see 2020 Annual Report; RIA, n.d.). The Executive Director of the RIA has publicly stated that celebrity selfies "helped to propel the quokka to international fame", resulting in setting new records for visitors travelling to the island and in turn helping the island fund its quokka research and conservation efforts (Clarke 2019b; Curto 2019). To track potential impacts of increased tourism activities on population health and stability, in 2018 the RIA initiated a long-term quokka monitoring program to track key indicators of condition like weight, weaning rate, and overall health (see 2020 Annual Report; RIA, n.d.). Results from the monitoring program in 2020–2021 indicated the quokka population remains stable and healthy (see 2021 Annual Report; RIA, n.d.).

Conservation funding generated from ecotourism, and amplified by social media users, can also defend species against poaching. The Tsavo Trust Wildlife Conservation Program in Kenya relies on gate entry fees to support the costs of protecting Kenya's National Parks. Not only does funding support park infrastructure and rangers, but because tourism also increases the number of human eyes and ears in the area, poachers are effectively deterred (Tsavo Trust 2019). By sharing photos of wildlife experiences on social media, more visitors are encouraged to travel and visit the park, increasing funding for park management and minimizing poaching.

Conservation-based legislation and policy actions

Given social media's role in galvanizing political movements (Shirky 2011), it has the potential to influence policy, legislation, and enforcement based on popular opinion. In some cases, social media can directly lead to policy action (examples below), though it can also be used to amplify support for protecting endangered species or removing invasive species (Supplementary Material 3). Social media can also influence conservation-related policy within social media platforms themselves. In 2017, the World Animal Protection (WAP) launched their Wildlife Selfie Code campaign to educate users on the ethics of wildlife selfies. WAP's campaign collected 250,000 signatures and, as a result, Instagram launched a content advisory page to inform users about the dangers of certain wildlife selfies. If a user searches for hashtags on Instagram that have been associated with harmful behaviours to wildlife (e.g., #slothselfie, #elephantride, #dolphinkiss), a warning message is auto-generated, leading users to a page with information about wildlife exploitation and links to WWF, the Wildlife Trade Monitoring Network (TRAFFIC), WAP, and National Geographic. This policy aims to educate the public on responsible wildlife interactions and reduce risks to endangered species (see help.instagram.com/859615207549041). Although investigating the effectiveness of warning messages is outside the scope of this article, it would be useful to know if such messages result in detectable positive conservation outcomes (e.g., changed behaviours, donations to conservation agencies).

The use of social media can also help to connect community members with local conservation issues, leading to legislative changes. The Taiwanese black kite (*Milvus migrans*), classified as Endangered by Taiwan's Red List (Fang 2005), has experienced a dramatic population decline since the 1980s that coincided with the widespread use of carbofuran (a highly toxic insecticide) and rodenticides for agricultural purposes (Guo and Lin 1992). Prompted by several poisoning incidents of black kites, as well as other farmland birds, Hong et al. (2018) hypothesized that poisoning may be an underreported yet important threat linked with, or driving, population declines. To gather more information about poisoning incidents, they created a citizen-science Facebook page in 2014 (i.e., Bird Poison Report, Taiwan; facebook.com/groups/1490158747925040/). Any person who found dead birds (of any species) on farmland could post photos and associated information (i.e., date, coordinates, crop type, species, number of birds) to the Facebook page for verification. By 2016, the Facebook page had received reports from citizens of 4753 dead birds in 213 separate poisoning incidents. Although Hong et al. (2018) noted that poisoning of farmland birds was occasionally reported in Taiwanese newspapers or community websites, such reports did not receive much public attention compared with their citizen-science Facebook page. They found that using social media resulted in substantially more data on poisoning incidents, and they further stated that images of poisoned birds aroused public concern and helped prompt government involvement (i.e., Effect of visual content, Table 1). In response, the Taiwanese Council of Agriculture cancelled their nationwide anti-rodent campaign (i.e., rodenticides) and announced bans on higher concentration carbofurans in 2017. Hong et al. (2018) credited their citizen-science Facebook group for raising awareness of the overall situation of poisonings of black kite and other farmland birds and helping trigger Taiwanese legislative action.

The use of powerful imagery on social media can spur swift governmental action to enforce laws (i.e., Effect of visual content; Table 1). For example, Stark et al. (2018) combined satellite (GPS) tracking data of a proboscis monkey group in Sabah, Malaysia, with high-resolution remote sensing data sets to evaluate habitat use and resource selection. Their study revealed that 30.1% of the monkey's critical forest habitat had been cleared and that clearing extended to a river's edge, breaking water resource laws that mandate a 20 m riparian reserve along riverbanks (Sabah's Water Enactment 1998 Section 40[1]). A press release, including the drone imagery combined with GPS data, was published in local and national newspapers and to the Danau Girang Field Centre (DGFC) Facebook page. The DGFC uses both Facebook and newspapers regularly for publishing press releases and urgent conservation issues, so any heightened interest in this specific press release would not simply be because it was the only urgent conservation issue posted; therefore, any heightened interest could be compared to other press-release posts on their page (Stark et al. 2018; Danica Stark, Calgary Zoo, personal communication, 2021). Their press release invoked a strong emotional response, eliciting a threefold increase in reach on Facebook compared with other posts lacking imagery (Stark et al. 2018). The day following dissemination of their press release, the Sabah State Government intervened and ordered an immediate cessation of further land clearing at reserves along the river (The Star 2015). A second example of powerful imagery spurring unprecedented government action involved a graphic post on Facebook of a pregnant, Critically Endangered douc (*Pygathrix cinerea*) being tortured and slaughtered in the presence of Vietnamese soldiers. The post made headlines, grabbing the attention of readers and generating public outcry (Nghiem et al. 2012). Under public pressure, the Vietnamese government arrested the three soldiers (Cota 2012; Nghiem et al. 2012). Messages that are factually correct and emotionally moving have proved effective in influencing public opinion (Sitar 2012); our examples demonstrate that when powerful imagery is included in evidence-based messaging on social media, it can motivate rapid governmental responses.

Celebrity influence can be key in amplifying social media campaigns and accelerate changes in policy (i.e., Endorsement of public figures and celebrities, Table 1). The case of the Critically Endangered vaquita porpoise (*Phocoena sinus*; Fig. 2C) is a particularly interesting, complex example of how

social media was used to encourage a collaborative agreement between several nations, a celebrity, and an NGO to protect the sole remaining population in the northern Gulf of California. In 2017, Leonardo DiCaprio encouraged his 17.5 million Twitter followers (4570 retweets, 9941 likes; twitter.com/leodicaprio/status/862485495632285696?lang=en) and 50.3 million Instagram followers (250,000 likes; instagram.com/p/BT7xnDLB8ax/) to join WWF in calling on Mexican President Enrique Peña Nieto to take permanent measures to protect the vaquita by extending a 2-year ban on gillnet fishing. After decades of devastating bycatch mortality, driven largely by an illegal gillnet fishery, the vaquita population has declined by 98% to fewer than 10 individuals (Jaramillo-Legorreta et al. 2019). DiCaprio's tweet and Instagram post, combined with WWF's vaquita campaign, inspired 200,000 people globally to email the Mexican President and urge him to act. In this case, it is unclear how many of the 200,000 people who emailed the Mexican president did so because of DiCaprio's posts or WWF's campaign. The Mexican President became engaged on social media, tweeting a series of replies to DiCaprio, stating the conservation actions Mexico had taken (O'Hare 2017). Six weeks later, the Government of Mexico announced a permanent ban on the use of gillnets in the northern Gulf of California and collaborative efforts to develop new fishing techniques to allow local communities to fish legally and sustainably (WWF 2017). Additionally, the American President Barack Obama signed a bilateral agreement with the Mexican President to increase cooperation and enforcement efforts to fortify efforts to minimize illegal gillnet fishing (see obamawhitehouse. archives.gov/the-press-office/2016/07/22/fact-sheet-united-states-mexico-relations). In this case, the power of social media brought together two nations and their presidents, celebrities, and concerned members of the public. From the perspective of social media supporting conservation, this seemed like an obvious win. Unfortunately, four years later in 2021, the Mexican government decided to reduce enforcement of illegal fishing in the designated protected area, which Sonne et al. 2021 deemed "Mexico's final push of the vaquita towards extinction". We highlight this case because we feel it is important to acknowledge that governments and policies can change over time and not to falsely convey a sense of permanent security in conservation legislation. We additionally note that the overall effectiveness of celebrity endorsement for conservation is not well quantified (Olmedo et al. 2020) and in some cases has not been positive (Duthie et al. 2017).

Risks of social media to wildlife conservation

Species exploitation and illegal trade

Illegal trade of wildlife is booming on social media platforms (Yu and Jia 2015; Sung et al. 2021). Social media's ease of access and high number of users make it a particularly difficult to manage venue. Currently, we lack the tools needed to monitor the mass amounts of content shared on these platforms (Di Minin et al. 2018), though machine-learning algorithms and artificial intelligence could offer a way forward in identifying illegal online sales and reducing online wildlife trafficking (Di Minin et al. 2018; Di Minin et al. 2019; Xu et al. 2019). However, in addition to intentional illegal trade, certain naïve online behaviours—like wildlife selfies involving holding or cuddling of wild animals—can unintentionally promote species exploitation. Although wildlife selfies have the potential to support conservation (e.g., quokkas; see Increases in conservation funding section), they can also accidentally result in an increased demand for wild animals. One such example involves nine species of small primates, the slow loris (*Nycticebus* spp.; **Fig. 2D**), all of which are listed as Vulnerable, Endangered, or Critically Endangered. In 2007, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) banned the trade of slow lorises because of a declining population status and an increase in exploitation. Though initially the number of illegally imported slow lorises confiscated by Japanese border controls decreased (**Supplementary Material 5**; Musing et al. 2015), in 2009, a YouTube video of a pet slow loris being tickled went viral (Nekaris et al. 2013) and correlated with a global increase in Google Trends searches for slow lorises

(**Supplementary Material 5**). The demand for selfies with slow lorises has since increased, coinciding with more slow lorises observed for sale in Indonesian markets (Nijman et al. 2017). Another likely factor in this increased demand is the celebrity Rihanna's 2013 Instagram selfie, depicting her cuddling with a slow loris in Thailand (Kitson and Nekaris 2017; Nijman et al. 2017). Here, a celebrity's selfie can normalize the false notion that holding wildlife has no negative consequences and can drive the social phenomenon "consumer's doppelganger effect" whereby individuals consciously mimic the (consumptive) behaviour of someone they admire or emulate (**Table 1**). Inadvertently, and fortunately, Phuket authorities were alerted to the celebrity's selfie with the protected slow loris, leading to the arrest of two poachers who brought out the animal for the photo opportunity (Piccoli 2013). Other CITES-listed animals like elephants, primates, kangaroos, and dolphins are among the most photographed in selfies, which in some cases has led to animal distress and (or) death (Noik 2017).

Because of its ease of use (Morgan and Chng 2018) and broad reach (King et al. 2014), social media can serve directly as a platform for illegal wildlife trade and, as a result, support wildlife overexploitation (i.e., overharvesting, trafficking, or poaching; Haines et al. 2016). Notorious examples of endangered species traded on social media include Asian otters (subfamily: Lutrinae; **Box 2**), reptiles and amphibians, birds, and orchids (*Paraphalaenopsis* spp.) (see **Supplementary Material 3** for more examples). A survey of Facebook listings revealed 1623 live birds and reptiles for sale in less than three weeks in the Philippines, many of which were non-native species (Canlas et al. 2017). Although posts of wildlife on social media in anthropogenic environments can increase demand for them as pets, exacerbating the threat posed by the wildlife trade (e.g., Asian otter species; **Box 2**), we note that more social media posts do not necessarily translate to increased trade or significant population changes (e.g., see the false "Nemo effect," Militz and Foale 2017).

Geotagging is also a cause for concern regarding wildlife exploitation, as it reveals the location of an individual or group of animals, allowing poachers to easily find and harvest them (Paxian 2019). In recent years, several NGOs published campaigns to encourage people to post generic geotags (e.g., regional level) for wildlife photos, or better yet, to not geotag at all (Haugen 2019). Encouragingly, social media platforms have acknowledged their role in wildlife exploitation and are attempting to curb illegal activities: in 2018, Facebook, Instagram, and other companies (e.g., Google, eBay) joined WWF's Coalition to End Wildlife Trafficking Online campaign and committed to reducing online trafficking by 80% by 2020 (Formanek et al. 2019; Nicolas 2020). Two years later however, in 2020, The Alliance to Counter Crime Online (ACCO) conducted a study that found Facebook was not only failing at reducing online trafficking, but rather it was enabling it (Paul et al. 2020). In just "two mouse clicks", ACCO researchers were able to locate substantial illicit wildlife content on hundreds of easily identifiable Facebook Pages and Groups developed solely to directly sell wildlife and wildlife parts online (Paul et al. 2020). Unfortunately, policing these practices remains challenging due to wording ambiguity (e.g., general tweets about lemurs versus desire for lemurs as pets) and the difficulty of linking online mentions to actual purchases or other illegal activities (Clarke et al. 2019c).

Increases in visitor pressure to protected areas

Social media has been implicated in increases in unsustainable use of certain protected areas (PAs). PAs are legally protected geographic regions (e.g., national parks, wilderness areas, nature reserves) that, when effectively managed and strategically located, can stem biodiversity loss and protect ecosystem services and cultural values (IUCN n.d.; Venter et al. 2014). PAs are widely recognized for their value in biodiversity conservation across terrestrial (Le Saout et al. 2013; Steven and Castley 2013), marine (Davies et al. 2017), and freshwater (Zolderdo et al. 2019) ecosystems and can mitigate climate change by storing terrestrial carbon (MacKinnon et al. 2020). We focus on PAs here because of their importance in protecting wildlife and supporting Convention on Biological Diversity Aichi Targets

(Venter et al. 2014; Watson et al. 2014; cbd.int/sp/targets/). Schuster et al. (2019) demonstrated that PAs, as well as protected Indigenous lands, have higher species richness (including threatened species) across Canada, Australia, and Brazil; however, species richness was still considerable in nonprotected areas, and so any recommendations we provide in this section are relevant and can be applied to both protected and nonprotected regions.

With its ability to sensationalize images, social media can encourage people to travel to specific locations and, once there, behave in specific ways (Llodra-Riera et al. 2015; Gretzel 2019). As tourists continue to flood PAs, the consequences of over-tourism (i.e., an excessive negative impact of tourism on communities and (or) natural environments; Koens et al. 2018) can become evident. While tourism can indeed be beneficial for conservation purposes when social media promotes outdoor experiences (Richardson and Sheffield 2017) or garners funding for conservation work, rapid increases in visitor pressure to PAs presents a panoply of risks to wildlife. For example, in Joffre Lakes Provincial Park, British Columbia, a fallen tree—dubbed "#instalog" (>27,000 Instagram posts)—has drawn huge influxes of tourists seeking photos. Because the park lacks the necessary infrastructure and workforce to manage this sudden flood of tourists, the mass social media attention and associated increased visitors have led to a degraded local environment, with waste being left behind and vegetation trampled (de l'Église 2019). In addition to these direct impacts, other risks of high visitor pressure can include accidental introductions of diseases, pathogens, and invasive species (Clout and De Poorter 2005). Globally, non-native species richness and abundance are higher where tourism activities occur compared with control areas in both terrestrial and aquatic environments (Anderson et al. 2015). Vehicles and watercraft are not only to blame for invasive species introductions—a single traveler can harbour on average 5,000,000 bacteria, 50,000 fungi, 3 seeds, and 40 nematodes in their footwear alone (McNeill et al. 2011).

Exposure to over-tourism can affect wildlife stress responses, lead to changes in behaviour, and ultimately affect survival and reproduction in a range of species (Larson et al. 2016). For example, Müllner et al. (2004) found that exposure to ecotourism activities reduced the survival and affected stress responses in hoatzin (*Opisthocomus hoazin*) chicks in the Cuyabeno Reserve, Ecuador, and Taylor and Knight (2003) discovered that several ungulate species in the Antelope Island State Park, United States, exhibited increased flushing (animals response to take flight) from hikers and mountain bikers, which can have negative energetic consequences and displace animals from otherwise suitable habitats. At Joffre Lakes, tourists commonly hand-feed Canada jays (*Perisoreus canadensis*; **Fig. 2E**), causing jay habituation to, and potential dependency on, humans (BC Parks 2019). Wildlife feeding can result in a variety of negative effects, including alteration of natural behaviour patterns, dependency, aggression, and health issues linked with non-natural food sources (Orams 2002). Because data from social media can offer detailed information about visitor use management in parks and PAs (Wilkins et al. 2021), data from posts could be used to update existing or inform new management strategies and better protect wildlife.

The perpetuation of misinformation and other anti-conservation behaviours

In a post-truth era, the spread of digital misinformation by social media is thought to be a major risk to society (Lewandowsky et al. 2017), as it can spread rapidly and is almost impossible to correct after it is widely accepted (Garrett and Weeks 2013). Based on Vosoughi et al. (2018) and Treen et al. (2020), we define misinformation as pertaining to information that is false, inaccurate, or misleading and that is created and spread, regardless of whether there is intent to deceive. We chose this definition as it is possible that misinformation online is unintentional, whereby the person sharing is not aware that the information itself is inaccurate. Additionally, we felt it was important to include the

term misleading as the basis of several examples below (e.g., greenwashing) are framed such that they are deliberately misrepresentative. Misinformation can diffuse significantly farther, faster, deeper, and more broadly than true information on social media (Vosoughi et al. (2018)), and psychological theory suggests that attempts to correct misinformation may result in a distrust of the new (correct) material itself (Garrett and Weeks 2013).

Misinformation can pose a serious issue for threatened species when messages that are incomplete or misaligned with conservation priorities are perpetuated on social media. This is particularly evident when social media users post pictures or videos with threatened species in anthropogenic settings or interacting with humans. For example, even though chimpanzees (*Pan troglodytes*) are Endangered, survey data revealed that the public is less likely to think chimpanzee populations are threatened when misportrayed in images: the presence of a human in a photograph with a chimpanzee resulted in people considering wild chimpanzee populations to be stable and healthy (compared to the same image without a human). Additionally, the presence of a human increased the likelihood that viewers would consider a chimpanzee appealing as a pet (Ross et al. 2011). Wild cat species, like lions (*Panthera leo*) and cheetahs (*Acinonyx jubatus*), both of which are listed as Vulnerable with decreasing populations, have similarly been misportrayed on social media. Van der Meer et al. (2019) found that when wild cat species were portrayed interacting with humans in images, people's desire to engage in such interactions increased and made people more than twice as likely to perceive wild cats as suitable for wildlife tourist attractions (WTAs). These WTAs, more often than not, profit at the expense of animal welfare, conservation, and human safety (Moorhouse et al. 2015; see van der Meer et al. 2019) and have largely been discouraged by animal welfare organizations (e.g., WAP 2015; PETA n.d.). When instead presented with an image of a wild cat in a wild setting, and not interacting with humans, people's desire to interact with wild cats was not significantly influenced. The authors recommend social media administrators and users who post images of wild animals to carefully consider the way in which wild animals are portrayed as it can promote attitudes, perceptions, and behaviours with negative conservation consequences. This is especially important for celebrities and other public figures to consider, as they have considerably larger followings compared with the average person. Social media posts depicting celebrities with endangered exotic animals, like Justin Bieber holding a lion cub and Kim Kardashian hugging a koala, are particularly problematic as they can influence a wider audience to perceive such interactions with wildlife as normal and (or) acceptable (Spee et al. 2019; **Table 1**) and have the potential to attract illegal wildlife trade (Mutalib 2018).

Social media can also present inaccurate conservation messages through "greenwashing" or "humane washing" where companies use buzzwords to make their practices appear more humane and (or) conservation oriented. Greenwashing is the "intentional action to mislead or deceive consumers with false claims on organization environmental posture" (Andreoli et al. 2017) and has become an increasingly common issue online (Lyon and Montgomery 2015). For instance, "Elephant Eco Valley," a wildlife tourist attraction in Thailand, is described on their Facebook page as an "eco-travel" elephant adventure, where elephants are not ridden and are permitted to roam free. However, these same elephants are also used at "Maetaman Elephant Adventure" (a second company with the same owner), where elephants are chained, ridden by humans, and perform for the public (Daly 2019). This type of "humane washing" leads social media users to perceive wildlife attractions as conservation-oriented when, in actuality, these facilities exploit wildlife. It is critical that people fact-check and verify the credibility of posts shared not only by organizations, but ensure the posts they share themselves are not further promoting misinformation.

Misinformation on social media can likewise contribute to invasive species spread. For example, Lenda et al. 2021 demonstrated that social media networks serve as a platform for users to share (mis)information, which is enhancing the spread of goldenrod (*Solidago canadensis*) invasions into

non-native regions. They discuss how the perpetuated notion of goldenrod honey as a "superfood", with unsupported healing properties, is driving a demand that leads beekeepers to cultivate goldenrod honey in non-native regions. Another invasive species, though less commonly denoted as such, is the emotionally charged and complex issue of free-roaming, outdoor domesticated cats (*Felis catus;* Fig. 2F). Social media platforms can bias the information each end-user receives, as people tend to interact more with users that share similar interests and beliefs (i.e., homophily). People are more likely to believe and share content that supports their pre-existing beliefs (i.e., Confirmation bias, Table 1; Frenda et al. 2011), leading to the creation of distinct homogenous groups on social media where only the same types of information are shared (Del Vicario et al. 2016). Among these groups, viewpoints often become polarized, hindering the spread of evidence-based conservation information (Bessi et al. 2015). Using social media to gather support and share ideas, pro-outdoor cat supporters propagate the misinformed view that free-roaming cats have little to no impact on local ecosystems (e.g., facebook.com/AlleyCatAllies), even though scientific evidence indicates that cats impose a wide range of large-scale negative impacts on wildlife (Trouwborst et al. 2020) and cause substantial wild-life mortality (Loss et al. 2013). Many advocacy groups use social media to promote trap, neuter, and return (TNR) programs as the best and most humane control method for feral cat populations, despite contradictory scientific evidence suggesting TNR programs alone are often unsuccessful (Peterson et al. 2012; Loss et al. 2013). As cats are beloved pets and incredibly popular on social media (e.g., #catsofinstagram has >172 million Instagram posts), social media users with pre-existing values and beliefs may be more likely to believe misinformed posts rather than evidence-based posts demonstrating the negative impacts of free-roaming cats.

Psychology of social media and its influence on conservation

Theories and models from social psychology provide a promising way to study the relationship between social media and people's conservation-related behaviour and actions (or lack thereof) (St John et al. 2010; Davis et al. 2015). For example, the "theory of planned behaviour" (TPB) is a socio-psychology model that links individuals' intentions to behaviours (Ajzen 1991) and is considered the most influential theoretical model to explain self-interest behaviours (Rivis and Sheeran 2003; Manfredo 2008; Mancha and Yoder 2015). TPB proposes that attitudes, subjective norms, and perceived behavioural controls will best explain behavioural intent (Ajzen 1991). Studies suggest that social media posts can influence peoples' attitudes and create social norms (Spartz et al. 2017; Wang et al. 2021), which may result in increased levels of engagement and awareness without a deep understanding of an issue (Sanne and Wiese 2018; Wu et al. 2020; Pittman et al. 2021). However, the level of behaviour change in the real world (e.g., donations, volunteering) may be less than behaviour change online (e.g., liking, sharing, commenting) because of resource (e.g., time and money) constraint (Büssing et al. 2019). The integrative use of both ecological or conservation science with psychological sciences to explain how attitudes and intentions can impact environmental behaviours collectively describes the ideology of the emergent field Conservation Psychology (see Clark et al. 2019a). The use of Conservation Psychology to understand people's online values and decision-making processes has been used extensively in marketing to influence patterns of consumption (Kotler and Lee 2011; Wright et al. 2015), so a similar understanding could help guide social media engagement that is more likely to influence pro-conservation behaviours.

Often, there are several psychological phenomena driving online behaviours (**Supplementary Material 6**). For example, people will validate their behaviours via social proof (the tendency to see an action as more appropriate when others are doing it) and consciously mimic behaviours of those they admire as a response (e.g., financial donations, product reviews or testimonials, online mentions or shares; Amblee and Bui 2011; Stephen 2016; Powers 2018). As people are repeatedly exposed to

messages due to social proof, mimicry, and the sorting algorithm in social media, the messages are more likely to reach a frequency that influences people's actions (effective frequency, Schmidt and Eisend 2015). The same psychological phenomena can, however, sometimes produce contrasting outcomes. For example, conscious mimicry can result in positive outcomes, where consumers mimic pro-environmental consumption behaviours, or negative outcomes, where consumers mimic irresponsible behaviours of someone they admire. When people are exposed to information different from their beliefs (e.g., impacts of plastic straws on sea turtles or effects of cats on wildlife), they may change their beliefs and behaviours to reduce the level of discomfort from conflicting beliefs (i.e., cognitive dissonance) or reject the new information and seek confirmation from information that aligns with their own beliefs (i.e., confirmation bias). Additionally, criticizing and (or) banning certain human interactions with wildlife could instead result in unintended consequences. The "Streisand Effect" is a social phenomenon whereby an attempt to hide, remove, or censor information accidentally further publicizes that information instead (Jansen and Martin 2015; Ohlheiser 2020). Considering the different psychological and social responses of end users will be important in effectively conveying conservation messaging and targeting pro-conservation social changes. **Table 1** details a list of relevant psychological phenomena and how they link to online behaviours potentially influencing wildlife conservation.

Limitations

In this article we highlight the different trends we found in our literature review, providing examples that illustrate both positive and negative effects of social media on wildlife, in an effort to engage social media users in actively considering the potential consequences of their online actions. Although this is a promising start, one clear issue we identified in our synthesis is the lack of articles examining causal relationships between the digital world and the "real" world. Pearson et al. (2016) has stated the need for more methodologically rigorous research to evaluate specific impacts of social media on environmental outcomes like pro-conservation knowledge and attitudes, and importantly, to evaluate behavioural responses to new knowledge. For instance, the example of celebrity selfies with quokkas on Rottnest Island, Australia, (shared on social media) undoubtedly increased awareness and resulted in increased tourism and associated revenues; government annual reports illustrate these trends clearly, and statements from the RIA Executive Director corroborate selfies driving increased visitors. However, these remain correlative findings, as a quantitative analysis of how social media alone increased tourism to and revenues for Rottnest Island is not available. This is a critical issue as the effectiveness of social media is ultimately based on its ability to produce tangible behavioural changes in people (e.g., Vaterlaus et al. 2015; Yammine et al. 2018).

Defining "success" in conservation has been an ongoing challenge (Game et al. 2014; Cooke et al. 2020); however, it has been suggested that one key aspect of what makes a conservation action successful is its ability to create the potential for change in policy, behaviour, and (or) management (Cooke et al. 2020). In addition, it is rare for conservationists to publish failures. Although each of the examples we provided do highlight how social media impacted conservation—and we offer several "successful" cases—we acknowledge that in most real-world cases, social media would likely serve as one of several tools at play to support a management strategy or conservation action. It may be hard to differentiate influences between an event occurring on social media, as in some cases organizations use multiple advertising approaches (like newspapers) for the same event such that the influence of social and traditional media is intertwined (Wu et al. 2020). We therefore acknowledge that we may have presented biased examples of success, as some of the information we gathered is focused on anecdotal evidence like statements of success from campaign organizers (e.g., **Box 1**).

Peer-reviewed conservation articles could serve as a useful repository of lessons learned from failed projects and support future research attempting to create successful conservation actions

(Knight 2009; Catalano et al. 2019). Shreedhar (2021) transparently shared their evaluation of the (failed) behavioural impact of Facebook advertisement (ads) effectiveness on engagement and online donations. They found that although social media ads did increase engagement, clicks on Facebook did not equal donations off Facebook; in fact, 200,000 impressions resulted in only one donation. Shreedhar (2021) provided recommendations, like streamlining the donation process and suggesting the use of storytelling as a tool to engage nonexpert audiences with complex environmental issues (also see Robiady et al. 2021).

Recommendations and conclusions

Based on the examples above and exploration of socio-psychological phenomena, we outline recommendations for using social media to maximize benefits for conservation and minimize risks (Table 2). "Actors" that can use social media to support wildlife conservation include: (*i*) social media administrators, (*ii*) public social media users, (*iii*) NGOs, and (*iv*) governing agencies. Here, "public social media users" can also include independent experts (e.g., conservationists not associated with an NGO or government) in addition to general public users. We offer best practices to increase awareness of conservation issues, incite pro-conservation human behaviours, increase conservation funding, and inform conservation legislation. Our recommendations focus on three main areas: improving messaging, policing misconduct online, and guidance for action. Many of these recommendations require small, practical changes to social media use and highlight the importance of effective communication. For example, to increase audience engagement and reach, messaging strategies by public users and NGOs should include simple, emotionally charged content while maintaining accuracy, as emotions drive information diffusion on social media platforms (Stieglitz and Dang-Xuan 2014; Lenda et al. 2020). Similarly, using human-based stories, metaphors, and catch-phrases are particularly persuasive in communicating evidence-based arguments (Jones and Crow 2017). Active participation by research scientists in online discussions (e.g., on Twitter) not only enhances the reach and impact of their findings, but also initiates broader public education of conservation-related issues (Darling et al. 2013). Messaging is particularly important for scientists and experts, who despite being well versed in evidence, can struggle to win public arguments or persuade decision-makers (Begon 2017). Several tools are available to help experts craft their messages for social media into simple messages that are appealing to emotions and focus on positive outcomes and solutions, which are known to more effectively reach a wider audience than stark presentation of facts on social media (Baron 2010).

Public users active on social media can act as conservation advocates by verifying source credibility before sharing a post, reporting suspicious or illegal activity to local law enforcement agencies, and educating others about the harm of irresponsible behaviours. It has been recommended that users not use the "report" function provided on social media platforms when illegal activity is posted online, because doing so will remove the post from the platform, effectively destroying evidence that could be used by law enforcement (ALDF n.d.; Doerner 2019). Instead, the viewer should screenshot or save the post in question (and any relevant identification information) for local law enforcement. New artificial intelligence technology is indeed available for social media platforms to police for wildlife exploitation (Di Minin et al. 2019) and could be enhanced by working collaboratively with regulators to promote online policies and practices that are socially and environmentally responsible. The active participation of governments in regulating behaviour on social media platforms to address illegal wildlife trade could additionally support conservation efforts.

Instagram now provides warning messages for potentially harmful behaviours (e.g., Instagram's wildlife selfie message) to educate the public and increase awareness against anti-conservation behaviours. However, social media platforms could also use auto-generated, positive alert messages when users responsibly share content about threatened species or PAs as positive reinforcement

Table 2. Examples of best-practice recommendations for the various users of social media to maximize conservation benefits and minimize risks to wildlife.

👥	🏛NGO	🏛	#	Best-practice recommendations
Messaging				
	✓	✓	✓	Identify and consider the target audience when tailoring messaging and campaigns (Wright et al. 2015)
✓				Post pictures of wild animals in wild settings, minimizing pictures with humans (Ross et al. 2011)
✓	✓	✓		Strategically correct misinformation by using a relatable advocate or influencer (Garrett and Weeks, 2013)
✓	✓	✓		Use non-standard marketing techniques to engage users, like integrating humour into content (Lenda et al. 2020) or employing a "storytelling" technique (Robiady et al. 2021)
	✓	✓	✓	Each social media platform has unique demographics, so ensure conservation campaigns are marketed across various platforms (Olafson and Tran 2021)
✓	✓	✓		Use accurate, non-partisan, and emotionally charged content (Stieglitz and Dang-Xuan, 2014)
✓	✓	✓		Incorporate popular hashtags and supporting links to petitions to raise campaign awareness (e.g., see Greenpeace's orangutan campaign)
✓	✓	✓	✓	Use accessible clear language and avoid jargon (McLeish 2010; Lyes et al. 2012)
	✓	✓		Promote responsible behaviours in protected and non-protected areas (see Schuster et al. 2019 for visuals of species richness across protected areas and nonprotected areas)
			✓	Use auto-generated alert messages to encourage positive behaviour (e.g., #leavenotrace, #beachcleanup) and discourage negative behaviour (e.g., #dolphinkiss) (Bowie et al. 2020)
Policing misconduct				
✓	✓			Save or screenshot posts of illegal and (or) anti-conservation activity and report to local law enforcement (ALDF n.d.; Doerner 2019)
✓	✓	✓		Do not geotag posts of threatened species or protected areas (Haugen 2019; Paxian 2019)
✓	✓			Fact-check and verify source credibility before sharing (e.g., see greenwashing example; Daly 2019)
	✓	✓	✓	Police social media platforms for wildlife exploitation using artificial intelligence software (Di Minin et al. 2019)
Guidance for action				
	✓	✓		Streamline the donation process for conservation efforts (Shreedhar 2021)
✓	✓	✓	✓	Use social media data to inform conservation strategies (Di Minin et al. 2015; Wilkins et al. 2021)
✓	✓			Target specific decision-makers on social media to incite change (e.g., see vaquita example; WWF 2017)
✓	✓	✓		Share content of underrepresented and (or) unappealing species to increase awareness (Veríssimo et al. 2017; Lenda et al. 2020)
	✓	✓		Collaborate with social scientists and marketing experts to maximize pro-conservation outcomes (St John et al. 2010)
	✓	✓		Ensure activism opportunities are accessible and well-advertised (e.g., petitions, marches, park clean-ups)
✓	✓	✓		Engage with celebrities to amplify conservation messaging (e.g., vaquita and quokka examples)
✓	✓	✓		Create posts with clear and simple recommendations for actions that the public can take to support conservation (e.g., sea turtle and single-use plastics example)
✓	✓	✓		Ensure content is posted on social media platforms at the best time (i.e., when most users are online; Arens 2020)

Note: We recommend the type and format of messaging be carefully considered in terms of conservation goals, encourage improvements in the policing of online misconduct, and suggest considerations that can guide conservation actions. Icon credits: public social media users, Mikicon, the nounproject.com; non-governmental organizations, public domain; governing agencies, Rflor; social media administrators, Adnen Kadri, the nounproject.com

👥 = public social media users

🏛NGO = non-governmental organizations

= social media administrators

🏛 = governing agencies

(e.g., #leavenotrace indicates users are consciously attempting to minimize impacts to the local environment). In fact, previous research found that participants in a survey ranked positive reinforcement interventions (e.g., rewards, incentives) highest for increasing their likelihood to shift purchasing choices (Bowie et al. 2020). Though a simple, auto-generated message positively reinforcing conservation-related behaviour is a seemingly small step, it is a step in the right direction.

Future work could use our conceptual models as a framework to study causation and quantify the potential influence of social media posts on human behaviour (**Fig. 1** and **Supplementary Material 6**, e.g., incorporation of socio-psychological models like TPB as detailed sub-models) or wildlife populations using Bayesian belief networks (Marcot et al. 2006), structural equation models (Grace et al. 2010), results chains (Margoluis et al. 2013), or controlled experiments (e.g., using counterfactuals or empirical evaluation; Ferraro and Pattanayak, 2006; Ferraro 2009). Additionally, theory-based qualitative approaches to impact evaluation, like General Elimination Methodology (GEM), can offer insights into cause-and-effect relationships by systematically ruling out alternative explanations for the outcome of interest (Scriven 2008) and have been useful in conservation contexts (e.g., Salazar et al. 2019; Boissat et al. 2021). Many of our examples focus on "output" indicators related to social media engagement (e.g., number of viewers or likes), and while output can provide evidence of reach, it does not always tell us if or how change specifically occurred (i.e., "outcome"). Theory-driven qualitative evaluations, like GEM, can therefore provide a methodologically rigorous alternative to quantitative analyses that can be useful even in complex systems with interacting variables and still provide a deeper understanding of the mechanisms that led to the outcome of interest (Baylis et al. 2016). We strove to provide a wide range of successful social media cases that achieved conservation benefit; digging deep into understanding the mechanisms behind why certain cases were successful when others were not, however, would be a useful but difficult undertaking. This is a deep knowledge gap that would be highly beneficial to address—if researchers conduct robust causal inference studies to better understand what drives successful conservation work on social media, then we can better direct our efforts to produce meaningful outcomes. We therefore recommend that future work prepare clear protocols and hypotheses that blend different disciplines of conservation, psychology, and (or) other relevant fields (e.g., behavioural economics, see Valatin et al. 2016) prior to starting a study. Doing so may help determine the underlying mechanism(s) of successful social media efforts. In the same vein, future work could systematically evaluate cases of already-published positive examples to determine potential factors underlying success and move this field forward in an effective and efficient manner. Human behaviour is the ultimate cause of both conservation problems and solutions (St John et al. 2010); if grounded in an understanding of both the ecology and psychology of a conservation problem, social media could help solve, rather than exacerbate, the problem.

While our list is not exhaustive, our goal is to generate simple and clear recommendations to the different actors to harness the power of social media for conservation. It is not uncommon for individuals to think there is nothing they can individually do to stem global biodiversity losses or are unsure of appropriate conservation actions to take, leading to apathy and inaction (Gifford 2011). Here, we stress the power of individual action to support conservation using social media. In today's rapidly changing world, social media presents a unique framework that, if used appropriately, can unify our voices and offer an opportunity to mobilize social change for global biodiversity conservation.

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Author contributions

JNB, RTB, H-YL, ML, KA, ACH, SAR, TTN, SJC, and JRB conceived and designed the study. JNB, RTB, H-YL, ML, KA, ACH, SAR, TTN, SJC, and JRB performed the experiments/collected the data. JNB, RTB, H-YL, ML, KA, ACH, SAR, TTN, SJC, and JRB analyzed and interpreted the data. JNB, RTB, H-YL, ML, KA, ACH, SAR, TTN, SJC, and JRB contributed resources. JNB, RTB, H-YL, ML, KA, ACH, SAR, TTN, SJC, and JRB drafted or revised the manuscript.

Competing interests

S. Cooke is a member of the Editorial Board at *FACETS*.

Data availability statement

All relevant data are within the paper and in the Supplementary Material.

Supplementary materials

The following Supplementary Material is available with the article through the journal website at doi:10.1139/facets-2021-0112.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

Supplementary Material 5

Supplementary Material 6

Supplementary Material 7

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