Ch1\_models\_caribou

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Based on model selection comparison of underlying distributions and zero-inflation, I chose an nbinom1 distribution for Caribou data, with zero-inflation and ActiveDays in the ZI model (see Ch1\_Caribou\_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 and linear density measured at 1750m best explained Caribou 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')

## 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 9.3 0.0 14 0.7568  
## rSite 7.1 2.3 13 0.2413  
## rMonth 1.9 12.6 13 0.0014  
## r0 0.0 14.5 12 <0.001

Random slope models fail to converge, so exclude. Continue modelling with 2 random effects. (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 + low1750 |
| L3 | Treatment + pSnow |
| L4 | Treatment + LineWidth |
| L5 | Treatment + VegHt |
| L6 | Treatment + LD1750 |
| L7 | Treatment + low1750 + pSnow |
| L8 | Treatment + low1750 + LineWidth |
| L9 | Treatment + low1750 + VegHt |
| L10 | Treatment + low1750 + LD1750 |
| L11 | Treatment + pSnow + LineWidth |
| L12 | Treatment + pSnow + VegHt |
| L13 | Treatment + pSnow + LD1750 |
| L14 | Treatment + LineWidth + VegHt |
| L15 | Treatment + LineWidth + LD1750 |
| L16 | Treatment + VegHt + LD1750 |
| L17 | Treatment + low1750 + pSnow + LineWidth |
| L18 | Treatment + low1750 + pSnow + VegHt |
| L19 | Treatment + low1750 + pSnow + LD1750 |
| L20 | Treatment + low1750 + LineWidth + VegHt |
| L21 | Treatment + low1750 + LineWidth + LD1750 |
| L22 | Treatment + low1750 + VegHt + LD1750 |
| L23 | Treatment + pSnow + LineWidth + VegHt |
| L24 | Treatment + pSnow + LineWidth + LD1750 |
| L24 | Treatment + pSnow + VegHt + LD1750 |
| L25 | Treatment + LineWidth + VegHt + LD1750 |
| L26 | Treatment + low1750 + pSnow + LineWidth + VegHt |
| L27 | Treatment + low1750 + pSnow + LineWidth + LD1750 |
| L28 | Treatment + pSnow + LineWidth + VegHt + LD1750 |
| L29 | Treatment + low1750 + LineWidth + vegHt + LD1750 |
| L30 | Treatment + low1750 + pSnow + VegHt + LD1750 |
| L31 | Treatment + low1750 + pSnow + LineWidth + VegHt + LD1750 |

## dLogLik dAIC df weight  
## 14 27.3 0.0 12 0.2249  
## 13 26.1 0.3 11 0.1911  
## 30 27.8 1.0 13 0.1366  
## 29 26.6 1.4 12 0.1129  
## 16 27.4 1.8 13 0.0928  
## 32 28.2 2.1 14 0.0796  
## 15 26.2 2.1 12 0.0786  
## 31 27.1 2.5 13 0.0658  
## 6 22.3 7.9 11 0.0044  
## 5 21.0 8.6 10 0.0031  
## 22 22.7 9.1 12 0.0024  
## 8 22.6 9.4 12 0.0020  
## 24 23.4 9.7 13 0.0017  
## 21 21.4 9.8 11 0.0017  
## 7 21.2 10.1 11 0.0014  
## 23 22.0 10.5 12 0.0012  
## 25 13.9 24.7 11 <0.001  
## 26 14.1 26.3 12 <0.001  
## 27 14.0 26.5 12 <0.001  
## 9 12.0 26.7 10 <0.001  
## 11 12.7 27.3 11 <0.001  
## 28 14.2 28.1 13 <0.001  
## 10 12.1 28.3 11 <0.001  
## 12 12.8 28.9 12 <0.001  
## 17 8.0 34.5 10 <0.001  
## 18 8.3 36.0 11 <0.001  
## 1 6.2 36.2 9 <0.001  
## 19 8.1 36.3 11 <0.001  
## 3 6.8 37.0 10 <0.001  
## 2 6.4 37.8 10 <0.001  
## 20 8.3 37.9 12 <0.001  
## 4 7.0 38.6 11 <0.001  
## Nullmod 0.0 42.6 6 <0.001

Five models within 2 dAIC points of each other, with model weights between 9 - 22%.

## 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 14 27.279944 0.0000000 2.248796e-01 0.2248796  
## 2 13 26.117004 0.3258787 1.910673e-01 0.4159468  
## 3 30 27.781085 0.9977172 1.365521e-01 0.5524989  
## 4 29 26.591128 1.3776307 1.129279e-01 0.6654268  
## 5 16 27.394784 1.7703188 9.279619e-02 0.7582230  
## 6 32 28.240996 2.0778965 7.956837e-02 0.8377914  
## 7 15 26.228773 2.1023406 7.860180e-02 0.9163932  
## 8 31 27.050444 2.4590005 6.576348e-02 0.9821567  
## 9 6 22.338165 7.8835569 4.365735e-03 0.9865224  
## 10 5 20.985547 8.5887945 3.068435e-03 0.9895909  
## 11 22 22.747081 9.0657263 2.417422e-03 0.9920083  
## 12 8 22.574317 9.4112535 2.033866e-03 0.9940421  
## 13 24 23.407462 9.7449638 1.721306e-03 0.9957634  
## 14 21 21.370829 9.8182300 1.659390e-03 0.9974228  
## 15 7 21.209268 10.1413513 1.411834e-03 0.9988347  
## 16 23 22.014866 10.5301556 1.162400e-03 0.9999971  
## 17 25 13.930374 24.6991388 9.740923e-07 0.9999980  
## 18 26 14.146586 26.2667150 4.448415e-07 0.9999985  
## 19 27 14.013418 26.5330511 3.893777e-07 0.9999989  
## 20 9 11.953161 26.6535661 3.666077e-07 0.9999992  
## 21 11 12.650484 27.2589203 2.708636e-07 0.9999995  
## 22 28 14.225000 28.1098884 1.769967e-07 0.9999997  
## 23 10 12.145688 28.2685116 1.635011e-07 0.9999999  
## 24 12 12.822568 28.9147518 1.183563e-07 1.0000000  
## 25 17 8.042959 34.4739701 7.345519e-09 1.0000000  
## 26 18 8.281747 35.9963936 3.431092e-09 1.0000000  
## 27 1 6.156871 36.2461457 3.028304e-09 1.0000000  
## 28 19 8.105448 36.3489905 2.876517e-09 1.0000000  
## 29 3 6.782396 36.9950949 2.082415e-09 1.0000000  
## 30 2 6.369866 37.8201555 1.378502e-09 1.0000000  
## 31 20 8.339055 37.8817779 1.336677e-09 1.0000000  
## 32 4 6.973745 38.6123977 9.276291e-10 1.0000000  
## 33 Nullmod 0.000000 42.5598875 1.288807e-10 1.0000000  
## EvidenceRatio  
## 1   
## 2 1.17696532412484  
## 3 1.64684049453493  
## 4 1.99135508218178  
## 5 2.42337065147264  
## 6 2.82624294030177  
## 7 2.86099742172238  
## 8 3.41952014755503  
## 9 51.5101272825469  
## 10 73.2880252609762  
## 11 93.0245220569289  
## 12 110.567563344124  
## 13 130.644760623985  
## 14 135.51942607356  
## 15 159.281906678765  
## 16 193.461364072109  
## 17 230860.614728904  
## 18 505527.388325742  
## 19 577535.707952542  
## 20 613406.451704891  
## 21 830231.750458856  
## 22 1270529.3989178  
## 23 1375400.87020993  
## 24 1900021.74626269  
## 25 30614522.5222879  
## 26 65541676.8246247  
## 27 74259246.0421405  
## 28 78177721.3839269  
## 29 107989810.82702  
## 30 163133227.518835  
## 31 168237786.098683  
## 32 242424004.478266  
## 33 1744866277.81755

Examining summaries for top 5 models (2dAIC)

In addtion to Treatment and ActiveDays, all 5 models contain pSnow and lowland. 3 contain LD, 2 contain 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 + pSnow + LD + ActiveDays |  | 597.5 |
| Treat + low + pSnow + ActiveDays |  | 599.8 |
| Treat + low + LD + pSnow + VegHt + ActiveDays | VegHt -0.85 +/- 0.88 | 596.5 |
| Treat + low + pSnow + VegHt + ActiveDays | VegHt -0.80 +/- 0.85 | 598.9 |
| Treat + low + LD LineWidth + ActiveDays | LineWidth 0.21 +/- 0.44 | 597.2 |

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

### Model averaging

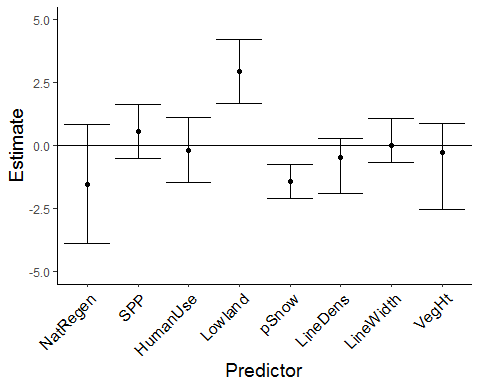
Multiple models are within 2dAIC scores of each other, suggesting that they all explain the data equally well. As my goal is to compare Treatment effects to the effects of other covariates, I do not just want the estimates given in the top model, but rather the best possible estimates for many covariates. 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 = Cariboutop)  
##   
## Component model call:   
## glmmTMB(formula = Caribou ~ <5 unique rhs>, data = det, family =   
## nbinom1, ziformula = ~1, dispformula = ~1)  
##   
## Component models:   
## df logLik AICc delta weight  
## 12456 12 -298.74 621.75 0.00 0.30  
## 1456 11 -299.90 622.04 0.28 0.26  
## 124567 13 -298.24 622.80 1.04 0.18  
## 14567 12 -299.43 623.13 1.38 0.15  
## 123456 13 -298.62 623.57 1.82 0.12  
##   
## Term codes:   
## cond(ActiveDays\_sc) cond(LD1750\_sc) cond(LineWidth\_sc)   
## 1 2 3   
## cond(low1750\_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)) -4.42817 0.67760 0.67834 6.528 < 2e-16  
## cond(LD1750\_sc) -0.48613 0.58842 0.58876 0.826 0.4090  
## cond(low1750\_sc) 2.95036 0.64233 0.64300 4.588 4.5e-06  
## cond(pSnow\_sc) -1.43094 0.34751 0.34788 4.113 3.9e-05  
## cond(ActiveDays\_sc) 1.62402 0.94060 0.94162 1.725 0.0846  
## cond(TreatmentHumanUse) -0.17315 0.66269 0.66341 0.261 0.7941  
## cond(TreatmentNatRegen) -1.52252 1.20269 1.20399 1.265 0.2060  
## cond(TreatmentSPP) 0.55359 0.54887 0.54947 1.007 0.3137  
## zi((Int)) -17.33585 5142.49336 5148.07654 0.003 0.9973  
## cond(VegHt\_sc) -0.26889 0.62832 0.62875 0.428 0.6689  
## cond(LineWidth\_sc) 0.02524 0.16685 0.16700 0.151 0.8799  
##   
## cond((Int)) \*\*\*  
## cond(LD1750\_sc)   
## cond(low1750\_sc) \*\*\*  
## cond(pSnow\_sc) \*\*\*  
## cond(ActiveDays\_sc) .   
## cond(TreatmentHumanUse)   
## cond(TreatmentNatRegen)   
## cond(TreatmentSPP)   
## zi((Int))   
## cond(VegHt\_sc)   
## cond(LineWidth\_sc)   
##   
## (conditional average)   
## Estimate Std. Error Adjusted SE z value Pr(>|z|)  
## cond((Int)) -4.4282 0.6776 0.6783 6.528 < 2e-16  
## cond(LD1750\_sc) -0.8199 0.5571 0.5577 1.470 0.1415  
## cond(low1750\_sc) 2.9504 0.6423 0.6430 4.588 4.5e-06  
## cond(pSnow\_sc) -1.4309 0.3475 0.3479 4.113 3.9e-05  
## cond(ActiveDays\_sc) 1.6240 0.9406 0.9416 1.725 0.0846  
## cond(TreatmentHumanUse) -0.1731 0.6627 0.6634 0.261 0.7941  
## cond(TreatmentNatRegen) -1.5225 1.2027 1.2040 1.265 0.2060  
## cond(TreatmentSPP) 0.5536 0.5489 0.5495 1.007 0.3137  
## zi((Int)) -17.3359 5142.4934 5148.0765 0.003 0.9973  
## cond(VegHt\_sc) -0.8265 0.8675 0.8685 0.952 0.3413  
## cond(LineWidth\_sc) 0.2108 0.4398 0.4402 0.479 0.6320  
##   
## cond((Int)) \*\*\*  
## cond(LD1750\_sc)   
## cond(low1750\_sc) \*\*\*  
## cond(pSnow\_sc) \*\*\*  
## cond(ActiveDays\_sc) .   
## cond(TreatmentHumanUse)   
## cond(TreatmentNatRegen)   
## cond(TreatmentSPP)   
## zi((Int))   
## 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(low1750\_sc) cond(pSnow\_sc)  
## Importance: 1.00 1.00 1.00   
## N containing models: 5 5 5   
## cond(Treatment) cond(LD1750\_sc) cond(VegHt\_sc)  
## Importance: 1.00 0.59 0.33   
## N containing models: 5 3 2   
## cond(LineWidth\_sc)  
## Importance: 0.12   
## 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 lowland and treatment interacting

## Family: nbinom1 ( log )  
## Formula:   
## Caribou ~ Treatment \* low1750\_sc + pSnow\_sc + LD1750\_sc + ActiveDays\_sc +   
## (1 | Site) + (1 | Month)  
## Zero inflation: ~1  
## Data: det  
##   
## AIC BIC logLik deviance df.resid   
## 625.2 700.6 -297.6 595.2 1113   
##   
## Random effects:  
##   
## Conditional model:  
## Groups Name Variance Std.Dev.  
## Site (Intercept) 0.8377 0.9153   
## Month (Intercept) 0.1701 0.4124   
## Number of obs: 1128, groups: Site, 59; Month, 12  
##   
## Overdispersion parameter for nbinom1 family (): 0.961   
##   
## Conditional model:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) -4.9984 0.9909 -5.044 4.55e-07 \*\*\*  
## TreatmentHumanUse 0.6857 1.0792 0.635 0.5252   
## TreatmentNatRegen -1.2289 1.7593 -0.699 0.4849   
## TreatmentSPP 1.2489 0.9219 1.355 0.1755   
## low1750\_sc 5.6002 2.5027 2.238 0.0252 \*   
## pSnow\_sc -1.4294 0.3469 -4.120 3.78e-05 \*\*\*  
## LD1750\_sc -0.6950 0.5774 -1.204 0.2287   
## ActiveDays\_sc 1.6206 0.9426 1.719 0.0855 .   
## TreatmentHumanUse:low1750\_sc -3.1078 2.7693 -1.122 0.2618   
## TreatmentNatRegen:low1750\_sc -1.1906 5.6208 -0.212 0.8322   
## TreatmentSPP:low1750\_sc -2.9364 2.5751 -1.140 0.2542   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Zero-inflation model:  
## Estimate Std. Error z value Pr(>|z|)  
## (Intercept) -17.76 6173.39 -0.003 0.998

Although not significant, this indicates that the main effect of lowland habitat on caribou detections decreases on HumanUse, NatRegen, and SPP lines relative to effect of lowland on control.