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Personality differences among domestic cats (*Felis catus*) in Norway and how they affect home range size

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Abstract

Research on animal personalities has greatly increased in the last few decades, revealing it as an influential contribution to survival and space utilisation. Domestic cats pose a risk to wildlife through disease transmission and predation. The aim of this study was to **1)** investigating and describing patterns in owner-reported personality of domestic cats living in Norway, **2)** investigating whether these patterns are linked with intrinsic factors or extrinsic factors, and **3)** researching whether owner-reported cat personality is related to behaviour, specifically home range size (95% and 50% kernel density estimates (KDE)). It also suggests non-invasive measures to reduce contact between cats and wildlife.

Recruited through social media, participating cat owners completed a questionnaire about their cats and its personality and received GPS equipment to track the cat. Participants rated 16 personality traits on a 5-point Likert scale on whether the trait fit their cat or not. Through PCA analysis, two clusters of personality traits were identified, and the traits energetic and confident were selected from each cluster for logistic regression. As a result of model averaging (candidate models with $\Delta AIC<2$), a cat's personality being reported as energetic increased significantly when cats required owners to manually open the door to go out, compared to having a cat flap. No significant effects were found through model averaging for the personality trait confident, but a negative trend was observed where confidence in males decreased with age.

No significant effect of personality was found for home range, 95% KDE, only a significant decrease with age, and a significant increase in rural areas compared to urban. For the core area, 50% KDE, the significant effects were a decrease with age, a decrease when cats were manually released outdoors, and an increase as an interaction between age and energetic personality.

This study suggests installing cat flaps as a non-invasive way of reducing the core area of cats, as well as the possibility of restricting energetic cats' outdoor hours. By reducing the home range and core area of cats, disease transmission between cats and wildlife may decrease as well as predation rates on wild and potentially endangered species.

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Introduction

Animal personality is defined by systematic differences in behavioural tendencies and emotions, across time and situations (Reale et al. 2007, referenced in Wat et al., 2020; Wolf & Weissing, 2012). One of the first written records of animal emotions was provided by Charles Darwin in the book *The expression of the emotions in man and animal* (Darwin, 1872). However, animal personalities were not given much research attention until the last few decades; the study by Stevenson-Hinde (1978) is regarded as one of the first studies to research animal personality, discovering three personality dimensions in rhesus monkeys (Gosling & John, 1999; Stevenson-Hinde & Zunz, 1978). Since then, the existence of animal personalities has been increasingly acknowledged by the scientific community and has resulted in subsequent studies on variation in animal personalities.

The two most common methods of collecting personality data are the coding method, based on observations during behavioural tests, and the rating method, based on questionnaires with an animal being rated on a scale from "not observed" to "always observed" behaviour by people who know the animal well (De Azevedo & Young, 2021). The rating method as a test for personality in animals has increased in popularity in recent years (Litchfield et al., 2017). A benefit of the rating method is that more animals can be included in the study at a relatively low costs (De Azevedo & Young, 2021; Ha & Ha, 2017). However, a questionnaire is subjective, and does not involve a standardised ethogram used in behavioural observation studies carried out by an observer. This raises the concern of applying anthropomorphism to the animals (Gosling & John, 1999; Weiss et al., 2012).

Using the rating and coding methods, scientists have been able to define several personality dimensions in animals and have identified the costs and benefits of variation in personalities. A common measure for personality is the bold-shy continuum, where bold personalities are quicker at approaching novel objects, are more active and express more exploratory behaviour (Wilson et al. (1994) cited in Brown et al., 2007). The bold-shy continuum is easily tested through the coding method and tests such as a novel object test (Carter et al., 2013). Aggressive and bold behaviour and personality has been positively related to food intake (Biro & Stamps, 2008). Yet, studies have found that a bold personality may put the individual at higher predation risk, and reduce survival rate (Réale et al., 2010). Hence, a more careful individual showing more anti-predator behaviour will be better at avoiding dangers and have a higher chance of

surviving predators. However, they may have a harder time finding food, as they do not take the same risks as bolder individuals.

Although personality is individual differences, there is still evidence that it is related to intrinsic (sex, age etc.) and extrinsic (environment, previous experience etc.) factors. For example, females were found to be less aggressive than males in both Cheetahs (*Acinonyx jubatus*) (Razal et al., 2016) and domestic dogs (*Canis familiaris*), and dogs ages 6-8 years were also found to be more aggressive than other age groups (Wallis et al., 2020). This underlines the importance of intrinsic factors on personality. The importance of extrinsic factors is indicated in a study on piglets where individuals reared in poor conditions developed more aggressive behaviour as adults compared to individuals farmed with opportunities to play with other litters and access to pasture (De Jonge et al., 1996).

Personality has also recently been considered a factor influencing home range size (Wat et al., 2020; Wauters et al., 2021). However, only a few studies have investigated this connection to this date (Spiegel et al., 2017; Wauters et al., 2021). The area in which an animal's daily activity takes place is defined as home range, and the area within the home range used most intensely is defined as core area (Powell, 2000). Research on the common brushtail possum (*Trichosurus vulpeculain*) has shown that more explorative individuals have a larger core area than those less exploratory (Wat et al., 2020). The interaction found between personality and sex showed that exploratory females had smaller core areas and home ranges, but in males this effect was reversed, where the exploratory males having larger home ranges and core areas (Wat et al., 2020). In general, males and females in polygynous species are expected to have a different home range size, as male home range size is driven by the access to reproductive females and by territorial defence, while females are motivated by food access (Ecuyer-Dab & Robert, 2004; Wat et al., 2020). Similar drivers for home range have also been observed in domestic cats (Liberg et al., 2000).

Personality has also been proven to influence the success of invasive species. Bold and aggressive personality types have higher success in the invasion process (Chapple et al., 2012). However, once invasion has occurred, individuals successful at finding food will have an advantage for establishing the population, and aggressive behaviour is beneficial in the competition for resources in the final stages of establishment (Fogarty et al., 2011; Sih et al., 2012). Domestic cats (*Felis* catus) are by many perceived as an invasive species, and are the reason for at least 63 vertebrate extinctions (Loss & Marra, 2017). It is estimated that between 100-350 million birds in Canada are killed by cats each year (Blancher, 2013). However,

domestic cats are an invasive species that usually do not rely on hunting for survival, as food is provided by owners. Yet, due to the short domestication process of cats, the hunting instinct their ancestors remains still intact (Bradshaw, 2006). Suggestions like collars with bells, castrating/neutering, or strictly keeping cats indoors at all times have been made in order to prevent the detrimental consequences that domestic cats impose on wildlife (Cecchetti et al., 2020).

This study focused on partially free-ranging domestic cats (*Felis catus*) in Norway. With cat owners as citizen scientists, the cats were GPS tracked to establish home range size. A questionnaire was used to obtain owner-reported personalities of the cats.

The objectives of this study were to **1)** investigate and describe patterns in owner-reported personality of domestic cats living in Norway, and **2)** whether these patterns are linked with intrinsic factors (e.g., age, sex, etc) or extrinsic factors (e.g., type of neighbourhood, number of cats in household, presence of a dog, etc.). Finally, I **3)** investigated whether owner-reported cat personality is related to behaviour, specifically home range size.

Materials and Methods

Study System

My research was part of the project "Kattesporet" (translated: Cat Tracks), which started in 2019 and is still ongoing. Its purpose is to use citizen scientists, including children, to track partially free-ranging domestic cats and quantify their spatial behaviour in Norway. Additionally, the project aims to involve school children (1st - 7th grade) in hands-on research, thereby promoting greater engagement in and motivation for science. As part of the "Kattesporet" project my study focused on cat personality, behaviour, and spatial use. The data collection for my study took place in autumn 2019 and autumn 2020.

The study took place on mainland Norway within a large latitudinal range (57-71° N), (Kartverket, n.d.). Climate and habitats vary among the study sites in Norway where cats were tracked. The west coast of Norway experiences higher humidity, more rainfall and milder temperatures compared to the eastern regions. The northern regions of Norway experiences colder winters in addition to the coastal climate (Dannevig & Harstveit, 2021). Most of the cats involved in the study lived in either the Oslo area of eastern Norway or in coastal or near-coastal regions, with a few exceptions of cats living in inland-regions (Figure 1).

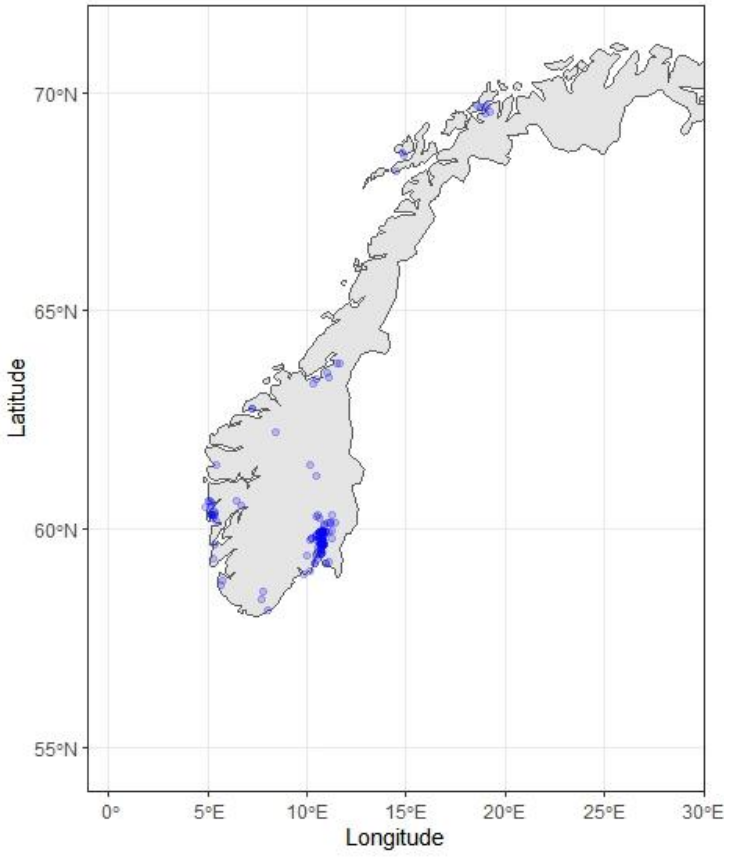

***Figure 1**: Map of Norway, with the coordinates for the home of each cat marked as blue points. Areas appearing in darker blue indicates a higher density of participating cats living there.*

The cats lived in either urban, suburban, or rural areas. In this study, urban was defined as a highly developed area, with little access to agricultural land or forests. Suburban was defined as larger areas with houses grouped together, and gardens sharing borders. However, some suburban areas were close to agricultural land or forests. Rural areas were defined as houses mainly surrounded

by agricultural land or forests, with a larger distance to the nearest neighbour, compared to suburban and urban households.

Participant recruitment

Participating families were recruited through social media over the summer and autumn period of 2019 and 2020. In 2019, participants were asked to fill out a questionnaire which included contact details and how often and for how long the cat was usually outside. To include personalities of cats tracked in 2019 for my study, owners who completed the GPS tracking in 2019 were asked to fill out a follow-up questionnaire in 2020 providing personality data.

For my study, the families who were still on the waiting list from 2019 were contacted in 2020 by email. These participants did both questionnaire and tracking in the autumn of 2020. Some new participants were also actively recruited through social media in 2020 or found the project themselves through word of mouth or the project's website (https://www.nmbu.no/fakultet/mina/forskning/kattesporet).

Data collection

Questionnaire

The questionnaires were made on the website called www.nettskjema.no, established by the University of Oslo (UiO). The personal information submitted (full name, email address and street address) is not considered sensitive information (Datatilsynet, n.d), but was still treated confidentially and according to Norwegian legislation.

Project participants were asked to complete two questionnaires. The owners registered their interest online by clicking a link and filling out a registration form (Appendix A). A second questionnaire (Appendix B) contained questions regarding the cat, including the owner's perception of the cat's personality, its living conditions, and weight. The personality traits included were faithful, cautious, nervous, independent, curious, energetic, persistent, peaceful, needy, domineering, warm, mischievous, playful, territorial, demanding, and confident. All these personality traits were given to the owners as statements, such as "My cat is: Faithful", and then answered on a 5-point Likert scale consisting of "1-Does not apply", "2-Applies a bit", "3-Partly applies", "4-Applies well" and "5- Applies very well".

The personalities chosen were based on Bennett et al. (2017), but for the purpose of my study, certain personality traits from Bennett et al. (2017) that I considered very anthropomorphic (e.g., charming and clumsy) were not selected. Another reason for not including all the

personalities was to keep the questionnaire short enough so the cat owners and children involved as citizen scientists would not lose interest in the project. Regardless of which year the cats were tracked, the same information was submitted for all cats. Additionally, owners who tracked their cats the previous year were asked whether the cats had any incident (e.g., castration/sterilisation, a kitten litter etc.) that could have caused behaviour to change between tracking and answering the questionnaire.

GPS tracking

The cats were equipped with a collar with a GPS unit of the type i-gotU GT-120 attached to it (Figure 2). The GPS units have a sensitivity of -159dBm, include a built-in patch antenna, 20 channels, and a SiRF III chipset (Morris & Conner, 2017). The expected horizontal position error for this GPS device is <10m (Allan et al., 2013; Morris & Conner, 2017), suitable for fine-scaled home range studies (Frair et al., 2010)

***Figure 2**: GPS unit i-gotU GT-120 with collar. To the right, unit is attached to study subjects; cats P331_9329079_Mie (top) and P331_9329674_Molte (bottom)*

The GPS was set to record a location every 10 seconds, which according to the computer program @tripPC used to configure the GPS units, gives a battery lifetime of 10 hours.

The GPS unit alone weighs 22 grams, and with the silicone casing and collar it weighs 35 grams. A piece of clear tape was placed around the GPS and the blue silicone casing to ensure the GPS did not accidentally fall out of the casing (Figure 2). The collar had an elastic band attached to the clip, so the collar would expand, and the cat could get free if the collar became stuck.

The participating cat owners were sent a parcel by post containing a collar with a GPS unit, a charger for the GPS unit, a form to write down when the cat enters or exists the owner's home and a welcome letter that explained the process and what is expected of them as participants. A link to a document with instructions explaining how to use the GPS was also provided.

The owners were responsible for ensuring that the GPS was securely attached to the cat, charged, and turned on while the cat was outside. They were also responsible for taking the GPS off and charging it when the cat was inside. The data collection lasted a week (with some

owners tracking for fewer or more than seven days) before the equipment was returned to Norwegian University of Life Sciences (NMBU) for data analysis.

Statistical analysis

The statistical analysis was done in the statistical programming environment R (R Core Team, 2020).

1) Patterns in cat personality

To assess overall patterns in cat personality traits in the study population and identify traits to use in subsequent analyses, I conducted a principal component analysis (PCA) using the function *prcomp*. I included the 16 traits from the personality questionnaire and scaled them. The package "Factoextra" (Kassambara & Mundt, 2020) was used to create the PCA plot.

2) Effects of intrinsic and extrinsic factors on cat personality

After seeing the scree plot from the PCA where the first four principal components had a large contribution to the overall variance, a decision was made to rather do a logistic regression on energetic and confident, to make the analysis simpler. I fitted separate ordinal regression models, one with energetic as a response variable and the other with confident as the response. For methods on ordinal regression, see Appendix C. I chose these two personality traits as they emerged as the ones with the highest eigenvector from the PCA (Appendix D). Sex and age were used as predictor variables for the ordinal regression.

To better observe trends in the output, the two selected personality traits were transformed from a 5-point Likert scale into either 0 or 1. The values "1-Does not apply", "2-Applies a bit" and "3-Partly applies" was changed to "0". Values "4-Applies well" and "5- Applies very well" were changed into "1". With the new logistical values, "1" means behaviour was highly observed in the specific cat, while "0" means the behaviour was not highly observed in the specific cat.

I built a separate set of candidate models using logistic regressions with the function *glm* for the two personality traits; energetic and confident. The explanatory variables used in the models were: age, sex (male/female), type of neighbourhood (rural/urban), number of cats in the area, a dog living in the house or not, how the cat was fed, method of outdoor release, vaccination status of cat, and whether the cat was purebred or of mixed breed. For the data analysis, the variable ruralurban was created, and "urban" and "suburban" were combined and called urban,

while rural remained a distinct category. For full overview and description of all variables, see Appendix E.

I used model selection (*mod.sel*) from the "MuMIn"-package (Barton, 2020) to find the best model based on AICc. Additionally, I extracted the cumulative weight for each model in the model selection tables with the function *cumsum*. For full overview of all candidate models used in each model regression, see appendices F and G. When more than one model was within ΔAIC <2 of the top model, I performed model averaging (*model.avg* from "MuMIn"-package (Barton, 2020)) using that subset of models. From the output of the model averaging function, the conditional average was chosen for the tables in the results section. The 95% confidence interval for each variable in the model averaging was found using the function *confint.*

3) Personality and home range size

GPS data was uploaded through the associated computer program @tripPC and imported to R (R Core Team, 2020). Packages "adehabitatHR" (Calenge, 2006) and "sp" (Bivand et al., 2013) was used to calculate 95% kernel density estimate and 50% kerned density estimate (KDE) (Bachmann, 2020; Sarfi, 2020).

To investigate whether owner-reported personality (hereafter "personality") in cats was related to home range size, an algorithm was created for the spatial analysis. Home range sizes of each cat were extracted giving the 95% KDE, and 50% KDE (core area). This was added to the data frame with the personalities for each cat. The 95% KDE and 50% KDE were given in the unit km^2 and were transformed to m^2.

A set of candidate models were built using linear regressions with the function *glm* for the two home range estimates (95% KDE and 50% KDE). The response variables used were the logarithm of 95% and the logarithm of 50% KDE (both in m^2) respectively. The explanatory variables used in the models were age, type of neighbourhood (rural/urban), method of outdoor release (manual/cat flap/restricted cat flap), energetic level (logistic, 0/1), sex (male/female), confident level (logistic 0/1), energetic (Likert scale 1-5) and confident (Likert scale 1-5). The full overview of all candidate models is shown in appendices H and I. To find the best model based AICc, I used model selection (*mod.sel)* from the "MuMIn"-package (Barton, 2020). I also used the function *cumsum* to extract the cumulative weight for each model in the model selection.

I applied model averaging (*model.avg* from "MuMIn"-package (Barton, 2020)) to the models in the model selection table that had ΔAIC <2. The conditional average from the output of the

model averaging function was chosen for the tables in the results section. The function *confint* created the 95% confidence interval for each variable in the model averaging.

The predictions for each home range estimate were created based on the best models for each kernel density estimate, as the significant variables from the model averaging were the same as the variables included in the top models of the model selection.

Results

Participants

In total, 148 cats participated in this study. Out of the 148 participating cats, only 134 had GPS data completed and submitted. Eighty-eight owners had already tracked their cat as part of this project in 2019 and were only asked to submit a supplementary questionnaire for the current study. Among these, 41 replied, contributing a personality questionnaire for 50 cats (top row in Figure 3). One-hundred and twenty-five other participants were also recruited in 2019 and were included in the project in autumn 2020. Among these, 59 owners replied and contributed personality questionnaires for 83 cats (middle row in Figure 3). Thirteen participants were recruited in autumn 2020 or found the project by themselves (bottom row in Figure 3), and among these, 15 cats were represented in the personality questionnaires. Figure 3 provides a full overview of how and when participants were recruited and how many cats were involved in each step.

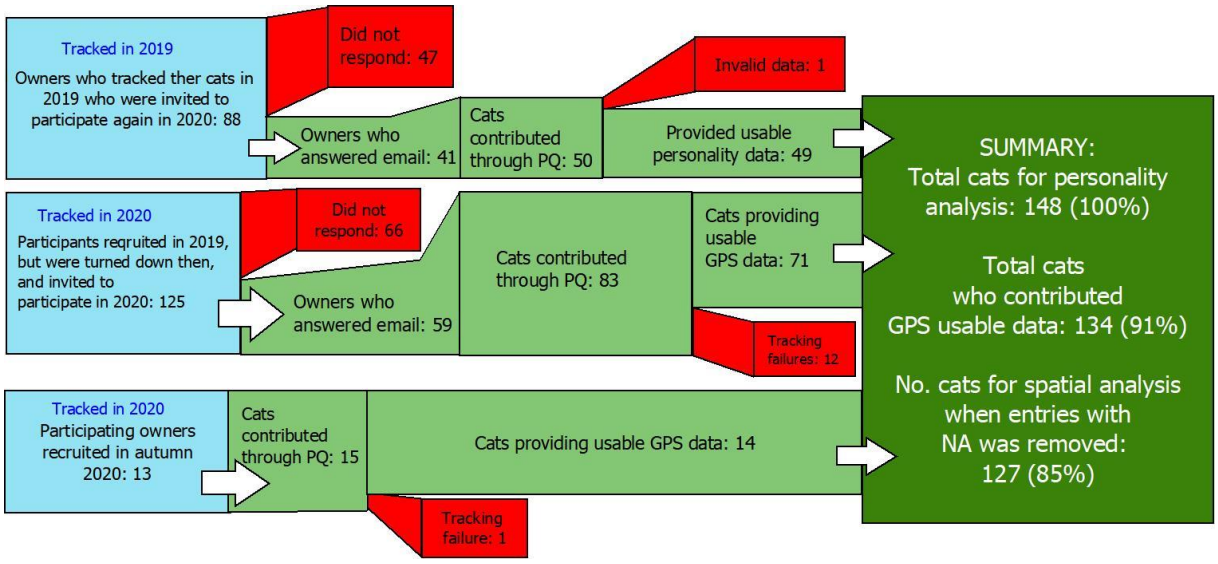

Figure 3: *Sankey diagram showing how participants were recruited, how many personality questionnaires (PQ) were submitted, and how many cats contributed spatial data (incl. how many cats were used in spatial analysis after removing NA).*

Among the 148 cats participating, seven (5%) lived in an urban area, 80 (54%) lived in a suburban area, and 61 (41%) lived in a rural area. There were 81 (55%) males, and 67 (45%) females. All cats were castrated, spayed, or neutered except four (3%; two males and two females. One of these females was on contraceptive pills.) Among the cats, 128 (86%) were mixed breeds or unknown breeds, commonly known as house cats. Average cat age was 5.2 years old (range 1-16+). There were 94 (64%) cats that relied on their owners to manually open the door to go outside, 48 (32%) had cat flaps, and six (4%) had a cat flap with a timer restricting the hours for accessing the outdoors.

1) Patterns in cat personality

The principal component analysis (PCA) shows that the 16 cat personality traits reported by owners were organized along two, mostly perpendicular axes, principal component (PC) 1 and 2 (Figure 4). One group of personality traits clustered together consisted of energetic, which had the highest eigenvector for PC2 (Appendix D), as well as playful, curious, and mischievous, with peaceful being negatively correlated to the aforementioned (i.e., pointing in the opposite direction). The other group of personality traits clustered together included confident, which had the highest eigenvector for PC1 (Appendix D), followed by faithful, domineering, needy, warm, territorial, demanding, persistent and independent, with nervous and cautious negatively correlated to the aforementioned.

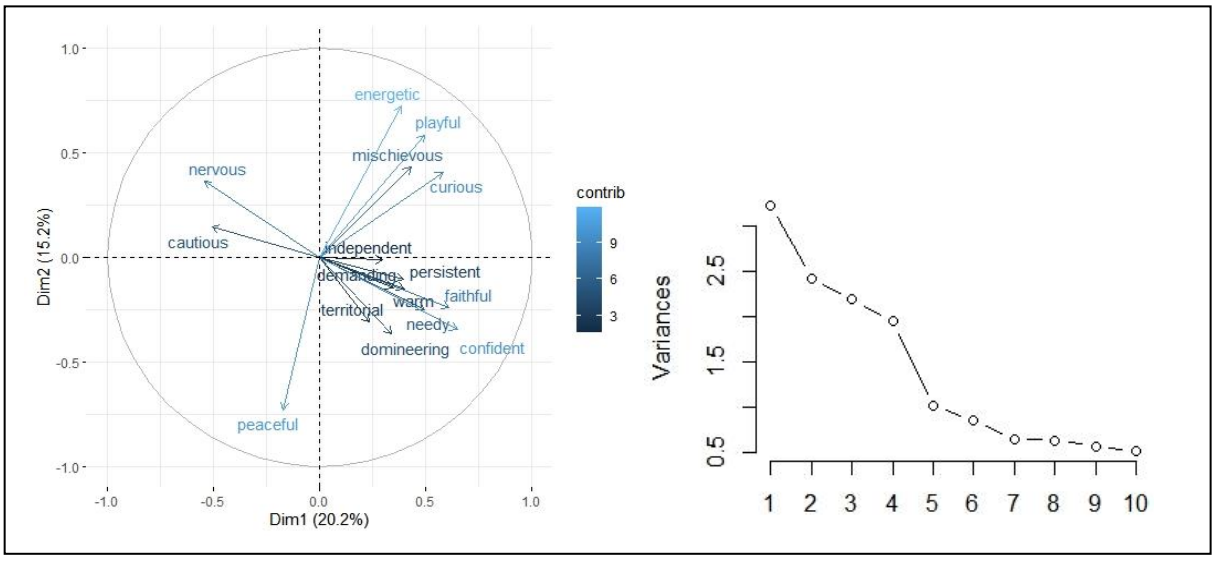

***Figure 4**: Left: Principal Component Analysis diagram of all personalities rated by the owners. Right: Scree plot of all principal components, and their contribution to the variance.*

2) Effects of intrinsic and extrinsic factors on cat personality

Energetic:

The best models (ΔAIC <2) explaining the variation between high and low levels of energetic personality (e.level, 0/1) were explained by age, sex and method of outdoor release (manual/cat flap/restricted cat flap; Table 1).

Table 1: Model selection criteria for 3 best regression models with ΔAIC <2, describing effects on energetic personality in cats, ranked by AICc. Decimals were reduced to 3 to fit table. For full table with all candidate models tested, see appendix F.

	MODEL	df	logLik	AICc	ΔAICc	weight	Cum.Wt
mod22	e.level ~ age + outdoor_release	4	-92.518	193.316	0.000	0.362	0.362
mod14	e.level ~ outdoor_release	3	-93.817	193.800	0.484	0.284	0.646
mod12	e.level ~ sex + age + outdoor_release	5	-92.205	194.833	1.517	0.169	0.815

The model averaged GLM with energy level (0/1) as the response variable showed that the probability of a cat having a highly energetic personality increased significantly when the cat relied on the owners to manually open the door to be let out (r = 0.842, p = 0.023), compared to cats with access to a normal cat flap (Table 2).

Table 2:
Results from model averaging for all models explaining energetic personality in cats, with ΔAIC <2. The intercept level for sex is "female", age is" 0", and outdoor_release is "cat flap". Decimals were reduced to 3 to fit table.

	Estimate	CI 2.5%	CI 97.5%	Std. Error	z value	Pr(>|z|)	
(Intercept)	-0.012	-0.852	0.828	0.426	0.027	0.978	
age	-0.073	-0.165	0.019	0.047	1.550	0.121	
$\text{outdoor\_release}_{\text{manual}}$	0.842	**0.118**	**1.565**	0.366	2.280	0.023	*
$\text{outdoor\_release}_{\text{restr. cat flap}}$	16.669	-1917.281	1950.620	978.443	0.017	0.987	
sex_{male}	0.282	-0.423	0.988	0.357	0.784	0.433	

Signif. codes: '*' p<0.05

Confident:

Through AIC model selection, the best models (ΔAIC <2) explaining the variance in cats having a confident personality was best described by the variables sex, age, type of neighbourhood, number of cats in household, and method of outdoor release (Table 3).

Table 3: Model selection criteria for the 6 regression models with ΔAIC <2 describing effects on confident personality in cats, ranked by AICc. Decimals were reduced to 3 to fit table. For full table with all candidate models tested, see appendix G.

	MODEL	df	logLik	AICc	ΔAICc	weight	Cum. Wt
mod4	c.level ~ sex * age * ruralurban	8	-88.753	194.541	0.000	0.203	0.203
mod19	c.level ~ cats_in_household	2	-95.646	195.374	0.833	0.134	0.336
mod2	c.level ~ sex * age	4	-93.702	195.684	1.143	0.114	0.451
mod1	c.level ~ age	2	-95.945	195.973	1.431	0.099	0.550
mod14	c.level ~ outdoor_release	3	-94.903	195.973	1.432	0.099	0.649
mod5	c.level ~ sex + age * ruralurban	5	-92.879	196.181	1.640	0.089	0.738

The model average for confident personality in cats showed that there were no significant variables. However, there was a negative trend observed for males as they got older (r = -0.319, p = 0.051; Table 4). The coefficient table and prediction plot for the best model (model 4) according to the model selection table (Table 3) is visualised in Table 5 and Figure 8.

Table 4: Results from model averaging for all models explaining confident personality in cats, with ΔAIC <2.
The intercept level for sex is "female", age is "0", ruralurban is "urban", cats_in_household is "0" and outdoor_release is "cat flap". Decimals were reduced to 3 to fit table.

	Estimate	CI 2.5%	CI 97.5%	Std. Error	z value	Pr(>|z|)	
(Intercept)	0.408	-0.722	1.538	0.577	0.707	0.480	
sex_{male}	1.399	-0.897	3.696	1.172	1.194	0.232	
age	0.024	-0.183	0.231	0.106	0.228	0.820	
$ruralurban_{rural}$	-0.804	-2.605	0.997	0.919	0.875	0.382	
$age:sex_{male}$	-0.319	-0.639	0.001	0.163	1.954	0.051	.
$ruralurban_{rural}:sex_{male}$	-1.486	-4.142	1.170	1.355	1.097	0.273	
$age:ruralurban_{rural}$	0.213	-0.122	0.548	0.171	1.248	0.212	
$age:ruralurban_{rural}:sex_{male}$	0.207	-0.276	0.690	0.246	0.841	0.401	
cats_in_household	0.125	-0.198	0.449	0.165	0.759	0.448	
$outdoor\_release_{manual}$	0.373	-0.350	1.096	0.369	1.010	0.312	
$outdoor\_release_{restr.\ Cat\ flap}$	1.273	-0.968	3.514	1.143	1.113	0.266	

Signif. codes: '.' p<0.1

Table 5: Summary of the top model (model 4) from the AIC selection table for confident. The intercept level for sex is “female”, age is ”0” and ruralurban is “urban”. Decimals were reduced to 3 to fit table.

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	0.245	0.614	0.399	0.690	
sexmale	2.184	0.972	2.247	0.025	*
age	0.048	0.092	0.521	0.602	
ruralurbanrural	-0.649	0.976	-0.665	0.506	
sexmale:age	-0.386	0.153	-2.527	0.012	*
sexmale:ruralurbanrural	-1.486	1.343	-1.106	0.269	
age:ruralurbanrural	0.201	0.190	1.057	0.291	
sexmale:age:ruralurbanrural	0.207	0.244	0.848	0.397	

Signif. codes: ‘*’ p<0.05

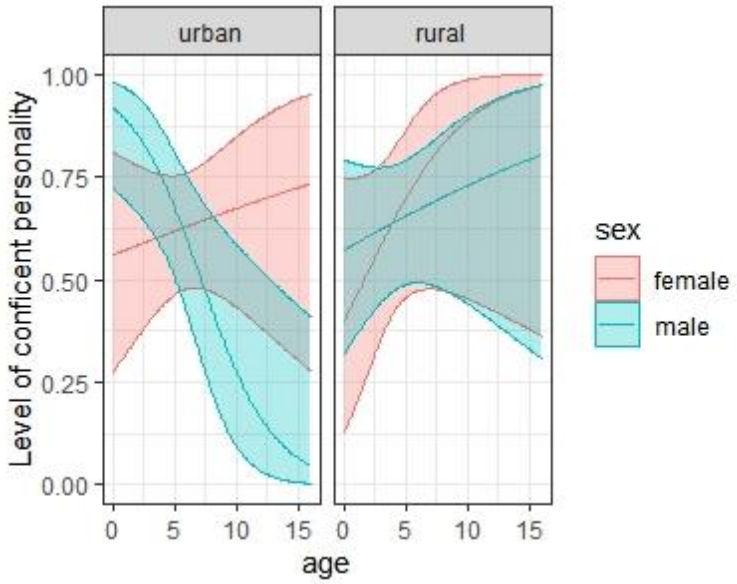

Figure 8: *Prediction for owners reporting their cats having a confident personality (0/1), as a function of the interaction between sex, age, and which type of neighbourhood they lived in. There is a 95% confidence interval for each graph representing male and female.*

3) Personality and home range size

The mean home range size (95% KDE) from all cats (outliers excluded) was 30.1ha (301,153m^2), ranging from 0.1ha (1,033 m^2) to 273.8ha (27,386,361 m^2). The mean of 95% KDE for males was 48ha (482,294 m^2), and 6.9ha (69,164 m^2) for females.

A personality effect on home range size was observed in the 50% kernel density estimate. In the interaction between age and high owner-reported energetic levels, a significant positive effect was observed when model averaging was applied for all models with ΔAIC <2.

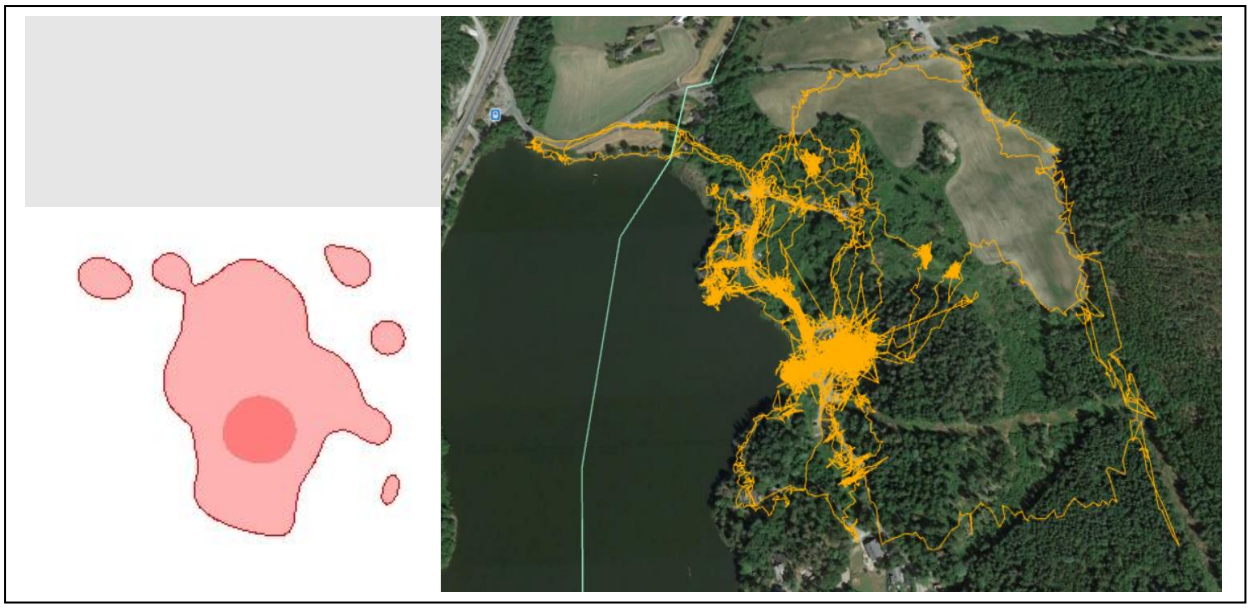

***Figure 9**: Example of visualised home range data for cat P17-S12-Pusur.*

Left: 95%KDE (light red) and 50%KDE (darker red). *Right: KML image of unprocessed tracking data.*

95%KDE

The best models (ΔAIC <2) from the model selection explaining the variation in the 95% KDE contained age, type of neighbourhood (rural/urban), method of outdoor release (manual/cat flap/restricted cat flap), and energetic level (e.level, 0/1; Table 6).

Table 6: Model selection criteria for the 6 regression models with ΔAIC <2 describing effects on the 95% Kernel home range in cats, ranked by AICc. Decimals were reduced to 3 to fit table. For full table with all candidate models tested, see appendix H.

	MODEL	df	logLik	AICc	ΔAICc	weight	Cum.Wt
mod30	log(kernel95.m2) ~ age + ruralurban	4	-199.853	408.034	0.000	0.181	0.181
mod22	log(kernel95.m2) ~ age + ruralurban + outdoor_release	6	-197.712	408.124	0.090	0.173	0.353
mod26	log(kernel95.m2) ~ age * e.level + ruralurban + outdoor_release	8	-196.038	409.297	1.263	0.096	0.449
mod31	log(kernel95.m2) ~ age + ruralurban + e.level + outdoor_release	7	-197.359	409.659	1.625	0.080	0.529
mod18	log(kernel95.m2) ~ age * ruralurban + outdoor_release	7	-197.478	409.897	1.863	0.071	0.600
mod16	log(kernel95.m2) ~ age * ruralurban	5	-199.744	409.984	1.950	0.068	0.669

The model averaging shows that 95% KDE is best described by age and type of neighbourhood. A significant decrease in 95% KDE was observed as the cats aged (r = -0.105, p = 0.008). while a significant increase for cats living in rural areas compared to cats in urban areas (r = 0.673, p = 0.014; Table 7).

Table 7: Results from model averaging for all models explaining the 95% KDE for cats, with ΔAIC <2.
The intercept level for age is" 0", ruralurban is "urban", e.level is "0" and outdoor_release is "cat flap". Decimals were reduced to 3 to fit table.

	Estimate	CI 2.5%	CI 97.5%	Std. Error	z value	Pr(>|z|)	
(Intercept)	10.386	**9.835**	**10.938**	0.281	36.918	< 2e-16	***
age	-0.105	**-0.182**	**-0.028**	0.039	2.662	0.008	**
$ruralurban_{rural}$	0.673	**0.135**	**1.212**	0.275	2.449	0.014	*
$outdoor\_release_{manual}$	0.287	-0.180	0.754	0.238	1.205	0.228	
$outdoor\_release_{restr.\ cat\ flap}$	-0.642	-1.691	0.407	0.535	1.199	0.230	
$e.level_1$	-0.102	-0.935	0.732	0.425	0.239	0.811	
$age:e.level_1$	0.095	-0.023	0.213	0.060	1.572	0.116	
$age:ruralurban_{rural}$	0.033	-0.082	0.148	0.059	0.558	0.577	

Signif. codes: '***' p<0.001, '**' p<0.01, '*' p<0.05

Predictions for 95% kernel density estimate

The best prediction for the 95% KDE of home range was according to both model selection and model averaging best described by age and type of neighbourhood (rural/urban). For model 30, there was a significant negative effect of age (r = -0.091, p = 0.002), and a significantly positive effect in rural areas, compared to urban (r = 0.770, p = 0.001; Table 8). The coefficient table and prediction plot for model 30 is visualised in Table 8 and Figure 10.

Table 8: Summary of the best model (model 30) from the AIC selection table for 95% KDE of home range. The intercept for age is "0" and ruralurban is "urban". Decimals were reduced to 3 to fit table.

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	10.406	0.203	51.199	< 2e-16	***
age	-0.091	0.029	-3.165	0.002	**
$ruralurban_{rural}$	0.770	0.217	3.546	0.001	***

Signif. codes: '***' p<0.001, '**' p<0.01

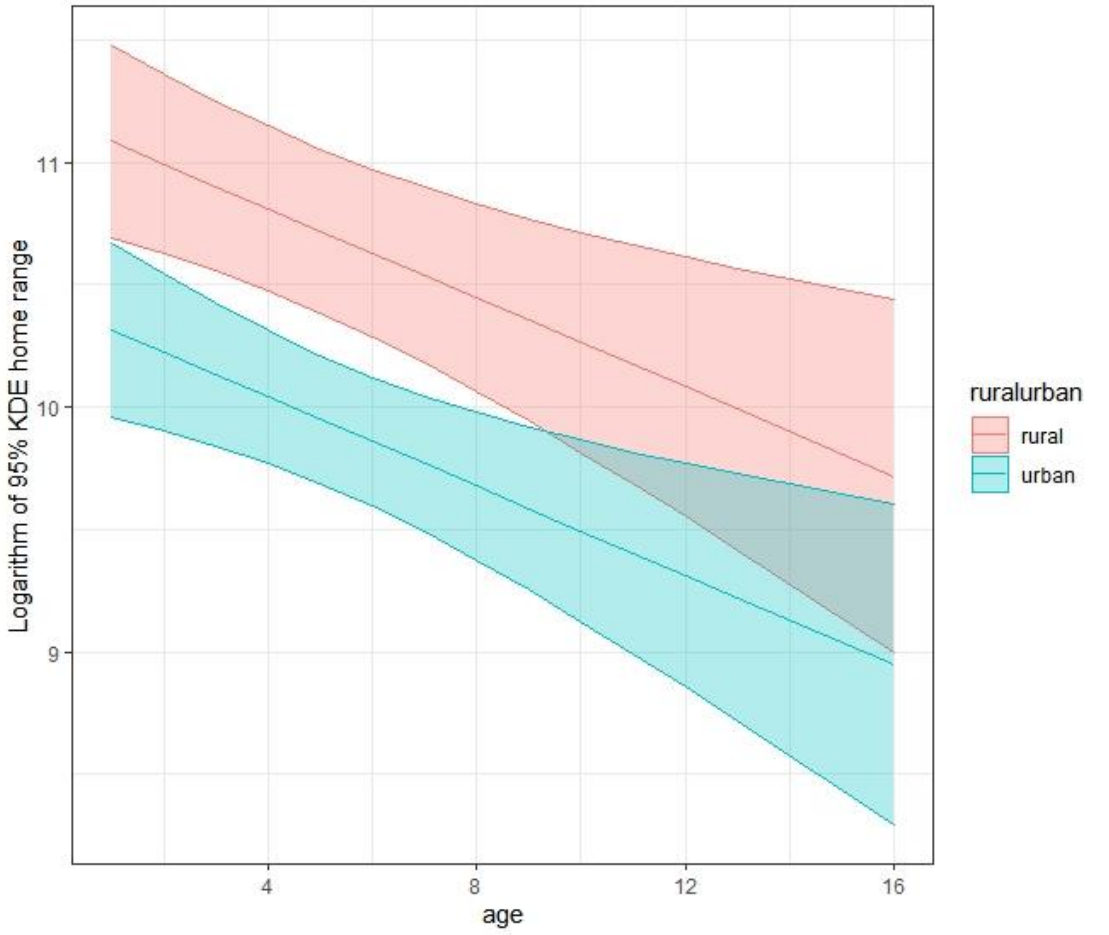

***Figure 10**: Prediction plot for model 30, predicting the 95% KDE for home range in cats as a function of age and type of neighbourhood. The scale on the y-axis is the logarithm of the 95% KDE of home range, and each graph for type of neighbourhood has a confidence interval of 95%.*

50% KDE

The model selection shows that the variables that best (ΔAIC <2) described the 50% KDE for the home range for cats was age, type of neighbourhood (rural/urban), method of outdoor release (manual/cat flap/restricted cat flap), energetic level (e.level, 0/1), confident level (c.level, 0/1) and sex (Table 9).

Table 9: Model selection criteria for the best 5 best models with ΔAIC <2, describing effects on the 50% Kernel home range in cats. Decimals were reduced to 3 to fit table. For full table with all candidate models tested, see Appendix I.

	MODEL	df	logLik	AICc	ΔAICc	weight	Cum.Wt
mod22	log(kernel50.m2) ~ age + ruralurban + outdoor_release	6	-198.270	409.241	0.000	0.238	0.238
mod26	log(kernel50.m2) ~ age * e.level + ruralurban + outdoor_release	8	-196.168	409.555	0.314	0.203	0.441
mod27	log(kernel50.m2) ~ age * e.level + ruralurban * c.level + outdoor_release	10	-194.573	411.043	1.802	0.097	0.538
mod31	log(kernel50.m2) ~ age + ruralurban + e.level + outdoor_release	7	-198.058	411.057	1.816	0.096	0.634
mod29	log(kernel50.m2) ~ age * e.level + ruralurban + outdoor_release + sex	9	-195.765	411.068	1.827	0.095	0.730

Model averaging of the models listed in Table 9 describes that the 50% KDE increased significantly as cats got older (r = -0.130, p = 0.011; Table 10). 50% KDE of home range size also increased when the cats relied on owners to manually open the door to be let out (r = 0.494, p = 0.042) compared to a normal cat flap (Table 10). Another significant variable was found in the interaction between age and a high energetic level in cats (r = 0.121, p = 0.049; Table 10). A trend was observed for an increase in 50% KDE of home range size when the cats lived in rural areas, however not significant (Table 10).

Table 10: Results from model averaging for all models with ΔAIC <2, explaining the 50% KDE of home range for cats.
The intercept level for age is" 0", ruralurban is "urban", e.level is "0", c.level is "0", outdoor_release is "cat flap", and sex is "female". Decimals were reduced to 3 to fit table.

	Estimate	CI 2.5%	CI 97.5%	Std. Error	z value	Pr(>|z|)	
(Intercept)	8.320	**7.634**	**9.005**	0.350	23.790	<2e-16	***
age	-0.130	**-0.229**	**-0.030**	0.051	2.544	0.011	*
$ruralurban_{rural}$	0.500	-0.039	1.038	0.275	1.819	0.069	.
$outdoor\_release_{manual}$	0.494	**0.018**	**0.970**	0.243	2.032	0.042	*
$outdoor\_release_{restr.\ cat\ flap}$	-0.751	-1.819	0.317	0.545	1.378	0.168	
$e.level_1$	-0.397	-1.308	0.514	0.465	0.855	0.393	
$age:e.level_1$	0.121	**0.001**	**0.241**	0.061	1.969	0.049	*
$c.level_1$	0.060	-0.479	0.599	0.275	0.218	0.827	
$c.level_1:ruralurban_{rural}$	0.555	-0.337	1.448	0.455	1.219	0.223	
sex_{male}	0.191	-0.243	0.625	0.222	0.861	0.389	

Signif. codes: '***' p<0.001, '*' p<0.05, '.' p<0.1

Predictions for 50% kernel density home range

The best models for 50% KDE of home range was model 22 and model 26 (see Table 12). Both these models included the variables described as the most significant in the model average for 50% KDE. The top model in the AIC for 50% KDE of home range described a significant decrease with age (r = -0.095, p = 0.001), a significant increase when the cats lived in a rural area, and a significant increase when the cat was let out manually by the owner (r = 0.469, p = 0.046) (Table 11, Figure 11)

Table 11: Summary of the best model (model 22) from the AIC selection table for 50% KDE of home range. The intercept for age is" 0", ruralurban is "urban", and outdoor_release is "cat flap". Decimals were reduced to 3 to fit table.

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	8.200	0.254	32.300	< 2e-16	***
age	-0.095	0.029	-3.257	0.001	**
$ruralurban_{rural}$	0.537	0.225	2.392	0.018	*
$outdoor\_release_{manual}$	0.469	0.233	2.013	0.046	*
$outdoor\_release_{restr.\ cat\ flap}$	-0.806	0.523	-1.540	0.126	

Signif. codes: '***' p<0.001, '**' p<0.01, '*' p<0.05

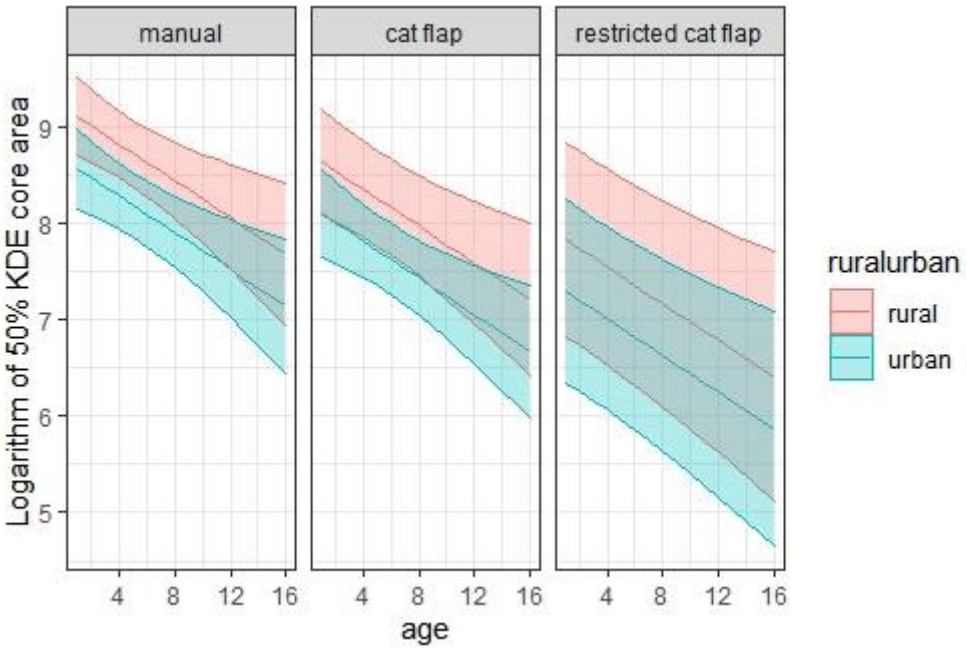

Figure 11: *Prediction plot for the best model (model 22) from model selection, predicting the 50% KDE for core area in cats as a function of age, type of neighbourhood and method of outdoor release. The scale on the y-axis is the logarithm of the 50% KDE of home range, and the graphs for each type of neighbourhood has a confidence interval of 95%.*

The second-best model from the model selection for 50% KDE of home range was model 26. It described a significant negative effect of age (r = -0.155, p = 0.001), a significant positive effect in rural areas (r = 0.555, p = 0.015) compared to urban areas, and a significant positive effect when the cat relied on owners manually opening the door (r = 0.521, p = 0.032) compared to a normal cat flap (Table 12). A positive trend was observed in the interaction between age and energetic levels, however not significant (Table 12, Figure 12).

Table 12: Summary of the best model (model 26) from the AIC selection table for 50% KDE of home range. The intercept for age is "0", e.level is "0", ruralurban is "urban", and outdoor_release is "cat flap". Decimals were reduced to 3 to fit table.

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	8.446	0.337	25.091	< 2e-16	***
age	-0.155	0.044	-3.495	0.001	***
$e.level_1$	-0.487	0.400	-1.218	0.226	
$ruralurban_{rural}$	0.555	0.225	2.464	0.015	*
$outdoor\_release_{manual}$	0.521	0.240	2.169	0.032	*
$outdoor\_release_{restr.\ cat\ flap}$	-0.694	0.537	-1.292	0.199	
$age{:}e.level_1$	0.114	0.060	1.904	0.059	.

Signif. codes: '***' p<0.001, '*' p<0.05, '.' p<0.1

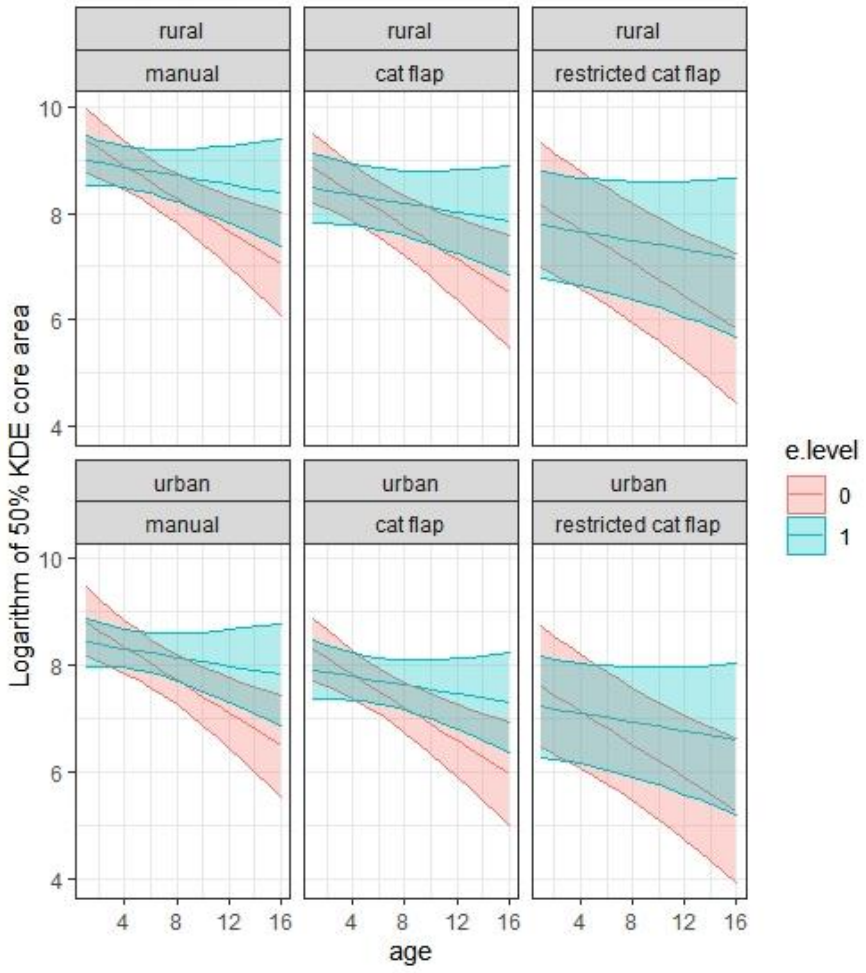

***Figure 12**: Prediction plot for model 26, predicting the 50% KDE for home range in cats as a function of type of neighbourhood, method of outdoor release and the interaction between age and energetic levels. The scale on the y-axis is the logarithm of the 50% KDE of home range.*

Discussion

1) Patterns in Cat Personality

Patterns in owner-reported cat personalities were successfully identified in this study. A division of personality traits into two groups was observed. My results are similar to those of Bennett et.al. (2017); the traits they defined in the "Playfulness" dimension (energetic, playful, quick, mischievous and curious) are the same as I found grouped together – although quick was excluded from my study. The second group of personality traits I identified contained traits that were split up and part of the three dimensions "Dominance", "Amiability" and "Demandingness" in Bennett et al. (2017). I may also have detected more dimensions if more personality traits were included in the questionnaire, or a larger sample size was available.

The traits peaceful, cautious and nervous were located at the opposite end of PCA axis 1 and 2 to the two main trait clusters, hence being negatively correlated to the larger clusters. The precision of the owner-reported personalities therefore appears reasonable as these traits are in essence antonyms for energetic and confident. This shows that cat owners may be helpful in mapping cat personalities and identifying the personality differences among cats.

To sum up, cat personalities can be defined in several dimensions. However, the large number of different methodologies applied, and personality dimensions being named in different ways (Bennett et al., 2017; Evans et al., 2019; Ha & Ha, 2017; Litchfield et al., 2017) inhibit good comparisons between studies. Working towards a common methodology and typology of cat personality would therefore be preferable.

A limitation for my study might be the potential for meaning in the personality traits being lost in translation. For instance, "warm" translated directly, would be "varm" in Norwegian, which could potentially be misunderstood by the owners as a term for temperature. With the chosen Norwegian translation "Kjærlig" in this study (translated to "loving"), some meaning might potentially have been lost in translation from English, to Norwegian, and back to English again. Other studies has also suggested that translations of personality traits may have had some consequences for their results (King et al., 2005).

An interesting potential future study would be to assess cat personalities through both the rating method with owner-reported personalities, as well as the coding method with standardised tests. It is apparent from research on cats and other species that both methods individually return well-defined personality types and traits (Bennett et al., 2017; Litchfield et al., 2017; Wat et al.,

2020), and studies on elephants, pandas and snow leopards reveal that the rating method and coding method give corresponding results (Gartner & Powell, 2012; Horback et al., 2013; Powell & Svoke, 2008). However, it would be interesting to see if this correspondence between methods is present in pet cats, as owners may have a more biased view of their cats, with pets being considered family members by some.

In general, improved knowledge on pet cats may also be used to find more effective ways of exploring the personality of wild animals. In the wild, study subjects are often sparser, time to gather personality data is potentially limited and methods more expensive.

2) Effects of intrinsic and extrinsic factors on cat personality

The patterns found in the owner-reported cat personality dimensions in my study were related to intrinsic and extrinsic factors. The variation in the energetic personality trait was best described by the method of releasing the cat outdoors. Cats that relied on their owners to be let out were reported by their owners to be significantly more energetic compared to cats that had access to a cat flap. This was also the most influential variable affecting energetic levels among cats in my study. This is somewhat surprising since intrinsic factors like sex and age normally play an important role in the activity levels of other animals, such as dogs and snow leopards (Gartner & Powell, 2012; Jones & Gosling, 2005; Wallis et al., 2020). Yet, to my knowledge, method of outdoor release has never been investigated in cats before, and provides new insight to how owners and the housing facilities may affect the cat's personality. An explanation for my observed result is perhaps that cats locked inside the house for several hours while owners are at work would build up energy and hence be perceived as generally more energetic to the owners when they come home. Future studies could investigate whether changing the method for outdoor release would change the cats' owner-reported energetic levels. It is also possible that other personality traits are influenced by how cats are let out. Identifying such traits could reveal more about cat personality.

No explanatory variable had a significant effect on how confident cats were. However, males were generally more confident than females and this is consistent with previous studies on captive animals, such as pandas and cheetahs (Powell & Svoke, 2008; Wielebnowski, 1999). Additionally, there is a trend that male confidence is maintained with age in rural areas, whereas it decreased with age in urban areas. This trend is perhaps a result of higher cat density in urban areas (Hall et al., 2016a) that increases competition. Male cats may therefore be more readily

knocked down the hierarchal ladder in urban areas as they get older. However, further research is needed to better understand this difference.

Other research commonly use the personality trait “Bold” in personality studies, and bold personalities are classified as brave in novel object tests, active and exploratory (Wilson et al. (1994) cited in Brown et al., 2007). I would argue that energetic and confident personalities are aspects of a bold personality. Future research could test how owner-reported energetic and confident cats react to a novel object test, and how they perform on the bold-shy continuum.

3) Personality and home range size

Home range size in domestic cats was influenced by the owner-reported personality trait energetic, as well as the type of neighbourhood the cat lived in (urban or rural), method of outdoor release (manual/cat flap/restricted cat flap) and age. Both the 95% and 50% kernel density estimates significantly decreased with cat age. This is in line with previous research on home range size of cats in Norway (Bachmann, 2020).

The core home range (50% KDE) was larger among cats dependent on manual release by owners. The easy access to food and shelter that the cat flap provides, may perhaps reduce the incentive for cats to expand their core area in search for these resources. As most males in this study were castrated their incentive to range more widely in search of reproductively active females may also be reduced (Ecuyer-Dab & Robert, 2004; Wat et al., 2020). Another explanation could be the connection between outdoor release and energetic levels (Table 2), where a cat that builds up energy inside while the owner is gone, would have excess energy and not just be perceived as more energetic, but therefore also roam further.

Additionally, there was a positive effect of the interaction between age and energetic levels, where energetic cats had a slower decline in core area size with age, compared to non-energetic cats. These results confirm a relationship between owner-reported cat personality and home range size. My study is to my knowledge the first to reveal such a relationship in cats. However, these variables had no significance effect on the 95% KDE. The results revealed that the core home range for non-energetic cats declined faster as cats aged, compared to energetic cats. This suggests that more energetic cats are more motivated to use a larger core area at older ages. The 95% KDE was not affected by these variables, but I speculate that other cat personality factors, e.g., aggression (Nilsson et al., 2014), could affect home range size even more, and further research into this topic is necessary.

Significant effects of sex on home range size was not observed in this study, despite being a main driver of home range size in other species (Wat et al., 2020; Wauters et al., 2021), as well as other studies on domestic cats (Hall et al., 2016b). It is possible that the significant differences in sex as an effect on home range size is eliminated as the majority of individuals in my study are de-sexed. The meta-analysis by Hall et al. (2016) also suggests that the timing of castration of male cats may affect home range size, as males castrated before reaching sexual maturity will have a more similar home range to females (Hall et al., 2016b). The timing of cat neutering was not obtained in my study.

Cats are readily available study subjects in most parts of the world and gaining knowledge on how to accurately access their personality may be later used in studies on wild animals. Cats are also, to my knowledge, the only animal in which we can apply the rating method with reliant observers who know the animal well, as well as the animal roaming freely. Most domestic animals in which the owners know the animal's personality well are either confined to a field or walked by owners. For wild animals, you need to capture them, assess their personality through the coding method and then releasing them again (Bremner-Harrison et al., 2018; Wat et al., 2020; Wauters et al., 2021). For wild animal in captivity, the researchers rely on the zookeepers who know the animals well for personality data, but then the animals are in captivity and roaming is restricted to within the zoo compounds. Cats therefore provide a unique opportunity for the rating method applied in roaming behaviour

Cat personality has been found to be related to the transmission of the lethal virus Feline Immunodeficiency Virus (FIV, commonly known as feline AIDS) in urban areas of Italy and France (Natoli et al., 2005). Bold males were more at risk of contracting the virus, compared to other groups. Results from my study show that energetic cats have larger core areas than non-energetic cats, and that cats in rural areas have larger home ranges than cats in urban areas. Households in rural areas have more wildlife and nature around them, inflicting a higher risk for disease transmission between wildlife and cats, and according to my results especially with energetic cats.

Reducing encounters between wildlife and domestic cats, in turn reduces risk of disease transmission and predation rate. I suggest installing cat flaps as a non-invasive way to reduce the core home range of cats, especially in rural areas. I also suggest that owners may consider restricting energetic cats' access to the outdoors, as they have shown to maintain a larger core home range as they age.

Conclusion

This study is the first to investigate differences in cat personalities in Norway and how it relates to home range size. The results from this study adds new perspectives to this fresh and growing branch of science.

The two clusters identified among the 16 personality traits showed distinct differences in cat personalities with energetic and confident as the highest eigenvectors for each principal component. Logistic regression showed cats that were manually let outside were more likely reported as energetic compared to cats who were manually released outside. No variable was found to significantly affect cat confidence level. However, a trend of male cats becoming less confident with increasing age in urban areas was observed. Whether changing the method of outdoor release would change the owner-reported energetic levels in cats, would be an interesting future study. It could reveal in greater detail how living conditions and owners affect the cat personalities. Developing a common methodology and typology for assessing cat personality would aid comparisons between studies.

Previous research on house cats have determined that sex, age and type of neighbourhood influences home range size (Bachmann, 2020; Hall et al., 2016b). My results agree with the existing data that home range (95% KDE) decreases with age, and cats in rural areas have larger home ranges compared to cats in urban areas. Significant sex differences were not detected in my study. This contrasts with some previous studies where males were observed to have significantly larger home ranges than females (Hall et al., 2016b). The core area (50% KDE) used by cats in this study was affected by age and type of neighbourhood in the same way as for their home range (95% KDE). However, cats who relied on owners to open the door to be let out had larger core areas than cats with access to cat flaps. To my knowledge, this has never been studied or observed before and reveal new insights to drivers of home range and core area size in domestic cats. The last factor that influenced the core area of cats in my study was the interaction between age and energetic levels, where cats reported as energetic had a lower decrease in home range with age compared to cats reported as non-energetic.

Future research on cat personality should also take other home range measures into consideration, e.g., speed of exploration (Minderman et al., 2010), distance travelled from home, space utilisation between individuals in the same area with both similar and different personalities. There is no doubt that cats pose a risk to vulnerable wildlife. Further research into

cat personalities and the relation to home range measures would also increase our capacity to predict how cats may interact with wildlife based on their personality.

I propose installing cat flaps, especially in rural areas, as a non-invasive way of reducing roaming in cats, as well as the possibility that owners of energetic may consider restricting their cats' access to outdoors.

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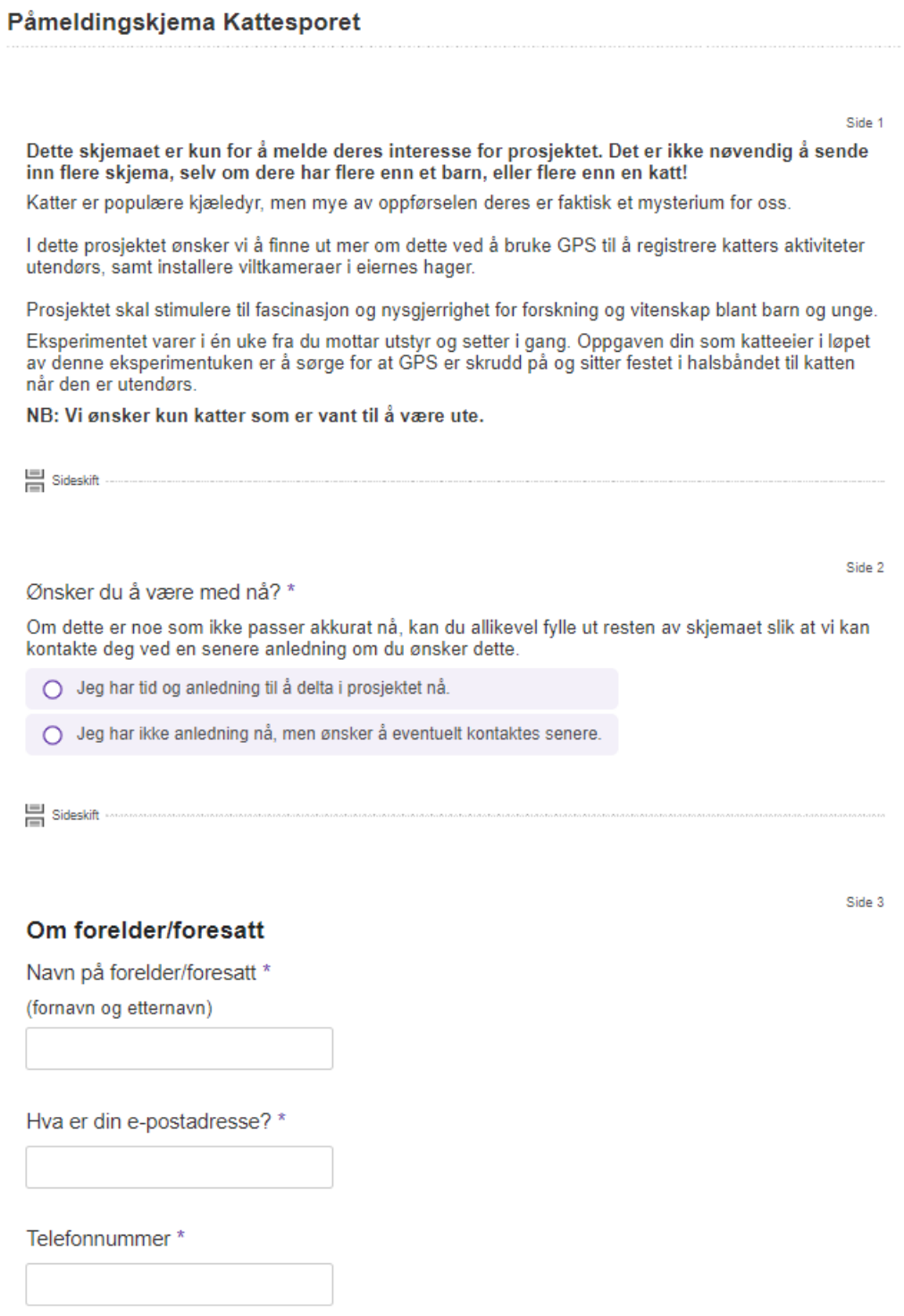
Appendix A

The initial form for participants to register their interest to the project (3 pages).



Påmeldingskjema Kattesporet

Side 1

Dette skjemaet er kun for å melde deres interesse for prosjektet. Det er ikke nøvendig å sende inn flere skjema, selv om dere har flere enn et barn, eller flere enn en katt!

Katter er populære kjæledyr, men mye av oppførselen deres er faktisk et mysterium for oss.

I dette prosjektet ønsker vi å finne ut mer om dette ved å bruke GPS til å registrere katters aktiviteter utendørs, samt installere viltkameraer i eiernes hager.

Prosjektet skal stimulere til fascinasjon og nysgjerrighet for forskning og vitenskap blant barn og unge.

Eksperimentet varer i én uke fra du mottar utstyr og setter i gang. Oppgaven din som katteeier i løpet av denne eksperimentuken er å sørge for at GPS er skrudd på og sitter festet i halsbåndet til katten når den er utendørs.

NB: Vi ønsker kun katter som er vant til å være ute.

Sideskift

Side 2

Ønsker du å være med nå? *

Om dette er noe som ikke passer akkurat nå, kan du allikevel fylle ut resten av skjemaet slik at vi kan kontakte deg ved en senere anledning om du ønsker dette.

- ○ Jeg har tid og anledning til å delta i prosjektet nå.
- ○ Jeg har ikke anledning nå, men ønsker å eventuelt kontaktes senere.

Sideskift

Side 3

Om forelder/foresatt

Navn på forelder/foresatt *

(fornavn og etternavn)

Hva er din e-postadresse? *

Telefonnummer *

Adresse *

(Adressen vi skal sende pakken til)

Postkode *

Poststed *

Har dere hage? *

- Ja
- Nei

Er du interessert i å plassere viltkamera i hagen som filmer katten din og annet dyreliv der? *

Dette elementet vises kun dersom alternativet «Ja» er valgt i spørsmålet «Har dere hage?»

Et viltkamera har sensorer som registrerer bevegelse. Dette gjør at det filmer bare når det er bevegelse foran kameraet.

- Ja
- Nei

Sideskift

Side 4

Om barnet som skal delta

Et av målene med prosjektet er øke barn og unges interesse for forskning. Barna i prosjektet skal bidra aktivt inn i forskningen. Husholdningen bør derfor ha minst et barn i skoletrinnet 6-10. (Eldre og yngre barn kan vurderes ved spesielt stor interesse)

Det er ikke nødvendig å sende inn flere påmeldinger selv om dere har flere barn.

Barnets alder

Velg …

Side 5

Om katten som skal delta

Selv om dere har flere katter, er det ikke nødvendig å sende inn to skjema. Dette skjemaet her er kun for å melde deres interesse for prosjektet. Dere vil få muligheten til å registrere så mange katter dere vil i en senere mail dere får dersom dere er aktuelle kandidater til vårt prosjekt. (Under her velger du bare en av kattene)

Hvor ofte er katte din ute i gjennomsnitt? *

- ○ Sjeldnere enn 1 gang om dagen
- ○ En gang om dagen
- ○ To ganger om dagen
- ○ Tre ganger om dagen eller oftere

Når katten din er ute, hvor lenge er den vanligvis ute i gjennomsnitt? *

- ○ Mindre enn 5 timer
- ○ 5-10 timer
- ○ 11-20 timer
- ○ Mer enn 20 timer

Sideskift

Side 6

Venteliste

Takk for din interesse i prosjektet. Aktuelle kandidater vil bli kontaktet fortløpende. Dersom du ikke blir kontaktet i år, får du nå muligheten til å sette deg på venteliste. Dersom prosjektet fortsetter i årene fremover, og du har satt deg på venteliste, vil du bli kontaktet når vi starter i gang igjen.

Husk å trykke send nederst på denne siden for at påmeldingen din skal bli registrert! Du godtar også da at NMBU lagrer disse dataene, og kontakter deg per e-post eller telefon.

Ønsker du å stå på venteliste til å delta i senere år? *

- ○ Ja, sett meg på venteliste
- ○ Nei, jeg ønsker ikke å være med ved en annen anledning i fremtiden

Appendix B

Questionnaire used to gather personality data and information on cat (7 pages)

Kattesporet: Informasjon om katten din

Side 1

Hva heter du (fornavn og etternavn)? *

Hva er din e-postadresse? *

Har dere hage? *

- Ja
- Nei

Er du interessert i å plassere viltkamera i hagen som filmer katten din og annet dyreliv der?

Dette elementet vises kun dersom alternativet «Ja» er valgt i spørsmålet «Har dere hage?»

Et viltkamera har sensorer som registrerer bevegelse. Dette gjør at det filmer bare når det er bevegelse foran kameraet.

- Ja
- Nei

Om katten

Kattens navn *

Last opp et bilde av katten din

NB! Bildet må være uten mennesker. Ved å laste opp bildet gir du NMBU tillatelse til å bruke bildet i forbindelse med omtale av prosjektet.

Velg fil

Maks 30 MB

Alder (år) *

Velg ...

Kjønn *

- Hann
- Hunn

Er den sterilisert/kastrert *

- Ja
- Nei

Dersom det er en usterilisert hunnkatt, går den på p-piller?

Dette elementet vises kun dersom alternativet «Hunn» er valgt i spørsmålet «Kjønn»

- Ja
- Nei

Vekt (kg) *

Rase *

Hvor mange katter bor i husholdningen (inkl. katten beskrevet i dette skjemaet)? *

Velg ...

Har dere hund/hunder som bor inne? *

- Ja
- Nei

Sideskift

Side 3

Kattens personlighet

Nedenfor finner du personlighetstrekk som vi ønsker du vurderer hvorvidt stemmer med personligheten til katten din på en skala fra 1 til 5. Om du mener personlighetstrekket IKKE stemmer med katten din velger 1, og dersom du mener det stemmer VELDIG GODT med katten din velger du 5.

Katten min er: Tillitsfull *

- 1: Stemmer ikke
- 2: Stemmer bare litt
- 3: Stemmer delvis
- 4: Stemmer godt
- 5: Stemmer veldig godt

Katten min er: Forsiktig *

- 1: Stemmer ikke
- 2: Stemmer bare litt
- 3: Stemmer delvis
- 4: Stemmer godt
- 5: Stemmer veldig godt

Katten min er: Nervøs *

- 1: Stemmer ikke
- 2: Stemmer bare litt
- 3: Stemmer delvis
- 4: Stemmer godt
- 5: Stemmer veldig godt

Katten min er: Selvstendig *

- 1: Stemmer ikke
- 2: Stemmer bare litt
- 3: Stemmer delvis
- 4: Stemmer godt
- 5: Stemmer veldig godt

Katten min er: Nysgjerrig *

- 1: Stemmer ikke
- 2: Stemmer bare litt
- 3: Stemmer delvis
- 4: Stemmer godt
- 5: Stemmer veldig godt

Katten min er: Aktiv/Energisk *

- 1: Stemmer ikke
- 2: Stemmer bare litt
- 3: Stemmer delvis
- 4: Stemmer godt
- 5: Stemmer veldig godt

Katten min er: Bestemt *

- 1: Stemmer ikke
- 2: Stemmer bare litt
- 3: Stemmer delvis
- 4: Stemmer godt
- 5: Stemmer veldig godt

Katten min er: Rolig *

- 1: Stemmer ikke
- 2: Stemmer bare litt
- 3: Stemmer delvis
- 4: Stemmer godt
- 5: Stemmer veldig godt

Katten min er: Oppmerksomhetssyk *

- 1: Stemmer ikke
- 2: Stemmer bare litt
- 3: Stemmer delvis
- 4: Stemmer godt
- 5: Stemmer veldig godt

Katten min er: Sjefete/Dominerende *

- 1: Stemmer ikke
- 2: Stemmer bare litt
- 3: Stemmer delvis
- 4: Stemmer godt
- 5: Stemmer veldig godt

Katten min er: Kjærlig *

- 1: Stemmer ikke
- 2: Stemmer bare litt
- 3: Stemmer delvis
- 4: Stemmer godt
- 5: Stemmer veldig godt

Katten min er: Rampete *

- 1: Stemmer ikke
- 2: Stemmer bare litt
- 3: Stemmer delvis
- 4: Stemmer godt
- 5: Stemmer veldig godt

Katten min er: Leken *

- 1: Stemmer ikke
- 2: Stemmer bare litt
- 3: Stemmer delvis
- 4: Stemmer godt
- 5: Stemmer veldig godt

Katten min er: Territoriell *

- 1: Stemmer ikke
- 2: Stemmer bare litt
- 3: Stemmer delvis
- 4: Stemmer godt
- 5: Stemmer veldig godt

Katten min er: Masete *

- 1: Stemmer ikke
- 2: Stemmer bare litt
- 3: Stemmer delvis
- 4: Stemmer godt
- 5: Stemmer veldig godt

Katten min er: Selvsikker *

- 1: Stemmer ikke
- 2: Stemmer bare litt
- 3: Stemmer delvis
- 4: Stemmer godt
- 5: Stemmer veldig godt

Hvor aktiv vil du si katten din er innendørs?

- Lavt aktivitetsnivå (f.eks. bare spiser og sover inne)
- Moderat aktivitetsnivå (f.eks. noe lek/utforskning foregår innendørs)
- Høyt aktivitetsnivå (f.eks. mye lek/utforskning foregår innendørs)

Side 4

Kattens helse

Er den vaksinert? *

- Ja
- Nei

Har den hatt noen sykdommer? *

- Ja
- Nei

Hvilke sykdommer har den hatt?

Dette elementet vises kun dersom alternativet «Ja» er valgt i spørsmålet «Har den hatt noen sykdommer?»

Sideskift

Side 5

Vaner og rutiner

Hvordan mates katten? *

- Fri tilgang
- Porsjoner

Er den vant til å ha på seg halsbånd? *

Det er ikke nødvendig at katten er vant med halsbånd. De fleste kattene venner seg fort til det.

- Ja
- Nei

Utegang

Hva slags type område bor dere i?

- ○ Landlig
- ○ Boligfelt
- ○ By

Når på døgnet er katten ute? (Flere alternativer er mulig) *

- ☐ Morgen
- ☐ Dagtid
- ☐ Kveld
- ☐ Natt

Hvordan slippes katten ut?

- ○ Fri tilgang til utearealer via katteluke
- ○ Begrenset tilgang til utearealer via katteluke (katteluken låses en viss periode av døgnet)
- ○ Eier slipper katten inn og ut

Hvor ofte pleier katten å ta med byttedyr hjem? *

- ○ Daglig/Nesten daglig
- ○ Ukentlig
- ○ Månedlig
- ○ Sjelden/aldri

Hvor mange andre katter pleier dere å se i området? *

- ○ 0-5
- ○ 6-10
- ○ 11 eller flere

Andre relevante opplysninger eller kommentarer (for eksempel: gravid, har kattunger, nylig operert, under medisinsk behandling)?

Appendix C

Ordinal regression

Ordinal regression of Energetic and Confident was conducted using the *polr* function from the MASS-package. From the ordinal regression model using age and sex as explanatory variables, the probability of the different energetic and confident levels were predicted. Effect prediction plots were made for both Energetic and Confident with sex and age as explanatory variables with the *effect* function from the "Effects"-package (Fox & Weisberg, 2018; Fox & Weisberg, 2019) (Table C1, Table C2, Figure C1 and Figure C2).

Table C1: Summary of ordinal logistic regression for Energetic as a function of sex and age.

Coefficients:

	Value	Std. Error	t value
age	-0.148	0.056	-2.656
sex_{male}	0.948	0.403	2.350
Intercepts:			
1|2	-4.353	0.819	-5.318
2|3	-2.133	0.459	-4.645
3|4	-0.930	0.407	-2.286
4|5	0.881	0.414	2.127
Residual Deviance:	233.526		
AIC:	245.526		

Table C2: Summary of ordinal logistic regression for Confident as a function of sex and age.

Coefficients:

	Value	Std. Error	t value
age	-0.235	0.392	-0.601
sex_{male}	-0.014	0.062	-0.226
Intercepts:			
1|2	-2.813	0.569	-4.943
2|3	-2.370	0.518	-4.579
3|4	-0.852	0.431	-1.977
4|5	0.853	0.431	1.979
Residual Deviance:	238.549		
AIC:	250.549		

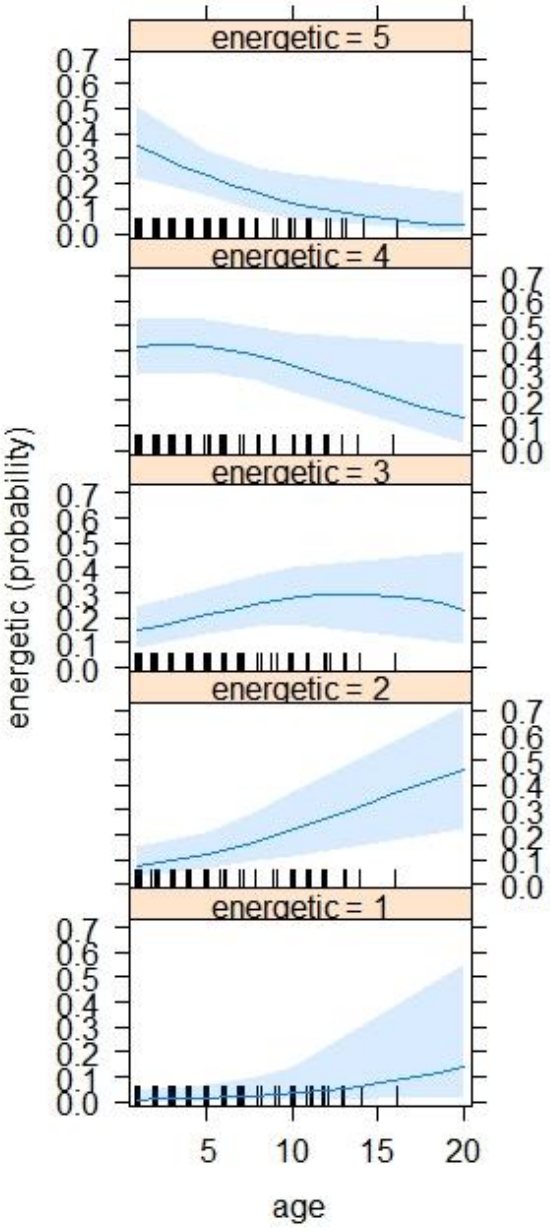


***Figure C2**: Effect plot of ordinal regression for the prediction of reported "Energetic" levels on cats, showing a relative decrease in the reported higher "energetic" levels as age increases.*

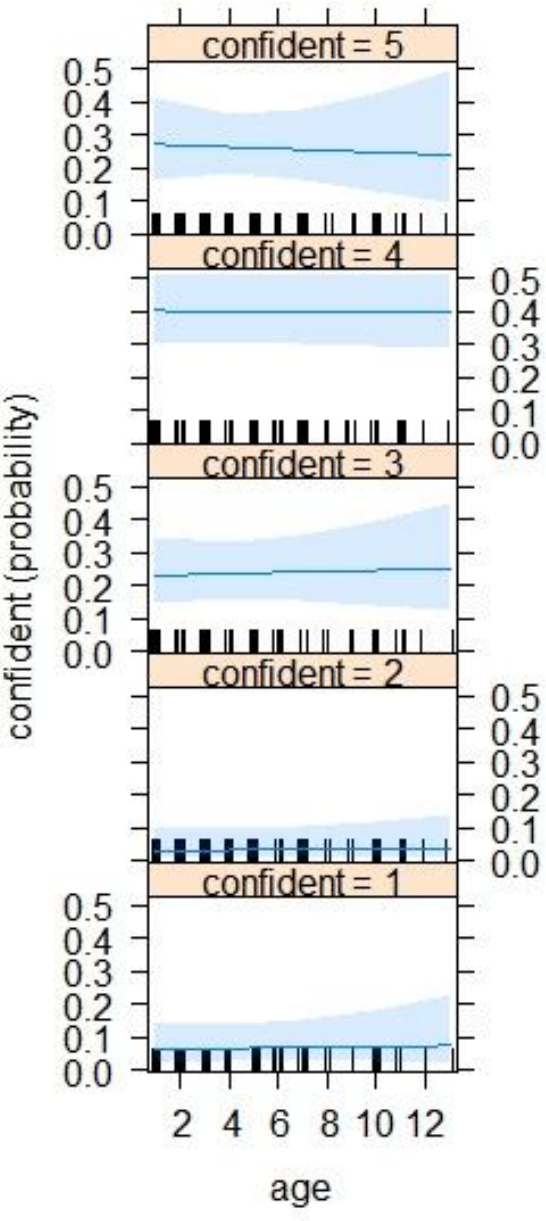


***Figure C1**: Effect plot showing the prediction for the probability of each level of "confident" being reported in a cat as age increases.*

Appendix D

Table D1: Eigenvectors for each personality trait in the Principal Component Analysis (PCA)

```
Standard deviations (1, .., p=16):
 [1] 1.7981333 1.5577883 1.4796716 1.3966218 1.0040979 0.9187872 0.8021045 0.7926964 0.7491013 0.7154810 0.6648127 0.6199211 0.5928194 0.5631341
[15] 0.5367791 0.4689126

Rotation (n x k) = (16 x 16):
                PC1         PC2         PC3         PC4          PC5          PC6          PC7         PC8          PC9         PC10
faithful     0.33958320 -0.15484151 -0.253148372  0.10356815 -0.0606680715  0.111594314 -0.386173580  0.31360529 -0.512517654  0.02067291
cautious    -0.28190027  0.09274712  0.269467688  0.16241650 -0.5588133297  0.256527619 -0.235396163  0.02781419  0.014478537 -0.01766445
nervous     -0.30231084  0.23374247  0.367213148  0.14594975 -0.1635292617 -0.140575587  0.025716707  0.16716771  0.018059561  0.17853116
independent  0.16557228 -0.00714596 -0.085116518 -0.38271013 -0.5039225833 -0.506917673  0.179037287 -0.02094483 -0.317267948  0.01929006
curious      0.32292827  0.26175999 -0.146355486 -0.04591770 -0.1999138181  0.374669945  0.010603929  0.23062712  0.344482812  0.36477452
energetic    0.21409449  0.46399622 -0.046438519  0.02243188 -0.2933947327 -0.127998494  0.111404008  0.19345047  0.031041585 -0.12683624
persistent   0.22064977 -0.06784247  0.358366233 -0.28516119 -0.0834865013  0.098467446 -0.450575495  0.10111325  0.220714014 -0.53580764
peaceful    -0.09687687 -0.46786913 -0.022984519  0.17825508 -0.3530666004  0.118732302 -0.142142884 -0.36936865 -0.034747712  0.11591814
needy        0.27476947 -0.15963607  0.080350587  0.45651531  0.0572390860 -0.107044391  0.172628508  0.31088014  0.206801635  0.02562983
domineering  0.18865204 -0.23540309  0.406778393 -0.15122342  0.0008565562 -0.066890802 -0.075053629  0.05156276 -0.026483999  0.64684938
warm         0.22120067 -0.09661150 -0.210548076  0.46896021 -0.2637752163  0.074379399  0.126447043 -0.16040762  0.009050653 -0.14751267
mischievous  0.23930146  0.27626563  0.316298156  0.14213670  0.2580613654  0.126624710 -0.180489055 -0.13693696 -0.462549129  0.05319979
playful      0.27592043  0.37631034  0.078432563  0.06471518 -0.0142358399  0.050138183  0.015896329 -0.67104608  0.008499443  0.05229168
territorial  0.13105158 -0.19894772  0.376923601 -0.10655338 -0.0620944801  0.410443256  0.663827741  0.07851032 -0.253366206 -0.23097384
demanding    0.19261601 -0.09226116  0.322697398  0.34688519  0.0427923148 -0.505884961 -0.045552104 -0.01768400  0.124203257 -0.13011488
confident    0.36128743 -0.22172958  0.005006794 -0.26860836 -0.0188570599 -0.007924408  0.001726448 -0.18616760  0.359696827  0.02580629
                PC11        PC12        PC13        PC14         PC15         PC16
faithful    -0.16780741  0.251421279 -0.23487410 -0.07764214  0.31256651  0.094440561
cautious    -0.16105763  0.048616029  0.07248614  0.36502536  0.17123894 -0.426648857
nervous     -0.18901853  0.182567901  0.15164132 -0.28519464  0.20311792  0.613082017
independent -0.01689565 -0.191082761  0.30669650 -0.14885067  0.05712136 -0.134592341
curious     -0.09825454 -0.493488174 -0.06597290 -0.23957851  0.05632494  0.013787161
energetic    0.06920686  0.327012339 -0.35679006  0.18325256 -0.53381073  0.096442233
persistent   0.29988626 -0.024971789  0.11186295 -0.24097641 -0.02490709  0.097450728
peaceful    -0.13595865 -0.029641950 -0.17283586 -0.36062223 -0.48732019  0.112292436
needy       -0.04561212  0.312942862  0.39367008 -0.29566972 -0.11490281 -0.379390134
domineering  0.46320125  0.136562355 -0.09550403  0.21375990 -0.02718456 -0.004267437
warm         0.41738777 -0.143144776  0.26136194  0.31582059  0.14502507  0.393730026
mischievous -0.21165959 -0.271186996  0.35530313  0.12660025 -0.36522062  0.037803593
playful      0.08269345  0.295071318 -0.11108505 -0.28725613  0.31442896 -0.167967854
territorial -0.06501732 -0.009518117 -0.19519974 -0.04535705  0.09004764  0.023232732
demanding   -0.19218553 -0.394677155 -0.45731134  0.08236486  0.16122441 -0.053036801
confident   -0.55079819  0.243037488  0.17395672  0.37134463  0.03007423  0.226927869
```

Appendix E

Table E1: Description of all variables used in models.

Variable Name in Models	**What it describes, values, and units**
age	Ranges 1 to 15. >15 was registered at 16
sex	male and female
weight	Weight in kg
pure_mixed	Whether the cat was purebred or breed was mixed/unknown
vaccinated	yes or no
feeding	Feeding through protions or ad-libidum
outdoor_release	How the cat was released outside: manually, cat flap or a timed cat flap with restricted hours
cats_in_area	How many cats the owners have observed living in their neighbourhood: 0-5, 6-10 or 11+
cats_in_household	How many cats live in the household in total
dog	Whether the cat lives with a dog/dogs, yes or no
e.level	1: the owners perceives the cat to have high energetic levels. 0: the ovner does not perceive the cat to have high energetic levels
c.level	1: the owners perceives the cat to have high confidence levels. 0: the ovner does not perceive the cat to have high confidence levels
ruralurban	What type of neighbourhood the cat lived in rural or urban (urban or suburban)

Appendix F

Model selection table for all candidate regression models with energetic level (0/1) as response variable, ranked by AICc. All regressions are binomial. Decimals reduced to 3, to fit table to page. Continuation on the next page. Full description of variables in Appendix E.

Rank	Model Name	Formula	(Intercept)	age	sex	age : sex	ruralurban	age : ruralurban	ruralurban : sex	age : ruralurban : sex	cats_in_area	dog	age : dog	feeding	age : feeding	outdoor_release	age : outdoor_release	vaccinated	age : vaccinated	cats_in_household	age : cats_in_household	pure_mixed	pure_mixed : sex	df	logLik	AICc	ΔAICc	weight	Cumulative Weight
1	mod22	e.level ~ age + outdoor_release	0.180	-0.074												+								4	-92.518	193.316	0.000	0.391	0.391
2	mod14	e.level ~ outdoor_release	-0.251													+								3	-93.817	193.800	0.484	0.307	0.699
3	mod12	e.level ~ sex + age + outdoor_release	-0.019	-0.069	+											+								5	-92.205	194.833	1.517	0.183	0.882
4	mod13	e.level ~ sex + age * outdoor_release	-0.518	0.023	+											+	+							7	-91.373	197.547	4.230	0.047	0.930
5	mod1	e.level ~ age	0.887	-0.095																				2	-97.655	199.393	6.076	0.019	0.948
6	mod2	e.level ~ sex * age	0.373	-0.018	+	+																		4	-96.158	200.596	7.279	0.010	0.959
7	mod15	e.level ~ age + dog	0.932	-0.093								+												3	-97.492	201.151	7.834	0.008	0.966
8	mod21	e.level ~ age + sex * pure_mixed	18.257	-0.115	+																	+	+	12	-87.452	201.215	7.899	0.008	0.974
9	mod3	e.level ~ sex + age	0.805	-0.093	+																			3	-97.580	201.327	8.010	0.007	0.981
10	mod16	e.level ~ age * dog	1.005	-0.107								+	+											4	-97.408	203.095	9.779	0.003	0.984
11	mod8	e.level ~ sex + age + dog	0.855	-0.091	+							+												4	-97.430	203.140	9.823	0.003	0.987
12	mod17	e.level ~ sex + age + vaccinated	0.867	-0.096	+													+						4	-97.570	203.420	10.103	0.003	0.989
13	mod19	e.level ~ cats_in_household	0.413																	-0.015				2	-99.916	203.915	10.598	0.002	0.991
14	mod20	e.level ~ sex + age * cats_in_household	1.332	-0.193	+															-0.231	0.044			5	-96.924	204.270	10.954	0.002	0.993
15	mod18	e.level ~ sex + age * vaccinated	0.291	-0.021	+													+	+					5	-96.943	204.310	10.993	0.002	0.995

Appendix F (cont.)

Rank	Model Name	Formula	(Intercept)	age	sex	age : sex	ruralurban	age : ruralurban	ruralurban : sex	age : ruralurban : sex	cats_in_area	dog	age : dog	feeding	age : feeding	outdoor_release	age : outdoor_release	vaccinated	age : vaccinated	cats_in_household	age : cats_in_household	pure_mixed	pure_mixed : sex	df	logLik	AICc	ΔAICc	weight	Cumulative Weight
16	mod5	e.level ~ sex + age * ruralurban	1.086	-0.122	+		+	+																5	-97.000	204.423	11.106	0.002	0.996
17	mod6	e.level ~ sex + age + cats_in_area	0.898	-0.099	+						+													6	-95.972	204.539	11.223	0.001	0.997
18	mod9	e.level ~ sex + age * dog	0.925	-0.107	+							+	+											5	-97.322	205.066	11.750	0.001	0.999
19	mod7	e.level ~ sex + age * ruralurban + cats_in_area	1.383	-0.148	+		+	+			+													8	-94.757	206.550	13.234	0.001	0.999
20	mod4	e.level ~ sex * age * ruralurban	0.489	-0.011	+	+	+	+	+	+														8	-94.889	206.815	13.498	0.000	1.000
21	mod10	e.level ~ sex + age + feeding	0.651	-0.093	+									+										6	-97.275	207.145	13.829	0.000	1.000
22	mod11	e.level ~ sex + age * feeding	0.968	-0.158	+									+	+									9	-96.238	211.781	18.464	0.000	1.000

Appendix G

Model selection table for all candidate regression models with confident level (0/1) as response variable, ranked by AICc. All regressions are binomial. Decimals reduced to 3, to fit table to page. Continuation on the next page. Full description of variables in Appendix E.

Rank	Model Name	Formula	(Intercept)	age	sex	age : sex	ruralurban	age : ruralurban	ruralurban : sex	age : ruralurban : sex	cats_in_area	dog	age : dog	feeding	age : feeding	outdoor_release	age : outdoor_release	vaccinated	age : vaccinated	cats_in_household	age : cats_in_household	pure_mixed	pure_mixed : sex	df	logLik	AICc	ΔAICc	weight	Cumulative Weight
1	mod4	c.level ~ sex * age * ruralurban	0.245	0.048	+	+	+	+	+	+														8	-88.753	194.541	0.000	0.203	0.203
2	mod19	c.level ~ cats_in_household	0.373																	0.125				2	-95.646	195.374	0.833	0.134	0.336
3	mod2	c.level ~ sex * age	-0.002	0.108	+	+																		4	-93.702	195.684	1.143	0.114	0.451
4	mod1	c.level ~ age	0.607	0.001																				2	-95.945	195.973	1.431	0.099	0.550
5	mod14	c.level ~ outdoor_release	0.336													+								3	-94.903	195.973	1.432	0.099	0.649
6	mod5	c.level ~ sex + age * ruralurban	1.212	-0.113	+		+	+																5	-92.879	196.181	1.640	0.089	0.738
7	mod15	c.level ~ age + dog	0.670	0.005								+												3	-95.628	197.423	2.881	0.048	0.786
8	mod22	c.level ~ age + outdoor_release	0.257	0.014												+								4	-94.862	198.003	3.461	0.036	0.822
9	mod3	c.level ~ sex + age	0.572	0.002	+																			3	-95.932	198.030	3.489	0.035	0.858
10	mod16	c.level ~ age * dog	0.785	-0.018								+	+											4	-95.426	199.131	4.590	0.020	0.878
11	mod10	c.level ~ sex + age + feeding	0.697	0.015	+									+										6	-93.290	199.176	4.634	0.020	0.898
12	mod17	c.level ~ sex + age + vaccinated	0.177	0.016	+													+						4	-95.516	199.311	4.769	0.019	0.917
13	mod8	c.level ~ sex + age + dog	0.644	0.005	+							+												4	-95.621	199.522	4.981	0.017	0.934
14	mod12	c.level ~ sex + age + outdoor_release	0.167	0.016	+											+								5	-94.797	200.017	5.475	0.013	0.947

Appendix G (cont.)

Rank	Model Name	Formula	(Intercept)	age	sex	age : sex	ruralurban	age : ruralurban	ruralurban : sex	age : ruralurban : sex	cats_in_area	dog	age : dog	feeding	age : feeding	outdoor_release	age : outdoor_release	vaccinated	age : vaccinated	cats_in_household	age : cats_in_household	pure_mixed	pure_mixed : sex	df	logLik	AICc	ΔAICc	weight	Cumulative Weight
15	mod7	c.level ~ sex + age * ruralurban + cats_in_area	1.062	-0.108	+		+	+			+													8	-91.504	200.045	5.503	0.013	0.960
16	mod18	c.level ~ sex + age * vaccinated	-0.153	0.061	+													+	+					5	-95.295	201.013	6.471	0.008	0.968
17	mod6	c.level ~ sex + age + cats_in_area	0.469	0.002	+						+													6	-94.258	201.112	6.571	0.008	0.975
18	mod9	c.level ~ sex + age * dog	0.743	-0.018	+							+	+											5	-95.404	201.231	6.689	0.007	0.982
19	mod20	c.level ~ sex + age * cats_in_household	0.632	-0.048	+															0.003	0.020			5	-95.512	201.446	6.905	0.006	0.989
20	mod11	c.level ~ sex + age * feeding	1.352	-0.117	+									+	+									9	-91.278	201.861	7.319	0.005	0.994
21	mod21	c.level ~ age + sex * pure_mixed	17.483	0.014	+																	+	+	12	-88.050	202.411	7.870	0.004	0.998
22	mod13	c.level ~ sex + age * outdoor_release	0.152	0.016	+											+	+							7	-94.539	203.879	9.337	0.002	1.000

Appendix H

Model selection table for all candidate regression models with the logarithm of 95% KDE in meters2 (log(kernel95.m2)) as response variable, ranked by AICc. All regressions are gaussian. Decimals reduced to 3, to fit table to page. Continuation on the next page.

Rank	Model Name	Formula	(Intercept)	sex	age	e.level	c.level	ruralurban	age:e.level	outdoor_release	ruralurban:sex	age:outdoor_release	energetic	confident	c.level:e.level	c.level:ruralurban	age:c.level	age:ruralurban	e.level : outdoor_release	df	logLik	AICc	ΔAICc	weight	Cumulative Weight
1	mod30	age + ruralurban	10.406		-0.091			+												4	-199.853	408.034	0.000	0.181	0.181
2	mod22	age + ruralurban + outdoor_release	10.328		-0.097			+		+										6	-197.712	408.124	0.090	0.173	0.353
3	mod26	age * e.level + ruralurban + outdoor_release	10.493		-0.145	+		+	+	+										8	-196.038	409.297	1.263	0.096	0.449
4	mod31	age + ruralurban + e.level + outdoor_release	10.214		-0.093	+		+		+										7	-197.359	409.659	1.625	0.080	0.529
5	mod18	age * ruralurban + outdoor_release	10.439		-0.117			+		+								+		7	-197.478	409.897	1.863	0.071	0.600
6	mod16	age * ruralurban	10.479		-0.105			+										+		5	-199.744	409.984	1.950	0.068	0.669
7	mod29	age * e.level + ruralurban + outdoor_release + sex	10.357	+	-0.147	+		+	+	+										9	-195.284	410.107	2.073	0.064	0.733
8	mod24	age + ruralurban * c.level + outdoor_release	10.387		-0.104		+	+		+						+				8	-196.543	410.306	2.273	0.058	0.791
9	mod27	age * e.level + ruralurban * c.level + outdoor_release	10.619		-0.165	+	+	+	+	+						+				10	-194.232	410.361	2.327	0.056	0.847
10	mod23	age + ruralurban + outdoor_release * e.level	10.297		-0.087	+		+		+									+	8	-196.901	411.022	2.988	0.041	0.888
11	mod17	age * ruralurban + sex	10.358	+	-0.103			+										+		6	-199.220	411.141	3.107	0.038	0.926
12	mod28	age * e.level + ruralurban * c.level + outdoor_release * e.level	10.716		-0.160	+	+	+	+	+						+			+	11	-193.606	411.507	3.473	0.032	0.958
13	mod21	c.level + age + sex + ruralurban + e.level	10.053	+	-0.083	+	+	+												7	-198.741	412.424	4.390	0.020	0.978
14	mod25	age + ruralurban * c.level + outdoor_release * e.level	10.359		-0.093	+	+	+		+						+			+	10	-195.647	413.191	5.157	0.014	0.991

Appendix H (cont.)

Rank	Model Name	Formula	(Intercept)	sex	age	e.level	c.level	ruralurban	age : e.level	outdoor_release	ruralurban : sex	age : outdoor_release	energetic	confident	c.level : e.level	c.level : ruralurban	age : c.level	age : ruralurban	e.level : outdoor_release	df	logLik	AICc	ΔAICc	weight	Cumulative Weight
15	mod5	ruralurban	9.920					+												3	-204.785	415.765	7.731	0.004	0.995
16	mod2	age	10.742		-0.100															3	-205.987	418.170	10.136	0.001	0.996
17	mod8	sex * ruralurban	9.768	+				+			+									5	-203.868	418.232	10.198	0.001	0.997
18	mod9	outdoor_release * age	10.517		-0.105					+		+								7	-201.691	418.323	10.289	0.001	0.998
19	mod14	ruralurban * c.level	9.881				+	+								+				5	-204.249	418.994	10.961	0.001	0.999
20	mod6	e.level * age	10.968		-0.146	+			+											5	-204.923	420.341	12.308	0.000	1.000
21	mod15	age * c.level	10.761		-0.125		+										+			5	-205.480	421.457	13.423	0.000	1.000
22	mod7	outdoor_release	9.916							+										4	-208.080	424.487	16.453	0.000	1.000
23	mod20	c.level + outdoor_release + sex	9.560	+			+			+										6	-206.061	424.822	16.789	0.000	1.000
24	mod19	sex + e.level + outdoor_release	9.589	+		+				+										6	-206.073	424.846	16.812	0.000	1.000
25	mod1	sex	10.009	+																3	-209.846	425.887	17.853	0.000	1.000
26	mod10	energetic	9.744										0.135							3	-210.656	427.507	19.473	0.000	1.000
27	mod3	e.level	10.091			+														3	-210.870	427.936	19.902	0.000	1.000
28	mod4	c.level	10.121				+													3	-211.101	428.397	20.363	0.000	1.000
29	mod12	confident	10.127											0.029						3	-211.358	428.911	20.877	0.000	1.000
30	mod11	energetic + confident	9.630										0.135	0.031						4	-210.610	429.547	21.513	0.000	1.000
31	mod13	e.level * c.level	10.015			+	+								+					5	-210.604	431.704	23.670	0.000	1.000

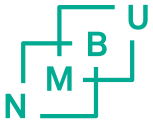
Appendix I

Model selection table for all candidate regression models with the logarithm of 50% KDE in meters^2 (log(kernel50.m2)) as response variable, ranked by AICc. All regressions are gaussian. Decimals reduced to 3, to fit table to page. Continuation on the next page.

Rank	Model Name	Formula	(Intercept)	sex	age	e.level	c.level	ruralurban	age:e.level	outdoor_release	ruralurban:sex	age:outdoor_release	energetic	confident	c.level:e.level	c.level:ruralurban	age:c.level	age:ruralurban	e.level:outdoor_release	df	logLik	AICc	ΔAICc	weight	Cum.Wt
1	mod22	age + ruralurban + outdoor_release	8.200		-0.095			+		+										6	-198.270	409.241	0.000	0.238	0.238
2	mod26	age * e.level + ruralurban + outdoor_release	8.446		-0.155	+		+	+	+										8	-196.168	409.555	0.314	0.203	0.441
3	mod27	age * e.level + ruralurban * c.level + outdoor_release	8.529		-0.173	+	+	+	+	+						+				10	-194.573	411.043	1.802	0.097	0.538
4	mod31	age + ruralurban + e.level + outdoor_release	8.111		-0.092	+		+		+										7	-198.058	411.057	1.816	0.096	0.634
5	mod29	age * e.level + ruralurban + outdoor_release + sex	8.346	+	-0.156	+		+	+	+										9	-195.765	411.068	1.827	0.095	0.730
6	mod18	age * ruralurban + outdoor_release	8.247		-0.104			+		+								+		7	-198.229	411.399	2.158	0.081	0.811
7	mod24	age + ruralurban * c.level + outdoor_release	8.219		-0.100		+	+		+						+				8	-197.352	411.924	2.684	0.062	0.873
8	mod28	age * e.level + ruralurban * c.level + outdoor_release * e.level	8.588		-0.170	+	+	+	+	+						+			+	11	-194.340	412.976	3.735	0.037	0.910
9	mod23	age + ruralurban + outdoor_release * e.level	8.156		-0.089	+		+		+									+	8	-197.926	413.072	3.831	0.035	0.945
10	mod30	age + ruralurban	8.354		-0.088			+												4	-202.712	413.753	4.512	0.025	0.970
11	mod25	age + ruralurban * c.level + outdoor_release * e.level	8.181		-0.094	+	+	+		+						+			+	10	-196.967	415.831	6.590	0.009	0.978
12	mod16	age * ruralurban	8.357		-0.088			+										+		5	-202.712	415.920	6.680	0.008	0.987
13	mod9	outdoor_release * age	8.375		-0.106					+		+								7	-200.972	416.886	7.645	0.005	0.992

Appendix I (cont.)

Rank	Model Name	Formula	(Intercept)	sex	age	e.level	c.level	ruralurban	age : e.level	outdoor_release	ruralurban:sex	age:outdoor_release	energetic	confident	c.level:e.level	c.level:ruralurban	age:c.level	age:ruralurban	e.level:outdoor_release	df	logLik	AICc	ΔAICc	weight	Cumulative weight
14	mod17	age * ruralurban + sex	8.287	+	-0.087			+										+		6	-202.546	417.793	8.552	0.003	0.995
15	mod21	c.level + age + sex + ruralurban + e.level	8.063	+	-0.082	+	+	+												7	-201.996	418.933	9.693	0.002	0.997
16	mod5	ruralurban	7.884					+												3	-207.123	420.442	11.201	0.001	0.998
17	mod2	age	8.662		-0.096															3	-207.665	421.526	12.285	0.001	0.999
18	mod7	outdoor_release	7.772							+										4	-206.899	422.125	12.884	0.000	0.999
19	mod6	e.level * age	8.946		-0.151	+			+											5	-206.299	423.094	13.854	0.000	0.999
20	mod20	c.level + outdoor_release + sex	7.471	+			+			+										6	-205.546	423.792	14.552	0.000	0.999
21	mod8	sex * ruralurban	7.770	+				+			+									5	-206.680	423.856	14.615	0.000	1.000
22	mod14	ruralurban * c.level	7.824				+	+								+				5	-206.681	423.858	14.617	0.000	1.000
23	mod19	sex + e.level + outdoor_release	7.513	+		+				+										6	-205.648	423.996	14.756	0.000	1.000
24	mod15	age * c.level	8.684		-0.123		+										+			5	-207.129	424.754	15.513	0.000	1.000
25	mod1	sex	8.001	+																3	-211.665	429.525	20.284	0.000	1.000
26	mod10	energetic	7.735										0.120							3	-211.968	430.131	20.890	0.000	1.000
27	mod3	e.level	8.042			+														3	-212.114	430.424	21.183	0.000	1.000
28	mod4	c.level	8.057				+													3	-212.240	430.674	21.433	0.000	1.000
29	mod12	confident	8.037											0.037						3	-212.484	431.164	21.923	0.000	1.000
30	mod11	energetic + confident	7.591										0.121	0.039						4	-211.896	432.119	22.878	0.000	1.000
31	mod13	e.level * c.level	7.962			+	+								+					5	-211.832	434.160	24.919	0.000	1.000



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