Monitoring common and scarce breeding birds in the Netherlands: applying a post-hoc stratification and weighting procedure to obtain less biased population trends

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The main objective of the Dutch Breeding Bird Monitoring Program (BMP) is to assess changes in population sizes of common and scarce breeding birds. Despite the large number of study plots, trends might be biased because plots are not equally distributed over the country. In this paper we present a post-hoc stratification and weighting procedure to correct for this non-random sampling. Indices and trends are first calculated for a number of species-specific strata (combinations of region, main habitat type and bird density class). Thereafter, the indices per stratum are weighted by population sizes (derived from an independently collected set of atlas data) and sampling effort per stratum. The procedure has a small but substantial effect on national trends, trends generally becoming less conservative. We believe that for the majority of breeding birds this procedure results in a substantial improvement of trends, and we will therefore continue the BMP in forthcoming years.

Key words: monitoring, breeding birds, non-random design, trend analysis, stratification, weighting

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Breeding birds are useful indicators of the state of the environment. Monitoring data therefore provide valuable information on the quality of nature and on the effectiveness of nature conservation policy. Furthermore, such data are useful for scientific research purposes, such as the evaluation of the effects of environmental changes, (local) conservation measures and habitat management (Furness & Greenwood 1993, Freeman *et al.* 2007).

In 1984, SOVON and Statistics Netherlands started the Breeding Bird Monitoring Program (BMP) in the Netherlands (Van Dijk 1992). The main objective of this monitoring scheme is to assess yearly changes and trends at national and regional scale in population sizes of common and scarce breeding birds, including nine species in the EU Bird Directive and 25 species on the Dutch Red List (Van Beusekom *et al.* 2005). Because it is not possible to count all individuals to calculate the true trend in species abundance, it is necessary to sample. An ideal monitoring scheme, resulting in accurate and representative population indices and trends, would consist of a large number of randomly selected study plots, and yearly participation of all observers from the beginning onwards. Despite the relatively large number of study plots, the BMP is not such an ideal scheme. Not all study plots are covered yearly, so it is necessary to cope with missing values (Ter Braak *et al.* 1994). Moreover, because participants (mainly volunteers) are free to choose their study areas, plots are not equally distributed over Dutch regions and habitat types. Also, within a specific habitat volunteers may have a preference for the most attractive sites, i.e. those which are species-rich and have high bird densities. In particular, within farmland, wet grasslands with high densities of meadow birds are oversampled, in comparison to dry grassland areas poor in species and numbers. This is no problem as long as trends between these strata are identical. However, if trends differ, the estimates of population changes may be biased. Here we describe a method to correct for biased sampling, using an independently collected set of atlas data. First we carried out a pilot study on meadow bird population trends, on the basis of which we applied a simplified approach to all other breeding bird species.

Materials and methods

Breeding Bird Monitoring Program (BMP)

The Dutch Breeding Bird Monitoring program is based on the method of intensive territory mapping in study plots (Hustings *et al.* 1985; Bibby *et al.* 1997). All common and scarce breeding birds in the Netherlands are covered. The scheme consists of five modules, focused on either all species or specified groups or habitats (scarce species, raptors, meadow birds, urban areas). Fieldwork and interpretation methods are highly standardized and are described in detail in a manual (Van Dijk 1985; Van Dijk 2004). Between March and July all plots (10 to 500 hectares in size) are visited 5-10 times. Size of study plots, as well as the number, timing and duration of visits, depend on habitat type and species coverage. All birds with territory or nest-indicative behaviour (e.g. song, pair bond, display, alarm, nests) are recorded on field maps. At the end of the season, species-specific interpretation criteria are used to determine the number of territories per species (Van Dijk 2004). Interpretation criteria focus on the type of behaviour observed, the number of observations required (depending on species-specific detection probabilities), and the period of observations (to exclude non-breeding migrants).

All observers submit their data on standard forms. After a first check by the project coordinator at SOVON, Statistics Netherlands performs standardized checks using computer routines to detect possible errors. Observers check and if necessary correct these errors. Between 1984 and 2004 a total of 3374 different study plots were covered, ranging from around 300 per year in 1984 to a maximum of around 1750 in 1998-2000.

Atlas data

Independently collected data from the second Dutch breeding bird atlas (SOVON 2002) are used to correct the BMP results. Fieldwork for the atlas was carried out using a sampling design based on the Dutch national grid, which consists of 1,674 5x5 km squares (henceforth referred to as atlas squares). In every atlas square eight (out of 25) 1x1 km squares were systematically selected, in which presence/absence of all breeding birds was assessed during two standardized one hour visits. Fieldwork was carried out in 1998-2000. Using geostatistical interpolation techniques (*stratified ordinary kriging*; Burrough & McDonnel 1998) a relative density (probability of occurrence) was calculated for all 1x1 km squares, based on the observations in 12 surrounding squares with the same habitat. For further details, see SOVON (2002).

Calculation of indices and trends

Yearly changes in numbers of species are presented as indices. From 1990 onwards, sampling efforts are sufficient to calculate indices for approximately 100 species. Indices are calculated using TRIM-software (Pannekoek & Van Strien 2005), specifically developed for the analysis of time series of counts with missing data, and based on loglinear Poisson regression. The regression model estimates year and site factors using the observed counts. Subsequently the model is used to predict the missing counts. Indices and standard errors are calculated using a complete data set with the predicted counts replacing the missing counts. Overdispersion, deviations from Poisson distribution, and serial correlation are taken into account.

Figure 1. Location of BMP study plots in the Netherlands 2000-2004. Only plots which are studied in at least two years are included.
Localització dels punts de mostratge del programa de seguiment d'ocells nidificants d'Holanda el 2000-2004. Únicament es van incloure els punts els quals s'havien prospectat dos anys.

The national indices are calculated using a post-hoc stratification and weighting procedure, to correct for the unequal distribution of study plots over Dutch regions (Figure 1) and habitat types (Figure 2). Indices and trends are first calculated for each stratum separately (stratified imputing of missing values). Thereafter, the indices per stratum are combined into a national

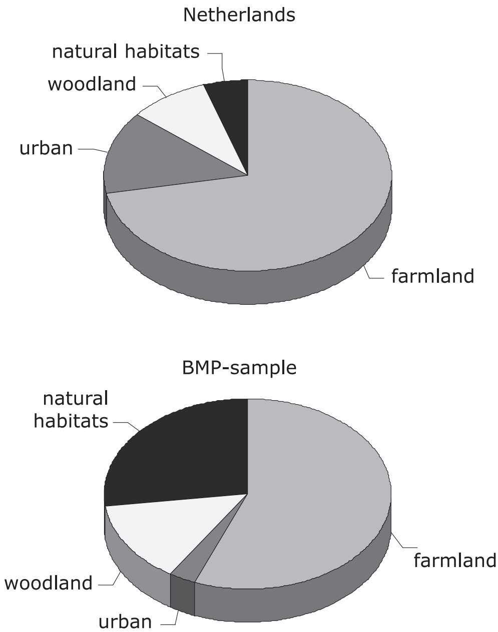

Figure 2. Relative distribution of main habitat types within the Netherlands (relative area; upper) and in the BMP sample (relative number of study plots; lower). *Distribució relativa del tipus d' hàbitats principals a Holanda (àrea relativa, dalt) i la mostra del BMP (nombre relatiu de punts de mostratge, baix)*

index, weighted by population sizes and sampling effort per stratum. If all strata were equally sampled according to the number of territories present, all weights would be similar. If a stratum is undersampled, the stratum index is given a higher weight in compiling the national index. A schematic overview of the procedure is presented in Figure 3.

Stratification

The following three variables are used in the stratification procedure, because these are thought to correlate most strongly with differences in breeding bird trends within the Netherlands: physio-geographic region, main habitat type and bird density.

The classification of 14 physio-geographic regions is based on main soil type, main landscape characteristics and location (Bal *et al.* 1995). The classification is independent of bird distributions. Main habitat types include farmland (arable land, grassland, hedgerows), woodland (deciduous, coniferous and mixed forest), heathland (dry and wet heathland, bog and inland drift sand), freshwater marsh, salt marsh, coastal dunes and urban habitats (city, suburb, industrial zone, park).

Species-specific bird density is used as a stratification variable because trends may differ between core areas with high densities (resulting from favourable habitat quality) and marginal areas with low densities (resulting from unfavourable habitat quality). We distinguish three classes: areas with high, medium and low densities. For each species all 1x1 km^2 are sorted according to relative density, based on atlas data. The top 15% squares are arbitrarily classified as high-density areas, the next highest 30% as medium-density areas and the remaining 55% as low-density areas.

For all species, strata are defined where species occur in substantial numbers, with strata being the combinations of physio-geographic region, main habitat type and bird density (the latter for meadow birds only, see result section). The stratification is done based on the expert judgement of two breeding bird specialists at SOVON. Strata are lumped if the minimum number of positive plots per year since 1990 is less than five (based on experience of Statistics Netherlands). Strata are lumped according to either region or main habitat type, depending on which strata trends are expected to be most similar. A total of over 1400 strata are defined for 102 species.

Weighting

To calculate relative population sizes per stratum, we returned to the relative densities in 1x1 km squares from the breeding bird atlas. The species-specific relationship between absolute densities in BMP-plots (studied in 1998-2000) and (mean) relative densities in the 1x1 km^2 is quantified by regression analysis. Relative densities are converted into absolute densities per square. On average 749 records were available per species for the regression analyses. For further details see SOVON (2002).

Next, absolute numbers per square are summed to obtain population sizes per physio-geographic region (and also bird densities for meadow birds) (step 1). To assess the relative

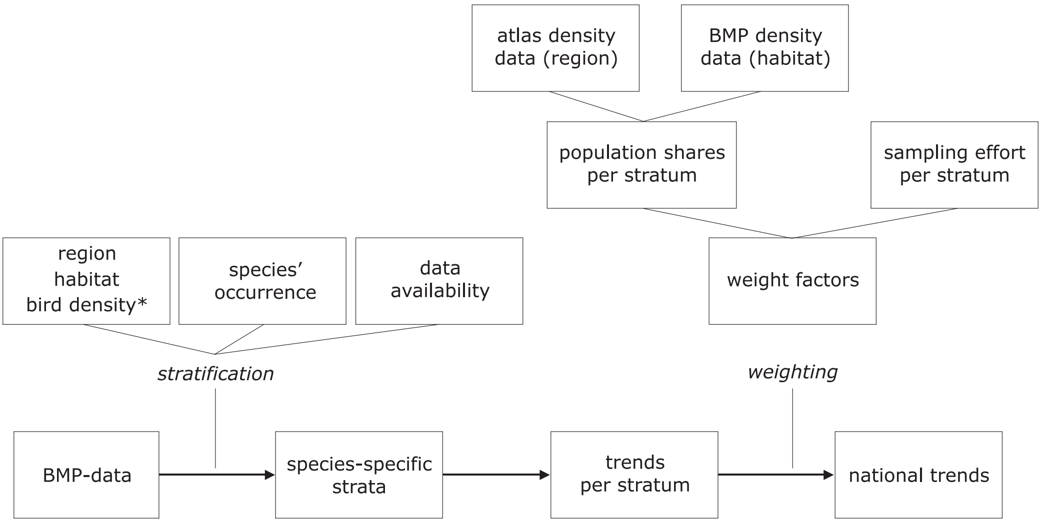

Figure 3. Flow chart of the post-hoc stratification and weighting procedure to obtain less biased population trends. For explanation see Materials & methods (*for meadow birds only).
Diagrama de flux del procediment d'estratificació i ponderació per obtenir tendències poblacionals menys esbiaixades. Per a una explicació més acurada vegeu Material i mètodes (per a ocells de pastures únicament).*

population sizes per habitat type within a region, we chose not to use the absolute densities per square, mainly because of considerable habitat heterogeneity within squares. Instead, for each habitat type we multiply the total area of habitat within a region (from GIS-assessment) by the average density in BMP plots consisting of more than 75% of that habitat (step 2). The result of step 2 is divided by the population size per region as calculated in step 1. For example, if the calculated population size of Skylark *Alauda arvensis* in region X was 2,000 territories (step 1), the areas of heathland and farmland in region X were 10,000 and 100,000 ha respectively (step 2), and the densities in heathland and farmland were 10 and 1 territories per 100 ha respectively (step 2), then the proportion of the population both in heathland and in farmland within region X is 0.5. If region X held 10% of the total Dutch population of Skylarks, then the proportion of the population in either heathland or farmland in region X is 0.5 * 0.1 = 0.05.

These proportions of population are used to assess weight factors. The weight factor for a particular stratum is the population proportion divided by the proportion of the number of territories counted in that stratum. All weights would be exactly one where no oversampling or undersampling occurs across strata. The weights are calculated for the atlas period 1998-2000 and then applied to all years from 1990 onwards, using the weight option in TRIM (Pannekoek and Van Strien 2005).

Results

Pilot study on meadow birds

Large differences in regional trends within farmland exist for nine species of meadow birds, as illustrated by Black-tailed Godwit *Limosa limosa* (Figure 4). In region ZKZ (polders on sea clay soils in the south-western part of the country) numbers have increased moderately between 1990 and 2004 (Wald test, $p<0.05$). Conversely, in region ZKN (polders on sea clay soils in the northern part of the country) numbers show moderate declines, and in region LVN (polders on peat soils in the north-eastern part of the country) numbers have strongly declined (both Wald test, $p<0.05$). Regionally distinct trends also exist for the other meadow bird species. These results underline the necessity of a stratification and weighting procedure.

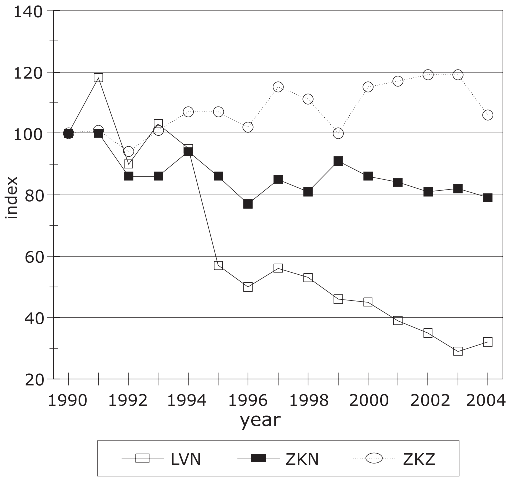

Figure 4. Population indices of Black-tailed Godwit *Limosa limosa* in three different regions within farmland in the Netherlands 1990-2004.
Índexs poblacionals del Tètol cuanegre Limosa limosa *en tres regions agrícoles diferents d'Holanda el 2000-2004.*

Without stratification and weighting, national Black-tailed Godwit numbers seem to have decreased only slightly in the period 1990-2000 (Figure 5). Stratification according to physiogeographic region alone results in an evident decline. The index in 2000 is 15% lower than the 2000 index without stratification. This implies that regions with decreasing Black-tailed Godwit populations are undersampled. Stratification according to both region and bird density results in a 2000 index that is 20% lower. Stratification in combination with weighting reduces the 2000 index by another 2%. The effect of weighting therefore appears much smaller than the effect of stratification, and the effect of stratification according to bird density is less than of stratification according to region. Results are similar for other meadow bird species.

Other breeding birds

Based on the results of the pilot study, and the availability of data, we have based our stratification and weighting procedure for all other breeding birds only on the variables physio-geographical region and main habitat type.

This means that we only use bird density as a stratification variable for nine species of meadow birds. The effect of these variables on corrected trends appears minimal, even for the meadow birds for which we expected that bias due to unequal sampling of high density areas would be largest.

For most species substantial and significant differences in trends exist between regions (Figure 6), and between main habitat types within regions (Figure 7) (Wald tests, $p<0.05$). The stratification and weighting procedure has a small but substantial effect on linear trends of common and scarce breeding birds in the period 1990-2004, trends generally becoming less

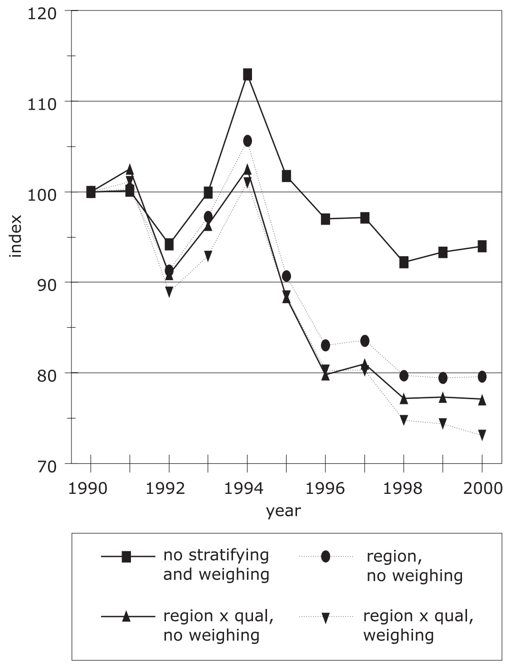

Figure 5. Population indices of Black-tailed Godwit *Limosa limosa* in farmland in the Netherlands 1990-2000. Presented are indices without stratification or weighting (solid line and squares), with stratification according to region only (dotted line and circles), with stratification according to both region and bird density (solid line and upward triangles), and with stratification according to region and bird density and weighting (dotted line and downward triangles).
Índexs poblacionals del Tètol cuanegre Limosa limosa *en zones agrícoles d'Holanda el 1999-2000. Es mostren els índexs sense estratificació ni ponderació (línia sòlida i quadrats), amb estratificació d'acord únicament a la regió (línia puntejada amb cercles), amb estratificació d'acord a la regió i a la densitat d'ocells (línia sòlida i triangles ascendents), i amb estratificació d'acord a la regió, a la densitat d'ocells i a la ponderació (línia puntejada i triangles descendents).*

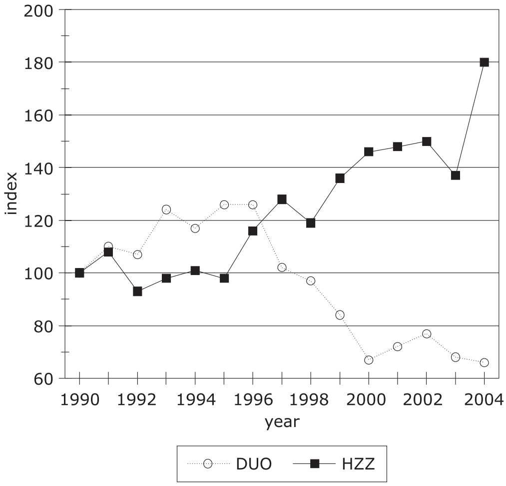

Figure 6. Population indices of Green Woodpecker *Picus viridis* in two different regions in the Netherlands 1990-2004.
Índexs poblacionals del Picot Verd Picus viridis *en dues regions diferents d'Holanda el 1999-2004.*

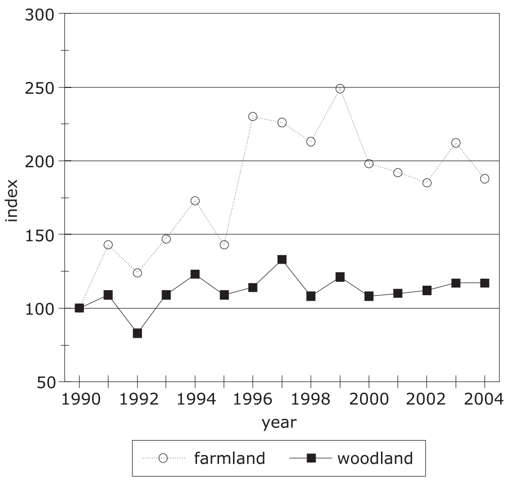

Figure 7. Population indices of Great Spotted Woodpecker *Dendrocopos major* in farmland and woodland in region HZN 1990-2004.
Índexs poblacionals del Picot Garser Gran Dendrocopos major *en zones agrícoles i forestals d'Holanda el 1990-2004.*

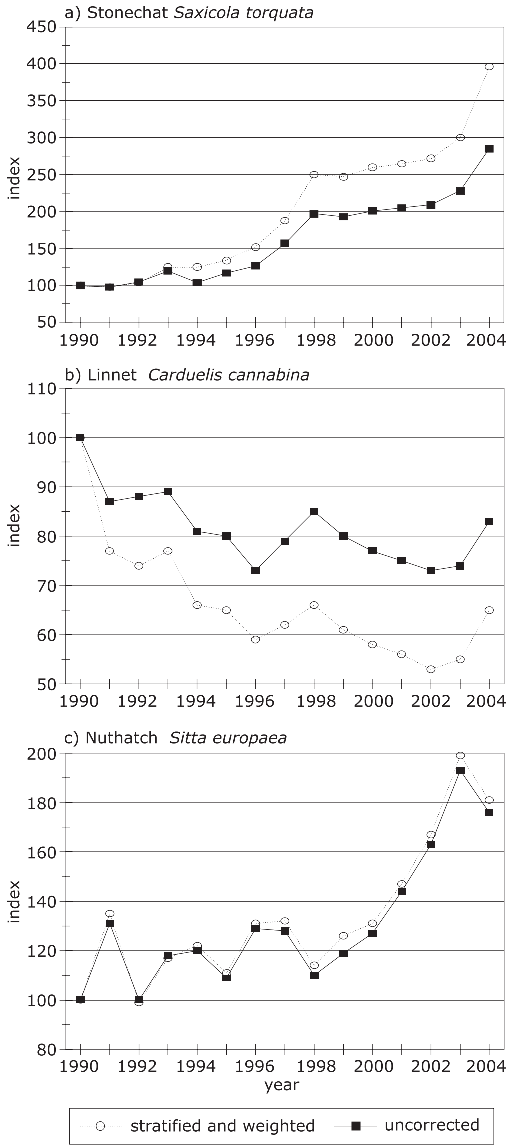

Figure 8. National population indices of Stonechat *Saxicola torquata*, Linnet *Carduelis cannabina* and Nuthatch *Sitta europaea* in the Netherlands 1990-2004. Presented are indices with stratification and weighting, and without these procedures (uncorrected).
Índexs nacionals de població del Bitxac Comú, el Passerell Comú i el Pica-soques Blau a Holanda el 1990-2004. Es mostren els índexs amb estratificació i ponderació i sense aquests procediments (dades no corregides).

conservative. Mean absolute change over all species is 3.26% per year (SE 0.40%) for corrected trends, and 2.88% per year (SE 0.29%) if trends are not corrected for unequal sampling, a difference which is significant (paired t-test, p=0.04). For 52 species, stratification and weighting results in a more positive (or a less negative) trend (Figure 8a). This implies that strata with increasing numbers are undersampled. For 47 species, trends are more negative (or less positive) after stratification and weighting (Figure 8b), which means that strata with decreasing numbers are undersampled. In the case of the Linnet, numbers are increasing in the heavily oversampled coastal dunes, whereas numbers in most other strata are decreasing. For the three remaining species stratified and unstratified trends are identical (Figure 8c), which implies that there is no unequal sampling for these species or that trends in (important) strata are similar.

Standard errors of linear trends have significantly increased by a factor 1.67 after stratification and weighting: 0.60% (SE 0.03%) versus 0.36% (SE 0.02%) without correction for unequal sampling (paired t-test, $p<0.0001$).

In appendix 1 year indices and linear trends are presented for 102 common and scarce breeding birds in the period 1990-2004, after stratification and weighting. In total 40 species have significantly increased in numbers, Greylag Goose *Anser anser* and Egyptian Goose *Alopochen aegyptiacus* most strongly. In total 37 species have significantly decreased in numbers, Long-eared Owl *Asio otus* and Wood Warbler *Phylloscopus sibilatrix* most strongly. The remaining 25 species are stable or show fluctuating numbers.

Discussion

In this paper we present a method which deals with probably one of the most important problems of the Dutch Breeding Bird Monitoring Program, the unequal sampling that results from the non-random plot selection. This problem also exists in other monitoring schemes in which participants can freely choose their study plots, such as the Dutch Butterfly Monitoring Scheme (Van Swaay *et al.* 2002) and the (former) British Common Bird Census (CBC) (Marchant *et al.* 1990). One solution for this problem is to start a new, randomised or random stratified scheme, as in the United Kingdom where the CBC has been replaced by the Breeding Bird Survey (Gregory 2000; Raven & Noble 2001). However, to guarantee sufficient participation of volunteer observers in a randomised scheme, less labour-intensive field work methods, such as point or line transect counts, would need to be adopted (Gibbons & Gregory 2006). One of the risks of designing and implementing such a new scheme for Dutch breeding birds is the incomparability of old and new data. As a result, BMP data might be seen as increasingly less relevant and useful, and the long-term perspective might be lost. This potential problem could be handled by running both schemes simultaneously for a few years, as was done in the United Kingdom (Freeman *et al.* 2007). However, we expect that justifying and funding this solution would be a major problem in our situation. More importantly, in a randomised scheme a very large number of points or transects would be necessary to achieve a sufficiently large sample size for scarce breeding birds, which are particularly important in nature policy and conservation. Lastly, randomised point or transect counts might be less useful at local scale, compared to the intensive territory mapping method (which results in more precise estimates of absolute numbers for all sites), for instance to evaluate the effects of local habitat management in nature reserves (Alldredge *et al.* 2008). Given these considerations, we have decided to correct for unequal sampling by implementing a stratification and weighting procedure in the calculation of indices and trends.

Our results show that large differences in species trends exist between regions and between habitats. This means that stratified imputing of missing values not only results in substantially different, but also improved (less biased) population trends. The results also show that weighting of strata has a further, but less marked, effect on national trends. Further evidence for the improvement of trends comes from the fact that impressions of ornithologists accord better with the corrected than the uncorrected trends (Teunissen *et al.* 2002).

For meadow birds in general, stratification according to bird density appears to have less effect than stratification according to physiogeographical region. This might be due to small differences in trends between high, medium and low density areas, or by large differences in weight factors, as a result of which differences in stratum trends are not expressed at the national scale. Clearly, many other factors may be responsible for differences in meadow bird trends, such as water table level, farming intensity, habitat management, nest protection and predation. However, we expect that most of these are correlated to either region or bird density to some extent. In addition, distinction of bird density areas might be insufficient, due to heterogeneity within the underlying study plots, or due to an inadequate scale of atlas data collection for this purpose. Based on the results for meadow birds, stratification according to bird densities was not implemented for other breeding birds.

We have chosen to use independently collected atlas data to calculate relative population sizes per region (weight factors), instead of using densities in BMP plots in combination with the surface of regions. The latter corrects for unequal sampling between regions, but assumes equal sampling within regions (and that densities in study plots are representative of the region concerned). A pilot on meadow birds revealed that these alternative weighting procedures yield very different results (Teunissen *et al.* 2002). Unfortunately, we have not been able to use atlas data to calculate relative population sizes for different habitat types within regions. These are therefore based on densities in BMP plots, which does assume representativeness within habitat strata. In addition, although for 67% of the strata only homogeneous plots are used (consisting of at least 75% of only one habitat type), population sizes in the remaining 33% of the strata are partly based on heterogeneous plots, due to too few homogeneous plots. Also, densities in 12% of the strata are based on less than three plots (especially in urban areas), which might result in unreliable weight factors. However, national trends generally appear to not be very sensitive to small deviations in weight factors.

For some strata insufficient data are available, especially for farmland and urban areas. Therefore, strata have to be lumped on the basis of expert judgement, which is subjective and difficult to standardize. Moreover, an even more refined stratification might be needed, because of trend differences within main habitat types (e.g. coniferous versus deciduous forest, arable land versus grassland). However, the more detailed the stratification, the more study plots are needed, and coniferous forest and arable land are particularly undersampled.

Standard errors of stratified national trends appear significantly larger than those of uncorrected national trends. This might be caused by the fact that sample sizes become smaller when dividing the total number of study plots over a large number of strata. In particular strata with relatively small sample sizes (5-10 study plots per year) and large weights (holding an important part of the species' population) will result in large standard errors, because a small sample size results in imprecise estimates of both trends and weight factors. An increase in the standard errors of national trends leads to a decrease in the power of the monitoring scheme. This effect will be balanced to some extent by the less conservative trends after stratification. From an earlier study, the BMP appeared to be quite sensitive for most breeding species. In a ten year period a 50% or smaller change would be detectable for 79 out of 89 species, using a probability of detection of 80% (Van Strien *et al.* 1994).

We conclude that for the majority of common and scarce breeding birds in the Netherlands the stratification and weighting procedure results in slightly different trends and indices, which provide a substantially better picture of their population status. Although we realize that a (stratified) random scheme is prone to less bias than a non-randomised scheme, at least for the group of common breeding birds, we plan to continue the BMP in its present form for the time being. In our opinion, the major challenge at the moment is to gather more data in undersampled strata. We will therefore try to set up a well-designed and labour-extensive scheme in habitats that are currently particularly undersampled. In 2007 such a scheme was launched for urban habitats (Van Turnhout & Aarts 2007). Combining trends from very different schemes has been proven to be a practical and statistically sound method (Gregory *et al.* 2005). We aim to carry out atlas projects at least once every 15-20 years, which is essential to validate the representativeness of the BMP sample and to periodically update the weight factors.

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Resum

Monitoratge d'espècies nidificants comunes i escasses a Holanda: aplicació dels procediments d'estratificació i ponderació per obtenir tendències poblacionals menys esbiaixades

El principal objectiu del programa de seguiment d'ocells reproductors d'Holanda (BMP) és avaluar els canvis de mida poblacional de les espècies reproductores comunes i escasses en aquest país. Tot i que aquest programa de seguiment disposa d'un gran nombre de punts de mostreig, les tendències poden estar esbiaixades perquè els punts no estan igualment distribuïts en el país. En aquest article es presenta un procediment d'estratificació i ponderació *a posteriori* per corregir aquesta desigualtat en la presa de dades. Els índexs i les tendències es van calcular primerament per a un nombre d'espècies específiques d'estrats (combinacions de regió, tipus principal d'hàbitat i categoria de densitat d'ocells). Posteriorment, els índexs per estrat van ser ponderats per les mides poblacionals (tal com es desprèn d'un conjunt de dades d'atles que van ser extrets de forma independent) i esforç de mostreig per estrat. El procediment té un petit però substancial efecte sobre les tendències nacionals, tendències que, en general, solen ser menys conservadores (és més fàcil trobar diferències significatives). S'espera que per a la majoria de les espècies reproductores el procediment impliqui una suficient i substancial millora de les tendències i, per tant, es continuarà amb el BMP en els pròxims anys.

Resumen

Monitoreo de especies reproductoras comunes y escasas en Holanda: aplicación de procedimientos de estratificación y ponderación para obtener tendencias poblacionales menos sesgadas

El principal objetivo del programa de seguimiento de aves reproductoras de Holanda (BMP) es evaluar los cambios de tamaño poblacional de las especies reproductoras comunes y escasas en ese país. A pesar del gran número de puntos de muestreo en este programa de seguimiento, las tendencias pueden estar sesgadas debido a que los puntos no están igualmente distribuidos en el país. En este artículo se presenta un procedimiento de estratificación y ponderación *a posteriori* para corregir esta desigualdad en la toma de datos. Los índices y las tendencias se calcularon primero para un número de especies específicas de estratos (combinaciones de región, tipo principal de hábitat y categoría de densidad de aves). Posteriormente, los índices por estrato fueron ponderados por los tamaños de población (tal como se desprende de un conjunto de datos de atlas que fueron extraídos de forma independiente) y esfuerzo de muestreo por estrato. El procedimiento tiene un pequeño pero sustancial efecto sobre las tendencias nacionales, tendencias que en general suelen ser menos conservadoras (es más fácil encontrar diferencias significativas). Se espera que para la mayoría de las especies reproductoras el procedimiento implique una suficiente y sustancial mejora de las tendencias y, por lo tanto, se continuará con el BMP en los próximos años.

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Appendix 1. National population indices and linear trends of 102 common and scarce breeding birds in the Netherlands 1990-2004. Headings are: scientific name, English name, annual indices 1990-2004 (1990 = 100), total number of positive study plots, slope of linear trend ('overall slope imputed', Pannekoek and Van Strien 2005), standard error of slope, and classification of linear trend : ++ strong increase (>5% per year), + moderate increase, 0 (no significant change), - moderate decline, -- steep decline (>5% per year).
Índexs de població nacional i tendències lineals de 102 espècies d'ocells nidificants comuns i escassos d'Holanda el 1990-2004. Sucessivament es mostren: el nom científic, el nom anglès, els índexs anuals el 1990-2004 (1990=100), nombre total de punts d'estudi, i pendent de la tendència lineal, error estàndard de la pendent, i classificació de la tendència lineal : ++ increment notable; (>5% per any); + increment moderat; 0 (canvi no significatiu); - descens moderat; -- descens pronunciat (>5% per any).

Scientific name	English name	1990	1991	1992	1993	1994	1995	1996
Tachybaptus ruficollis	Little Grebe	100	50	69	83	94	138	75
Podiceps cristatus	Great Crested Grebe	100	107	105	103	111	96	86
Cygnus olor	Mute Swan	100	106	116	103	104	114	112
Anser anser	Greylag Goose	100	110	114	162	280	398	495
Alopochen aegyptiacus	Egyptian Goose	100	91	115	125	224	269	289
Tadorna tadorna	Common Shelduck	100	104	108	100	117	125	110
Mareca strepera	Gadwall	100	102	113	102	119	138	143
Anas crecca	Common Teal	100	109	93	93	87	90	59
Anas platyrhynchos	Mallard	100	93	80	82	91	96	100
Anas querquedula	Garganey	100	83	83	88	91	96	63
Anas clypeata	Northern Shoveler	100	96	105	105	99	83	61
Aythya ferina	Common Pochard	100	89	94	102	110	100	87
Aythya fuligula	Tufted Duck	100	103	105	109	107	114	99
Accipiter gentilis	Northern Goshawk	100	132	130	117	119	121	138
Accipiter nisus	Eurasian Sparrowhawk	100	135	118	125	153	131	140
Buteo buteo	Common Buzzard	100	118	113	138	141	148	152
Falco tinnunculus	Common Kestrel	100	108	86	95	74	58	82
Falco subbuteo	Eurasian Hobby	100	100	78	59	53	47	52
Perdix perdix	Grey Partridge	100	93	83	88	75	57	58
Coturnix coturnix	Common Quail	100	41	139	94	132	106	89
Phasianus colchicus	Common Pheasant	100	103	95	89	80	74	81
Rallus aquaticus	Water Rail	100	72	81	98	130	129	86
Gallinula chloropus	Common Moorhen	100	78	105	110	108	114	78
Fulica atra	Common Coot	100	97	101	103	108	104	93
Haematopus ostralegus	Eurasian Oystercatcher	100	116	101	89	83	87	78
Vanellus vanellus	Northern Lapwing	100	99	88	94	99	98	107
Gallinago gallinago	Common Snipe	100	87	64	56	66	56	54
Scolopax rusticola	Eurasian Woodcock	100	59	55	46	79	105	53
Limosa limosa	Black-tailed Godwit	100	101	89	94	102	86	81
Numenius arquata	Eurasian Curlew	100	93	104	80	76	78	82
Tringa totanus	Common Redshank	100	90	94	94	96	93	97
Columba oenas	Stock Dove	100	115	101	117	115	123	150
Columba palumbus	Common Wood Pigeon	100	111	100	106	104	96	98
Streptopelia decaocto	Eurasian Collared Dove	100	87	82	81	80	69	84
Streptopelia turtur	European Turtle Dove	100	83	88	78	69	76	72
Cuculus canorus	Common Cuckoo	100	89	98	110	101	106	99
Strix aluco	Tawny Owl	100	91	86	95	91	84	100
Asio otus	Long-eared Owl	100	75	63	67	51	54	62
Picus viridis	European Green Woodpecker	100	99	127	144	145	157	152
Dryocopus martius	Black Woodpecker	100	87	79	90	98	104	111
Dendrocopos major	Great Spotted Woodpecker	100	102	95	108	118	117	126
Dendrocopos minor	Lesser Spotted Woodpecker	100	92	93	116	137	124	150
Lullula arborea	Wood Lark	100	121	157	214	336	294	313
Alauda arvensis	Eurasian Skylark	100	85	88	84	82	72	65
Hirundo rustica	Barn Swallow	100	81	85	72	55	49	55
Anthus trivialis	Tree Pipit	100	85	86	85	85	77	100

1997	1998	1999	2000	2001	2002	2003	2004	plots	slope	error	tr
75	92	133	153	160	168	167	180	463	1,07	0,008	++
82	81	80	93	92	91	86	83	806	0,98	0,003	-
134	147	164	164	165	166	173	195	828	1,05	0,005	+
753	792	1083	1378	1745	2338	3158	3702	575	1,32	0,018	++
253	314	399	514	606	730	772	834	986	1,18	0,008	++
131	144	120	128	133	139	131	123	896	1,02	0,004	+
141	171	220	255	267	282	278	321	798	1,10	0,006	++
59	61	68	77	81	87	84	81	486	0,98	0,006	-
87	74	87	93	95	96	95	88	1701	1,00	0,006	0
80	91	102	119	100	85	69	61	630	0,99	0,007	0
71	97	108	94	88	82	72	69	999	0,98	0,004	-
92	105	120	106	109	115	103	107	300	1,01	0,010	0
120	127	126	136	137	139	131	128	1263	1,02	0,004	+
125	124	131	126	126	128	131	132	646	1,01	0,008	0
141	142	143	124	118	112	129	125	689	1,00	0,011	0
160	167	174	180	183	186	186	190	1363	1,04	0,006	+
60	67	63	61	56	51	49	48	987	0,95	0,006	-
52	68	52	49	49	49	50	40	474	0,95	0,013	-
51	43	39	40	37	35	36	47	685	0,93	0,006	--
257	195	156	137	149	164	95	153	466	1,05	0,010	+
71	70	71	67	64	61	64	70	1401	0,97	0,005	-
83	118	151	156	149	142	156	124	578	1,04	0,005	+
62	71	87	98	94	91	76	84	1095	0,99	0,007	0
82	91	108	108	107	107	103	100	1190	1,00	0,004	0
71	66	64	62	60	58	57	50	1467	0,95	0,002	-
101	94	97	93	90	88	90	84	1479	0,99	0,002	-
57	59	57	56	56	57	57	59	381	0,98	0,006	-
57	62	57	64	61	58	66	56	360	0,99	0,011	0
83	79	79	77	74	71	67	65	936	0,97	0,002	-
84	82	76	77	75	73	72	78	663	0,98	0,005	-
100	108	102	108	107	107	99	100	1046	1,01	0,002	+
144	132	121	128	122	117	126	132	1119	1,01	0,006	+
95	93	93	89	85	82	80	89	1652	0,98	0,003	-
101	103	97	99	105	110	109	101	641	1,02	0,006	+
68	59	53	46	39	36	35	36	1042	0,93	0,011	--
105	91	89	82	80	80	77	83	1299	0,98	0,004	-
83	80	111	77	85	94	91	95	617	1,00	0,007	0
41	43	47	36	33	30	24	30	690	0,92	0,007	--
147	139	160	161	176	195	268	229	929	1,06	0,012	+
106	99	99	106	105	105	94	91	470	1,01	0,006	0
139	124	137	125	132	143	137	128	1168	1,03	0,005	+
184	198	172	166	187	211	255	248	661	1,07	0,008	++
330	339	297	318	312	307	274	269	414	1,06	0,010	+
66	64	58	57	52	48	38	41	1350	0,94	0,003	--
60	60	70	73	68	67	84	97	393	1,00	0,007	0
93	96	108	107	101	95	97	107	964	1,01	0,004	+

Scientific name	**English name**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Anthus pratensis	Meadow Pipit	100	86	86	88	87	89	79
Motacilla flava	Blue-headed Wagtail	100	72	72	66	71	84	98
Motacilla alba	White Wagtail	100	97	87	91	74	79	78
Troglodytes troglodytes	Winter Wren	100	78	84	98	101	121	64
Prunella modularis	Dunnock	100	112	104	111	103	94	111
Erithacus rubecula	European Robin	100	101	104	124	117	120	102
Luscinia megarhynchos	Common Nightingale	100	108	77	100	122	121	107
Luscinia svecica	Bluethroat	100	113	130	134	151	184	161
Phoenicurus ochruros	Black Redstart	100	103	80	71	63	54	90
Phoenicurus phoenicurus	Common Redstart	100	103	78	95	105	102	102
Saxicola torquata	European Stonechat	100	98	104	125	125	134	152
Turdus merula	Common Blackbird	100	98	96	105	108	99	107
Turdus philomelos	Song Thrush	100	96	90	103	111	111	117
Turdus viscivorus	Mistle Thrush	100	93	98	102	95	99	91
Locustella naevia	Common Grasshopper Warbler	100	90	89	87	89	113	122
Locustella luscinioides	Savi's Warbler	100	82	72	78	80	87	91
Acrocephalus palustris	Marsh Warbler	100	76	68	70	67	73	87
Acrocephalus scirpaceus	European Reed Warbler	100	77	92	100	122	132	113
A. schoenobaenus	Sedge Warbler	100	79	100	114	122	178	193
Hippolais icterina	Icterine Warbler	100	86	87	73	66	61	61
Sylvia curruca	Lesser Whitethroat	100	80	93	91	111	113	117
Sylvia communis	Common Whitethroat	100	89	87	93	95	101	116
Sylvia borin	Garden Warbler	100	96	99	103	98	98	109
Sylvia atricapilla	Blackcap	100	91	103	114	124	120	102
Phylloscopus sibilatrix	Wood Warbler	100	61	57	116	67	66	60
Phylloscopus collybita	Northern Chiffchaff	100	82	102	107	101	112	99
Phylloscopus trochilus	Willow Warbler	100	86	79	79	78	88	85
Regulus regulus	Goldcrest	100	43	50	43	46	55	58
Muscicapa striata	Spotted Flycatcher	100	83	80	78	83	71	67
Ficedula hypoleuca	European Pied Flycatcher	100	90	82	88	80	88	81
Aegithalos caudatus	Long-tailed Tit	100	113	97	112	104	79	97
Parus palustris	Marsh Tit	100	114	92	95	95	84	108
Parus montanus	Willow Tit	100	103	90	76	81	65	66
Parus cristatus	Crested Tit	100	97	101	96	99	71	91
Parus ater	Coal Tit	100	93	82	89	93	72	91
Parus caeruleus	Blue Tit	100	118	111	114	118	107	139
Parus major	Great Tit	100	102	100	99	105	94	117
Sitta europaea	Eurasian Nuthatch	100	135	99	117	122	111	131
Certhia brachydactyla	Short-toed Treecreeper	100	94	88	96	102	91	97
Oriolus oriolus	Eurasian Golden Oriole	100	106	105	130	121	103	112
Garrulus glandarius	Eurasian Jay	100	117	113	110	108	117	114
Pica pica	Common Magpie	100	88	82	77	83	81	76
Corvus monedula	Western Jackdaw	100	97	70	84	80	76	76
Corvus corone	Carrion Crow	100	108	103	103	113	123	112
Sturnus vulgaris	Common Starling	100	99	92	101	99	93	79
Passer domesticus	House Sparrow	100	99	87	86	75	85	81
Passer montanus	Eurasian Tree Sparrow	100	83	66	64	68	79	84
Fringilla coelebs	Common Chaffinch	100	113	112	129	136	130	149
Chloris chloris	European Greenfinch	100	98	91	101	95	86	88
Carduelis carduelis	European Goldfinch	100	101	133	142	128	127	129
Carduelis cannabina	Common Linnet	100	77	74	77	66	65	59
Carduelis cabaret	Lesser Redpoll	100	113	78	66	36	46	45
Pyrrhula pyrrhula	Eurasian Bullfinch	100	90	79	90	102	93	100
Coccothraustes coccot.	Hawfinch	100	113	118	119	120	135	134
Emberiza citrinella	Yellowhammer	100	104	108	106	120	112	124
Emberiza schoeniclus	Common Reed Bunting	100	93	106	113	122	111	118

1997	1998	1999	2000	2001	2002	2003	2004	plots	slope	error	tr
71	83	81	84	82	80	75	78	1534	0,99	0,003	-
93	100	89	98	82	70	61	70	966	0,99	0,004	0
76	81	73	65	62	59	66	70	1201	0,97	0,005	-
57	68	87	94	100	107	100	99	1655	1,01	0,005	0
96	92	89	84	88	94	109	101	1483	0,99	0,005	0
88	107	125	128	125	123	115	117	1347	1,01	0,003	+
113	108	112	99	95	91	85	100	748	1,00	0,006	0
179	200	197	201	209	218	237	256	845	1,06	0,006	+
109	116	96	94	85	80	83	99	518	1,01	0,009	0
107	104	101	101	91	82	82	82	1002	0,99	0,004	-
188	250	247	260	265	272	300	396	791	1,11	0,005	++
110	111	114	118	117	118	119	118	1660	1,02	0,004	+
118	123	131	143	147	155	172	153	1368	1,04	0,005	+
90	85	82	82	81	81	84	87	1147	0,98	0,005	-
134	152	150	165	152	143	147	187	906	1,05	0,006	+
86	88	102	114	113	112	106	90	237	1,02	0,007	+
84	80	73	72	68	65	69	82	1023	0,99	0,005	0
107	95	104	110	102	97	96	109	959	1,01	0,005	0
175	189	183	226	225	225	189	222	720	1,07	0,004	++
53	49	53	45	44	45	47	62	758	0,95	0,007	-
87	84	89	94	82	73	86	99	952	0,99	0,004	-
124	127	126	134	125	117	116	134	1821	1,03	0,003	+
99	95	93	81	82	83	78	80	1418	0,98	0,004	-
122	133	137	135	141	147	144	153	1448	1,03	0,004	+
42	40	36	33	34	37	35	27	485	0,92	0,007	--
121	134	98	89	95	102	113	117	1581	1,01	0,003	+
80	74	79	73	67	61	62	69	1609	0,98	0,004	-
49	62	87	113	110	108	138	119	511	1,07	0,006	++
73	59	64	64	58	54	65	86	730	0,98	0,010	-
101	98	89	85	81	77	96	98	530	1,00	0,006	0
94	61	68	71	71	73	79	66	1139	0,96	0,011	-
95	94	84	89	94	100	106	101	542	1,00	0,004	0
77	69	69	65	64	62	65	53	856	0,96	0,005	-
86	90	93	93	93	94	103	90	436	1,00	0,006	0
83	71	63	77	83	94	91	87	433	0,99	0,005	0
138	117	121	120	125	129	137	132	1494	1,02	0,004	+
121	106	105	101	103	105	112	110	1607	1,01	0,003	+
132	114	126	131	147	167	199	181	675	1,04	0,004	+
102	91	94	104	105	107	125	123	1057	1,02	0,005	+
98	94	80	80	78	76	81	72	853	0,97	0,008	-
133	116	127	119	123	128	138	129	1246	1,02	0,005	+
70	64	70	70	71	71	78	71	1033	0,98	0,006	-
71	84	88	80	82	85	92	106	744	1,01	0,006	0
120	108	123	127	130	135	124	126	1537	1,02	0,005	+
95	73	71	78	78	78	65	73	1020	0,97	0,008	-
70	62	63	53	54	55	52	51	493	0,95	0,007	-
88	76	74	56	56	57	78	62	569	0,98	0,008	-
150	139	143	133	136	142	155	147	1411	1,02	0,004	+
93	88	90	85	91	99	110	124	965	1,01	0,006	0
204	200	194	205	233	266	243	244	769	1,07	0,009	++
62	66	61	58	56	53	55	65	1421	0,97	0,004	-
103	55	49	37	45	55	24	70	125	0,95	0,018	-
98	96	93	92	89	87	103	100	600	1,00	0,006	0
164	113	95	103	96	90	101	90	564	0,98	0,007	-
124	124	125	118	120	123	125	131	710	1,02	0,005	+
120	118	126	128	131	134	151	180	1019	1,03	0,004	+