# A Population Monitoring Framework for Five Subspecies of Island Fox (*Urocyon littoralis*)

*Prepared for*

The Recovery Coordination Group
of the
Island Fox Integrated Recovery Team

*Prepared by*

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# Acknowledgements

This document was developed in response to the Technical Analysis Request (TAR) 2.1 issued by the Recovery Coordination Group (RCG) of the Channel Islands Fox Integrated Recovery Team (Recovery Team). It represents the effort of the Monitoring Task Force, formed in response to TAR 2.1, to develop island-specific monitoring protocols for review by the Population Modeling Technical Expertise Group (TEG), Wild Population Management TEG, and Fox Health TEG, as well as land managers of the Channel Islands. As such, this framework reflects a culmination of years of investigation, discussion, and planning by the Recovery Team, its many dedicated participants, and all who have contributed to the understanding of this species.

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# Executive Summary

Island foxes (*Urocyon littoralis*) inhabit the six largest Channel Islands off the coast of southern California, with a separate subspecies recognized on each island: San Miguel Island fox (*U. l. littoralis*), San Nicolas Island fox (*U. l. dickeyi*), San Clemente Island fox (*U. l. clementae*), Santa Catalina Island fox (*U. l. catalinae*), Santa Rosa Island fox (*U. l. santarosae*), and Santa Cruz Island fox (*U. l. santacruzae*). Due to their limited geographic distribution and small population sizes, foxes on all six islands have been listed as Threatened by the State of California, and all subspecies except those on San Nicolas and San Clemente have been listed as Endangered by the U.S. Fish and Wildlife Service (USFWS) due to recent precipitous population declines and high risk of extinction.

Due to the persistent high risk of this island species, robust monitoring of fox populations and their threats is a key component of recovery and long-term management. This document presents a framework for population monitoring for five subspecies of island fox on San Miguel, San Nicolas, Santa Catalina, Santa Rosa, and Santa Cruz Islands. A monitoring framework previously developed for the U.S. Navy on San Clemente Island, in addition to years of monitoring and research on all six islands, provided the foundation for the current effort. This document thus represents the first comprehensive synthesis of monitoring data, objectives, and protocols across multiple Channel Islands with foxes.

Sections 1-3 of this report describe the considerations and approaches used to identify specific monitoring objectives, determine parameters to address these objectives, and develop protocols to measure these parameters. Sections 4-8 present illustrative island-specific examples of monitoring scenarios designed to address current monitoring objectives, but with different levels of effort and precision. We provide at least two alternative trapping scenarios for each island, along with expected precision (e.g., for resulting population estimates), effort required, and estimated habitat representation. It is expected that island managers will tailor and adapt protocols for on-the-ground use, based on their resources and priorities, understanding that there is generally a trade-off between monitoring intensity and information value.

## Monitoring Objectives and Parameters

This framework reflects the culmination of years of investigation, discussion, and planning by the Island Fox Integrated Recovery Team, island managers, veterinarians, population modelers, statisticians, and other scientists who have contributed to the understanding of this charismatic species. The motivation for this effort was the recognition that monitoring objectives and protocols have varied among islands and over time. Going forward, the monitoring objectives for this framework address the essential core of information in which managers should invest, recognizing logistical and monetary constraints and the inherent trade-offs for precision. These objectives are:

1. Track recovery of fox populations relative to recovery criteria, which will be defined in the Recovery Plan for this species developed by the USFWS.
2. Determine when delisting is warranted (as defined in the USFWS Recovery Plan).

3. Guide island-specific management decisions such as those related to captive breeding, vaccination, eagle removal, and management of human activities.
4. Refine parameter estimates for population viability analyses (PVA), and facilitate other cross-island comparisons.

This framework incorporates the general philosophy of the Recovery Coordination Group (RCG), which emphasizes close tracking of fox mortality rates to identify the presence and intensity of the fox's primary threats, namely eagle predation and disease, and to rapidly detect new threats. Precise temporal-scale knowledge of mortality is vital for triggering management actions to control these threats. Mortality rates, especially for adults, exert the greatest influence on the risk of extinction for island foxes in population viability analyses, and observed mortality rates can be used to accurately predict future risk. Population size estimates and general trends in abundance can help corroborate conclusions regarding population status made from mortality data. While other philosophical approaches emphasize precise estimates of population size and abundance trends, our reliance on mortality rates derives from the commitment to monitor mortality precisely and the relationship between mortality rates and population status.

## Tracking Recovery

Based on this general philosophy, management goals of island managers, and further input from population modelers and Technical Expertise Groups (TEG), the following monitoring parameters were targeted for the purpose of tracking and determining recovery:

- Annual mortality rates at high precision (with associated cause-specific mortality rates)─sufficient to detect an annual eagle-specific mortality rate of ≥2.5%, averaged over 3 years.
- Population trend (or lambda [λ]) at low to moderate precision, estimated from annual population estimates or from population models.
- Annual population size, with 80% confidence interval.

In anticipation of a recovery plan for the island fox, the RCG, land managers, and population modelers proposed recovery criteria, with the following related to monitoring:

1. An island fox population must have no more than 5% risk of quasi-extinction over a 50-year period. This risk level must be based on the following:
   - The risk of extinction must be calculated based on the lower 80% confidence interval for a 3-year average of population size estimates, and the upper 80% confidence interval for a 3-year average of mortality rate estimates.
   - This risk level must be sustained for at least 5 years.
   - Quasi-extinction is defined as a population size of ≤30 individuals.
2. An island fox population trend must be increasing so that the average population estimate in year 5 is greater than that of year 1.
3. A golden eagle management strategy, approved by the land manager(s) charged with the recovery of an island fox population, must include monitoring protocols able to detect an

annual island fox mortality rate caused by golden eagle predation of ≥2.5%, averaged over 3 years.

These components of the proposed recovery criteria, together with the RCG philosophy, influenced the targeted precision of monitoring protocols in this framework, i.e., high precision in mortality rates but greater flexibility in precision of population and trend estimates. This framework provides protocols that estimate true population size (N), with an estimate indicated by a "hat" ( $\hat{N}$ ).

### Guiding Management

Island managers identified the following additional parameters needed to guide management decisions:

- Overall and cause-specific mortality rates by age and sex, to examine all causes of mortality (all islands).
- Habitat-specific density (San Nicolas, Santa Rosa, Santa Cruz).
- Habitat-specific survival (Santa Cruz).
- Reproduction measured in terms of annual recruitment (San Miguel, Santa Rosa).
- Disease and health profiles, as sampled from all dead foxes and from a subset of the living population, based on sampling protocols determined by the Fox Health TEG (all islands).

## Population Sampling Considerations

Experts involved in developing a previous island fox monitoring framework for the U.S. Navy on San Clemente Island recommended trapping and radio telemetry as key components for islandwide fox monitoring to address mortality rates and causes. Trapping also provides the best means of estimating population sizes with known precision and confidence intervals. The use of GPS collars provides an additional means of monitoring habitat use and, possibly, mortality. To minimize stress to foxes, as well as labor and equipment costs, we recommend scenarios in which both these objectives may, for the most part, be met with one annual trapping effort, thereby making the best use of personnel resources and reducing disruption to foxes that might occur from multiple trapping efforts.

In determining specific trapping protocols, we considered a wide range of factors, including the ecology and behavior of the species, the logistical constraints on each island, and the selection of feasible monitoring methods that can provide the desired measurements in the most efficient and statistically robust manner. For island foxes, some key biological issues are their social structure (and existence of territories held by monogamous pairs), their ability to inhabit essentially every habitat type on the islands, and the timing of parturition. Access constraints on the islands, and concern for animal welfare, limit the choice and design of sampling protocols. Steep and rugged terrain, primitive road conditions or lack of roads, and large size of three of the islands make the use of large trapping grids infeasible, and ecologically sensitive areas seasonally restrict access to some areas for trapping.

The choice of trapping protocols involves tradeoffs between desired precision, feasibility and cost, and the extent of trapping; these, in turn, are influenced by the status of the population. For large populations with high survival, the risk of quasi-extinction is low; that is, these populations lie far from the 5% quasi-extinction isocline (Box ES-1). High precision in population estimates may be less important in such cases, compared to populations with smaller N and/or higher mortality, and managers may choose to reduce the extent of trapping and subsequently generate population estimates with lower precision (i.e., with CV >20%), thereby reducing costs, efforts, and potential risk and stress to foxes.

Our goal was to identify feasible trapping approaches for each island that would generate a statistically robust estimate with adequate precision and representation of island habitats. We provide recommended monitoring protocols that strive to estimate population size with a coefficient of variation (CV) of ≤20% when feasible. CV($\hat{N}$) is a measure of precision equal to the standard error of the estimate divided by the estimate itself. There is flexibility in the required precision of trend, and this level of precision will ultimately be decided by island managers, in their decision on trapping protocols. Although one standardized sampling approach across all islands would have been desirable, objectives and constraints differ somewhat across islands. Therefore, island-specific protocols must be tailored accordingly. The key parameters obtained from trapping should nevertheless be comparable among islands.

**Box ES-1. Example of risk isoclines, with the status of a hypothetical population plotted.**

The combination of a population's 3-year average size and mortality rate can be plotted to determine the population's status in relation to predetermined risk isoclines (shown here as 5, 10, and 30% risk isoclines). In this case, the population's status (shown as a point estimate along with 80% confidence intervals) is well below the isocline representing a 5% risk of quasi-extinction over 50 years, indicating a low level of risk.