Population Recovery Objectives and Their Use in Recovery Planning: A Brief Review

Photo: R. Adam Martin

Prepared by,
Center for Natural Lands Management

For,
United States Fish and Wildlife Service
Cooperative Agreement #F14 AC00838

Summary

For species listed under the Endangered Species Act, developing a recovery plan that contains specific recovery goals, and the management actions to achieve them, is an important step in creating a pathway to species recovery. A recovery objective often considered is setting a minimum viable population (MVP) size desired for downlisting or delisting. Ideally, setting a minimum viable population size is determined through a population viability analysis (PVA) that models extinction risk incorporating demographic, stochastic, and genetic factors. Such an analysis, however, requires extensive data that are often not available. In these situations, options for recovery planners include: 1) not including a population size recovery target, or 2) setting a population goal based on information gleaned through past population viability analyses.

In October 2013, the streaked horned lark *(Eremophilis alpestris strigata)* was listed as threatened under the Endangered Species Act (ESA). Recovery planners are currently seeking input on potential recovery goals, especially related to population size. A MVP has not been estimated for the species. Here, we briefly discuss whether a population size recovery objective should be included in a recovery plan, and if so, how the population size objective should be determined. We base our comments on a review of published MVP analyses and recovery delisting or downlisting targets for other species listed under the ESA.

The majority of literature available indicates that population objectives for conservation/recovery should number in the 1000s, not the 100s. A meta-analysis of minimum viable populations concluded that conservation planning targets should include a minimum habitat area sufficient to support ≥ 7000 sexually mature individuals (Reed et al. 2003). They define an MVP as one with a 99% probability of persistence over 40 generations. Similarly, Traill et al. (2007), who conducted an MVP meta-analysis from 30 years of published data, found that the median size for MVP was 4,169 individuals (95% CI = 3,577 – 5,129). Even though they did not find support for life history predictors of MVP size, they have made available a taxa-specific MVP dataset to allow conservation practitioners to search for MVPs based on taxa as a preliminary guide. Using their data set, we calculated that the average MVP for the groups Aves and Passerines was 5,269 and 6,415 individuals respectively. Finally, Frankham (1995) recommended 4,500 individuals as an effective population size target based on genetic data.

However, there are critics of these generalized targets. Flather et al. (2011) take issue with the process that authors have taken in standardizing MVP estimates and neglecting environmental context. They suggest a species-specific MVP can only be estimated adequately with a very long-term dataset. Although Flather et al. (2011) criticize generalized targets, they do allow that setting general targets for populations are valuable to stimulate action and in the context of setting downlisting or delisting objectives, a common benefit attributed to the use of MVPs.

In a cursory review of Recovery Plans published by the United States Fish and Wildlife Service (USFWS) for birds listed under the Endangered Species Act (ESA) from 2000-present

(Table 1) to build on the work reviewed by Elphick et al. (2001), recovery objectives did not always include a population target, nor was the population size at the time of planning always known. Population targets varied quite dramatically for those species where delisting population criteria were identified; most plans included recovery criteria in the 1000s, although for some species population criteria were as low as 350 (e.g., whooping crane). Many population targets did have species-specific MVPs. However, in an analysis of population recovery targets in recovery plans, Elphick et al. (2001) found that the estimated population size at the time of listing was the only single variable associated with downlisting population objectives. Having conducted a population viability analysis was not correlated with population goals.

In summary, a solution to consider is developing a short-term (or preliminary) population size recovery target that can be refined as additional demographic data is collected from the various lark subpopulations in the Pacific Northwest. Based on the literature, using a generalized MVP estimate is scientifically defensible and provides the benefit of having a target to energize action. Conducting a PVA and determining a minimum viable population of streaked horned larks may be a recovery action priority. There also are many other important components to include in a recovery plan. In this review, most recovery plans usually included language related to (a) self-sustaining population, often to be demonstrated within a determinate time period, (b) adequate distribution, and (c) genetic viability as components necessary to achieve downlisting or delisting objectives

PVA/MVP literature reviewed organized by publication date:

Elphick, C.S., J.M. Reed, and J.M. Bonta. 2001. Correlates of population recovery goals in endangered birds. *Conservation Biology* 15(5):1285-1291.

The authors reviewed all bird recovery plans published through 1999 and evaluated the variation in population objectives set for the plans. Population goals to delist vary considerably, from as few of 400 individuals to as many as 20,000 (mean (SE) = 5556 (1370); median = 4000). Downlisting population goals also varied, from 120 to 12,000 (mean (SE) = 3575 (1061); median = 1500). The variables considered to explain the variation were: body mass, annual fecundity, maximum life span, year of plan, listing status (only related to delisting population goals), if a population viability analysis had been conducted, broad-scale endangerment (if listed throughout US or only in portion of its range), and estimated population size at the time of planning. Of these variables, the size of the population at the time of planning best explained the variation in population objectives for delisting ($r^2=0.75, p<0.001$) and the correlation was even higher for downlisting objectives ($r^2=0.86, p<0.001$). No other single variable was significantly associated with population goals for downlisting. However, there were two additional variables significantly associated with delisting: year of the plan and broad-scale endangerment. Population targets increased through time and were higher for species that were listed throughout the US. These three variables together (year of plan, population size at planning, and broadscale endangerment) explained 86.4% of the variation for delisting and 94.4% for downlisting.

To build on the review conducted by Elphick et al. (2001), we did a cursory review of bird recovery plans published 2000-present (Table 1). We pulled information regarding the population status at the time of planning, the delisting criteria related to population objectives, and whether or not a population viability analysis had been conducted. 12 of the 22 recovery plans reviewed did have a PVA or other model already completed at the time of planning. In the majority of the remaining plans one of the recovery tasks was to collect data and/or conduct a PVA, and often that task was ranked as a high priority.

Reed, D.H., J.J. O'Grady, B.W. Brook, J.D. Ballou, and R. Frahkham. 2003. Estimates of minimum viable population sizes for vertebrates and factors influencing those estimates. *Biological Conservation*. 113: 23-24.

The authors suggest that using PVAs to estimate MVPs can lead to scientifically defensible generalizations concerning viable populations. They evaluated this in response to criticism that there cannot be a widely applicable MVP due primarily to the perception that there is a high level of environmental and taxonomic specificity related to population dynamics. The authors developed or found in the literature PVAs for 102 vertebrate species that were based on actual life history data. They used these PVAs to evaluate demographic, ecological, study, and taxonomic parameters influencing MVP. They define MVP size as one with a 99% probability of persistence over 40 generations.

An MVP mean of 7316 individuals (median = 5816) provide the basis for the authors' assertion that "a minimum habitat area capable of supporting approximately 7000 sexually mature adults is required to maintain long-term MVPs of vertebrates in the wild." Study duration had a surprising impact on MVPs, with shorter studies (relative to generation length of the organism) causing a "systematic underestimation of extinction risk, rather than simply a less precise estimation, as often assumed." Longer studies had larger MVPs because the extended duration captured greater variability in the data. The authors conclude that greater than 12 generations of data are required. There were no significant differences in population sizes due to global latitude, taxonomic grouping, or trophic level. MVPs were significantly affected by population growth rate (lambda: λ); a lower lambda correlated with higher MVP.

Traill, L.W., C.J.A. Bradshaw, and B.W. Brook. 2007. Minimum viable population size: a meta-analysis of 30 years of published estimates. *Biological Conservation.* 139:159-166.

The authors conducted a meta-analysis of published MVPs since the early 1970s; 287 MVP estimates for 212 species were analyzed. Using a unique approach to control for differences in modeling techniques, they standardized the estimates and derived a frequency distribution of MVPs with a median of 4169 individuals (95% CI = 3577-5129), similar to recommended effective population size of 4500 individuals based on genetic data (Frankham 1995). 95% of 141 published articles used PVA as their basis for estimating extinction risk and 60% of published PVAs included genetic effects. In general, the authors found no simple short-cuts or rules of thumb. They did not find support that MVP sizes were explained by ecological or life history predictors, and concluded that species' MVP sizes are context-specific. In contrast, for species where demographic data are unavailable, they suggest that the uniquely standardized database of MVPs can be used as a preliminary guide of the MVP size range that may be expected for a taxa of interest.

We used this dataset provided and calculated that the average MVP for the groups Aves and Passerines was 5269 and 6415 individuals, respectively.

Traill, L.W., B.W.Brook, R.R. Frankham, C.J.A. Bradshaw. 2010. Pragmatic population viability targets in a rapidly changing world. *Biological Conservation*. 143:28-34.

The authors liken the challenges faced by climate change scientists when policy decisions do not reflect the scientific information available to the science and its application (or lack thereof) to biological conservation. They argue that often the "evidence-based scientific estimates of what is required to achieve viability are (often considerably) larger than targets outlined by conservation organizations." In general the authors advocate a minimum target of at least 5000 individuals and lend support to the idea that a generalized MVP has real value in conservation planning, particularly due to the realities of generating adequate sample sizes and limited resources.

Flather, C.H., G.D. Hayward, S.R. Beissinger, and P.A. Stephens. 2011. Minimum viable populations: is there a 'magic number' for conservation practitioners? *Trends in Ecology and Evolution.* 26(6):307-316.

The authors refute the idea that a threshold ≥5000 individuals can be used as a generalized MVP that is unaffected by taxonomy, life history, or environmental conditions. They take issue with the processes used by Reed et al. (2003) and Traill et al. (2007) to standardize MVP estimates, and highlight that MVPs can be dependent on environmental context. This second assertion is supported by the considerable variability in independent estimates of MVP for a single species, e.g., grizzly bear, wolf, Asian elephant, mountain gorilla and red-cockaded woodpecker. They suggest that previous authors did not find "significant variability of MVP *between* taxa simply because there is such enormous variation of MVPs *within* taxa." In addition, they highlight the need to adequately address density dependence in the populations, which can only be treated adequately with a very long-term, and thus rare, dataset. The authors assert that an MVP is really only useful to generate action and or to determine conservation targets, and even that value is constrained by model uncertainty. To actually *conserve* the target taxa, "there is no substitute for diagnosing and treating the mechanisms behind the decline of the population, actions that are unlikely to be informed by using a 'magic number' to set a target for conservation."

Frankham, R., C.J.A. Bradshaw, and B.W. Brook. 2014. Genetics in conservation management: Revised recommendations for the 50/500 rules, Red List criteria and population viability analyses. *Biological Conservation.* 170:56-63.

The authors suggest increases in the recommendations initially made in the 1980s regarding genetically effective population size (N_e) and its extrapolation to census population size (N) – the 50/500 rules. They suggest that the rule should be at least doubled; effective population size necessary to avoid inbreeding depression in the short-term (i.e. within 5 generations) is ≥100 and is ≥1000 to maintain evolutionary potential in perpetuity. They further suggest that the historically recommended ratio of N_e:N be increased to 0.1:0.2, which can account for comprehensive estimates of N_e and different ratios for species with different life histories. The authors consider fragmentation to be a serious threat and further recommend that conservationists continue to assess genetic connectivity among populations and consider gene flow augmentation as appropriate. Finally, they assert that PVAs need to routinely include inbreeding depression on total fitness and long-term scenarios should model the effects of evolutionary potential.

Streaked Horned Lark PVA/MVP Literature Reviewed:

Schapaugh, A.W. 2009. The dynamics and viability of the endangered streaked horned lark. Masters of Environment thesis. The Evergreen State College.

The author developed a stage- and space-structured demographic model to understand streaked horned lark viability. Underlying data were collected from 2002-2005 on 4 sites in South Puget Sound, one Columbia River island, and 2 sites on the Washington coast. Both deterministic and stochastic models were built and yielded similar results. The results indicated that each subpopulation regardless of initial size declined to extinction within 25 years. The analyses indicated that adult survival had the greatest influence on population persistence; the models were far more sensitive to changes in survival than fecundity. The simulations showed differing rates between geographic locales, with the Coastal subpopulation most responsive to changes in vital rates; a 20% increase in adult survival was sufficient to raise lambda above one. However, these space-structured analyses were hampered by small sample sizes, particularly for Columbia River and Washington coast samples. An MVP for streaked horned larks in Washington was not reported.

Camfield, A.F., S.F. Pearson, and K. Martin. 2011. A demographic model to evaluate population declines in the endangered streaked horned lark. *Avian Conservation and Ecology*. 9(2):4.

The authors estimated vital rates (fecundity, adult and juvenile survival) and conducted a life-stage simulation model to evaluate which vital rate has the greatest influence on population growth rate (lambda; λ). While simulated increases in adult survival, followed by juvenile survival and fecundity, had the greatest influence on population growth rate, only when all three vital rates were raised concurrently did lambda approach a level of 1. Their estimate of population growth indicates that streaked horned lark populations in WA are declining rapidly ($\lambda = 0.62 \pm 0.10$). Underlying data were collected from 2002-2005 on 4 sites in South Puget Sound, one Columbia River island, and 2 sites on the Washington coast. An MVP for streaked horned larks in Washington was not reported.

Table 1. Summary of delisting criteria, population status at planning, and whether or not a PVA had been conducted in USFWS-published bird recovery plans 2000-present					
Species Common Name	**Year published**	**New or Revision**	**Population status at time of planning**	**Delisting population recovery criteria**	**Model**
Southwestern Willow Flycatcher	2002	New	1200-1300 pairs	3900 individuals in metapopulation	PVA conducted
Steller's eider	2002	New	Estimates range from 176-2543 individuals	No population objective	PVA in development. Recovery tasks aimed at getting more information
Red cockaded woodpecker	2005	Revision	14,068 individuals	Complex recovery objective because of species biology regarding breeding groups and "helper" individuals	Simulation model of population dynamics performed
Great lakes piping plover	2003	New	12-51 pairs	150 viable pairs	PVA conducted
Nene	2004	Revision	1275 individuals	2000 individuals	Two PVAs conducted
Mariana crow	2005	Draft revision	95 pairs	225 pairs for delisting, 150 pairs for downlisting	Spatially-explicit model of populations is a recovery task
Whooping crane	2007	Third revision	338 wild individuals and 135 captive	360 self-sustaining individuals and 153 in captivity	PVA conducted
Snowy plover	2007	New	1205-2205 in US and last count in Baja of 1344 (in 1991-92)	3000 breeding adults	PVA conducted
Rota bridles white eye	2007	New	1000 individuals	Restore to 1982 population of 10,000 individuals	Recovery task to collect data to support modeling
Guam kingfisher	2008	Revision	100 individuals in captivity	2000 wild adults	Recovery task to conduct population model
Alala	2009	Revision	56 individuals in captivity	No population objective	Recovery task to collect data to conduct PVA
Short tailed albatross	2008	New	2400 individuals (400-500 breeding pairs)	1000 breeding pairs	PVA conducted
Puerto Rican parrot	2009	New	25-28 wild individuals and 228 in captivity	Population objective to be determined	PVA conducted
Laysan duck	2009	Revision	611 individuals	1800 individuals	PVA conducted
Yuma clapper rail	2009	Draft revision	Unknown	Minimum of 824 in US, or higher as established through research and modeling	1st recovery task to determine minimum # breeding pairs in US that provides for a statistically and genetically secure population
Attwater's prairie chicken	2010	2nd revision	90 wild individuals and 157 captive	6000 breeding adults	No PVA

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Ivory-billed woodpecker	2010	New	Unknown - zero?	Not set	PVA conducted on rare large-bodied woodpeckers with implications for ivory-billed
Northern spotted owl	2011	1st revision	No reliable range-wide estimate of popn size. Instead use demographic data to evaluate trends.	Recovery criterion 1 – stable or increasing population trend	Population model
Hawaiian water birds	2011	2nd revision	Stilt ~ 2000	Stilt – 2000 birds	PVA conducted
			Duck < 500	Duck, Coot, Moorhen – 2000 birds or other target based on Stilt PVA	No PVA conducted
			Coot ~ 2000		
			Moorhen < 450		
Mexican Spotted Owl	2012	1st revision	1301 owl sites occupied by one or more individuals	Stable or increasing occupancy trend	Occupancy modeling an identified action
Tidal Marsh ecosystems of northern and central California (includes CA clapper rail)	2013	8th Revision	601 individuals	5,492 individuals	PVA conducted
Thick billed parrot	2013	Recovery plan addendum to supplement Mexican PACE	1870-2097 individuals	Downlist when self-sustaining population is maintained over a 20-yr period. Delisting criteria not set – need more info. "Without knowledge of a minimum popn size needed to ensure species survive, it would be unreasonable to provide delisting criteria"	Recovery task to "determine minimum viable population size, temporal and spatial distribution, and number of breeding colonies needed for recovery"

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