Model complexity and model choice for animal movement models

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Outline

1. Animal movement

2. Florida panthers

3. Hidden Markov models

4. Basic analysis (vdK et al.)

5. Incorporating diurnal variation

6. Broader issues/outlook

Acknowledgements

To do

- pix!
- general REFS: Turchin, Morales et al, Langrock ... ?

Animal movement: data

- observations:
  e.g. mass mark-recapture, longitudinal density, direct observation, telemetry (VHF, GPS)
- most methods provide a sequence of times and locations for each individual
- summaries:
  - home range
    (convex hull, kernel density estimate, etc.)
  - root-mean-squared displacement
  - step length and turning angle
- covariates:
  e.g. habitat map, individual characteristics (sex, age, weight . . .)

Animal movement: questions

- simple description
- how do animals' movements change as a function of their (internal or external) environment?
  what does that tell us about their biology?
- how might animals' distributions, etc. change when conditions (density, habitat, ...) change?

Biological/conservation issues

- Florida panther: *Felix ...*
- severely reduced habitat, endangered
- small, isolated population
- currently recovering

Panther movement questions

- abc

Panther movement data

- panthers tracked, captured
- GPS collars
- 18 males (13 male, 5 female, 1-15 years old)
- 3200 panther days, hourly/bihourly; 49000 locations
- ?? per panther
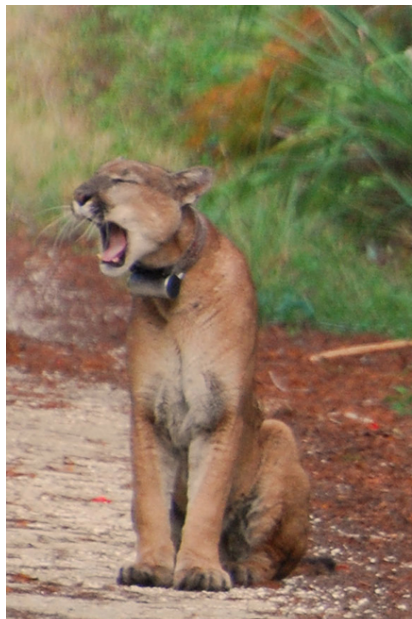
example movement tracks

FIXME: picture here! (animation?? map background??)

Hidden Markov models

- finite mixture model with temporal dependence
- discrete time steps
- discrete latent state; *transition matrix*
- observations from *emission distributions*
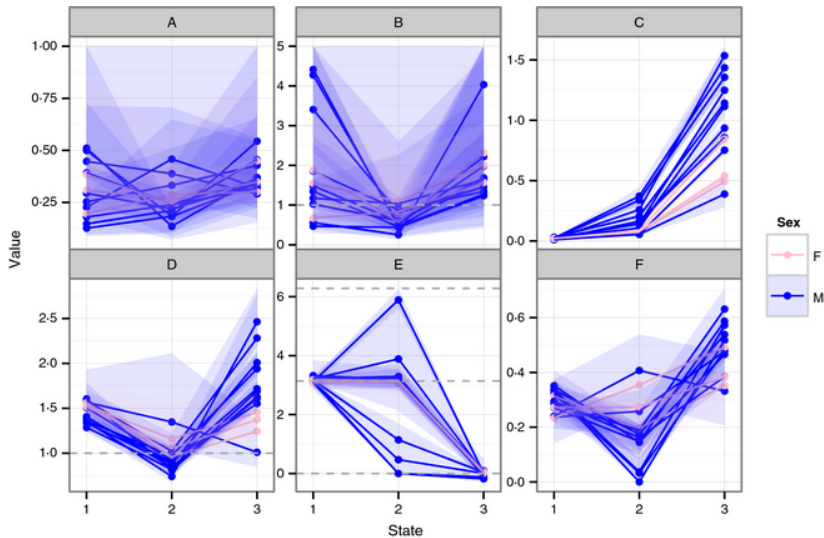 (continuous or discrete, univariate or multivariate)
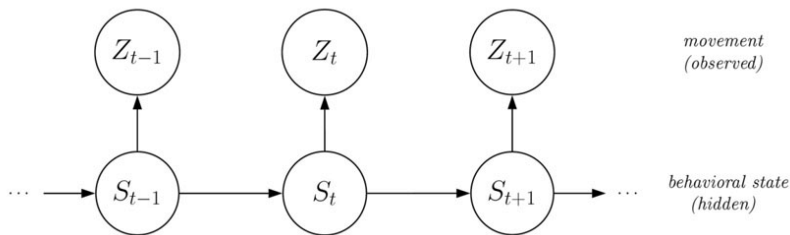
Hidden Markov models (cont.)

- *forward-backward algorithm* for estimating parameters
- *Viterbi algorithm* for estimating most probable state sequences
- depmixS4 package (Visser and Speekenbrink, 2010) (also moveHMM (Michelot et al., 2016), move.HMM (Augustine, 2016))

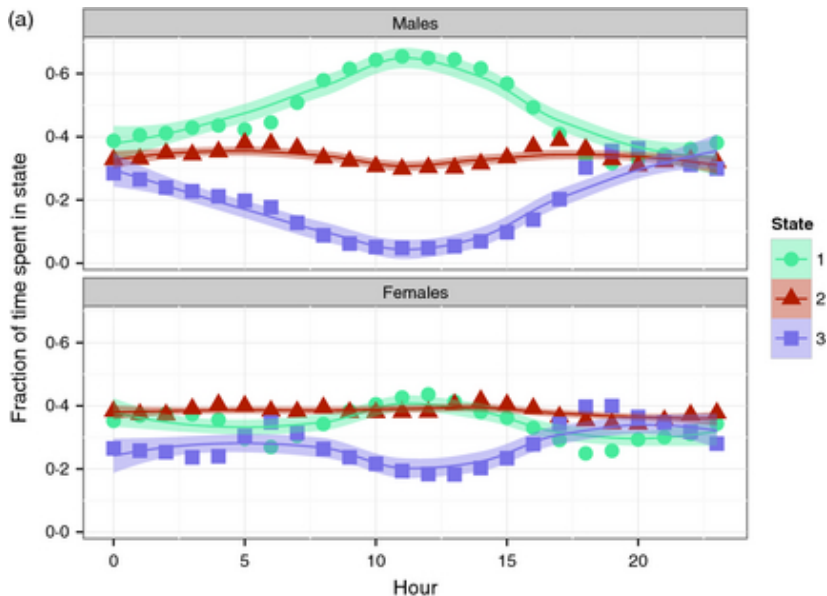## State distributions

(a)
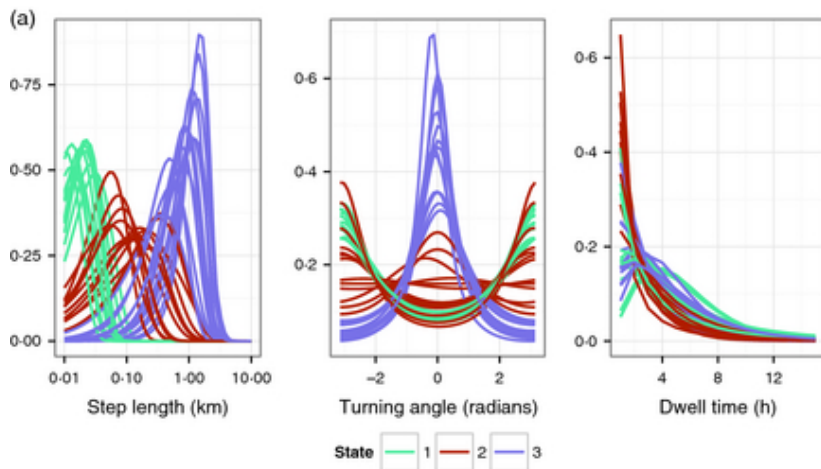
Parameter estimates

Transition parameters

picture/table here of transition parameters (network diagram??)

Diurnal variation

what can we conclude so far?

good news

- basic biology: males move faster, farther
- three states are identifiable, sensible
- ...

bad news

- diurnal variation in Viterbi results - but it's not in the model!
- estimates of model complexity are too high

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good news
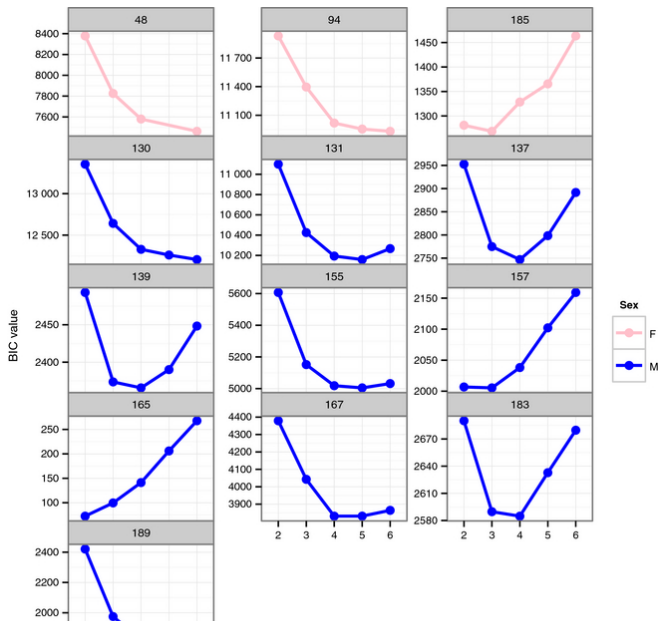
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bad news

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Model complexity

Broadening the model

Attempting to fix these problems:

- extend the model to allow covariates
- specifically, allow for diurnal variation
    - simplify model (log-Normal step length only)
    - *fixed* state-specific emissions parameters
      (step length mean and std dev)
    - time-varying transition parameters
    - also try *finite mixture models*
      (independent occupancy)
- how much does this help?

Animal movement Panthers HMM Basic analysis **Diurnal model** Broader issues/outlook References
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Temporal models

figure showing alternative temporal models

Comparison

Figure 1 from paper

Goodness of fit

Figure 2 from paper

Temporal patterns

Figures 3 (and 4?) from paper

Model complexity

Figure showing BIC plots for all cats tried

Model complexity

Simulation results

Big data and small models

- simple model families +
  model misspecification $\rightarrow$
  overparameterization

an aside on AIC vs BIC

Tools needed

- cross-validation (Wenger and Olden, 2012)
- diagnostic plots
- score tests?

References

Augustine, B., 2016. Flexible, user-friendly hidden (semi) Markov models for animal movement data.

Michelot, T., Langrock, R., and Patterson, T.A., 2016. *Methods in Ecology and Evolution*, in press. **doi**:10.1111/2041-210X.12578.

Visser, I. and Speekenbrink, M., 2010. *Journal of Statistical Software*, 36(7):1–21.

Wenger, S.J. and Olden, J.D., 2012. *Methods in Ecology and Evolution*, 3(2):260–267. ISSN 2041210X. **doi**:10.1111/j.2041-210X.2011.00170.x.