

**Supplementary material**

## Appendix 1. Supplementary results based on entire bird assemblages.

### Geographical patterns in traits

The geographical variation in assemblage mean clutch size in all birds depicted a relatively distinct spatial pattern where species with the largest clutches in absolute measure dominated in the middle parts of European continent (Fig. A1a), but none of the geographical variables came significant in GLS model (Table A1).

Assemblage mean number of broods per breeding season in all birds showed a strong latitudinal gradient as species with the lowest clutches dominated in northern areas (Table A1, Fig. A1b). Further, longitude had a negative effect and altitude a positive effect on clutch size, but these variables were less important than latitude.

The geographical trend of assemblage mean reproductive investment per breeding season in all birds was not very conclusive (Fig. A1c); only altitude came negatively significant (Table A1), however, the explained variability was very poor ( $r^2$  Predict = 2.5 %).

### Environmental determinants of trait variation

#### *Clutch size*

In GLS model based on all birds assemblage mean clutch size increased with increasing sum of NDVI during breeding season (Table A2) and decreased with increasing length of the season. Further, in GLS tax model clutch size decreased with increasing annual seasonality in NDVI. Overall, the effect of the environmental variables on clutch size was not very strong and the variability explained solely by predictor variables (i.e. without space,  $r^2$  Predict) in both GLS and GLS tax model was very low (4.8 and 0.1 %, respectively).

### *Number of broods per season*

In all birds, assemblage mean number of broods increased with increasing length of the season (Table A2) and also with the sum of NDVI during breeding season, but its effect was relatively weak.

### *Overall reproductive investment per season*

The results for both GLS and GLS tax model were very similar and all significant variables had a comparable effect on assemblage mean reproductive investment in all birds. Reproductive investment increased with increasing length of the season (Table A2). In contrast, reproductive investment decreased with increasing annual seasonality in NDVI and the sum of NDVI during breeding season.

Table A1. Geographical correlates of assemblage mean clutch size, the number of broods per season and reproductive investment per season in all European birds. Importance of geographical variables is indicated by the values of Standardized Coefficients.

|                        | Clutch size |           | Number of broods per season |           |           | Reproductive investment per season |           |           |           |
|------------------------|-------------|-----------|-----------------------------|-----------|-----------|------------------------------------|-----------|-----------|-----------|
|                        | GLS         | Std Coeff | Std Error                   | GLS       | Std Coeff | Std Error                          | GLS       | Std Coeff | Std Error |
| Latitude               | –           |           | –                           | –0.77**   | <0.001    |                                    | –         |           | –         |
| Longitude              | –           |           | –                           | –0.195*   | <0.001    |                                    | –         |           | –         |
| Altitude               | –           |           | –                           | 0.157***  | <0.001    |                                    | –0.097**  |           | <0.001    |
| F                      | –           |           |                             | 1744.21   |           |                                    | 52.03     |           |           |
| r <sup>2</sup> Predict | –           |           |                             | 0.718     |           |                                    | 0.025     |           |           |
| r <sup>2</sup> Total   | –           |           |                             | 0.876     |           |                                    | 0.725     |           |           |
| AIC Predict            | –           |           |                             | –12231.37 |           |                                    | –10197.27 |           |           |
| AIC Total              | –           |           |                             | –13924.26 |           |                                    | –12805.81 |           |           |

GLS = Generalized Least Squares regression model; Std Coeff = Standardized Coefficient; Std Error = Standard Error; F = F statistic; r<sup>2</sup> Predict = variability explained by predictor variables; r<sup>2</sup> Total = variability explained by predictor variables and space; AIC Predict = Akaike Information Criterion of the model containing only predictor variables; AIC Total = AIC of the model containing predictor variables and space; \*p < 0.05; \*\*p < 0.01; \*\*\*p < 0.001

Table A2. Environmental correlates of assemblage mean clutch size, the number of broods per season and reproductive investment per season in all European birds. Results for GLS regression models are provided for both raw data and data controlled for taxonomy. Importance of independent environmental variables is indicated by the values of Standardized Coefficients.

| Clutch size in all European birds                        |           |           |           |           |
|--|-----------|-----------|-----------|-----------|
|  | GLS       |           | GLS tax   |           |
|  | Std Coeff | Std Error | Std Coeff | Std Error |
| Seasonality in NDVI <sub>year</sub>                      | –         | –         | –0.188*** | <0.001    |
| Sum of NDVI <sub>breed</sub>                             | 0.078**   | <0.001    | –         | –         |
| Length of season   | –0.082**  | 0.005     | –0.041*   | 0.002     |
| F  | 52.1      |           | 0.103     |           |
| r <sup>2</sup> Predict                                   | 0.048     |           | 0.001     |           |
| r <sup>2</sup> Total                                     | 0.764     |           | 0.802     |           |
| AIC Predict  | –10390.65 |           | –13716.88 |           |
| AIC Total  | –13261.67 |           | –17044.78 |           |
| Number of broods per season in all European birds        |           |           |           |           |
|  | GLS       |           | GLS tax   |           |
|  | Std Coeff | Std Error | Std Coeff | Std Error |
| Seasonality in NDVI <sub>year</sub>                      | –         | –         | –         | –         |
| Sum of NDVI <sub>breed</sub>                             | 0.038**   | <0.001    | 0.032*    | <0.001    |
| Length of season   | 0.607***  | 0.003     | 0.348***  | 0.002     |
| F  | 1878.6    |           | 591.4     |           |
| r <sup>2</sup> Predict                                   | 0.647     |           | 0.365     |           |
| r <sup>2</sup> Total                                     | 0.919     |           | 0.888     |           |
| AIC Predict  | –11777.62 |           | –14176.16 |           |
| AIC Total  | –14808.6  |           | –17737.48 |           |
| Reproductive investment per season in all European birds |           |           |           |           |
|  | GLS       |           | GLS tax   |           |
|  | Std Coeff | Std Error | Std Coeff | Std Error |
| Seasonality in NDVI <sub>year</sub>                      | –0.134**  | <0.001    | –0.188*** | <0.001    |
| Sum of NDVI <sub>breed</sub>                             | –0.122*** | <0.001    | –         | –         |
| Length of season   | 0.238***  | 0.006     | 0.273***  | 0.003     |
| F  | 35.94     |           | 208.4     |           |
| r <sup>2</sup> Predict                                   | 0.05      |           | 0.169     |           |
| r <sup>2</sup> Total                                     | 0.662     |           | 0.669     |           |
| AIC Predict  | –10270.13 |           | –13755.09 |           |
| AIC Total  | –12393.64 |           | –15650.04 |           |

GLS = Generalized Least Squares regression model; GLS tax = model with clutch size, number of broods and reproductive investment per season controlled for taxonomy (see Methods); Std Coeff = Standardized Coefficient; Std Error = Standard Error; NDVI = Normalized Difference Vegetation Index; F = F statistic;  $r^2$  Predict = variability explained by predictor variables;  $r^2$  Total = variability explained by predictor variables and space; AIC Predict = Akaike Information Criterion of the model containing only predictor variables; AIC Total = AIC of the model containing predictor variables and space; \* $P < 0.05$ ; \*\* $P < 0.01$ ; \*\*\* $P < 0.001$ .

Figure A1 Geographical variation in clutch size, the number of broods per season and reproductive investment per season of all European birds. Mean values for each local assemblage (grid cell 50 × 50km) are visualized for clutch size (a), number of broods (b) and reproductive investment (c). Clutch size, the number of broods and egg mass were  $\log_{10}$  transformed before calculation of the means. Reproductive investment values were calculated as follows:  $\log_{10}$  (clutch size × number of broods per season × female-mass controlled egg mass).

Figure A1a

**a**

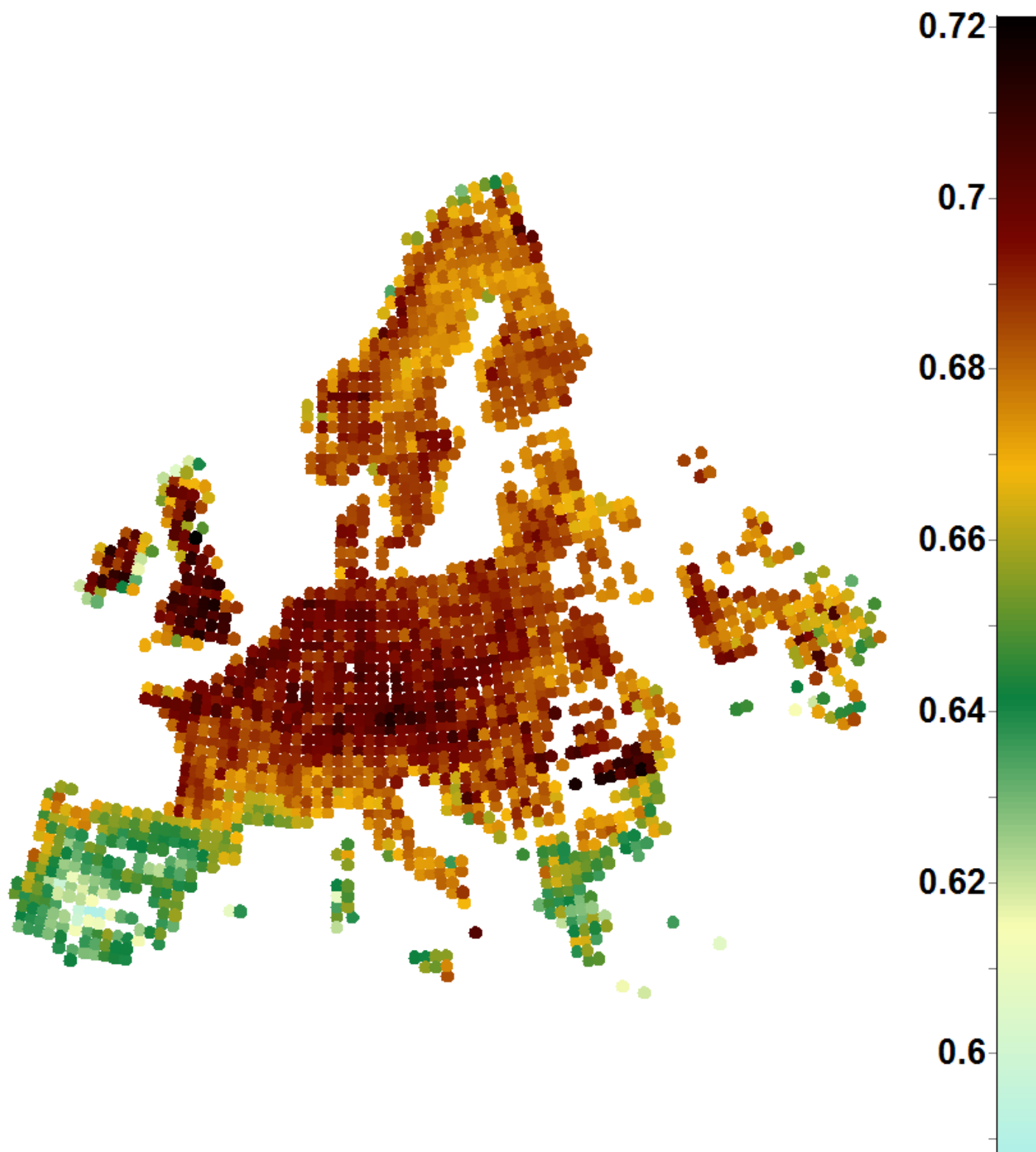




Figure A1b

**b**

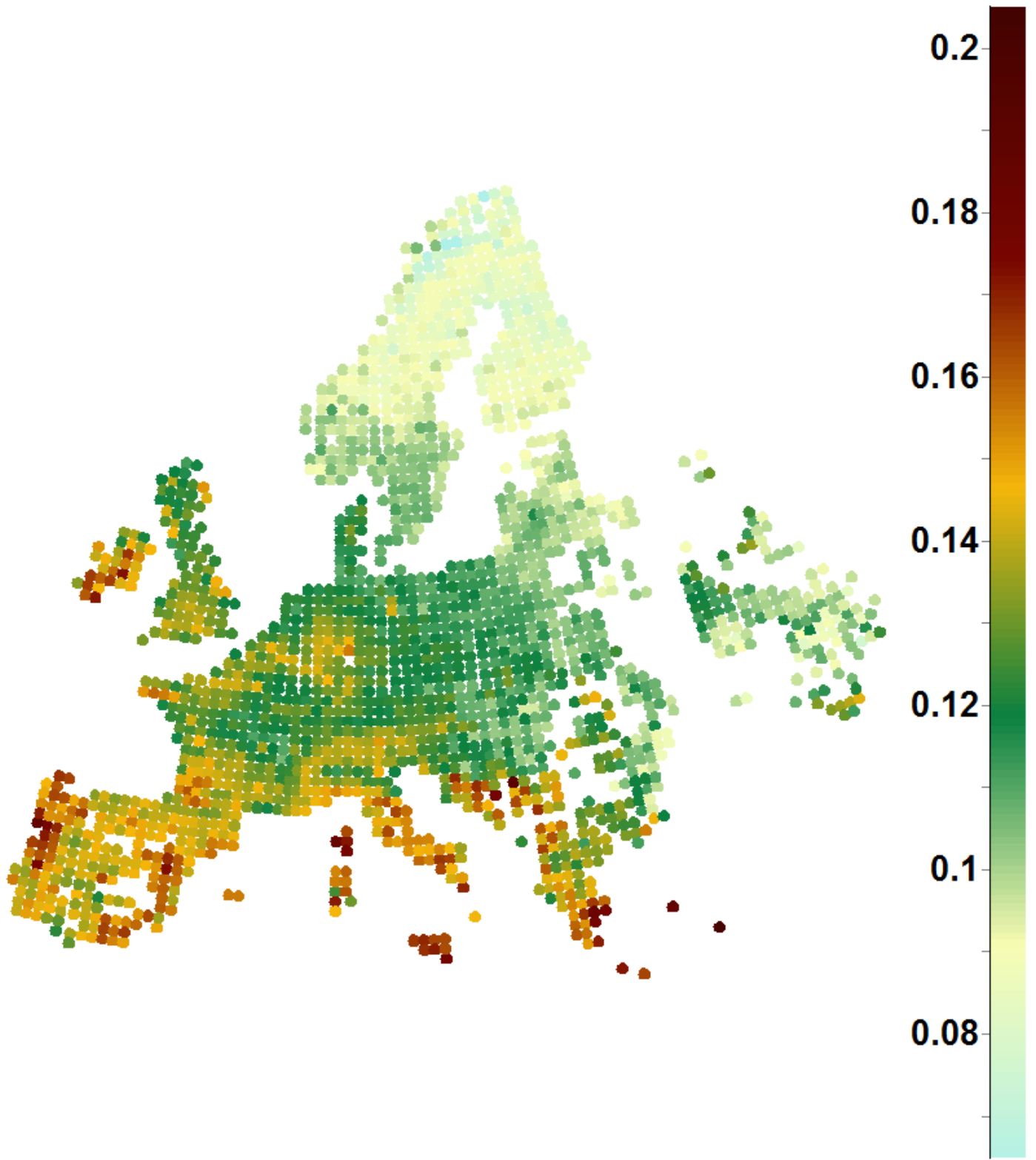
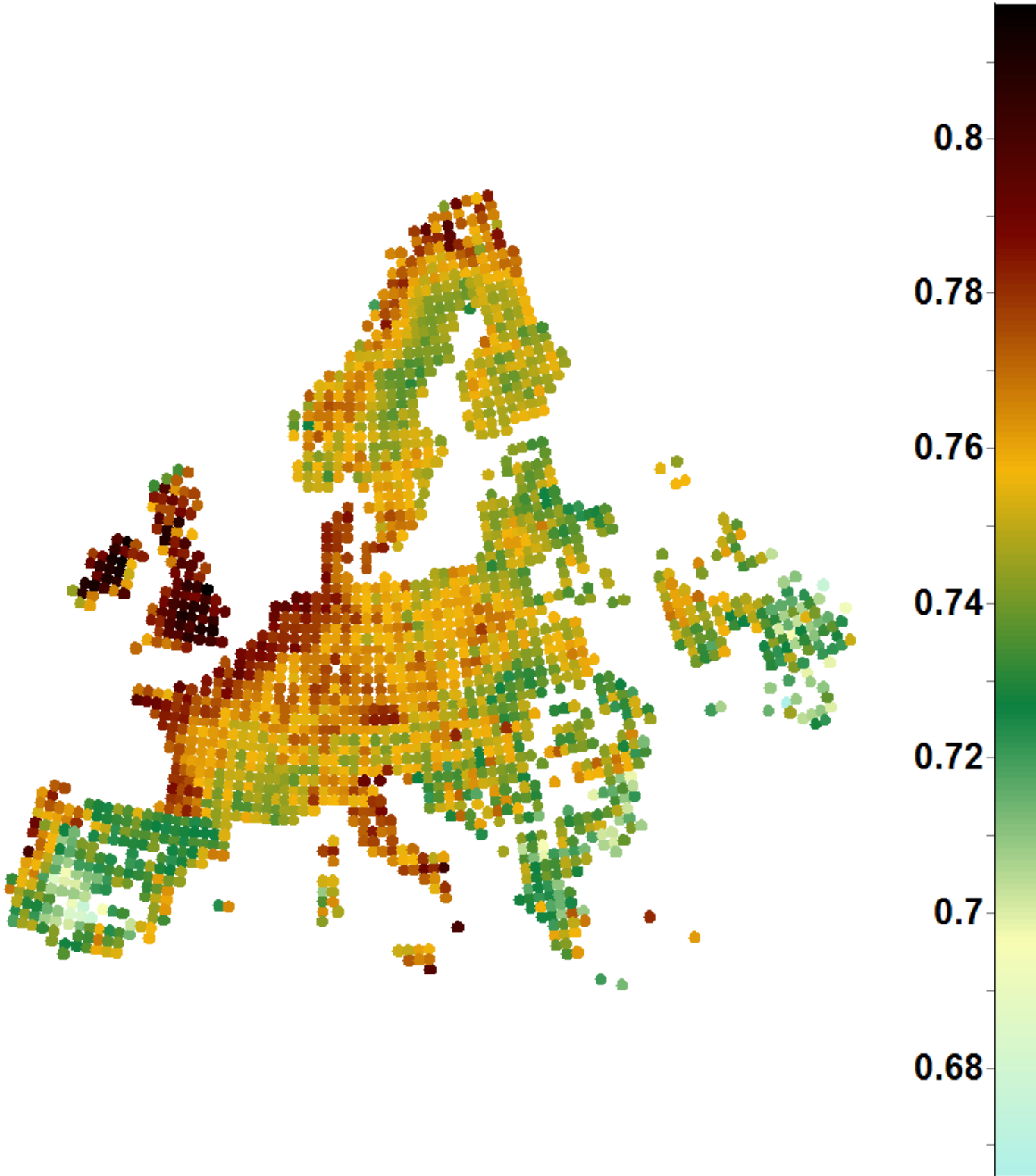


Figure A1c

C



## Appendix 2. Results of the analyses based on length of the growing season estimated by Growing Degree Days (GDD).

### Clutch size

In altricial birds, the results of the models based on length of the growing season (estimated by GDD) were exactly the same as the results of models based on length of the breeding season (estimated by period of laying eggs, see Table A3 and also Table 2), as length of the growing season was not significant in any model and only sum of NDVI during breeding season affect assemblage mean clutch size positively.

In precocial birds, assemblage mean clutch size increased with increasing sum of NDVI during breeding season (Table A3) and also with the length of the growing season. Further, clutch size increased with increasing annual seasonality in NDVI in GLS model. However, the variability explained solely by predictor variables was very low in GLS model ( $r^2$  Predict = 0.1%).

### Number of broods per season

In altricial birds, assemblage mean number of broods was positively affected by the length of the growing season (Table A4) and by sum of NDVI during breeding season, but only in GLS tax model.

In precocial birds, we found that the length of the growing season had positive effect on assemblage mean number of broods (Table A4). Contrary, we found a negative effect of annual seasonality in NDVI. But, the variability explained solely by predictor variables was rather low in all models ( $r^2$  Predict = 0.1–6.5 %).

## Overall reproductive investment per season

In altricial birds, assemblage mean reproductive investment related positively to length of the growing season (Table A5). Similarly, we found a positive effect of sum of NDVI during breeding season but this effect was significant only in GLS tax model. Further, we found a negative effect annual seasonality in NDVI, but only in GLS model.

In precocial birds, we found a positive relationship between reproductive investment and length of the growing season (Table A5) and sum of NDVI during breeding season. Moreover, reproductive investment increased with decreasing annual seasonality in NDVI.

Table A3. Length of growing season (GDD) and other environmental correlates of assemblage mean clutch size in European birds. Altricial and precocial birds are analyzed separately. Results for GLS regression models are provided for both raw data and data controlled for taxonomy. Importance of independent environmental variables is indicated by the values of Standardized Coefficients.

| Clutch size                         | Altricial birds |           |           |           | Precocial birds |           |           |           |
|-------------------------------------|-----------------|-----------|-----------|-----------|-----------------|-----------|-----------|-----------|
|                                     | GLS             |           | GLS tax   |           | GLS             |           | GLS tax   |           |
|                                     | Std Coeff       | Std Error | Std Coeff | Std Error | Std Coeff       | Std Error | Std Coeff | Std Error |
| Seasonality in NDVI <sub>year</sub> | –               | –         | –         | –         | 0.115**         | <0.001    | –         | –         |
| Sum of NDVI <sub>breed</sub>        | 0.132***        | <0.001    | 0.042*    | <0.001    | 0.297***        | <0.001    | 0.222***  | <0.001    |
| GDD                                 | –               | –         | –         | –         | 0.459***        | <0.001    | 0.05*     | <0.001    |
| F                                   | 116.80          |           | 0.21      |           | 0.068           |           | 246.06    |           |
| r <sup>2</sup> Predict              | 0.054           |           | 0.001     |           | 0.001           |           | 0.194     |           |
| r <sup>2</sup> Total                | 0.773           |           | 0.779     |           | 0.599           |           | 0.54      |           |
| AIC Predict                         | –13326.93       |           | 15370.08  |           | –5061.14        |           | –12312.51 |           |
| AIC Total                           | –16254.40       |           | –18474.8  |           | –6927.14        |           | –13462.19 |           |

GLS = Generalized Least Squares regression model; GLS tax = model with clutch size controlled for taxonomy (see Methods); Std Coeff = Standardized Coefficient; Std Error = Standard Error; NDVI = Normalized Difference Vegetation Index; F = F statistic; r<sup>2</sup> Predict = variability explained by predictor variables; r<sup>2</sup> Total = variability explained by predictor variables and space; AIC Predict = Akaike Information Criterion of the model containing only predictor variables; AIC Total = AIC of the model containing predictor variables and space; \*p < 0.05; \*\*p < 0.01; \*\*\*p < 0.001.

Table A4. Length of growing season (GDD) and other environmental correlates of assemblage mean of the number of broods per season in European birds. Altricial and precocial birds are analyzed separately. Results for GLS regression models are provided both for raw data and data controlled for taxonomy. Importance of independent environmental variables is indicated by the values of Standardized Coefficients.

| Number of broods per season         | Altricial birds |           |           |           | Precocial birds |           |           |           |
|-------------------------------------|-----------------|-----------|-----------|-----------|-----------------|-----------|-----------|-----------|
|                                     | GLS             | GLS tax   |           | GLS       | GLS tax         |           |           |           |
|                                     | Std Coeff       | Std Error | Std Coeff | Std Error | Std Coeff       | Std Error | Std Coeff | Std Error |
| seasonality in NDVI <sub>year</sub> | –               | –         | –         | –         | –0.035          | <0.001    | –0.1*     | <0.001    |
| sum of NDVI <sub>breed</sub>        | –               | –         | 0.085*    | <0.001    | –               | –         | –         | –         |
| GDD                                 | 0.09*           | <0.001    | 0.08*     | <0.001    | 0.03*           | <0.001    | 0.06*     | <0.001    |
| F                                   | 0.205           |           | 2.255     |           | 71.433          |           | 45.57     |           |
| r <sup>2</sup> Predict              | 0.001           |           | 0.002     |           | 0.065           |           | 0.043     |           |
| r <sup>2</sup> Total                | 0.878           |           | 0.874     |           | 0.677           |           | 0.57      |           |
| AIC Predict                         | –10351.04       |           | –11399.07 |           | –9363.91        |           | –11699.12 |           |
| AIC Total                           | –14662.11       |           | –15646.7  |           | –11535.7        |           | –13322.08 |           |

GLS = Generalized Least Squares regression model; GLS tax = model with the number of broods per season controlled for taxonomy (see Methods); Std Coeff = Standardized Coefficient; Std Error = Standard Error; NDVI = Normalized Difference Vegetation Index; F = F statistic; r<sup>2</sup> Predict = variability explained by predictor variables; r<sup>2</sup> Total = variability explained by predictor variables and space; AIC Predict = Akaike Information Criterion of the model containing only predictor variables; AIC Total = AIC of the model containing predictor variables and space; \*p < 0.05; \*\*p < 0.01; \*\*\*p < 0.001.

Table A5. Length of growing season (GDD) and other environmental correlates of assemblage mean reproductive investment per season in European birds. Altricial and precocial birds are analyzed separately. Results for GLS regression models are provided both for raw data and data controlled for taxonomy. Importance of independent environmental variables is indicated by the values of Standardized Coefficients.

| Reproductive investment<br>per season | Altricial birds |           |           |           | Precocial birds |           |           |           |
|---------------------------------------|-----------------|-----------|-----------|-----------|-----------------|-----------|-----------|-----------|
|                                       | GLS             |           | GLS tax   |           | GLS             |           | GLS tax   |           |
|                                       | Std Coeff       | Std Error | Std Coeff | Std Error | Std Coeff       | Std Error | Std Coeff | Std Error |
| seasonality in NDVI <sub>year</sub>   | -0.088**        | <0.001    | -         | -         | -               | -         | -0.118**  | <0.001    |
| sum of NDVI <sub>breed</sub>          | -               | -         | 0.099**   | <0.001    | 0.216***        | <0.001    | 0.055*    | <0.001    |
| GDD                                   | 0.1**           | <0.001    | 0.021*    | <0.001    | 0.09*           | <0.001    | 0.129***  | <0.001    |
| F                                     | 118.638         |           | 0.102     |           | 99.664          |           | 155.47    |           |
| r <sup>2</sup> Predict                | 0.104           |           | 0.001     |           | 0.089           |           | 0.186     |           |
| r <sup>2</sup> Total                  | 0.78            |           | 0.814     |           | 0.491           |           | 0.471     |           |
| AIC Predict                           | -10905.56       |           | -11702.36 |           | -7039.54        |           | -10190.21 |           |
| AIC Total                             | -13788.92       |           | -15154.81 |           | -8229.9         |           | -11070.8  |           |

GLS = Generalized Least Squares regression model; GLS tax = model with reproductive investment per season controlled for taxonomy (see Methods); Std Coeff = Standardized Coefficient; Std Error = Standard Error; NDVI = Normalized Difference Vegetation Index; F = F statistic; r<sup>2</sup> Predict = variability explained by predictor variables; r<sup>2</sup> Total = variability explained by predictor variables and space; AIC Predict = Akaike Information Criterion of the model containing only predictor variables; AIC Total = AIC of the model containing predictor variables and space; \*p < 0.05; \*\*p < 0.01; \*\*\*p < 0.001.

## Appendix 3. Results of the analyses testing the difference between altricial and precocial species.

### Clutch size

In the case of clutch size, interactions between geographical and environmental variables and reproductive mode ('young') came statistically significant in all models, except GLStax, where interaction between seasonality in NDVI<sub>year</sub> and reproduction mode was not significant (Table A6, A7).

### Number of broods per season

In number of broods per season, all interactions between geographical and environmental variables and young came statistically significant, except the interaction between sum of NDVI<sub>breed</sub> and young in GLS model (Table A6, A7).

### Overall reproductive investment

In overall reproductive investment, the interactions between latitude and young, and also altitude and young were not significant, otherwise all interactions between geographical and environmental variables were statistically significant (Table A6, A7).



Table A6. The effect of interaction between geographical variables and reproductive mode on assemblage mean clutch size, the number of broods per season and reproductive investment per season in European birds. Datasets for altricial and precocial birds were pooled together before analysis. Importance of geographical variables is indicated by the values of Standardized Coefficients.

| Clutch size                        | GLS Std Coeff | Std Error |
|------------------------------------|---------------|-----------|
| Latitude × young                   | −0.225***     | <0.001    |
| Longitude × young                  | −0.07**       | <0.001    |
| Altitude × young                   | −0.325***     | <0.001    |
| F                                  | 331.484       |           |
| r <sup>2</sup> Predict             | 0.195         |           |
| r <sup>2</sup> Total               | 0.302         |           |
| AIC Predict                        | −12622.64     |           |
| AIC Total                          | −13204.68     |           |
| Number of broods per season        | GLS Std Coeff | Std Error |
| Latitude × young                   | 1.025***      | <0.001    |
| Longitude × young                  | −0.153***     | <0.001    |
| Altitude × young                   | 0.044***      | <0.001    |
| F                                  | 6594.62       |           |
| r <sup>2</sup> Predict             | 0.829         |           |
| r <sup>2</sup> Total               | 0.981         |           |
| AIC Predict                        | −17880.01     |           |
| AIC Total                          | −26775.72     |           |
| Reproductive investment per season | GLS Std Coeff | Std Error |
| Latitude × young                   | −             | −         |
| Longitude × young                  | −0.648**      | <0.001    |
| Altitude × young                   | −             | −         |
| F                                  | 2002.71       |           |
| r <sup>2</sup> Predict             | 0.328         |           |
| r <sup>2</sup> Total               | 0.361         |           |
| AIC Predict                        | −15535.53     |           |
| AIC Total                          | −15739.62     |           |

GLS = Generalized Least Squares regression model; Std Coeff = Standardized Coefficient; Std Error = Standard Error; F = F statistic; r<sup>2</sup> Predict = variability explained by predictor variables; r<sup>2</sup> Total = variability explained by predictor variables and space; AIC Predict = Akaike Information Criterion of the model containing only predictor variables; AIC Total = AIC of the model containing predictor variables and space; \*p < 0.05; \*\*p < 0.01; \*\*\*p < 0.001.

Table A7. The effect of interaction between environmental variables and reproductive mode on assemblage mean clutch size, the number of broods per season and reproductive investment per season in European birds. Datasets for altricial and precocial birds were pooled together before analysis. Results for GLS regression models are provided for both raw data and data controlled for taxonomy. Importance of geographical variables is indicated by the values of Standardized Coefficients.

| Clutch size                                 | GLS       |           | GLS tax   |           |
|---|-----------|-----------|-----------|-----------|
|   | Std Coeff | Std Error | Std Coeff | Std Error |
| Seasonality in NDVI <sub>year</sub> × young | 0.245***  | <0.001    | –         | –         |
| Sum of NDVI <sub>breed</sub> × young        | –0.756*** | <0.001    | –0.716*** | <0.001    |
| Length of season × young                    | 0.215***  | 0.003     | –0.172*** | <0.001    |
| F   | 188.1     |           | 4702.77   |           |
| r <sup>2</sup> Predict                      | 0.121     |           | 0.7       |           |
| r <sup>2</sup> Total                        | 0.368     |           | 0.83      |           |
| AIC Predict                                 | –12260.7  |           | –25403    |           |
| AIC Total                                   | –13611.66 |           | –27868.9  |           |
| <hr/>                                       |           |           |           |           |
| Number of broods per season                 | GLS       |           | GLS tax   |           |
|   | Std Coeff | Std Error | Std Coeff | Std Error |
| Seasonality in NDVI <sub>year</sub> × young | 0.06***   | <0.001    | –0.293*** | <0.001    |
| Sum of NDVI <sub>breed</sub> × young        | –         | –         | –0.171*** | <0.001    |
| Length of season × young                    | 0.888***  | <0.001    | 0.768***  | <0.001    |
| F   | 16112.87  |           | 547.278   |           |
| r <sup>2</sup> Predict                      | 0.887     |           | 0.287     |           |
| r <sup>2</sup> Total                        | 0.955     |           | 0.735     |           |
| AIC Predict                                 | –19596.62 |           | –23837.62 |           |
| AIC Total                                   | –23360.72 |           | –27879.3  |           |
| <hr/>                                       |           |           |           |           |
| Reproductive investment per season          | GLS       |           | GLS tax   |           |
|   | Std Coeff | Std Error | Std Coeff | Std Error |
| Seasonality in NDVI <sub>year</sub> × young | –0.023    | <0.001    | –0.039    | <0.001    |
| Sum of NDVI <sub>breed</sub> × young        | –0.699*** | <0.001    | –0.324*** | <0.001    |
| Length of season × young                    | 0.06      | 0.002     | –0.234*** | 0.001     |
| F   | 758.67    |           | 669.09    |           |
| r <sup>2</sup> Predict                      | 0.357     |           | 0.329     |           |
| r <sup>2</sup> Total                        | 0.564     |           | 0.587     |           |
| AIC Predict                                 | –15711.58 |           | –21012.89 |           |
| AIC Total                                   | –17299.59 |           | –23001    |           |

GLS = Generalized Least Squares regression model; GLS tax = model with clutch size, number of broods and reproductive investment per season controlled for taxonomy (see Methods); Std Coeff = Standardized Coefficient; Std Error = Standard Error; NDVI = Normalized Difference Vegetation Index; F = F statistic; r<sup>2</sup> Predict = variability explained by predictor variables; r<sup>2</sup> Total = variability explained by predictor variables and space; AIC Predict = Akaike Information Criterion of the model containing only predictor variables; AIC Total = AIC of the model containing predictor variables and space; \*p < 0.05; \*\*p < 0.01; \*\*\*p < 0.001.