The Ecological Niche and Ecological Niche Modeling

Tereza Jezkova
School of Life Sciences, University of Nevada, Las Vegas

Modified, T Kittel
March 2012
What drives species distributions?

• All species have tolerance limits for environmental factors beyond which individuals cannot survive, grow, or reproduce.
Tolerance limits exist for all important environmental factors.
Critical factors and Tolerance Limits

Terrestrial Ecosystems

- Sunlight
- Temperature
- Precipitation
- Wind
- Latitude
  (distance from equator)
- Altitude
  (distance above sea level)
- Fire frequency
- Soil

Aquatic Life Zones

- Light penetration
- Water currents
- Dissolved nutrient concentrations
  (especially N and P)
- Suspended solids
Critical factors and Tolerance Limits

• For some species, one factor may be most important in regulating a species’ distribution and abundance.

• Usually, many factors interact to limit species distribution.
• Organism may have a wide range of tolerance to some factors and a narrow range to other factors.
FUNDAMENTAL NICHE

Historical factors

Biotic factors

REALIZED NICHE

Realized environment
Fundamental versus realized niche

**Fundamental (theoretical) niche**
- is the full spectrum of environmental factors that can be potentially utilized by an organism

**Realized (actual) niche**
- represent a subset of a fundamental niche that the organism can actually utilize restricted by:
  - historical factors (dispersal limitations)
  - biotic factors (competitors, predators)
  - realized environment (existent conditions)
Tolerance Limits and Optimum Range

Niche shift

Are niches stable?  NO!

Realized niche shifts all the time due to
• changing biotic interactions,
• realized environment,
• time to disperse
• **Fundamental niche shift** when tolerance limits change → due to **EVOLUTIONARY ADAPTATION**
Resource Partitioning

- **Law of Competitive Exclusion** - No two species will occupy the same niche and compete for exactly the same resources
  - Extinction of one of them
  - Niche Partitioning (spatial, temporal)
Niche partitioning and Law of Competitive Exclusion

Chthamalus

Balanus

Chthamalus

Balanus

Chthamalus

Balanus

Chthamalus

Balanus
Niche partitioning and Law of Competitive Exclusion
Ecological niche modeling

Purpose:

- Approximation of a Species Distribution
Ecological niche modeling

Purpose:

- Potential Niche Habitat Modeling
  (Invasive species, diseases)
Ecological niche modeling

Purpose:

- Site Selection or conservation priority: Suitability Analysis
Ecological niche modeling

Purpose:

- Species Diversity Analysis
Ecological niche modeling

Two types:

1. **DEDUCTIVE**: A priori knowledge about the organism
   Example: SWReGAP [http://fws-nmefwrn.nmsu.edu/swregap/habitatreview/](http://fws-nmefwrn.nmsu.edu/swregap/habitatreview/)
Ecological niche modeling

Two types:
2. CORRELATIVE: Self-learning algorithms based on known occurrence records and a set of environmental variables
Occurrence records:

- Own surveys (small scale)
- Digital Databases (e.g. museum specimens)

MANIS (mammals)  http://manisnet.org/
ORNIS (birds)      http://olla.berkeley.edu/ornisnet/
HERPNET (reptiles) http://www.herpnet.org/

HAVE TO BE GEOREFERENCED (must have coordinates)
WORLDCLIM  http://worldclim.org/

Variables:
• Temperature (monthly)
• Precipitation (monthly)
• 19 Bioclimatic variables
• Current, Future, Past

Resolution:
• ca. 1, 5, 10 km

Coverage
• World
Southwest Regional Gap Analysis Project [http://earth.gis.usu.edu/swgap](http://earth.gis.usu.edu/swgap)

Variables:
• Landcover

Resolution:
• ca. 30 m

Coverage
• western states
Natural Resources Conservation Service (NRCS)

Variables:
- Soils

Resolution:
- ca. 30 m

Coverage
- USA but incomplete
Ecological niche modeling

Step 1: occurrence records
Step 2: environmental variables
Step 3: current ecological niche
Step 4: projected ecological niche
Ecological niche modeling – models from Maxent
Problems: Models are only as good as the data that goes into it!!!

Calibration of Models
• Insufficient or biased occurrence records
• Insufficient or meaningless environmental variables

Projection-Source Model
• Inaccuracies in climate reconstructions
• Dispersal limitations
• Non-analogous climates
• Niche shift (evolution)

!!! WRONG INTERPRETATIONS !!!
Predicting the distribution of Sasquatch in western North America: anything goes with ecological niche modelling

J. D. Louie, P. Aniceto and M. J. Hickman

ABSTRACT

The availability of user-friendly software and publicly available biodiversity databases has led to a rapid increase in the use of ecological niche modelling to predict species distributions. A potential source of error in publicly available data that may affect the accuracy of ecological niche models (ENMs), and one that is difficult to correct for, is incorrect (or incomplete) taxonomy. Here we remind researchers of the need for careful evaluation of database records prior to use in modelling, especially when the presence of cryptic species is suspected or many records are based on indistinct evidence. To draw attention to this potential problem, we construct ENMs for the North American Sasquatch (i.e. Bigfoot). Specifically, we use a large database of georeferenced putative sightings and footprints for Sasquatch in western North America, demonstrating how combining environmentally predicted distributions of a taxon's potential range can be generated from questionable site-occurrence data. We compare the distribution of Bigfoot with an ENM for the Black bear, Ursus americanus, and suggest that many sightings of this cryptid may be cases of misidentification.

Keywords

Bigfoot, biodiversity informatics, climatic change, ecological niche models, North American Sasquatch, species distributions, Ursus americanus.