

Supplementary Material for BoCC4

Eaton *et al.* (2015) gave a brief description of the criteria and data sources used to conduct the Birds of Conservation Concern 4 (BoCC4) assessment. Here we give fuller detail, drawing on the lengthier descriptions given for the BoCC3 assessment (Eaton *et al.* 2009) with additional information where relevant to BoCC4.

BoCC4 criteria

Red-list criteria

IUCN: Global conservation status. Species that are Globally Threatened (Critically Endangered, Endangered and Vulnerable, but not Near Threatened) under IUCN guidelines, as assessed by BirdLife International, the IUCN Red List Authority for birds, in 2015 (www.iucnredlist.org).

HD: Historical decline in breeding populations. Species judged to have declined severely between 1800 and 1995, from an assessment conducted by Gibbons *et al.* (1996a), and which have not recovered subsequently. The process by which species should be deemed to have shown partial recovery from historical decline (hence move to the Amber list), or complete recovery (move to the Green list), or subsequently faltered from those recoveries, was a subject of much debate. We agreed that the initial assessments of historical decline by Gibbons *et al.*, based on a semi-quantitative scoring of population changes within five periods, were robust; and that it was still appropriate that any HD species doubling its population size or more within the relevant 25-year period, and exceeding 100 breeding pairs, should move to the Amber list (provided it did not qualify as Red under other criteria). We made one change to this step to be consistent with other criteria, and introduced an assessment of trend over the longer-term period, defined as the entire period used for assessments since the first BoCC review, starting in 1969. A key concern, however, was how to treat changes subsequent to a move to Amber (HDrec), namely how any future recovery or decline should be regarded. The criterion used for BoCC3 stipulated that a decline of 20% between BoCC reviews should dictate that a species returns to the Red list, whereas a further increase of 20% over a similar period would enable a species to move to the Green list (unless it qualified as Amber under any other criteria). We felt that this was a rather unsatisfactory approach, in that in both cases the criterion used a non-standard measurement period unrelated to those used for other BoCC criteria, and which could lead to changes in status due to relatively insubstantial and short-term fluctuations in population size.

Therefore, for BoCC4 we have used the following rationale: a species should be moved to the Green list (if not qualifying against other Red or Amber criteria) if it shows continued and substantial recovery from historical decline beyond the level (HDrec) that qualified the species for the Amber list. When it moves to Green, the species should be considered as having recovered permanently and would no longer be considered against the historical decline criterion, i.e. any subsequent decline would be assessed only against the relevant decline criteria such as BDp (see below). That being the case, we felt that at least another doubling of numbers should be required to permit movement to the Green list. In fact, we now require a species to have shown a further increase of at least 167% from its HDrec level in order to move to the Green list. This higher threshold ensures that if a

species subsequently declines by anything less than 25% (thus does not trigger a return to the Amber list under the moderate decline criterion), it will still remain at more than double its HDrec numbers.

As an example, imagine a hypothetical species that qualified for the *BoCCI* Red list under the historical decline criterion, but no others. This species increased from 100 to 300 pairs within 25 years (well over the doubling to 200 required) and thus was moved from Red to Amber in *BoCC2*. If, by the time of this current review, it had increased to 900 pairs (an increase of 200% from its HDrec level of 300 pairs and thus above the 167% threshold of 801 pairs), it would be moved to the Green list and the HD criterion would no longer apply. If it had failed to increase by this rate, but remained above 200 pairs, it would stay on the Amber list. Finally, if it had declined to below 200 pairs, it would return to the Red list. In the last two cases, the HD criterion would still play a role in future assessments.

Decline criteria. As with the *BoCC3* assessment, we have used two time periods to assess change in both population and range; a 25-year trend period, as used in all *BoCC* assessments, and an additional, longer-term trend period, from the beginning of the 25-year time period used for the first *BoCC* assessment (1969–94) until the most recent data (in effect around 43 years, depending on the data sources used). Consequently, this assessment takes account of species whose declines lie between those that are ‘historical’ and ‘recent’, and which have led to an impoverishment of bird populations from which there has been no recovery. This period also ties in well with the availability of robust monitoring data, coinciding with the start of the Common Birds Census (CBC) and increased Wetland Bird Survey (WeBS) coverage in the late 1960s, the first breeding bird atlas (1968–72; Sharrock 1976), and the first UK seabird census, Operation Seafarer (1969–70; Cramp et al. 1974). Note that species Red-listed under *BDp²* show a wide range in their pattern of decline, although all have declined by at least 50% over the period. Some species (e.g. Song Thrush *Turdus philomelos*) declined steeply in the earlier part of the period but have undergone little decline since; some (e.g. Arctic Skua *Stercorarius parasiticus*) have declined steeply in recent years; and a small number have shown a steady decline throughout the longer period (e.g. Turtle Dove *Streptopelia turtur*). In some instances, species have shown recovery, but not yet reached the 50% of their population level at the beginning of the *BoCCI* period, and so remain Red-listed.

BDp: Breeding population decline. Severe decline in the UK breeding population size (>50%) over 25 years (*BDp¹*) or the longer-term trend period (*BDp²*).

WDp: Non-breeding population decline. Severe decline in the UK non-breeding population size (>50%) over 25 years (*WDp¹*) or the longer-term (*WDp²*) as defined above. Non-breeding trends were assessed only if a species has substantially independent breeding and non-breeding populations, otherwise only the breeding population was assessed. The same was true for other criteria which could be applied to both breeding and non-breeding populations.

BDr: Breeding range decline. Severe decline in UK range (>50%) between the breeding bird atlases in 1988–91 and 2007–11 (*BDr¹*) or 1968–71 and 2007–11 (*BDr²*), as measured by the calculated change in the number of occupied 10-km squares.

WDr: Non-breeding range decline. Severe decline in UK range (>50%) between the wintering bird atlases in 1981–84 and 2007–11 (*WDr¹*), as measured by the calculated change in the number of

occupied 10-km squares. Since there are only two wintering bird atlases, it was not possible to measure range change over a longer time period. Note that while *BoCC* reviews have always intended to assess range change in the non-breeding season, this is the first assessment able to do so.

Amber-list criteria

ERLOB: European Red List status. Previous *BoCC* assessments have used Species of European Conservation Concern assessments (SPECs; see Tucker & Heath 1994 and BirdLife International 2004) as an indication of wider regional concern for a species, and thus Amber-listed any UK species that was SPEC-listed. Although a new assessment of species status across Europe, the European Red List of Birds (ERLOB; BirdLife International 2015), was published in 2015, this produced only IUCN Red List assessments of regional extinction risk (IUCN 2012) with no consideration of the wider suite of measures (species rarity, localisation, moderate decline and depletion) included in SPEC assessments. At present, it is not clear when or if new SPECs will be published. Therefore, to complete the *BoCC* assessment, we faced a quandary: to delay publication of *BoCC* in the hope that SPEC assessments would be completed or to drop the use of SPECs as part of *BoCC*. We chose the latter option, and thus have Amber-listed any species on the European Red List (Critically Endangered, Endangered or Vulnerable). We recognise that the exclusion of species that were previously SPEC-listed has had an impact on our final lists, by moving species from Amber to Green but we feel that our decision provides a sound basis for this and future *BoCC* assessments.

HDrec: Historical decline – recovery. As described above, previously Red-listed for historical decline, followed by an increase of at least 100% over 25 years or the longer-term period. This also applies if the move to HDrec happened in a previous *BoCC* assessment, having remained above the 100% increase threshold, but not having recovered further to move to Green (see text under historical decline above). **BDMp:** Breeding population decline. As for Red-list criterion BDp, but with moderate decline (>25% but <50%) over 25 years (BDMp¹) or the longer-term period (BDMp²). **WDMp:** Non-breeding population decline. As for Red-list criterion WDp, but with moderate decline (>25% but <50%) over 25 years (WDMp¹) or the longer-term period (WDMp²). **BDMr:** Breeding range decline. As for Red list criterion BDr, but with moderate decline (>25% but <50%) between 1988–91 and 2007–11 (BDMr¹) or 1968–71 and 2007–11 (BDMr²). **WDMr:** Non-breeding range decline. As for Red-list criterion WDr, but with moderate decline (>25% but <50%) between 1981–84 and 2007–11 (WDMr¹).

BR & WR: Breeding and non-breeding rarity. Species qualified as rare breeders (BR) if the UK breeding population was <300 pairs, and as rare non-breeders (WR) if the UK non-breeding population was <900 individuals.

BL & WL: Breeding and non-breeding localisation. Species were considered localised if more than 50% of the UK population was found at ten or fewer sites in either the breeding (BL) or the non-breeding (WL) season. Sites were defined as either Special Protection Areas (SPAs; Stroud *et al.* 2001) or Important Bird Areas (IBAs; Heath & Evans 2000). Rare breeders or rare non-breeders (see above) were not assessed against this criterion, as their small population sizes predispose them to be restricted to a small number of sites.

Note that tables 2 & 3 in Eaton *et al.* (2015) indicate whether species qualify as localised in SPAs, IBAs, or both, and if so gives a range (in ten percent bands e.g. 50-60%) of the population found in the top ten sites. In cases where the species qualifies under both SPAs and IBAs, the range band may differ between the two, in which case the range band given is the highest of the two.

BI & WI: Breeding and non-breeding international importance. Species were considered of international importance if the UK holds at least 20% of the European population in either the breeding (BI) or the non-breeding (WI) season. European estimates were derived from data collated as part of the ERLOB assessment, but for non-breeding waterbirds we used estimates for the flyway populations for northwest Europe (wildfowl) or East Atlantic (waders) (Wetlands International 2015).

Data sources

We are fortunate in that, thanks to the efforts of thousands of dedicated volunteer birdwatchers working in tandem with professional research and conservation organisations, birds in the UK are one of the best-monitored taxonomic groups anywhere in the world. We are thus well equipped to make status assessments such as *BoCC*, and for many species can make robust assessments against all the *BoCC* criteria. This is not true for all species, however, and it is highly likely that some data gaps have influenced our assessment. The principal sources of data are described below; table SMI lists the species and circumstances in which alternative data sources or trend periods were used.

BTO/JNCC Common Birds Census (CBC) and BTO/JNCC/RSPB Breeding Bird Survey (BBS)

These two surveys have provided the backbone of monitoring of common breeding birds in the UK since 1966. The former ran from 1966 to 2000 and involved observers mapping territories within relatively small plots they had chosen themselves. Although it measured population trends of breeding birds in most habitats, it had a small sample size, biases in habitat coverage, and very poor coverage outside England. As a result of these deficiencies, the BBS was started in 1994, with an overlap of seven years before the CBC ceased in 2000. The BBS uses a line transect method in randomly selected 1-km squares, and is more representative both geographically and of all habitats (see Harris *et al.* 2015 for further details of the scheme and results). A far greater sample size (e.g. more than 3,639 squares in 2014) means that the BBS is able to monitor trends in more species, so some (e.g. Wood Warbler *Phylloscopus sibilatrix*) are reported from 1994 onwards only. For species covered by both surveys, the overlap period means that in most cases data from both surveys can be jointly modelled to produce trends spanning 1966 to date (Freeman *et al.* 2007). However, for a small number of species, the divergence in CBC and BBS trends within the 1994–2000 overlap period means that joint models cannot be produced. In such cases, UK trends have been produced by modelling trends from the two schemes separately and ‘anchoring’ the two together in 1994. As is good practice when using smoothing, the last year of indices has not been used (although the full run of years is used in deriving the indices) and we have chosen trend periods to be consistent with the data submitted under Article 12 reporting, thus trends run to 2012: 1969–2011 for the longer-term trend, 1987–2012 for the 25-year trend, and 1994–2012 (18 years) for those species monitored by the BBS only. For a small number of wetland species, it was considered more appropriate to incorporate data from the Waterways Bird Survey (WBS), which monitored plots along rivers,

streams and canals between 1974 and 2011, and its replacement the Waterways Breeding Bird Survey, which has run since 1998. A similar modelling approach was used as with CBC and BBS data, with smoothing and hence the end year excluded. For Grey Wagtail *Motacilla cinerea* and Dipper *Cinclus cinclus*, riparian specialists, data from just the two waterways surveys was used, and for Little Grebe *Tachybaptus ruficollis*, Common Kingfisher *Alcedo atthis*, Common Sandpiper *Actitis hypoleucos* and Sand Martin *Riparia riparia*, which are found in a wider range of wetland habitats some of which are better covered by the BBS, data was incorporated from all four surveys, with the CBC/BBS and WBS/WBBS components given equal weighting. Details of the BBS and the latest results can be found in Harris *et al.* (2015) and at www.bto.org/volunteer-surveys/bbs

BTO/JNCC/RSPB Wetland Bird Survey (WeBS) and WWT/JNCC/SNH Goose and Swan Monitoring Programme

Together these schemes provided annual trends for most wildfowl species from 1966/67 onwards and for waders from 1974/75 onwards, with a few other waterbird species monitored over shorter periods. National Wildfowl Counts started in the UK in 1947, since when coverage has grown and evolved into the present-day WeBS, which utilises volunteer counters to monitor waterbirds at a network of key sites throughout the winter. Around 3,000 observers now make counts at 2,000 sites on the same weekend every month from September to March (many sites are counted year-round). More details on the scheme and the latest results can be found in Holt *et al.* (2015) and at www.bto.org/volunteersurveys/webs. Robust trends can be generated for most wildfowl species from 1966/67 onwards, and from 1974/75 for waders; a few other waterbird species are covered from later years (e.g. Common Coot *Fulica atra* and Great Crested Grebe *Podiceps cristatus* from 1983/84). As with trends for common breeding species, these indices are smoothed (using counts from peak winter months) and used to the penultimate year for which data are available, and a reporting period consistent with that used for reporting to Article 12 i.e. 2011/12. For some species of the open coast (e.g. Purple Sandpiper *Calidris maritima*), WeBS trends may not be representative of overall changes in the population as WeBS coverage of the principal habitats used is poor, and trends are biased towards populations on estuaries. Trends for a number of geese (e.g. Pink-footed Goose *Anser brachyrhynchus*) are based on data from the WWT/JNCC/SNH Goose and Swan Monitoring Programme, which co-ordinates annual counts at key sites – see <http://monitoring.wwt.org.uk/our-work/goose-swan-monitoring-programme>.

Seabird monitoring

Trends in breeding seabird numbers come from two main sources. Three UK censuses have produced complete estimates of most species at 15-year intervals: Operation Seafarer (1969–70; Cramp *et al.* 1974), Seabird Colony Register (1985–88; Lloyd *et al.* 1991) and Seabird 2000 (1998–2001; Mitchell *et al.* 2004). However, not all seabirds were covered in the earlier censuses (e.g. European Storm-petrel *Hydrobates pelagicus* and Leach's Storm-petrel *Oceanodroma leucorhoa*), or were surveyed using methods incomparable between surveys (e.g. Black Guillemot *Cephus grylle*), so we are lacking trends for a number of species.

In addition, the Seabird Monitoring Programme (SMP), initiated in 1986 to survey a UK-wide sample of colonies annually, provides annual indices for the more widespread seabird species. For some species it was possible to combine census estimates from 1969–70 onwards with SMP results to

report on changes in seabird population sizes over the longer-term trend period. Recent examination of the SMP trends for representativeness of the sampling framework and thus potential bias in the trends produced has suggested that for some species the SMP trend may not be representative of true change in the population: as a consequence, the trend for Lesser Black-backed Gull *Larus fuscus* was excluded from consideration. See www.jncc.defra.gov.uk/page-1550 for further details on the SMP.

Rare, scarce and localised breeding birds

Rare Breeding Birds Panel (RBBP) data provided trends since 1973 for rare breeders (defined, loosely, as species with UK populations of less than 2,000 pairs, although data collation for less rare species began more recently than 1973). We used data up to 2012 (Holling *et al.* 2014) to create long-term and 25-year trends, sometimes in combination with estimates from single-species surveys. In order to smooth the between-year variation in numbers of breeding birds reported by the RBBP, the mean number of pairs (using the maximum total number of pairs) was calculated over five-year periods at the beginning and end of trend periods: 1973–77 for the longer period, and 1983–87 for the 25-year period, to 2008–12. Population trends were calculated as the percentage change between these means. See www.rbbp.org.uk for further details on RBBP data.

Periodic and other surveys

Many of the species trends (and population estimates) used in this status assessment were generated from surveys conducted under the Statutory Conservation Agency and RSPB Annual Breeding Bird Scheme (SCARABBS), which entails periodic (nowadays at intervals of six or 12 years) surveys of rare and localised breeding species such as Dotterel (Hayhow *et al.* 2015). Other sources of trends and population estimates include BTO-led surveys, for example of Common Nightingale *Luscinia megarhynchos* and Peregrine *Falco peregrinus*, the 2003/04–2005/06 Winter Gull Roost Survey (WinGS) and the GWCT/BTO Woodcock surveys of 2003 and 2013. Trends for Red Grouse *Lagopus lagopus* up to the start of the BBS in 1994 were derived from the Game & Wildlife Conservation Trust's National Gamebag Census (Aebischer & Baines 2008). We list the use of species survey data in table SMI.

Range change data

For measuring trends in range we relied on the three breeding bird atlases (Sharrock 1976, Gibbons *et al.* 1993 and Balmer *et al.* 2013) and two wintering bird atlases (Lack 1986 and Balmer *et al.* 2013). Given the 20-year gaps between breeding atlases, some BoCC assessments (e.g. BoCC3) have been forced to rely on rather out-of-date measures of change in range. The recent Bird Atlas 2007–11 allowed us to generate up-to-date measures of change in breeding range over both the long-term (between the first and third atlases, a period of 40 years) and a 20-year period (between the second and third atlases, approximating to the 25-year trend period). In addition, we were able for the first time to calculate (near) 25-year trends in non-breeding range, based on the two winter atlases with fieldwork periods covering 1981/82 to 1984/85 and 2007/08 to 2010/11.

Note that in a few instances, such as for Common Goldeneye *Bucephala clangula* and Green Sandpiper *Tringa ochropus*, it was felt that true patterns of range change were obscured by variation in

the reporting of non-breeding birds (e.g. late migrants reported during the breeding season) and thus the atlas range change trends were not used.

Population estimates and estimates of localisation

Population estimates were derived from a range of sources and almost all are as reported by APEP (Musgrove *et al.* 2013). To maintain consistency with the data used for UK reporting under the Wild Birds Directive, we did not update these estimates to account for any additional data available since their publication, except for species for which the results from new national surveys, such as those under the SCARABBS programme, were available (e.g. Dotterel *Charadrius morinellus*; Hayhow *et al.* 2015) (see table SMI).

For a number of scarce non-breeding species population estimates were not available from Musgrove *et al.* (2013) as they felt the available data was insufficient. However, as we did in *BoCC3*, we felt able to use expert opinion to judge whether these species were rare non-breeding visitors (i.e. had populations of less than 900 individuals): we believe that Great Shearwater *Puffinus gravis*, Sooty Shearwater *Puffinus griseus*, Balearic Shearwaters *Puffinus mauretanicus*, Curlew Sandpiper *Calidris ferruginea*, Little Stint *Calidris minuta*, are not rare non-breeders, but Spotted Redshank *Tringa erythropus* and Wood Sandpiper *Tringa glareola* are considered to be rare non-breeders.

Localisation estimates were derived using these UK estimates and data collated in the third review of the UK's network of SPAs (Stroud *et al.* in prep.). There has been no update of the population estimates within IBAs since the *BoCC3* review; since these form an important complementary approach to assessing localisation within SPAs, we simply reused the existing *BoCC3* assessments for IBAs. In the case of SPAs, data were available only for those species listed on Annex I of the EU Birds Directive and other migratory species, and then only for SPAs that have been designated for each species. For non-breeding populations, site estimates are maxima and may not reflect regular patterns of site usage; moreover, for species with a comprehensive network of designated sites, the sum of site totals may comfortably exceed the total population estimate owing to the same individual birds using multiple sites. The use of IBAs and SPAs as 'sites' for the purpose of this assessment is thus not perfect, owing to issues with data availability and the varying nature of the sites themselves (they vary enormously in size, for example). However, we believe that this is a more standardised approach than using any other definition of sites (reserves or WeBS count sites, for example) and maintains consistency with previous *BoCC* assessments. Rare breeders or non-breeders (species qualifying under criteria BR or VR) were not assessed against this criterion since, by virtue of their small numbers (and hence often small range), such species are likely to be restricted to a small number of sites. Amber-listing under the localised criterion is intended to signal a species' vulnerability, as relatively small-scale pressures (e.g. development) could affect a large proportion of the population adversely.

Table SMI. Details on species trends and population estimates not derived using standard data sources or trend periods as described above.

Species	Notes on data – sources, treatment, time periods
Bean Goose <i>Anser fabalis</i>	Long-term non-breeding trend from 1981/82 onwards.
Eurasian Teal <i>Anas crecca</i>	Breeding trend from WBS/WBBS data from 1995 onwards.

Common Scoter <i>Melanitta nigra</i>	RBBP data used in preference to SCARABBS survey data for breeding trends, due to longer data sequence.
Goosander <i>Mergus merganser</i>	Breeding trends from WBS/WBBS data from 1980 onwards.
Red Grouse <i>Lagopus lagopus</i>	Breeding trends from combined modelling of National Gamebag Census and BBS data.
Black Grouse <i>Tetrao tetrix</i>	Trend between surveys in 1991-92 and 2004.
Capercaillie <i>Tetrao urogallus</i>	25-year trend between SCARABBS surveys in 1992/93 and 2009/10.
Red-throated Diver <i>Gavia stellata</i>	Breeding trend between SCARABBS surveys in 1994 and 2006.
Black-throated Diver <i>Gavia arctica</i>	Breeding trend between SCARABBS surveys in 1985 and 2006.
Grey Heron <i>Ardea cinerea</i>	Breeding trend from BTO Heronries Census.
Red-necked Grebe <i>Podiceps grisegena</i>	Wintering trend from WeBS 1992/93 to 2011/12 (no longer-term trend).
Slavonian Grebe <i>Podiceps auritus</i>	Wintering trend from WeBS 1992/93 to 2011/12 (no longer-term trend).
Black-necked Grebe <i>Podiceps nigricollis</i>	Wintering trend from WeBS 1992/93 to 2011/12 (no longer-term trend).
Hen Harrier <i>Circus cyaneus</i>	Breeding trend between SCARABBS surveys in 1988/89-2010.
Golden Eagle <i>Aquila chrysaetos</i>	Breeding trend between SCARABBS surveys in 1982 and 2003.
Spotted Crake <i>Porzana porzana</i>	RBBP data used in preference to SCARABBS survey data for breeding trends, due to longer data sequence. 2012 survey estimate used for breeding population size in preference to APEP estimate.
Corn Crake <i>Crex crex</i>	25-year trend between SCARABBS surveys in 1993 and annual monitoring in 2014, longer-term trend used population estimate from 1968-1972 breeding bird atlas.
Ringed Plover <i>Charadrius hiaticula</i>	Breeding trend between BTO surveys in 1984 and 2007.
Dotterel <i>Charadrius morinellus</i>	Breeding trend between SCARABBS surveys in 1987-88 and 2011; 2011 survey used for population estimate.
Whimbrel <i>Numenius phaeopus</i>	New analysis to correct for differences in effort between surveys in 1989-94 and 2009 used (D. Jackson pers comm.).
Woodcock <i>Scolopax rusticola</i>	Trend from GWCT/BTO Woodcock surveys in 2003 and 2013.
European Nightjar <i>Caprimulgus europaeus</i>	Breeding trend between SCARABBS surveys in 1982 and 2003.
Merlin <i>Falco columbarius</i>	Breeding trend between SCARABBS surveys in 1983-84 and 2008.
Peregrine Falcon <i>Falco peregrinus</i>	Breeding trend between BTO surveys in 1982 and 2014 (preliminary results).
Woodlark <i>Lullula arborea</i>	Breeding trend from RBBP data from 1973 onwards and SCARABBS surveys in 1986 and 2006.
Dartford Warbler <i>Sylvia undata</i>	Breeding trends between SCARABBS surveys in 1974, 1984 and 2006.
Ring Ouzel <i>Turdus torquatus</i>	Breeding trend between estimate from 1988-91 breeding atlas and 2012 SCARABBS survey; 2012 survey used for population estimate.
Hawfinch <i>Coccothraustes coccothraustes</i>	Breeding trend between RSPB woodland resurveys in 1984-85 and 2003-04.
Twite <i>Carduelis flavirostris</i>	Unpublished small sample BBS trend (1995-2011) used in preference to SCARABBS survey data for breeding trends, due to longer data sequence; 2013 SCARABBS survey used for population estimate.

Snow Bunting <i>Plectrophenax nivalis</i>	Population estimate from SCARABBS survey in 2011.
Cirl Bunting <i>Emberiza cirlus</i>	Breeding trends between population estimate from 1968-71 breeding atlas and SCARABBS surveys in 1989 and 2009.

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