Ch1\_models\_WTDeer

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Based on model selection comparison of underlying distributions and zero-inflation, I chose an nbinom1 distribution for WTDeer data, with zero-inflation and ActiveDays in the ZI model (see Ch1\_WTDeer\_modelDistribution.Rmd).  
I previously had decided to include ActiveDays in the ZI model. However, to retain the same amount of data in each model, I need to omit rows with NAs. NA rows are usually those in which cameras were inactive. Therefore, in the final dataset used in modelling, ActiveDays should have a greater effect on the count data, not the zero mass, so it should be included in the conditional model. Here I will: 1. Double check random structure using all covariates 2. Build models assessing Treatment effect, including other combinations of covariates to account for additional noise and compare their effect to Treatment 4. Perform model selection with AIC  
5. Calculate evidence ratios (AICwt of Best Model/ AICwt of other models)  
6. Checking residuals of Top Model

Previous scale analysis showed lowland habitat at 2000m and linear density measured at 750m best explained WTDeer detections

### 1. Random structure and Active Days

Random structure was previously assessed, but here I will confirm using all model covariates. Also comparing random intercepts vs random slope

## Warning in fitTMB(TMBStruc): Model convergence problem; non-positive-  
## definite Hessian matrix. See vignette('troubleshooting')

## Warning in fitTMB(TMBStruc): Model convergence problem; singular  
## convergence (7). See vignette('troubleshooting')

## Warning in fitTMB(TMBStruc): Model convergence problem; non-positive-  
## definite Hessian matrix. See vignette('troubleshooting')

## dLogLik dAIC df weight  
## r2 39.0 0.0 14 1   
## rSite 26.4 23.2 13 <0.001  
## rMonth 9.2 57.6 13 <0.001  
## r0 0.0 74.0 12 <0.001

Random slope models fail to converge, so exclude. Continue modelling with 2 random effects. ActiveDays in conditional model had slightly less model weight, so continue modelling ActiveDays in ZI only. ## Model Set  
(note that numbered models from dredge do not correspond with numbers in table; I have listed models in order of increasing complexity, dredge did not) Also: ActiveDays is also fixed in all models (including NULL)

|  |  |
| --- | --- |
| Model Name | Covariates |
| L0 | 1 |
| L1 | Treatment |
| L2 | Treatment + low2000 |
| L3 | Treatment + pSnow |
| L4 | Treatment + LineWidth |
| L5 | Treatment + VegHt |
| L6 | Treatment + LD750 |
| L7 | Treatment + low2000 + pSnow |
| L8 | Treatment + low2000 + LineWidth |
| L9 | Treatment + low2000 + VegHt |
| L10 | Treatment + low2000 + LD750 |
| L11 | Treatment + pSnow + LineWidth |
| L12 | Treatment + pSnow + VegHt |
| L13 | Treatment + pSnow + LD750 |
| L14 | Treatment + LineWidth + VegHt |
| L15 | Treatment + LineWidth + LD750 |
| L16 | Treatment + VegHt + LD750 |
| L17 | Treatment + low2000 + pSnow + LineWidth |
| L18 | Treatment + low2000 + pSnow + VegHt |
| L19 | Treatment + low2000 + pSnow + LD750 |
| L20 | Treatment + low2000 + LineWidth + VegHt |
| L21 | Treatment + low2000 + LineWidth + LD750 |
| L22 | Treatment + low2000 + VegHt + LD750 |
| L23 | Treatment + pSnow + LineWidth + VegHt |
| L24 | Treatment + pSnow + LineWidth + LD750 |
| L24 | Treatment + pSnow + VegHt + LD750 |
| L25 | Treatment + LineWidth + VegHt + LD750 |
| L26 | Treatment + low2000 + pSnow + LineWidth + VegHt |
| L27 | Treatment + low2000 + pSnow + LineWidth + LD750 |
| L28 | Treatment + pSnow + LineWidth + VegHt + LD750 |
| L29 | Treatment + low2000 + LineWidth + vegHt + LD750 |
| L30 | Treatment + low2000 + pSnow + VegHt + LD750 |
| L31 | Treatment + low2000 + pSnow + LineWidth + VegHt + LD750 |

## dLogLik dAIC df weight  
## 6 19.5 0.0 11 0.186   
## 22 20.3 0.6 12 0.141   
## 14 20.2 0.6 12 0.135   
## 30 20.9 1.2 13 0.102   
## 8 19.5 2.0 12 0.070   
## 24 20.4 2.3 13 0.059   
## 5 17.3 2.6 10 0.052   
## 16 20.2 2.6 13 0.051   
## 32 21.1 2.9 14 0.043   
## 21 17.9 3.2 11 0.038   
## 13 17.9 3.2 11 0.037   
## 29 18.6 3.8 12 0.027   
## 7 17.3 4.6 11 0.019   
## 23 18.0 5.1 12 0.015   
## 15 17.9 5.2 12 0.014   
## 31 18.7 5.7 13 0.011   
## 1 8.1 18.8 9 <0.001  
## 9 8.7 19.6 10 <0.001  
## 2 8.5 20.0 10 <0.001  
## 17 8.4 20.3 10 <0.001  
## 10 9.1 20.8 11 <0.001  
## 3 8.1 20.8 10 <0.001  
## 25 9.0 21.1 11 <0.001  
## 18 8.8 21.5 11 <0.001  
## 11 8.7 21.6 11 <0.001  
## 4 8.5 22.0 11 <0.001  
## 26 9.4 22.3 12 <0.001  
## 19 8.4 22.3 11 <0.001  
## 12 9.1 22.8 12 <0.001  
## 27 9.0 23.1 12 <0.001  
## 20 8.8 23.5 12 <0.001  
## 28 9.4 24.3 13 <0.001  
## Nullmod 0.0 29.1 6 <0.001

Five models within 2 dAIC points of each other, with model weights between 7 - 19%.

## Evidence Ratios and Cumulative model weight (calculating confidence intervals)

Calculating evidence ratios (AIC wt of best model/AIC weight of others) gives:

## ModelNames dLogLikelihood dAIC Modelweight CumulativeWeight  
## 1 6 19.533946 0.0000000 1.864584e-01 0.1864584  
## 2 22 20.256673 0.5545448 1.413072e-01 0.3277656  
## 3 14 20.211193 0.6455046 1.350245e-01 0.4627901  
## 4 30 20.933450 1.2009910 1.022799e-01 0.5650699  
## 5 8 19.549103 1.9696861 6.964182e-02 0.6347118  
## 6 24 20.389688 2.2885145 5.937962e-02 0.6940914  
## 7 5 17.251562 2.5647680 5.171896e-02 0.7458103  
## 8 16 20.228896 2.6100993 5.055990e-02 0.7963702  
## 9 32 21.074463 2.9189648 4.332483e-02 0.8396951  
## 10 21 17.938786 3.1903192 3.782797e-02 0.8775230  
## 11 13 17.921443 3.2250056 3.717757e-02 0.9147006  
## 12 29 18.613004 3.8418834 2.731037e-02 0.9420110  
## 13 7 17.251590 4.5647107 1.902688e-02 0.9610378  
## 14 23 17.987440 5.0930113 1.460995e-02 0.9756478  
## 15 15 17.921452 5.2249865 1.367699e-02 0.9893248  
## 16 31 18.666143 5.7356055 1.059525e-02 0.9999200  
## 17 1 8.116679 18.8345343 1.516055e-05 0.9999352  
## 18 9 8.734702 19.5984878 1.034724e-05 0.9999455  
## 19 2 8.522854 20.0221840 8.371823e-06 0.9999539  
## 20 17 8.360790 20.3463109 7.119291e-06 0.9999610  
## 21 10 9.142917 20.7820580 5.725527e-06 0.9999668  
## 22 3 8.131461 20.8049690 5.660313e-06 0.9999724  
## 23 25 8.979559 21.1087727 4.862620e-06 0.9999773  
## 24 18 8.774940 21.5180119 3.962827e-06 0.9999812  
## 25 11 8.747040 21.5738108 3.853794e-06 0.9999851  
## 26 4 8.531752 22.0043879 3.107348e-06 0.9999882  
## 27 26 9.395378 22.2771350 2.711213e-06 0.9999909  
## 28 19 8.360935 22.3460207 2.619421e-06 0.9999935  
## 29 12 9.149909 22.7680728 2.121084e-06 0.9999957  
## 30 27 8.980105 23.1076810 1.789834e-06 0.9999974  
## 31 20 8.776858 23.5141748 1.460642e-06 0.9999989  
## 32 28 9.398430 24.2710311 1.000448e-06 0.9999999  
## 33 Nullmod 0.000000 29.0678915 9.090120e-08 1.0000000  
## EvidenceRatio  
## 1   
## 2 1.31952575193172  
## 3 1.3809232762758  
## 4 1.82302185674298  
## 5 2.67739165959073  
## 6 3.14010824076787  
## 7 3.60522427462672  
## 8 3.68787225102929  
## 9 4.30373141888785  
## 10 4.92911571816206  
## 11 5.01534800652303  
## 12 6.82738494549311  
## 13 9.79973525605826  
## 14 12.7624296282638  
## 15 13.6329991445403  
## 16 17.5983079537788  
## 17 12298.9248480672  
## 18 18020.1144406726  
## 19 22272.142975065  
## 20 26190.5901901897  
## 21 32566.1606718827  
## 22 32941.3666430337  
## 23 38345.2649829281  
## 24 47051.8733593758  
## 25 48383.0785945318  
## 26 60005.6476476662  
## 27 68773.0689399956  
## 28 71183.0752706217  
## 29 87907.1464178168  
## 30 104176.359569516  
## 31 127655.101323352  
## 32 186374.905054767  
## 33 2051220.88524251

Examining summaries for top 4 models (2dAIC)

In addtion to Treatment and ActiveDays, all 5 models contain LD and lowland. 2 contain pSnow and/or VegHt, and 1 contains LineWidth

### Pretending variables

Comparing deviance of top models - if covariate does not add much, resdiual deviance will be similar across models

|  |  |  |
| --- | --- | --- |
| Model | Est. + SE of addtional variables | Residual Deviance |
| Treat + low + LD + ActiveDays |  | 1398.2 |
| Treat + low + LD + VegHt + ActiveDays | VegHt 0.49 +/- 0.40 | 1396.7 |
| Treat + low + LD + pSnow + ActiveDays | Snow -0.46 +/- 0.38 | 1396.8 |
| Treat + low + LD + pSnow + VegHt + ActiveDays | Snow same VegHt -0.49 +/- 0.38 | 1395.4 |
| Treat + low + LD + LineWidth + ActiveDays | LineWidth -0.06 +/- 0.37 | 1398.1 |

Parameter estimates and deviance are similar, indicating all models are roughly equivalent to one another.

### Model averaging

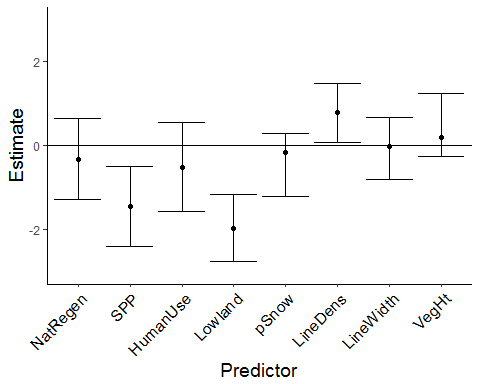
Multiple models are within 2dAIC scores of each other, suggesting that they all explain the data equally well. As my goal is to compare Treatment effects to the effects of other covariates, I do not just want the estimates given in the top model, but rather the best possible estimates for many covariates. I will therefore model average to obtain a weighted average estimate (effect size) of covariates included in models that are within 2 dAIC of one another or within 95% confidence intervals, whichever is more conservative.

##   
## Call:  
## model.avg(object = WTDtop)  
##   
## Component model call:   
## glmmTMB(formula = WTDeer ~ <5 unique rhs>, data = det, family =   
## nbinom1, ziformula = ~1, dispformula = ~1)  
##   
## Component models:   
## df logLik AICc delta weight  
## 1246 11 -699.08 1420.40 0.00 0.30  
## 12467 12 -698.36 1421.00 0.60 0.22  
## 12456 12 -698.40 1421.09 0.69 0.21  
## 124567 13 -697.68 1421.69 1.29 0.16  
## 12346 12 -699.07 1422.41 2.01 0.11  
##   
## Term codes:   
## cond(ActiveDays\_sc) cond(LD750\_sc) cond(LineWidth\_sc)   
## 1 2 3   
## cond(low2000\_sc) cond(pSnow\_sc) cond(Treatment)   
## 4 5 6   
## cond(VegHt\_sc)   
## 7   
##   
## Model-averaged coefficients:   
## (full average)   
## Estimate Std. Error Adjusted SE z value Pr(>|z|)  
## cond((Int)) -2.205615 0.486348 0.486875 4.530 5.9e-06  
## cond(LD750\_sc) 0.783153 0.357582 0.357969 2.188 0.028687  
## cond(low2000\_sc) -1.969826 0.407397 0.407839 4.830 1.4e-06  
## cond(ActiveDays\_sc) 2.079664 0.584519 0.585139 3.554 0.000379  
## cond(TreatmentHumanUse) -0.511610 0.543179 0.543755 0.941 0.346765  
## cond(TreatmentNatRegen) -0.318864 0.489423 0.489954 0.651 0.515173  
## cond(TreatmentSPP) -1.447440 0.486905 0.487430 2.970 0.002982  
## zi((Int)) -3.829437 2.314130 2.316629 1.653 0.098326  
## cond(VegHt\_sc) 0.185098 0.334179 0.334359 0.554 0.579860  
## cond(pSnow\_sc) -0.171253 0.322166 0.322347 0.531 0.595233  
## cond(LineWidth\_sc) -0.007079 0.124949 0.125081 0.057 0.954871  
##   
## cond((Int)) \*\*\*  
## cond(LD750\_sc) \*   
## cond(low2000\_sc) \*\*\*  
## cond(ActiveDays\_sc) \*\*\*  
## cond(TreatmentHumanUse)   
## cond(TreatmentNatRegen)   
## cond(TreatmentSPP) \*\*   
## zi((Int)) .   
## cond(VegHt\_sc)   
## cond(pSnow\_sc)   
## cond(LineWidth\_sc)   
##   
## (conditional average)   
## Estimate Std. Error Adjusted SE z value Pr(>|z|)  
## cond((Int)) -2.20562 0.48635 0.48688 4.530 5.9e-06  
## cond(LD750\_sc) 0.78315 0.35758 0.35797 2.188 0.028687  
## cond(low2000\_sc) -1.96983 0.40740 0.40784 4.830 1.4e-06  
## cond(ActiveDays\_sc) 2.07966 0.58452 0.58514 3.554 0.000379  
## cond(TreatmentHumanUse) -0.51161 0.54318 0.54375 0.941 0.346765  
## cond(TreatmentNatRegen) -0.31886 0.48942 0.48995 0.651 0.515173  
## cond(TreatmentSPP) -1.44744 0.48690 0.48743 2.970 0.002982  
## zi((Int)) -3.82944 2.31413 2.31663 1.653 0.098326  
## cond(VegHt\_sc) 0.48836 0.38281 0.38322 1.274 0.202543  
## cond(pSnow\_sc) -0.46391 0.38131 0.38172 1.215 0.224244  
## cond(LineWidth\_sc) -0.06469 0.37275 0.37316 0.173 0.862377  
##   
## cond((Int)) \*\*\*  
## cond(LD750\_sc) \*   
## cond(low2000\_sc) \*\*\*  
## cond(ActiveDays\_sc) \*\*\*  
## cond(TreatmentHumanUse)   
## cond(TreatmentNatRegen)   
## cond(TreatmentSPP) \*\*   
## zi((Int)) .   
## cond(VegHt\_sc)   
## cond(pSnow\_sc)   
## cond(LineWidth\_sc)   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Relative variable importance:   
## cond(ActiveDays\_sc) cond(LD750\_sc) cond(low2000\_sc)  
## Importance: 1.00 1.00 1.00   
## N containing models: 5 5 5   
## cond(Treatment) cond(VegHt\_sc) cond(pSnow\_sc)  
## Importance: 1.00 0.38 0.37   
## N containing models: 5 2 2   
## cond(LineWidth\_sc)  
## Importance: 0.11   
## N containing models: 1

### Predictor Effect Sizes

## Warning: Removed 3 rows containing missing values (geom\_point).

## Warning: Removed 3 rows containing missing values (geom\_errorbar).



## Exploring Interactions

Interaction coefficients describe how much the slope of the continuous variable changes at one level of the categorical relative to the reference level Use top model, with Treatment and lowland interacting

## Family: nbinom1 ( log )  
## Formula:   
## WTDeer ~ low2000\_sc + ActiveDays\_sc + Treatment \* LD750\_sc +   
## (1 | Site) + (1 | Month)  
## Zero inflation: ~1  
## Data: det  
##   
## AIC BIC logLik deviance df.resid   
## 1415.7 1486.1 -693.9 1387.7 1114   
##   
## Random effects:  
##   
## Conditional model:  
## Groups Name Variance Std.Dev.  
## Site (Intercept) 0.7837 0.8853   
## Month (Intercept) 0.6850 0.8276   
## Number of obs: 1128, groups: Site, 59; Month, 12  
##   
## Overdispersion parameter for nbinom1 family (): 1.45   
##   
## Conditional model:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) -2.1913 0.4664 -4.699 2.62e-06 \*\*\*  
## low2000\_sc -2.0484 0.3964 -5.168 2.37e-07 \*\*\*  
## ActiveDays\_sc 2.0918 0.5648 3.704 0.000212 \*\*\*  
## TreatmentHumanUse -0.5908 0.4913 -1.202 0.229207   
## TreatmentNatRegen -0.1898 0.4405 -0.431 0.666516   
## TreatmentSPP -1.4420 0.4438 -3.249 0.001159 \*\*   
## LD750\_sc 1.0443 0.5017 2.081 0.037407 \*   
## TreatmentHumanUse:LD750\_sc 1.0015 1.0157 0.986 0.324131   
## TreatmentNatRegen:LD750\_sc 0.6106 0.8885 0.687 0.491925   
## TreatmentSPP:LD750\_sc -1.9610 0.8186 -2.395 0.016600 \*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Zero-inflation model:  
## Estimate Std. Error z value Pr(>|z|)  
## (Intercept) -4.130 3.673 -1.124 0.261

Interpreted as SPP decreasing the main increasing effect of LineDens on detections. Will not include as according to the coplot this effect may be driven by one control site only (high linear density and high number of detections). Also, I did not include this interaction a priori but rather after examining effects of Treatment and LineDens separately.