Workshop: **Synoptic Modeling of Animal Location Data Combining Animal Movements, Home Range and Resource Selection** IWMC Durban, South Africa, 7/9/12

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A Systematic Process for Analyzing Location Data using Synoptic Models

1. State research question clearly with details of why location data are required to answer it. Specifically: what type of data is necessary (scale/order) and how will it be used to answer key question(s)?
2. Define animal population of interest and sampling approach providing inference to it. Ideally draw samples randomly but more typically we use stratified random samples of animals (see below).
3. Identify potentially important strata:
   - Age-sex-behavior classes of animals (e.g. Male, Female, Breeding, Migrating, Resident)
   - Temporal seasons:
     - Breeding
     - Summer
     - Fall
     - Migration to winter or seasonal ranges
     - Winter
4. Select type of spatial analysis:
   - Model space use with a **synoptic model** combining home range with resource (habitat) selection
   - Model movements with a **synoptic model** combining a movement model with resource (habitat) selection
   - 3-d spatial synoptic models for birds (with height in canopy) or fish (depth) are perfectly feasible
   - Choose to leave this approach:
     - Delineate sharp boundary (Minimum Convex Polygon or Convex Hulls, Getz et al. 2007)
     - Apply a spatial density estimator (kernels)
     - Polygon or non-parametric density approaches invalidate further synoptic spatial modeling
5. List interesting ideas (hypotheses) about ecological factors, processes or drivers determining patterns of space use: e.g.,
   - Probability of encountering potential mates
   - Need to provision a nest or den
   - Movements to water or salt licks
   - Food resources or cover requirements
   - Energetic demands of movement
   - Density of intraspecific or interspecific competitors
   - Probability of encountering or escaping predators/hunters/poachers
6. Select a null model for space use:
   - Need to provision a nest or den (bivariate normal)
   - Need to defend a territory against conspecifics (exponential power)
7. State the ideas (hypotheses) in form of multiple parametric (synoptic) models where parameters express effects of key ecological factors or processes, are feasible to estimate with maximum likelihood methods and these competing models can be compared using information theoretic methods.
8. Assemble potentially predictive covariate maps.
9. Fit multiple competing synoptic models for each stratum.
10. Re-evaluate original strata by evaluating /testing differences and collapsing strata where feasible.
11. Refit models, if necessary, with collapsed strata and select the best model(s).
12. Write it up, present it, use it and start validating and improving it through adaptive management.

Key Estimators

Weighted Distributions:

$$s(x) = \frac{f_0(x)w(x)}{\int_x f_0(x)w(x)}$$

where w(x) is a weighting function (Lele and Keim 2006) to estimate any resource selection probability distribution *s(x)*. We (Horne et al. 2008) proposed using a product linear weighting or link function, $w(x) = \prod_j 1 + \beta_j H_j(x)$, in 2008. Johnson et al. (2008) proposed a very similar model to the synoptic model to estimate habitat selection but used a different weighting function, the exponential, which is easier to estimate. They proposed using a bivariate normal distribution for the home range as a measure of availability and suggested the weighting function could follow an exponential form ($w(x)$=exp($\beta' H(x)$). Therefore an efficient version of this **synoptic model** can be written as

$$f_u(x) = \frac{f_0(x)\exp(\beta' H(x))}{\int_x f_0(x)\exp(\beta' H(x))}$$

where f_u is the probability of use of location *x* and f_0 is an available location's probability of use under the null model (bivariate normal or we could use exponential power or bimodal parametric home range models too).

Key References

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Key Sources Download Animal Space Use and Synoptic Model software from
http://www.cnr.uidaho.edu/population_ecology/
to C:/SynopticSpaceModel for a quick start
Download the R program and packages from http://cran.r-project.org/