Small population consequences of white-nose syndrome: a sensitivity analysis

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Introduction

White-nosed syndrome causes severe declines in the abundance of eastern species of hibernating bats

Currently the dynamics of small bat populations is unknown

Small populations are generally at higher risk of extinction due to environmental stochasticity alone

Additional detrimental effects of small population sizes may include reduced thermoregulatory ability leading to reduced winter survival rates

Understanding post WNS population dynamics is critical for determining the potential for WNS to cause extinction

Objectives

Quantify the impacts of environmental stochasticity on extinction risk of small populations

Estimate the impacts of reduced adult winter survival at small population levels on extinction risk

Methods

We employed a stage-based matrix model developed by Thogmartin et al (submitted) for Indiana bats

Model description

Historical hibernacula data for Indiana bats are used for default population starting values and hibernacula limits

Values can be adjusted to starting population sizes

By default 2 scenarios are run

1) without WNS

2)with WNS: infection proabilities can be adjusted

Post WNS effects on vital rates

Survival and reprodutive parameters for each year post WNS can be adjusted to reflect amelioration of effects over a time or a continuing effect of WNS

Effects of small population sizes on vital rates

Currently internal code changes are necessary to run scenarios with "threshold" population values below which vital rates are changed

Environmental Stochasticity values

Values can be adjusted in R GUI

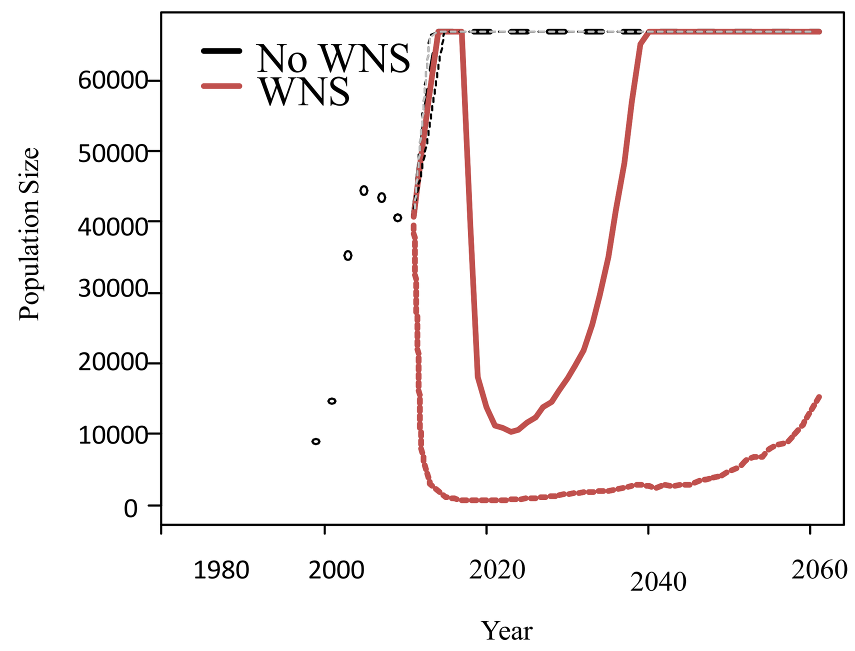
Additional Take

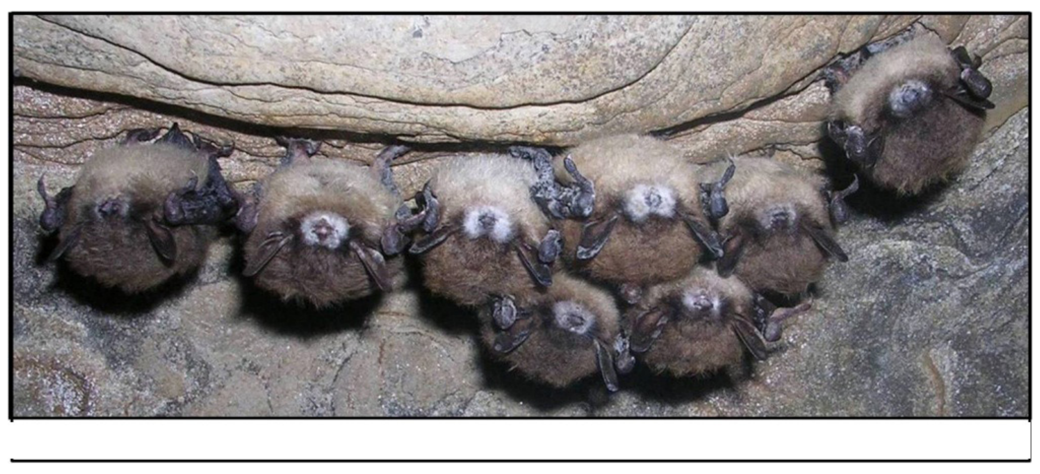
Take can be included for different seasons to reflect other sources of stress on populations

Model Output

Population size over time with measures of uncertainty

Example output





Scenarios

Environmental Stochasticity (ES)

We ran simulations with ES rates from 4% to 8% and 12%

We adjusted starting population size at each ES value to 500 and 1000

Adult Winter Survival (AWS)

We ran simulations with AWS reduced for populations below 250 to 0.95, 0.85, 0.75, and 0.65 or pre-WNS levels

We adjusted starting populations sizes at each AWS value to 500 and 1000

Results

Environmental Stochasticity

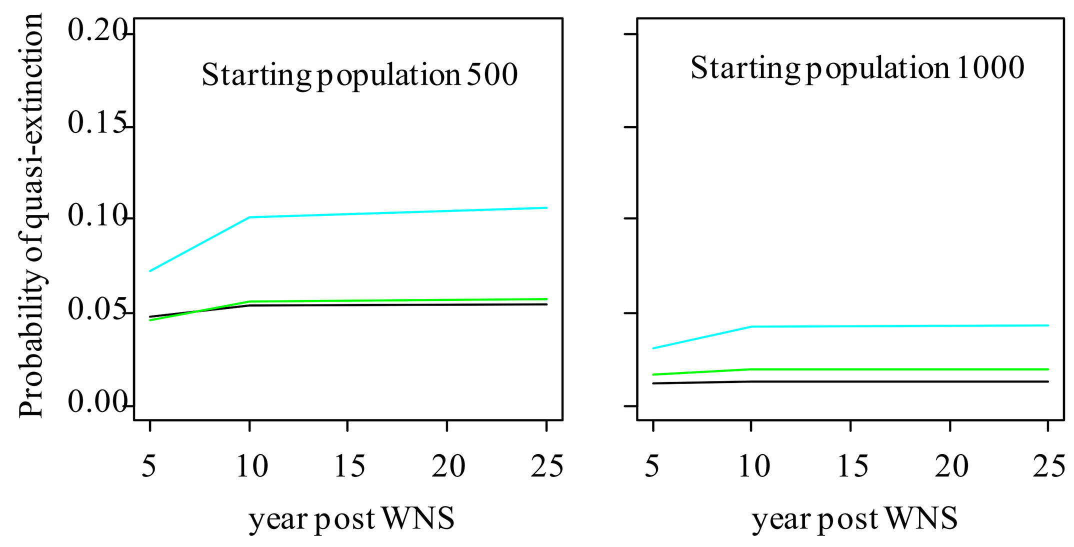


Figure 1. Probability of quasi-extinction (where QE=25) for simulated bat populations at environmental stochasticity rates of 4% (black line), 8% (green line), and 12% (blue line)

At the default starting population of 40,700 bats, the probability of quasi-extinction (where QE<=25 bats) was <1% for all values of ES (4%, 6%, and 12%)

At a starting population of 1000 the probability of quasi-extinction was <5% at year 25 for all values of ES.

At a starting population of 500, the probability of quasi-extinction reached a maximum of 11% for ES values of 12%.

Results (cont'd)

Adult Winter Survival

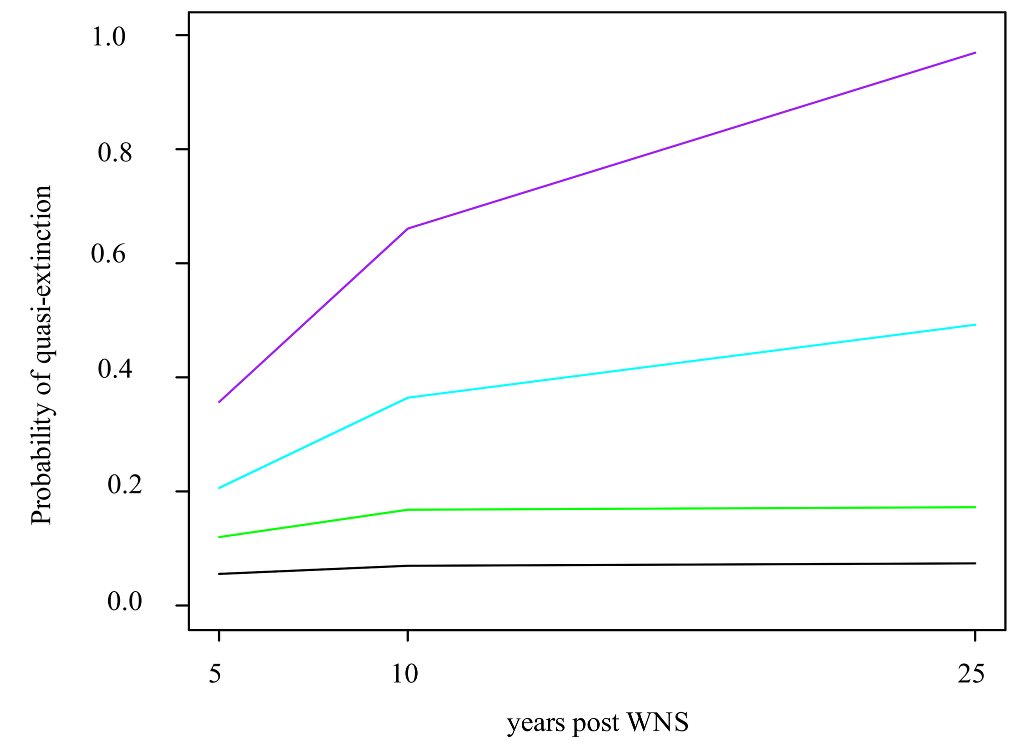


Figure 2. Quasi-extinction risk for starting populations of 500 bats where adult winter survival was decreased to 0.95 (black line), 0.85 (green line), 0.75 (blue line), and 0.65 (purple line) of pre-WNS levels

For default starting populations, QE risk was <1% for all scenarios.

For small starting populations of 500, QE risk reached threshold values at approximately 10 years post-WNS of approximately 8% and 18% for the 95% and 85% scenarios respectively.

For 75% and 65% scenarios QE risk continued to increase >25 years

Conclusions

Environmental stochasticity alone can increase the risk of extinction for small populations

The ability of post-WNS bat populations to recover to pre-WNS population levels may be largely dependent on the dynamics of small bat populations

Currently there is much uncertainty associated with the population-level consequences of WNS for bats

Future Directions

Develop a population-level model to estimate the range-wide extinction risk for myotis species

Incorporate movements between hibernacula

Solicit expert opinion on western myotis populations and the potential spread of WNS to properly parameterize population models for western myotis

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