How Remotely Sensed Data Can be Used to Study the Effects of Environmental Gradients on Organisms: A Case Study

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Introduction

Among the many factors that affect species distribution, one of the most evident is the nexus of physiology with the environment. This relationship between biotic and abiotic factors can be an aid to better estimate species abundance since perfect detection is rarely possible. Woodland Salamanders are a good example.

Because they are lungless, and thus respire through their skin, they are dependent on moist environs to maintain hydration and are often hidden in underground refugia. This makes them hard to find but also provides clues as to their likely location if we can understand how they are distributed across abiotic gradients that facilitate moisture balance. Indicators of surface moisture were a primary focus of this study.

A study was undertaken during the spring and fall (periods of high surface activity) of 2016 to determine how occupancy and abundance of terrestrial salamanders changed across spatial gradients. Gathering detailed, in situ, biotic and abiotic measurements was necessarily time consuming, but provides an opportunity to investigate which, if any, of these can be taken or derived from Digital Elevation Models or Remotely Sensed data such as spectral imagery.

We replaced in situ abiotic measurements with those derivable from geographic data and compared the resulting models with the original models to determine what measurements might be derived from the many available sources of high resolution GIS data and therefore be incorporated in future studies to save resources.

Site Location

Lilley Cornett Woods is a mixed mesophytic old-growth forest that encompasses 554 acres, located in Letcher County in southeastern Kentucky. The area of this study was in a portion of the forest designated as old-growth, which has remained untouched for 150 years.

Photo Credit, Alex Baecher.

Methods

Forty-one plots were chosen in 2016 to reflect a variety of abiotic factors. In situ measurements were taken of temperature, soil moisture, canopy cover, ground cover, aspect, and salamanders present, among others. These were incorporated into models of occupancy and abundance.

A Digital Elevation Model (DEM) of 1.11 meter spatial resolution was used to derive Topographic Position Index (TPI), a measurement of slope position, and Topographic Wetness Index (TWI), a steady state wetness index, Direct Solar Radiation, and distance from stream. Ten, and 20 meter DEM's were aggregated from the 1.11 meter DEM and used to compare the effects of resolution on Topographic Position Index, and Topographic Wetness Index. The effect of neighborhood size on TPI, and algorithm on TWI, were also investigated.

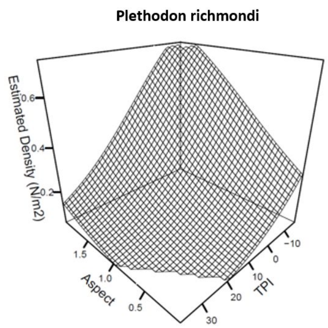
Normalized Difference Vegetation Index (NDVI), a measure of vegetation derived from NAIP imagery was compared with in situ measurements of canopy cover to evaluate its effectiveness as a proxy at the spatial extent encompassed by the 2016 study.

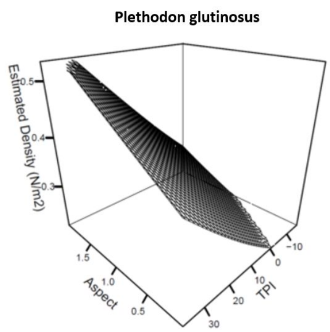
Beer's aspect transformation was used to measure northeastness versus southeastness since it was hypothesized that moisture loving salamanders would be more prevalent on northeastern facing slopes.

Occupancy and Abundance models were fit using these data combined with the original salamander counts from the 2016 study. N-mixture models were used to estimate abundance given imperfect detection. Models were then ranked using AICc, and model averaging was used to make predictions across all models.

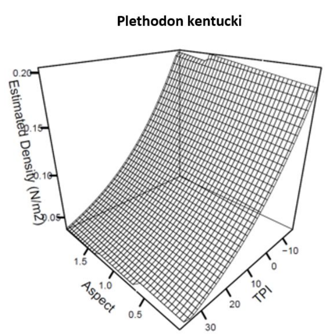
Results

TPI and aspect were the two most important variables in the abundance model for all three species of Woodland Salamanders considered, although each species responded differently. NDVI and

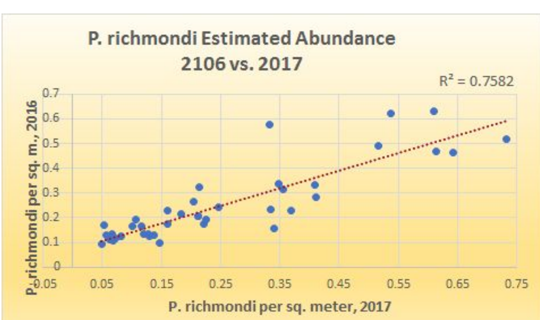




Direct Solar Radiation, while not the most prominent covariates, were still noteworthy for P. richmondi and P. glutinosus, respectively. When we compared



estimated abundance from the 2016 study with our estimated abundance, only P. richmondi was strongly correlated.



Conclusions

We found TPI to be the most useful index for predicting salamander abundance. TWI was of less utility than we first assumed it would be as an indicator of soil moisture, however there is reason to investigate modifications to it. We believe NDVI is a useful indicator of canopy cover but that the homogeneity of forest cover in our study area obscured it's usefulness. Other measures of moisture, such as Normalized Difference Wetness Index, a relative measure of water content in leaves are worthy of study as well.

Further research is warranted over a wider extent of Lilley Cornett Woods, enabling comparisons between the old growth portion with secondary growth, as well as surrounding areas. If salamander population data can be collected in these areas, it is thought that GIS proxy data would be a more powerful tool for demonstrating salamander distribution over environmental gradients.

References

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