Contents

Chapter 2

Method and materials

2.1 Study species

The species I'll focus on in this thesis are the species that most frequently was observed *(>50 events)*, excluding farmed animals (e.g. cattle), humans and dogs, and grouped categories of animals (e.g. birds). Given that the decisions on cameras placement (height and angle) were made with photo capturing lynx() in mind, I have also excluded smaller species from the analysis. This includes three species, squirrel(), hare() and European pine marten*(Martes martes)*. Though they showed up frequently on many locations, there are inevitably some cameras that are too biased towards larger animals, resulting in an inconsistency of their detection rates. In turn, it is difficult to distinguish whether the species was affected by the white LED or not, as they could have triggered the camera, but already escaped the frame.

In the end, the species I have used in my analyses are roe deer*()*, red fox*()*, badger*(Meles meles)*, moose*()*, red deer*(Cervus elaphus)* and lynx.

2.2 Study area

The study area (59.36-60.47° N, 9.43-10.91° E) extends over much of the southeastern parts of Norway in counties Flå, Krødsherad, Sigdal, Ringerike, Modum, Hole, Lier, Øvre Eiker, Asker, Oslo, Enebakk, Indre Østfold, Våler, Råde, Moss, Frogn and Vestby. The climate has a continental character due to rain shadows of the mountain ridges from the west.

The mean annual temperatures ranges from 2-6℃and precipitation lies between 700-1500mm (Moen 1999). Topography is predominantly flat towards the south, and more rugged and elevated towards the north. The landscape is a mosaic of forest and agricultural areas, divided with a wide network of gravel roads. The area is situated in the southern boreal and the boreonemoral zones.

Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*) make up the dominating boreal coniferous forests, with frequent presence of silver birch (*Betula pendula*) and downy birch (*Betula pubescens*), then aspen (*Populous tremula*), alder (*Alnus incana*) and black alder (*Alnus glutinosa*).

Growing season length 170 - 190 days (Moen, 1999, map 6, s.21) Snow cover length

Most cameras were set in forest areas, usually by a tractor path or human trail, sometimes by animal paths. Their distance from houses or roads varied to a large extent, and some areas were logged (ved Vansjø) and even greatly changed under development of new infrastructure (toglinje på nordligste kamera 1255)

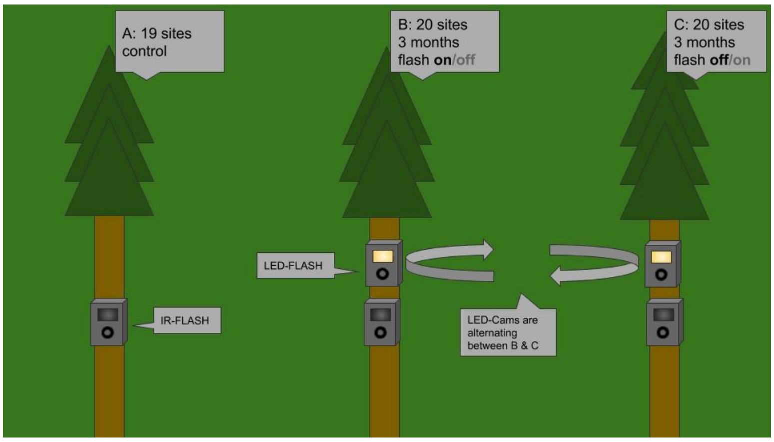

Figure 2.1: Experiment setup

2.3 Study design

For the study I chose 60 already established camera sites with infrared light(Reconyx and Browning models), in order to have a reference of capture frequencies. The cameras had been installed on trees 1-3 meters from human or tractor paths, 40-120 cm above ground level, with the original aim to photo capture lynx (Odden 2015). I divided the sites randomly into three groups of 20 cameras. Cameras in group A remained unchanged, whilst group B and C were equipped with an additional white LED camera (Reconyx PC850) in alternating 3 month-periods, as shown in figure 2.1.

The preinstalled cameras were set up and handled by people from the Norwegian Institute of Nature Research (NINA) and — at the sites further from Oslo — by members of the Norwegian Hunters and Fishers Society (NJFF). Thus, the installation of the cameras did not follow a strict protocol, nor were their locations chosen randomly. The overall placement was systematic as decided by NINA, then there was a deliberately-biased placement of the CTs put up in areas where the individual handler deemed it most likely to photograph lynx, and hence, based on a combination of site accessibility and expectations of animal occurence (Burton et al. 2015).

As shown in figure 2.1, I set up all white LED cameras above the cameras already in place. However, at the particular site shown in figure 2.2c on the facing page the infrared camera had been installed so far above ground level that I chose to position the white LED camera below the camera already in place. For the periods without white flash treatment, I moved the cameras to their next site. However, the boxes installed on the trees remained (see figure 2.2d). First, I equipped Group B with white LED in a 3 week period from January - February 2019. The boxes remained untill the end of the experiment. Group C, on the other hand, had no extra boxes before the start of the second period in May 2019 (i.e. remained identical to the control group A untill May).

I visited sites of group B and C at least once every three months in order to move the LED cameras. For convenience I visited sites of group A less often. However, as the cameras were part of other, ongoing projects, they were occasionally visited by other workers from NINA to retreive the Secure Digital memory cards (hereby SD Cards) for data. This was mostly the case for sites close to, and south of, Oslo, or rather, the cameras not normally operated by members of the NJFF.

(a) Browning infrared,
installed on a fallen tree

(b) Reconyx infrared,
installed with a snow cap

(c) Reconyx infrared above,
installed 160 cm above ground level

(d) Browning infrared,
white LED flash has just been removed

Figure 2.2: The preinstalled cameras varied in the way they were set up. Lower cameras with infrared, upper cameras with white LED (except in example c)

Table 2.1: Camera models

Producent	Model name	Flash type	Trigger speed	N
	HC500 Semi-Covert IR	IR	0.2s	?
Reconyx	HC600 High-Output Covert IR	Black	0.2s	?
HyperFire	PC800 Profoessional Semi-Covert IR	IR	0.2s	?
Series	PC900 Professional Covert IR	Black	0.2s	?
	PC850 Professional White Flash LED	White	0.2s	20
Browning	Spec Ops: Extreme	IR	0.7s	24

2.4 Data Collection

Five different models of RECONYX™ (address: 3828 Creekside Ln, Ste 2, Holmen, WI 54636, USA, www.reconyx.com) cameras were used, and one model of BROWNING™ (address: One Browning Place, Morgan, UT 84050, USA, www.browningtrailcameras.com) 2.1.

Reconyx-cameras have been reported of having an average trigger speed of 0.2 seconds, whereas the Browning model was reported an average of 0.7 seconds (Trigger speed shootout, Trailcampro 2014).

Cameras were operating 24 hours per day. The RECONYX™ cameras were set to take one time lapse photo per day in order to verify that the cameras had been operational. The cameras were programmed to have highest possible sensitivity, as described in Odden 2015. They were set to take 3 pictures per series, as fast as possible using *rapidfire*, and retrigger immediately using *no delay*. At the start of the study, I adjusted the BROWNING™ camera settings from 3 to 8 photos per trigger, in order to gather more data on behavioural responses to the white LED flash stimuli. However, behavioural responses are beyond the scope of this study.

Unfortunately, with such data heavy settings, memory cards are more vulnerable to filling up before being collected, in areas with sheep and cattle, or when cameras get triggered by grass or branches blowing in the wind. Therefore, the BROWNING™ cameras, which also happen to be the northernmost cameras, tended to have more gaps of inoperable days.

Whenever I noticed vegetation blocking the view of the camera, or excessively triggering it, I removed the vegetation.

2.5 Data processing

All SD cards were delivered to NINA for data collection. Firstly, a facial recognition algorithm (FRA) is used to sort all the pictures. Afterwards, a human sorter checks the softwares' output, confirming all the correct decisions (i.e. species detections) and correcting all the wrong ones. The goal is to fully automate this process, which is a request from The Norwegian Data Protection Authority (DPA) in relation to usage of cameras in densely crowded areas (e.g. parks). As per the four eyes principle, the detection rate of photographed species has gone up as a result of the FRA (pers.comm. John Odden).

The output I got as a result, was a data frame containing a time stamp for every shutter activity, including all meta data from the camera, coupled with predicted species (FRA output, with a confidence number), verified species (by human sorters), number of animals and distance from camera. The time stamps from the white flash cameras were used to verify whether an animal was in fact flashed or not, which I then used as my main predictor in the modelling.

I defined one event as any 1 species passing with a buffer time of 5 min before or after

The true number of active camera days are confounded by the inconvenient lack of time lapse photos from the Browning cameras. To approach the true number of active days, I assumed all Browning cameras to be functional every day, unless the camera was inactive when I visited it. In that case, I considered the camera inactive since the day of its last photo.

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Hypothesis 1: Usage of white LED flash will stress one or more species in general, and therefore lower the detection rate of the stressed species. The effect will likely vary in extent between species.

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Hypothesis 2: The effect of the white LED will correlate with urbanisation-factors, as individuals that live closer to urban areas are habituated to Artificial Light At Night (ALAN), and thus will have a weaker response to the white LED

2.6 Statistical analysis

To test for effects of the white LED flash I used the R programming language (R Core Team 2020), in the RStudio IDE (RStudio Team 2020). Session info in appendix **??**. If my significance tests gave a $p = 0.05$, I would consider it significant, although there is nothing magical about an $\alpha = 0.05$ as has been noted by many before me **IeC {\textbullet }** .

To test H_1 I looked for differences in mean detection rate per day, using Generalised Linear Mixed Models (GLMM) with the R package lme4 ((**IeC {\textbullet }**). White LED present/absent was the predictor, while location ID and month was used as random factors, to control for underlying differences between sites, and seasonal changes.

In addition, I used a Cox proportional hazards regression model (CPH model) (Cox, 1972), as a time to event analysis. Also called Survival analysis, the model compares groups' risk of experiencing an event (the *hazard ratio* between the groups) , and was first developed for use in medicinal studies (e.g. cancer risk studies).

I used the CPH model to elaborate on the effect of the white LED by checking whether *confirmed* events of a flashed species affected the time untill said species' *re*detection. The coxme() function from the coxme package (**coxme-package)**) was used to include random effect arguments.

Then, to test for H_2, I performed a new Cox PH, without the random effects, and looked for a interaction between the flashed-variable, and a spatial covariate for distance to nearest ALAN. For this, I used the coxph() function from R package Survival (Therneau 2020).

For the GLMM, I used a XX as p-test For the Cox model, I used the Wald test as the significance test, with xyz distribution over df degrees of freedom. osvosv.

The XX was used to check assumptions for GLMM

The Schoenfeld test was used to check for the survival model's assumption of proportional hazards.

Chapter 3

Results

In the end I had XXXX operational camera trap days, where XXX in the control group A, YYY in group B and ZZZ in group C. Pooled together, group B and C had MMM days with an additional white LED camera (flash = TRUE), and NNN days with only an IR camera (flash = FALSE).

Of all the detected species, the most common were roe deer(), red fox(), hare(), badger(), moose(), squirrel(), red deer() and European pine marten(). There were BBBBB photos of nothing, where 9000 were time lapses (reconyx), the rest of them were continuing series, likely triggered by vegetation in front of the trigger (GGG events, HHH photoseries), or single events (CCC).

3.0.1 Number of pictures taken or whatnot

There were a peak number of photos taken between april and october, when excluding photos of "nothing" from the count. January and February are incomplete months, in both 2019 and 2020, and hence cannot be fairly compared to the other months in this barplot.

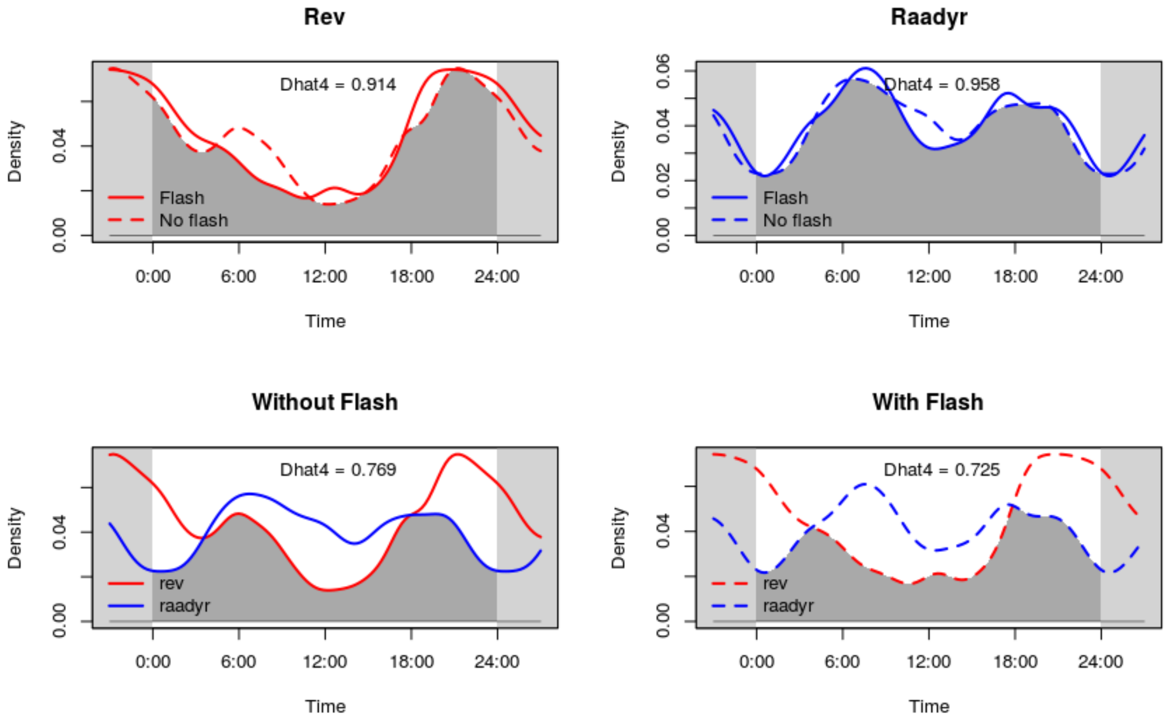
3.1 Overlap analysis

For foxes, sites with only IR flash produced a more rugged curve than did the sites with a white LED flash. Proportion of foxes at sites were markedly lower before sunrise, and then higher afterwards. Interestingly, there were more datapoints from the IR sites, which would usually produce smoother curves, by picking up less random variation. There is a resembling phenomenon happening in the evening twilight as well, right before the peak time of activity before midnight.

The Dhat4 calculation reveals a larger difference in overlap for foxes, than for roe deer, but this seems to mainly stem from the twilight hours.

Table 3.1: Table with kable

	A Control	B IR	B LED	C IR	C LED
elg	128	78	90	75	57
grevling	217	123	254	254	125
raadyr	608	271	249	396	395
rev	257	152	202	195	160



3.2 Box plots

There were no significant changes in frequencies of any of the most common species when a white LED was present compared to when it was absent. Perhaps a slight trend towards higher frequencies in the white LED periods inside each group, but not when compared to the control group.

3.3 Time to event analysis

I ran a survival analysis on the data to see whether the presence of a white LED flash affected the time to event for any species. Assuming the white LED stresses an animal, it would be natural to expect that the animal would shy away from the area, thus decreasing the chance of said animal reappearing. In turn, one could expect longer intervals between each detection of the species.

Having seen several examples of both foxes and roe deer getting startled by the white LED, and fleeing, my expectation was to find a significant decrease in detections of both these species. However, the opposite seems to have happened, especially for the red fox. There is a slightly shorter time to event

Unmarked species makes it hard to estimate the extent of the effect, but as long as the species density isn't too large,

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