Ch1\_models\_Wolf

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Based on model selection comparison of underlying distributions and zero-inflation, I chose an nbinom1 distribution for Wolf data, with zero-inflation. 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 500m and linear density measured at 1250m best explained Wolf detections

### 1. Random structure and Active Days

Random structure was previously assessed, but here I will confirm using all model covariates.

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

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

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

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

## dLogLik dAIC df weight  
## r2 47.9 0.0 14 0.946   
## rSite 44.1 5.7 13 0.054   
## rMonth 3.1 87.7 13 <0.001  
## r0 0.0 91.9 12 <0.001  
## rSiteS NA NA 22 NA   
## rMonthS NA NA 22 NA   
## r2S NA NA 32 NA

Random slope models fail to converge, so exclude. Continue modelling with 2 random effects. ## 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 + low500 |
| L3 | Treatment + pSnow |
| L4 | Treatment + LineWidth |
| L5 | Treatment + VegHt |
| L6 | Treatment + LD1250 |
| L7 | Treatment + low500 + pSnow |
| L8 | Treatment + low500 + LineWidth |
| L9 | Treatment + low500 + VegHt |
| L10 | Treatment + low500 + LD1250 |
| L11 | Treatment + pSnow + LineWidth |
| L12 | Treatment + pSnow + VegHt |
| L13 | Treatment + pSnow + LD1250 |
| L14 | Treatment + LineWidth + VegHt |
| L15 | Treatment + LineWidth + LD1250 |
| L16 | Treatment + VegHt + LD1250 |
| L17 | Treatment + low500 + pSnow + LineWidth |
| L18 | Treatment + low500 + pSnow + VegHt |
| L19 | Treatment + low500 + pSnow + LD1250 |
| L20 | Treatment + low500 + LineWidth + VegHt |
| L21 | Treatment + low500 + LineWidth + LD1250 |
| L22 | Treatment + low500 + VegHt + LD1250 |
| L23 | Treatment + pSnow + LineWidth + VegHt |
| L24 | Treatment + pSnow + LineWidth + LD1250 |
| L24 | Treatment + pSnow + VegHt + LD1250 |
| L25 | Treatment + LineWidth + VegHt + LD1250 |
| L26 | Treatment + low500 + pSnow + LineWidth + VegHt |
| L27 | Treatment + low500 + pSnow + LineWidth + LD1250 |
| L28 | Treatment + pSnow + LineWidth + VegHt + LD1250 |
| L29 | Treatment + low500 + LineWidth + vegHt + LD1250 |
| L30 | Treatment + low500 + pSnow + VegHt + LD1250 |
| L31 | Treatment + low500 + pSnow + LineWidth + VegHt + LD1250 |

## dLogLik dAIC df weight  
## 13 8.0 0.0 11 0.1879  
## 14 8.4 1.2 12 0.1045  
## 9 6.3 1.3 10 0.0963  
## 29 8.2 1.6 12 0.0830  
## 15 8.1 1.8 12 0.0759  
## 25 6.7 2.5 11 0.0531  
## 30 8.6 2.7 13 0.0478  
## 11 6.6 2.8 11 0.0454  
## 10 6.4 3.1 11 0.0402  
## 16 8.4 3.1 13 0.0398  
## 31 8.2 3.6 13 0.0316  
## 26 6.9 4.2 12 0.0233  
## 27 6.8 4.3 12 0.0215  
## 5 4.7 4.5 10 0.0200  
## 12 6.6 4.7 12 0.0181  
## 32 8.6 4.7 14 0.0176  
## 6 5.1 5.7 11 0.0108  
## 1 3.1 5.7 9 0.0107  
## Nullmod 0.0 6.0 6 0.0096  
## 28 6.9 6.1 13 0.0091  
## 21 4.9 6.1 11 0.0087  
## 7 4.8 6.3 11 0.0081  
## 17 3.5 7.0 10 0.0058  
## 3 3.4 7.2 10 0.0050  
## 22 5.3 7.3 12 0.0049  
## 2 3.2 7.5 10 0.0044  
## 8 5.2 7.6 12 0.0041  
## 23 4.9 8.1 12 0.0033  
## 18 3.7 8.6 11 0.0025  
## 19 3.6 8.8 11 0.0023  
## 4 3.4 9.1 11 0.0020  
## 24 5.3 9.3 13 0.0018  
## 20 3.7 10.5 12 <0.001

Five models within 2 dAIC points of each other, with model weights between 7 - 18%.

## 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 13 7.975417 0.000000 0.1878892825 0.1878893  
## 2 14 8.388688 1.173458 0.1044933835 0.2923827  
## 3 9 6.306928 1.336978 0.0962899288 0.3886726  
## 4 29 8.158277 1.634280 0.0829893986 0.4716620  
## 5 15 8.068351 1.814132 0.0758522024 0.5475142  
## 6 25 6.712556 2.525722 0.0531432862 0.6006575  
## 7 30 8.607463 2.735908 0.0478417601 0.6484992  
## 8 11 6.555005 2.840824 0.0453967626 0.6938960  
## 9 10 6.432689 3.085455 0.0401701926 0.7340662  
## 10 16 8.423390 3.104054 0.0397983732 0.7738646  
## 11 31 8.192185 3.566463 0.0315830706 0.8054476  
## 12 26 6.889545 4.171743 0.0233356291 0.8287833  
## 13 27 6.809049 4.332735 0.0215308196 0.8503141  
## 14 5 4.733273 4.484288 0.0199595758 0.8702737  
## 15 12 6.636935 4.676964 0.0181264223 0.8884001  
## 16 32 8.608890 4.733054 0.0176251309 0.9060252  
## 17 6 5.120470 5.709893 0.0108146999 0.9168399  
## 18 1 3.106562 5.737710 0.0106653263 0.9275052  
## 19 28 0.000000 5.950834 0.0095872677 0.9370925  
## 20 21 6.945140 6.060554 0.0090754776 0.9461680  
## 21 7 4.902826 6.145182 0.0086994669 0.9548675  
## 22 17 4.825338 6.300159 0.0080508169 0.9629183  
## 23 3 3.489958 6.970918 0.0057568690 0.9686751  
## 24 22 3.353700 7.243434 0.0050235450 0.9736987  
## 25 2 5.324259 7.302316 0.0048778026 0.9785765  
## 26 8 3.220676 7.509482 0.0043978333 0.9829743  
## 27 23 5.155963 7.638907 0.0041222510 0.9870966  
## 28 18 4.938086 8.074662 0.0033152132 0.9904118  
## 29 19 3.652143 8.646548 0.0024907375 0.9929025  
## 30 4 3.589574 8.771686 0.0023396701 0.9952422  
## 31 24 3.426222 9.098389 0.0019870643 0.9972293  
## 32 20 5.326334 9.298166 0.0017981711 0.9990274  
## 33 Nullmod 3.711750 10.527334 0.0009725689 1.0000000  
## EvidenceRatio  
## 1   
## 2 1.79809741204471  
## 3 1.95128696071038  
## 4 2.2640154718015  
## 5 2.47704452239625  
## 6 3.53552247090048  
## 7 3.92730706167055  
## 8 4.13882558448467  
## 9 4.67733088186674  
## 10 4.72102920898513  
## 11 5.94905051990193  
## 12 8.05160560813186  
## 13 8.72652719528464  
## 14 9.4134907467656  
## 15 10.3654918500033  
## 16 10.6603056473769  
## 17 17.3735087476193  
## 18 17.6168340318726  
## 19 19.5977923742949  
## 20 20.7029636207797  
## 21 21.5977927327081  
## 22 23.3379152803878  
## 23 32.6374082760542  
## 24 37.4017315590449  
## 25 38.5192466823488  
## 26 42.7231474068838  
## 27 45.5792924671616  
## 28 56.6748713298471  
## 29 75.4352001823279  
## 30 80.3058877667857  
## 31 94.5562173885424  
## 32 104.489102697562  
## 33 193.188655457757

Examining summaries for top 8 models (2dAIC)

Aside from Treatment and ActiveDays, all 5 models contain pSnow. 4 contain low, 1 each contains LineWidth, VegHt, or LD

### Pretending variables

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

|  |  |  |
| --- | --- | --- |
| Model | Est. + SE of possible pretending variables | Residual Deviance |
| Treat + pSnow + low + ActiveDays |  | 1190.8 |
| Treat + pSnow + low + LD + ActiveDays | LD 0.324 +/- 0.357 | 1190.0 |
| Treat + pSnow + ActiveDays |  | 1194.2 |
| Treat + low + pSnow + LineWidth + ActiveDays | LineWidth 0.164 +/- 0.380 | 1190.6 |
| Treat + pSnow + low + VegHt + ActiveDays | VegHt 0.244 +/- 0.399 | 1190.5 |

### Model averaging

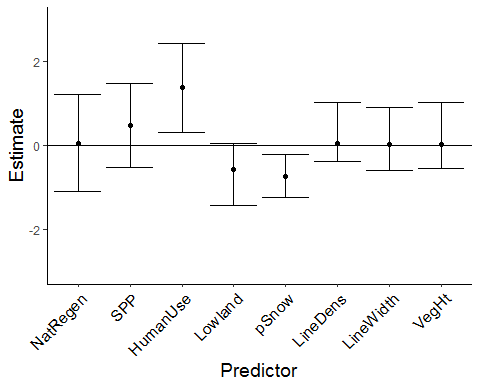
Multiple models are within 2dAIC scores of each other, suggesting that they all explain the data equally well. As my goal is to compare Treatment effects to the effects of other covariates, I do not just want the estimates given in the top model, but rather the best possible estimates for many covariates. 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 = Wolftop)  
##   
## Component model call:   
## glmmTMB(formula = Wolf ~ <5 unique rhs>, data = det, family =   
## nbinom2, ziformula = ~1, dispformula = ~1)  
##   
## Component models:   
## df logLik AICc delta weight  
## 1456 11 -595.41 1213.06 0.00 0.35  
## 12456 12 -595.00 1214.27 1.22 0.19  
## 156 10 -597.08 1214.35 1.30 0.18  
## 14567 12 -595.23 1214.73 1.68 0.15  
## 13456 12 -595.32 1214.91 1.86 0.14  
##   
## Term codes:   
## cond(ActiveDays\_sc) cond(LD1250\_sc) cond(LineWidth\_sc)   
## 1 2 3   
## cond(low500\_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)) -3.34274 0.55294 0.55354 6.039 < 2e-16  
## cond(low500\_sc) -0.57132 0.43380 0.43408 1.316 0.188121  
## cond(pSnow\_sc) -0.72860 0.26289 0.26317 2.769 0.005631  
## cond(ActiveDays\_sc) 2.56084 0.67567 0.67640 3.786 0.000153  
## cond(TreatmentHumanUse) 1.37943 0.54181 0.54239 2.543 0.010983  
## cond(TreatmentNatRegen) 0.06240 0.58940 0.59004 0.106 0.915780  
## cond(TreatmentSPP) 0.47471 0.50857 0.50911 0.932 0.351117  
## zi((Int)) -0.83153 0.59223 0.59287 1.403 0.160752  
## cond(LD1250\_sc) 0.06102 0.20001 0.20014 0.305 0.760460  
## cond(VegHt\_sc) 0.03647 0.17711 0.17725 0.206 0.836968  
## cond(LineWidth\_sc) 0.02237 0.15091 0.15105 0.148 0.882270  
##   
## cond((Int)) \*\*\*  
## cond(low500\_sc)   
## cond(pSnow\_sc) \*\*   
## cond(ActiveDays\_sc) \*\*\*  
## cond(TreatmentHumanUse) \*   
## cond(TreatmentNatRegen)   
## cond(TreatmentSPP)   
## zi((Int))   
## cond(LD1250\_sc)   
## cond(VegHt\_sc)   
## cond(LineWidth\_sc)   
##   
## (conditional average)   
## Estimate Std. Error Adjusted SE z value Pr(>|z|)  
## cond((Int)) -3.3427 0.5529 0.5535 6.039 < 2e-16  
## cond(low500\_sc) -0.6973 0.3766 0.3770 1.849 0.064416  
## cond(pSnow\_sc) -0.7286 0.2629 0.2632 2.769 0.005631  
## cond(ActiveDays\_sc) 2.5608 0.6757 0.6764 3.786 0.000153  
## cond(TreatmentHumanUse) 1.3794 0.5418 0.5424 2.543 0.010983  
## cond(TreatmentNatRegen) 0.0624 0.5894 0.5900 0.106 0.915780  
## cond(TreatmentSPP) 0.4747 0.5086 0.5091 0.932 0.351117  
## zi((Int)) -0.8315 0.5922 0.5929 1.403 0.160752  
## cond(LD1250\_sc) 0.3245 0.3567 0.3571 0.909 0.363515  
## cond(VegHt\_sc) 0.2442 0.3991 0.3996 0.611 0.541025  
## cond(LineWidth\_sc) 0.1639 0.3790 0.3794 0.432 0.665802  
##   
## cond((Int)) \*\*\*  
## cond(low500\_sc) .   
## cond(pSnow\_sc) \*\*   
## cond(ActiveDays\_sc) \*\*\*  
## cond(TreatmentHumanUse) \*   
## cond(TreatmentNatRegen)   
## cond(TreatmentSPP)   
## zi((Int))   
## cond(LD1250\_sc)   
## cond(VegHt\_sc)   
## cond(LineWidth\_sc)   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Relative variable importance:   
## cond(ActiveDays\_sc) cond(pSnow\_sc) cond(Treatment)  
## Importance: 1.00 1.00 1.00   
## N containing models: 5 5 5   
## cond(low500\_sc) cond(LD1250\_sc) cond(VegHt\_sc)  
## Importance: 0.82 0.19 0.15   
## N containing models: 4 1 1   
## cond(LineWidth\_sc)  
## Importance: 0.14   
## 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 pSnow and treatment interacting

## Family: nbinom1 ( log )  
## Formula:   
## Wolf ~ Treatment \* pSnow\_sc + low500\_sc + VegHt\_sc + ActiveDays\_sc +   
## (1 | Site) + (1 | Month)  
## Zero inflation: ~1  
## Data: det  
##   
## AIC BIC logLik deviance df.resid   
## 1219.8 1295.2 -594.9 1189.8 1113   
##   
## Random effects:  
##   
## Conditional model:  
## Groups Name Variance Std.Dev.  
## Site (Intercept) 1.1378 1.0667   
## Month (Intercept) 0.1704 0.4128   
## Number of obs: 1128, groups: Site, 59; Month, 12  
##   
## Overdispersion parameter for nbinom1 family (): 0.337   
##   
## Conditional model:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) -3.14618 0.50443 -6.237 4.46e-10 \*\*\*  
## TreatmentHumanUse 1.33612 0.52230 2.558 0.0105 \*   
## TreatmentNatRegen -0.08565 0.59010 -0.145 0.8846   
## TreatmentSPP 0.35742 0.49159 0.727 0.4672   
## pSnow\_sc -0.07875 0.37984 -0.207 0.8358   
## low500\_sc -0.68986 0.36612 -1.884 0.0595 .   
## VegHt\_sc 0.28065 0.38999 0.720 0.4718   
## ActiveDays\_sc 2.46224 0.63251 3.893 9.91e-05 \*\*\*  
## TreatmentHumanUse:pSnow\_sc -0.77004 0.41036 -1.876 0.0606 .   
## TreatmentNatRegen:pSnow\_sc -0.94461 0.71154 -1.328 0.1843   
## TreatmentSPP:pSnow\_sc -0.98432 0.40958 -2.403 0.0162 \*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Zero-inflation model:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) -0.6439 0.3227 -1.995 0.046 \*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

This indicates that the main effect of snow on wolf detections decreases on HumanUse, NatRegen, and SPP lines relative to effect of snow on control. This would mean that the negative effect of snow on wolf detections is slightly offset by HumanUse lines