The prohibition of recreational hunting of wild ungulates in National Parks: what alternatives are there?

Antonio Carpio[1]

[1]Affiliation not available

March 28, 2023

Antonio J. Carpio[1], E. Laguna[1,*], R. Pascual-Rico[1,*], M. Martínez-Jauregui[2], J. Guerrero-Casado[3], J. Vicente[1], R. C. Soriguer[4], E. Delgado[1], P. Acevedo[1]

1 Instituto de Investigación en Recursos Cinegéticos, IREC (UCLM-CSIC-JCCM), Ronda Toledo 12, 13071 Ciudad Real, Spain.

2 National Institute for Agriculture and Food Research and Technology (INIA), Forest Research Centre (CIFOR). Ctra. de La Coruña km. 7.5, 28040 Madrid, Spain.

3 Department of Zoology, University of Córdoba, C-1 Campus Rabanales, 14071 Córdoba, Spain.

4 Estación Biológica de Doñana (CSIC), Av. Américo Vespucio, s.n, E-41092 Sevilla, Spain.

**Corresponding authors. Email:*

Roberto.Pascual@uclm.es eduardo.laguna@uclm.es

Abstract

On December 5th, 2020, a new regulation prohibited recreational hunting on estates located within national parks. Before the ban, ten national parks in Spain had already reported negative ecological consequences associated with high ungulate densities. The new situation after the ban signifies that policies to control populations of wild ungulates should depend exclusively on the parks' authorities, without the collaboration of recreational hunting, which implies a series of environmental and social challenges. However, control requires i) sufficient financial and human resources, and ii) social acceptance for extracting animals and extractive procedures within national parks. In this context, a more integrated management and policy plan is required, including both the protection of natural processes, conservation of species, and the explanation to the society about related conflicts to wild ungulates and the need of their population control. Finally, to improve the acceptance of policies and reduce conflicts, it is important to involve stakeholders in the decision-making processes concerning wildlife management.

Keywords: Hunters; Population control; Protected areas; Social perception; Ungulates

Introduction

Human development and landscape modification along centuries has caused the modification of wildlife populations and their suitable habitats (Vitousek, et al., 1997). Currently, there are habitats not sufficiently large for ecosystem self-regulation, and/or natural predators missed (or very scarce) being ineffective in regulating prey populations, such as wild ungulates (van Beeck Calkoen et al., 2020). This mammal group are key species in many ecosystems by conditioning nutrient cycles or influencing forest dynamics (Danell et al., 2006). However, due to ecosystem alteration by human activities and the current increasing wild ungulate populations throughout a rewilding process in Global North countries (Carpio et al., 2021; Navarro

and Pereira, 2015) different management strategies are used to avoid or mitigate derived conflicts from ungulate-human interactions (Pascual-Rico et al., 2021).

Wild ungulate management is mainly focused on regulating and limiting their populations by fencing (VerCauteren et al. 2006), supplementary/diversionary feeding (Dunkley and Cattet, 2003; Pascual-Rico et al., 2018), contraception (Boulanger et al. 2012), or through individuals' extraction such as relocations (Massei et al. 2010) or hunting (Simard et al. 2013). The application of each strategy depends on the problems caused by wild ungulates and the environment. For instance, fencing or diversionary feeding are used to reduce crop damages (Pascual-Rico et al., 2018; VerCauteren et al. 2006), whereas translocations are an option when hunting is not allowed (Massei et al. 2011), such as in urban or peri-urban areas. Instead, hunting is commonly applied where it is secure for human, even in protected areas (Kays, et al. 2017), such as National Parks (NPs; usually the legal figure with the highest degree of protection of a territory due to its ecological and cultural value).

At the same time, the social perception and public support about lethal management tools applied on wild ungulate populations, such as hunting, may be viewed as negative by various social groups (Koval and Merting, 2004). Thus, indirect population control without lethal consequences is preferred by general public (Garrido et al., 2017), since hunting animals is perceived as inappropriate in NPs (Martínez-Jauregui et al., 2020).

At European scale exist a variety of management tools applied to control ungulate populations, including hunting, but in less than 30% of NPs (van Beeck Calkoen et al., 2020). As some North European countries (e.g. Hiedanpaa and Pellikka, 2015; Rauset et al., 2016), recently in Spain the Government became 'no-go' recreational hunting areas the NPs, since December 2020, but decided since 2014 (Law 30/2014). According to the legislation, hunting is considered incompatible with the objectives and purposes of NPs due to the repercussions on natural processes and its impact on public use (RD 389/2016). From that moment on recreational hunting is prohibited, signifying that the wild ungulate population control policy now depends exclusively on the parks' authorities. This new situation implies a series of environmental and social challenges. From an environmental point of view, the inadequate control of populations may have a series of cascade effects on ecosystems (Cote et al., 2004). From a social point of view, perceptions and public support must be considered in addition to any ecological consequences to increase probability of success of applied management strategy (Martinez-Jauregui et al., 2021).

In Spain there are 16 NPs (Table S1), in 14 of which inhabit wild ungulates, including native (*R. pyrenaica* , *C. pyrenaica, C. capreolus, C. elaphus* and *S. scrofa*) and introduced species (*O. o. gmelin, D. dama* and *A. lervia*), which were introduced and promoted by hunting societies in those NPs (Nogales et al., 2006). Eleven NPs have native wild ungulate species, and eight have exotic species (Figure 1). Twelve parks include ungulate population control in their management plans (*MITECO*), and 11 have reported negative ecological consequences of high densities in these management plans and/or in scientific literature.

Hosted file

`image1.emf` available at https://authorea.com/users/470656/articles/631503-the-prohibition-of-recreational-hunting-of-wild-ungulates-in-national-parks-what-alternatives-are-there

Figure 1. Map showing the distribution of National Parks (red) and wild ungulate species: *1-Sus scrofa; 2-Cervus elaphus; 3-Capreolus capreolus; 4-Rupicapra pyrenaica; 5-Capra pyrenaica; 6-Dama dama; 7- Ovis orientalis gmelin; 8- Ammotragus lervia* . Number in brackets indicates the species present in each National Park.

Wild ungulates situation in National Parks

Focusing on three iconic Spanish NPs allow understand management difficulties on wild ungulate populations. These are Monfrague, Cabaneros and Sierra de Guadarrama NPs (Fig. 1), and they are allocated in regions with long and deeply rooted traditions concerning big game hunting in the centre of the Iberian Peninsula.

Cabaneros NP (408.6 km^2) has an average density of*C. elaphus* that may exceed 20 ind/km^2. In the last five years, an average number of over 1,000 animals were captured alive on a yearly basis from the public zone of this park. Despite animal extraction, population are still increasing (own data). In this park, wild ungulate populations limit tree regeneration (Perea and Gil, 2014), showed important effects of ungulates on the environment (vegetation and soil characteristics) influencing small mammal behaviour and population dynamics (Navarro-Castilla et al., 2017).

Similar data and population trends for *C. elaphus* are found in Monfrague NP (184.0 km^2), where the hypothetical carrying capacity is around 17 ind/km^2, but there is already an average density of 26 ind/km^2. In this NP, annual extraction is almost 900 animals on both public and private land (*http://doe.juntaex.es/pdfs/doe/2017/2230o/17062525.pdf*).

In the case of Sierra de Guadarrama NP (339.6 km^2), in 2016 existed a management plan to reduce *C. pyrenaica* population and mitigate vegetation and soil damage caused by the species (Martinez-Jauregui and Solino, 2021). However, this management plan was cancelled by court decision due to an appeal filed by the Animalist Party Against the Mistreatment of Animals (Partido Animalista Contra el Maltrato Animal, PACMA). The main objective of this plan is the extraction of 2,700 individuals over the next five years (mainly by using traps and relocation, or direct culling). Currently, there is another on-going improved plan to manage *C. pyrenaica* population with the same objective (Management plan for ibex populations in the Sierra de Guadarrama National Park, 2022). In this, *C. pyrenaica*average density estimated is 38 ind/km^2, and the aim is to reduce it to 12 ind/ km^2.

In the current no-hunting scenario, NPs authorities should assume logistical challenges of these management actions. These actions require huge economic and human resources to carry them out but are more efficient than hunting (Mysterud et al., 2019). As a reference, for the use of professional marksmen or women (instead of recreational hunters) costs run from about $100 to $200 per deer in the USA, and spaying can also be expensive ($ 500-1,000 per deer), while costs of relocation and translocation can be as low as $150 to 200 per deer (Doerr, 2001). These numbers are used to contextualize the magnitude of what the control of ungulate populations in NPs will involve in the following years.

How can population control be implemented in NPs?

Before the implementation of no-hunting policy (i.e., in December 2020), hunting was allowed on some Spanish NPs. However, hunting was not enough to avoid ungulate population increase (Massei 2023). Indeed, some common hunting practices could contribute to increase ungulate population, such as supplementary feeding or watering (Milner et al., 2014).

All of the above raises a question, how can population control be efficiently implemented in NPs? It will obviously require an extra effort and the provision of a proper budget by the administration. Lethal-based methods can currently control ungulate population increase in an efficient manner, even when the way in which they are implemented is still, in many cases, insufficient (Mysterud et al., 2019). Other studies indicate that local control of abundant cervid populations through recreational hunting may be difficult to achieve in many natural environments (Simard et al., 2013), due to compensatory mechanisms or inability to remove a sufficient proportion of the population to cause a population decline (Bengsen et al., 2019). However, no efficient alternatives with which to control ungulate populations (and the related conflict) in a long-term sustainable manner have been shown to be realistically viable, such as state-employed cullers, the relocation of individuals or fertility control, (Hobbs et al., 2000; Raiho et al., 2015; Refoyo et al., 2015). It should be noted that an insufficient control may have relevant economic and ecological consequences (Carpio et al., 2021). According to Raiho et al. (2015), the combination of different management strategies should be considered to improve efficiency on ungulate management.

Besides the combination of classical management tools applied, other proposals should be taken into account to warrant management plans success, such as strategies based on ecosystem functioning recovery. As ecosystem functioning recovery that could be effective on wild ungulate management, mitigating some conflicts, is the passive recolonization of top-predators' carnivores (i.e., Iberian wolf *Canis lupus signatus*

). This implies the return of a trophic interaction predator-prey that has not occurred in some of the NPs for decades. Predators can affect directly prey demography by consumption (Gervasi et al. 2012), but also indirectly by "landscape of fear" (Ripple and Beschta, 2003). When predators are present, ungulates modify their spatial and feeding patterns, presenting as adaptive response a predator avoidance behaviour (Tizzani et al., 2022). For instance, it has been detected vegetation damage reduction when wolf where reintroduced in Yellowstone (USA; Ripple and Beschta, 2003). Behaviour modification of ungulates can lead to significant ecological consequences, improving ecosystem functioning and reducing human intervention (Ripple and Beschta, 2003).

In Spain, Iberian wolf is recolonizing areas where it was extirpated (Clavero et al. 2022). Recently, it has been detected in Guadarrama NPs (*MITECO, 2020*), where it was removed from in the 40s of the last Century. Currently, *C. pyrenaica* is overabundant in this NP, and the return of this top-predator offers the opportunity to monitor this natural experiment in Spain. To evaluate predator's presence effect on the ungulate population in this NP will allow to understand its ecological role and if it contributes on ungulate management.

Towards an integrative solution: instilling education and awareness

Besides the application of management tools on wild ungulate populations focused on efficacy, it is relevant also to focus on obtaining social support to increase probabilities of management success (Martinez-Jauregui et al., 2020). Commonly, non-lethal management tools applied are preferred by general public (Garrido et al., 2017), for instance, passive strategies that consist of limiting the access of ungulates to some resources (e.g., crops, food to livestock) or to protect susceptible plant species to ungulates (Kalisz et al. 2014; Sabo et al. 2019).

Experience and research demonstrate that well-designed, well-executed stakeholder involvement processes can facilitate the implementation of socially acceptable management actions (Chase et al., 2002). This situation is particularly contentious in the case of NPs, where the management of certain ecological situations may be necessary, particularly when the habitat protected by the NPs has already been created or is maintained through human activities. Even when, from an ecological point of view, there is information to design and implement actions for population control, education and awareness measures may, therefore, be necessary to stress public awareness of how biological control should be implemented (Martinez-Jauregui et al., 2020). It is evident that parts of society have negative perceptions of reducing ungulate populations by employing lethal methods. However, this perception improves when they are confronted with technical information concerning the consequences of overabundance on ecosystems and humans (Martinez-Jauregui and Solino, 2021). In this respect, involving the stakeholders (i.e., hunters and visitors of NPs in our particular case) much more directly in the solutions could help everyone to understand why these measures should be adopted. In this respect, adaptive ungulate management plans, including the proper monitoring of populations and their impacts, should be very well informed, and a sufficient budget available (Apollonio et al., 2017). Only by communicating objective information, distinct from any stakeholder pressures, can Spanish society be a part of the solution for the wildlife management problems in NPs.

Further involve hunters and visitors of NPs, which are the main stakeholders regarding hunting on NPs, we must consider education and awareness regarding wild ungulate management (and wildlife from a broader perspective), that reaches a greater general public. For this, promoting science divulgation in other social areas, such as schools, high schools or universities, together with ecological literacy promotion, can be very effective (Courchamp et al., 2015; Jordan et al., 2009). This ecological education should be focused beyond the wildlife management in protected areas since the management of these species goes further the physical limits of those spaces (i.e., vehicle collisions on highways, crop damages, diseases transmission to livestock).

Conclusion

In summary, it is necessary to counterbalance the alternatives of population control or hunting, with the missions of NPs, more precisely to preserve wilderness areas (Watson et al., 2016). In addition, more integrated management and policy plans are required (van Beeck Calkoen et al., 2020), including both the protection

and the promotion of natural processes and species conservation. Besides, it is essential the education of society's on management and conservation strategies (Keigley, 2018). This approach requires science-based resource management in order to guarantee the efficacy of management plans and their acceptance by the main stakeholders (Vicente et al., 2019).

Declarations

Ethical Approval

Not applicable

Competing interests

The authors declare no conflict of interest.

Authors' contributions

Antonio J. Carpio, Pelayo Acevedo and Joaquin Vicente conceived the paper and led its design. Antonio J. Carpio and Eduardo Laguna conducted the literature research. Antonio J. Carpio, R. Pascual-Rico and M. Martinez-Jauregui wrote the first draft with input from all the authors. Jose Guerrero-Casado made the map and provided the pictures.

Funding

AJC is supported by a 'Juan de la Cierva' contract (IJC2020-042629-I) funded by MCIN/AEI/10.13039/501100011033 and by the European Union Next Generation. RPR was co-funded by the ESF and Plan Propio I+D+i UCLM, and FJC2020-045938-I/MCIN/AEI/10.13039/501100011033 and European Union Next Generation.

Availability of data and materials

Not applicable

References

Apollonio, M., Belkin, V. V., Borkowski, J., Borodin, O. I., Borowik, T., Cagnacci, F., et al., 2017. Challenges and science-based implications for modern management and conservation of European ungulate populations. *Mammal Research, 62* (3), 209–217.

Bengsen, A. J., Forsyth, D. M., Harris, S., Latham, A. D. M., McLeod, S. R., & Pople, A. (2020). A systematic review of ground-based shooting to control overabundant mammal populations. *Wildlife Research, 47* (3), 197–207.

Carpio, A. J., Apollonio, M., & Acevedo, P. (2021). Wild ungulate overabundance in Europe: contexts, causes, monitoring and management recommendations. *Mammal Review, 51* (1), 95–108.

Chase, L. C., Siemer, W. F., & Decker, D. J. (2002). Designing stakeholder involvement strategies to resolve wildlife management controversies. *Wildlife Society Bulletin, 30* (3), 937–950.

Clavero, M., Garcia-Reyes, A., Fernandez-Gil, A., Revilla, E., & Fernandez, N. (2022). Where wolves were: setting historical baselines for wolf recovery in Spain. Animal Conservation.*https://doi.org/10.1111/acv.12814*

Cote, S. D., Rooney, T. P., Tremblay, J. P., Dussault, C., & Waller, D. M. (2004). Ecological impacts of deer overabundance. *Annual Review of Ecology, Evolution, and Systematics, 35* , 113–147.

Courchamp, F., Dunne, J. A., Le Maho, Y., May, R. M., Thebaud, C., & Hochberg, M. E. (2015). Fundamental ecology is fundamental. *Trends in Ecology & Evolution, 30* (1), 9-16.

Doerr, M. L., McAninch, J. B., & Wiggers, E. P. (2001). Comparison of 4 Methods to Reduce White-Tailed Deer Abundance in an Urban Community. *Wildlife Society Bulletin, 29* , (4)1105–1113.

Danell, K., Bergstrom, R., Duncan, P., Pastor, J. (Eds.), 2006. Large herbivore ecology, ecosystem dynamics and conservation (Conservation Biology). Cambridge University Press, Cambridge.

Dunkley, L., & Cattet, M. R. L. (2003). A comprehensive review of the ecological and human social effects of artificial feeding and baiting of wildlife. *Canadian Cooperative Wildlife Health Centre: Newsletters & Publications, 21* , 1–68

Garrido, F. E., Castro, F., & Villafuerte, R. (2017). Control hunting of wild animals: health, money, or pleasure? *European Journal of Wildlife Research* , 63, 95.

Hiedanpaa, J., & Pellikka, J. (2015). Adapting moose hunting: a case study on fragmented hunting grounds around Nuuksio National Park in Helsinki metropolitan area, Finland. *European Journal of Wildlife Research* , *61* , 303-312.

Hobbs, N. T., Bowden, D. C., & Baker, D. L. (2000). Effects of fertility control on populations of ungulates: general, stage-structured models. *Journal Wildlife Management* , 473–491.

Jordan, R., Singer, F., Vaughan, J., & Berkowitz, A. (2009). What should every citizen know about ecology? *Frontiers in Ecology and the Environment, 7* (9), 495-500.

Kalisz, S., Spigler, R. B., & Horvitz, C. C. (2014). In a long-term experimental demography study, excluding ungulates reversed invader's explosive population growth rate and restored natives. *Proceedings of the National Academy of Sciences* , *111* (12), 4501-4506.

Kays, R., Parsons, A. W., Baker, M. C., Kalies, E. L., Forrester, T., Costello, R., Rota, C.T., Millspaugh, J.J. & McShea, W. J. (2017). Does hunting or hiking affect wildlife communities in protected areas?. *Journal of Applied Ecology, 54* (1), 242-252.

Keigley, R. B. (2018). How perceptions about naturalness affect science in Yellowstone National Park. *Rangeland Ecology Management, 71* (3), 395–401.

Koval, M. H., &Mertig, A. G. (2004). Attitudes of the Michigan public and wildlife agency personnel toward lethal wildlife management. *Wildlife Society Bulletin* , *32* (1), 232-243.

Law 30/2014, de 3 de diciembre, de Parques Nacionales.

BOE-A-2014-12588.

Management plan for ibex populations in the Sierra de Guadarrama National Park. *In Spanish* : *Plan de gestion de las poblaciones de cabra montes en el Parque Nacional de la Sierra de Guadarrama* . 2022. Consejeria de Medio Ambiente, Vivienda y Agricultura Direccion General de Biodiversidad y Recursos Naturales. Direccion General de Biodiversidad y Recursos Naturales

Martinez-Jauregui, M., & Solino, M. (2021). Society's preferences when ecological values and health risks are at stake: An application to the population control of a flagship ungulate (Iberian ibex) in Sierra de Guadarrama national park, Spain. *Science of Total Environment, 776* , 146012.

Martinez-Jauregui, M., Delibes-Mateos, M., Arroyo, B., & Solino, M. (2020). Addressing social attitudes toward lethal control of wildlife in national parks. *Conservation Biology, 34* (4), 868–878.

Massei G, Quy RJ, Gurney J, Cowan DP. (2010). Can translocations be used to mitigate human–wildlife conflicts? *Wildlife Research* , 37, 428–439.

Massei, G. (2023). Fertility Control for Wildlife: A European Perspective. *Animals, 13* (3), 428.

Massei, G., Roy, S., & Bunting, R. (2011). Too many hogs? A review of methods to mitigate impact by wild boar and feral hogs. *Human-Wildlife Interactions, 5* (1), 79-99.

Milner, J. M., Van Beest, F. M., Schmidt, K. T., Brook, R. K., & Storaas, T. (2014). To feed or not to feed? Evidence of the intended and unintended effects of feeding wild ungulates. *The Journal of Wildlife*

Management, 78 (8), 1322-1334.

Mysterud, A., Strand, O., Rolandsen, C. M. (2019). Efficacy of recreational hunters and marksmen for host culling to combat chronic wasting disease in reindeer. *Wildlife Society Bulletin, 43* (4), 683–692.

Navarro-Castilla, A., Diaz Esteban, M., & Barja, I. (2017). Does ungulate disturbance mediate behavioural and physiological stress responses in Algerian mice (*Mus spretus*)? A wild exclosure experiment. *Hystrix 28* (2), 165-172.

Navarro, L.M., Pereira, H.M., (2015). Rewilding abandoned landscapes in Europe. In: Pereira, H., Navarro, L. (Eds.), Rewilding European Landscapes. Springer, Cham, pp. 3–23.

Nogales, M., Rodriguez-Luengo, J. L., & Marrero, P. (2006). Ecological effects and distribution of invasive non-native mammals on the Canary Islands. *Mammal Review, 36* (1), 49–65.

Pascual-Rico, R., Morales-Reyes, Z., Aguilera-Alcala, N., Olszańska, A., Sebastián-González, E., Naidoo, R., Moleón, M., Lozano, J., Botella, F., von Wehrden, H., Martín-López, B., & Sánchez-Zapata, J. A. (2021). Usually hated, sometimes loved: A review of wild ungulates' contributions to people. *Science of The Total Environment, 801* , 149652.

Pascual-Rico, R., Pérez-García, J. M., Sebastián-González, E., Botella, F., Giménez, A., Eguía, S., & Sánchez-Zapata, J. A. (2018). Is diversionary feeding a useful tool to avoid human-ungulate conflicts? A case study with the aoudad. *European Journal of Wildlife Research, 64* , 1-7.

Perea, R., & Gil, L. (2014). Tree regeneration under high levels of wild ungulates: The use of chemically vs. physically-defended shrubs.*Forest Ecology and Management* , 312, 47-54.

Plan de gestión de las poblaciones de cabra montés en el Parque Nacional de la Sierra de Guadarrama. 2022. Consejería de Medio Ambiente, Vivienda y Agricultura Dirección General de Biodiversidad y Recursos Naturales

Raiho, A. M., Hooten, M. B., Bates, S., & Hobbs, N. T. (2015). Forecasting the effects of fertility control on overabundant ungulates: white-tailed deer in the National Capital Region. *PLoS One, 10* (12), e0143122.

Rauset, G. R., Andrén, H., Swenson, J. E., Samelius, G., Segerström, P., Zedrosser, A., & Persson, J. (2016). National parks in northern Sweden as refuges for illegal killing of large carnivores. *Conservation Letters, 9* (5), 334–341.

Real Decreto 389/2016, de 22 de octubre, por el que se aprueba el Plan Director de la Red de Parques Nacionales.

Refoyo, P., Olmedo, C., Polo, I., Fandos, P., & Muñoz, B. (2015). Demographic trends of a reintroduced Iberian ibex *Capra pyrenaica victoriae* population in central Spain. *Mammalia, 79* (2), 139–145.

Ripple, W. J., & Beschta, R. L. (2003). Wolf reintroduction, predation risk, and cottonwood recovery in Yellowstone National Park. *Forest Ecology and Management, 184* (1-3), 299-313.

Sabo, A. E., Forrester, J. A., Burton, J. I., Jones, P. D., Mladenoff, D. J., & Kruger, E. L. (2019). Ungulate exclusion accentuates increases in woody species richness and abundance with canopy gap creation in a temperate hardwood forest. *Forest Ecology and Management, 433* , 386-395.

Schusler, T. M. (2004). Ecological impacts of high deer densities. Teaching issues and experiments in ecology. Vol. 2, 1-7.

Simard, M. A., Dussault, C., Huot, J., & Côté, S. D. (2013). Is hunting an effective tool to control overabundant deer? A test using an experimental approach. *Journal of Wildlife Management, 77* (2), 254–269.

Tizzani, P., Bessone, M., Rossi, L., & Meneguz, P. G. (2022). Does predation risk affect spatial use in an introduced ungulate species? The case of a Mediterranean mouflon alpine colony. *European Journal of Wildlife Research, 68* (5), 66.

van Beeck Calkoen, S.T., Mühlbauer, L., Andrén, H., Apollonio, M., Balčiauskas, L., Belotti, E., et al. (2020). Ungulate management in European national parks: why a more integrated European policy is needed. *Journal of Environmental Management, 260* , 110068.

VerCauteren, K. C., Lavelle, M. J., & Hygnstrom, S. (2006). From the field: fences and deer-damage management: a review of designs and efficacy. *Wildlife Society Bulletin, 34* (1), 191-200.

Vicente, J., Apollonio, M., Blanco-Aguiar, J. A., Borowik, T., Brivio, F., Casaer, J., et al. (2019). Science-based wildlife disease response. *Science, 364* (6444), 943–944.

Vitousek, P. M., Mooney, H. A., Lubchenco, J., & Melillo, J. M. (1997). Human domination of Earth's ecosystems. *Science, 277* (5325), 494-499.

Watson, J. E., Shanahan, D. F., Di Marco, M., Allan, J., Laurance, W. F., Sanderson, E. W., Mackey, B., & Venter, O. (2016). Catastrophic declines in wilderness areas undermine global environment targets. *Current Biology, 26* (21), 2929–2934.