Public Abstract

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Title:Multi-scale factors related to abundance of bats and insect prey in savannas, woodlands, and forests in the Ozark Highlands, USA

Restoration of savanna and woodland ecosystems are high priorities for state and federal agencies in the Midwest and prescribed fire and mechanical tree thinning are the main tools used to restore these communities. Information on how bat species and their insect prey respond to restoration is needed to guide management decisions for species of conservation concern. There is a heightened urgency to collect demographic data during the summer maternity season due to white-nose syndrome (WNS) and other threats to bat populations. Our objectives were to: 1) evaluate the performance of the n-mixture model for repeated count data and the general multinomial-Poisson model for removal sampling (n-mixture model and removal model, respectively) for estimating bat abundance from simulated mist-net capture data, 2) determine the relationships between prescribed fire, vegetation structure, and site characteristics on insect abundance, and 3) determine the effect of restoration, vegetation structure, and landscape factors on bat species abundances across a gradient of savannas, woodlands, and non-managed forest in the Ozark Highlands of Missouri.

We fit the n-mixture and removal models in the UNMARKED package in R, and simulated datasets that examined how both models would perform based on potential study design constraints, various probabilities of detection, and population sizes. We simulated 4 scenarios each based on 85 iterations on 1000 randomly generated datasets. We calculated relative bias (RB), mean absolute error (MAE), and mean absolute percent error (MA%E) from model predictions to evaluate model performance. Relative bias, MAE, and MA%E decreased as detection probability and bat abundance increased. Model fit was acceptably low when bat abundance was >70, and detection probability was > 0.5 for n-mixture models. The removal model outperformed the n-mixture model in all scenarios except when detection probability was 0.05. The removal model correctly estimated bat abundance for 50% of simulated scenarios versus the n-mixture model's 3 out of 43. Utilization of the removal model using data from repeated mist-net surveys may allow resource managers and conservationists to better quantify how resource management and landscape composition affect bat species abundance and overall populations. We provide managers with evidence of the utility of the removal model to estimate bat abundances from repeated mist-net survey data while incorporating meaningful habitat, management, and landscape covariates. Furthermore, documenting changes in populations sizes during the summer maternity season will enable improved conservation practices for species management.

We sampled insects at 8 plots in 2014, and 4 plots in 2015 and 2016 within 250 m of each mist-net sites. We fit generalized linear mixed effects models to evaluate a priori hypotheses on the effects of savanna woodland restoration on insect abundances. Prescribed fire did affect insect abundances at plots surrounding each mist-net site. Insect plots burned 2 or 3 times within the last ten years had higher insect abundances for some insect response groups compared to non-managed plot. Year since a plot burned also affected insect abundances, with sites burned more recently within 3 years had lower insect abundances for some insect response groups and in others – we found no relationship. We only evaluated insect Orders and did not examine specific families or species richness to understand how management affects diversity of insects.
Temperature was the best predictor of insect abundances at plots for most response variables, and we

found support for site aspect, and tree density by size classes. Managers should be mindful that different insect groups had different responses to prescribed fire, therefore a diversity of practices in the landscape will provide for more diverse insect prey Overall, restoration practices did not have a lasting negative effect on insect abundances, and some positive effects.

We conducted mist-net surveys at 89 sites across the Ozark region of Missouri from 2014-2016, and collected demographic data on 4 bat species captured: northern long-eared bat (Myotis septentrionalis), tri-colored bat (Perimyotis subflavus), evening bat (Nycticeius humeralis), and eastern red bat (Lasiurus borealis). We fit the removal model to evaluate multi-scale a priori hypotheses on the effects of restoration, landscape factors, and prey availability at sites that potentially affect either the detection or abundance of bats at sites. Top models for all four bat species highlighted the importance of evaluating multiple spatial scales in ecological studies. Overall, we found no evidence that restoration negatively affected any of the bat species investigated; although, northern long-eared bats abundance presented stronger positive relationship to percent forest and increased tree densities than to percent savanna-woodlands within 1km. Our study was the first to predict abundances from repeated count data from mist-net surveys during the summer maternity season and accounting for varying detection probabilities. We did not find support for relationships between potential insect prey and bat abundances. Eastern red bats, tricolored, and evening bat abundances were positively related to prescribed fire and negatively to tree densities or percent canopy and therefore should respond positively to savanna and woodland restoration. Northern long-eared bat had higher abundances at sites with higher tree densities of pole and saw timber and eastern red bat and northern long-eared bat abundances was positively related to sites with higher percentage of forest and savanna-woodland habitat within 1 km of mist-net sites. Evening bat abundances was the greatest at sites that had higher fire frequencies within 1 km of a mist-net site. We suggest managers consider the tradeoffs among species in these abundance relationships when planning management and that restoration of savanna and woodlands, when part of a larger management goal to create heterogeneity of forest types, will likely promote higher abundances of all four bat species.