STATE WILDLIFE GRANT PROJECT REPORT—INDIANA

Assisted Migration as a Conservation Tool in the Management of Spatially Isolated Populations: A Case Study in Allegheny Woodrats

Genetic information gathered from this juvenile Allegheny woodrat captured in Harrison County will help biologists determine the reproductive processes of the population.

CURRENT STATUS

Third year of a three-year project

FUNDING SOURCES AND PARTNERS

State Wildlife Grant Program (T7R13)
Purdue University

PROJECT PERSONNEL

Principal Investigator: Dr. Robert K. Swihart, Purdue University, Department of Forestry and Natural Resources, Professor and Head

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COLLABORATORS

Dr. Glenn E. Stauffer, Pennsylvania Cooperative Fish and Wildlife Research Unit, Pennsylvania State University,

Dr. Robert C. Lacy, Chicago Zoological Society, Senior Conservation Scientist

BACKGROUND AND OBJECTIVES

The Allegheny woodrat *(Neotoma magister)* is a small mammal found in rocky habitats in Eastern deciduous forests. In Indiana, woodrats are restricted to the cliffs overlooking the Ohio River. These unique rocky habitats often are patchily distributed throughout the species' range and along this river corridor. This condition creates a context in which small populations of woodrats are connected to one another through rare dispersal events (i.e., movement of individuals among populations).

As a small-bodied mammal, this species has limited dispersal capacity. Therefore, the few individuals that leave the population in which they were born tend to settle in adjacent populations. Very few settle more than 2 miles away; however, this limited exchange of individuals among populations is critical for them to maintain genetic diversity.

During the past 40 years, Allegheny woodrats have declined rapidly both within Indiana and throughout much of their range. The reasons include:

1) increased mortality associated with raccoon roundworm, a common parasite carried by raccoons;

2) reduced food availability due to the extinction of the American chestnut and declining oak abundance;

3) and, most importantly in Indiana, habitat loss and fragmentation resulting in genetic decline as populations have become increasingly isolated from one another.

Due to factors such as road and bridge construction, quarry development, or habitat degradation, many of Indiana's remnant woodrat populations are now separated by distances greater than 2 miles. Without woodrats moving among populations, genetic diversity inevitably is lost through genetic drift. The rate at which genetic diversity is lost depends upon population size (larger populations have greater potential to maintain genetic diversity) and relative reproductive success of individuals (the more evenly individuals contribute to the next generation, the better genetic diversity is preserved).

Through a collaborative effort between the Indiana Department of Natural Resources (DNR) and Purdue University, we have been working throughout the past 10 years to address these factors. Through intensive management, we reduced the prevalence of raccoon roundworm infection among raccoons that occupied woodrat habitats, thereby reducing the risk of disease exposure for woodrats. We also have restored genetic diversity to healthy levels for these isolated woodrat populations through a series of translocations (i.e., the deliberate movement of a species such as a reintroduction into vacant habitat or supplementation of small populations) from robust wild populations in Kentucky and from woodrats born in captivity.

In response, Indiana's critically endangered woodrat populations have nearly tripled, but challenges remain for these populations. Despite genetic diversity having been restored among isolated and inbred populations, the extensive habitat fragmentation that ultimately caused these problems remains unchanged. Distances between many of Indiana's woodrat populations exceed their dispersal capacity. Therefore, genetic diversity will continue to be lost due to genetic drift, and inbreeding will once again threaten these populations. To maintain the progress made, we need to devise an optimal strategy to reconnect these populations through translocations to preserve healthy levels of genetic diversity.

METHODS

To develop an optimal strategy to maintain genetic diversity, we must first understand the rates in which genetic diversity is lost through genetic drift. Therefore, we are conducting analyses to describe woodrat survival rates (demographic processes) and assess the variation among woodrats in the number of offspring produced (reproductive processes). Together, demographic and reproductive processes drive the rate in which genetic diversity is lost. To characterize woodrat demographic processes, we have built statistical models to describe variation in woodrat survival as a function of age, sex, genetic diversity, year and site (population). These analyses will allow us to identify the demographic factors most critical in limiting the recovery of woodrat populations.

Our next step is to characterize variation in reproductive processes. To do this we will use genotypes (an individual's unique genetic makeup at a number of different "genes") to identify the mother and father for every juvenile woodrat captured from 2005 through 2013. We will then evaluate the relationship between the number of offspring produced and the five factors mentioned previously.

We are working to integrate our understanding of woodrat demographics and reproduction to identify optimal patterns and schedules for translocating woodrats among populations over successive generations. The goal is maximizing the retention of genetic diversity. Further, we will construct this model to have broad applicability. By changing some key species-specific parameters, the model could be applied to other endangered species for which habitat fragmentation threatens natural movement of individuals among populations.

PROGRESS TO DATE

Completion of this project depends upon integrating three independent aspects:

1) a demographic model to describe woodrat survival rates,

2) a reproduction model to describe variation in reproductive success, and

3) a computer simulation program to estimate the rate in which genetic diversity will be lost from populations and the level of translocations needed to offset these losses.

As a necessary first step before we can begin building demographic and reproduction models, we generated complete genotypes at 11 microsatellite markers (these could be thought of as nonfunctional or noncoding genes within an individuals genome) for 453 woodrats captured within Indiana from 2010 to 2013 to supplement our genetic database of 389 individuals captured between 2005 and 2009.

In collaboration with Dr. Glenn E. Stauffer, we developed models that describe annual woodrat survival rates relative to age, sex, genetic diversity, year and site (population). Specifically, we developed mark-recapture models (developed within both a Bayesian and Maximum Likelihood framework) to evaluate the influence of sex on the probability of capture and the influence of sex, population, year, local population size (abundance), weight and individual genetic diversity (heterozygosity) on annual survival rates.

We found that the probability of capture was high but varied substantially between males (about 76%) and females (about 95%). Survival varied by age, with low annual survival for juveniles, highest annual survival for 1-year-olds, and decreasing survival among aged woodrats (i.e., those more than 2 years old). Heavier juveniles were more likely to survive to sexual maturity (adulthood).

We have begun using parentage analysis to describe patterns of reproductive success among woodrats. One challenge we have encountered is that a number of our presumed juvenile woodrats cannot be assigned to a mother and/or father captured in the populations. There are two hypotheses why.

1) We are capturing a lower proportion of the population than estimated in our previous analysis.

2) We have assumed that woodrats first captured in a given year (e.g., 2013) represent young-of-the-year (juveniles), and that we should be looking at all of the adults captured in 2013 and 2012 as possible parents. However, it may be that some of these individuals first captured in 2013, were in fact born in 2012, and we should be including them as possible parents as opposed to juveniles. We are currently analyzing patterns in the change in weight of individuals captured across multiple years to develop probabilistic criteria for whether these newly captured individuals are more likely to be adults that were not captured in the previous year's trapping effort or juveniles that were born early in the season and have achieved adult sizes in their first six months of life.

Computer simulation models are a deliberate simplification of the natural world—in this case, woodrat population processes. Such models allow us to ask questions about processes that would be difficult to examine in nature. We have identified the program VORTEX as software that will allow us to construct simulation models of genetic drift and the genetic response of populations to translocation. VORTEX is commonly used by scientists who are working on species conservation and recovery and has a large, collaborative and supportive user group. Working within VORTEX required an expansion of the functionality offered by the program for complete realization of the project objectives. Accordingly, we collaborated with Dr. Robert C. Lacy, the developer of VORTEX, to expand the functionality of VORTEX to meet the needs of this simulation analysis. We will proceed to build a spatially and genetically explicit metapopulation viability model as soon as the description of reproductive success is completed.

COST: $189,305 FOR THE COMPLETE THREE-YEAR PROJECT