Trait-Based Screening of Extinction Risk in Texas Bat Species

Overview
This project investigates whether simple ecological traits can be used to screen native Texas bat species for an elevated extinction risk. Rather than attempting a precise prediction, the goal of this project is to evaluate whether trait-based analytical models can provide useful relative risk rankings that may help support conservation prioritization when data is limited.

Motivation
Bats play a critical role in Texas ecosystems. They provide crucial insect control, pollination, and nutrient cycle that is critical for the environment. However, due to habitat loss, disease, and human activity, many species are facing increased threats. Because conservation resources are finite, the early detection of potentially vulnerable species is essential. This project explores a data driven approach to early risk screening.

Data
This project focuses specifically on 15 bat species found to be native to Texas.

Sources:
- IUCN Red List: extinction risk classification and population trends
- EltonTraits: species level ecological traits

Response Variable:
- High_risk (binary): species are classified as either ‘Vulnerable’ or ‘Endangered’ versus others

Predictors:
- Bode mass (grams)
- Diet breadth (as a proxy for ecological specialization)

Missing trait values for this project were imputed using median imputation after restricting the dataset to focal species to avoid bias.

Methods
A logistical regression model was used to relate extinction risk to ecological traits. After an initial regression was run, the model complexity was intentionally limited due to small sample size to ensure stability. Model performance was then evaluated using leave-one-out cross-validation. Two classification thresholds were examined:

- 0.5 (for a conservative classification)
- 0.25 (for a precautionary classification)

This threshold comparison analysis highlights the tradeoffs between sensitivity and specificity relevant to conservation screening.

Results

The model in this project exhibited moderate ability to rank species by relative extinction risk.

- Diet breadth showed a positive association with extinction risk
- Body mass showed a weak negative correlation
- At a threshold of 0.5, the model achieved high specificity but zero sensitivity
- At a threshold of 0.25, the model's sensitivity improved while maintaining an acceptable level of specificity

Cross-validation predicted probabilities revealed that some species that are not currently classified as high risk exhibit traits that may be associated with elevated modeled vulnerability. Figure 1 shows LOOV predicted extinction risk probabilities for each species, ranked from lowest to highest risk.

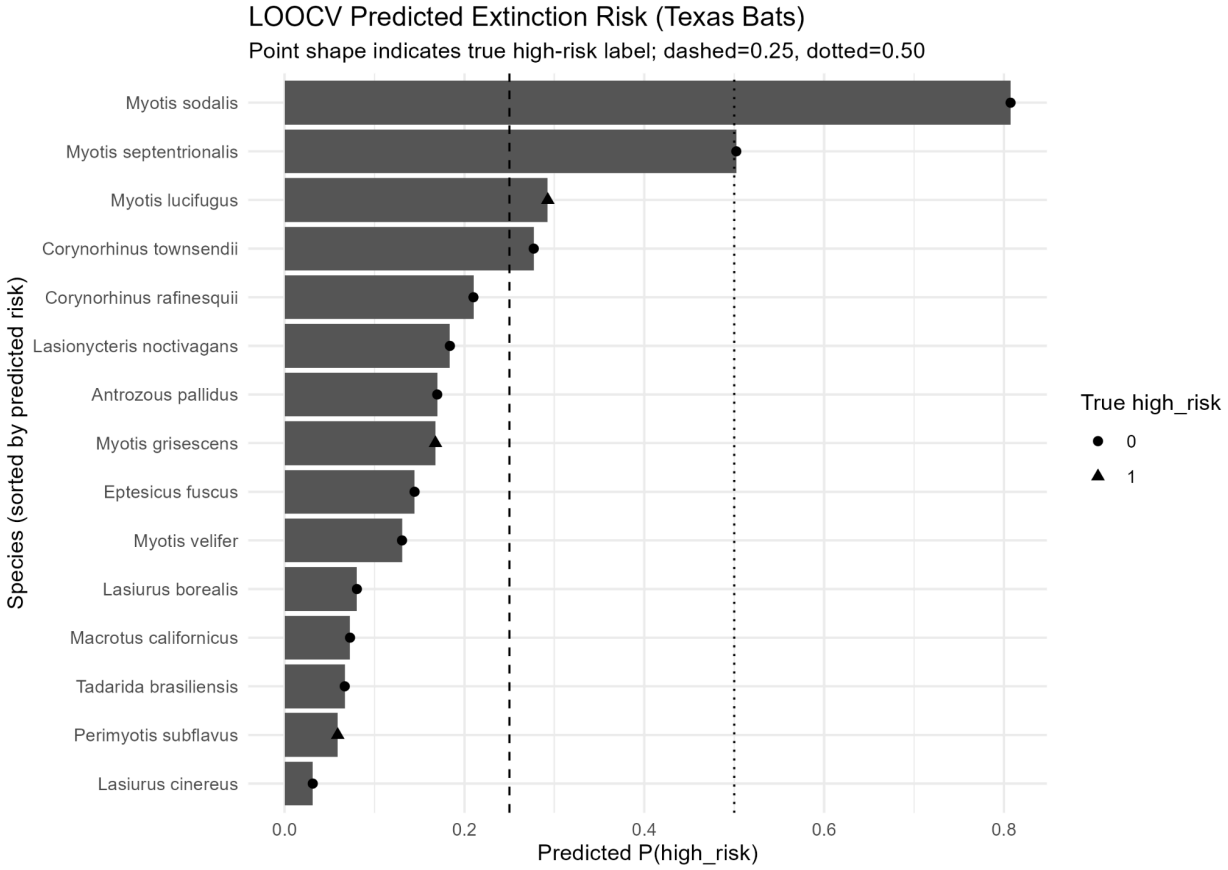

Figure 1. Leave-one-out cross-validation predicted extinction risk for 15 Texas bat species. Bars represent predicted probabilities from a simplified logistic regression model using body mass and diet breadth as predictors. Point shape indicates the true IUCN high-risk classification. Dashed lines denote classification thresholds of 0.25 and 0.5.

Interpretation

The results suggest that trait-based models may be moderately useful as a screening tool for conservation efforts, capable of identifying species that merit closer monitoring rather than making definitive conservation determinations. This aligns with the intended role of such models in data limited ecological contexts.

Limitations

There are several recognizable limitations of this project, including:

- Small sample size, which limits statistical inference and model complexity
- Trait data is coarse and does not capture regional or temporal variation
- The model is not intended to infer causality or replace formal conservation assessments

Conclusion

This project demonstrates an end-to-end analytical workflow using real world ecological data, and emphasizes responsible modeling, appropriate validation, and clear communication of limitations. Trait-based screening approaches, when applied with caution, may be useful in providing valuable complementary insight for conservation prioritization efforts.