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Tourist photographs as a scalable framework for wildlife monitoring in protected areas.

Tourist photographs as a scalable framework for wildlife monitoring in protected areas

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Protected areas are critical to conservation efforts in the face of rapid biodiversity declines [1]. Yet the resources for conservation are often limited and shared amongst many competing priorities [2]. As a consequence, even basic monitoring surveys are absent within most protected areas [3]. Although a range of wildlife monitoring methods exist, considerable focused survey effort is often required to yield accurate and precise estimates [4]. This makes monitoring difficult to sustain or replicate, limiting access to the data required for evidence-based conservation decisions. Citizen-scientists have been proposed as an important complement to the finite resources available for basic monitoring within protected areas [5]; however, the full potential of this approach has yet to be realised. Wildlife tourists and guides are especially focussed on encountering and photographing fauna and flora, yet the data collected in these efforts is rarely harnessed for conservation monitoring within protected areas. A detailed understanding of photographic tourism's potential role in wildlife monitoring has been lacking, but is essential for the development of new tools to harness the data being collected through tourism. Here, we demonstrate that tourist-contributed data can aid wildlife monitoring in protected areas by providing population estimates of large carnivores comparable to those from traditional survey methods. Our approach could capitalize upon the immense number of wildlife photographs being taken daily as part of the global > 30-billion USD, wildlife-based tourism industry.

To determine whether tourist photographs could provide monitoring data useful for conservation, we conducted several concurrent surveys of large carnivore density in the Okavango Delta, Botswana, between September 2017 and February 2018. Over a core study area of ~670 km2, we implemented tourist-photograph (herein the citizen-science method), cameratrap, spoor-tracking, and call-in-station surveys for five large carnivore species: lion (Panthera leo), spotted hyaena (Crocuta crocuta), leopard (Panthera pardus), African wild dog (Lycaon pictus) and cheetah (Acinonyx jubatus). For our citizen-science surveys, we partnered with Santawani Safari Lodge to collect wildlife photographs from all tour groups passing through their lodge. Upon arrival, new groups were introduced to the research team and offered the opportunity to contribute their photographs for monitoring. Up to two guests per group were provided with a miniature GPS logger set to automatically record locations at one-minute intervals. Images and GPS loggers were then collected on the group's last evening. Contributing guests took photographs of a computer screen displaying the current time in UTC. This calibration image was used to synchronise camera times with timestamps on GPS-logger tracks of game-drive routes. We identified large carnivores to an individual level using unique pelage or whisker spot patterns and assigned spatial coordinates to sightings by matching corrected image timestamps with GPS tracks. For each species, we then estimated species densities using spatial capture–recapture methods for transect surveys [6]. A full description of the monitoring methods can be found in the Supplemental Information.

For four of the five carnivore species monitored, the citizen-science method provided density estimates that were comparable to those derived from other monitoring approaches (overlapping 95% confidence intervals, Figure 1A) and which were more precise. The exception was from spoor surveys for hyaenas; we speculate that the lack of confidence interval overlap between citizen-science and spoor survey estimates may reflect the low number of sightings by tourists and/or inflated spoor density estimates arising from using data derived purely from trailbased surveys. The citizen-science method was also the only approach to identify cheetahs within the study area.

Implementing the citizen-science monitoring program costs 1.2–96.9% less than each of the other survey methods (Figure 1B). Excluding camera trapping surveys, researcher time investments represented the highest cost associated with each of the methods. In the citizen-science method, relatively little time was spent on data collection, with 74% of researcher time investments instead spent on data processing.

Our results demonstrate that wildlife tourists are valuable sources of monitoring data. This is the first study to show that wildlife tourist photographs can provide monitoring data comparable to those generated from traditional approaches. Ultimately, the most appropriate survey methods for conservation practitioners will depend on individual project needs and resources (for example, camera traps, whilst costly, can capture full species assemblages). Our citizen-science method is suited to the monitoring of large, individually identifiable charismatic fauna located within areas frequented by tourists and could be used to gain information on species distributions and demographics.

All guest groups approached (n = 26) participated in the project, providing 25,062 photographs over 78 days, highlighting their eagerness to participate in conservation efforts. Thus, our approach could aid the monitoring of charismatic megafauna popular with tourists. These species often provide important ecological and economic ecosystem services and are often under intense anthropogenic pressures [7]. For example, tigers (Panthera tigris) in Asia, jaguars (Panther onca) in Central and South America, and humpback whales (Megaptera novaeangliae) off the North American coast are all subjects of a large tourism industry and may benefit from citizenscience data collection using our approach.

Whilst cheetah density was not estimable, due to limited sightings, the information provided by tourist photographs (for example, on behaviours and resource use) provide a range of additional ecological and conservation opportunities. Such direct observations can aid the monitoring of endangered species by providing wildlife officials with information on the location, status, and health of heavily persecuted groups; this project provided Botswana's anti-poaching patrols with valuable information from opportunistic rhinoceros sightings.

Following equipment purchase, the citizen-science surveys provided both robust density estimates and savings of up to 836 USD per survey season, relative to other methods. Protected areas are often significantly underfunded; African protected areas with lions have total annual funding deficits of up to 2.1 billion USD [2]. Tourist photographs offer a costeffective opportunity to implement the long-term monitoring programs required for evidence-based management decisions within such resource limited locations [8]. Emerging technologies, such as artificial intelligence for automated image classification, may improve the economies of scale of the citizen-science method further by reducing the costs associated with data processing [9], and may reduce the risks of data-processing bottlenecks. Thus, there exists an opportunity to create largely automated citizen-driven monitoring programs, with wildlife tour operators facilitating data collection and automated workflows processing images and yielding density metrics, with minimal researcher involvement.

Engaging citizen-scientists in data collection reduces the effort associated with traditional wildlife monitoring techniques, thereby facilitating the rapid detection of changes in population size. Such partnerships have the potential to foster a greater public awareness of conservation and stem the tide of biodiversity loss [10].

Supplemental Information

Supplemental Information includes one figure, one table, experimental procedures, acknowledgements, author contributions and references and can be found with this article online at https://doi.org/10.1016/j.cub.2019.05.056.

References

1. Leverington, F., Costa, K.L., Pavese, H., Lisle, A., and Hockings, M. (2010). A global analysis of protected area management effectiveness. Environ. Manage. 46, 685–698.

2. Lindsey, P.A., Miller, J.R.B., Petracca, L.S., Coad, L., Dickman, A.J., Fitzgerald, K.H., Flyman, M.V., Funston, P.J., Henschel, P., Kasiki, S., et al. (2018). More than $1 billion needed annually to secure Africa's protected areas with lions. Proc. Natl. Acad. Sci. USA 115, E10788–E10796.

3. Martin, J., Kitchens, W.M., and Hines, J.E. (2007). Importance of well-designed monitoring programs for the conservation of endangered species: case study of the snail kite. Conserv. Biol. 21, 472–481.

4. Gálvez, N., Guillera-Arroita, G., Morgan, B.J.T., and Davies, Z.G. (2016). Cost-efficient effort allocation for camera-trap occupancy surveys of mammals. Biol. Conserv. 204, 350–359.

5. Steger, C., Butt, B., and Hooten, M.B. (2017). Safari science: assessing the reliability of citizen science data for wildlife surveys. J. Appl. Ecol. 54, 2053–2062.

6. Russel, R.E., Royle, J.A, Desimone, R., Schwartz, M.K., Edwards, V.L., Pilgrim, V.L., and Mckelvey, K.S. (2012). Estimating abundance of mountain lions from unstructured spatial sampling. J. Wildl. Manag. 76, 1551–1561.

7. Ripple, W.J., Estes, J.A., Beschta, R.L., Wilmers, C.C., Ritchie, E.G., Hebblewhite, M., Berger, J., Elmhagen, B., Letnic, M., Nelson, M.P., et al. (2014). Status and ecological effects of the world's largest carnivores. Science 343, 1241484.

8. White, E.R. (2019). Minimum time required to detect population trends: the need for long-term monitoring programs. BioScience 69, 40–46.

9. Norouzzadeh, M.S., Nguyen, A., Kosmala, M., Swanson, A., Palmer, M.S., Packer, C., and Clune, J. (2018). Automatically identifying, counting, and describing wild animals in camera-trap images with deep learning. Proc. Natl. Acad. Sci. USA 115, E5716–E5725.

10. Schuttler, S.G., Sorensen, A.E., Jordan, R.C., Cooper, C., and Shwartz, A. (2018). Bridging the nature gap: can citizen science reverse the extinction of experience? Front. Ecol. Environ. 16, 405–411.

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