

WILD 502

Lab 10 – Occupancy models for single-species, single-season

This week's lab provides you with an introduction to single-species occupancy modeling. You'll work with data from multiple observers and two habitats to model occupancy and detection for an interesting creature from New Zealand: the Mahoenui giant weta.



The data were collected by 3 different observers on 72 sites that differed in terms of browsing levels. Observers and browsing level may have affected occupancy and/or detection. Each observer visited each site at least once. Most sites were not visited on all 5 occasions. If a site was not visited on a given occasion, a '.' appears in the encounter history for that site on the relevant occasion. The input file contains data for 2 groups (browsed sites [1st group] and unbrowsed sites 2nd group]) and 10 covariates: (1-5) *obs11*, *obs12*, ..., *obs15* are indicators for whether or not observer 1 surveyed the site on occasions 1-5, respectively; (6-10) *obs21*, *obs22*, ..., *obs25* are indicators for whether or not observer 2 surveyed the site on occasions 1-5, respectively. (If no observer surveyed the site, I put a '9' in the column just so that you can see how things line up and to make it easier to see that no one surveyed the site on some days. By the way, MARK does not allow missing values for individual covariates, so you can't put a '.' in for the observer covariate values on those days.)

I've posted a pdf of pages 116-122 of the MacKenzie *et al.* Occupancy book for you to see how they describe the work (http://www.montana.edu/rotella/documents/502/Weta_text.pdf). Here is a list of the models they ran.

No.	Model	No.	Model
1	psi(.), p(.)	9	psi(Browse), p(.)
2	psi(.), p(Browse)	10	psi(Browse), p(Browse)
3	psi(.), p(Day)	11	psi(Browse), p(Day)
4	psi(.), p(Obs)	12	psi(Browse), p(Obs)
5	psi(.), p(Day+Browse)	13	psi(Browse), p(Day+Browse)
6	psi(.), p(Day+Obs)	14	psi(Browse), p(Day+Obs)
7	psi(.), p(Obs+Browse)	15	psi(Browse), p(Obs+Browse)
8	psi(.), p(Day+Obs+Browse)	16	psi(Browse), p(Day+Obs+Browse)

To run these models in MARK, use the 'Occupancy Estimation' Data type and fill in the relevant details (5 occasions, 2 groups, 10 covariates).

Set up each of the models using the design matrix and either the default PIM, which has 10 p 's (5 for each group) and 2 psi 's (1 for each group). Remember: in a single-season design, psi is constant through the season but can vary by group (or by individual site covariates); p can vary by occasion and/or by site. The design matrix for model 16 is set up as follows.

B0:	B1:	B2:	B3:	B4:	Parm	B5:	B6:	B7:	B8:	B9:
1	0	0	0	0	1:p	obs11	obs21	1	0	0
0	1	0	0	0	2:p	obs12	obs22	1	0	0
0	0	1	0	0	3:p	obs13	obs23	1	0	0
0	0	0	1	0	4:p	obs14	obs24	1	0	0
0	0	0	0	1	5:p	obs15	obs25	1	0	0
1	0	0	0	0	6:p	obs11	obs21	0	0	0
0	1	0	0	0	7:p	obs12	obs22	0	0	0
0	0	1	0	0	8:p	obs13	obs23	0	0	0
0	0	0	1	0	9:p	obs14	obs24	0	0	0
0	0	0	0	1	10:p	obs15	obs25	0	0	0
0	0	0	0	0	11:Psi	0	0	0	1	0
0	0	0	0	0	12:Psi	0	0	0	0	1

Here is another version of a design matrix for model 16 (this one has overall intercept terms for p and for psi ; it also codes the covariate values used for the 8th beta and the 10th beta as being adjustments for the unbrowsed sites – I did this so you get beta-hats back that match what the RMark code reports). Notice that you get the same estimates of p and psi from these 2 alternative design matrices that both yield the same model. Some of the beta-hats will be different though. Please do be sure you understand why both of those last 2 sentences are true and ask questions if you don't.

B1 p-d1(ref=obs3,brwse)	B2 p-d2	B3 p-d3	B4 p-d4	B5 p-d5	Parm	B6 p-obs1	B7 p-obs2	B8 p-unbr	B9 psi-int	B10 psi-unbr
1	0	0	0	0	1:p	obs11	obs21	0	0	0
1	1	0	0	0	2:p	obs12	obs22	0	0	0
1	0	1	0	0	3:p	obs13	obs23	0	0	0
1	0	0	1	0	4:p	obs14	obs24	0	0	0
1	0	0	0	1	5:p	obs15	obs25	0	0	0
1	0	0	0	0	6:p	obs11	obs21	1	0	0
1	1	0	0	0	7:p	obs12	obs22	1	0	0
1	0	1	0	0	8:p	obs13	obs23	1	0	0
1	0	0	1	0	9:p	obs14	obs24	1	0	0
1	0	0	0	1	10:p	obs15	obs25	1	0	0
0	0	0	0	0	11:Psi	0	0	0	1	0
0	0	0	0	0	12:Psi	0	0	0	1	1

If you use the 2nd version, you can drop various columns to achieve the other models that are nested inside this most general model. For example, if you drop columns for B2-B5 you drop the daily variation in p . If you drop columns for B6-B7, you drop observer differences. If you drop the column for B8, p no longer is allowed to differ between browsed and unbrowsed sites. And, if you drop the column for B10, psi no longer is allowed to differ between browsed and unbrowsed sites.

Assignment

1. Run each model in the table above and provide the table of model-selection results. [Note: you will get a slightly different model-selection order than that presented in the book chapter because you're working with AICc & not AIC.]
2. What factors seem to affect p and how large are the differences in estimated p among sampling conditions?
3. Provide your estimates of p_j for each observer and day ($j = 1, 2, \dots, 5$) from the best model.
4. What are some reasons that you think might explain why p might differ among observers?
5. Please provide an example where p might differ among observers for occupancy surveys in a species of interest to you.
6. Does ψ_i seem to be influenced by browsing (consider model-selection uncertainty and uncertainty in estimates). [Note: the researchers provide an interesting discussion of the fact that there was an *a priori* prediction that browsed sites would have higher occupancy. Thus, they noted that it might well be most appropriate to construct 1-tailed confidence intervals for the beta-hat associated with the effect of browsing on ψ_i (see their text for more on this topic).]
7. What are the estimates of ψ_i from the top model for browsed and for un-browsed sites?
 - a. Show how you would obtain those estimates (what equation you would use from the estimated coefficients)
 - b. Provide a measure of uncertainty for the estimates of ψ_i .
8. How do the estimates of ψ_i from occupancy modeling compare to the naïve estimates obtained by simply calculating how many plots had the species detected on them?
9. Please provide a table of estimated occupancy (& associated precision) for browsed and unbrowsed sites from each model within 4 AIC units of the top model (stopping there to save you time, but you could go through the whole list if you wanted to) using the table format I provide below. Given those values, what inferences can you draw from the results? I encourage you to read over what the authors had to say in their book. Also, the model-averaging tool ought to be quite valuable here. Finally, note the footnote to the table below.

Model name	Model Wt.	Browsed	Unbrowsed	Difference ¹
		$\hat{\psi}_{browsed}$ (SE)	$\hat{\psi}_{unbrowsed}$ (SE)	$\hat{\psi}_{browsed-unbrowsed}$ (SE)
01. $\psi(\cdot), p(\cdot)$				
02. $\psi(\cdot), p(\text{Browse})$				
03. $\psi(\cdot), p(\text{Day})$				
04. $\psi(\cdot), p(\text{Obs})$				
05. $\psi(\cdot), p(\text{Day+Browse})$				
06. $\psi(\cdot), p(\text{Day+Obs})$				
07. $\psi(\cdot), p(\text{Obs+Browse})$				
08. $\psi(\cdot), p(\text{Day+Obs+Browse})$				
09. $\psi(\text{Browse}), p(\cdot)$				
10. $\psi(\text{Browse}), p(\text{Browse})$				
11. $\psi(\text{Browse}), p(\text{Day})$				
12. $\psi(\text{Browse}), p(\text{Obs})$				
13. $\psi(\text{Browse}), p(\text{Day+Browse})$				
14. $\psi(\text{Browse}), p(\text{Day+Obs})$				
15. $\psi(\text{Browse}), p(\text{Obs+Browse})$				
16. $\psi(\text{Browse}), p(\text{Day+Obs+Browse})$				
Model Averaged Value (give mean & SE¹)				() ¹

¹Note: use the delta method to obtain an estimate of SE for differences (set covariance = 0).

10. Please briefly describe a situation where occupancy models would be useful for species of interest to you. A ψ