Biological Conservation 197 (2016) 229–234

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/bioc

Conservation action implementation, funding, and population trends of birds listed on the Endangered Species Act

David Luther [a,*], James Skelton [b], Christopher Fernandez [a], Jeffrey Walters [b]

[a] George Mason University, 4400 University Drive MS3E1, Fairfax, VA 22030, USA
[b] Virginia Tech, 1405 Perry St, Blacksburg, VA 24061, USA

ARTICLE INFO

Article history:
Received 24 November 2015
Received in revised form 11 March 2016
Accepted 18 March 2016
Available online 2 April 2016

Keywords:
Conservation actions
Expenditures
Endangered Species Act
Threatened species
Birds

ABSTRACT

Current rates of species endangerment and extinction are unprecedented in modern times. Conservation efforts aim to slow down, stop, and reverse threats to species and thus the current loss of biodiversity. However, the extinction risk to species continues to rise. Thus far, research has examined the efficiency and the effectiveness of conservation actions individually, yet, the full suite of implemented conservation actions should be considered. We assessed all implemented conservation actions for avian species listed under the Endangered Species Act (ESA) in the United States. Using data available through the US Fish and Wildlife Service (USFWS) we assessed the relationships between conservation actions implemented, population trends, and financial expenditures for all listed species each year between 1996 and 2013. We found positive associations between the amount of funding allocated for a species and their population trend. Implementation of the conservation actions habitat protection and educational awareness were positively associated with annual funding for a species. Our results highlight the disparity in conservation action implementation and resource allocation between ESA listed species on the mainland and on islands in the USA. Together these results and the cause and effect relationships they suggest could provide a pathway toward more effective conservation programs.

1. Introduction

The number of species threatened with extinction is higher than at any other time in recent history (Barnosky et al., 2011, Pimm et al., 2014). Conservation biologists attempt to stop loss of biodiversity through conservation actions, such as habitat protection, education and awareness, *ex-situ* programs, removing invasive species, and legislation (Salafsky et al., 2008). Such conservation efforts have delivered numerous successes in which species have been brought back from the brink of extinction. Between 1994 and 2004, conservation efforts likely prevented at least 16 avian species from going extinct (Butchart et al., 2006, Rodrigues et al., 2006). The Endangered Species Act in the United States of America and subsequent conservation actions implemented after species were listed as threatened or endangered is thought to have protected 227 species from extinction (Schwartz 2008). In addition, conservation efforts have had a substantial impact on overall trends in extinction risk as measured by the Red List Index, reducing the declining trajectory of 20% of threatened mammal and bird species (Hoffmann et al., 2010).

Available resources for conservation are currently insufficient to confront expanding threats (Miller et al., 2002, McCarthy et al., 2012, Restani and Marzluff, 2001, 2002), so it is important for practitioners to understand the factors that predispose conservation actions toward success. To date there has been little analysis of influences on the results of these conservation actions (Chapman et al., 2014). In the United States, the Endangered Species Act (ESA) was enacted to reverse the declining population trends of endangered species. The U.S. Fish and Wildlife Service (USFWS) creates a recovery plan with specific actions assigned to aid the recovery of each endangered and threatened species. In addition, they provide 5-year reviews on the progress of the conservation of each listed species. Together these reports provide information about both the conservation actions recommended and implemented, and the population trends of species listed under the ESA. Previous research has focused on the effectiveness of the Endangered Species Act and found that recovery of some species has been associated with the amount of funding, the length time on the act, the type of recovery plan, and implementation of critical habitat (see Gibbs and Currie, 2012)., In this paper we focus on the implementation of specific conservation actions to assess their effectiveness and their association with funding. We apply four specific research questions to the available information:

1. Are the recommended conservation actions being implemented?
2. Which conservation actions in place are positively correlated with increasing population trends?
3. Is there a relationship between conservation action implementation and the amount of money spent on conservation actions?

* Corresponding author.
E-mail addresses: dluther@gmu.edu (D. Luther), jrwalt@vt.edu (J. Walters).

http://dx.doi.org/10.1016/j.biocon.2016.03.019
0006-3207/

4. Is there a relationship between the amount of money spent and population recovery?

Birds are an excellent study group to investigate such questions within the context of the ESA as they are easily studied and identifiable, and there are large networks of researchers studying birds and compiling information about their conservation status. Due to these networks of researchers generally there is more available information for birds than other taxa, which can help inform conservation decisions as well as assess the impact of conservation actions.

2. Methods

Information on avian species identity, recovery plan, 5-year reviews, and conservation expenditures were all found on publically available USFWS websites, http://www.fws.gov/info/databases2.html. Recommended conservation actions were found in the recovery plan for each listed species and sorted into the following categories; enforce regulations, population monitoring, habitat restoration (including habitat maintenance), habitat protection, invasive species control (competitors and predators, including native as well as nonnative species), *Ex-situ*, reintroduction, education, legislation, and research (after Salafsky et al., 2008). The USFWS ROAR database has information on all implemented conservation actions at 5-year intervals from 1995 through 2013. We used these data to identify in which year each conservation action was implemented for each species (https://ecos.fws.gov/roar/pub/ConfigureRecActionReport.do?path=ROAR%20Custom%20Queries.Public%20Actions%20AdHoc). Where data were available for multiple populations of a listed species we summed the population information so that the analysis would be at the level of the listing unit, not subpopulations within the listing unit.

Population level information was collected from the 5-year review for each listed species, including the number of individuals and the number of populations, as well as the year. All data were transformed to the number of individuals for each species, for example for species reported in number of breeding pairs rather than number of individuals, we multiplied breeding pairs times two. The amount of money spent on the conservation of each species in a given year was collected from the USFWS ESA library, http://www.fws.gov/endangered/esa-library/. The total amount of money spent for a species in a year was used and averaged based on the available data from 1996 to 2013.

Species were categorized as living on continents, 35 species, or islands, 51 species, because species on continents and islands often face different threats and require different conservation strategies. Island species included all ESA listed avian species on both oceanic islands, such as Puerto Rico and Hawaii, and continental islands, such as the Channel Islands in California. Four species were excluded from the analysis because USFWS listed them as exempt from recovery or extinct (see Appendix 1 for a list of all listed species and those not included in this study). While some other species are thought to be extinct since their listing, specifically some Hawaiian species (see Eliphick et al. (2010) for a full list), some of those species are included in this study because they had recovery plans, conservation actions were implemented for them, and they were not listed as exempt from recovery.

We used t-tests to compare the total number of conservation actions recommended and the number implemented for all species, the number of conservation actions implemented for species on islands and the continental US, and the number of conservation actions implemented for endangered and threatened species. We used paired t-tests to determine if the number of conservation actions recommended differed from the number implemented for each class of conservation action, for endangered species, for threatened species, for continental species, and for island species. For the paired t-tests of classes of conservation actions, to reduce the possibility of false positive results from multiple tests we used a Bonferroni correction factor and adjusted the alpha value from 0.05 to 0.0125.

To determine which conservation actions were associated with increasing or decreasing population trends we first conducted linear regression on the available population data from the USFWS for each species to determine the population trend of each species; two species had fewer than 3 years of available population data and were not included. Based on these results each species was labeled as having an increasing, stable, or decreasing population (see supplement for population trend regression results for each species). We used an information theoretic approach to select the best multiple regression logistic model for the binary response of population trend (increase or decrease), starting with a full model that included all implemented conservation actions, as well as total funding, and landmass. In our initial model, population trend was the binary response variable while conservation action implementation, yes or no for each species, and landmass type, island or mainland, inhabited by a species were the predictor variables. We then used forward and reverse stepwise AIC model selection to choose the best model from all possible subsets (step function R stats package version 2.15.3).

To examine the relationships between average annual funding and the implementation of each management action we used binomial general linear models (GLMs) with annual funding, log transformed, as a predictor, and implementation of each conservation action as a response. We used a GLM to predict number of actions implemented as well as which actions were implemented as a function of total funding. Finally, we used a binomial GLM to regress population trend against total funding, annual funding, plan year, landmass type, and the number of years a species was funded. Total funding was log transformed to meet assumptions of a normal distribution. All statistical analyses were performed in R statistical software version 2.15.3.

3. Results

Overall there were more conservation actions recommended, 6.6 ± s.e. 0.05, than implemented, 5.0 ± s.e. 0.07 (T-ratio = 4.2, DF = 86, $P < 0.0001$). Species listed as endangered and living on islands had significantly more conservation actions recommended than implemented while continental species and threatened species did not. These differences were significant for the following conservation actions and circumstances: monitoring, invasive species control, education, habitat protection, reintroduction, and *ex-situ* conservation (see Table 1 for statistical results; Fig. 1). However, significantly more actions were implemented than recommended for enforcing regulations for continental species, and for implementing new legislation for island species.

There were significantly more conservation actions implemented for continental than island species, 7.1 ± s.e 0.53 and 5.7 ± s.e. 0.44, respectively, (T-ratio = 2.07, DF = 84, $P = 0.04$), but there was no significant difference between threatened and endangered species in number of conservation actions implemented. There was more habitat protection (T-Ratio = 2.78, DF = 84, $P = 0.0067$) and habitat restoration (T-Ratio = 3.17, DF = 84, $P = 0.001$) implemented for continental species than species on islands, but none of the conservation actions were implemented differently for threatened and endangered species.

Sixteen continental and ten island species had increasing population trends, while eighteen continental and forty species on islands had declining populations. Species on islands were significantly more likely to have decreasing population trends than continental species (ChiSquare Pearson = 6.13, $P = 0.013$). Population trend was not associated with any specific conservation actions.

On average more money was spent per year for species in the continental U.S. than species on islands (T-Ratio = 4.6, DF = 82, $P < 0.0001$), with $2,908,615 (s.e. ±$433,906) spent on average per year for continental species (median $1,334,335), and $293,164 (s.e. ±$357,808) spent on average per year for island species (median $125,733). There was no significant difference in the amount of money spent annually between endangered and threatened species. The five species that received the most money on average, red-cockaded woodpecker,