Developing EAM parameters for the EAM using Malcolm's model (*adapted from our final technical report to our funding agency, SERDP*). The full final report is also posted at the website http://www.clfs.umd.edu/lries/EERC/EERC.html

NOTE: For this system, there are five habitat types: WOODS, SCRUB, OPEN, SCTREES (scattered trees), and BIROADS (large roads that fragment habitat patches) and four focal species: GCWA (golden-cheeked warbler), BCVI (black-capped vireo), BAWW (black-and-white warbler), BEWR (bewick's wren).

The EAM requires estimates for four parameters: Dmin, edge density, Dmax, interior density. We are currently using Malcolm's model to develop parameters for the EAM when field data are available. Malcolm's model estimates a value (in our case, detection rate) as a function of four parameters: e0, D0, Dmax and k. Of the four model parameters, two are directly transferable to the EAM, Dmax and k (which is the same as the interior density). To use Malcolm's model to determine Dmin and the edge density, it is necessary to determine the density value at the edge. To do this, the "infinite.edge.effect" function (in the R-package "edgefx") is used to calculate the density when d=0 (using the parameters returned by the analysis). If the predicted density is greater than 0, then Dmin = 0 and the edge density is whatever value was returned. If the returned value is less than 0, then it is necessary to determine the distance, d, where the predicted density is 0. That value for d can be interpreted as Dmin and the edge density is set to 0. It is important to stress that the Malcolm parameter D0 is not analogous to the EAM parameter Dmin (although they are related). When D0>0, a non-linear relationship near the edge is expected, even if the edge density is greater than 0. This shape can be captured by using Dmin to indicate where edge densities begin to level off as the edge is neared. However, when we employed model selection theory to distinguish among a suite of candidate models, we never found support of a model where D0>0 for our data, so we did not address that issue in depth.

In developing parameters for the EAM, we also had to grapple with the restriction that the interior density should always be the same when species and focal habitat are held constant. For instance, GCWA within WOODS habitat should have the same interior density at all four edge types (OPEN, SCRUB, SCTREES, BIROAD). Because edge responses are estimated from completely independent data for all four edge types, it is unlikely any of the four separate models would return the *exact* same interior density (k). Further, when data are highly variable as they are at Ft. Hood, multiple models converge on a variety of parameter combinations that lead to moderate to substantial variability in the estimates for k. However, model predictions tend to be more similar within the edge zone (see Figs. 15 and 16). To ensure that interior densities are always consistent when species and focal habitat are held constant, we used a combined method of choosing candidate models that converge near the same interior density (k). To make final adjustments, we modified Dmax while holding e0 constant until values of k converged exactly. This allowed us to meet our assumption of equal values of k between edge types within the same focal habitat, while introducing only a minimal impact on the predictions within the edge zone.

For the four focal species, we began by choosing the best model for each species-edge type combination (the model with the lowest AIC score). But when models returned parameters for k that were very different within the same focal habitat type, we selected, when available, a different, closely ranked model (within 2 AIC points) that predicted a more similar value of k. In order to meet our assumption of having equal interior densities within the same habitat type, we then determined the value of Dmax (assuming the same e0) that gives the desired interior density value (using the "infinite.edge.function" in the "edgefx" R-package). To determine edge density and Dmin, we used the same function to determine the density at the edge. If the model reached 0 density, we determined the distance at which this occurred, and used that as Dmin in our model. This occurred consistently for the BAWW and at SCRUB|BIROAD edges for the BEWR. Neither the GCWA nor the BCVI reached zero density at the edge. This suggests that individuals are "spilling over" from preferred habitat into adjacent lower quality habitats. Unfortunately, there were insufficient data in non-habitat to develop edge response parameters using Malcolm's model. So, in these cases, we estimated spillover functions based on visual inspection of the data, but also assuring edge densities were equal for the same edge types. The output from Malcolm's models and the final parameters developed for the EAM are shown in Table 6.

It is clear from this exercise that developing these parameters still relies on experience and some interpretation on the part of the EAM user. This is partly due to the high variability in Ft. Hood data. Ecological data tend to be "noisy" in general, so this problem may be a persistent one. However, the problem here was exacerbated by a survey design that was not intended to estimate edge response functions. The fact that the Malcolm model converged on multiple solutions for several (but not all) species/edge type combinations is indicative of the variability in these data. However, while models were variable in their convergence on Dmax and k, behavior near the edge was largely consistent for most of the parameter combinations. In reality, our evidence for Dmax and k were weakest when we were forced to choose low-ranked models in order to "force" k to converge for multiple edge types. This was true in only a few cases (where delta AIC is greater than 2). The worst case was for BEWR (see Table 6). The best models for this species always chose Dmax far beyond the range of our data, which indicates that Dmax may not have been reached within the range of field sampling. Despite having to grapple with multiple models, the comparison of AIC values and final parameters shows that model tweaking (to meet our assumption of equal values of k within the same habitat) was kept to a minimum and often had a minimal effect on the final parameters. Ultimately, despite the adjustments made, this approach is still far less subjective than past ones, and is likely to be more objective and easier to implement in situations where the field sampling designs were more appropriate for model parameterization.

Table 6. Parameters from three competing models to measure edge effects (DNC, INFINITE, COMPLEX) which will be compared to a NULL model. The models with the lowest AIC score indicates the "best" model based on data fit and number of parameters.

<table>
<tr><th></th><th></th><th></th><th colspan="4">MODEL BUILD RESULTS</th><th colspan="4">EAM PARAMETERS</th></tr>
<tr><th>Edge Type</th><th>Year</th><th>Model</th><th>e0</th><th>Dmax</th><th>k</th><th>ΔAIC</th><th>Dmin</th><th>Edge Dens</th><th>Dmax</th><th>Int Dens</th></tr>
<tr><td><u>Golden-cheeked warbler (GCWA)</u></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>WOODS|OPEN</td><td>Mean</td><td>COMPLEX</td><td>-0.0028**</td><td>314***</td><td>1.04***</td><td>0.00</td><td>0</td><td>0.16</td><td>314</td><td>1.04</td></tr>
<tr><td>WOODS|SCRUB</td><td>Mean</td><td>COMPLEX</td><td>-0.005</td><td>203**</td><td>1.08***</td><td>0.00</td><td>0</td><td>0.10</td><td>188</td><td>1.04</td></tr>
<tr><td>WOODS|SCTREES</td><td>Mean</td><td>COMPLEX</td><td>-0.0014</td><td>402*</td><td>1.14***</td><td>0.607</td><td>0</td><td>0.60</td><td>315</td><td>1.04</td></tr>
<tr><td>WOODS|BIROAD</td><td>Mean</td><td>COMPLEX</td><td>-0.0015</td><td>218</td><td>1.08***</td><td>2.746</td><td>0</td><td>0.77</td><td>180</td><td>1.04</td></tr>
<tr><td>SCRUB|WOODS</td><td>Mean</td><td></td><td colspan="4">Parameters from visual inspection</td><td>0</td><td>0.10</td><td>150</td><td>0</td></tr>
<tr><td><u>Black-capped vireo (BCVI)</u></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>SCRUB|WOODS</td><td>Mean</td><td>IDEAL</td><td>-0.0021</td><td>179</td><td>0.84</td><td>2.724</td><td>0</td><td>0.47</td><td>130</td><td>0.74</td></tr>
<tr><td>SCRUB|BIROAD</td><td>Mean</td><td>COMPLEX</td><td>-0.0010</td><td>343*</td><td>0.74***</td><td>0.830</td><td>0</td><td>0.40</td><td>343</td><td>0.74</td></tr>
<tr><td>WOODS|SCRUB</td><td>Mean</td><td></td><td colspan="4">Parameters to match Woods density</td><td>0</td><td>0.47</td><td>50</td><td>0</td></tr>
<tr><td><u>Black-and-white warbler (BAWW)</u></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>WOODS|OPEN</td><td>2005</td><td>COMPLEX</td><td>-0.0025</td><td>195*</td><td>0.45***</td><td>0.00</td><td>28</td><td>0.00</td><td>110</td><td>0.23</td></tr>
<tr><td>WOODS|SCRUB</td><td>Mean</td><td>COMPLEX</td><td>-0.0026</td><td>128</td><td>0.23***</td><td>1.67</td><td>49</td><td>0.00</td><td>128</td><td>0.23</td></tr>
<tr><td>WOODS|SCTREES</td><td>Mean</td><td>COMPLEX</td><td>-0.0035</td><td>135**</td><td>0.26***</td><td>0.39</td><td>60</td><td>0.00</td><td>120</td><td>0.23</td></tr>
<tr><td>WOODS|BIROAD</td><td>Mean</td><td>COMPLEX</td><td>-0.0026</td><td>128</td><td>0.26***</td><td>1.297</td><td>31</td><td>0.00</td><td>110</td><td>0.23</td></tr>
<tr><td>SCRUB|WOODS</td><td>Mean</td><td></td><td colspan="4">Parameters from visual inspection</td><td>0</td><td>0.00</td><td>0</td><td>0</td></tr>
<tr><td><u>Bewick's wren (BEWR)</u></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>SCRUB|WOODS</td><td>Mean</td><td>IDEAL</td><td>-0.0037</td><td>180*</td><td>0.63***</td><td>13.738</td><td>0</td><td>0.08</td><td>120</td><td>0.42</td></tr>
<tr><td>SCRUB|BIROAD</td><td>Mean</td><td>COMPLEX</td><td>-0.00944</td><td>89'</td><td>0.42***</td><td>2.34</td><td>47</td><td>0.00</td><td>89</td><td>0.42</td></tr>
<tr><td>WOODS|SCRUB</td><td>Mean</td><td></td><td colspan="4">Parameters from visual inspection</td><td>0</td><td>0.08</td><td>400</td><td>0</td></tr>
</table>

'p<0.10, *p<0.05, **p<0.01, ***p<0.0001