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HAL Authorization

1 **Tiny terminological disagreements with far reaching consequences**
2 **for global bird trends**

3 *Running Head:* Terminology influences bird trends

4 Hannah Fraser^{*a}, Jean-Baptiste Pichancourt^b, and Alain Butet^c

5 ^aSchool of Biosciences, The University of Melbourne, Parkville, Victoria, Australia

6 ^bCSIRO, Dutton Park, Queensland, Australia

7 ^cOSUR, UMR CNRS 6553 ECOBIO, University Rennes1, Ave. Gal. Leclerc, 35042, Rennes
8 Cedex, France.

9 *Corresponding author: hannahsfraser@gmail.com

10

11 **Abstract**

12 Various combinations of data and expert opinion have been used to select species for indices of
13 bird trends. Commonly these indices break species into groups based on their habitat preference
14 such as woodland specialist, farmland specialist and generalist birds. It is unclear what influence
15 differences in how species are allocated to these groups might have on trends in these indices.
16 There is uncertainty surrounding reported trends in these bird groups with studies variously
17 showing declines or increases in prevalence. This is usually attributed to ecological factors but if
18 studies classify bird groups differently this variation may be due to inconsistency in
19 classification. Disagreement about whether these bird groups are stable, increasing or declining
20 has the potential to obscure important changes in bird prevalence and impede appropriate, timely
21 conservation.

22 We examined how consistently European and Australian researchers classified woodland,
23 farmland and generalist birds, and whether this affected the trends in indices of these groups.
24 Researchers from both regions classified species differently, and the population trends seen in
25 these groups were strongly affected by differences in classification. While all classifications we
26 studied suggest that populations are consistently declining for Australian woodland and
27 European farmland birds and increasing for European woodland birds. European generalist and
28 Australian farmland and generalist birds may be seen as increasing or decreasing in prevalence
29 depending on classification.

30 Our results question the current practice of idiosyncratically classifying indicators in scientific
31 research and conservation. Current practice is making it more difficult to infer whether, when
32 and how to preserve bird groups in Europe and Australia, potentially leading to sub-optimal

33 biodiversity outcomes. We offer suggestions for building consensus on how to classify these bird
34 groups in order to provide more reliable evidence to support conservation decisions.

35 **Key-words**

36 classification, farmland bird, generalist, indicator, specialist, standardize, trends, woodland bird

37 **1. Introduction**

38 Globally, governments are united in the desire to preserve Earth's remaining biodiversity, as
39 evidenced by the creation of the Convention on Biological Diversity and the Aichi targets, along
40 with other commitments made at national and regional scales. Attempts to gain an understanding
41 of global biodiversity trends have inspired the creation of numerous biodiversity indicators
42 (Tittensor et al., 2014). These indicators are restricted to specific taxa, areas, or aspects of
43 biodiversity loss (Cairns et al., 1993; EBCC, 2014; Gottschalk et al., 2010; IUCN, 2000;
44 Scholefield et al., 2011).

45 Birds are particularly charismatic and diverse and as a result have been extensively studied and
46 monitored, eventuating in the development of multiple indicators of their trends through time
47 (DEFRA, 2013; EBCC, 2014; Gregory and Strien, 2010; Olsen et al., 2005; Rayner et al., 2014).
48 These indicators typically group birds by their primary habitat association to pick up changes
49 associated with habitat modifications. However, Fraser et al. (2015) indicated that the species
50 included in these groups differ between studies. The study, based in Australia, found that the
51 species experts classify as woodland birds differ substantially and may lead to meaningful
52 differences in results. However, an English study found that the indicators of bird trends derived
53 from the Breeding Bird Survey were robust to changes in species classification (Renwick et al.,
54 2012). Our study aims to compare how sensitive bird indices in Europe and Australia are to
55 differences in species classification demonstrated in the literature. We look at how indices of
56 trends in bird groups differ under published classifications of farmland, woodland, and generalist
57 bird groups. If indices of trends in these bird groups differ substantially then results from
58 different studies are not comparable. This impedes scientific progress because researchers can no
59 longer justify drawing conclusions from the body of research on farmland, woodland or

60 generalist birds, only from the minority of article which classify species identically. This is
61 problematic in all research but especially in conducting systematic reviews and meta-analyses as
62 it thwarts the direct comparison of results between studies. Disagreement about trends in a bird
63 group between studies may obscure declines causing necessary conservation efforts to be
64 delayed or deemed unnecessary.

65 Researchers and conservationists throughout Australia and Europe are concerned that forest and
66 woodland birds are declining due to deforestation, fragmentation and degradation of forests and
67 woodlands (Ford et al., 2001; Gil-Tena et al., 2009; Gregory et al., 2007; Hewson et al., 2007;
68 Vickery et al., 2004; Watson, 2011). The reduced amount of habitat available and the increased
69 need to disperse through hostile environments are thought to lead to declines in forest and
70 woodland birds (Deconchat et al., 2009; Garrard et al., 2012; Gil-tena et al., 2014). The
71 relationship is complicated in Europe because in areas such as Britain woodland habitat is
72 receding while in some Mediterranean countries it is expanding.

73 In Europe there is also concern about a possible decline in farmland birds as a result of
74 reductions in the extent and quality of remaining traditional farmland habitats. This decline in
75 farmland habitats is thought to have been triggered by the European Union's Common
76 Agricultural Policy which had a two-fold effect: intensifying agricultural practices and indirectly
77 increasing afforestation (Pithon et al., 2005; Vanhinsbergh et al., 2002; Vickery et al., 2004). In
78 2003, the European Common Agricultural Policy was revised to address this (Butler et al., 2010)
79 and, along with the promotion of agri-environmental schemes, this effort may have redressed the
80 issue but declines in farmland birds continue to be reported (Aviron et al., 2009).

81 Declines in farmland and forest/woodland birds are thought to be accompanied by increases in
82 species which have broader habitat requirements (the generalists) and are able to persist in
83 modified areas (McKinney and Lockwood, 1999). It is hypothesised that there is a global rise in
84 the population of generalist birds as a result of biotic homogenization caused by extinctions,
85 habitat degradation, urbanization and introduced species (Crocini et al., 2008; Gregory and Strien,
86 2010; McKinney, 2006; Robertson et al., 2013; Rooney et al., 2007). There is also evidence that
87 common bird species (mainly generalists) are declining in Australia (Birdlife Australia, 2015)
88 but more evidence is required in Europe and Australia to conclude that there is an increase in
89 generalist birds.

90 In this study we examine whether the proposed trends in three bird groups (woodland specialist,
91 farmland specialist and generalist) are robust to classification according to different published
92 sources. Evidence from Fraser et al. (2015) demonstrated that the classification of Australian
93 woodland birds is problematic and in this study we aimed to extend their research by
94 investigating whether: i) inconsistent classification is problematic for other well studied bird
95 groups, ii) European researchers classify species more or less consistently than Australian
96 researchers and, iii) inconsistent classification of species substantially impacts the interpretation
97 of indices of trends in bird groups.

98 2. Materials and Methods

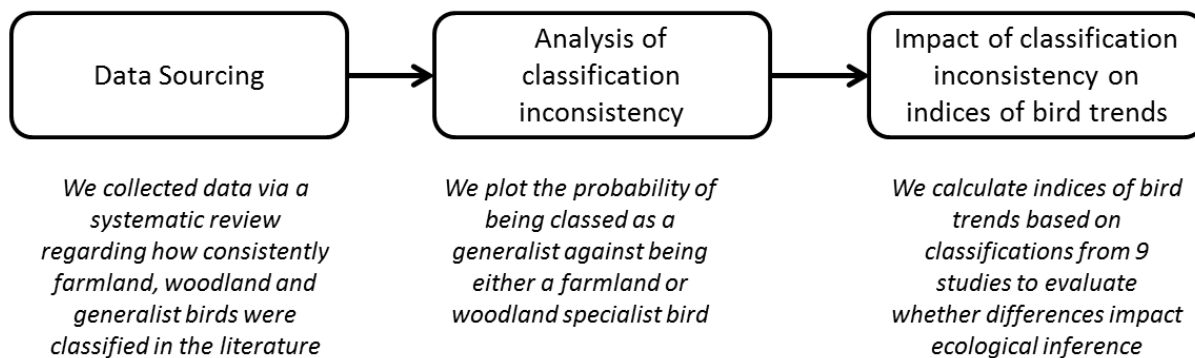
99 The terminology used to identify groups of bird species varied between and within regions. We
100 accounted for this difference by defining each group explicitly.

101 Farmland specialists: These species are thought to specialise in agricultural areas with low
102 density to no trees and an abundances of grasses, forbs or crops. They may include shelterbelts or
103 hedgerows. Terms often used in the literature to describe these species were ‘farmland’, ‘open
104 country’, ‘hedgerow’ and ‘savannah’.

105 Woodland specialists: These species are thought to specialise in with areas with a treed over-
106 storey. Terms often used to describe these species in the literature were ‘woodland’, ‘woodland-
107 dependent’, ‘forest’ and ‘woodland/forest’.

108 Generalists: These species are characterized by lacking dependence on a particular habitat type.
109 In the Australian bird literature studies often consider ‘woodland’ and ‘open country’ specialist
110 species and ‘open tolerant’ species which inhabit both habitats. In that context, we consider the
111 term ‘open tolerant’ to refer to generalists. Other terms used to describe this group were
112 ‘generalist’ and ‘ubiquitous’.

113 Hereafter we refer to the terms ‘farmland’, ‘woodland’ and ‘generalist’ species for the sake of
114 simplicity. We determine how consistently birds are being classified as woodland and farmland
115 specialist and generalist species and investigate the influence any inconsistency has on the trends
116 in indices of abundance and reporting rate of these groups. To do this we use the index of yearly
117 multiplicative trend which is used to report bird trends by the European Bird Census Council
118 (EBCC) (EBCC, 2014) (Fig. 1).



119

120 Figure 1) Diagram showing the structure of this article beginning with sourcing data and ending
 121 with analysing the effect of inconsistent classification on an index of bird trends

122 2.1. Data sourcing

123 The results from two systematic reviews were combined for this study; one collected data on
 124 woodland and farmland specialist and generalist birds internationally, the other augmented the
 125 data with additional records from Australia which was poorly represented in the initial search.

126 The first review searched several databases (Elsevier, JSTOR and Wiley online library, SCOPUS
 127 and Web of Science), for articles including the terms ‘woodland bird’; ‘woodland’ and ‘bird’;
 128 ‘forest bird’; forest’ and ‘bird’; ‘farmland bird’; ‘farmland’ and ‘bird’; ‘open country bird’; ‘open
 129 country’ and ‘bird’; ‘generalist’ and ‘bird; and ‘ubiquitous’ and ‘bird’. The search returned 2593
 130 articles. Articles focused on non-avian species or communities, single or pairs of species were
 131 removed after which 439 articles remained. The articles which specified at least two groups of
 132 bird species were retained for further analysis (e.g. generalist and farmland birds). Studies which
 133 only considered a single category were excluded to avoid confounding the species that did not
 134 fall into the category of interest with those that were not seen during the study. This new search
 135 yielded 37 articles from Europe, one article from Australia (Appendix A), four from Africa, three
 136 from Asia, five from South America and four from North America.

137 Previous research in (Fraser et al., 2015) had identified a body of research surrounding
138 Australian woodland birds. We used their search to augment our dataset subject to the above
139 exclusion criteria. Articles from Africa, Asia, North America and South America were discarded
140 due to low sample size.

141 The data was analysed in two ways (Figure 1). First, by analysing the level of inconsistency in
142 the classification of bird species on two axes using the full range of articles gathered using the
143 systematic review: farmland specialist – woodland specialist and generalist – specialist (in either
144 woodland or farmland habitats). Second, we took nine of the articles from the systematic review
145 and used them to analyse the effect of classifying species differently on indices of trends in
146 woodland specialist, farmland specialist and generalist species.

147 2.2. Analysis of classification inconsistency

148 The papers sourced in the systematic review variously classified birds into two or three of the
149 categories, i.e. woodland specialist, farmland specialist and generalist species. Each category was
150 considered by a different number of articles, with the majority of articles considering woodland
151 birds (n=58), and the fewest articles considering generalist birds (n=35). Therefore, finding the
152 percentage of studies classifying species into each category would be biased towards certain
153 classifications (i.e. if more studies concern woodland birds these might appear to be more
154 consistently classified) and confused by missing data (e.g. a study of farmland and woodland
155 birds might find a Magpie and classify it as a woodland specialist but, if they did not have the
156 woodland category it would be unclear whether they saw the species but did not consider it a
157 farmland bird or they did not see the species) (For more detailed explanations, see Fraser et al.,
158 2015).

159 To avoid this bias, we considered the data on two axes: i) the proportion of studies which
160 considered woodland vs farmland specialists and ii) the proportion of studies which considered
161 specialists (in either woodland or farmland habitats) vs generalists. Only studies that classified
162 species into both woodland and farmland categories were used to determine the position of
163 species (n=49) on the woodland – farmland specialist axis. Then we grouped farmland and
164 woodland species into one ‘specialist’ group and used studies which considered generalists and
165 (at least one type of) specialist species to calculate the position of species (n=35) on the
166 generalist – specialist axis (Appendix B). By doing this, the position of species on the
167 generalist/specialist axis may be less certain than their position on the farmland/woodland axis
168 (Figure 2). To minimise this affect we excluded species which were considered by fewer than
169 three studies that considered woodland and farmland categories and fewer than three studies than
170 considered specialist and generalist categories.

171 The classification of species was then plotted onto the two axes (farmland specialist – woodland
172 specialist and specialist – generalist). It was expected that species that were less consistently
173 classified on the farmland/woodland axis (i.e. are nearer the 0.5 mark) would be more likely to
174 be regarded as generalist species (i.e. would have higher values on the Y axis than other species),
175 which could be modelled as a second order polynomial equation. This relationship was examined
176 by using regression analysis and the r^2 value of the relationship was calculated to determine
177 whether it meaningfully explained variation in classification. A high r^2 value would support this
178 hypothesis, a low r^2 value would suggest that species that are consistently classified as woodland
179 or farmland birds are just as likely to be classed as generalists as species that are classified as
180 woodland birds 50% of the time and farmland birds 50% of the time.

181 2.3. Impact of classification inconsistencies on bird trends

182 The purpose of this article is to evaluate the impact that classifying bird groups differently has
183 upon inference about their trends through time. Therefore, we have endeavoured to present our
184 results in a similar format to those presented by the EBCC and BirdLife Australia which
185 typically present smoothed year by year trend graphs and a single estimate of the slope of the
186 trend. To illustrate the impact of different classifications of woodland, farmland and generalist
187 birds, we selected four studies from the systematic review which separated species into all three
188 categories for each region (Australia and Europe) and their species lists used to delineate
189 different possible sets of woodland specialist, farmland specialist and generalist birds. In
190 Australia only four studies classified species into all three categories. More studies were
191 available for Europe so the four most recent studies were selected and a fifth study was added for
192 farmland and woodland birds to represent the EBCC classification of these groups (EBCC, 2014)
193 (Table 1, see Appendix C for species lists). In total, nine different lists of woodland, farmland
194 and generalist birds were examined.

195 Data on the abundance of 163 European species (EBCC, 2014) and the reporting rate of 516
196 Australian species (BirdLife International and NatureServe, 2014) was available. The European
197 Bird Census Council (EBCC) has devised a method for measuring trends in groups of birds
198 (including farmland and woodland species) over time (EBCC, 2014). The abundance of each
199 species at year one is used as a reference point for the index of bird abundance (i.e. at year 1 the
200 index is 100, subsequent values represent percentage difference from year 1). Using this as a
201 reference point, the log of the indices and the slope of the regression line are calculated. Back-
202 transforming this slope gives the ‘yearly multiplicative trend’, which provides the average
203 percentage change in the index (of abundance) per year (EBCC, 2001). The EBCC then takes the

204 geometric mean of the abundance of species within a group at each time-step to calculate trends
205 in the various bird groups. This method was used to calculate the multiplicative trend in
206 abundance of 163 European bird species and reporting rate of 516 Australian bird species, over
207 the 15-year period between 1998 and 2012 using data provided by Birdlife Australia and the
208 European Bird Census Council. We replicated the global tendency of researchers to
209 idiosyncratically re-combine species-level indices by using 4 published bird lists of farmland,
210 woodland and generalist bird indices from Australia and 5 from Europe to predict the trends in
211 these indices.

212 Some birds were added to the EBCC dataset after 1997 so are missing in earlier years; also
213 surveys of some species were not implemented in all years. When there was missing data in the
214 European dataset log-linear models were used, as implemented in TRIM software, to fill the gaps
215 (EBCC, 2001). There were no missing values in the Australian dataset but sampling effort varied
216 and sites were selected for sampling haphazardly (compared to the European data set which
217 collects data at standard sites), so zero values of reporting rate were recorded in some years for
218 species which were rare, cryptic or range restricted. As proportional decreases in each species are
219 weighted equally in the multiplicative trend index, a 100% decrease in one of these species
220 disproportionately influences the index. To mitigate this effect, we excluded species which had
221 zero reporting rates in any year (86 species). This data was used to calculate Pearson correlation
222 coefficients between abundance/reporting rate indices (geometric mean of species'
223 abundance/reporting rate at year 1 =100, subsequent years' values represent percentage change
224 from year 1) under 9 classifications (Table 1) from different articles. We propose that, given
225 these trends are calculated from the same data using the same method, an r^2 value below 0.2
226 should be considered very poor agreement and 0.2-0.5 poor agreement. An r^2 value between 0.5

227 and 0.8 would represent an acceptable level of agreement and an r^2 value greater than 0.8 would
 228 be evidence of strong agreement.

229 Table 1: Articles included in analysis of the effect of different classification on bird trends

Europe					
Source	Calviño-Cancela 2013	Gregory et al. 2007	Guilherme & Miguel Pereira 2013	Mimet et al. 2014	EBCC (2014)
Geographic extent	Spain	Europe	Portugal	France	Europe
No. woodland specialists	19	33	16	9	33
No. farmland specialists	7	19	10	13	37
No. generalists	19	21	10	14	NA
Australia					
Source	Barrett et al. 1994	Haslem & Bennett 2008	Radford, Bennett & Cheers 2005	Silcocks et al. 2005	
Geographic extent	NSW	Victoria	Victoria	Australia	
No. woodland specialists	75	56	77	206	
No. farmland specialists	16	17	24	64	
No. generalists	17	17	34	54	

230

231 The data also allowed us to determine the slope of trends in these groups through time by using
 232 Ordinary Least Squares regression on the abundance/reporting rate indices. This yielded the
 233 average yearly change in abundance/reporting rate indices under each studied classification of
 234 farmland, generalist and woodland birds in Australia and Europe (Figure 4).

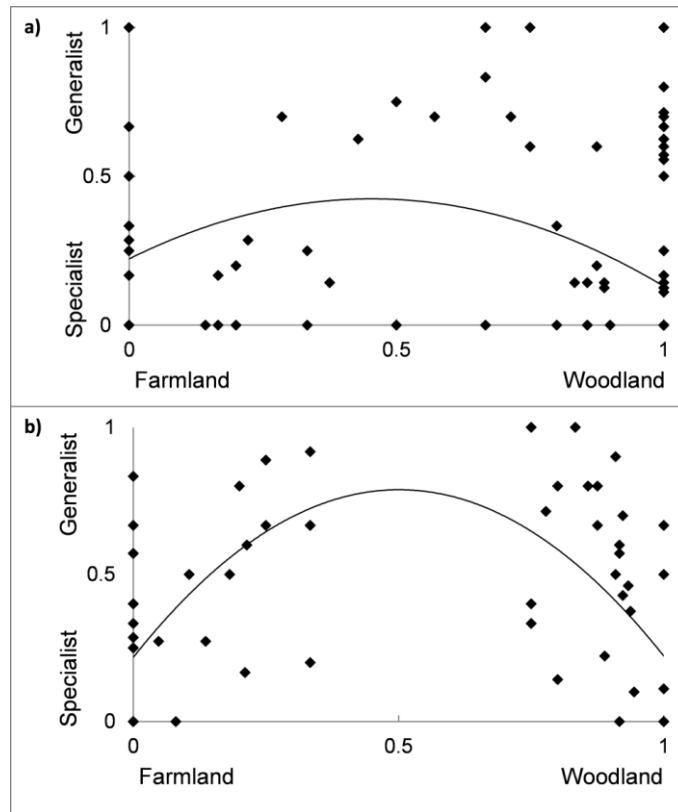
235 To demonstrate the full possible range of variability in these indices we also calculated the
 236 multiplicative trend index for each bird group by sub setting the species which had been
 237 classified into each bird group to only include i) the ten most steeply declining species and ii) the
 238 ten most steeply increasing species, to provided minimum and maximum conceivable trends for
 239 these groups (Figure 4).

240 **3. Results**

241 3.1. Classification inconsistencies

242 Figure 2 illustrates the proportion of studies in which birds are classified as woodland specialists
243 as opposed to farmland specialists, against the proportion of studies in which species are
244 classified as a generalist as opposed to a (either a farmland or woodland) specialist species (see
245 Appendix A for species list and classification proportions). Australian (Fig. 2a) birds are
246 classified less consistently on the farmland-woodland axis, with birds spanning the full range of
247 values from consistently classed as farmland specialist to consistently classed as woodland
248 specialist species. In Europe (Fig. 2b), classification of birds as farmland or woodland specialists
249 is more consistent, with no species classified in between $\frac{1}{4}$ and $\frac{2}{3}$ of studies as farmland
250 specialists.

251 The number of species assigned to each category in more than 50% of studies varied
252 substantially between the two regions. The majority of Australian researchers classified 24 of the
253 112 birds (21%) as farmland specialists and 86 (77%) as woodland specialists. Of these birds 22
254 (20%) were more likely to be considered generalist than specialist species. In comparison, the
255 majority of European researchers classified 36 of 71 (51%) birds as farmland specialists and 35
256 (49%) as woodland specialists while 24 (34%) species were more likely to be considered
257 generalist than specialist species.



258

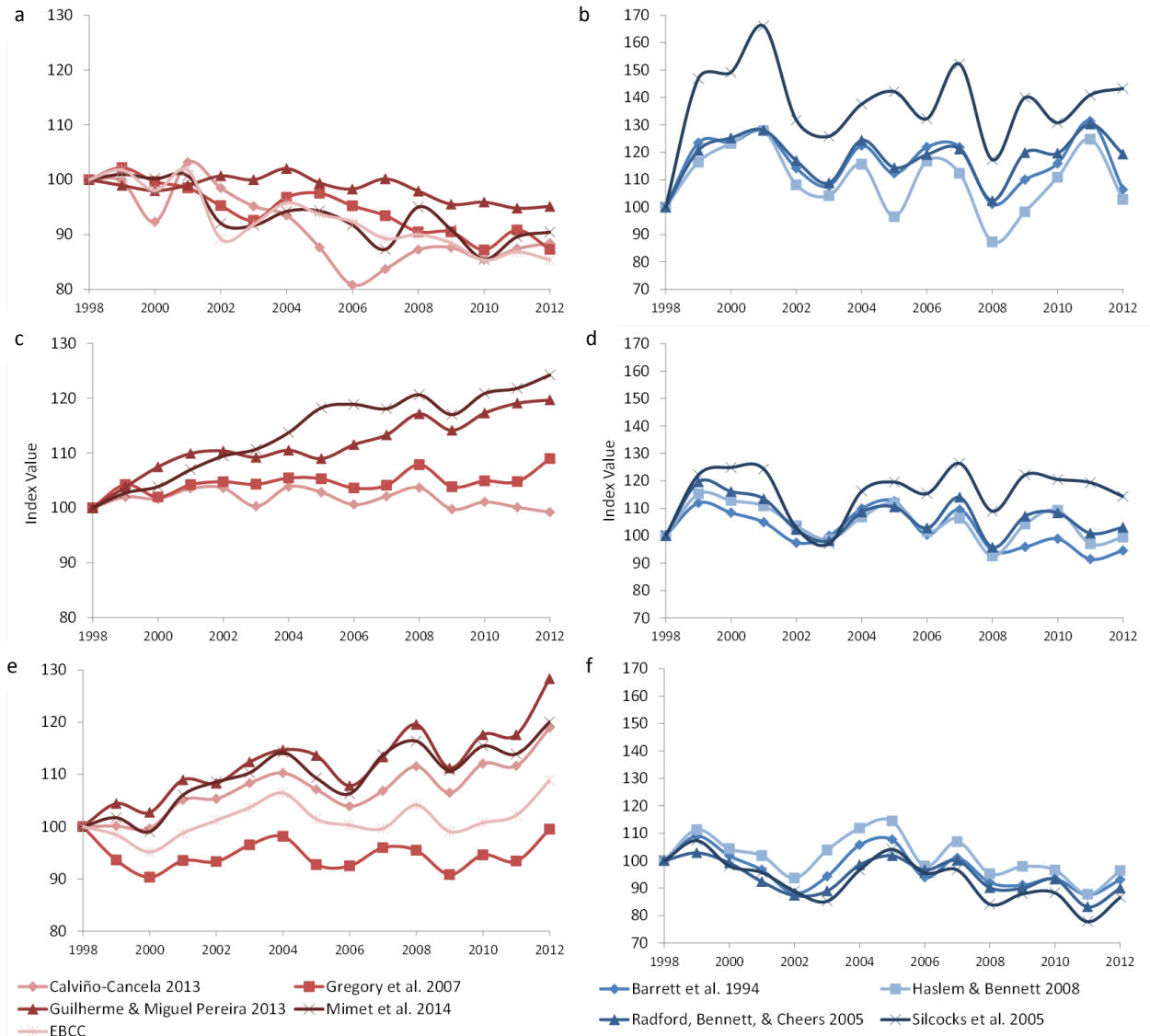
259 Figure 2) Classification consistency of species where the y axis shows the proportion of studies
 260 (n ranges from 3 to 26) in which a species is regarded as a generalist as opposed to a specialist
 261 (in either woodland or farmland habitats) and the x axis shows the proportion of studies in which
 262 the same species are regarded as a farmland specialist as opposed to a woodland specialist: a)
 263 shows 112 Australian species, b) shows 71 European species. Each point represents one species,
 264 though some species overlap. Lines show second order polynomial relationships between the two
 265 variables.

266 It was initially expected that species that were less consistently classified on the farmland-
 267 woodland specialist axis would be more likely to be regarded as generalist species, but evidence
 268 for a second order polynomial relationship, as displayed in Fig. 2, is not compelling (r^2 values of
 269 0.1 and 0.3, for Australian and European birds respectively). It appears that, particularly in the
 270 case of Australian species, the proportion of studies in which a species is classified as a farmland
 271 or woodland specialist is unrelated to the proportion of studies in which it is regarded as a
 272 generalist.

273 3.2. Impact of classification inconsistencies on bird trends

274 Although fluctuating through time, the trends in the European farmland specialist birds are
275 relatively stable between 1998 and 2012, regardless of which article's classification was used to
276 delineate the group (Fig. 3a). Indices of trends in European farmland birds were poorly
277 correlated under some classifications and strongly correlated under others with r^2 values ranging
278 from 0.36 (between articles by Guilherme and Miguel Pereira 2013 and Mimet et al. 2014) and
279 0.92 (between articles by Gregory et al. 2007 and Mimet et al. 2014).

280 By contrast, there was a big difference in the trends in Australian farmland specialist birds
281 depending on classification, with the classification from the report by Silcocks et al 2005
282 showing a steep increase in farmland specialist prevalence compared to the other three
283 classifications (Fig. 3b). The trend index from the Silcocks et al 2005 classification was not
284 strongly correlated with the other trends with r^2 values ranging from 0.73 to 0.84. However, the
285 other trends were well correlated with r^2 values ranging from 0.82 to 0.91.



286

287 Figure 3) Trends in indices of species groups from 1998 to 2012 for a) European farmland birds,
 288 b) Australian farmland birds, c) European generalist birds, d) Australian generalist birds, e)
 289 European woodland birds, and f) Australian woodland birds. Lines represent trends in indices
 290 obtained using species lists from five European articles and four Australian articles.

291

292 European generalist species show a steady increase in index value (of abundance) except when
 293 using the classification from the article by Calvino-Cancela 2013, when their trend is fairly
 294 stable through time. Article E1 is very poorly correlated with the other indices with r^2 values

295 ranging from -0.18 to 0.17, the other trends have correlation coefficients ranging from 0.72 to
296 0.91.

297 Australian generalist species showed greater differences, with the classification from the article
298 by Silcocks et al. 2005 again showing a greater increase than the other classifications (r^2 values
299 for correlations with other articles ranging from 0.41 to 0.78), and classifications from articles by
300 Barrett et al. 1994 and Haslem and Bennett 2008 revealing the possibility of a decline in index
301 value (of reporting rate) (Fig. 3d). Trends from classifications by Barrett et al. 1994, Haslem and
302 Bennett 2008 and Radford, Bennett and Cheers 2005 were well correlated with r^2 values ranging
303 from 0.78 to 0.93.

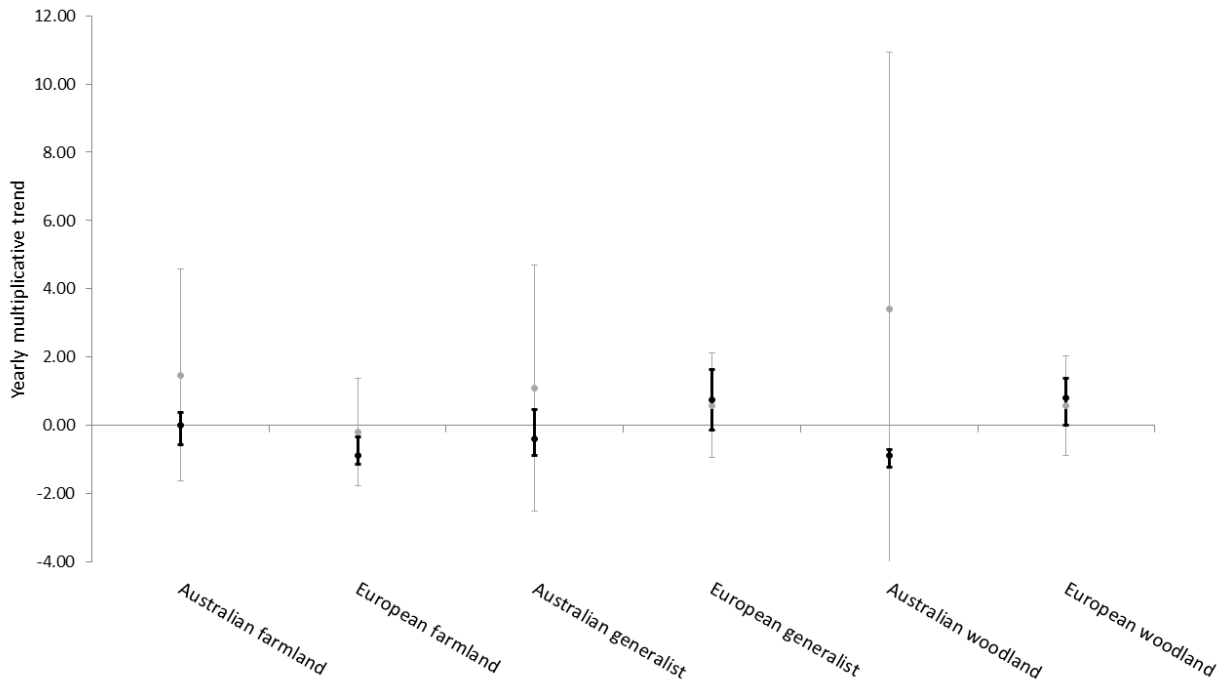
304 There is a general trend towards an increase in European woodland specialist birds although this
305 is less clear under the classifications from Gregory et al 2007 and Mimet et al. 2014 (Fig. 3e).
306 Trends yielded from Gregory et al 2007 correlates poorly with those from Guilherme and Miguel
307 Pereira 2013 and Mimet et al 2014 (r^2 values 0.31 and 0.34) but the other trends are better
308 correlated (r^2 values from 0.68 to 0.98).

309 The index values for Australian woodland specialist birds fluctuate so widely (Figure 3f) that it
310 is difficult to discern the downward trend (Figure 4) but indices from all articles' classifications
311 are reasonably well correlated with r^2 values ranging from 0.81 to 0.94.

312 3.3. Differences in index values

313 The EBCC, among other organisations, present a single value for the trend in bird groups
314 through time. Figure 4 shows the variation in these values that is achieved using the
315 classifications from articles studied above as well as the maximum conceivable variation

316 achieved by alternately calculating trends in declining and increasing woodland and farmland
317 specialist, and generalist birds.



318
319 Figure 4) Yearly multiplicative trend (EBCC, 2001) for European and Australian farmland,
320 generalist and woodland birds. Black points and error bars represent the mean and range
321 achieved using assessed above. Grey points and error bars represent the median minimum and
322 maximum achieved when alternately considering the 10 most declining or 10 most increasing ...
323 specialist birds and increases in European woodland specialist birds. However, when considering

324 Figure 4 demonstrates the high uncertainty that differences in classification brings to these
325 indices of bird trends. Based on published classifications, Australian generalist and farmland
326 specialist birds and European generalist birds may be increasing or decreasing over time. The
327 direction of trends (increase or decrease) for Australian woodland and European farmland and
328 woodland specialists was robust to differences between these classifications, with indices from
329 all articles showing a decrease in Australian woodland specialist birds and European farmland
330 specialist birds and increases in European woodland specialist birds. However, when considering
331 the maximum conceivable variation (grey error bars in Figure 4) it is evident that all of these bird

332 groups may be considered to be either increasing or decreasing depending on which species are
333 included in the index.

334 **4. Discussion**

335 Our study highlights the global tendency of researchers to classify bird groups associated with
336 the same habitats differently, even when there are organisationally endorsed indices available
337 (see Gregory & Strien, 2010; EBCC, 2014). Classifying woodland, farmland and generalist birds
338 in different ways substantially changed the trends in the indices of these groups. This has
339 profound implications for the research and conservation of these bird groups. Many studies build
340 on existing research into farmland, woodland and generalist species. However, our research
341 suggests that the results are likely to differ from study to study purely because the authors do not
342 classify the same species as being part of the same group. This is influential in all research but
343 makes it particularly difficult to conduct structured comparisons between articles using meta-
344 analyses or systematic reviews. Unless each article classifies the species within the group of
345 interest identically, it is impossible to know whether differences between studies are ecologically
346 important or due to inconsistent classification.

347 This inconsistent classification is likely perpetuated because there is currently no standard
348 protocol to help decide which published classification to use over another. As a consequence it is
349 not uncommon to see authors use the classification that best fit the objective of the their own
350 study (Fraser et al., 2015). If there is no clear ‘best’ classification and evidence from a suite of
351 studies variously report that a bird group is declining, increasing or remaining stable, it will be
352 more difficult to justify, find funding for and implement conservation actions. Further, evidence
353 suggests that the way bird groups respond to habitat variables such as fragmentation also varies

354 according to their classification (Fraser et al., 2015). Therefore, bird groups may respond
355 differently to management interventions depending on how they have been classified.

356 Our study showed that, depending on which classification is used, trends in farmland, generalist
357 and woodland birds vary substantially. The direction of trends in Australian woodland and
358 European farmland and woodland birds remains the same regardless of which published
359 classification is used but the slope of the trend varies. If you consider the trends found when,
360 either by chance or design, only the species considered are those which are increasing or only
361 those which are declining (Figure 4) the variation is even more pronounced. For example,
362 depending on whether the declining or increasing species are included in the trend index,
363 Australian woodland birds may be decreasing at a rate of -4.1% or increasing at a rate of 10.9%
364 per year.

365 Although our evidence shows that, some conceptualisations of ‘woodland’ and ‘farmland’
366 specialist, and ‘generalist’ birds may suggest that a decline or increase is possible in each of
367 these bird groups (grey error bars in Figure 4). Our work supports proposed declines in
368 Australian woodland birds (Ford, 2011; Watson, 2011) and European farmland birds (Butler et
369 al., 2010; Sanderson et al., 2013), based on the published classifications we studied. We found
370 evidence of an increase in European woodland birds, which contradicts the literature expectation
371 of a decline in these groups (Gil-Tena et al., 2009; Gregory et al., 2007). However, given the
372 variability in trends using different published classifications, it is not possible to conclude with
373 certainty whether Australian farmland and generalist birds or European generalist birds are
374 declining, increasing or stable. The results provide no strong evidence regarding the
375 hypothesised global increase in generalist species; depending on how they are classified their
376 populations may be increasing, decreasing or remaining stable through time.

377 Our findings show that researchers are classifying species inconsistently in both Europe and
378 Australia. However, European researchers classify woodland and farmland species more
379 consistently than Australian researchers, and this is likely to be (in part) related to the existence
380 or organisationally supported indices for these bird groups. For instance, European organizations
381 such as the British Trust for Ornithology (DEFRA, 2014) and the European Bird Census Council
382 (EBCC, 2014) have indices that give researchers guidance about how to define and classify these
383 groups. However, this study demonstrates that the existence of these guidelines does not
384 completely eliminate inconsistencies, as studies continue to classify species idiosyncratically.
385 Comparatively, Australia is lacking widely available indices and guidelines for studying
386 farmland and woodland bird groups. A few attempts at producing authoritative classifications of
387 woodland and farmland species have been made (Silcocks *et al.*, 2005; DEPI, 2013) but these
388 have fallen short of being widely accepted; the report by Silcocks *et al.* (2005) is only available
389 by contacting the author, and the Victorian Temperate Woodland Bird Community is listed under
390 the Flora and Fauna Guarantee Act (DEPI, 2013), but is only relevant to one state of Australia
391 and is limited to a small set of species.

392 Unlike farmland and woodland bird groups, there is no authorized list of generalist species in
393 either Europe or Australia. Researchers use a range of methods to determine whether a species is
394 a specialist or generalist. These approaches combine expert opinion and data on the occurrence
395 or abundance of species and may calculate habitat specialization by evaluating the relative
396 occurrence or abundance of a species in different habitat types (Devictor *et al.*, 2008; Julliard *et*
397 *al.*, 2006). However, these studies often only consider a limited selection of habitat types, and
398 consider birds that don't depend on any of these habitats to be generalist species. Therefore,
399 specialists in unstudied habitats may be regarded as generalists by default. For example, a study

400 that considers farmland and edge birds may call those which are equally prevalent in edge and
401 farmland habitats generalists, but these birds may not have been called generalist species if the
402 study considered farmland, edge and woodland habitats. Given the different methods of
403 calculating habitat specialization and the lack of an authorized list, the inconsistent classification
404 of generalist species is understandable.

405 The confusion around the classification of generalist, woodland and farmland birds leads to
406 conflicting results and conclusions, as evidenced by the lack of robust trends for some groups
407 found in this study. This has the potential to lead to spurious conclusions about the correct way
408 to implement actions to conserve these bird groups.

409 Our research suggests that having available, organisationally endorsed, bird prevalence indices
410 (as is the case for woodland and farmland birds in Europe) might improve the shared
411 understanding of the species belonging to these groups. However, even in Europe woodland and
412 farmland birds are still being classified inconsistently. This may be due to the existence of
413 multiple endorsed farmland and woodland bird indices (DEFRA, 2014; EBCC, 2014; Gregory et
414 al., 2005) or may reflect researchers' unwillingness to use standard indices. We hope that, by
415 providing evidence that it directly affects findings and inhibits the generalizability of studies, this
416 article will increase researcher willingness to build consensus around standard indices.

417 Our methods are sufficient to demonstrate the amount of inconsistency in the classification of
418 farmland, generalist and woodland birds and the impact of this inconsistency on inference about
419 trends in bird groups. But the multiplicative trend index is more suitable to the European than the
420 Australian data. The European data is collected at standard sites at the same time each year and
421 only relatively common species are included, reducing the between-year variation in species

422 abundance in the dataset. In contrast, the Australian reporting rate data is collected on all species
423 by citizen scientists at sites of their choosing which vary year to year. As a result, there is an
424 elevated probability of achieving a zero value in the Australian data particularly for species that
425 are rare or occur in poorly sampled areas. These zero values can strongly influence the index
426 because each species is weighted equally and a zero value means 100% decrease. To overcome
427 this, we have removed all of the Australian species which have a reporting rate of zero in any
428 year. We acknowledge that by doing so we are preferentially excluding species which are rare or
429 range restricted and may be of particular interest when constructing an index of bird trends.

430 It should be noted that ‘farmland specialist’, ‘woodland specialist’ and ‘generalist’ birds
431 represent very simplistic categories; and classifying birds like this reduces our ability to make
432 relevant inference on how species depend on subtle habitat variables. However, this
433 approximation is commonly used in research and conservation management. In this context, our
434 results provide a useful insight into how sensitive findings about these bird groups may be to
435 how they are classified. We provide a number of recommendations that may allow these groups
436 to be classified more consistently and minimize the chance of obtaining inconsistent results.

437 Firstly, we propose that researchers systematically present species lists and group classifications
438 to increase the falsifiability of any statement inferred from their analyses. Next, we propose that
439 researchers view the degree to which species are generalists or specialists as a life history trait
440 (similar to dispersal ability), rather than as a classification for species which do not fit into a pre-
441 defined category. Agreed upon lists of generalist bird species could be developed for Europe and
442 Australia in collaboration with well-regarded ornithological organizations such as Birdlife or the
443 European Bird Census Council.

444 We recommend that research organizations in Europe examine the need for classifying farmland
445 and woodland birds differently in their indices and look toward developing a shared
446 understanding and shared index for these bird groups. In some circumstances, it may be
447 justifiable to classify indices differently, especially if there are regional differences in habitat
448 availability or the occurrence of birds. For instance, some species may use a wider variety of
449 habitats in the centre of their range than at the range edges, due to greater habitat availability or
450 increased competition. However, this should be objectively evaluated and the indices should be
451 accompanied by advice regarding when one would be superior to another. It may also be
452 meaningful to include information on a regional index as well as one which is designed to be
453 used consistently across regions. This would balance the generalisability of the information
454 against regional specificity.

455 In cases where differences in classification are largely due to diverse opinions of experts, we
456 propose unifying behind a single index (and classification). This may involve discussion of how
457 life history traits factor in to determining whether species are farmland or woodland specialists or
458 generalists as well as the implementation of more nuanced categories (e.g. farmland birds may be
459 broken into field and hedgerow categories to better discern the effects of changes in farmland
460 management). Unifying bird indices or clearly stating why bird indices differ would hopefully
461 increase the consistency with which European researchers classify farmland and woodland birds.
462 Australian researchers should develop a standard list of woodland and farmland birds that is
463 easily available and endorsed by an organization such as BirdLife Australia.

464 There are a number of strategies for developing indicators of bird groups, based on expert
465 opinion (Gregory and Strien, 2010), subjective measures of resource requirements (Butler et al.,
466 2012), or objective measures such as relative habitat use (Larsen et al., 2011). Any of these

467 methods could be applied to the problem of delineating these groups provided that they are
468 representative, falsifiable, sensitive to changes over a short timeframe (Gregory and Strien,
469 2010) and supported by the research and conservation community. This last criterion is crucial
470 and undervalued, without it you simply add another under-used indicator to the field. It is also
471 very difficult to achieve. We propose that an approach which involves the participation of
472 stakeholders and researchers is more likely to be supported (and used) by the research and
473 conservation community. Participation in this kind of decision process increases transparency
474 and benefits from a diverse range of experience and perspectives as well as increasing the trust in
475 and of ownership over the final index (Reed, 2008).

476 This study is the first to demonstrate the influence of inconsistent classification on trends in
477 indices of biodiversity at an international scale. This study proved that the fluctuations and trends
478 in indices of bird groups in Europe and Australia differ substantially depending on which
479 published classification was used to determine the species included in each group, with different
480 classifications of the same groups sometimes finding opposite trends. We suggest that, where
481 possible, researchers and institutions unify behind a single classification and index of woodland,
482 farmland and generalist birds for each region.

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622

623 **Supporting Information:**

624 The following Supporting Information is available for this article online

625 Appendix A: Systematic review article selection process

626 Appendix B: Species list detailing proportion of classification on the woodland-farmland and
627 specialist-generalist dichotomies

628 Appendix C: Bird lists used to classify species for Fig. 2 analyses