Biodiversity Informatics, 20, 2026, pp. 59-73

THE RECOVERY OF STRAY BIODIVERSITY DATA IN ENVIRONMENTAL ASSESSMENT REPORTS

Maite Telletxea[1, 2], Arturo H. Ariño[*, 1, 2], Rafael Miranda[1,2], and David Galicia[1,2]

[1]*Universidad de Navarra, Instituto de Biodiversidad y Medioambiente BIOMA, Irunlarrea 1, 31008, Pamplona, Spain*

[2]*Universidad de Navarra, Facultad de Ciencias, Departamento de Biología Ambiental, Biodiversity Data Analytics and Environmental Quality Group (BEQ), Irunlarrea 1, 31008, Pamplona, Spain*

Abstract. The global biodiversity crisis, driven by habitat loss, climate change, and overexploitation, demands efficient data management and accessibility to inform conservation decisions. While open-access biodiversity data have increased, a substantial portion, termed "dark data," remains unpublished and inaccessible. We explored the mobilization of dark data existing in Environmental Assessment (EA) reports in Spain to improve the Digital Accessible Knowledge for 43 field-recorded threatened species. Based on the IUCN Red List criteria, we evaluated the impact of EA-related dark data on two required metrics: the extent of occurrence (EOO) and area of occupancy (AOO). Our results show that integrating dark data increased EOO and AOO for 23% and 93% of the field-recorded threatened species, respectively, including endangered species like *Aquila adalberti*. We highlight the importance of mobilizing data collected during the EA processes and ensuring that data are made findable, accessible, interoperable, and reusable (FAIR) to inform conservation decisions. Mobilizing EA-related dark data offers a cost-effective approach by which to strengthen biodiversity management, facilitate decision-making, and justify biodiversity conservation.

Key words: dark data, environmental assessment, Digital Accessible Knowledge, threatened species, data mobilization, Spain

Introduction

Threats to biodiversity are escalating globally and at unprecedented rates (Barnosky et al., 2011; Pimm et al., 2014; Baldauf & de Oliveira Lunardi, 2020), leading to precipitous declines in global biodiversity (WWF, 2022). Habitat loss, climate change, pollution, and overexploitation are among the main drivers of this biodiversity decline (IPBES, 2019; WWF, 2022), which science has increasingly been able to document and measure via global indicators such as the Living Planet Index (Loh et al., 2005). These indicators reveal that the biodiversity crisis affects different species differently (Hochkirch et al., 2023), thus requiring the assessment of species' extinction risk to prioritize conservation actions effectively.

To address this variation, species are commonly classified based on their conservation status in different international, national, and regional catalogues, which often leads to specific protection measures and conservation funding (Butchart et al., 2006; Hoffmann et al., 2015). The IUCN Red List of Threatened Species (IUCN Red List) is widely acknowledged as the most comprehensive, objective global approach for assessing the extinction risk of biodiversity according to five quantitative criteria, evaluating indicators such as population trends or geographic ranges (Butchart et al., 2007; Mace et al., 2008). Although the IUCN Red List is based on robust and standardized guidelines (IUCN Standards and Petitions Committee, 2022), the precision and consistency of the assessments depend primarily on the amount, quality, as well as accessibility of primary biodiversity data or records (PBR) that support the estimation of species distribution and trends (Ribeiro et al., 2022).

[*] Corresponding author: artarip@unav.es

PBR are "data that place a taxon in time and space" (Sousa-Baena et al., 2014; Barve, 2014), and are essential to estimating species richness and distribution patterns, understanding species' environmental requirements, compiling checklists, and describing new species (Cadman et al., 2011; Sousa-Baena et al., 2014; Ball-Damerow et al., 2019; Escribano et al., 2019). When PBR are digital, accessible in standard formats, published openly, and enable integration with other data, they are called "Digital Accessible Knowledge" or DAK (Sousa-Baena et al., 2014), and therefore, they can be openly used to support decision-making, monitor, and identify gaps in knowledge (Tenopir et al., 2011; Costello & Wieczorek, 2014; Escribano et al., 2019; González-Alonso & Ariño, 2022). Over the past few decades, international approaches such as the Global Biodiversity Information Facility (GBIF), a global research infrastructure established in 2001, have substantially improved management and accessibility to these data by providing free, open, and standardized digital access to biodiversity data worldwide (Edwards, 2001; Curry & Humphries, 2007; Muñoz et al., 2019). As a result, over 3.5×10^9 occurrence records are currently publicly available in the portal and rising.

Despite successful approaches, as with an iceberg, only a small portion is visible, while most biodiversity records remain hidden below the surface (Ariño, 2010; Ball-Damerow et al., 2019). The remaining biodiversity data, in the submerged section of the biodiversity "*databerg*," remain inadequately managed, locked, unpublished, and largely unused. These "*DarK Data*" (hereinafter DKD) are existing data that are nearly invisible to potential users, potentially valuable but likely to remain underused and eventually lost (Heidorn, 2008; Lewis et al., 2018; Peterson et al., 2018). DKD represent lost opportunities to strengthen baseline knowledge and, ultimately, to support evidence-based conservation decisions and integrated biodiversity management, one of the goals established on the Kunming–Montreal Global Biodiversity Framework, adopted during the 15th Conference of Parties to the United Nations Convention on Biological Diversity (Convention on Biological Diversity, 2022).

The existence of DKD reflects infrastructural-technical (e.g., lack of data management and accessibility infrastructure), socio-cultural (e.g., limited incentives and lack of recognition for data sharing), policy-political and legal (e.g., legal indeterminacy), and economic (e.g., insufficient funding) limitations impacting data management and accessibility practices (Chavan & Ingwersen, 2009; Escribano et al., 2018; Muñoz et al., 2019). Over time, the biodiversity informatics community has been refining standards and principles, such as the Darwin Core (DwC) standard—developed in 1999 and formally ratified by Biodiversity Information Standards (TDWG) in 2009 (Wieczorek et al., 2012)—and the FAIR principles (Wilkinson et al., 2016)—to make scientific data easy to find through standard search engines (findability), easy to access (accessibility), standardized to facilitate their use (interoperability), and well-documented to allow their reuse for different purposes (reusability). Although organizations such as GBIF have encouraged data publication and have invested heavily in tools like the Integrated Publishing Toolkit to simplify the process in line with these frameworks (Robertson et al., 2014; Figueira et al., 2023), their implementation remains delayed in some sectors, limiting mobilization of large volumes of biodiversity data into global knowledge.

One significant source of DKD is Environmental Assessments (EA), the leading technical and administrative procedure for controlling human development impacts on biodiversity, applied across many countries worldwide, including Spain (Dias et al., 2022; Ley 21/2013, 9 de diciembre). EA was introduced into Spanish regulations in 1986 for the Environmental Impact Assessment (EIA) of proposed projects and, later, in 2006 for the Strategic Environmental Assessment (SEA) for plans and programs (Ley 21/2013, 9 de diciembre). EA procedures routinely involve field surveys that generate PBR, but the absence of efficient data management (e.g., standardization, quality control, documentation, and long-term storage) and accessibility practices leads to EA-related PBR typically being stuck in technical or administrative EA reports and rarely published in standardized, reusable formats (Cadman et al., 2011; King et al, 2012). In Spain, the central government is responsible for EA activities whose authorization corresponds to the state, while, in the remaining cases, regional governments are in charge (Enríquez-de-Salamanca et al., 2016). Therefore, these administrations not only regulate development activities but also store large volumes of EA-related biodiversity data, including PBR for priority species. These data remain inaccessible for reuse to inform future studies, scientific research, environmental planning, and decision-making (Cadman et al., 2011; Calas et al., 2020).

In this context, EA-related DKD are not being used widely enough to realize their potential because they are unavailable (Stall et al., 2019). This problem becomes even more significant when we refer to threatened or listed species. At the national level, the Spanish National Catalogue of Endangered Species (CEEA, acronym in Spanish) is a public administrative register that identifies and categorizes threatened species populations as endangered (EN) or vulnerable (VU); the same occurs at the regional level. For such listed species, public administrations are required to inform about their conservation status and implement specific conservation measures to manage their populations actively (Real Decreto 139/2011, de 4 de febrero; Comisión Estatal del Patrimonio Natural y la Biodiversidad, 2012). While considerable amounts of EA-related data could serve these ends, they go largely wasted. If we could make these EA-related DKD findable, accessible, interoperable, and reusable (FAIR), they could become a complementary but powerful tool for better decision-making and conservation planning. Mobilizing such DKD is a very cost-effective strategy to strengthen the backbone of biodiversity DAK with relatively low investment and would increase the efficiency of biodiversity data management.

In this study, we explore the contribution of the EA-related DKD once mobilized and integrated into the existing GBIF-published DAK for threatened species in Spain. Specifically, we evaluate whether incorporating EA-related DKD introduces changes in DAK temporal coverage and in the estimation of extent of occurrence (EOO) and area of occupancy (AOO), two spatial metrics widely used for evaluating the conservation status of species according to the IUCN Red List Criteria. The outcome is a view of the degree to which DKD can be mobilized to enrich current data that are in currency for science and policy.

Materials and Methods

Species occurrence data

We targeted the 119 species present in Spain cataloged as EN (50 species) or VU (69 species) in the CEEA from the taxonomic groups of interest: amphibians, birds, fishes, mammals, and reptiles (Appendix S1). We restricted the analysis to peninsular Spain (i.e., not including the Balearic or Canary islands).

We selected threatened species occurrence data from a dataset gathering all EA-related stray records of species included in CEEA between 1994 and February 2023, found in the Records of Decision (RODs) published in the Official State Gazette (Telletxea et al., 2025). This dataset was generated through automated text-mining techniques and manual curation to identify, validate, and categorize EA-related species records. By mobilizing non-actionable stray data from EA reports into a structured and interoperable format, this resource constitutes an important contribution to both biodiversity knowledge in Spain and data mobilization practices. Telletxea et al. (2025) provided a dataset including species records categorized into literature-based records, absences, and PBR, the latter available in GBIF. We quantified the total number of published RODs citing threatened species and calculated the proportion that reported new PBR for the last four years. Temporal trends in EA-related PBR reporting were assessed by comparing annual counts and percentages across years. The PBR of field-recorded threatened species included in the dataset, minus discarded records, such as detection errors and duplicates, constituted a sample of the Spanish threatened species' DKD.

Presence-only occurrence data for the threatened species in Spain were obtained from GBIF (GBIF.org, accessed on 9 and 27 October 2023). The search was limited to the 43 species for which DKD were found in the RODs. Given the documented biases and gaps in GBIF-published data (Gaiji et al., 2013), also for the Iberian Peninsula (Ronquillo et al., 2020), we applied a conservative data filtering to minimize their potential effects. Species searches were performed using the accepted scientific names according to the GBIF taxonomic backbone to avoid record omission owing to extensive taxonomic synonymy; subspecies-level records were excluded. Records listed as material sample or fossil specimen from the 'basisOfRecord' field were discarded, retaining primarily observation-based records. Occurrence data were constrained to include only those with consistent coordinates (i.e., falling in the specified country), no geospatial issues, and coordinate uncertainty not exceeding the maximum DKD uncertainty. Records that did not meet these characteristics were considered poor-quality, and were excluded from further analyses. This filtering was intended to guarantee that the resulting dataset provided a broad temporal and geographic baseline for threatened species in peninsular Spain, representing a sample of these species' DAK prior to the mobilization of EA-related data.

Data processing

The DKD and DAK for the threatened species were mapped using a geographic information system (GIS), QGIS v. 3.24.3 (QGIS.org, 2022). Occurrences outside a 0.45° (approximately 55 km) buffer around peninsular Spain were excluded, including coastal records of threatened species but avoiding Spanish island territories that administratively belong to peninsular provinces, such as Alborán Island or the Columbretes Islands.

The potential impact of the EA-related DKD incorporation into DAK was assessed from the number of records, the temporal coverage of DKD and DAK, and the two spatial metrics used in the IUCN Red List Criteria: EOO and AOO. These metrics were applied as a methodological approach to quantify changes in threatened species' geographic range resulting from the incorporation of EA-re-

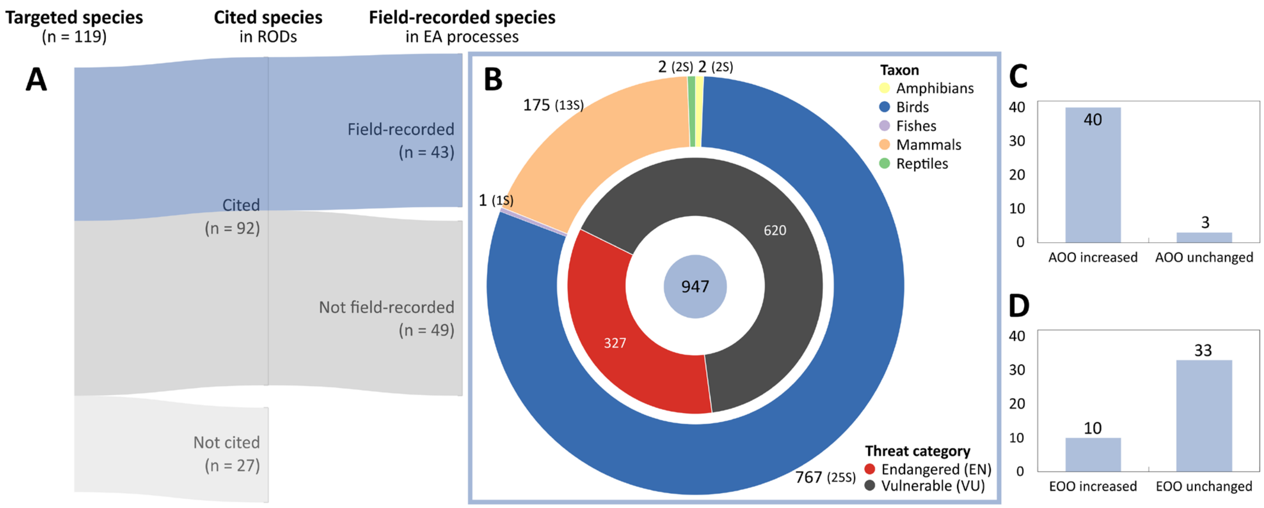

Figure 1. Impact of Environmental Assessment (EA)-related records on threatened species. A) Alluvial diagram summarizing the transition of targeted threatened species (n = 119) to not cited in Records of Decision (RODs, n = 27), cited but not field-recorded (n = 49), and cited and field-recorded (n = 43). B) Taxonomic composition (outer ring) and national threat category (inner ring) of the 947 EA-related primary biodiversity records (PBR) associated with the 43 field-recorded species. C) Number of field-recorded species showing increased or unchanged area of occupancy (AOO) after the inclusion of EA-related PBR. D) Number of field-recorded species showing increased or unchanged extent of occurrence (EOO) after the inclusion of EA-related PBR.

lated DKD into GBIF-published DAK. QGIS v. 3.24.3 was used to measure these Red List parameters, providing an objective and repeatable methodology.

EOO is defined as "the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a species, excluding cases of vagrancy" (IUCN Standards and Petitions Committee, 2022). The recommended method for estimating EOO is the minimum complex polygon, also called the convex hull (Joppa, 2016; IUCN Standards and Petitions Committee, 2022), defined as "the smallest polygon in which no internal angle exceeds 180 degrees, and which contains all the sites of occurrence" (IUCN, 2012). EOO was estimated by measuring the area of the minimum complex polygon using two sets of data for each threatened species: DAK and combined DAK-DKD. The DKD contribution was estimated as the percentage of the increase in EOO.

AOO is defined as "the area within its EOO which is occupied by a taxon" (IUCN Standards and Petitions Committee, 2022). Although the IUCN Red List guidelines recommend 2x2-km cells as the reference for estimating AOO (IUCN Standards and Petitions Committee, 2022), we used 10x10-km grid as the scale used in national biodiversity reporting[1] by the Spanish Ministry for the Ecological Transition and the Demographic Challenge (Comisión Estatal del Patrimonio Natural y la Biodiversidad, 2012) and to match the spatial resolution of the available occurrence data. Since this analysis targets relative changes in spatial metrics, rather than absolute values or species recategorization, the choice of grid size does not invalidate the results. AOO was estimated by adding the area of the cells occupied by each threatened species using two sets of data: DAK and combined DAK-DKD. The DKD contribution was estimated as the percentage of the increase in AOO.

Results

After removing discarded and poor-quality occurrences, the initial dataset of 43 threatened species GBIF-published records was reduced to 126,749 occurrences in peninsular Spain. The majority of excluded records were associated primarily with high coordinate uncertainty, followed by geospatial issues and missing coordinates. Similarly, a dataset of 4630 threatened species records was obtained from Telletxea et al. (2025). After removing 271 automatic detection errors and 29 duplicate records, the final dataset of EA-related records comprised 4330 records, including 947 field-recorded EA-related records in peninsular Spain.

Seventy-seven percent (92 out of 119) of targeted threatened species were cited in RODs, but PBR existed only for 47% (43 out of 92) of cited species (Figure 1A). Specifically, in RODs for peninsular Spain, there were 767 occurrences for 25 bird species, 175 occurrences for

[1] Available in https://www.miteco.gob.es/es/biodiversidad/temas/inventarios-nacionales/inventario-especies-terrestres/inventario-nacional-de-biodiversidad/bdn-ieet-default.html.

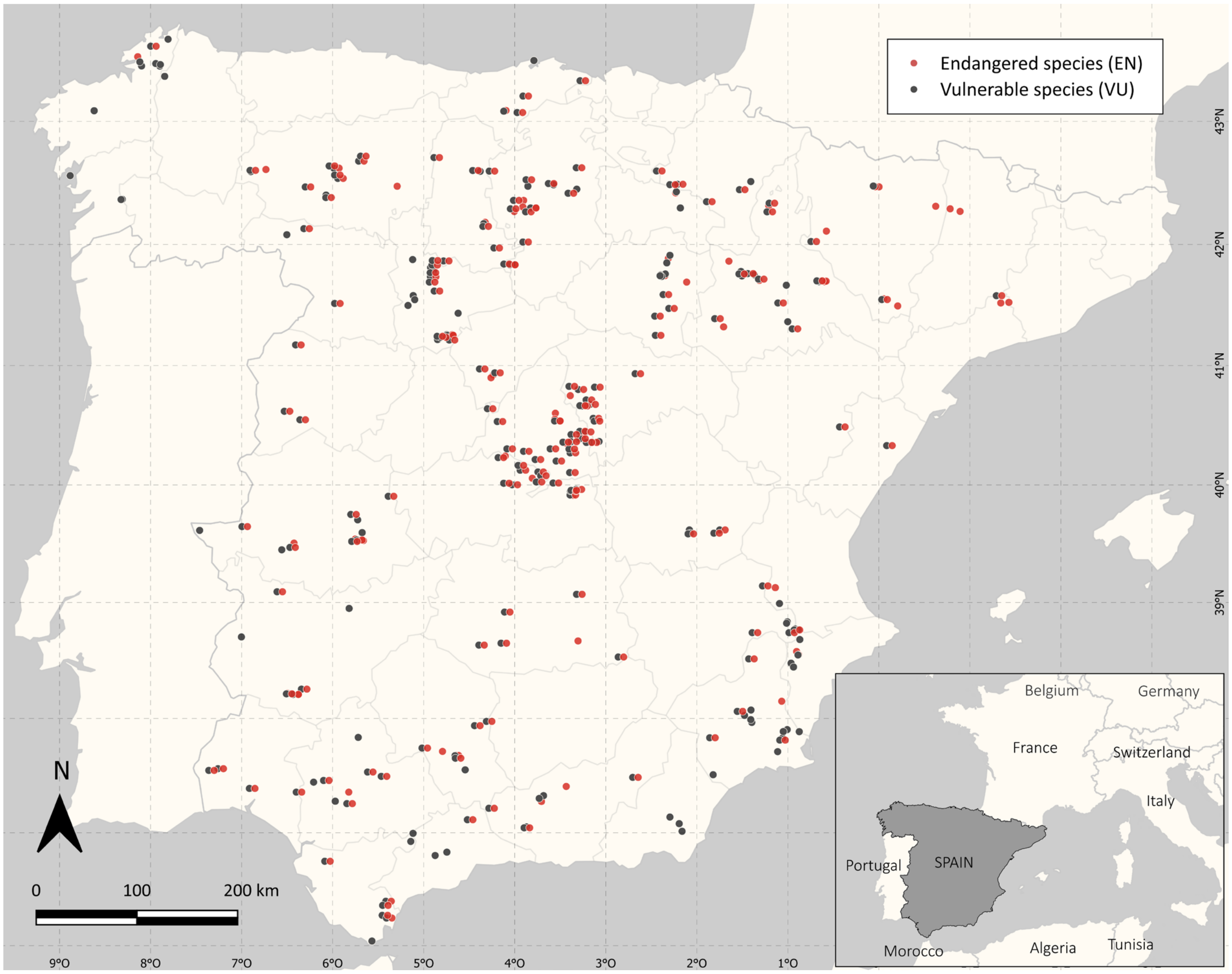

Figure 2. Dark data (DKD) records from endangered species (red points) and vulnerable species (grey points) in Records of Decision (RODs) published in the Official State Gazette.

13 mammal species, two occurrences for two amphibian and two reptile species, and one occurrence for one fish species, comprising 947 DKD records of field-recorded threatened species: 327 records for EN species, and 620 records for VU species (Figure 1B).

EA-related PBR have been reported irregularly in RODs since 2013. However, the number of EA reports documenting field-recorded data has increased in recent years. Up to 2019, the number of published RODs reporting PBR was seven. In 2020 and 2021, only 10.2% (6 out of 59) and 21.4% (15 out of 70) of the published RODs, respectively, provided PBR. In 2022, the percentage rose to 53.8% (77 out of 143), and in 2023, it was 87.2% (123 out of 141 provided new PBR). This implies that the EA-related PBR are temporarily concentrated between 2020 and 2023. EA-related PBR were also irregularly distributed across peninsular Spain, with a higher concentration of records in specific sites, whereas large areas remained poorly represented (Figure 2).

Mobilizing EA-related DKD extended the DAK temporal coverage for 19% (8 out of 43) of field-recorded threatened species by incorporating more recent records, adding on average 1.9 years of occurrence information for these eight species. Mobilizing EA-related DKD increased spatial knowledge derived from DAK, increasing both AOO and EOO, for 23% (10 out of 43) of field-recorded threatened species (Figure 1C-D). For 70% (30 out of 43) of field-recorded threatened species, mobilizing DKD slightly increased their AOO but not EOO. The remaining 7% (3 out of 43) corresponded to field-recorded threatened species whose spatial knowledge (AOO and EOO) did not increase after DKD mobilization (Figure 1C-D). The estimated AOO of the 43 species are presented in Appendix S2.

Changes in spatial knowledge of field-recorded threatened species resulting from mobilizing EA-related DKD varied by taxonomic groups and national threat category. All mammal species, the only fish species, and all but one

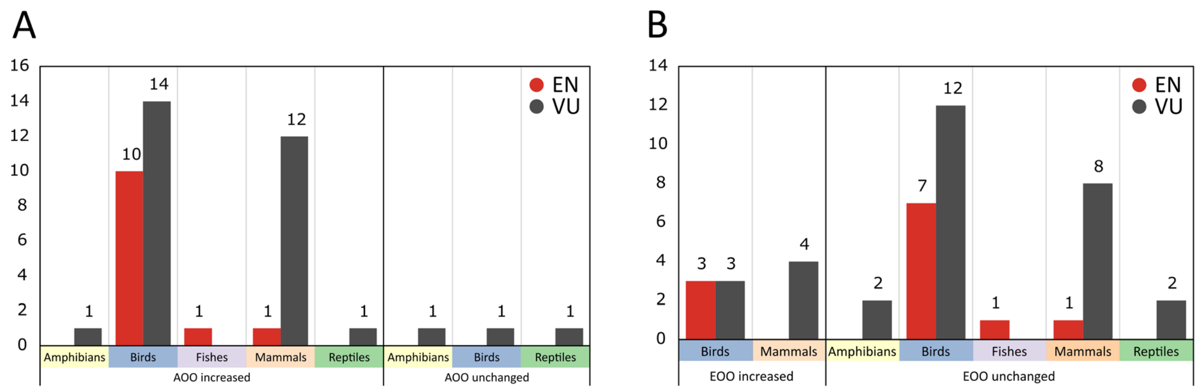

Figure 3. Number of field-recorded species showing an increase or no change in A) area of occupancy (AOO) and B) extent of occurrence (EOO) after the mobilization of Environmental Assessment (EA)-related primary biodiversity records (PBR), categorized by taxonomic group and national threat category. Red bars represent endangered (EN) species and grey bars represent vulnerable (VU) species. Taxon colors correspond to those used in Figure 1.

bird species showed increases in AOO (Figure 3A). However, only six birds and four mammals showed increases in EOO (Figure 3B); data by species are in Appendix S3. All EN field-recorded species showed increases in AOO, as did 90% of VU field-recorded species (Figure 3A).

Table 1 highlights the contributions to the number of records, AOO, and EOO for the 10 threatened species whose AOO and EOO increased. The Common Noctule (*Nyctalus noctula*), a vulnerable bat species, showed the highest increase in the number of records with EA-related DKD contributing 10.1% to the DAK. These records made important contributions to the AOO of all species (Figure 4A), with an increase of 14.2%, and a slight 4.6% increase in EOO (Table 1). The Spanish Imperial Eagle (*Aquila adalberti*), an endangered bird species, showed the highest increase in EOO with EA-related DKD contributing 9.1% to the EOO based on DAK. These records also contributed to the AOO estimated based on DAK (Figure 4B), with an 11.9% increase (Table 1). The Giant Noctule (*Nyctalus lasiopterus*) and Cinereous Vulture (*Aegypius monachus*) also showed considerable increases in their AOO: 8.6% and 7.2%, respectively. On the other hand, species such as Montagu's Harrier (*Circus pygargus*) and Little Bustard (*Tetrax tetrax*) showed only minor increases in AOO without EOO expansion (Figure 4C-D), and species such the Spur-thighed Tortoise (*Testudo graeca*) and the Long-tailed Salamander (*Chioglossa lusitanica*) did not show detectable changes (Figure 4E-F).

Discussion

The mobilization of EA-related DKD measurably increased the estimated AOO based on DAK for 40 threatened species. This represents one-third of the total threatened species, but 93% of field-recorded species. Species showing increases in EOO fell to 23% of the field-recorded species, meaning that increases in AOO were noticeably more frequent than increases in EOO. This difference suggests that EA-related PBR predominantly completed AOO estimates rather than redefining species distribution limits. The fact that all EN field-recorded species showed an increase in AOO suggests that spatial gaps in DAK and lack of monitoring may still exist even for the most threatened species at the national level (Lomolino, 2004; Kaplan et al., 2023), which may be present in more areas than initially known.

The mobilization of EA-related DKD also extended the temporal range of eight threatened species by adding more recent records to the DAK, which is key to establishing sound time series, essential for detecting changes in species' geographic distributions and evaluating trends (Magurran et al., 2010; Figueira et al., 2023). The fact that EA-related PBR were concentrated in recent years reflects that, although EA procedures have traditionally included some—more or less appropriate—field surveys (Treweek, 1996), the data collected during this fieldwork have only recently begun to be reported systematically in RODs (e.g., Resolución de 14 de mayo de 2021; Resolución de 23 de septiembre de 2022; Resolución de 12 de enero de 2023). This increasing trend allowed the mobilization of more than 1200 PBR (Telletxea et al., 2025), and our results suggest that fieldwork in EA can provide valuable information to the DAK if the PBR are properly managed and subsequently made accessible.

Although DAK published via GBIF provided a broad temporal and spatial baseline for current knowledge of threatened species, a high proportion of records were discarded during filtering, mainly because of high coordinate uncertainty, followed by previously documented geospa-

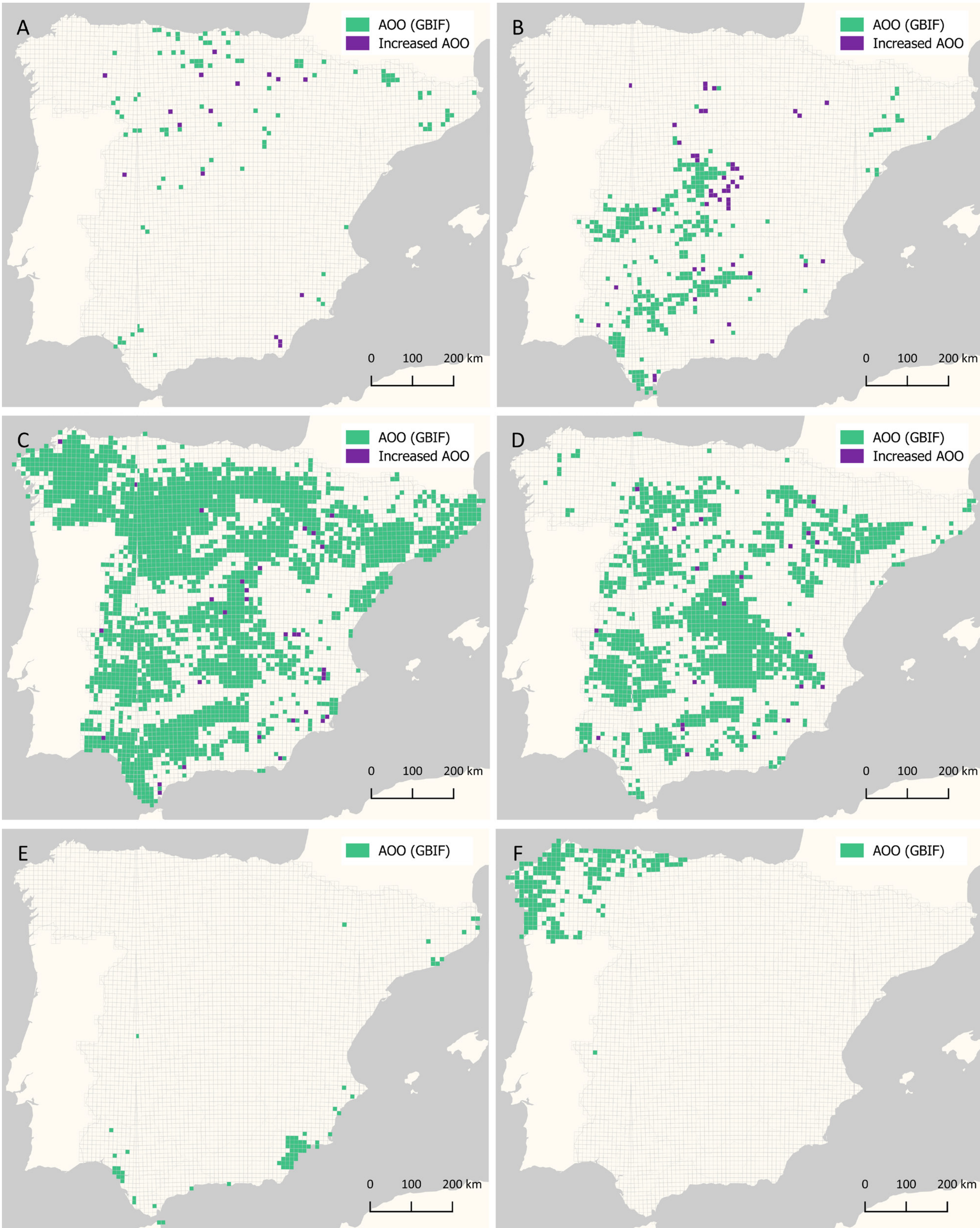

Figure 4. Area of occupancy (AOO) of A) *Nyctalus noctula*, B) *Aquila adalberti*, C) *Circus pygargus*, D) *Tetrax tetrax*, E) *Testudo graeca*, and F) *Chioglossa lusitanica*. Green: estimated from GBIF presence data. Purple: AOO added by the mobilized Environmental Assessment (EA)-related dark data (DKD).

Table 1. Summary of the contributions to the number of records, area of occupancy (AOO), and extent of occurrence (EOO) of the ten threatened species (red: endangered; black: vulnerable) that increased their EOO when incorporating dark data (DKD). The complete table of the field-recorded species is in Appendix S4.

Species	DKD records	GBIF records	Records contribution (%)	AOO contribution (%)	EOO contribution (%)
Aquila adalberti	69	3309	2.04	11.90	9.08
Nyctalus noctula	16	142	10.13	14.19	4.61
Milvus milvus	168	15849	1.05	3.35	2.43
Aegypius monachus	63	5207	1.20	7.17	2.33
Neophron percnopterus	45	7311	0.61	1.84	1.48
Microtus cabrerae	1	607	0.16	0.33	1.25
Aquila fasciata	51	7315	0.69	2.52	0.70
Nyctalus lasiopterus	12	202	5.61	8.55	0.61
Oxyura leucocephala	1	3643	0.03	0.87	0.39
Myotis myotis	27	1280	2.07	2.88	0.13

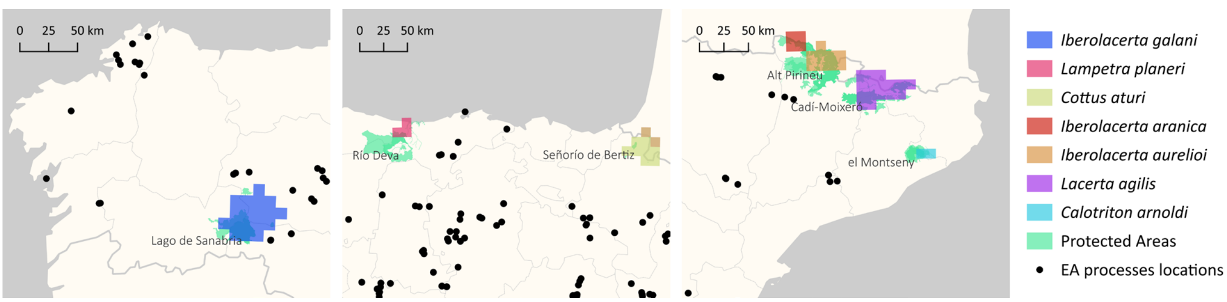

Figure 5. The distribution range of seven threatened species not reported in Environmental Assessment (EA) processes. Colored 10x10-km cells represent the officially reported species distribution area by the Spanish Ministry for the Ecological Transition and the Demographic Challenge under the Habitats Directive for the 2013–2018 period (Ministerio para la Transición Ecológica y el Reto Demográfico, 2020). Green polygons represent the protected areas designated in Spain near the distribution of the seven species. Black dots indicate locations where EA processes were conducted.

tial issues and missing coordinates (Otegui et al., 2013; Ronquillo et al., 2020). This reduction in DAK records points to a fundamental idea about evidence-based conservation: conservation decisions must be based on sufficient, robust, high-quality data (Pullin & Knight, 2001). Much of traditional conservation practice has been based on anecdotal information instead of evidence, which has limited ability to make decisions or assess the status of threatened species (Pullin & Knight, 2001; Sutherland et al., 2004). In a new scenario in which we increasingly rely on evidence, insufficient fit-for-use records (Hill et al., 2010) hinder assessment of species' conservation status. In this context, when many records are discarded due to uncertainty, with associated loss of spatial representation, our ability to detect trends or adequately assess the species extinction risk is compromised. These information gaps draw attention to the need to identify strategies to increase the available DAK, improve data quality, and maximize the amount of fit-for-use data to inform threatened species assessments or to guide decision-making, such as publishing existing underutilized EA-related data.

Scientific studies and publications (King et al., 2012), initiatives such as Data4Nature (Agence Française de Développement, 2020), and best-practice guides (Agence Française de Développement, 2021; Cadman et al., 2011; Rodrigues et al., 2022) discuss the importance of publishing already existing EA-related data. However, these papers do not characterize and quantify the impact of existing EA-related DKD on current biodiversity DAK. In this context, our results present empirical evidence of the contribution of EA-related records, showing that, in some cases, EA studies may constitute the only inventory conducted in an area for years (Figueira et al., 2023). As such, when mobilized and standardized, EA-related data can contribute to building a solid base of scientific knowledge (Weaver et al., 2008; King et al., 2012; Figueira et al., 2023), particularly for threatened species.

However, our results show that about two-thirds of threatened species included in the CEEA were cited in RODs, but only about one-third of targeted threatened species is reported in RODs as field-recorded. The fact that a high proportion of threatened species were not field-documented does not necessarily indicate deficiencies in fieldwork or EA methods. EA are not designed to systematically sample national biodiversity and environment, as other inventories, monitoring networks, or projects do (Aguilar et al., 1994; Área de Inventario y Estadísticas Forestales, 2021; Valdés, 2021), but to assess potential impacts in specific areas that may be affected significantly by projects, plans, or programs (Ley 21/2013, de 9 de diciembre).

Besides, many threatened species have a considerable portion of their geographic ranges covered by protected areas, such as natural parks, nature reserves, or Natura 2000 sites (Spiliopoulou et al., 2023), some of which, like the latter, are specifically established to preserve targeted species and habitats (Council Directive 92/43/EEC of 21 May). In these protected areas, resource exploitation is often limited or incompatible with the purposes that justified their creation (Ley 42/2007, de 13 de diciembre). Consequently, EA procedures are less likely to be conducted in these areas, reducing the likelihood that EA-related fieldwork will generate new records of species whose presence is restricted to these areas. In fact, among the 29 uncited species were endemic species or species with restricted distributional areas (Figure 5), such as the Galán's Rock Lizard (*Iberolacerta galani*), occurring in the Lake of Sanabria Natural Park (Arribas, 2009), the European Brook Lamprey (*Lampetra planeri*), present in the ZEC Rio Cares-Deva (Decreto 156/2014, de 29 de diciembre), and the Montseny Book Newt (*Calotriton arnoldi*), endemic to the Montseny Natural Park and Biosphere Reserve (Guinart et al., 2022).

Therefore, whether owing to the conditions requiring specific projects, plans, or programs, or the existence of protected areas restricting certain activities, the taxonomic composition and, especially, the spatial distribution of the EA-related PBR are strongly influenced by the location of the proposed activities, rather than by the actual distribution of the threatened species. The taxonomic composition of mobilized data across the different selected taxonomic groups is consistent with the distribution of their total data available through GBIF in Spain according to the last annual activity report (GBIF, 2024). Birds accounted for the majority of EA-related DKD, both in terms of species and number of records, followed by mammals; thus, they were the taxonomic groups that benefited most from DKD mobilization. This situation suggests a well-known taxonomic bias towards more easily observable groups of species that are the focus of conservationists' attention. However, as discussed in other cases, the overrepresentation of bird records is not problematic (Gaiji et al., 2013), as the critical issue is that each unused generated data had already been mobilized and could already be used to lay the foundation for knowledge of threatened species and conservation. The spatial distribution of mobilized DKD reflects dependence on EA activity, with records often concentrated in areas of predictably more intense EA activity. Therefore, the EA-related mobilized DKD should be interpreted as complementary to, not a substitute for, those systematic inventories and monitoring networks, since they provide specific information on priority species surveyed in the field and present in areas that may be—or already are—affected by human development activities, rather than offering a comprehensive representation of national biodiversity patterns.

Acknowledging their additional value, we must work on the management and accessibility of EA data. In Spain, ordinary EA procedures have an essential phase where the plans, programs, or projects are announced for public consultation (Ley 21/2013, de 9 de diciembre). Plans, programs, or project details, such as the environmental document and the environmental study, are published in this phase for consultation in the Official State Gazette. However, the information does not remain permanently published. The EA procedure's main documentary source, permanently published and available to the public in the Official State Gazette, are the RODs because their issuance is mandatory to continue the EA procedure (Ley 21/2013, de 9 de diciembre; Villarroya & Puig, 2013). These final RODs are synthesis documents from which Telletxea et al. (2025) were able to mobilize priority species records, and commonly do not include all the biodiversity data generated as part of EA. Furthermore, although publicly available, the data are neither actionable nor standardized to facilitate their future reuse for other purposes (King et al., 2012).

The management and publication of EA-related biodiversity data should be mandatory or at least have incentives. In the most stringent situation, the incorrect management of the new EA-related biodiversity data should be reason enough to void the procedure. There is no culture nor obligation of data management and publication in EA practice (King et al., 2012), so this suggestion may sound like a drastic solution; changes in established procedures take time and persistence, but the problem of data management inefficiency and data loss is urgent now that optimizing resources is so essential (Stall et al., 2019). A more conservative approach, that of offering incentives such as scholarly recognition of the data (e.g., citable data papers) may also provide a stopgap towards that goal (Chavan & Penev, 2011). Even so, we can find examples from the private sector that are increasingly making efforts to publish biodiversity data. Through GBIF, 131 companies currently contribute almost 14 x 10^6 records, including consulting or energy companies (GBIF, 2025).

Early data management and accessibility would involve a moderate additional cost of an EA (Agence Française de Développement, 2020) but would prevent the loss of valuable information and the later mobilization efforts. The average cost, mainly related to data formatting, is estimated at around 3300€ per EA, less than 0.7% of the total cost of an environmental procedure (Agence Française de Développement, 2020). However, following the protocols proposed by GBIF for the publication of data on its facility does not seem to entail such a budget; the additional cost would rather translate into the hours of data standardizing and publishing. Therefore, the cost of efficient data management and publishing could be much lower than the cost suggested by the Agence Française de Développement, although the option of publishing a data paper might in some cases incur into Article Processing Costs (APC).

Improving the management and accessibility of EA-related PBR should not be considered a purely technical matter, but rather a prerequisite for translating EA procedures into concrete results in conservation planning and decision-making. Without data management and accessibility, the EA-related PBR cannot be efficiently integrated into our baseline accessible knowledge on threatened species, limiting their use in conservation status metrics such as AOO or EOO, and, consequently, in extinction risk assessments. Indeed, the ultimate value of mobilizing EA-related PBR resides in their potential to be reused to inform future conservation decisions, as they can help better reflect the actual species' distribution and trends. It is important to note that, by improving our knowledge of a species, reassessments could lead to its downlisting into a lower category (Hoffmann et al., 2010), but this would not necessarily imply a reduction in our duty to protect them: it would lead to a clearer prioritization of actions and a better allocation of conservation resources. In fact, from a cost-benefit perspective, the mobilization and reuse of existing but underutilized EA-related data, even with additional cost (Agence Française de Développement, 2020), represents an efficient strategy for potentially improving knowledge and assessments of threatened species without requiring new fieldwork efforts and resources—that is, reducing costs (Calas et al., 2020).

EA is described as one of the more successful policy innovations of the 20th Century, and it is an established and mandatory process in more than 100 countries (Petts, 1999). The Agence Française de Développement (2020) estimates that each EA produces between 500 and 1000 PBR, suggesting that this procedure generates large volumes of dark biodiversity data at the global level, estimated at up to 300,000 records (Agence Française de Développement, 2020). If properly managed, standardized, and mobilized, EA-related data has the potential to enrich the information basis for decision-making and conservation planning, both nationally and internationally.

Conclusions

EA-related DKD, while not designed to comprehensively represent threatened biodiversity, increased the spatial and temporal DAK for a subset of threatened species, notably expanding the estimation of AOO for 40 threatened species. Therefore, EA-related data are a specific and complementary source of information useful for improving the amount and consistency of accessible biodiversity data and obtaining the best available evidence to inform conservation status assessments of threatened species. It is sensible to utilize these newly mobilized data to guide conservation, especially when these data are readily available and of known provenance. There are multiple ways to use these data; for example, these FAIR-ified data are already suitable for ecological niche modeling studies. However, if we want to unlock their full potential and if outputs are to be universally and indefinitely comparable, some data management standards and publication guidelines must be systematically adopted. Public administrations should promote or require the use of existing infrastructures, standards, and protocols (provided by platforms such as GBIF) to facilitate the accessibility and reuse of EA-related PBR. In this way, EA procedures could contribute not only to impacts assessment but also to flipping the databerg.

Acknowledgments

We would like to acknowledge the Association of Friends of the University of Navarra for the financial support for M. Telletxea, and Francisco Pando and an anonymous reviewer for very thorough and thoughtful comments that greatly improved the clarity of the manuscript.

Conflict of Interest Statement

The authors have declared that no competing interests exist.

Data Accessibility

The dataset of Environmental Assessment (EA)-related stray data is available in *Biodiversity Data Journal* (https://doi.org/10.3897/BDJ.13.e142302), and the DAK for threatened species was accessed via the Global Biodiversity Information Facility (GBIF) (https://doi.org/10.15468/dl.a3rqze and https://doi.org/10.15468/dl.6jf8km). All of the Appendices (1-4) are available at https://hdl.handle.net/1808/36303.

References

Agence Française de Développement. (2020). *Data4Nature: Presentation of the Data4Nature initiative*. https://www.afd.fr/en/ressources/data4nature-presentation-initiative

Agence Française de Développement. (2021). *Data4Nature: Practical Recommendations Guide for Publishing Primary Biodiversity Data*. https://www.afd.fr/en/ressources/data-4nature-practical-recommendations-guide-publishing-primary-biodiversity-data

Aguilar, A., Forcada, J., Borrell, A., Silvani, L., Grau, G., Gazo, M., Calzada, N., Pastor, T., Badosa, E., Arderiu, A., & Samaranch, R. (1994). *Inventario de Cetáceos Mediterráneos Ibéricos: Status y Problemas de Conservación*. Ministerio para la Transición Ecológica y el Reto Demográfico, Madrid

Área de Inventario y Estadísticas Forestales (AIEF). (2021). *Red de Seguimiento a gran Escala de Daños en los Bosques (Red de Nivel I). Manual de Campo*. Ministerio para la Transición Ecológica y el Reto Demográfico, Madrid

Ariño, A. H. (2010). Approaches to estimating the universe of natural history collections data. *Biodiv Inf*, *7*(2). https://doi.org/10.17161/bi.v7i2.3991

Arribas, O. (2009). *Iberolacerta galani*. The IUCN Red List of Threatened Species 2009: e.T157271A5066930. https://dx.doi.org/10.2305/IUCN.UK.2009.RLTS.T157271A5066930.en. Accessed 08 April 2024

Barnosky, A. D., Matzke, N., Tomiya, S., Wogan, G. O., Swartz, B., Quental, T. B., Marshall, C., McGuire, J. L., Lindsey, E. L., Maguire, K. C., Mersey, B., & Ferrer, E. A. (2011). Has the Earth's sixth mass extinction already arrived? *Nature*, *471*(7336), 51–57. https://doi.org/10.1038/nature09678

Baldauf, C., & de Oliveira Lunardi, V. (2020). Multiple perspectives on biodiversity conservation: From concept to heated debate. In: *Participatory Biodiversity Conservation*, Springer, Cham, pp. 15–32. https://doi.org/10.1007/978-3-030-41686-7_2

Ball-Damerow, J. E., Brenskelle, L., Barve, N., Soltis, P. S., Sierwald, P., Bieler, R., LaFrance, R., Ariño, A. H., & Guralnick, R. P. (2019). Research applications of primary biodiversity databases in the digital age. *PLoS One*, *14*(9):e0215794. https://doi.org/10.1371/journal.pone.0215794

Barve, V. (2014). Discovering and developing primary biodiversity data from social networking sites: A novel approach. *Ecol Inform*, *24*:194–199. https://doi.org/10.1016/j.ecoinf.2014.08.008

Butchart, S. H. M., Stattersfield, A. J., & Collar, N. J. (2006). How many bird extinctions have we prevented? *Oryx*, *40*(3):266–278. https://doi.org/10.1017/S0030605306000950

Butchart, S. H. M., Akçakaya, H. R., Chanson, J., Baillie, J. E. M., Collen, B., Quader, S., Turner, W. R., Amin, R., Stuart, S. N., & Hilton-Taylor, C. (2007). Improvements to the Red List Index. *PLoS One*, *2*(1):e140. https://doi.org/10.1371/journal.pone.0000140

Cadman, M., Chavan, V., King, N., Willoughby, S., Rajvanshi, A., Mathur, V., Roberts, R., & Hirsch, T. (2011). *Publishing EIA-related primary biodiversity data: GBIF-IAIA best practice guide*. Fargo ND, USA. https://doi.org/10.35035/doc-5xdm-8762

Calas, J., Chenin, E., & Ellebode, C. (2020). *Biodiversity Data: Development Banks As Part Of The Solution.* ID4D. https://web.archive.org/web/20201130013603/https://ideas4development.org/en/biodiversity-data-role-development-bank/

Chavan, V., & Ingwersen, P. (2009). Towards a data publishing framework for primary biodiversity data: Challenges and potentials for the biodiversity informatics community. *BMC Bioinformatics*, *10*:1–11. https://doi.org/10.1186/1471-2105-10-S14-S2

Chavan, V., & Penev, L. (2011). The data paper: A mechanism to incentivize data publishing in biodiversity science. *BMC Bioinformatics*, *12*:1–12. https://doi.org/10.1186/1471-2105-12-S15-S2

Comisión Estatal del Patrimonio Natural y la Biodiversidad. (2012). *Directrices para la vigilancia y evaluación del estado de conservación de las especies amenazadas y de protección especial*. Comité de Flora y Fauna Silvestres de la Comisión Estatal para el Patrimonio Natural y la Biodiversidad (CEPNB). Aprobadas por la Comisión Estatal para el Patrimonio Natural y la Biodiversidad. Ministerio de Agricultura, Alimentación y Medio Ambiente, Madrid. https://www.miteco.gob.es/content/dam/miteco/es/biodiversidad/temas/conservacion-de-especies/doc_directrices_vigilancia_evaluacion_v10_tcm30-198875.pdf

Convention on Biological Diversity. (2022). *Kunming-Montreal Global Biodiversity Framework*. CBD/COP/DEC/15/4. Secretariat of the Convention on Biological Diversity. Montreal, Canada. https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf

Costello, M. J., & Wieczorek, J. (2014). Best practice for biodiversity data management and publication. *Biol Conserv*, *173*:68–73. https://doi.org/10.1016/j.biocon.2013.10.018

Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. *Official*

Journal of the European Union, *L 206*, 22 July 1992. http://data.europa.eu/eli/dir/2009/147/2019-06-26

Curry, G. B., & Humphries, C. J. (2007). *Biodiversity databases: Techniques, politics, and applications*. Taylor & Francis. https://library.oapen.org/handle/20.500.12657/41647

Decreto 156/2014, de 29 de diciembre, por el que se declara la Zona Especial de Conservación Río Cares-Deva (ES1200035) y se aprueba el I Instrumento de Gestión Integrado de diversos espacios protegidos en los ríos Cares y Deva. *Boletín Oficial del Principado de Asturias*, *2*, de 3 de enero de 2015

Dias, A. M. S., Cook, C., Massara, R. L., & Paglia, A. P. (2022). Are Environmental Impact Assessments effectively addressing the biodiversity issues in Brazil? *Environ Impact Assess*, *95*:106801. https://doi.org/10.1016/j.eiar.2022.106801

Edwards, J. L. (2001). The Global Biodiversity Information Facility: An international network of interoperable biodiversity databases. *Joho Chishiki Gakkaishi*, *10*(4):58–61. https://doi.org/10.2964/jsik_KJ00001039357

Enríquez-de-Salamanca, Á., Martín-Aranda, R. M., & Díaz-Sierra, R. (2016). Consideration of climate change on environmental impact assessment in Spain. *Environ Impact Assess Rev*, *57*:31–39. https://doi.org/10.1016/j.eiar.2015.11.009

Escribano, N., Galicia, D., & Ariño, A. H. (2018). The tragedy of the biodiversity data commons: a data impediment creeping nigher? *Database*, *2018*, bay033. https://doi.org/10.1093/database/bay033

Escribano, N., Galicia, D., & Ariño, A. H. (2019). Completeness of Digital Accessible Knowledge (DAK) about terrestrial mammals in the Iberian Peninsula. *PLoS One*, *14*(3):e0213542. https://doi.org/10.1371/journal.pone.0213542

Figueira, R., Beja, P., Villaverde, C., Vega, M., Cezón, K., Messina, T., Archambeau, A., Johaadien, R., Endresen, D., & Escobar, D. (2020). *Guidance for private companies to become data publishers through GBIF*. GBIF Secretariat, Copenhagen. https://doi.org/10.35035/doc-b8hq-me03

Gaiji, S., Chavan, V., Ariño, A. H., Otegui, J., Hobern, D., Sood, R., & Robles, E. (2013). Content assessment of the primary biodiversity data published through GBIF network: Status, challenges and potentials. *Biodiv Inf*, *8*:94–172. https://journals.ku.edu/jbi/article/view/4124/4201

GBIF. (2024). *Activity report Spain*. https://analytics-files.gbif.org/country/ES/GBIF_CountryReport_ES.pdf

GBIF. (2025). *Businesses sharing data through GBIF. Which companies are publishing biodiversity data through GBIF?* GBIF. https://www.gbif.org/composition/1XtRfS0nTKs8HtRd18Q7ai/businesses-sharing-biodiversity-data-via-gbif. Accessed 02 January 2026

GBIF.org. (9 October 2023). GBIF occurrence download https://doi.org/10.15468/dl.9jet3c

GBIF.org. (27 October 2023). GBIF occurrence download https://doi.org/10.15468/dl.6jf8km

González-Alonso, M., & Ariño, A. H. (2023). Digitally accessible knowledge about airborne pollen data in Spain. *Aerobiologia*, *39*:175–179. https://doi.org/10.1007/s10453-022-09776-1

Guinart, D., Solórzano, S., Amat, F., Grau, J., Fernández-Guiberteau, D., & Montori, A. (2022). Habitat management of the endemic and critical endangered Montseny brook newt (*Calotriton arnoldi*). *Land*, *11*(3):449. https://doi.org/10.3390/land11030449

Heidorn, P. B. (2008). Shedding light on the DKD in the long tail of science. *Lib Trends*, *57*(2):280–299. https://doi.org/10.1353/lib.0.0036

Hill, A. W., Otegui, J., Ariño, A. H., & Guralnick, R. P. (2010). *GBIF position paper on future directions and recommendations for enhancing fitness-for-use across the GBIF network, version 1.0*. Global Biodiversity Information Facility, Copenhagen. https://www.gbif.org/document/80623/gbif-position-paper-on-future-directions-and-recommendations-for-enhancing-fitness-for-use-across-the-gbif-network

Hoffmann, M., Hilton-Taylor, C., Angulo, A., Böhm, M., Brooks, T. M., Butchart, S. H. M., Carpenter, K. E., Chanson, J., Collen, B., Cox, N. A., Darwall, W. R. T., Dulvy, N. K., Harrison, L. R., Katariya, V., Pollock, C. M., Quader, S., Richman, N. I., Rodrigues, A. S., Tognelli, M. F., Vié, J.-C., Aguiar, J. M., Allen, D. J., Allen, G. R., Amori, G., Ananjeva, N. B., Andreone, F., Andrew, P., Aquino Ortiz, A. L., Baillie, J. E. M., Baldi, R., Bell, B. D., Biju, S. D., Bird, J. P., Black-Decima, P., Blanc, J. J., Bolaños, F., Bolivar-G., W., Burfield, I. J., Burton, J. A., Capper, D. R., Castro, F., Catullo, G., Cavanagh, R. D., Channing, A., Chao, N. L., Chenery, A. M., Chiozza, F., Clausnitzer, V., Collar, N. J., Collett, L. C., Collette, B. B., Cortez Fernandez, C. F., Craig, M. T., Crosby, M. J., Cumberlidge, N., Cuttelod, A., Derocher, A. E., Diesmos, A. C., Donaldson, J. S., Duckworth, J. W., Dutson, G., Dutta, S. K., Emslie, R. H., Farjon, A., Fowler, S., Freyhof, J., Garshelis, D. L., Gerlach, J., Gower, D. J., Grant, T. D., Hammerson, G. A., Harris, R. B., Heaney, L. R., Hedges, S. B., Hero, J.-M., Hughes, B., Hussain, S. A., Icochea M., J., Inger, R. F., Ishii, N., Iskandar, D. T., Jenkins, R. K. B., Kaneko, Y., Kottelat, M., Kovacs, K. M., Kuzmin, S. L., La Marca, E., Lamoreux, J. F., Lau, M. W. N., Lavilla, E. O., Leus, K., Lewison, R. L., Lichtenstein, G., Livingstone, S. R., Lukoschek, V., Mallon, D. P., McGowan, P. J. K., McIvor, A., Moehlman, P. D., Molur, S., Muñoz Alonso, A., Musick, J. A., Nowell, K., Nussbaum, R. A., Olech, W., Orlov, N. L., Papenfuss, T. J., Parra-Olea, G., Perrin, W. F., Polidoro, B. A., Pourkazemi, M., Racey, P. A., Ragle, J. S., Ram, M., Rathbun, G., Reynolds, R. P., Rhodin, A. G. J., Richards, S.

J., Rodríguez, L. O., Ron, S. R., Rondinini, C., Rylands, A. B., Sadovy de Mitcheson, Y., Sanciangco, J. C., Sanders, K. L., Santos-Barrera, G., Schipper, J., Self-Sullivan, C., Shi, Y., Shoemaker, A., Short, F. T., Sillero-Zubiri, C., Silvano, D. L., Smith, K. G., Smith, A. T., Snoeks, J., Stattersfield, A. J., Symes, A. J., Taber, A. B., Talukdar, B. K., Temple, H. J., Timmins, R., Tobias, J. A., Tsytsulina, K., Tweddle, D., Ubeda, C., Valenti, S. V., van Dijk, P. P., Veiga, L. M., Veloso, A., Wege, D. C., Wilkinson, M., Williamson, E. A., Xie, F., Young, B. E., Akçakaya, H. R., Bennun, L., Blackburn, T. M., Boitani, L., Dublin, H. T., da Fonseca, G. A. B., Gascon, C., Lacher, T. E., Mace, G. M., Mainka, S. A., McNeely, J. A., Mittermeier, R. A., Reid, G. M., Rodriguez, J. P., Rosenberg, A. A., Samways, M. J., Smart, J., Stein, B. A., & Stuart, S. N. (2010). The impact of conservation on the status of the world's vertebrates. *Science*, *330*(6010):1503–1509. https://doi.org/10.1126/science.1194442

Hoffmann, M., Duckworth, J. W., Holmes, K., Mallon, D. P., Rodrigues, A. S., & Stuart, S. N. (2015). The difference conservation makes to extinction risk of the world's ungulates. *Conserv Biol*, *29*(5):1303–1313. https://doi.org/10.1111/cobi.12519

Hochkirch, A., Bilz, M., Ferreira, C. C., Danielczak, A., Allen, D., Nieto, A., Rondinini, C., Harding, K., Hilton-Taylor, C., Pollock, C. M., Seddon, M., Vié, J.-C., Alexander, K. N. A., Beech, E., Biscoito, M., Braud, Y., Burfield, I. J., Buzzetti, F. M., Cálix, M., Carpenter, K. E., Chao, N. L., Chobanov, D., Christenhusz, M. J. M., Collette, B. B., Comeros-Raynal, M. T., Cox, N., Craig, M., Cuttelod, A., Darwall, W. R. T., Dodelin, B., Dulvy, N. K., Englefield, E., Fay, M. F., Fettes, N., Freyhof, J., García, S., García Criado, M., Harvey, M., Hodgetts, N., Ieronymidou, C., Kalkman, V. J., Kell, S. P., Kemp, J., Khela, S., Lansdown, R. V., Lawson, J. M., Leaman, D. J., Magos Brehm, J., Maxted, N., Miller, R. M., Neubert, E., Odé, B., Pollard, D., Pollom, R., Pople, R., Presa Asensio, J. J., Ralph, G. M., Rankou, H., Rivers, M., Roberts, S. P. M., Russell, B., Sennikov, A., Soldati, F., Staneva, A., Stump, E., Symes, A., Telnov, D., Temple, H., Terry, A., Timoshyna, A., van Swaay, C., Väre, H., Walls, R. H. L., Willemse, L., Wilson, B., Window, J., Wright, E. G. E., & Zuna-Kratky, T. (2023). A multi-taxon analysis of European Red Lists reveals major threats to biodiversity. *PLoS One*, *18*(11):e0293083. https://doi.org/10.1371/journal.pone.0293083

IPBES. (2019). *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. IPBES Secretariat, Bonn. https://doi.org/10.5281/zenodo.3826598

IUCN Standards and Petitions Committee. (2022). *Guidelines for Using the IUCN Red List Categories and Criteria*. Version 15.1. https://www.iucnredlist.org/documents/RedListGuidelines.pdf

IUCN. (2012). *IUCN Red List Categories and Criteria: Version 3.1*. 2nd ed. IUCN. Gland and Cambridge.

Joppa, L. N., Butchart, S. H., Hoffmann, M., Bachman, S. P., Akçakaya, H. R., Moat, J. F., Böhm, M., Holland, R. A., Newton, A., Polidoro, B., & Hughes, A. (2016). Impact of alternative metrics on estimates of extent of occurrence for extinction risk assessment. *Conserv Biol*, *30*(2):362–370. https://doi.org/10.1111/cobi.12591

Kaplan, A., Marambio, M., López-Sendino, P., Agell, G., Chic, Ó., Espeja, S., García González, M., Vicioso, M., Vilanova, M., Rendal Freire, S., Furundarena Hernández, A. B., Caro Torti, M. B., Martín Solà, M., González Navarro, J., Herrera Pérez, R., Moro Abad, L., Ayza, O., & Garrabou, J. (2023). *Informe Programas de Seguimiento en España: Especies Marinas Amenazadas.* Observadores del Mar. https://doi.org/10.20350/digitalCSIC/16055

King, N., Rajvanshi, A., Willoughby, S., Roberts, R., Mathur, V. B., Cadman, M., & Chavan, V. (2012). Improving access to biodiversity data for, and from, EIAs–a data publishing framework built to global standards. *Impact Assess Proj A*, *30*(3):148–156. https://doi.org/10.1080/14615517.2012.705068

Ley 42/2007, de 13 de diciembre, del Patrimonio Natural y de la Biodiversidad. *Boletín Oficial del Estado*, *299*, de 14 de diciembre de 2007. https://www.boe.es/eli/es/l/2007/12/13/42/con

Ley 21/2013, de 9 de diciembre, de evaluación ambiental. *Boletín Oficial del Estado*, *296*, de 11 de diciembre de 2013. https://www.boe.es/eli/es/l/2013/12/09/21/con

Lewis, K. P., Vander Wal, E., & Fifield, D. A. (2018). Wildlife biology, big data, and reproducible research. *Wildlife Soc B*, *42*(1):172–179. https://doi.org/10.1002/wsb.847

Loh, J., Green, R. E., Ricketts, T., Lamoreux, J., Jenkins, M., Kapos, V., & Randers, J. (2005). The Living Planet Index: using species population time series to track trends in biodiversity. *Philos Trans R Soc Lond B*, *360*(1454):289–295. https://doi.org/10.1098/rstb.2004.1584

Lomolino, M. V. (2004). Conservation biogeography. In *Frontiers of Biogeography: New Directions in the Geography of Nature*. Lomolino, M. V., Heaney, L. R. (eds). Sinauer, Sunderland

Mace, G. M., Collar, N. J., Gaston, K. J., Hilton-Taylor, C., Akçakaya, H. R., Leader-Williams, N., Milner-Gulland, E. J., & Stuart, S. N. (2008). Quantification of extinction risk: IUCN's system for classifying threatened species. *Conserv Biol*, *22*(6):1424–1442. https://doi.org/10.1111/j.1523-1739.2008.01044.x

Magurran, A. E., Baillie, S. R., Buckland, S. T., Dick, J. M., Elston, D. A., Scott, E. M., Smith, R. I., Somerfield, P. J., &

Watt, A. D. (2010). Long-term datasets in biodiversity research and monitoring: assessing change in ecological communities through time. *Trends Ecol Evol*, *25*(10):574–582. https://doi.org/10.1016/j.tree.2010.06.016

Ministerio para la Transición Ecológica y el Reto Demográfico. (2020). Rangos de especies Artículo 17 (2013-2018). Península, Baleares y Canarias. https://www.miteco.gob.es/es/biodiversidad/temas/espacios-protegidos/red-natura-2000/rn_cons_seguimiento_art17_inf_2013_2018.html

Muñoz, G., Kissling, W. D., & van Loon, E. E. (2019). Biodiversity Observations Miner: A web application to unlock primary biodiversity data from published literature. *Biodivers Data J*, *7*:e28737. https://doi.org/10.3897/BDJ.7.e28737

Otegui, J., Ariño, A. H., Encinas, M. A., & Pando, F. (2013). Assessing the primary data hosted by the Spanish node of the Global Biodiversity Information Facility (GBIF). *PLoS One*, *8*(1):e55144. https://doi.org/10.1371/journal.pone.0055144

Peterson, A. T., Asase, A., Canhos, D. A. L., de Souza, S., & Wieczorek, J. (2018). Data leakage and loss in biodiversity informatics. *Biodivers Data J*, 6:e26826. https://doi.org/10.3897/BDJ.6.e26826

Petts, J. (ed). (2009). *Handbook of Environmental Impact Assessment, Volume 2: Impact and Limitations* (Vol. 2). John Wiley & Sons

Pimm, S. L., Jenkins, C. N., Abell, R., Brooks, T. M., Gittleman, J. L., Joppa, L. N., Raven, P. H., Roberts, C. M., & Sexton, J. O. (2014). The biodiversity of species and their rates of extinction, distribution, and protection. *Science*, *344*(6187), 1246752. https://doi.org/10.1126/science.1246752

Pullin, A. S., & Knight, T. M. (2001). Effectiveness in conservation practice: Pointers from medicine and public health. *Conserv Biol*, *15*(1):50–54. https://doi.org/10.1111/j.1523-1739.2001.99499.x

QGIS.org. (2022). QGIS Geographic Information System. QGIS Association. Open-Source Geospatial Foundation Project

Real Decreto 139/2011, de 4 de febrero, para el desarrollo del Listado de Especies Silvestres en Régimen de Protección Especial y del Catálogo Español de Especies Amenazadas. *Boletín Oficial del Estado*, *46*, de 23 de febrero de 2011. https://www.boe.es/eli/es/rd/2011/02/04/139/con

Resolución de 14 de mayo de 2021, de la Dirección General de Calidad y Evaluación Ambiental, por la que se formula la declaración de impacto ambiental del proyecto “Parque eólico El Escudo de 151,2 MW, en Campoo de Yuso, Luena, San Miguel de Aguayo y Molledo (Cantabria)”. *Boletín Oficial del Estado*, *129*, 31 de mayo de 2021, pp. 66661 a 66700. https://www.boe.es/buscar/doc.php?id=BOE-A-2021-9051

Resolución de 23 de septiembre de 2022, de la Dirección General de Calidad y Evaluación Ambiental, por la que se formula declaración de impacto ambiental del proyecto “Parque eólico Tórtoles de 148 MW y su infraestructura de evacuación, en Tórtoles de Esgueva, Avellanosa de Muñó, Estepar, Mahumud, Mazuela, Presencio, Royuela de Río Franco, Tordómar, Torresandino, Villafruela, Villahoz y Villaverde del Monte, en Burgos”. *Boletín Oficial del Estado*, *238*, 4 de octubre de 2022, pp. 136195 a 136219. https://www.boe.es/buscar/doc.php?id=BOE-A-2022-16172

Resolución de 12 de enero de 2023, de la Dirección General de Calidad y Evaluación Ambiental, por la que se formula declaración de impacto ambiental del proyecto “Parque Solar Fotovoltaico Rivera de 419,95 MWP y 340,496 MWN, y su infraestructura de evacuación, en la provincia de Huelva”. Resolución de 12 de enero de 2023, de la Dirección General de Calidad y Evaluación Ambiental, por la que se formula declaración de impacto ambiental del proyecto “Parque Solar Fotovoltaico Rivera de 419,95 MWP y 340,496 MWN, y su infraestructura de evacuación, en la provincia de Huelva”. *Boletín Oficial del Estado*, *25*, 30 de enero de 2023, pp. 12915 a 12937. https://www.boe.es/buscar/doc.php?id=BOE-A-2023-2425

Ribeiro, B. R., Guidoni-Martins, K., Tessarolo, G., Velazco, S. J. E., Jardim, L., Bachman, S. P., & Loyola, R. (2022). Issues with species occurrence data and their impact on extinction risk assessments. *Biol Conserv*, *273*:109674. https://doi.org/10.1016/j.biocon.2022.109674

Robertson, T., Döring, M., Guralnick, R., Bloom, D., Wieczorek, J., Braak, K., Otegui, J., Russell, L., & Desmet, P. (2014). The GBIF integrated publishing toolkit: facilitating the efficient publishing of biodiversity data on the internet. *PLoS One*, *9*(8):e102623. https://doi.org/10.1371/journal.pone.0102623

Rodrigues, A., Endresen, D., Figueira, R., Villaverde, C., Vega, M., King, N., Rajvanshi, A., & Treweek, J. (2022). *Best Practices for Publishing Biodiversity Data from Environmental Impact Assessments*. GBIF Secretariat, Copenhagen. https://doi.org/10.35035/doc-5xdm-8762

Ronquillo, C., Alves-Martins, F., Mazimpaka, V., Sobral-Souza, T., Vilela-Silva, B., Medina, N. G., & Hortal, J. (2020). Assessing spatial and temporal biases and gaps in the publicly available distributional information of Iberian mosses. *Biodiversity Data J*, *8*:e53474.

Sousa-Baena, M. S., Garcia, L. C., & Peterson, A. T. (2014). Completeness of digital accessible knowledge of the plants of Brazil and priorities for survey and inventory. *Divers Distrib*, *20*(4):369–381. https://doi.org/10.1111/ddi.12136

Spiliopoulou, K., Brooks, T. M., Dimitrakopoulos, P. G., Oikonomou, A., Karavatsou, F., Stoumboudi, M. T., & Triantis, K. A. (2023). Protected areas and the ranges of threatened species: Towards the EU Biodiversity Strategy 2030. *Biol Conserv*, *284*:110166. https://doi.org/10.1016/j.biocon.2023.110166

Sutherland, W. J., Pullin, A. S., Dolman, P. M., & Knight, T. M. (2004). The need for evidence-based conservation. *Trends Ecol Evol*, *19*(6):305–308. https://doi.org/10.1016/j.tree.2004.03.018

Stall, S., Yarmey, L., Cutcher-Gershenfeld, J., Hanson, B., Lehnert, K., Nosek, B., Parsons, M., Robinson, E., & Wyborn, L. (2019). Make scientific data FAIR. *Nature*, *570*(7759):27–29. https://doi.org/10.1038/d41586-019-01720-7

Telletxea, M., Miranda, R., Ariño, A. H., & Galicia, D. (2025). Mobilizing primary biodiversity records in environmental assessment in Spain. *Biodivers Data J*, *13*:e142302. https://doi.org/10.3897/BDJ.13.e142302

Tenopir, C., Allard, S., Douglass, K., Aydinoglu, A. U., Wu, L., Read, E., Manoff, M., & Frame, M. (2011). Data sharing by scientists: practices and perceptions. *PLoS One*, *6*(6):e21101. https://doi.org/10.1371/journal.pone.0021101

Treweek, J. (1996). Ecological and environmental impact assessment. *J Appl Ecol*, *33*:191–199. https://doi.org/10.2307/2404742

Valdés, L., Bode, A., Latasa, M., Nogueira, E., Somavilla, R., Varela, M. M., González-Pola, C., & Casas, G. (2021). Three decades of continuous ocean observations in North Atlantic Spanish waters: The RADIALES time series project, context, achievements and challenges. *Prog Oceanogr*, *198*:102671. https://doi.org/10.1016/j.pocean.2021.102671

Villarroya, A., & Puig, J. (2013). A proposal to improve ecological compensation practice in road and railway projects in Spain. *Environ Impact Assess Rev*, *42*:87–94. https://doi.org/10.1016/j.eiar.2012.11.002

Weaver, A., Pope, J., Morrison-Saunders, A., & Lochner, P. (2008). Contributing to sustainability as an environmental impact assessment practitioner. *Impact Assess Proj A*, *26*(2):91–98. https://doi.org/10.3152/146155108X316423

Wieczorek, J., Bloom, D., Guralnick, R., Blum, S., Döring, M., Giovanni, R., Robertson, T., & Vieglais, D. (2012). Darwin Core: an evolving community-developed biodiversity data standard. *PLoS One*, *7*(1):e29715. https://doi.org/10.1371/journal.pone.0029715

Wilkinson, M., Dumontier, M., Aalbersberg, I. J., Appleton, G., Axton, M., Baak, A., … & Zhao, J. (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Sci data*, *3*(1):1–9. https://doi.org/10.1038/sdata.2016.18

WWF. (2022). *Living Planet Report 2022 – Building a nature-positive society*. Almond, R. E. A., Grooten, M., Juffe Bignoli, D., Petersen, T. (eds). WWF, Gland, Switzerland. https://www.wwf.org.uk/sites/default/files/2023-05/WWF-Living-Planet-Report-2022.pdf