Predicting potential wind-energy development conflicts with the eastern red bat (*Lasiurus borealis*) in Indiana.

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Identifying potentially suitable habitat for *L. borealis*

- Modeling distribution species important for management
- Output predictions and maps invaluable in developing conservation plans (Phillips et al. 2004)
- Eastern red bat (*Lasiurus borealis*) affected by
  - Wind turbines
  - Forest management
- Studies focus on local areas – *L. borealis* requires mature hardwood forests (Hutchinson and Lacki 2000) and streams (Elmore et al. 2005) – unclear association with development.

Methods

- Mobile acoustic surveys
  - 28 surveys using Anabat SD2 May to August of 2012 at 13 Indiana state forests
  - Routes approximately 25 miles in and around the forests.
- Bat call identification
  - Echoclass (v2.0, U.S. Army Engineer Research and Development Center): species set 1
- MaxEnt inputs
  - Presence localities (GPS locations)
  - Background data (biased to roads)
  - 20 variables - MaxEnt logistic output: stream length, proportion of streams in hardwoods, proportion of hardwood forest, length of forest edge, and proportion of developed areas. Each of these was considered at scales of 500m, 1km, 3km, and 5km.

Results

- 290 *L. borealis* for presence points
- Mean AUC: 0.634

Identifying potential wind energy development sites

- Goal is to estimate the potential for wind energy development across Indiana
- Wind turbines pose direct and indirect threats to *L. borealis*
  - *L. borealis* makes up 22% (~215,000) of total bat fatalities between 2000 and 2011 (Arnett and Baerwald)
- Modeling tools can be useful when mortality data is not available in certain areas (Roscioni et al. 2013)
- Specific variables are used to determine the suitability of a site for wind energy development (AWS Truepower)
  - Optimal winds speeds at heights >80m
  - High elevations
  - Minimize distance to existing transmission lines
  - Terrain that permits wind funneling

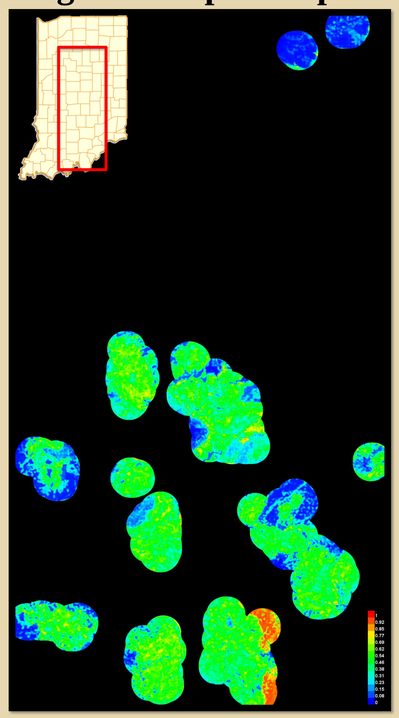
Methods

- MaxEnt inputs
  - Presence localities of present and proposed wind turbines obtained from Federal Aviation Administration (FAA) website
  - Turbines in Indiana determined to be "No Hazard"
  - Background data (biased to counties where turbines occur)
  - 5 variables (presently) – MaxEnt logistic output: wind power (watts/m^2) at 80m and 100m, wind speed at 80m and 100m, and land cover type

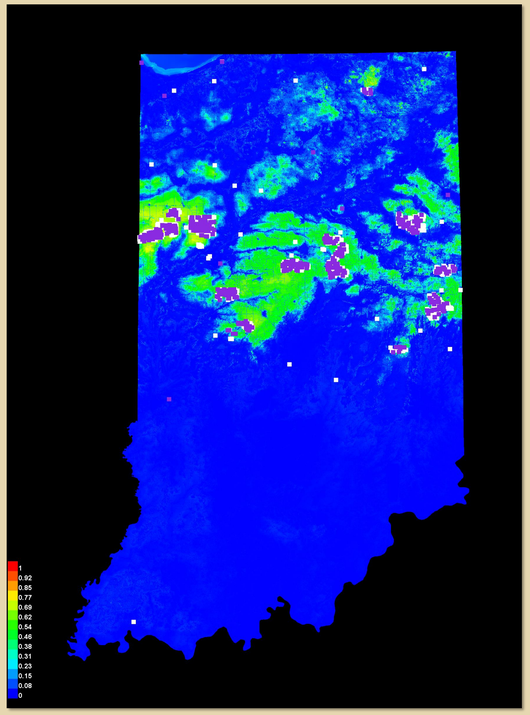
Results

- 1253 presence points for training, 417 for testing
- Mean AUC: 0.858

Logistic Output Maps



Output of model estimating potentially suitable areas for *L. borealis* around Indiana state forests. Warmer colors indicate better conditions.



Output of model estimating the potential for wind energy development in Indiana. Warmer colors indicate better conditions for wind development. White and violet dots indicate turbines.

Importance of variables for *L. borealis* model

Variable	Percent Contribution	Affect on Prediction
Proportion of hardwood at 500m	31.5	Positive, plateaus at 20% hardwoods
Proportion of hardwood at 5km	16.9	Positive, but peaks at 85% hardwoods
Proportion of area with forest edge at 5km	10.7	Positive, but peaks at 15% edge

Importance of variables for wind turbine model

Variable	Percent Contribution	Affect on Prediction
Wind power at 50m	67.9	Peaks at 300watts/m^2
Land Cover Type	11.9	Hay/pasture
Wind power at 100m	10.1	Peaks at 450watts/m^2

Future direction and questions

- Include more variables for estimating potential sites for wind turbines
  - Elevation, population, presence of water, etc.
- Should we include additional environmental variables for the *L. borealis* model?
- Identify overlapping areas between suitable *L. borealis* habitat and wind energy facilities
  - How can we compare the two maps?
  - How can we improve the output?
  - Do any of these areas pose a potential threat to the suitability of *L. borealis* habitat?
  - Are there environmental variables that wind farm developers prefer that *L. borealis* also uses to select habitat?

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