Uncertainty in Population Estimates for Endangered Animals and Improving the Recovery Process

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INTRODUCTION

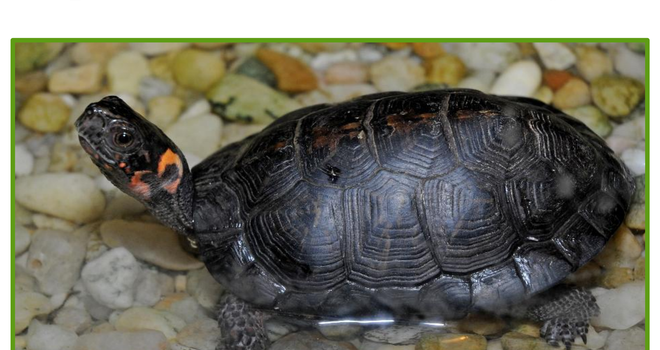
In the United States, wildlife species of conservation concern are listed as either "endangered" or "threatened" depending on their status and probability of extinction. The Endangered Species Act of 1973 (ESA) was created to provide a means by which endangered and threatened species and the ecosystems upon which they depend could be conserved (ESA sec. 2(5b)). Each species placed under the ESA is given a recovery plan and recovery plans contain all the available biological information for a listed species and specify the recovery criteria that (when achieved) will provide the basis for downlisting (i.e., reclassifying a species from endangered to threatened) or delisting (i.e., removing a species from the protection of the ESA).

Piping plover (*Charadrius melodus*), the only listed bird species found in Pennsylvania (© 2002 Sidney Maddock).

In 1988 an amendment required that all recovery plans include "objective, measurable" delisting criteria. Population size is an example of such a criteria. Setting population targets is important because the targets allow biologists to determine if conservation efforts are successful. However, quantitative recovery criteria do not necessarily promote increasing populations because of political pressure for lower recovery. In response, a number of researchers recommend that population estimates for recovery should incorporate a margin of error to create more robust estimates for stipulated recovery criteria with the incorporation of uncertainty associated with quantitative criteria to avoid premature delisting of species.

Indiana Bat (*Myotis sodalis*), the only listed mammal species found in Pennsylvania (© Justin Boyles).

The objective of our study was to evaluate whether recovery plans calculate uncertainty for quantitative data by using population size for listed terrestrial vertebrate species as an example. Our specific objectives included: (1) identify percentage of recovery plans that stipulate a current population size, (2) if a measure of uncertainty was associated with species estimates of current population size (3) identify the number of recovery plans that stipulate a population size as a recovery criteria, and (4) provide recommendations to help incorporate error or uncertainty into the recovery process.



Northern bog turtle (*Clemmys muhlenbergii*), the only listed reptile species found in Pennsylvania (© John White).

METHODS

We reviewed all finalized recovery plans for listed terrestrial vertebrate species in the United States up to 2012. Digital copies of the plans were obtained as Portable Document Files (PDFs) from the web-based USFWS Threatened and Endangered Species System (TESS) (https://ecos.fws.gov/ecp/species-reports). The following data were recorded: 1) if current population size(s) were given 2) if a measure of uncertainty or variance was associated with current estimates of population size and 3) if population size was stipulated for recovery (*i.e.*, downlisting and delisting). Key word searches were preformed within each PDF in order to locate information: population, downlist, delist, variance variability, mean, mode, median, S.D., standard, confidence, interval, maximum, and minimum.

A chi-square analysis was used to determine if there were any significant differences in the number of recovery plans that provided a current population size estimate, a calculated uncertainty in the current population estimate and a population size as a recovery criterion between each decade (*i.e.*, 1980–1989, 1990–1999, 2000–2009, 2010–2013) and between each Class of terrestrial vertebrate (*i.e.*, Amphibia, Aves, Mammalia and Reptilia). Statistical significance was based on a p-value < 0.05.

RESULTS & DISCUSSION

A total of 200 listed terrestrial vertebrates out of 240 had completed recovery plans, 59% of plans specified a current population size and 14.5% specified a variance for the population size estimate. Of the recovery plans with downlisting criteria, 24% reported variance for the current population size. Of the recovery plans with delisting criteria, 20% reported a variance for the current population size. The percentage of plans that provided a current population size did not differ significantly by decade (χ^2 = 2.10, *p-value* = 0.55), but the percentage of recovery plans that provided an estimate of variance for the current population size did (χ^2 = 16.04, *p-value* = 0.001) (Figure 1). The percentage of recovery plans that provided a current population size (χ^2 = 9.57, *p*-value = 0.02) and the percentage of recovery plans that provided an estimate of variance (χ^2 = 37.80, *p*-value < 0.01) both differed between terrestrial vertebrate Classes (Figure 2). More recovery plans for birds and mammals reported estimates of current population size and variance for population size compared to reptiles and amphibians (Figure 2).

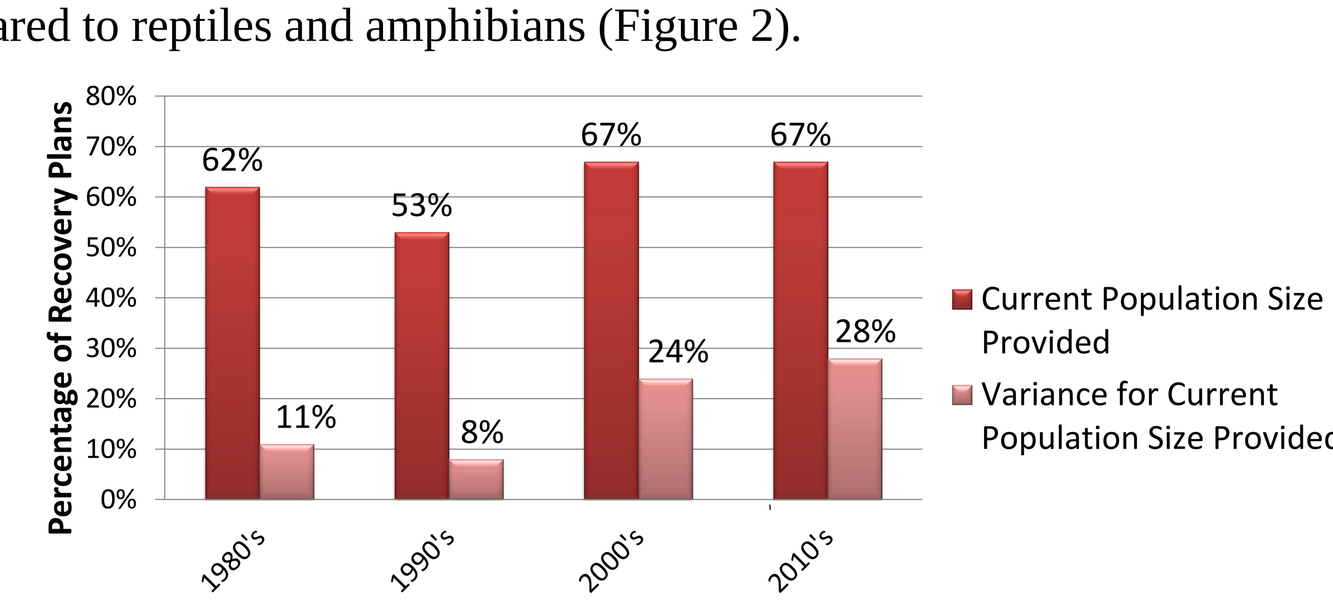


Figure 1. Comparison in the percentage of terrestrial vertebrate recovery plans that provide a current population and provide an estimate of uncertainty (e.g., variance) for the current population size estimate by decade.

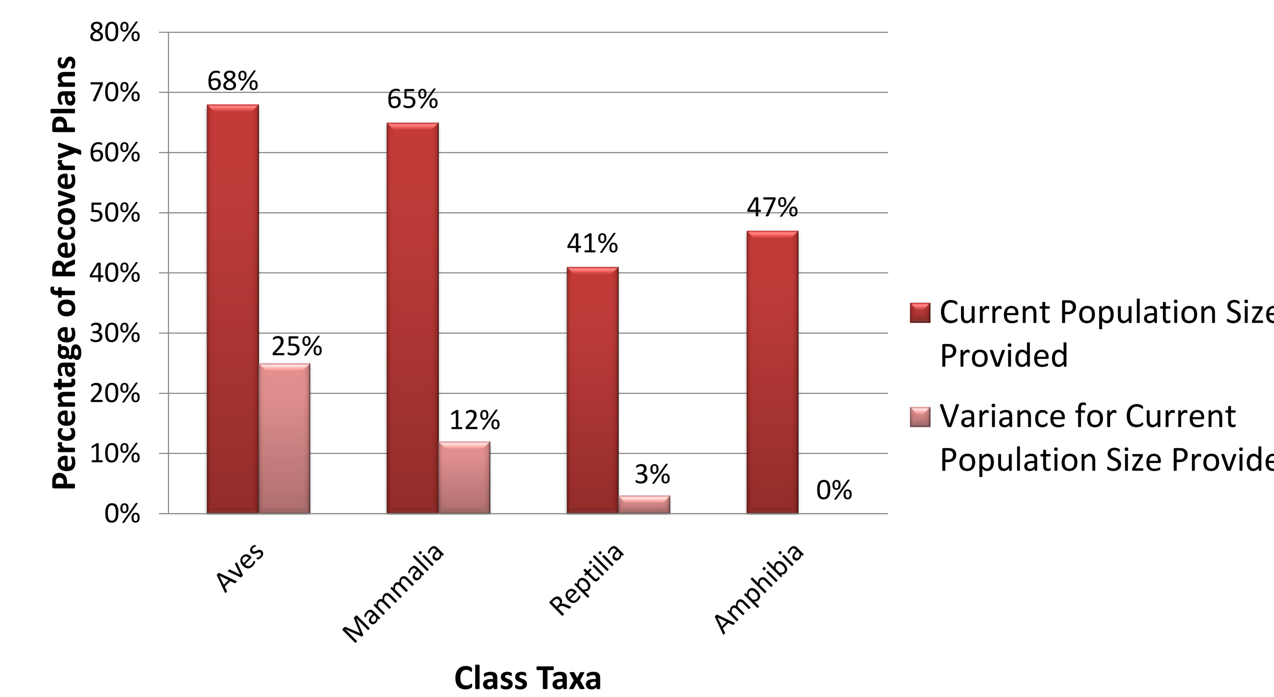


Figure 2. Comparison in the percentage of terrestrial vertebrate recovery plans that provide a current population and provide an estimate of uncertainty (e.g., variance) for the current population size estimate by animal Class taxa.

Overall, the ESA has been making a positive difference for species at risk of extinction. However, less than a quarter of recovery plans reported variance with their population size estimates. One approach for developing more detailed and robust recovery criteria when defining population size is by incorporating uncertainty into calculations of a minimum detectable difference between current population size and specified recovery criteria for delisting. A minimum detectable difference (MDD) represents the smallest difference or change that would be statistically significant when comparing different samples depending on the variance of the samples and a defined level of uncertainty. The equation below can be used to determine with MDD indicated as σ:

$$\delta \geq \sqrt{\frac{2S_P^2}{n}}\,(t_{\alpha,v} + t_{\beta(1),v})$$

For example, based on the Whooping crane recovery plan, cranes can be downlisted when their population size reaches 360 birds. The total annual population size for cranes in the last 10 years have been 219, 248, 244, 255, 256, 270, 292, 317, 335 and 343. This gives us an n = 10, s^2_p (variance) = 1,756, a 2-tailed value = 1.83 and a one-tailed value = 1.37 for 90% confidence at nine degrees of freedom. This produces an MDD of 46.98 or 47. Thus, a crane biologist would be >90% confident the recovery criteria was achieved when the total crane population size was 407.

Whooping crane (*Grus americana*), (© LM Otero).

A measure of variance can be used in calculating a MDD to prevent premature delisting of a species. Delisting of a species should be a cautious undertaken because the negative consequences of erroneous delisting (*i.e.*, extinction) outweigh the costs of retaining species on the endangered species list.