Appendix A1. List of Advisory Board Members

Term	Name	Affiliation	Country
Miss	Broadway, Melissa	EAZA/Wild Planet Trust	UK
Mr.	Bushell, Mark	Bristol Zoo	UK
Dr.	Cabana, Francis	Wildlife Reserves Singapore	Singapore
Dr.	Che-Castaldo, Judy	Lincoln Park Zoo	USA
Dr.	Delfour, Fabienne	Université Paris 13 Nord/Parc Astérix	France
Dr.	Eckley, Lindsay	Chester Zoo	UK
Dr.	Farmer, Holly	Wild Planet Trust	UK
Mr.	Harrison, Bernard	Wild Welfare/Bernard Harrison and Friends	Singapore
Dr.	Mann, Judy	The South African Association for Marine Biological Research	South Africa
Prof.	Manteca, Xavier	ZAWEC/Universitat Autonoma de Barcelona	Spain
Prof.	Maple, Terry	Georgia Institute of Technology	USA
Prof.	Melfi, Victoria	Hartpury University	UK
Dr.	Newbolt, Joanna	Wild Planet Trust/University of Plymouth	UK
Dr.	Ogden, Jackie	AZA/SAFE program	USA
Mr.	Oliveira Braga de Morais, Igor	Zoo Brasília /Brazilian Association of Zoos and Aquariums - AZAB	Brazil
Dr.	Pereboom, Zjef	Antwerp Zoo	Belgium
Dr.	Plowman, Amy	Wild Planet Trust	UK
Dr.	Pullen, Kirsten	Wild Planet Trust	UK
Dr.	Sherwen, Sally	Zoos Victoria/University of Melbourne	Australia
Mr.	Tapley, Ben	Zoological Society of London	UK
Dr.	Veasey, Jake	Wild Welfare/Operations Ocean Wise/Vancouver Aquarium/Care for the Rare/Veasey Zoo Design	UK/Canada
Dr.	Ward, Samantha	Nottingham Trent University	UK
Mr.	Werth, John	PAAZA	South Africa
Dr.	Willemsen, Madelon	BIAZA/the Technical University of Delft	UK/The Netherlands
Dr.	Yamanash, Yumi	Kyoto City Zoo/Kyoto University	Japan

Appendix A2. List of journals and report series already searched for studies relevant to our topic as part of the Conservation Evidence project. †Please note that volumes/years not mentioned in brackets, as well as many more journals, have been searched by Conservation Evidence as part of their wider project and are listed on their website (see https://www.conservationevidence.com/journalsearcher/index). However, these were searched prior to the initiation of this project and unfortunately did not extract studies relevant to our topic; hence they are not listed in this table. *Apart for in situ conservation studies, these journals were searched for ex situ studies related only to captive breeding.

Aquatic Conservation: Marine and Freshwater Ecosystems
Aquatic Ecosystem Health & Management
Aquatic Mammals (2017-2018)
Acta Chiropterologica (2018)
Acta Oecologica-International Journal of Ecology
Acta Herpetologica (2013-2018)
Acta Theriologic Sinica (2018)
African Journal of Herpetology (formerly The Journal of The Herpetological Association of Africa) (2013-2018)
African Journal of Marine Science (2018)
African Sea Turtle Newsletter (2014-2018)
American Naturalist (2018)
Amphibian and Reptile Conservation (1996-2018)
Amphibia-Reptilia (1980-2018)
Antarctic Science (1980-2018)
Applied Herpetology (2003-2009 - last volume published)*
Aquatic Biology (2007 – 2018)
Aquatic Conservation: Marine and Freshwater Ecosystems (2018)
Aquatic Ecology (2017 - 2018)
Aquatic Living Resources = Resources Vivantes Aquatiques (2017-2018)
Asiatic Herpetological Research (formerly Chinese Herpetological Research) (1993-2008)
Asian Herpetological Research (formerly Asiatic Herpetological Research) (2010-2018)
Australian Mammalogy (2018)
Austral Ecology (2018)
Basic and Applied Herpetology (2011-2018)
Biawak (2007-2017)
Bibliotheca Herpetologica (1999-2017)
Biology Letters (2018)
Biotropica (2018)
Bulletin of the Chicago Herpetological Society (1990-2018)
Bulletin of the Maryland Herpetological Society (1980-2015)
Bulletin of the Herpetological Society of Japan (1999-2008 - last volume published)*
Canadian Field Naturalist (2018)
Canadian Journal of Fisheries and Aquatic Sciences (2013-2018)
Caribbean Herpetology (2010-2018)
CCAMLR Science (1985-2016)
Chelonian Conservation and Biology (1993-1996 and 2005-2018; 1997-2004 currently being searched)
Chelonian Research Monographs (1996-2017)
Collinsorum (formerly Journal of Kansas Herpetology) (2012-2018)
Contemporary Herpetology (1998-2009 - last volume published)*
Copeia (2004-2018)
Current Herpetology (formerly Acta Herpetologica Japonica and Japanese Journal of Herpetology) (1964-2018)
Ecological Entomology
Ecological Management & Restoration (2018)
Entomologia Experimentalis et Applicata
Environmental Entomology
Forest Ecology & Management (2018)
Freshwater Science (2017 - 2018)
Frontiers in Marine Science (2017-2018)
Herpetologica (2013-2018
Herpetofauna (2003-2007)*
Herpetological Bulletin (2008-2017)
Herpetological Conservation and Biology (2006-2018)
Herpetological Journal (2002-2014)
Herpetological Monographs (2013-2018)
Herpetological Review (1980-2018)
Herpetology Notes (2008-2018)
Herpetozoa (1988-2018)
Hydrobiologia (2018)
Hystrix (2018)
ICES Journal of Marine Science (2018)
Insect Conservation and Diversity
IUCN Crocodile Specialist Group Articles (2006-2017)
IUCN Crocodile Specialist Group Reports (2005-2017)
Journal for Nature Conservation (2018)
Journal of Bat Conservation & Research (2018)
Journal of Cetacean Research and Management (2013 – 2018)
Journal of Forest Research (2018)
Journal of Herpetological Medicine and Surgery (2009-2018)
Journal of Herpetology (2004-2018)
Journal of Insect Science
Journal of Insect Conservation
Journal of Kansas Herpetology (formerly Kansas Herpetological Society Newsletter) (1974-2011)
Journal of Mammalogy (2018)
Journal of North American Herpetology (formerly Contemporary Herpetology) (2014-2017)
Journal of Sea Research (2017-2018)
Kansas Herpetological Society Newsletter (1974-2001)
Knowledge and Management of Aquatic Ecosystems
Latin American Journal of Marine Mammals (2017-2018)
Latin American Journal of Aquatic Mammals
Limnologica – Ecology and Management of Inland Waters
Mammal Research (2018)
Mammal Review (2018)
Mammal Study (2018)
Mammalia (2018)

Appendix A2. List of journals continued.

Mammalian Biology (2018)

Marine and Freshwater Research (previously Australian Journal of Marine and Freshwater Research) (1980-2018)

Marine Ecology (1980-2018)

Marine Environmental Research (2017-2018)

Marine Mammal Science (2017-2018)

Marine Pollution Bulletin (2017-2018)

Marine Turtle Newsletter (1976-2018)

Mesoamerican Herpetology (2014-2017)

Natural England Access to Evidence – Freshwater Invertebrates

Natural England Access to Evidence – Marine Invertebrates

Natural England Access to Evidence – Reptiles

Natural England Access to Evidence – Terrestrial Invertebrates

Neotropical Entomology

New Zealand Journal of Marine and Freshwater Research (1967-2018)

Phyllomedusa (2002-2018)

Regional Studies in Marine Science (2017-2018)

Reptile Rap (1999-2016)

Revista de Biología Tropical

Riparian Ecology and Conservation

Russian Journal of Herpetology (1996-2018)

Salamandra (German Journal of Herpetology) (1965-2017)

South American Journal of Herpetology (2013-2018)

Testudo (1978-2016)

Tropical Conservation Science

Tropical Ecology

Wildlife Conservation Society working papers (1976-2018)

Wildlife Research (2018)

Wildlife Society Bulletin (2018)

Appendix 3. Conservation Evidence Criteria to select publications from journals or reports

Criteria A: Conservation Evidence includes studies that measure the effect of an action that might be done to conserve biodiversity

1. Does this study measure the effect of an action that is or was under the control of humans, on wild taxa (including captives), habitats, or invasive/problem taxa? If yes, go to 3. If no, go to 2.
2. Does this study measure the effect of an action that is or was under the control of humans, on human behaviour that is relevant to conserving biodiversity? If yes, go to Criteria B. If no, exclude.
3. Could the action be put in place by a conservationist/decision maker to protect, manage or restore wild taxa or habitats, to reduce impacts of threats to wild taxa or habitats, or to control or mitigate the impact of the invasive/problem taxon on wild taxa or habitats? If yes, include. If no, exclude.

Explanation:

1.a. Study must have a measured outcome on wild taxa, habitats or invasive species: excludes studies on domestic/agricultural species, theoretical modelling or opinion pieces. See Criteria B for actions that have a measured outcome on human behaviour only.

b. Action must be carried out by people: excludes impacts from natural processes (e.g. tree falls, natural fires), impacts from background variation (e.g. soil type, vegetation, climate change), correlations with habitat types, where there is no test of a specific action by humans, or pure ecology (e.g. movement, distribution of species).

2. Study must test an action that could be put in place for conservation. This excludes assessing impacts of threats (actions which remove threats would be included), unless the threat acts as an appropriate control for an action. For example, woodland that has been cut down/degraded could be compared with woodland that has been left intact to test the action 'Retain native woodland', but only where an active decision was taken to retain part of the habitat for the purposes of biodiversity conservation. The test may involve comparisons between sites/factors not originally put in place or modified for conservation but which could be (e.g. mown vs unmown sites, fenced vs unfenced sites – where the mowing/fencing is as you would do for conservation, even if that was not the original intention in the study – or fishing gear change, for reasons unrelated to conservation, which could be implemented to reduce threats to biodiversity).

If the title and/or abstract are indicative of fulfilling our criteria, but you do not have sufficient information to judge whether the action was under human control, the action could be applied by a conservationist/decision maker or whether there are data quantifying the outcome, then include. If the article has no abstract, but the title is suggestive, then include.

We sort articles into folders by which taxon/habitat they have an outcome on. If the title/abstract does not specify which species/taxa/habitats are impacted, then please scan the full article and then assign to folders accordingly.

The outcome for wild taxa/habitats can be negative, neutral or positive, does not have to be statistically significant but must be quantified (if hard to judge from abstract, then include it for closer inspection by the synopsis authors). It could be any outcome that has implications for the health of individuals, populations, species, communities or habitats, including, but not limited to the following:

Individual health, condition, welfare or behaviour, including in captivity: growth, size, weight, nutrition, stress (including during use of invasive vs non-invasive monitoring practices in captivity), disease levels or immune function (exclude captive management veterinary studies for illness/disease/injury), movement, use of natural/artificial habitat/structure, range, crop damage or predatory or nuisance behaviour that could lead to retaliatory action by humans.

Breeding (include all in-captivity studies relating to breeding, reproduction, contraception, population management): egg/sperm/larvae production, sperm motility/viability after freezing,

artificial fertilization success, mating success, contraception success, seed/fruit production, seed germination rates, birth rate, clutch/litter size, chick size, fledging success, 'overall recruitment'

Genetics: genetic diversity, genetic suitability (e.g. adaptation to local conditions, use of correct flyways for migratory species, etc.)

Life history: age/size at maturity, survival, mortality

Population measures: number, abundance, density, presence/absence, biomass, movement, cover, age-structure, species distributions (only in response to a human action), disease prevalence, sex ratio

Community/habitat measures: species richness, diversity measures (including trait/functional diversity), community composition, community structure (e.g. trophic structure), area covered (e.g. by different habitat types), physical habitat structure (e.g. rugosity, height, basal area)

Actions within the scope of Conservation Evidence include:

• clear management actions: prescribed burning, mowing, planting vegetation, controlling or eradicating invasive species, creating wildlife road crossings, creating or restoring habitats
• international, national or local policies: creation of protected areas, bylaws, local voluntary restrictions
• reintroductions or management of wild species in captivity
• actions that reduce human-wildlife conflict
• actions that change human behaviour, resulting in an impact or potential impact on wild taxa or habitats
• See https://www.conservationevidence.com/data/index for more examples of actions.

Note on study types:

Include any literature reviews, systematic reviews, meta-analyses or short notes that review studies that fulfil these criteria.

Exclude theoretical modelling studies, as no action has been taken. However, studies that use models to analyse real-world data, or compare models to real-world situations are included (if they otherwise fulfil these criteria).

Criteria B: Conservation Evidence includes studies that measure the effect of an action that might be done to change human behaviour for the benefit of biodiversity

1. Does this study measure the effect of an action that is or was under human control on human behaviour (actual or intentional) which is likely to protect, manage or restore wild taxa or habitats, or reduce threats to wild taxa or habitats? If yes, go to 2. If no, exclude.
2. Could the action be put in place by a conservationist, manager or decision maker to change human behaviour? If yes, include. If no, exclude.

Explanation:

1. a. Study must have a measured outcome on actual or intentional human behaviour including self-reported behaviours: excludes outcomes on human psychology (tolerance, knowledge, awareness, attitude, perceptions or beliefs).

1. b. Change in human behaviour must be linked to outcomes for wild taxa and habitats, excludes changes in behaviour linked to outcomes for human benefit, even if these occurred under a conservation program (e.g. we would exclude a study demonstrating increased school attendance in villages under a community based conservation program).

1. c. Action must be under human control: excludes impacts from climatic or other natural events.

2. Study must test an action that could be put in place for conservation: excludes studies with no action e.g. correlating human personality traits with likelihood of conservation-related behaviours.

The human behaviour outcome of the study can be negative, neutral or positive, does not have to be statistically significant but must be quantified (if hard to judge from abstract, then include). It could be any behaviour that is likely to have an outcome on wild taxa and habitats (including mitigating the impact of invasive/problem taxon on wild taxa or habitats). Outcomes include, but are not limited to, the following:

Change in adverse behaviours (which directly threaten biodiversity): unsustainable or illegal hunting, burning, grazing, urban encroachment, creating noise, entering sensitive areas, polluting or dumping waste, clearing or habitat destruction, introducing invasive species

Change in positive behaviours: uptake of alternative/sustainable livelihoods, number of households adopting sustainable practices, donations

Change in policy or conservation methods: placement of protected areas, protection of key habitats/species

Change in consumer or market behaviour: purchasing, consuming, buying, willingness to pay, selling, illegal trading, advertising, consumer fraud

Behavioural intentions to do any of the above

Actions which are particularly likely to induce a human behaviour change outcome include, but are not limited to, the following:

• enforcement: closed seasons, size limits, fishing gear/hunting restrictions, auditable/traceable reporting requirements, market inspections, increase number of rangers, patrols or frequency of patrols in, around or within protected areas, improve fencing/physical barriers, improve signage, improve equipment/technology used by guards, use of Unmanned Autonomous Vehicles/drones for rapid response, DNA analysis, GPS tracking
• behaviour change: promote alternative/sustainable livelihoods, payment for ecosystem services, ecotourism, poverty reduction, increased appreciation or knowledge, debunking misinformation, altering or re-enforcing local taboos, financial incentives.
• governance: protect or reward whistle-blowers, increase government transparency, ensure independence of judiciary, provide legal aid
• market regulation: trade bans, taxation, supply chain transparency laws
• consumer demand reduction: Increase awareness or knowledge, fear appeals (negative association with undesirable product), benefit appeal (positive association with desirable behaviour), worldview framing, moral framing, employing decision defaults, providing decision support tools, simplifying advice to consumers, promoting desirable social norms, legislative prohibition
• sustainable alternatives: certification schemes, captive bred or artificial alternatives, sustainable alternatives
• new policies and regulations for conservation/protection

We allocate studies to folders by their outcome. All studies under Criteria B go in the 'Behaviour change' folder. They are additionally duplicated into the relevant taxon/habitat folder(s) if there is a specific intended final outcome of the human behaviour change (if none mentioned, file only in Behaviour change).

Examples of titles and abstracts we would include under criteria A related to ex situ studies and captive animal management (key sentences are underlined):

Ogilvy, V., Preziosi, R.F. Fidgett, A.L. 2012. A brighter future for frogs? The influence of carotenoids on the health, development and reproductive success of the red-eye tree frog. *Animal Conservation* 15, 480-488.

Ex situ conservation is an important tool for the prevention of species extinction in amphibians. Currently, there is limited

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information on the nutritional requirements of amphibians in captivity, and there have been anecdotal reports of skin colour degradation in captive amphibians. Amphibians use carotenoids for skin pigmentation, and because carotenoids are only obtainable through the diet, colour degradation could result from limited carotenoid availability. Studies of other vertebrate taxa have shown that carotenoids contribute to health and reproductive success; however, their importance to amphibians is currently unknown. We assessed the influence of carotenoids on the health and development of red-eye tree frogs (*Agalychnis callidryas*) during larval and post-metamorphic stages, and looked at effects on skin colour and reproductive success. Carry-over effects of larval exposure to carotenoids were also investigated, and the effects of carotenoids on skin colour development and degradation in adulthood were examined. Carotenoids did not significantly influence larval growth or survival; however, post-metamorphic carotenoid availability significantly increased growth rate in female but not in male frogs. Frogs fed a carotenoid diet post-metamorphosis had significantly redder skin than controls, and larval carotenoid exposure significantly influenced post-metamorphic skin colour. Fecundity was significantly higher in female frogs raised on a carotenoid diet post-metamorphosis compared with controls. Finally, skin colour did not change in adulthood despite changes in dietary carotenoid availability, which suggests that there is a critical period during post-metamorphic growth for deposition of carotenoids in the skin. We have shown that carotenoids influence the development, phenotype and reproductive success of *A. callidryas*, and these important nutrients should therefore be considered when nutritional recommendations for amphibians are made.

Human action = diet supplementation (carotenoids), outcome = skin colour, reproductive success, larval and post-metamorphic growth; folders = ex situ, amphibian

Heezik, Y.V., Seddon, P.J. & Maloney, R.F. (1999) Helping reintroduced houbara bustards avoid predation: effective anti-predator training and the predictive value of pre-release behaviour. *Animal Conservation* 2, 155-163.

The success of captive-breeding and release programmes is often compromised by predation of released individuals, which are naive about predators. Pre-release behavioural preparation of release candidates in the form of anti-predator training has been attempted infrequently, usually using models of predators, but success was most often measured in terms of improved behavioural responses rather than survival to breeding age after release. Here we report that post-release survival of captive-reared houbara bustards (Chlamydotis [undulata] macqueenii) was improved through exposure to a live predator before release: a result with possible applications for a wide range of species currently the focus of reintroduction projects. We also show that rearing houbara with minimal human contact and training with a model of a predator had no effect on post- release survival. Moreover, neither pre-release behavioural responses to a model predator nor the degree of tonic immobility were predictors of post- release survival.

Human action = reintroduction of houbara busard, captive breeding, undertake a headstarting programme; outcome = post-release survival, pre-release behaviour; folders = ex situ, bird

O'Brien, J.K., Steinman, K.J., Montano, G.A., Dubach, J.M. Robeck, T.R. 2016. Chicks produced in the Magellanic penguin (*Spheniscus magellanicus*) after cloacal insemination of frozen-thawed semen. *Zoo Biology* 35, 326-338.

The in vitro and in vivo functionality of cryopreserved spermatozoa was examined over two breeding seasons in a zoological colony of Magellanic penguins *Spheniscus magellanicus*. Frozen-thawed semen was inseminated into five anesthetized females, over a total of eight egg production cycles, with a different male used for each artificial insemination (AI) within each season. Females were maintained within the colony in cordoned nest sites to prevent copulation with their paired male, and were inseminated every 3-10 days until the first oviposition. Semen frozen from seven males using a straw method retained 39.8%, 25.7%, 74.0%, and 52.1% of its initial total motility, progressive motility, average path velocity, and plasma membrane integrity, respectively. Normal morphology of motile cells was reduced ($P < 0.05$) during freeze-thawing from 76.7% immediately prior to freezing to 65.3% post-thawing. Conceptive females received 1.6 perpendicular to 0.2 inseminations before the first oviposition, with 19.2 +/- 1.6 x 10(6) motile, morphologically normal spermatozoa per insemination. Overall fertility was 53.3% (8/15 eggs), hatchability was 50.0% (4/8), and genetic analyses confirmed that all embryos and hatchlings were sired by the AI male. Fertile eggs were laid at 4.0-12.1 days after AI, indicating that frozen-thawed spermatozoa resided in the female reproductive tract for up to similar to 7.2 days prior to fertilization. Results demonstrate that frozen-thawed Magellanic penguin spermatozoa are fully functional in vivo and support the use of genome banking and AI as tools for managing the sustainability of zoological penguin populations.

Human action = Artificially inseminate females, use cryopreserved gametes, captive breed; outcome = sperm quality, fertility, hatchability; folders = ex situ, bird

Examples of titles and abstracts we would include under bidiversity criteria A (key sentences are underlined):

Basset, Y., Barrios, H., Ramirez, J. A., Lopez, Y., Coronado, J., Perez, F., Leponce, M. (2017) Contrasting the distribution of butterflies and termites in plantations and tropical forests. *Biodiversity and Conservation* 26, 151-176.

In the tropics vast areas of natural forests are being converted into plantations. The magnitude of the resulting loss in arthropod biodiversity and associated ecosystem services represents a significant topic of research. In this study we contrasted the abundance, species richness and faunal turnover of butterflies, resident butterflies (i.e., whose host plants were ascertained to occur in the habitats studied) and termites between small (average 4.3 ha) 20+ year old exotic plantations (teak and Terminalia), native plantations (Cedro espino), and an old growth forest in Panama. We used Pollard walks and manual search to quantify the abundance or occurrence of butterflies and termites, respectively. In 2014 we observed 4610 butterflies representing 266 species and 108 termite encounters (out of 160 quadrats) representing 15 species. Butterflies were more abundant and diverse in plantations than in the forest, whereas this pattern was opposite for resident butterflies and termites. There was marked faunal turnover between plantations and forest. We conclude that (a) the magnitude of faunal changes between forest and plantations is less drastic for termites than for butterflies; (b) resident butterfly species are more impacted by the conversion of forest to plantations than all butterflies, including transient species; and (c) species richness does not necessarily decrease in the series forest > native > exotic plantations. Whereas there are advantages of studying more tractable taxa such as butterflies, the responses of such taxa can be highly unrepresentative of other invertebrate groups responsible for different ecological services.

Human action = growing native vs. exotic plantations, outcome = butterfly and termite abundance and species richness; folders = invertebrates

Gonzalez, L. M., Montoto, F. G., Mereck, T., Alves, J., Pereira, J., de Larrinoa, P. F., El-Kadhir, N. (2017) Preventing crop raiding by the Vulnerable common hippopotamus *Hippopotamus amphibius*

in Guinea-Bissau. *Oryx* 51, 222-229.

Guinea-Bissau is host to the westernmost subpopulation of the common hippopotamus *Hippopotamus amphibius*, which is one of only two known populations inhabiting coastal waters. The presence of hippopotamuses causes conflict with rice farmers as a result of crop damage and the absence of effective measures to protect crops. To develop an effective method for protecting rice fields, we studied the patterns of access to flooded and rain-fed rice fields by hippopotamuses and assessed the effect of the installation of electric fences. Hippopotamuses were detected in 54% of the flooded fields (n = 100) and in 31.9% of the rain-fed fields (n = 91). They were detected more frequently in fields on offshore islands than on the mainland, in unfenced than in fenced fields, and in fields closer to running water. Hippopotamuses entered fenced flooded fields less frequently than unfenced, and were detected most frequently at the end of the rainy season and the start of the dry season, and in the period of vegetative stem growth. Electric fences were an effective deterrent and facilitated increased rice production. The maintenance and cost of the electric fencing were acceptable to farmers, and therefore the use of such fencing is recommended to resolve the conflict between hippopotamuses and farmers in Guinea-Bissau and in other areas with similar conditions.

Human action = fencing fields (to prevent human conflict with wild population), outcome = presence/absence of hippopotamuses in fields; folders = mammals

Lydersen, J. M., Collins, B. M., Brooks, M. L., Matchett, J. R., Shive, K. L., Povak, N. A., Smith, D. F. 2017. Evidence of fuels management and fire weather influencing fire severity in an extreme fire event. *Ecological Applications* 27, 2013-2030.

Following changes in vegetation structure and pattern, along with a changing climate, large wildfire incidence has increased in forests throughout the western United States. Given this increase, there is great interest in whether fuels treatments and previous wildfire can alter fire severity patterns in large wildfires. We assessed the relative influence of previous fuels treatments (including wildfire), fire weather, vegetation, and water balance on fire-severity in the Rim Fire of 2013. We did this at three different spatial scales to investigate whether the influences on fire severity changed across scales. Both fuels treatments and previous low to moderate-severity wildfire reduced the prevalence of high-severity fire. In general, areas without recent fuels treatments and areas that previously burned at high severity tended to have a greater proportion of high-severity fire in the Rim Fire. Areas treated with prescribed fire, especially when combined with thinning, had the lowest proportions of high severity. The proportion of the landscape burned at high severity was most strongly influenced by fire weather and proportional area previously treated for fuels or burned by low to moderate severity wildfire. The proportion treated needed to effectively reduce the amount of high severity fire varied by spatial scale of analysis, with smaller spatial scales requiring a greater proportion treated to see an effect on fire severity. When moderate and high-severity fire encountered a previously treated area, fire severity was significantly reduced in the treated area relative to the adjacent untreated area. Our results show that fuels treatments and low to moderate-severity wildfire can reduce fire severity in a subsequent wildfire, even when burning under fire growth conditions. These results serve as further evidence that both fuels treatments and lower severity wildfire can increase forest resilience.

Human action = fuel treatments i.e. prescribed fire and thinning, outcome = fire severity; it is not specified how fire severity was measured, but is suggestive of including amount of forest burned, this is an example of a borderline study we would like you to include; folders = forest/woodlands

Examples of titles and abstracts we would NOT include under criteria A:

Wood, J., Koutsos, E., Kendall, C.J., Minter, L.J., Tollefson, T.N. Heugten, K.A.V. 2019. Analyses of African elephant (*Loxodonta africana*) diet with various browse and pellet inclusion levels. *Zoo Biology* 39, 37-50.

To more closely simulate the diet of free-ranging elephants, the diet of six (2.4) African elephants *Loxodonta africana* was altered to include more browse and less pelleted complete feed (5% total diet). Dietary proximate compounds, minerals, vitamins A (and carotenoids), D and E, and fatty acids were analyzed on pelleted diet items and forages including hay, grass, and browse. A total of 42 browse species were offered over 1 year with an average total diet inclusion of 5.2% (dry matter basis) per day. Dietary Na and Se were low while Fe and Mn were high compared to published intake levels for elephants. Analyzed nutrients within browse varied widely among seasons and species. Ingredient analyses were used to create predicted elephant nutrient intake for (a) the current diet, (b) a diet excluding pellets, and (c) a diet excluding pellets and providing browse at doubled levels. Formulated diets excluding pellets had lower mineral levels than the current diet and doubled browse did not alter mineral inclusions of concern. This study provides seasonal data on the nutrient levels of Southeastern browse species important for various pachyderm and herbivorous species. Predicted nutrient intake with new diet scenarios does not support the exclusion of pellets in the diets of African elephants without greater browse quantity availability, strict diet management, or additional supplements.

Action tested: Alter the diet of elephants. But no outcomes

Ogden, R., Ghazali, M., Hopper, J., Čulík, L. King, T. (2018) Genetic assessments for antelope reintroduction planning in four European breeding programmes. *Journal of Zoo and Aquarium Research* 6, 79-84. The potential reintroduction value of zoo animals is often cited as a reason for maintaining captive populations. To validate this argument, it is important for conservation breeding programmes to consider the evolutionary history and population genetic diversity of their founders, so that managers can understand the possible consequences of breeding decisions in captivity and to evaluate the options for releasing individuals back to the wild. For the European captive populations of roan antelope *Hippotrogus equinus*, greater kudu *Trogelophus strepsiceros* or *Strepsiceros* spp., common eland *Trogelophus oryx* and waterbuck *Kobus ellipsiprymnus* or *Kobus* spp., there is a need to understand more about their genetic status and to evaluate their likely geographic origin within their natural distribution. We employed DNA nucleotide sequencing of the mitochondrial (mtDNA) control region to identify the maternal lineage of captive animals and inform decision making concerning future possible translocations in each species. Sequence data from 60 individual antelope were compared against existing reference data from wild populations. Sequence analysis of roan, greater kudu and common eland allowed inference of the broad geographic origin and subspecies of each animal's maternal lineage. For waterbuck, clear discrimination of ellipsen and defassa subspecies was not possible due to a zone of hybridisation preventing unambiguous assignment of captive waterbuck to subspecies. Our findings highlight the application of molecular genetic research to a persistent challenge in zoo population management; namely, the need to understand captive genetic variation relative to that found in the wild.

No action tested. Note that "identify the maternal lineage (genetic assessment) before reintroduction" could be an action, but here it was not tested (no data on reintroduction).

Shanmugam, A.A., Kumar, J.K., Selvaraj, I. Selvaraj, V. 2011.

Effects of Body Weight and Season on Serum Lipid Concentrations in Sloth Bears (*Melursus ursinus ursinus*). *Journal of Zoo and Wildlife Medicine* 42, 373-381.

Serum lipid levels were measured in 66 healthy sloth bears (*Melursus ursinus ursinus*) living under semicaptive conditions with access to natural food resources in the Bannerghatta Biological Park (Karnataka, India), a portion of their native habitat range in the Indian peninsula. Total cholesterol, triglycerides, high-density lipoprotein (HDL) cholesterol, and low-density lipoprotein cholesterol levels were analyzed. The effects of age, body weight, and season on these lipid parameters were statistically evaluated. There were no correlations between age and any of the serum lipid parameters analyzed. Positive correlations of body weight to both triglyceride and HDL cholesterol levels in these bears were identified. In addition, seasonal trends in physiological serum lipid values, potentially due to variations in the sloth bear diet, were identified. Serum triglyceride levels were higher during postmonsoon season and cholesterol levels were higher during winter compared to other seasons. Serum lipid values obtained from sloth bears in this study were also compared to previously published data on other members of the family Ursidae. This is the first report of serum lipid values as a reference for sloth bears. These values can be used as sensitive predictors of overall health and nutritional status to aid in the captive management and feeding of these bears.

Study correlating serum lipid concentrations with body weight and season. No clear action tested.

Casado-Coy, N., Martínez-García, E., Sánchez-Jerez, P., Sanz-Lázaro, C. (2017) Mollusc-shell debris can mitigate the deleterious effects of organic pollution on marine sediments."*Journal of Applied Ecology* 54, 547-556. 1.

Organic pollution is widespread in coastal areas and can have profound impacts on the seabed. Coastal sediments play an important role at a global scale in the recycling of organic matter, and this process is influenced by the habitat complexity of the sediments, among other factors. Mollusc shells are produced as a waste product from a range of anthropogenic activities, but we demonstrate that they can be used to increase the habitat complexity of sediments. 2. We studied the effect of mussel-shell debris (shell-hash) on the biogeochemical processes of marine sediments affected by organic pollution, using a mesocosm experiment simulating the bioturbation effects of macrofauna. 3. We found that shell-hash improved the ecological status of organically polluted sediments by reducing the accumulation of sulphide from anaerobic metabolic pathways. 4. Additionally, when shell-hash was present in an organically polluted sediment, there was a decrease in ammonium release to the water column, thus preventing the negative ecological consequences of eutrophication. 5. Synthesis and applications. Our study indicates that shell-hash debris can be used as a potential tool to mitigate the effects of organic enrichment on marine sediments. A density of shell-hash debris of 1900 g m(-2) in the sediment can diminish toxic by-products (sulphides and ammonium) derived from the stimulation of anaerobic metabolic pathways by organic pollution, at levels that are biologically relevant. The mitigation effect of shell-hash is more pronounced in sediments where macrofauna is not present.

Human action = adding shell-hash to marine sediments, but outcome is measured only on chemical composition of sediment and not on any component of biodiversity

Examples of titles and abstracts we would include under behaviour change criteria B:

Ulambayar, T., Fernández-Giménez, M. E., Baival, B., Batjav, B. (2017) Social Outcomes of Community-based Rangeland Management in Mongolian Steppe Ecosystems. *Conservation Letters* 10, 317-327.

Community-based rangeland management (CBRM) has been promoted as a promising option for achieving both rangeland conservation and community well-being. However, research on its effectiveness is limited, and the reported outcomes are mixed, especially with regard to socioeconomic outcomes. We measured social outcomes of CBRM in Mongolia by comparing 77 formally organized pastoral groups with 65 traditional herder neighborhoods across four ecological zones. We used household surveys, focus groups, and interviews to measure livelihoods, social capital, and management behavior. Members of CBRM groups were significantly more proactive in addressing resource management issues and used more traditional and innovative rangeland management practices than non-CBRM herders. However, the group types did not differ in social capital or on most livelihood measures. Our results demonstrate that formal CBRM is strongly associated with herder behavior, but calls for consideration of how to reach livelihood outcomes, a key incentive for community-based conservation.

Action = community based rangeland management, outcome = use of specific types of management practices by herders; folders = behaviour change and grasslands

Moorhouse, T. P., Balaskas, M., D'Cruze, N. C., Macdonald, D. W. (2017) Information could reduce consumer demand for exotic pets. *Conservation Letters* 10, 337-345.

The global wildlife trade is a growing threat to biodiversity, species conservation and animal welfare. A major driver is consumer demand for exotic pets, and there have been calls for information campaigns to combat this. We created a novel, online survey to assess whether such campaigns could be effective. Our website "matched' individuals with an exotic pet, and asked them to rate how likely they were to purchase one. We manipulated the information shown about each pet, giving either a "control" statement, describing the species' diet, or one of four types of "treatment" statement describing zoonotic disease, animal welfare, legal or species conservation consequences. Respondents shown disease or legality information had a 39% reduced probability of selecting higher purchase likelihoods. Information on welfare and conservation impacts did not significantly lower purchase likelihoods. Information campaigns may reduce demand for exotic pets, particularly if focused on zoonotic disease and legal consequences.

Action = changing information provided about exotic pets online, outcome = people self-reported probability of purchase was reduced by 39%, or not changed, depending on information offered; folders = behaviour change

Thomas-Walters, L. Raihani, N. J. (2017) Supporting Conservation: The Roles of Flagship Species and Identifiable Victims. *Conservation Letters* 10, 581-587.

Psychological insights into human behavior can have enormous applied value for promoting charitable giving. Nevertheless, the application of these insights to conservation appeals featuring nonhuman animals has scarcely been explored. Although people often donate more when presented with single identifiable victims, whether this effect also extends to nonhumans is not known. Similarly, although many conservation appeals feature flagship species, it is unclear whether flagship species generate increased donations. We experimentally investigated how (1) identifiable versus statistical beneficiaries and (2) flagship versus nonflagship species affected donations to a conservation charity. Unexpectedly, subjects did not donate more when presented with single identifiable beneficiaries rather than groups of beneficiaries. Flagship species, on the other hand, increased donation amounts

relative to appeals featuring nonflagship species. We discuss how these findings can inform and improve the effectiveness of conservation fundraising appeals.

Action = changing the characteristics of species presented in conservation appeals, outcome = amount of donation given by people; folders = behaviour change

Forrester, T. D., Baker, M., Costello, R., Kays, R., Parsons, A. W., McShea, W. J. (2017) Creating advocates for mammal conservation through citizen science. *Biological Conservation* 208, 98-105.

Citizen science initiatives have shown promise to provide informal education about nature and conservation and simultaneously gather scientific data at large scales. eMammal is a platform for citizen science projects that recruits volunteers to place camera traps that collect data in the form of wildlife photographs. Our project offered informal education on wildlife ecology and conservation to volunteers through training materials, feedback during the project, and a natural history blog. We tested whether our education efforts and volunteer activities affected their project specific skills, wildlife knowledge, conservation attitudes, and what kind of information they shared with their social network. Volunteers accurately (>90%) identified 15 of 20 wildlife species captured in the photos and reduced the rejection rate of camera placements over time. Our surveys showed that volunteer's attitudes toward conservation were high before joining the project and did not change after participating. However, volunteer knowledge of wildlife was higher after working with eMammal. Volunteers also became advocates for mammal conservation by sharing their new knowledge. Roughly half of our volunteers reported actively discussing some type of information related to wildlife both before (50%) and after (54%) the project. However, after volunteering they were 84% more likely to discuss local mammals or local mammal conservation. The likelihood of discussing local mammals was positively influenced by the number of predator photos captured by volunteers, showing that the type of experience can influence how information is spread through a volunteer's social network. Citizen science can connect people to the natural world while simultaneously providing reliable data for conservation.

Action = participating in eMammal, outcome = likelihood of discussing local mammals and their conservation; folders = behaviour change and mammals

Randrianarison, H. Watzold, F. (2017) Are buyers of forest ecosystem services willing to consider distributional impacts of payments to local suppliers? Results from a choice experiment in Antananarivo, Madagascar. *Environmental Conservation* 44, 74-81.

A controversial issue in the debate on payments for ecosystem services (PESs) is whether distributional goals should be considered in the design of such schemes. We contribute to this debate by analysing the preferences of citizens of Antananarivo (Madagascar) as potential buyers of forest ecosystem services from a developing country. We conducted a choice experiment to investigate citizens' willingness to pay to conserve the endemic spiny forests in southwest Madagascar and their preferences for including distributional goals in the design of a PES scheme aimed at spiny forest conservation. We found that respondents were willing to pay for forest conservation and preferred a PES scheme in which the poorest households in a community would receive the largest share of payments over a scheme in which every household would receive the same share, which, in turn, they preferred over a PES scheme in which they would have no information about its distributional impact. In comparing these results with those of a similar survey in a developed country (in Cottbus, Germany), we find that the preference ranking regarding distributional impacts is identical. However, citizens in Cottbus attach greater importance to the consideration of distributive goals in PESs than citizens in Antananarivo.

Human Action = Distributional payments for Ecosystem Services; Outcome = willingness to pay; folders = behaviour change and forests

Hinsley, A., Nuno, A., Ridout, M., John, F. A. S., Roberts, D. L. (2017) Estimating the Extent of CITES Noncompliance among Traders and End-Consumers; Lessons from the Global Orchid Trade. *Conservation Letters* 10, 602-609.

The Convention on the International Trade in Endangered Species of Wild Flora and Fauna (CITES) regulates trade in over 35,000 species, over 70% of which are orchids. To investigate rule-breaking behavior among traders and buyers in a specific international wildlife trading community, we used direct questions (DQs) and the unmatched count technique (UCT) to survey the orchid growing community about CITES compliance and their knowledge and opinions of the rules. In DQ, 9.9% had smuggled, 4.8% had laundered, and 10.8% had been sent orchids from online purchases without paperwork; UCT estimates did not differ significantly. Growers with greater knowledge of CITES rules were more likely to break them, and there were widespread negative views of CITES among respondents. We recommend targeted enforcement focusing on both online trade and at the point of import, coupled with efforts to encourage traders and end-consumers to engage with discussions on CITES rule implementation

Human action = knowledge of CITES rules, outcome = likelihood of breaking rules; folders = behaviour change, individual plant populations

Hancock, J. M., Furtado, S., Merino, S., Godley, B. J., Nuno, A. (2017) Exploring drivers and deterrents of the illegal consumption and trade of marine turtle products in Cape Verde, and implications for conservation planning. *Oryx* 51, 428-436.

Conservation regulations aimed at restricting resource use are commonly used to manage and protect natural resources but their implementation depends on the compliance of resource users. The design of effective regulations should be informed by an understanding of the factors that affect compliance, considering contextual socio-economic information. Changes have been implemented in the national legislation protecting marine turtles in the Cape Verde archipelago, where historical and recent records indicate heavy human predation pressure on nesting and foraging marine turtles. We present an assessment of levels of illegal harvesting and consumption of marine turtle products on two of the islands, Boa Vista and Santiago, and an analysis of their potential drivers. Key stakeholders were interviewed to investigate the perceived impact of the main interventions employed in Cape Verde to reduce illegal harvesting, trade and consumption of marine turtles. Despite an apparent decrease in harvesting and consumption, our results suggest there has been a shift from subsistence harvesting to trade in Boa Vista. The existence of laws to protect marine turtles was perceived as a deterrent to harvesting, and awareness campaigns and a lack of availability were perceived as reasons for the decrease in consumption in Boa Vista and Santiago, respectively. Aiming to inform ongoing discussions, we recommend a multi-targeted approach focusing on both suppliers and consumers to magnify conservation effectiveness. Regular impact evaluation focusing on harvest and consumption is needed to improve the design of regulations and inform policy decision making.

Human action = introduced laws and awareness campaigns, outcome = laws were a perceived deterrent to harvesting and campaigns were a perceived reason for decrease in turtle consumption. It is hard to judge (from abstract) whether there

is sufficient evidence linking the action with the outcome, and whether the outcome is self-reported behaviour (which we would include) or perceptions (which we wouldn't), so this article is borderline but therefore should be included; folders: behaviour change, reptiles

Colleony, A., Clayton, S., Couvet, D., Saint Jalme, M., Prévot, A. C. (2017) Human preferences for species conservation: Animal charisma trumps endangered status. *Biological Conservation* 206, 263-269.

A good deal of research has recently focused on people's commitment to biodiversity conservation by investigating their "willingness-to-pay" (WTP). Because of the public's self-reported preferences for species that are more charismatic or similar to humans, conservation programs are often biased toward these species. Our study aimed to explore the determinants of WTP among 10066 participants in a zoo conservation program. The program aims to raise money to support conservation programs and involves donating a sum of money to "adopt" an animal in the zoo. We explored whether participants were influenced by particular scientific characteristics of the animal (IUCN conservation status and phylogenetic distance from humans) or by more affect-related characteristics, such as the charisma of the animal. We found that participants did not choose an animal to adopt because of the endangered status of the species, and did not donate more to endangered species than to other species. Instead, they were more likely to choose a charismatic species. However, surprisingly, those who chose a less charismatic species gave more money on average to the program than those who adopted more charismatic species, suggesting a higher level of commitment among the former. These results therefore suggest that this type of conservation program may not be an effective way of reconnecting people with conservation issues related to endangered species. We therefore advise zoos to communicate more strongly on the level of threat to species and to increase the ratio of endangered over charismatic species in their animal adoption programs. (C) 2016 Elsevier Ltd. All rights reserved.

Human action = offering people animals with different characteristics to adopt (the action or test here is not very clear but the study should be included until the article can be read in full); outcome = peoples' willingness to pay; folders = behaviour change

Examples of titles and abstracts we would NOT include in behaviour change:

Sterling, E. J., Betley, E., Sigouin, A., Gomez, A., Toomey, A., Cullman, G., Filardi, C. (2017) Assessing the evidence for stakeholder engagement in biodiversity conservation. *Biological Conservation* 209, 159-171.

Engaging local stakeholders is a central feature of many biodiversity conservation and natural resource management projects globally. Current literature on engagement predominantly focuses on individual case studies or specific geographical contexts, making general conclusions regarding the effect of these efforts on conservation outcomes difficult. We reviewed evidence from the peer-reviewed and grey literatures related to the role of stakeholder engagement (both externally-driven and self-organized engagement) in biodiversity conservation at the local scale using both quantitative and qualitative approaches. We critically appraised and extracted data using mixed methods for case studies (n = 82) and meta-analyses (n = 31) published from 2011 to 2015. We conducted an inductive thematic analysis on background literature references published from 2000 to 2016 (n = 283). The quantitative analysis assessed multiple variables, and yielded no significant results, but suggested a possible relationship between success in producing attitudinal change towards conservation and four engagement factors. Our qualitative analysis identified six dimensions of engagement processes that are critical for successful outcomes when a project is externally-driven, and suggests that understanding of governance and social-cultural context plays an important role in all types of stakeholder engagement efforts. Finally, we reflect on the effectiveness of relying primarily on evidence available from published literature to understand links between conservation and stakeholder engagement, in particular with regard to self-organized engagement.

There is a human action = engagement of local stakeholders, but the outcome is a change in attitude towards conservation, and not a behaviour change

Appendix A4. List of anticipated relevant outcomes/metrics used to assess the reproductive success, health and welfare of captive animals.

Outcome category	Type of outcome/metric extracted
Population structure	Population size, age structure, sex ratio
Reproductive success	Egg/sperm production, artificial fertilisation success, mating success, fecundity, offspring quality/condition, overall recruitment, age/size at maturity
Survival	Survival or mortality, life span
Condition	Growth, size, weight, body condition, disease/injury, stress levels (e.g. using cortisol or other relevant hormone levels), immune function, species'/organisms' microbiome (e.g. gut microbiome)
Behaviour	Use/usage/avoidance/latency to approach (e.g. of enrichment object, new habitat, additional structures, new diet…), frequency and/or duration of stereotypies or other abnormal behaviours, emotional or cognitive state/response, preference (e.g. for food items or enrichment object), human-animal interactions, time budget
Genetic	Genetic diversity, genetic relatedness (to rest of the population), inbreeding coefficient, genetic distinctiveness

Appendix A5. List of study designs included in the systematic map.

Term	Meaning
Replicated	The intervention was repeated on more than one individual or site (enclosure or facility). In conservation, behaviour and ecology, the number of replicates is much smaller than it would be for medical trials (when thousands of individuals are often tested). If the replicates are sites, pragmatism dictates that between five and ten replicates is a reasonable amount of replication, although more would be preferable. We provide the number of replicates wherever possible. Replicates should reflect the number of times an intervention has been independently carried out, from the perspective of the study subject, therefore individuals housed within the same enclosure would not usually be considered independent replicates.
Randomized	The intervention was allocated randomly to individuals or sites. This means that the initial condition of those given the intervention is less likely to bias the outcome.
Paired sites	Sites are considered in pairs, within which one was treated with the intervention and the other was not. Pairs, or blocks, of sites are selected with similar environmental conditions. This approach aims to reduce environmental variation and make it easier to detect a true effect of the intervention.
Controlled	Individuals or sites treated with the intervention are compared with control individuals or sites not treated with the intervention. (The treatment is usually allocated by the investigators (randomly or not), such that the treatment or control groups/sites could have received the treatment).
Before-and-after	Monitoring of effects was carried out before and after the intervention was imposed (or in an "A-B-A" format).
Site comparison	A study that considers the effects of interventions by comparing sites that historically had different interventions (e.g. intervention vs no intervention) or levels of intervention. Unlike controlled studies, it is not clear how the interventions were allocated to sites (i.e. the investigators did not allocate the treatment to some of the sites).

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