



# The potential for biodiversity offsetting to fund invasive species eradications on islands

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Balancing development and biodiversity conservation presents significant challenges. One approach, biodiversity offsetting, represents “measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts resulting from project development” and is a final step in a mitigation hierarchy following steps of avoidance, minimization, rehabilitation, and restoration (Business and Biodiversity Offsets Programme 2012). Norton and Warburton (2015) used the main islands of New Zealand as a case study to provide a well-reasoned assessment of the potential for biodiversity offsetting to fund invasive non-native species control. They identify 7 key conditions that must be met to satisfy the approach: “technically possible to reduce invasive species to levels that enhance native biodiversity; affordable; sufficiently large to compensate for the impact; adaptable to accommodate new strategic and tactical developments while not compromising biodiversity outcomes; acknowledge uncertainties associated with managing pests; based on an explicit risk assessment that identifies the cost of not achieving target outcomes; and include financial mechanisms to provide for in-perpetuity funding.” We propose extending the assessment to include eradication of invasive non-native species (hereafter invasive species) on smaller islands, where it is feasible, cost effective, and can result in lasting, worldwide biodiversity gains. Eradication of invasive species is the complete and permanent removal of an invasive population, whereas control represents ongoing suppression of a population with the threat from invasive species expected to return once suppression ceases (Cromarty et al. 2002).

A primary condition for effective invasive species control for biodiversity offsetting is that it be technically possible to reduce invasive species impacts to levels that enhance native biodiversity (Norton & Warburton 2015). In terms of eradication, efforts thus far have largely focused on damaging invasive mammals that have significant impacts to island biota (Townsend et al. 2006; Medina et al. 2011), and a long history of completed projects has demonstrated feasibility. More than 1200 eradications have been undertaken on 840 islands worldwide: the overall success rate is approximately 85% (DIISE 2014). Control of invasive species also requires financial mechanisms to allow for in-perpetuity funding (Norton & Warburton 2015) to maintain an invasive population at a level below which native biodiversity is adversely affected. In contrast, invasive mammal eradication requires an initial financial investment to achieve complete removal of a threat within a short period. Following eradication, low, continuous investment is required to avoid recolonization (i.e., biosecurity). In many cases, especially over the long term, eradication has financial and ecological advantages over control. For example, Pascal et al. (2008) found the cumulative costs (number of person hours required in the field) of annual invasive rodent control exceeded the cost of eradication after 6 years. They also showed eradication resulted in a better conservation outcome than control; reproductive success of Cory’s shearwaters (*Calonectris diomedea*) was significantly higher (11%).

Benefits of invasive species eradications should also be sufficiently large to compensate for the proposed impact from development (Norton & Warburton 2015).

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Previous invasive mammal eradications on islands have significantly benefited biodiversity and threatened species e.g., increases in reproductive success and abundance of native species and recolonization by extirpated native species (Lorvelec & Pascal 2005; Bellingham et al. 2010). The intent of biodiversity offsetting is to identify compensation for biodiversity loss a priori (Business and Biodiversity Offsets Programme 2012). Projects aimed at eradication of invasive species via other post hoc compensatory mechanisms provide informative examples of species-based impact compensation. The eradication of invasive black rats (*Rattus rattus*) on Anacapa Island, California, cost \$1.5 million and was primarily driven by a need to compensate for seabirds killed by an oil spill (American Trader Trustee Council 2001). Project outcomes included increased numbers of the Xantus's Murrelet (now Scripps' Murrelet [*Synthliboramphus scrippsi*], listed as vulnerable on the International Union for Conservation of Nature [IUCN] Red List) (Whitworth et al. 2013); increased breeding activity of Cassin's Auklets (*Ptychoramphus aleuticus*) (Whitworth et al. 2015); and the first confirmed active nest site of Ashy Storm-petrels (*Oceanodroma homochroa*, listed as endangered on the IUCN Red List) (Harvey et al. 2013).

A more recent a priori example is the current Return to 1616 island restoration project on Dirk Hartog Island, Western Australia, which includes the eradication of feral sheep, goats, and cats; reestablishment of native vegetation; and reintroduction of 10 native mammals (Gillen et al. 2011; Western Australia Department of Parks and Wildlife 2015). This 20-year effort is to be funded in part by the Gorgon Barrow Island Net Conservation Benefits Fund (GBINCBF), including a recent commitment of \$8.5 million through 2018 (Government of Western Australia 2012). The GBINCBF is an outcome of the Gorgon Project, a natural gas extraction development on Barrow Island, whereby \$60 million is required to provide a net conservation benefit, defined as "demonstrable and sustainable additions to or improvements in biodiversity conservation values of Western Australia targeting, where possible, the biodiversity conservation values affected or occurring in similar bioregions to Barrow Island" (Chevron Australia 2015).

Examples of potential species-based offsetting exist in Hawaii, where a nexus exists between renewable energy development and threatened species conservation. Plans exist to transform Hawaii's 90% dependency on imported fossil fuels to 70% clean energy generation by 2030 (State of Hawaii 2014). One-third of the birds listed under the U.S. Endangered Species Act reside in Hawaii (VanderWerf 2012), including the Nene (*Branta sandvicensis*), Hawaiian Petrel (*Pterodroma sandwichensis*), and Newell's Shearwater (*Puffinus newelli*), species that are considered threatened by turbine strikes, artificial lights, and habitat loss from renewable energy develop-

ment (US Department of Energy 2014). Kaho'olawe is an uninhabited island where eradication of invasive cats (*Felis catus*) and rats (*Rattus* sp.) would provide an essential baseline activity toward broader island restoration (The Nature Conservancy 2014). Multiple animal species can be restored to Kaho'olawe (Lindsey et al. 1997), including Newell's Shearwater, Hawaiian Petrel, and Nene. Although avoidance and minimization via best management practices can reduce species impacts at development sites (US Fish and Wildlife Service 2012), biodiversity offsetting may also be necessary to achieve ambitious state-wide renewable energy targets. Restoration of the entirety of Kaho'olawe, including invasive mammal eradication, revegetation, and threatened species translocation represents a potential like-for-like offset opportunity for species affected by renewable energy development. One challenge for regulators charged with implementing species-based offsets is that the objective is to achieve a net gain or no net loss from a specific impact from a particular project, whereas the broader goal for threatened species recovery is to reduce the threat of extinction, which is beyond the scope of the offset activities (Wilcox & Donlan 2009). Species-based offsets should also not cause an increased mortality risk to other species (Finkelstein et al. 2008). Recovery planning needs to assess the relative contribution of the eradication relative to all threats to a species (e.g., seabirds at risk from invasive mammals and fisheries bycatch) (Pascoe et al. 2011).

Islands have disproportionately higher levels of biodiversity, threatened species, and extinctions than mainlands. Thus, they are an important focal area for high-impact conservation actions. Invasive species present a key risk to insular species and are a logical target for resource managers (Tershy et al. 2015). For many islands, eradication of invasive species is a tractable solution and under the right circumstances represents a noteworthy opportunity for biodiversity offsetting.

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## Literature Cited

- American Trader Trustee Council. 2001. Final restoration plan and environmental assessment for seabirds injured by the *American Trader* oil spill. Report of the American Trader Natural Resource Trustee Council, U.S. Fish and Wildlife Service, California Department of Fish and Game, and National Oceanic and Atmospheric Administration, Washington, D.C. Available from <http://www.gc.noaa.gov/ge-rp/amtrad2.pdf>.
- Bellingham PJ, Towns DR, Cameron EK, Davis JJ, Wardle DA, Wilmhurst JM, Mulder CPH. 2010. New Zealand island restoration: seabirds, predators, and the importance of history. *New Zealand Journal of Ecology* 34:115-136.

- Business and Biodiversity Offsets Programme (BBOP). 2012. Standard on biodiversity offsets. BBOP, Washington, D.C. Available from [http://www.forest-trends.org/documents/files/doc\\_3078.pdf](http://www.forest-trends.org/documents/files/doc_3078.pdf) (accessed April 2015).
- Chevron Australia. 2015. Gorgon Project. Environmental approvals. Chevron Australia, Perth. Available from <https://www.chevronaustralia.com/our-businesses/gorgon/environmental-approvals> (accessed April 2015).
- Cromarty P, Broome K, Cox A, Empson RA, Hutchinson WM, McFadden I. 2002. Eradication planning for invasive alien species on islands: the approach developed by the New Zealand Department of Conservation. Pages 85–91 in Veitch CR, Clout MN, editors. Turning the tide: the eradication of invasive species. IUCN, Gland, Switzerland.
- DIISE. 2014. The database of island invasive species eradications (developed by Island Conservation, Coastal Conservation Action Laboratory UCSC). IUCN SSC Invasive Species Specialist Group, University of Auckland, and Landcare Research New Zealand. Available from <http://diise.islandconservation.org> (accessed April 2015).
- Finkelstein M, et al. 2008. Evaluating the potential effectiveness of compensatory mitigation strategies for marine bycatch. *PLoS ONE* **3**: (e2480) DOI: 10.1371/journal.pone.0002480.
- Gillen K, Rose D, Morris K, Sims C, McCluskey P, Desmond A, Fitzgerald B, Gray G. 2011. Dirk Hartog Island National Park ecological restoration strategic plan. Western Australian Department of Environment and Conservation, Perth.
- Government of Western Australia. 2012. Clock turned back 400 years on Dirk Hartog Is. Government of Western Australia, Perth. Available from [http://www.sharkbay.org/Assets/media\\_statement\\_December\\_2012.pdf](http://www.sharkbay.org/Assets/media_statement_December_2012.pdf) (accessed April 2015).
- Harvey AL, Mazurkiewicz DM, McKown M, Barnes KW, Parker MW, Kim SJ. 2013. Ashy Storm-Petrel, Scripps's Murrelet, and Cassin's Auklet reproductive status assessments and restoration recommendations in 2011–2012. Report. California Institute of Environmental Studies, Davis. Available from [http://www.montroserecovery.noaa.gov/wp-content/uploads/2014/03/Harveyetal\\_ANACAPA\\_2011to2012\\_FINAL\\_Report.pdf](http://www.montroserecovery.noaa.gov/wp-content/uploads/2014/03/Harveyetal_ANACAPA_2011to2012_FINAL_Report.pdf) (accessed April 2015).
- Lindsey GD, et al. 1997. Technical options and recommendations for faunal restoration of Kaho'olawe. USGS - Pacific Island Ecosystems Research Center, Kilauea Field Station, HI. Technical report to Kaho'olawe Island Reserve Commission, Hawaii DLNR, Honolulu.
- Lorvelec O, Pascal M. 2005. French attempts to eradicate non-indigenous mammals and their consequences for native biota. *Biological Invasions* **7**:135–140.
- Medina FM, Bonnaud E, Vidal E, Tershy BR, Zavaleta ES, Donlan CJ, Keitt BS, Le Corre M, Horwath SV, Nogales M. 2011. A global review of the impacts of invasive cats on island endangered vertebrates. *Global Change Biology* **17**:3503–3510.
- Norton DA, Warburton B. 2015. The potential for biodiversity offsetting to fund effective invasive species control. *Conservation Biology* **29**:5–11.
- Pascal M, Lorvelec O, Bretagnolle V, Culioli J-M. 2008. Improving the breeding success of a colonial seabird: a cost-benefit comparison of the eradication and control of its rat predator. *Endangered Species Research* **4**:267–276.
- Pascoe S, Wilcox C, Donlan CJ. 2011. Biodiversity offsets: A cost-effective interim solution to seabird bycatch in fisheries? *PLoS ONE* **6** (e25762) DOI: 10.1371/journal.pone.0025762.
- State of Hawaii. 2014. Hawaii clean energy initiative. State of Hawaii, Honolulu. Available from <http://www.hawaiicleanenergyinitiative.org/> (accessed April 2015).
- Tershy BR, Shen K-W, Newton KM, Holmes ND, Croll DA. 2015. The importance of islands for the protection of biological and linguistic diversity. *BioScience* DOI: 10.1093/biosci/biv031.
- The Nature Conservancy (TNC). 2014. Kaho'olawe Island Reserve: 'Ili O Kealaikahiki - conservation action plan. Produced for the Kaho'olawe Island Reserve Commission. TNC, Honolulu.
- Towns DR, Atkinson IAE, Daugherty CH. 2006. Have the harmful effects of introduced rats on islands been exaggerated? *Biological Invasions* **8**:863–891.
- US Department of Energy. 2014. Hawai'i clean energy draft programmatic environmental impact statement (Draft PEIS) US Department of Energy, Washington, D.C. Available from <http://hawaiicleanenergypeis.com/wp-content/uploads/2012/05/Hawaii-Clean-Energy-Draft-PEIS.pdf> (accessed April 2015).
- US Fish and Wildlife Service (USFWS). 2012. U.S. Fish and Wildlife Service land-based wind energy guidelines. USFWS, Washington, D.C. Available from [http://www.fws.gov/ecological-services/es-library/pdfs/WEG\\_final.pdf](http://www.fws.gov/ecological-services/es-library/pdfs/WEG_final.pdf) (accessed April 2015).
- VanderWerf EA. 2012. Hawaiian bird conservation action plan. Pacific Rim Conservation, Honolulu.
- Western Australia Department of Parks and Wildlife. 2015. Nature conservation. Shark Bay World Heritage Area Western Australia. Return to 1616. Western Australia Department of Parks and Wildlife, Perth. Available from <http://www.sharkbay.org/DHIERP.aspx> (accessed April 2015).
- Whitworth DL, Carter HR, Gress F. 2013. Recovery of a threatened seabird after eradication of an introduced predator: eight years of progress for Scripps's Murrelet at Anacapa Island, California. *Biological Conservation* **162**:52–59.
- Whitworth DL, Harvey AL, Carter HR, Young RJ, Koepke JS, Mazurkiewicz DM. 2015. Breeding of Cassin's Auklets *Ptychorampbus aleuticus* at Anacapa Island, California, after eradication of black rats *Rattus rattus*. *Marine Ornithology* **43**:19–24.
- Wilcox C, Donlan CJ. 2009. Need for a clear and fair evaluation of biodiversity offsets for fisheries bycatch. *Conservation Biology* **23**:770–772.