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OPINION
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Chelonians as Ideal Indicators for Evaluating Global Conservation Outcome

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INTRODUCTION

Wildlife is a vital component of the ecosystem and plays a critical role in maintaining the ecological environment that humans depend on for survival (Ervin, 2016). Unfortunately, due to excessive harvesting and habitat destruction, many species have declined rapidly or have become extinct (Brondizio et al., 2019; Scheffers et al., 2019). Increasing attention, labor, and financial resources are being devoted to wildlife protection (UNEP-WCMC and IUCN, 2021) making it essential to evaluate overall conservation outcome. Moreover, the results can be used to review and improve previous programs (UNEP-WCM et al., 2018), and provide wildlife protection advice to policymakers (Stevenson et al., 2021).

With the development of technology, scientific conservation assessment methods should be constantly updated. In general, ecosystem conservation approaches have advocated a single-species approach (Friedlander et al., 2007). However, the overall assessment of the health of the ecosystem is fairly labor-intensive and time-consuming. Moreover, more is often known about specific species targeted for protection than about other components of the ecosystem (Maxwell et al., 2011).

SELECTING A SUITABLE INDICATOR

In conservation, the choice of indicators to be monitored is critical because each evaluation has a different focus. The various approaches to evaluating conservation outcome should be regarded as complementary rather than as alternatives. As the requirements for safeguarding ecological environment become increasingly stricter and widespread, particularly with detectable destruction, such as deforestation, hunting (with fire, gun, or net), it is also becoming difficult to implement them in most countries and regions. For legal punishment on illegal behavior and activity to be effective, it is crucial to ensure that we can measure the necessary responses on the targeted taxa, such as vegetation, birds, and mammals. The most obvious and common conservation indicator is vegetation, but it has its drawbacks. For example, vegetation losses can occur in the forest interiors, where they may not be as easily detected, and species may disappear even from well-protected vegetation (Redford, 1992; Gong et al., 2017), creating a situation like "silent spring". Indeed, well-protected vegetation can create an illusion of good conservation, especially in the eyes of the majority of policymakers and non-professional citizens. However, it cannot fully reflect the conservation outcome. Therefore, it is crucial to select a reliable taxon as an indicator for monitoring.

Among the vertebrates, chelonians should be a suitable taxon. Compared to other major groups of reptiles, chelonians are slow and defenseless (Lovich et al., 2018), and much easier to track and observe than snakes and lizards. Birds and mammals are often regarded as priorities and targets for global protection by conservation programs, but chelonian diversity are seldom given adequate consideration (Roll et al., 2017). Similarly, amphibians have been widely used as indicator species in environmental monitoring (Pounds et al., 2006); however, these taxa are mostly nocturnal and heavily dependent on water, so their distribution is quite limited, and they are sensitive to short-term and local environmental changes, such as temperature, pollution, and loss of water supply, and their populations fluctuate greatly (Richter et al., 2003; Relyea, 2006). As such, they are likely not ideal as long-term indicators.

CHELONIANS ARE VULNERABLE TO HUNTING

Chelonians are arguably the most threatened of the major groups of vertebrates, as of the IUCN Red List 2021, 171 chelonians species (62.4% of 274 red-listed species and 47.9% of 357 scientifically recognized species) are officially considered globally threatened (Rhodin et al., 2021). The threats facing chelonians are varied and include habitat loss, overexploitation, predation, invasive species, diseases, and climate change (Gibbon et al., 2000; Browne and Hecnar, 2007). While chelonians may be susceptible to the effects of anthropogenic climate change (Butler, 2019), demonstrating its impacts may prove to be quite challenging.

Chelonians' life-history traits (e.g., long lifespan, delayed sexual maturity, and small clutches of eggs) make them highly vulnerable to human impacts and extremely susceptible to hunting (Wu et al., 2020; Wang et al., 2021). Hunting activities threatened survival of the offsprings of the species and leads to a significant decline in the population. Thus, the population will decline rapidly if the protection is weak (Eisemberg et al., 2011), and may even become extinct (Stanford et al., 2020). Hunting is the most traditional, direct, and dominant factor in chelonians destruction (Wu et al., 2020).

Chelonians have high economic, cultural, and ornamental value. They are also used as pets, utilized in traditional Chinese medicine, and eaten by humans, making almost all of them a popular and long-term target for hunting. Chelonians have naturally high densities and biomasses (Iverson, 1982); hence, if they are well protected, their populations tend to be large (Lovich et al., 2018). In these cases, they are easy to observe and quantify, making them good conservation indicators. Most chelonian populations can maintain a stable level or even increase when the human impact is reduced (Berry et al., 2020). For example, the density of yellow-bellied sliders (*Trachemys scripta scripta*) was about 220,000/km^2 in some habitats where hunting by humans are absent (DeGregorio et al., 2012). Without human impact, about 10,000 loggerhead sea turtles (*Caretta caretta*) females can nest each year in each of the following locations: Florida, North Carolina, the Cape Verde Islands, and western Australia (Witherington et al., 2006). In other words, illegal hunting should be forbidden in areas where it is possible to enforce the law effectively.

The most direct evidence is that Sung et al. (2013) demonstrated that the number of big-headed turtles (*Platysternon megacephalum*) in areas with good conservation performance was significantly higher than in areas with poor conservation performance. Likewise, a 34-year mark-recapture study of Agassiz's desert tortoise (*Gopherus agassizii*) found that the population densities in protected areas were significantly higher than in adjacent locations outside the protected areas (Berry et al., 2020). These findings show that chelonians can be abundant and play an important role in the material and energy flow in the ecosystems, provided they are not actively hunted by humans (Lovich et al., 2018). Changes in wildlife abundance are almost always used as indicators of conservation outcome (Barnes et al., 2016; Kiffner et al., 2020). Therefore, the prevention of hunting is the most basic requirement for biodiversity conservation, and chelonian is the simplest and most effective indicator for evaluating conservation outcome.

The effectiveness of using chelonians as indicators to evaluate conservation outcome has already been partially demonstrated. For example, the use of sea turtles as a model for the conservation of a highly mobile endangered marine vertebrate is effective (Schofield et al., 2013). Gong et al. (2017) conducted a long-term study of chelonians, where they highlighted the damaging impact of poaching in nature reserves on wild populations.

CONCLUSION

Taken together, we propose that chelonians should be used as indicator taxa for evaluating conservation outcome, particularly as an early warning indicator of weak protection and rampant hunting by humans. In other words, if chelonians are rarely seen in areas where they should be abundant, then the conservation performance in such area is likely lacking or at least should be questioned. To the best of our knowledge, this paper is the first to propose the chelonians as an ideal taxon for testing conservation performance. With growing attention on the use of this taxa as a key indicator, we hope to raise the public and scientific awareness on the plight of this critical yet extinction-prone reptilian taxa.

AUTHOR CONTRIBUTIONS

RB was responsible for drafting and writing the manuscript and initiating communication with the rest of the co-authors and incorporating changes. FX, DD, TL, and HS edited the manuscript. TL and HS provided valuable feedback from personal experience with animal conservation, contributed to the correction, and synthesis of the manuscript. All authors contributed to the article and approved the submitted version.

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REFERENCES

Barnes, M. D., Craigie, I. D., Harrison, L. B., Geldmann, J., Collen, B., Whitmee, S., et al. (2016). Wildlife population trends in protected areas predicted by national socio-economic metrics and body size. *Nat. Commun.* 7, 12747. doi: 10.1038/ncomms12747

Berry, K. H., Yee, J. L., Shields, T. A., and Stockton, L. (2020). The catastrophic decline of tortoises at a fenced natural area. *Wildlife Monogr.* 205, 1–53. doi: 10.1002/wmon.1052

Brondizio, E. S., Settele, J., Díaz, S., and Ngo, H. T. (2019). *Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Bonn: IPBES Secretariat. Available online at: https://ipbes.net/global-assessment (accessed December 15, 2020).

Browne, C. L., and Hecnar, S. J. (2007). Species loss and shifting population structure of freshwater turtles despite habitat protection. *Biol. Conserv.* 138, 421–429. doi: 10.1016/j.biocon.2007.05.008

Butler, C. J. (2019). A review of the effects of climate change on chelonians. *Diversity*. 11, 1–22. doi: 10.3390/d11080138

DeGregorio, B. A., Grosse, A. M., and Gibbons, J. W. (2012). Density and size class distribution of yellow-bellied sliders (*Trachemys scripta scripta*) inhabiting two barrier island wetlands. *Herpetol. Conserv. Bio*. 7, 306–312.

Eisemberg, C. C., Rose, M., Yaru, B., and Georges, A. (2011). Demonstrating decline of an iconic species under sustained indigenous harvest – the pig-nosed turtle (*Carettochelys insculpta*) in Papua New Guinea. *Biol. Conserv.* 144, 2282–2288. doi: 10.1016/j.biocon.2011.06.005

Ervin, J. (2016). *National Biodiversity Strategies and Action Plans: Natural Catalysts for Accelerating Action on Sustainable Development Goals. Interim Report*. New York, NY: United Nations Development Programme (UNDP).

Friedlander, A. M., Brown, E. K., and Monaco, M. E. (2007). Coupling ecology and GIS to evaluate efficacy of marine protected areas in Hawaii. *Ecol. Appl.* 17, 715–730. doi: 10.1890/06-0536

Gibbon, J. W., Scott, D. E., Ryan, T. J., Buhlmann, K. A., Tuberville, T. D., Metts, B. S., et al. (2000). The global decline of reptiles, Déjà Vu amphibians. *BioScience*. 50, 653–666. doi: 10.1641/0006-3568(2000)050[0653:TGDORD]2.0.CO;2

Gong, S., Shi, H., Jiang, A., Fong, J. J., Gaillard, D., and Wang, J. (2017). Disappearance of endangered turtles within China's nature reserves. *Curr. Biol.* 27, R170–R171. doi: 10.1016/j.cub.2017.01.039

Iverson, J. B. (1982). Biomass in turtle populations: a neglected subject. *Oecologia.* 55, 69–76. doi: 10.1007/BF00386720

Kiffner, C., Binzen, G., Cunningham, L., Jones, M., Spruiell, F., and Kioko, J. (2020). Wildlife population trends as indicators of protected area effectiveness in northern Tanzania. *Ecol. Indic*. 110, 105903. doi: 10.1016/j.ecolind.2019.105903

Lovich, J. E., Ennen, J. R., Agha, M., and Gibbons, J. W. (2018). Where have all the turtles gone, and why does it matter? *Bioscience*. 68, 771–781. doi: 10.1093/biosci/biy095

Maxwell, S., Breed, G. A., Godley, B. J., Parnell, R. J., Makanga-Bahouna, J., Pemo-Makaya, E., et al. (2011). Using satellite tracking to optimize protection of long-lived marine species: Olive Ridley sea turtle conservation in Central Africa. *PLoS ONE*. 6, e19905. doi: 10.1371/journal.pone.0019905

Pounds, J. A., Bustamante, M. R., Coloma, L. A., Consuegra, J. A., Fogden, M. P., Foster, P. N., et al. (2006). Widespread amphibian extinctions from epidemic disease driven by global warming. *Nature*. 439, 161–167. doi: 10.1038/nature04246

Redford, K. H. (1992). The empty forest. *BioScience.* 42, 412–422. doi: 10.2307/1311860

Relyea, R. A. (2006). The effects of pesticides, pH, and predatory stress on amphibians under mesocosm conditions. *Ecotoxicology*. 15, 503–511. doi: 10.1007/s10646-006-0086-0

Rhodin, A. G. J., Iverson, J. B., Bour, R., Fritz, U., Georges, A., Shaffer, H. B., et al. (2021). Turtles of the world: annotated checklist and atlas of taxonomy, synonymy, distribution, and conservation status (9th Ed.). *Chelonian Res. Monogr.* 8, 1–472. doi: 10.3854/crm.8.checklist.atlas.v9.2021

Richter, S. C., Young, J. E., Johnson, G. N., and Seigel, R. A. (2003). Stochastic variation in reproductive success of a rare frog, *Rana sevosa*: implications for conservation and for monitoring amphibian populations. *Biol. Conserv.* 111, 171–177. doi: 10.1016/S0006-3207(02)00260-4

Roll, U., Feldman, A., Novosolov, M., Allison, A., Bauer, A. M., Bernard, R., et al. (2017). The global distribution of tetrapods reveals a need for targeted reptile conservation. *Nat. Ecol. Evol*. 1, 1677–1682. doi: 10.1038/s41559-017-0332-2

Scheffers, B. R., Oliveira, B. F., Lamb, I., and Edwards, D. P. (2019). Global wildlife trade across the tree of life. *Science.* 366, 71–76. doi: 10.1126/science.aav5327

Schofield, G., Scott, R., Dimadi, A., Fossette, S., Katselidis, K. A., Koutsoubas, D., et al. (2013). Evidence-based marine protected area planning for a highly mobile endangered marine vertebrate. *Biol. Conserv*. 161, 101–109. doi: 10.1016/j.biocon.2013.03.004

Stanford, C. B., Iverson, J. B., Rhodin, A. G., van Dijk, P. P., Mittermeier, R. A., Kuchling, G., et al. (2020). Turtles and tortoises are in trouble. *Curr. Biol.* 30, R721–R735.

Stevenson, S. L., Watermeyer, K., Caggiano, G., Fulton, E. A., Ferrier, S., and Nicholson, E. (2021). Matching biodiversity indicators to policy needs. *Conserv. Biol.* 35, 522–532. doi: 10.1111/cobi.13575

Sung, Y. H., Karraker, N. E., and Hau, B. C. H. (2013). Demographic evidence of illegal harvesting of an endangered Asian turtle. *Conserv. Biol*. 27, 1421–1428. doi: 10.1111/cobi,.12102

UNEP-WCMC and IUCN (2021). *Protected Planet Live Report 2020*. Cambridge; Gland: UNEP-WCMC and IUCN. Available online at: https://livereport.protectedplanet.net/ (accessed June 23, 2021).

UNEP-WCMC, IUCN, NGS (2018). *Protected Planet Report 2018: Tracking Progress Towards Global Targets for Protected Areas*. Cambridge: UNEP-WCMC; Gland: IUCN; Washington, D.C.: NGS.

Wang, J., Parham, J. F., and Shi, H. (2021). China's turtles need protection in the wild. *Science.* 371, 473. doi: 10.1126/science.abg3541

Witherington, B. E., Herren, R., and Bresette, M. (2006). "Caretta caretta-Loggerhead sea turtle," in *Biology and Conservation of Florida Turtles*. Chelonian Research Monographs, No. 3, ed P. A. Meylan (Lunenburg: Chelonian Research Foundation). p. 74–89.

Wu, J., Wu, Y., Rao, D., Zhou, T., and Gong, S. (2020). China's wild turtles at risk of extinction. *Science*. 268, 838. doi: 10.1126/science.abc0997

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