

Suivi hivernal des oiseaux communs (SHOC)

Analysis of the common wintering birds in France 2014-2018

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Part I

Set-up of the analyses

1 METHODOLOGY

Naturaconsta provided the raw observations made during the *Suivi Hivernal des Oiseaux Communs* (SHOC). It consists of 9445 observations during 420 visits over 73 sites and 125 species. The birds are counted during a walk along at a transect. The length of the transects range from 2.62 to 6.4 km. The distance between the bird and the observer is recorded in four classes: "0-50m", "50-100m", ">100m" and "passing".

1.1 STATISTICAL MODELS

In order to get comparable results, we fit the same set of models to each species. The model estimates the average density of birds at a given site in a given winter and period. The first period ranges for the beginning of December to mid Janary. The second period from mid January to the end of February.

1.1.1 Detection function

The first step is the estimate the detection function. The detection function gives the probability that a bird is detected based on the distance to the observer. The detection function assumes that the observer sees every bird at distance 0 m. The probability of detection decreases as the distance between bird and observer increases (fig. 1.1). We describe this detection function with a half-normal density curve with parameter σ_d . The parameter σ_d governs how fast the detectability deteriorates. The detection probability at a distance of 1.96 σ_d is about 5%. Suppose that the detection at some distance is 50%. The observer will see only 1 out of 2 birds at that distance. So the true number of birds is twice the number of observed birds at the distance.

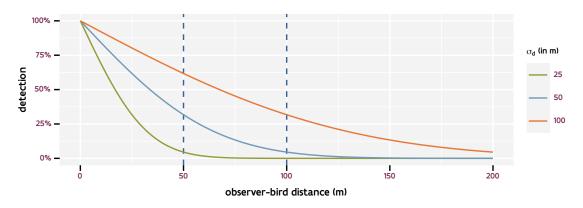


Figure 1.1: Example of two half-normal detection functions with different σ_d

We need to estimate σ_d based on the data. Idealy we would have an 'exact' distance estimate for each observation. The available poses some challenges at this point. The class 'passing' is not usable as it has no associated distance. The data contains the distance classes instead of exact distances. A workaround for this problem is to work with the average detection within the distance class. This average distance is equivalent to the surface under the detection function.

We estimate this detection function by fitting a base model to the data. The base model (1.1) with a non-linear trend along winter contains following terms:

- β_0 : the overall intercept during the first period at distance 0-50m.
- β_1 : the difference between the second and the first period.
- β_2 : the difference between distance 0-50m and 50-100m.
- β_3 : the difference between distance 0-50m and >100m.
- b_w : effect of winter w, modelled as a first order random walk with variance. σ_w^2 (1.2)
- b_s : effect of site s, modelled as a random intercept with variance σ_s^2 (1.3).
- ullet $\log(length)$ is an offset term correcting for the transect length (in km).

$$\eta_{wis} = \beta_0 + \log(length) + \beta_1 P_2 + \beta_2 D_{50-100m} + \beta_3 D_{>100m} + b_u + b_s$$
(1.1)

$$\Delta_{b_w} = b_w - b_{w-1} \sim \mathcal{N}(0, \sigma_w^2) \tag{1.2}$$

$$b_s \sim \mathcal{N}(0, \sigma_s^2)$$
 (1.3)

The η_{wis} of the base model is linked to the observed counts Y_{wis} via either a negative binomial distribution (1.4) using the log link between η and μ (1.5). The negative binomial distribution can capture overdispersion which is often present in count data of animals.

$$Y_{wis} \sim NB(\mu_{wis}, n)$$
 (1.4)

$$\log(\mu_{wis}) = \eta_{wis} \tag{1.5}$$

The term e^{β_2} in the base model estimates the ratio of the area under the distance function between the distance classes 50-100 m and 0-50 m (fig. 1.2). Likewise is e^{β_3} an estimate for the ratio between >100 m and 0-50m. In practice, there is an upperbound to the distance d_{max} at which we can observe birds. So the distance class >100 m is actual the distance class 100- d_{max} m. Next we search for an optimal σ_d and d_{max} value matching with these two ratios. We restrict σ_d to be between 20 and 200 m and d_{max} between 150 m and 1000 m.

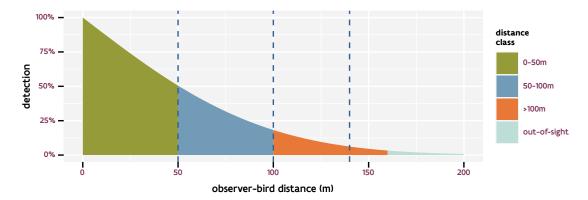


Figure 1.2: Area under the detection function for each distance class for σ_d = 75 m and an out-of-sight distance d_{max} of 160m.

1.1.2 Final models

Once we know σ_d we can calculate the average detection probability for each of the distance classes. We replace the terms β_2 and β_3 in (1.1) with the calculated $\log(detection)$ in (1.6). The \log function is needed due to the \log link in (1.5). The observed number of birds represents an area defined by the length of the transect and the width of the distance class. Therefore we have to replace the offset term $\log(length)$ by $\log(area)$. The width of the distance classes 0-50 m and 50-100m is clear (50m). Therefore their area is 0.05 km² for ever km of transect. The width of the distance class >100 m is set to $d_{max}-100$ m.

$$\eta_{wis} = \beta_0 + \log(area) + \log(detection) + \beta_1 P_2 + b_w + b_s \tag{1.6}$$

We can rearrange (1.6) into (1.7). Applying the inverse link function yields (1.8) or the number of birds corrected for the sampled area and the average detection probability depends on the overall intercept β_0 , the period effect β_1 , the temporal trend b_w and the site effect b_s . (1.8) thus estimates the trend in density of birds (number of bird per km²). e^{b_w} estimates the relative change in bird density over time.

$$\eta_{wis} - \log(area) - \log(detection) = \beta_0 + \beta_1 P_2 + b_w + b_s \tag{1.7}$$

$$\eta_{wis} - \log(area) - \log(detection) = \beta_0 + \beta_1 P_2 + b_w + b_s$$

$$\frac{\mu_{wis}}{area \times detection} = e^{\beta_0} e^{\beta_1 P_2} e^{b_w} e^{b_s}$$
(1.8)

Beside (1.6), we also fit the variant with a linear trend β_4 instead of the non-linear trend b_w (1.9).

$$\eta_{wis} = \beta_0 + \log(area) + \log(detection) + \beta_1 P_2 + \beta_4 W + b_s \tag{1.9}$$

1.2 FITTING THE MODEL

The models are fit the statistical software R version 3.6.1 (R Core Team, 2019) using the INLA package version 18.07.12 (Rue et al, 2017). It fits Bayesian models using Integrated Nested Laplace Approximation (INLA). Fitting Bayesian models imply select prior distributions for a number of parameters.

- β_0 , β_1 , β_2 , β_3 and β_4 use a Gaussian prior with 0 mean and variance 1000 $\mathcal{N}(0,1000)$
- σ_w^2 uses a PC prior with u=0.25 and $\alpha=0.5$ σ_s^2 uses a PC prior with u=0.6 and $\alpha=0.5$
- n is modelled as $n=e^{\theta}$ with a $\theta \sim \Gamma(e^{-7},e^{-7})$

A PC (penalised complexity) prior is defined by two parameters u and α . u defines a threshold value for σ , and α defines the probability that the estimated σ exceeds this threshold value (1.10). The density of this prior is given in (1.11).

$$P(\sigma > u) = \alpha \tag{1.10}$$

$$\pi(\tau) = \frac{\lambda}{2} \tau^{-3/2} exp(-\lambda \tau^{-1/2})$$
 (1.11)

$$\lambda = -\frac{\log(\alpha)}{u} \tag{1.12}$$

2 DATA EXPLORATION

This chapter explores the full dataset. We will try to estimates trends for as much species as possible. Stable models require sufficient data. Therefore, we apply a set of rules on the available data of each species. These rules are partly based on common statistical knowledge and our experience with similar data in the past. And partly based on the data analysed in this project. If a model for a given species turns out to be unstable, then we make the rules more strict. We apply the same set of rules for every species so the results are comparable among the species.

This chapter shows both the rule and the summary of the data on which the rule applies. This illustrates the available data and how the rule restricts the data. Note that these rules will remove data for some species or some sites. When volunteers collect more data in the future for such species and sites, they might have sufficient data to pass all the rules.

2.1 RULE 1: A SITE MUST BE SAMPLED DURING AT LEAST 3 WINTERS

The models take both a site and a winter effect into account. When a site is sampled during only one or two winters, then model has a hard time separating the site and winter effect. This can lead to an unstable model. Therefore it is safer to restrict the data to sites with a sufficient number of visits over several winters.

Table 2.1 displays how many sites have data from 1, 2, 3, ... different winters. 37 sites have data from less than 3 different winters and are currently ignored.

Table 2.1: Number of sites with data from a number of winters.

winters	sites
1	13
2	24
3	14
4	10
5	12

2.2 RULE 2: USE ONLY RELEVANT SITES FOR A SPECIES

Some species at not present at every site. When a species is absent at a site, the counts are always zero. The numbers are not changing at that site, so locally there is no trend. If we would take such site into account, the overall trend will be biased towards zero.

Species that are rarely seen at a site pose a problem too. Imaging a species is only seen at the first winter with on average 10 individuals. The model tries to fit the first winter at this site as $\log(10)=2.303$. All other winters at this site should be $\log(0)=-\infty$. This results is a strong negative local trend, which again biases the global trend.

Therefore, we require that a species is observed at a site during at least 3 different years before taking that site into account for this species. Table 2.2 is a very large table because it contains a row for each of the 107 species observed in the data. 40 species at so rare that there is not a single site at which they are observed during 3 different years.

Table 2.2: number of sites at which a species was observed split by the number of winters (columns) during which the species was observed at a site.

scientific	1	2	3	4	5	sufficient
Turdus merula	4	3	13	5	9	27
Corvus corone	3	3	12	7	8	27
Alauda arvensis	0	5	11	5	7	23
Fringilla coelebs	4	4	6	7	7	20
Parus major	2	4	9	4	7	20
Erithacus rubecula	5	3	8	5	6	19
Columba palumbus	7	8	9	7	3	19
Cyanistes caeruleus	5	6	7	2	8	17
Sturnus vulgaris	1	13	5	7	5	17
Buteo buteo	8	5	9	3	4	16
Garrulus glandarius	1	5	10	1	3	14
Turdus viscivorus	8	3	8	5	0	13
Pica pica	6	3	5	1	6	12
Troglodytes troglodytes	4	8	5	6	1	12
Corvus frugilegus	6	3	2	5	4	11
Turdus pilaris	12	5	5	2	4	11
Streptopelia decaocto	3	3	4	3	3	10
Vanellus vanellus	7	6	6	4	0	10
Passer domesticus	3	6	1	4	4	9
Falco tinnunculus	9	5	5	3	1	9
Perdix perdix	4	0	5	4	0	9
Emberiza citrinella	4	4	3	3	2	8

scientific	1	2	3	4	5	sufficient
Pluvialis apricaria	6	2	4	4	0	8
Carduelis carduelis	7	3	6	2	0	8
Picus viridis	8	7	5	2	0	7
Dendrocopos major	7	6	3	2	1	6
Anthus pratensis	5	1	3	3	0	6
Sitta europaea	1	1	1	2	2	5
Poecile palustris	4	1	3	0	2	5
Aegithalos caudatus	6	5	3	2	0	5
Turdus philomelos	9	4	5	0	0	5
Corvus monedula	5	3	2	1	1	4
Regulus regulus	3	3	2	1	1	4
Phasianus colchicus	3	4	1	1	1	3
Columba livia	3	0	1	1	1	3
Ardea cinerea	7	6	2	0	1	3
Pyrrhula pyrrhula	4	3	2	0	1	3
Cygnus olor	0	2	2	0	1	3
Ardea alba	4	1	2	0	1	3
Anthus spinoletta	0	0	0	1	1	2
Tringa ochropus	1	1	1	0	1	2
Coccothraustes coccothraustes	6	0	1	0	1	2
Phalacrocorax carbo	5	0	1	0	1	2
Numenius arquata	0	0	1	0	1	2
Turdus iliacus	9	4	1	1	0	2
Fulica atra	1	0	1	1	0	2
Passer montanus	2	2	2	0	0	2
Prunella modularis	10	1	2	0	0	2
Dryocopus martius	1	1	2	0	0	2
Certhia brachydactyla	3	1	0	0	1	1
Anas platyrhynchos	3	2	0	1	0	1
Alopochen aegyptiaca	0	1	0	1	0	1
Gallinula chloropus	0	1	0	1	0	1
Columba oenas	0	1	0	1	0	1
Aythya ferina	0	0	0	1	0	1
Aythya fuligula	0	0	0	1	0	1
Chloris chloris	10	6	1	0	0	1
Spinus spinus	4	5	1	0	0	1
Linaria cannabina	8	3	1	0	0	1
Phoenicurus ochruros	3	2	1	0	0	1
Periparus ater	2	2	1	0	0	1
Motacilla alba	6	1	1	0	0	1
Larus ridibundus	5	1	1	0	0	1
Certhia familiaris	3	1	1	0	0	1
Ciconia ciconia	0	0	1	0	0	1
Anas strepera	0	0	1	0	0	1
Larus canus	0	0	1	0	0	1
Regulus ignicapilla	1	5	0	0	0	0
Sylvia atricapilla	3	3	0	0	0	0
Emberiza schoeniclus	1	3	0	0	0	0
LINDENIZA SCHOCHICIAS						
Accipiter nisus	6	2	0	0	0	0

scientific	1	2	3	4	5	sufficient
Larus argentatus	3	2	0	0	0	0
Grus grus	0	2	0	0	0	0
Lophophanes cristatus	0	2	0	0	0	0
Gallinago gallinago	5	1	0	0	0	0
Emberiza cirlus	4	1	0	0	0	0
Egretta garzetta	3	1	0	0	0	0
Serinus serinus	3	1	0	0	0	0
Saxicola rubicola	2	1	0	0	0	0
Emberiza calandra	2	1	0	0	0	0
Poecile montanus	1	1	0	0	0	0
Lanius excubitor	1	1	0	0	0	0
Corvus corax	1	1	0	0	0	0
Gyps fulvus	0	1	0	0	0	0
Dendropicos medius	0	1	0	0	0	0
Fringilla montifringilla	9	0	0	0	0	0
Circus cyaneus	8	0	0	0	0	0
Phylloscopus collybita	6	0	0	0	0	0
Anser anser	2	0	0	0	0	0
Anas crecca	2	0	0	0	0	0
Falco peregrinus	2	0	0	0	0	0
Scolopax rusticola	2	0	0	0	0	0
Dryobates minor	2	0	0	0	0	0
Tachybaptus ruficollis	1	0	0	0	0	0
Podiceps cristatus	1	0	0	0	0	0
Ciconia nigra	1	0	0	0	0	0
Milvus milvus	1	0	0	0	0	0
Alectoris rufa	1	0	0	0	0	0
Lymnocryptes minimus	1	0	0	0	0	0
Actitis hypoleucos	1	0	0	0	0	0
Strix aluco	1	0	0	0	0	0
Alcedo atthis	1	0	0	0	0	0
Anthus trivialis	1	0	0	0	0	0
Motacilla flava	1	0	0	0	0	0
Cettia cetti	1	0	0	0	0	0
Acanthis flammea	1	0	0	0	0	0

2.3 RULE 3: WE NEED AT LEAST 100 OCCURRENCES PER SPECIES

An occurrence is non-zero observation at unique combination of site, year and period. For a stable model we need at least 100 occurrences.

58 of the 67 species have less than 100 occurrences and are thus too rare for the analysis. The final set of of species is listed in table 2.3.

Table 2.3: Number of occurrences per species.

scientific	occurrences	analysis
Turdus merula	207	sufficient
Corvus corone	189	sufficient

Fringilla coelebs Parus major Cyanistes caeruleus Erithacus rubecula Columba palumbus Sturnus vulgaris Buteo buteo Garrulus glandarius Pica pica Passer domesticus Corvus frugilegus Turdus pilaris Troglodytes troglodytes Turdus viscivorus Streptopelia decaocto Emberiza citrinella Falco tinnunculus Pluvialis apricaria Sitta europaea Picus viridis Dendrocopos major Anthus pratensis Poecile palustris Aegithalos caudatus 146 sufficient sufficient sufficient 127 sufficient 128 sufficient 129 sufficient 120 sufficient 120 sufficient 120 sufficient 121 sufficient 120 sufficient 121 sufficient 122 sufficient 123 sufficient 124 sufficient 125 sufficient 126 sufficient 127 sufficient 127 sufficient 128 sufficient 129 sufficient 120 sufficien	scientific	occurrences	analysis
Parus major Cyanistes caeruleus Erithacus rubecula Columba palumbus Sturnus vulgaris Buteo buteo Passer domesticus Corvus frugilegus Turdus pilaris Turdus viscivorus Streptopelia decaocto Emberiza citrinella Palco viridis Pardus vanellus Carduelis carduelis Proceile palustris Dendrocopos major Anthus pratensis Poecile palustris Aegithalos caudatus Regulus regulus Corvus monedula Ardea cinerea Cygnus olor Phalacrocoraux et albay Numenius arquata Anthus spinoletta Turdus sinufficien Insufficien	Alauda arvensis	149	sufficient
Cyanistes caeruleus Erithacus rubecula Columba palumbus Sturnus vulgaris Buteo buteo Garrulus glandarius Pica pica Passer domesticus Corvus frugilegus Troglodytes troglodytes Treptopelia decaocto Emberiza citrinella Falco tinnunculus Perdix perdix Vanellus vanellus Stata europaea Picus viridis Dendrocopos major Anthus pratensis Poecile palustris Aegithalos caudatus Regulus regulus Corvus monedula Ardea cinerea Cygnus dara Cyanus daray Corthaus taray Corcethraustes coccothraustes Aythya fuligula Gallinula chloropus Prusuella modularis Prasser montanus Prasser montanus Fusus fficien 127 sufficient 120 sufficient 120 sufficient 120 sufficient 121 sufficient 120 sufficient 121 sufficient 122 sufficient 123 sufficient 124 sufficient 125 sufficient 125 sufficient 126 sufficient 127 sufficient 128 sufficient 129 sufficient 130 sufficient 131 insufficient 132 insufficient 133 insufficient 144 insufficient 155 sufficient 156 sufficient 157 sufficient 157 sufficient 158 insufficient 168 insufficient 179 sufficient 189 sufficient 180 sufficient 180 sufficient 180 sufficient 180 sufficient 180 sufficient 180 sufficient 181 sufficient 181 sufficient 182 sufficient 183 insufficient 184 sufficient 185 sufficient 186 sufficient 186 sufficient 187 sufficient 187 sufficient 188 insufficient 188 insufficient 188 insufficient 185 sufficient 186 sufficient 186 sufficient 187 sufficient 187 sufficient 188 insufficient 187 sufficient 187 sufficient 188 insufficient 188 insufficient 188 insufficient 188 insufficient 188 insufficient 188 insufficient 187 sufficient 188 insufficient 189 sufficient 180 suffi	Fringilla coelebs	146	sufficient
Frithacus rubecula Columba palumbus Sturnus vulgaris Buteo buteo Garrulus glandarius Pica pica Passer domesticus Corvus frugilegus Tiroglodytes troglodytes Tiroglodytes troglodytes Tiroglodytes trinulus Sturnus vanellus Perdix perdix Vanellus vanellus Pluvialis apricaria Picus viridis Dendrocopos major Anthus pratensis Poecile palustris Aegithalos caudatus Regulus regulus Turdus philomelos Corvus monedula Ardea cinerea Columba livia Ardea alba Pyrrhula pyrrhula Fulicus viricien Lorundus vanelus Corcothraustes coccothraustes Apunellia modularis Prunella modularis Prunella modularis Prusu fincient 112 sufficient s	Parus major	139	sufficient
Columba palumbus Sturnus vulgaris Buteo buteo Garrulus glandarius Pica pica Passer domesticus Corvus frugilegus Turdus pilaris Streptopelia decaocto Emberiza citrinella Perdix perdix Vanellus vanellus Picus viridis Dendrocopos major Anthus pratensis Poecile palustris Aegithalos caudatus Regulus regulus Turdus pilorlos Turdus predix Ardea cinerea Cygnus olor Phalacrocorax carbo Phasianus colchicus Corvus monedula Anthus spinoletta Turdus spinoletta Turdus spinoletta Turdus pyrrhula Prunella modularis Prunella modularis Prunella modularis Prunella modularis Prunella modularis Prusu finsufficien Insufficien Insuff	Cyanistes caeruleus	127	sufficient
Sturnus vulgaris Buteo buteo Garrulus glandarius Pica pica Passer domesticus Corvus frugilegus Turdus pilaris Troglodytes troglodytes Turdus viscivorus Streptopelia decaocto Emberiza citrinella Falco tinnunculus Perdix perdix Vanellus vanellus Carduelis carduelis Pluvialis apricaria Sitta europaea Picus viridis Dendrocopos major Anthus pratensis Poecile palustris Regulus regulus Turdus pilomelos Corvus monedula Ardea cinerea Cygnus olor Phalacrocorax carbo Phasianus colchicus Certhia brachydactyla Turdus spinoletta Turdus spinoletta Turdus spinoletta Turdus pringlia Turdus pringlia Turdus pringlia Turdus pringlia Turdus pyrrhula Perdix P	Erithacus rubecula	120	sufficient
Buteo buteo 98 insufficien Garrulus glandarius 88 insufficien Pica pica 88 insufficien Passer domesticus 70 insufficien Turdus pilaris 69 insufficien Turdus pilaris 64 insufficien Turglodytes troglodytes 63 insufficien Turdus viscivorus 60 insufficien Streptopelia decaocto 57 insufficien Emberiza citrinella 46 insufficien Falco tinnunculus 45 insufficien Turdus vanellus 39 insufficien Perdix vanellus 39 insufficien Sitta europaea 32 insufficien Picus viridis 31 insufficien Picus viridis 31 insufficien Poecile palustris 29 insufficien Anthus pratensis 29 insufficien Regulus regulus 23 insufficien Turdus philomelos 21 insufficien Corvus monedula 21 insufficien Ardea cinerea 20 insufficien Phalacrocorax carbo 71 insufficien Purrhula pyrrhula 72 insufficien Numenius arquata 10 insufficien Numenius arquata 10 insufficien Numenius arquata 10 insufficien Turdus spinoletta 10 insufficien Turdus spinoletta 10 insufficien Turdus spinoletta 10 insufficien Turdus iliacus 10 insufficien Turdus	Columba palumbus	113	sufficient
Garrulus glandarius Pica pica Passer domesticus Corvus frugilegus Turdus pilaris Troglodytes troglodytes Turdus viscivorus Streptopelia decaocto Emberiza citrinella Falco tinnunculus Perdix perdix Vanellus vanellus Carduelis carduelis Picus viridis Dendrocopos major Anthus pratensis Pegulus regulus Regulus regulus Regulus regulus Corvus monedula Ardea cinerea Cygnus olor Phasianus colchicus Corthia brachydactyla Tringa ochropus Coccothraustes coccothraustes Aythya fuligula Gallinula chloropus Prusulis insufficien Regulus regulus Tinsufficien Insufficien Insufficie	Sturnus vulgaris	112	sufficient
Pica pica 88 insufficien Passer domesticus 70 insufficien Corvus frugilegus 69 insufficien Turdus pilaris 64 insufficien Turdus viscivorus 60 insufficien Emberiza citrinella 46 insufficien Falco tinnunculus 45 insufficien Falco tinnunculus 45 insufficien Perdix perdix 41 insufficien Puvialis apricaria 32 insufficien Sitta europaea 32 insufficien Picus viridis 31 insufficien Anthus pratensis 29 insufficien Regulus regulus 23 insufficien Regulus regulus 24 insufficien Corvus monedula 21 insufficien Phasianus colchicus 17 insufficien Phasianus colchicus 17 insufficien Purrhula pyrrhula 14 insufficien Pyrrhula pyrrhula 15 insufficien Purunellia modularis 7 insufficien Regulua reducus 8 insufficien Prunella modularis 7 insufficien Reguluala 7 insufficien Regulus requata 10 insufficien Regulus arquata 10 insufficien Regulus iliacus 17 insufficien Regulus iliacus	Buteo buteo	98	insufficient
Passer domesticus Corvus frugilegus Turdus pilaris Troglodytes troglodytes Turdus viscivorus Streptopelia decaocto Emberiza citrinella Falco tinnunculus Perdix perdix Vanellus vanellus Carduelis carduelis Pluvialis apricaria Sitta europaea Picus viridis Dendrocopos major Anthus pratensis Poecile palustris Aegithalos caudatus Regulus regulus Turdus philomelos Corvus monedula Ardea cinerea Cygnus olor Phasianus colchicus Columba livia Arthus spinoletta Turdus iliacus Certhia brachydactyla Tringa ochropus Coccothraustes coccothraustes Punella modularis Prusufficien Insufficien Regulus regulua Regulua redustris Regulius requia Regithalos caudatus Regulus resultistes Regulus res	Garrulus glandarius	88	insufficient
Corvus frugilegus Turdus pilaris Troglodytes troglodytes Turdus viscivorus Streptopelia decaocto Emberiza citrinella Falco tinnunculus Perdix perdix Vanellus vanellus Carduelis carduelis Pluvialis apricaria Sitta europaea Picus viridis Dendrocopos major Anthus pratensis Poecile palustris Aegithalos caudatus Regulus regulus Turdus philomelos Corvus monedula Ardea cinerea Cygnus olor Phasianus colchicus Columba livia Arthus spinoletta Turdus iliacus Certhia brachydactyla Tringa ochropus Coccothraustes coccothraustes Punella modularis Prusufficien Insufficien Regulus regulua Regulua reducta insufficien Regulus requia Regulus requia Regulus requia Regulus requia Regulus requia Regulus resultistes Regulus	Pica pica	88	insufficient
Turdus pilaris Troglodytes troglodytes Troglodytes troglodytes Troglodytes troglodytes Turdus viscivorus Streptopelia decaocto Emberiza citrinella Falco tinnunculus Perdix perdix Vanellus vanellus Carduelis carduelis Pluvialis apricaria Sitta europaea Picus viridis Dendrocopos major Anthus pratensis Poecile palustris Aegithalos caudatus Regulus regulus Turdus philomelos Corvus monedula Ardea cinerea Cygnus olor Phalacrocorax carbo Phasianus colchicus Columba livia Ardea alba Pyrrhula pyrrhula Fulica atra Numenius arquata Anthus spinoletta Tringa ochropus Coccothraustes coccothraustes Aythya fuligula Gallinula chloropus Prunella modularis Passer montanus Pasi insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 10 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 10 insufficien 10 insufficien 10 insufficien 10 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 1	Passer domesticus	70	insufficient
Troglodytes troglodytes Turdus viscivorus Streptopelia decaocto Emberiza citrinella Falco tinnunculus Perdix perdix Vanellus vanellus Carduelis carduelis Pluvialis apricaria Sitta europaea Picus viridis Dendrocopos major Anthus pratensis Aegithalos caudatus Regulus regulus Turdus philomelos Corvus monedula Ardea cinerea Cygnus olor Phasianus colchicus Columba livia Anthus spinoletta Turdus iliacus Certhia brachydactyla Tringa ochropus Prusella modularis Pusidis vinsufficien Cocothraustes coccothraustes Pusser montanus Positicien Corus monedula rinsufficien Cocothraustes coccothraustes Cocynus deliricien Cocynus de	Corvus frugilegus	69	insufficient
Turdus viscivorus Streptopelia decaocto Emberiza citrinella Falco tinnunculus Perdix perdix Vanellus vanellus Carduelis carduelis Pluvialis apricaria Sitta europaea Picus viridis Dendrocopos major Anthus pratensis Poecile palustris Aegithalos caudatus Regulus regulus Turdus philomelos Corvus monedula Ardea cinerea Cygnus olor Phasianus colchicus Columba livia Ardea alba Pyrrhula pyrrhula Fulica atra Numenius arquata Anthus spinoletta Turdus iliacus Coerthia brachydactyla Tringa ochropus Punella modularis Passer montanus Passer montanus 60 insufficien insuf	Turdus pilaris	64	insufficient
Streptopelia decaocto Emberiza citrinella Falco tinnunculus Perdix perdix Vanellus vanellus Carduelis carduelis Pluvialis apricaria Sitta europaea Picus viridis Dendrocopos major Anthus pratensis Pegulus regulus Turdus philomelos Corvus monedula Ardea cinerea Cygnus olor Phasianus colchicus Columba livia Ardea alba Pyrrhula pyrrhula Fulica atra Numenius arquata Anthus spinoletta Turdus iliacus Certhia brachydactyla Tringa ochropus Pusudini avanus Passer montanus Passer montanus Tinsufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 10 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 10 insufficien 10 insufficien 10 insufficien 10 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien	Troglodytes troglodytes	63	insufficient
Emberiza citrinella 46 insufficient Falco tinnunculus 45 insufficient Perdix perdix 41 insufficient Vanellus vanellus 39 insufficient 39 insufficient 39 insufficient 39 insufficient 31 insufficient 32 insufficient 34 insufficient 35 insufficient 36 insufficient 36 insufficient 37 insuf	Turdus viscivorus	60	insufficient
Falco tinnunculus Perdix perdix Vanellus vanellus Carduelis carduelis Pluvialis apricaria Sitta europaea Picus viridis Dendrocopos major Anthus pratensis Poecile palustris Aegithalos caudatus Regulus regulus Turdus philomelos Corvus monedula Ardea cinerea Cygnus olor Phasianus colchicus Columba livia Ardea alba Pyrrhula pyrrhula Fulica atra Numenius arquata Anthus spinoletta Turdus insufficien Numenius arquata Anthus spinoletta Turinga ochropus Coccothraustes coccothraustes Aythya fuligula Gallinula chloropus Prunella modularis Passer montanus 39 insufficien insufficien 31 insufficien 32 insufficien 33 insufficien 34 insufficien 35 insufficien 36 insufficien 37 insufficien 38 insufficien 39 insufficien 30 insufficien 30 insufficien 31 insufficien 32 insufficien 33 insufficien 34 insufficien 35 insufficien 36 insufficien 37 insufficien 38 insufficien 39 insufficien 30 insufficien 30 insufficien 31 insufficien 32 insufficien 32 insufficien 33 insufficien 34 insufficien 36 insufficien 37 insufficien 38 insufficien 39 insufficien 39 insufficien 30 insufficien 30 insufficien 31 insufficien 31 insufficien 32 insufficien 32 insufficien 32 insufficien 31 insufficien 32 insufficien 45 insufficien 46 insufficien 47 insufficien 48 insufficien 49 insufficien 40 insufficien 40 insufficien 41 insufficien 41 insufficien 42 insufficien 43 insufficien 44 insufficien 45 insufficien 46 insufficien 47 insufficien 47 insufficien 47 insufficien 48 insufficien 49 insufficien 40 insufficien 40 insufficien 41 insufficien 41 insufficien 41 insufficien 42 insufficien 43 insufficien 44 insufficien 45 insufficien 46 insufficien 47 insufficien 47 insufficien 48 insufficien 49 insufficien 40 insufficien 41 insufficien 41 insufficien 41 insufficien 41 insufficien 41 insufficie	Streptopelia decaocto	57	insufficient
Perdix perdix Vanellus vanellus Carduelis carduelis Pluvialis apricaria Sitta europaea Picus viridis Dendrocopos major Anthus pratensis Poecile palustris Aegithalos caudatus Regulus regulus Turdus philomelos Corvus monedula Ardea cinerea Cygnus olor Phalacrocorax carbo Phasianus colchicus Columba livia Ardea alba Pyrrhula pyrrhula Fulica atra Numenius arquata Anthus spinoletta Turdus insufficien Aythya fuligula Gallinula chloropus Prunella modularis Passer montanus 13 insufficien 13 insufficien 24 insufficien 25 insufficien 26 insufficien 27 insufficien 28 insufficien 29 insufficien 20 insufficien 21 insufficien 22 insufficien 23 insufficien 24 insufficien 25 insufficien 26 insufficien 27 insufficien 28 insufficien 29 insufficien 20 insufficien 21 insufficien 22 insufficien 23 insufficien 24 insufficien 25 insufficien 26 insufficien 27 insufficien 28 insufficien 29 insufficien 20 insufficien 20 insufficien 21 insufficien 22 insufficien 23 insufficien 24 insufficien 25 insufficien 26 insufficien 27 insufficien 28 insufficien 29 insufficien 20 insufficien 20 insufficien 21 insufficien 22 insufficien 23 insufficien 24 insufficien 25 insufficien 26 insufficien 27 insufficien 28 insufficien 29 insufficien 20 insufficien 20 insufficien 21 insufficien 21 insufficien 22 insufficien 23 insufficien 24 insufficien 25 insufficien 26 insufficien 27 insufficien 28 insufficien 29 insufficien 29 insufficien 20 insufficien 20 insufficien 21 insufficien 21 insufficien 22 insufficien 23 insufficien 24 insufficien 25 insufficien 26 insufficien 27 insufficien 28 insufficien 29 insufficien 29 insufficien 20 insufficien 20 insufficien 21 insufficien 21 insufficien 21 insufficien 21 insufficien 22 insufficien 23 insufficien 24 insufficien 25 insufficien 26 insufficien 27 insufficien 28 insufficien 29 insufficien 29 insufficien 20 insufficien 20 insufficien 20 insufficien 21 insufficien 21 insufficien 21 insufficien 21 insufficien 22 insufficien 23 insufficien 24 insufficien 25 insufficien 26 insufficien 27 insufficien 28 insufficien	Emberiza citrinella	46	insufficient
Vanellus vanellus Carduelis carduelis Pluvialis apricaria Sitta europaea Picus viridis Dendrocopos major Anthus pratensis Poecile palustris Aegithalos caudatus Regulus regulus Turdus philomelos Corvus monedula Ardea cinerea Cygnus olor Phasianus colchicus Columba livia Ardea alba Pyrrhula pyrrhula Fulica atra Numenius arquata Anthus spinoletta Turdus insufficien Coccothraustes coccothraustes Aythya fuligula Gallinula chloropus Prunella modularis Passer montanus 39 insufficien 39 insufficien 30 insufficien 31 insufficien 32 insufficien 33 insufficien 34 insufficien 35 insufficien 36 insufficien 37 insufficien 38 insufficien 39 insufficien 30 insufficien 30 insufficien 31 insufficien 32 insufficien 33 insufficien 34 insufficien 35 insufficien 36 insufficien 37 insufficien 38 insufficien 39 insufficien 39 insufficien 30 insufficien 30 insufficien 31 insufficien 32 insufficien 33 insufficien 34 insufficien 35 insufficien 36 insufficien 37 insufficien 38 insufficien 39 insufficien 39 insufficien 30 insufficien 31 insufficien 32 insufficien 34 insufficien 35 insufficien 36 insufficien 37 insufficien 38 insufficien 39 insufficien 30 insufficien 30 insufficien 31 insufficien 31 insufficien 32 insufficien 47 insufficien 48 insufficien 49 insufficien 40 insufficien 41 insufficien 41 insufficien 41 i	Falco tinnunculus	45	insufficient
Vanellus vanellus39insufficienCarduelis carduelis39insufficienPluvialis apricaria32insufficienSitta europaea32insufficienPicus viridis31insufficienDendrocopos major30insufficienAnthus pratensis29insufficienPoecile palustris29insufficienAegithalos caudatus24insufficienRegulus regulus23insufficienTurdus philomelos21insufficienCorvus monedula21insufficienArdea cinerea20insufficienCygnus olor19insufficienPhalacrocorax carbo17insufficienPhasianus colchicus17insufficienColumba livia17insufficienArdea alba16insufficienPyrrhula pyrrhula14insufficienPyrrhula pyrrhula14insufficienFulica atra12insufficienNumenius arquata10insufficienAnthus spinoletta10insufficienTurdus iliacus10insufficienCerthia brachydactyla8insufficienTringa ochropus8insufficienCoccothraustes coccothraustes8insufficienAythya fuligula7insufficienGallinula chloropus7insufficienPrunella modularis7insufficienPasser montanus7insufficien	Perdix perdix	41	insufficient
Pluvialis apricaria Sitta europaea Picus viridis Dendrocopos major Anthus pratensis Poecile palustris Aegithalos caudatus Regulus regulus Turdus philomelos Corvus monedula Ardea cinerea Cygnus olor Phasianus colchicus Columba livia Ardea alba Pyrrhula pyrrhula Fulica atra Numenius arquata Anthus spinoletta Turdus iliacus Coccothraustes coccothraustes Aythya fuligula Fulica modularis Passer montanus 32 insufficien 33 insufficien 34 insufficien 35 insufficien 36 insufficien 37 insufficien 38 insufficien 39 insufficien 30 insufficien 31 insufficien 32 insufficien 33 insufficien 34 insufficien 35 insufficien 36 insufficien 37 insufficien 38 insufficien 39 insufficien 30 insufficien 31 insufficien 32 insufficien 33 insufficien 34 insufficien 36 insufficien 37 insufficien 38 insufficien 39 insufficien 30 insufficien 31 insufficien 32 insufficien 34 insufficien 35 insufficien 36 insufficien 37 insufficien 38 insufficien 39 insufficien 30 insufficien 31 insufficien 31 insufficien 32 insufficien 34 insufficien 35 insufficien 36 insufficien 37 insufficien 38 insufficien 39 insufficien 30 insufficien 31 insufficien 31 insufficien 32 insufficien 34 insufficien 35 insufficien 36 insufficien 37 insufficien 38 insufficien 39 insufficien 30 insufficien 30 insufficien 31 insufficien 31 insufficien 31 insufficien 30 insufficien 31 insufficien 41 insufficien 42 insufficien 43 insufficien 44 insufficien 45 insufficien 47 insufficien 47 insufficien 48 insufficien 49 insufficien 40 insufficien 40 insufficien 40 insufficien 41 insufficien 41 insufficien 41 insufficien 41 insufficien 41 insufficien 42 insufficien 41 insufficien 41 insufficien 41 insufficien 42 insufficien 41 insufficien 41 insufficien 42 insufficien 41 insufficien 41 insufficien 41 insufficien 41 insufficien 42 insufficien 41 insufficien 41 insufficien 42 insufficien 41 insufficien 42 insufficien 42 insufficien 43 insufficien 44 insufficien 45 insufficien 46 insufficien 47 insufficien 47 insufficien 48 insufficien 49 insufficien 40 insufficien	Vanellus vanellus	39	insufficient
Sitta europaea 32 insufficien Picus viridis 31 insufficien Dendrocopos major 30 insufficien Anthus pratensis 29 insufficien Aegithalos caudatus 24 insufficien Regulus regulus 23 insufficien Turdus philomelos 21 insufficien Ardea cinerea 20 insufficien Cygnus olor 19 insufficien Phalacrocorax carbo 17 insufficien Phasianus colchicus 17 insufficien Ardea alba 16 insufficien Pyrrhula pyrrhula 14 insufficien Pulica atra 12 insufficien Numenius arquata 10 insufficien Anthus spinoletta 10 insufficien Turdus iliacus 10 insufficien Coccothraustes coccothraustes 11 insufficien Coccothraustes coccothraustes 12 insufficien Coccothraustes coccothraustes 13 insufficien Coccothraustes coccothraustes 14 insufficien Callinula chloropus 7 insufficien Callinula modularis 7 insufficien Casser montanus 7 insufficien Tinsufficien	Carduelis carduelis	39	insufficient
Sitta europaea Picus viridis Dendrocopos major Anthus pratensis Poecile palustris Aegithalos caudatus Regulus regulus Turdus philomelos Corvus monedula Ardea cinerea Cygnus olor Phasianus colchicus Columba livia Ardea alba Pyrrhula pyrrhula Fulica atra Numenius arquata Anthus spinoletta Turdus iliacus Coccothraustes coccothraustes Aythya fuligula Passer montanus 31 insufficien 32 insufficien 33 insufficien 34 insufficien 35 insufficien 36 insufficien 37 insufficien 38 insufficien 39 insufficien 40 insufficien 41 insufficien 42 insufficien 43 insufficien 44 insufficien 45 insufficien 46 insufficien 47 insufficien 48 insufficien 49 insufficien 40 insufficien 40 insufficien 41 insufficien 42 insufficien 43 insufficien 44 insufficien 45 insufficien 46 insufficien 47 insufficien 48 insufficien 49 insufficien 40 insufficien 40 insufficien 41 insufficien 42 insufficien 43 insufficien 44 insufficien 45 insufficien 46 insufficien 47 insufficien 48 insufficien 49 insufficien 40 insufficien 40 insufficien 41 insufficien 42 insufficien 43 insufficien 44 insufficien 45 insufficien 46 insufficien 47 insufficien 47 insufficien 48 insufficien 49 insufficien 40 insufficien 40 insufficien 41 insufficien 42 insufficien 43 insufficien 44 insufficien 45 insufficien 46 insufficien 47 insufficien 48 insufficien 49 insufficien 40 insufficien 40 insufficien 41 insufficien 41 insufficien 42 insufficien 41 insufficien 42 insufficien 41 insufficien 42 insufficien 42 insufficien 43 insufficien 44 insufficien 45 insufficien 46 insufficien 47 insufficien 48 insufficien 49 insufficien 40 insuffic	Pluvialis apricaria	32	insufficient
Picus viridis31insufficientDendrocopos major30insufficientAnthus pratensis29insufficientPoecile palustris29insufficientAegithalos caudatus24insufficientRegulus regulus23insufficientTurdus philomelos21insufficientCorvus monedula21insufficientArdea cinerea20insufficientCygnus olor19insufficientPhalacrocorax carbo17insufficientPhasianus colchicus17insufficientColumba livia17insufficientArdea alba16insufficientPyrrhula pyrrhula14insufficientFulica atra12insufficientNumenius arquata10insufficientAnthus spinoletta10insufficientTurdus iliacus10insufficientCerthia brachydactyla8insufficientTringa ochropus8insufficientCoccothraustes coccothraustes8insufficientAythya fuligula7insufficientGallinula chloropus7insufficientPrunella modularis7insufficientPasser montanus7insufficient	•		insufficient
Dendrocopos major Anthus pratensis Poecile palustris Aegithalos caudatus Regulus regulus Turdus philomelos Corvus monedula Ardea cinerea Cygnus olor Phasianus colchicus Columba livia Ardea alba Pyrrhula pyrrhula Fulica atra Anthus spinoletta Turdus iliacus Certhia brachydactyla Tringa ochropus Coccothraustes Aythya fuligula Gallinula chloropus Prunella modularis Passer montanus 29 insufficien 29 insufficien 21 insufficien 22 insufficien 23 insufficien 24 insufficien 25 insufficien 26 insufficien 27 insufficien 28 insufficien 29 insufficien 20 insufficien 21 insufficien 21 insufficien 22 insufficien 23 insufficien 24 insufficien 26 insufficien 27 insufficien 28 insufficien 29 insufficien 21 insufficien 21 insufficien 22 insufficien 23 insufficien 24 insufficien 24 insufficien 26 insufficien 27 insufficien 28 insufficien 29 insufficien 29 insufficien 20 insufficien 21 insufficien 21 insufficien 22 insufficien 23 insufficien 24 insufficien 24 insufficien 26 insufficien 27 insufficien 28 insufficien 29 insufficien 29 insufficien 20 insufficien 20 insufficien 21 insufficien 21 insufficien 22 insufficien 22 insufficien 23 insufficien 24 insufficien 24 insufficien 26 insufficien 27 insufficien 28 insufficien 29 insufficien 20 insufficien 20 insufficien 21 insufficien 21 insufficien 21 insufficien 21 insufficien 21 insufficien 22 insufficien 22 insufficien 23 insufficien 24 insufficien 24 insufficien 24 insufficien 24 insufficien 26 insufficien 27 insufficien 28 insufficien 29 insufficien 20 insufficien 20 insufficien 20 insufficien 21 insufficien 20 insufficien 21 insufficien 21 insufficien 22 insufficien 24 insufficien 24 insufficien 26 insufficien 27 insufficien 28 insufficien 29 insufficien 20 insufficien 20 insufficien 20 insufficien 20 insufficien 20 insufficien 20 insufficien 21 insufficien 21 insufficien 21 insufficien 21 insufficien 22 insufficien 23 insufficien 24 insufficien 26 insufficien 27 insufficien 28 insufficien 29 insufficien 20 insufficien 20 insufficien 20 insufficien 20 insufficien 20 insufficien	•		insufficient
Anthus pratensis Poecile palustris Aegithalos caudatus Regulus regulus Turdus philomelos Corvus monedula Ardea cinerea Cygnus olor Phalacrocorax carbo Phasianus colchicus Columba livia Ardea alba Pyrrhula pyrrhula Pyrrhula pyrrhula Fulica atra Numenius arquata Anthus spinoletta Turdus iliacus Coccothraustes coccothraustes Aythya fuligula Gallinula chloropus Prunella modularis Passer montanus 29 insufficien 19 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 10 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 10 insufficien 10 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insufficien 10 insufficien 10 insufficien 10 insufficien 10 insufficien 11 insufficien 12 insufficien 13 insufficien 14 insufficien 15 insufficien 16 insufficien 17 insufficien 18 insufficien 19 insufficien 10 insuffici		30	insufficient
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scientific	occurrences	analysis
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Dryocopus martius	6	insufficient
Aythya ferina	5	insufficient
Columba oenas	5	insufficient
Phoenicurus ochruros	5	insufficient
Ciconia ciconia	4	insufficient
Larus ridibundus	4	insufficient
Larus canus	4	insufficient
Chloris chloris	4	insufficient
Anas strepera	3	insufficient
Motacilla alba	3	insufficient
Periparus ater	3	insufficient
Certhia familiaris	3	insufficient
Spinus spinus	3	insufficient
Linaria cannabina	3	insufficient

3 AVAILABLE OUTPUT

3.1 TABLE WITH LINEAR TRENDS

Part II starts with table 4.1 which lists the linear trend for all species. 'model' indicates which model is best based on Watanabe–Akaike information criterion (WAIC) (Gelman et al, 2014). Lower WAIC values imply a better model fit, while taking the model complexity into account. L indicates that the trend is linear, which implies that the change is constant. A trend is linear when the linear model has a lower WAIC than the non-linear model. NL indicates that the trend is non-linear. The change between consecutive years is not constant. Thus one should interpret the given linear change with caution. A trend is non-linear when the WAIC of the non-linear model is more than 2 units smaller than that of the linear model. When the WAIC of the non-linear model is less than 2 units smaller than the linear model, we state that the model is possibly non-linear. This is indicated as NL?. Trends of non-linear models are best interpreted based on the trend figures.

3.2 CREDIBLE INTERVALS

Because we apply a Bayesian model, all intervals are credible intervals. Credible intervals are conceptually different from confidence intervals. However, both indicate a similar uncertainty of an estimate. A layperson can use credible intervals as if they are confidence intervals. Therefore we will not elaborate on the difference between credible and confidence intervals. Just know that they are credible intervals, not confidence intervals.

3.3 TREND CLASSIFICATION

We compare the 95% credible intervals with a reference, upper and lower threshold to classify the strength of the effect into 10 classes. The change of a linear trend is converted into a change over the length of the data. The change of an index is the actual change between the two years. The reference is set to 0 (no change). The credible interval of a significant effect does not contain 0. We selected a change of -25% (3/4 of the initial value) as the lower threshold. We use the complement¹ of that (+33% or 4/3 of the initial value) as the upper threshold. A -25% or +33% change over 5 years is equivalent to an average yearly change of -5.6% or +5.9% in case of a linear trend.

Below are the symbols, interpretations and rules for each of the 10 classes.

- ++ **strong increase**: A significant positive trend and significantly stronger than the upper threshold.
- +~ **moderate increase**: A significant positive trend and significantly weaker than the upper threshold.
- + increase: A significant positive trend, not significantly different from the upper threshold.
- ~ **stable**: A non-significant trend and significantly between the lower and upper threshold.
- - increase: A significant negative trend, not significantly different from the lower threshold.
- -~ **moderate decrease**: A significant negative trend and significantly weaker than the lower threshold.

 $^{^{1}}log(3/4) = -0.2877$ and log(4/3) = 0.2877

- -- **strong decrease**: A significant negative trend and significantly stronger than the lower threshold.
- ?+ potential increase: A non-significant trend, significantly above the lower threshold.
- ?- potential decrease: A non-significant trend, significantly above the upper threshold.
- ? **unknown**: A non-significant trend, both the lower and upper threshold are probable.

One of the benefits is that we distinguish ~ (stable) and ? (unknown). Both are non-significant. The main difference between both cases is the uncertainty. We set the thresholds at important changes. If the uncertainty is large, then the credible interval contains both the lower and the upper threshold. So we have no clue what is happening, hence the unknown class. If the uncertainty is small, then the credible interval contains neither the lower nor the upper threshold. In this case we do known that the change is less extreme that the thresholds. So if there is a change, it will be smaller than important changes (the thresholds). This is informative, even though the change is not significant.

3.4 FIGURES

Each modelled species gets its own chapter with results. All results are display in a graphical format.

3.4.1 Estimated bird density

The results start with a figure showing the estimated bird density an observer would encounter at an average site during the first period. The line displays the point estimate for each winter. This is the most likely value for the average bird density. The three ribbons display the uncertainty around this point estimate. They are, from small/dark to wide/light, the 30%, 60% and 90% credible intervals. These numbers in the figure are always based on the non-linear model (1.6). The caption indicates whether the model is non-linear and how strong the linear trend is.

3.4.2 Indices

An index is a change compared to a baseline. This baseline is typically the estimate for some reference year. E.g we use 2013 as a baseline and compare 2015 with 2013 or 2016 with 2013. However we cannot use the figure with 2013 as baseline to compare 2015 with 2016. For that we need a figure with either 2015 or 2016 as baseline. To facilitate any pairwise comparison among years, we display one figure for every year using that year as baseline.

3.4.3 Index raster

Currently a separate index figure for each reference year is doable since the data contains only 5 years. The number of index figures will grow over the years, making it harder to interpret them. The third plot summarises the information on a raster. The x axis holds the year we want to interpret. The y axis holds the reference year. The dots given the relative change from the baseline (y axis) to the other year (x axis). Their colour indicates the strength of the change. Stronger changes have darker dots, white dots indicate no change. Red dots indicate a decrease from the baseline, blue dots an increase. A baseline with all red (blue) dots indicates the year with the largest (smallest) numbers. The shape of the dots indicates the classification of the effect. Informative dots (significant or non-significant but stable) get solid shapes.

Part II

Trends

4 LINEAR TRENDS

Table 4.1: Average yearly change

euring	scientific	french	class	model	change
10990	Erithacus rubecula	Rougegorge familier	++	non-linear	25.5%, (7.1%; 48.7%)
11870	Turdus merula	Merle noir	+	non-linear	19.0%, (5.6%; 34.4%)
16360	Fringilla coelebs	Pinson des arbres	?+	possibly non-linear	18.3%, (-0.8%; 41.2%)
15820	Sturnus vulgaris	Étourneau sansonnet	?+	possibly non-linear	18.1%, (-5.6%; 48.0%)
14640	Parus major	Mésange charbonnière	?+	linear	6.9%, (-3.9%; 19.1%)
6700	Columba palumbus	Pigeon ramier	?	possibly non-linear	3.2%, (-25.9%; 45.4%)
9760	Alauda arvensis	Alouette des champs	?	possibly non-linear	2.0%, (-14.5%; 21.8%)
15670	Corvus corone	Corneille noire	?	possibly non-linear	-0.1%, (-17.0%; 19.8%)
14620	Cyanistes caeruleus	Mésange bleue	?	linear	-2.1%, (-14.5%; 12.2%)

5 COLUMBA PALUMBUS (PIGEON RAMIER)

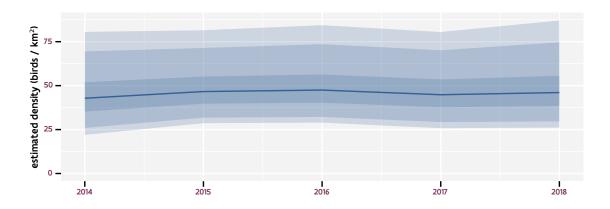


Figure 5.1: Estimated density (birds/km²) for *Columba palumbus* (Pigeon ramier) based on a non-linear model. The linear yearly change (?) is +3.2% (-25.9%; +45.4%). The trend is possibly non-linear.



Figure 5.2: Indices for different reference years

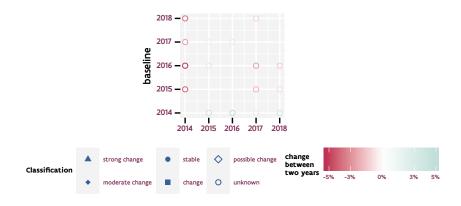


Figure 5.3: Relative change between years

6 ALAUDA ARVENSIS (ALOUETTE DES CHAMPS)

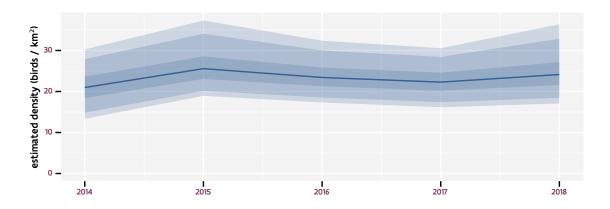


Figure 6.1: Estimated density (birds/km²) for *Alauda arvensis* (Alouette des champs) based on a non-linear model. The linear yearly change (?) is +2.0% (-14.5%; +21.8%). The trend is possibly non-linear.



Figure 6.2: Indices for different reference years

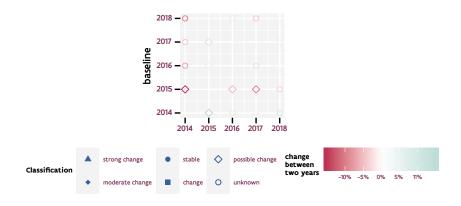


Figure 6.3: Relative change between years

7 ERITHACUS RUBECULA (ROUGEGORGE FAMILIER)

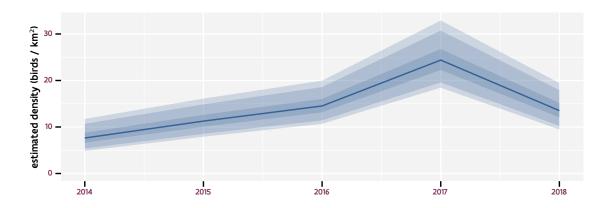


Figure 7.1: Estimated density (birds/km²) for *Erithacus rubecula* (Rougegorge familier) based on a non-linear model. The linear yearly change (++) is +25.5% (+7.1%; +48.7%). The trend is non-linear.

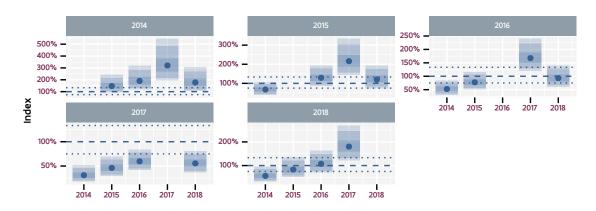


Figure 7.2: Indices for different reference years

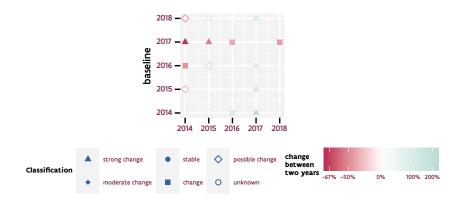


Figure 7.3: Relative change between years

8 TURDUS MERULA (MERLE NOIR)

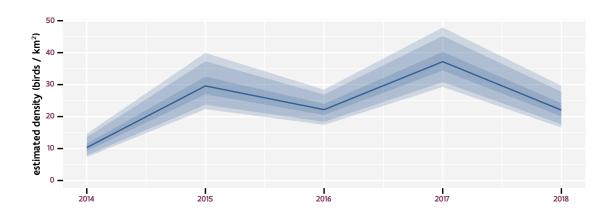


Figure 8.1: Estimated density (birds/ km^2) for *Turdus merula* (Merle noir) based on a non-linear model. The linear yearly change (+) is +19.0% (+5.6%; +34.4%). The trend is non-linear.

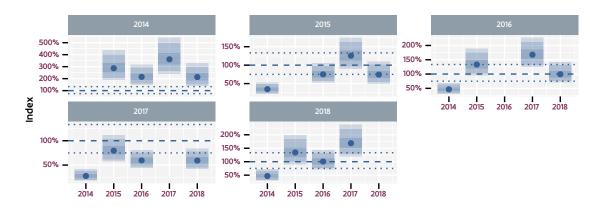


Figure 8.2: Indices for different reference years



Figure 8.3: Relative change between years

9 CYANISTES CAERULEUS (MÉSANGE BLEUE)

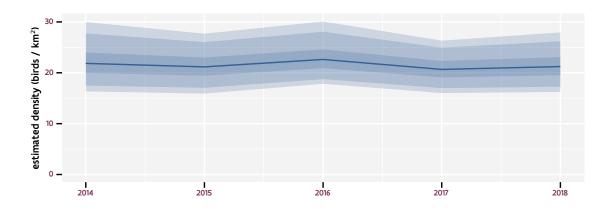


Figure 9.1: Estimated density (birds/km²) for *Cyanistes caeruleus* (Mésange bleue) based on a non-linear model. The linear yearly change (?) is -2.1% (-14.5%; +12.2%). The trend is linear.



Figure 9.2: Indices for different reference years

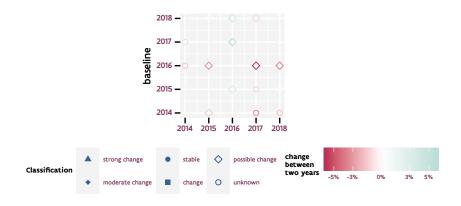


Figure 9.3: Relative change between years

10 PARUS MAJOR (MÉSANGE CHARBONNIÈRE)

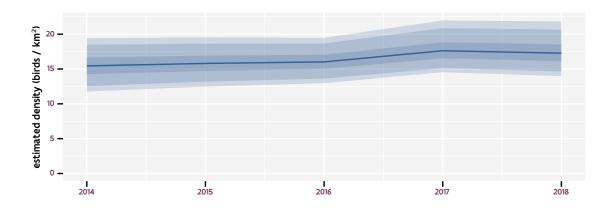


Figure 10.1: Estimated density (birds/km²) for *Parus major* (Mésange charbonnière) based on a non-linear model. The linear yearly change (?+) is +6.9% (-3.9%; +19.1%). The trend is linear.



Figure 10.2: Indices for different reference years

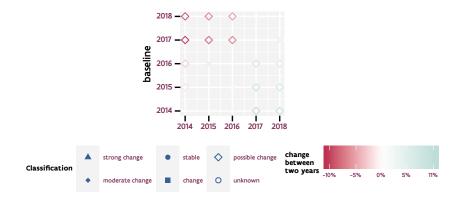


Figure 10.3: Relative change between years

11 CORVUS CORONE (CORNEILLE NOIRE)

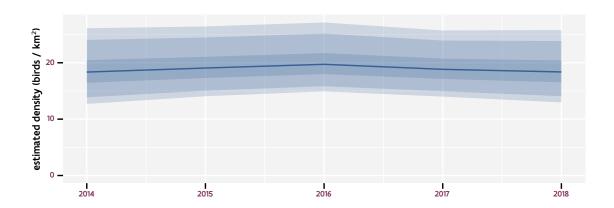


Figure 11.1: Estimated density (birds/km²) for *Corvus corone* (Corneille noire) based on a non-linear model. The linear yearly change (?) is -0.1% (-17.0%; +19.8%). The trend is possibly non-linear.



Figure 11.2: Indices for different reference years

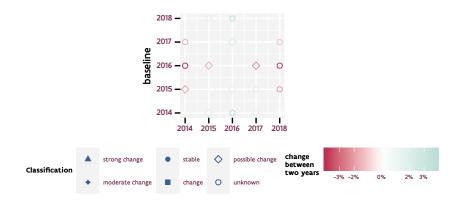


Figure 11.3: Relative change between years

12 STURNUS VULGARIS (ÉTOURNEAU SANSONNET)

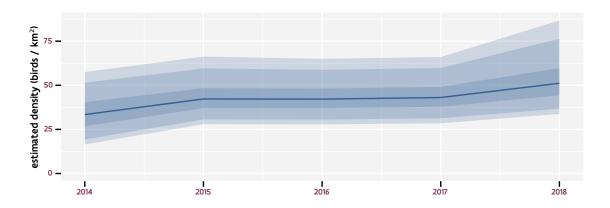


Figure 12.1: Estimated density (birds/km²) for *Sturnus vulgaris* (Étourneau sansonnet) based on a non-linear model. The linear yearly change (?+) is +18.1% (-5.6%; +48.0%). The trend is possibly non-linear.



Figure 12.2: Indices for different reference years

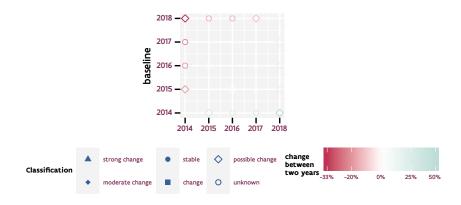


Figure 12.3: Relative change between years

13 FRINGILLA COELEBS (PINSON DES ARBRES)

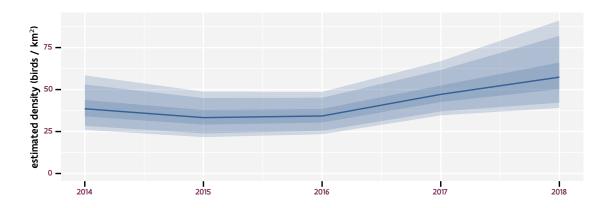


Figure 13.1: Estimated density (birds/km²) for *Fringilla coelebs* (Pinson des arbres) based on a non-linear model. The linear yearly change (?+) is +18.3% (-0.8%; +41.2%). The trend is possibly non-linear.

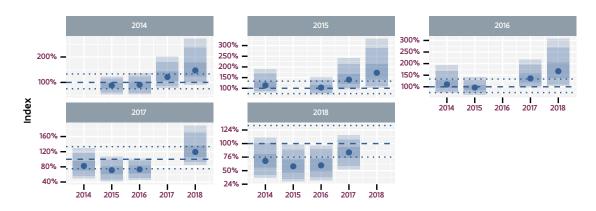


Figure 13.2: Indices for different reference years

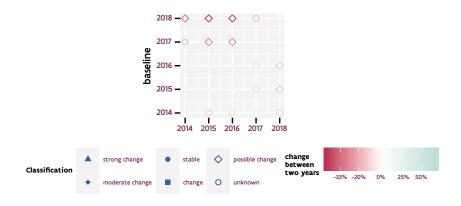


Figure 13.3: Relative change between years

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