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1 **Data transparency regarding the implementation of European**  
2 **'no net loss' biodiversity policies**

3

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30 **Abstract**

31 'No net loss' (NNL) conservation policies seek to address development impacts on  
32 biodiversity. There have been no peer-reviewed multinational assessments concerning the  
33 actual implementation of NNL policies to date. Such assessments would facilitate more  
34 informed debates on the validity of NNL for conservation, but assessing implementation  
35 requires data. Here, we explore data transparency concerning NNL implementation, with four  
36 European countries providing a case study.

37 Biodiversity offsets (offsets) are the most tangible outcome of NNL policy. Using an  
38 expert network to locate all offset datasets available within the public domain, we collated  
39 information on offset projects implemented in France, Germany, the Netherlands and  
40 Sweden. Implementation data for offsets were found to be non-transparent, but the degree of  
41 transparency varies widely by country. We discuss barriers preventing data transparency –  
42 including a perceived lack of necessity, lack of common protocols for collecting data, and a  
43 lack of resources to do so. For the data we collected we find that most offsets in Europe: are  
44 not within protected areas; involve active restoration; and, compensate for infrastructure  
45 development. The area occupied by European offsets is at least of the order  $\sim 10^2$  km<sup>2</sup>.

46 Transparent national NNL databases are essential for meeting good practice NNL  
47 principles, but are not currently available in Europe. We discuss what such databases might  
48 require to support evaluation of NNL policy effectiveness by researchers, the conservation  
49 community and policymakers.

50

51 Keywords: *Biodiversity offset; compensation; Europe; mitigation hierarchy; no net loss;*  
52 *policy evaluation; data transparency.*

## 53 1.1 Introduction

54 The conservation policy principle of 'no net loss' (NNL) of biodiversity, originating in US and  
55 European environmental legislation in the 1970s, has attracted considerable attention from  
56 researchers and decision-makers. NNL policies are those through which any negative  
57 biodiversity impacts associated with economic development are quantified, mitigated and fully  
58 compensated for (Gardner et al., 2013). Those seeking to achieve the NNL objective  
59 commonly do so through implementing actions categorised into a mitigation hierarchy (e.g.  
60 predicted development impacts are sequentially *Avoided*, *Minimised*, *Remediated*, and finally  
61 *Offset*; Gardner et al., 2013; Bull et al., 2016). Theoretical barriers to achieving NNL are well  
62 documented (Bull et al., 2013). While the concept of NNL appeals to many policymakers,  
63 academics and NGOs, it is deemed unethical and open to misapplication by some (Gordon et  
64 al., 2015). Nonetheless, NNL-type policies are widespread (being applicable to certain  
65 projects in almost every country on the planet) and increasingly adopted by the private sector  
66 (Maron et al., 2016a).

67

68 Post-implementation evaluation of NNL policies is uncommon, including for the most  
69 controversial component of the mitigation hierarchy, biodiversity offsetting (Bull et al., 2013;  
70 ten Kate et al., 2014). Biodiversity offsets ('offsets') involve compensating for unavoidable  
71 residual impacts through conservation or restoration activities elsewhere. Some published  
72 analyses of offset implementation exist, assessing data on the implementation of offset  
73 projects at sub-national to national scales. They find that a minority of offsets are  
74 implemented as per technical requirements, yet conclude that the approach is improving and  
75 has some potential for conservation (Matthews & Endress, 2008; Brown et al., 2014;  
76 Olszynski, 2015; May et al., 2016).

77

78 Transparency (e.g. ensuring that "clear, up to date, and easily accessible information is  
79 provided to stakeholders and the public on the offset design and implementation, including  
80 outcomes"; BBOP, 2012) is considered good practice for offsetting. Further, the availability of  
81 comprehensive and reliable datasets on offset implementation would be essential for  
82 understanding the scope of offset activity, and is a prerequisite for eventually assessing the

83 effectiveness and suitability of offsetting for conservation in different regional and national  
84 contexts. Yet to date there has been no explicit assessment of data transparency in the  
85 implementation of offset projects, or indeed in NNL policy outcomes more generally; let alone  
86 a comparative analysis that would enable lessons to be shared across jurisdictions. The lack  
87 of readily available data on the implementation of NNL policy hampers any effort to make  
88 clear, empirical statements in relation to key controversies surrounding NNL, and ultimately,  
89 evaluation of the contribution made by NNL policy to biodiversity conservation. The need to  
90 ascertain the validity of NNL has become increasingly pressing with the introduction of far-  
91 reaching policies supporting their use (Maron et al., 2016a). It is thus critical to better  
92 understand the degree to which data on offsetting efforts, and NNL-related measures more  
93 generally, are available. We note that the desire to obtain transparent and reliable data is a  
94 topical concern for conservation science more broadly. The availability and accessibility of  
95 data with relevance to topics in conservation has improved notably in recent decades – for  
96 instance, with resources such as the Global Biodiversity Information Facility (Gaiji et al.,  
97 2013), remotely sensed imagery (Turner et al., 2003), the World Database on Protected  
98 Areas (UNEP-WCMC, 2017), and the PREDICTS database (Hudson et al., 2014). This is  
99 consistent both with the movement towards evidence-based conservation (Sutherland et al.,  
100 2004), and with profound changes in the way scientific data are created and disseminated  
101 (Kitchin, 2014).

102

103 Our main objective was to assess the availability and transparency of data on offset projects  
104 implemented under a NNL objective, for multiple countries. We collated all accessible data on  
105 offsets implemented by key countries within Europe that are actively implementing NNL  
106 policies. We assess the state of data on offset implementation, to understand whether such  
107 information is *unavailable*, *available*, or *transparent* (by which we mean both *available* and  
108 readily *accessible*). As a secondary objective, we sought to analyse data on known offset  
109 projects, to provide a first quantitative measure of European offsetting effort. It should be  
110 noted that, whilst such data go beyond policy analysis and capture implementation, they do  
111 not allow an assessment of the ecological effectiveness of offsets in achieving NNL – the  
112 latter would require widespread empirical assessment.

113

114 Europe is an active region for multinational NNL policy, and simulations suggest that such  
115 policies could result in good outcomes for nature against business-as-usual scenarios (Schulp  
116 et al., 2016). Yet, there has been no assessment to date concerning the physical  
117 implementation of NNL (Tucker et al., 2014; Schulp et al., 2016). For context: the current EU  
118 Biodiversity Strategy aims “to halt the loss of biodiversity and the degradation of ecosystem  
119 services in the EU by 2020, and to restore them in so far as feasible”. This includes to “ensure  
120 no net loss of biodiversity and ecosystem services” (Target 2, Action 7), including through  
121 offsetting schemes (Tucker et al. 2014). Since then, potential NNL approaches have been  
122 discussed extensively by the EU Commission and by member states. Whilst legislative NNL  
123 requirements, which make provisions for offsetting, already exist in certain protected areas  
124 (Natura 2000 sites) as a result of the EU Habitats Directive, the Strategy and associated  
125 discussions imply that NNL of biodiversity could be sought more widely (Wende et al., in  
126 press). Consequently, whilst biodiversity impact mitigation is already required in EU member  
127 states through the Directive on Environmental Impact Assessment, and offsetting is similarly  
128 enabled for Natura 2000 sites protected under the Birds and Habitats Directives, there is a  
129 movement towards more general provisions for biodiversity offsets. An exploration of the level  
130 of data transparency for NNL implementation in Europe is therefore highly conservation  
131 policy-relevant.

132

## 133 **2.1 Materials and methods**

### 134 2.1.1 *Methodology*

135 We compiled all publicly available data on offset projects through a process of intensive data  
136 extraction, alongside expert verification, for four countries: France, Germany, the Netherlands  
137 and Sweden. Our intention was to explore offset implementation for a significant (in terms of  
138 implementation) subset of European countries, and these four countries are documented as  
139 being key countries actually implementing NNL projects in Europe (Tucker et al., 2014). It  
140 should be noted that policies that make provision for offsets are in place or in discussion  
141 throughout Europe, as a result of both national legislation and EU Directives (Fig. 1; Maron et  
142 al., 2016a). However, given that the four countries included within our study are considered to

143 be leading proponents of offsetting, and contain a significant proportion of the terrestrial  
144 surface of Europe (>10%), we consider the selection justified. To obtain relevant data, we  
145 began by contacting at least three established national NNL experts in each country, where  
146 'experts' were considered to be those either publishing academic research on offsets in that  
147 country in peer-reviewed journals, or those working directly on offset projects (listed in Table  
148 A.1). We sought to ensure that for each country, our experts included those representing  
149 academia, the public sector, and the private sector. These individuals were asked to indicate  
150 all known data sources on offset implementation for that country, and notify us of any other  
151 potentially useful individual or organisational contacts. Consequently, those further individual  
152 and organisational contacts were approached until contacts confirmed that no further data  
153 were readily accessible. Since all data were provided to us through the recommendation of  
154 multiple experts, we did not independently verify the data.

155

156 To be included within our study, offset projects had to be associated with a NNL objective, i.e.  
157 offsets with the underlying intention as captured by Bull et al. (2013): "(1) they provide  
158 additional substitution or replacement for unavoidable negative impacts of human activity on  
159 biodiversity, (2) they involve measurable, comparable biodiversity losses and gains, and (3)  
160 they demonstrably achieve, as a minimum, no net loss of biodiversity". To operationalize  
161 these criteria for each country, we collated information on any offset projects that were  
162 presented as an offset and appeared to have been implemented, or were in the process of  
163 being implemented. We ignored offset projects that were at the proposal stage.

164

165 For each country, we determined first whether offset data were *unavailable* or *available*. In the  
166 latter case, we then comprehensively reviewed online data sources (from single projects to  
167 offset databases) to extract information relevant to the following questions:

- 168 1. What is the implementation status of each offset project (e.g. in progress/complete)?
- 169 2. What component of biodiversity is targeted (e.g. species, habitat types)?
- 170 3. What conservation management actions are involved (e.g. designation as protected  
171 area, habitat restoration)?
- 172 4. Where are they approximately located (latitude/longitude)?

- 173 5. How much area does each offset project occupy?
- 174 6. Which sector is causing the impacts for which offsets are required (e.g. transport
- 175 infrastructure, extractive)?
- 176 7. For what specific development project does each offset project provide ecological
- 177 compensation?
- 178 8. Where is that development project located (latitude/longitude)?
- 179 9. What components of biodiversity are impacted by that development project?

180

181 A condition for including offsets within our analyses was that sufficient information existed to

182 allow us to answer questions 1 – 3 above, and either question 4 or 5. Based on the amount

183 and type of data that we could collate, we determined whether offset data could be

184 considered *available* or *transparent*. ‘Availability’ is defined as data being publicly available

185 (however difficult to obtain), and ‘transparent’ is defined as data being readily accessible in

186 e.g. existing databases online. In addition, we requested all key expert contacts (Table A.1) to

187 provide a qualitative explanation of the primary barriers obstructing the collation and

188 dissemination of offset data in their country. Having collated the data, we assessed the total

189 number of individual offset projects, the approximate area occupied by those offsets, and the

190 proportion of offset types by development activity and compensation type (e.g. active

191 restoration, or averted loss), in each country and in sub-national regions.

192

193 To meet the secondary objective of the manuscript, to provide a preliminary estimate of

194 offsetting effort across Europe, we generated maps in QGIS Geographic Information System

195 v.2.8.1<sup>1</sup> of all offset locations (base data: Natural Earth v.3.1.0<sup>2</sup>). For interest, we analysed the

196 overlap with protected areas registered for each country in the World Database on Protected

197 Areas (WDPA; UNEP-WCMC, 2015). The ‘points in polygons’ analysis tool was implemented

198 for these overlapping layers, and attributes table from the resulting shapefiles exported (.csv

199 format). Note again that in this study we sought to understand implementation status, and not

200 the *effectiveness* of offsets – as such, we did not include a question on effectiveness. Judging

201 offset effectiveness can be extremely subjective, varying depending upon the stakeholder in

---

<sup>1</sup> <http://qgis.osgeo.org>

<sup>2</sup> <http://www.naturalearthdata.com>

202 question. As a result, the question of offset effectiveness is worthy of multiple studies in its  
203 own right.

204

#### 205 2.1.2 *Methodological challenges*

206 Given that information was mainly available in the relevant national language for each  
207 country, the research team included native speakers of Dutch, French and German. However,  
208 the lack of a Swedish co-author necessitated the use of Google Translate. A number of  
209 Sweden-based experts were consulted (Table A.1), to avoid misinterpretation. Further, the  
210 term used for 'biodiversity offset' can have subtly different meanings in different languages,  
211 and there is often no specific term for offsets as distinct from 'compensation' more generally  
212 (Bull et al., 2016). Again, offsets were here defined as per Bull et al. (2013).

213

214 Due to international variation, it was necessary to clarify what we considered a single 'offset  
215 project'. In some instances, a single restoration project offsets a single development, whereas  
216 in others, multiple restoration projects can be combined to compensate for a single  
217 development. Similarly, in some countries, developers turn to 'habitat banks' (i.e. a collection  
218 of previously implemented offset actions from which developers can buy credits) as an  
219 aggregated offset potentially associated with multiple development projects. To allow  
220 evaluation across countries with different approaches, we considered a single 'offset project'  
221 to be one contiguous area of land upon which ecological compensation activities of some kind  
222 are undertaken as a result of a NNL policy. Consequently, we treated habitat banks as single  
223 offset projects even they provided compensation for multiple developments.

224

225 Precise location data were only accessible online for offsets in France. In all other cases, the  
226 project location was described or displayed visually on online maps, and we extracted  
227 approximate latitude/longitude coordinates using Google Maps. Doing so introduced spatial  
228 uncertainty to offset coordinates, which we conservatively estimate to be  $\pm 3$ km of the true  
229 location. Improved data would be required to accurately map sites. However, for the purposes  
230 of assessing their broad distribution and data transparency we considered this an acceptable  
231 margin of error.

232

### 233 3.1 Results

234 For each country, we present results as follows: (i) NNL policy context; (ii) description of offset  
235 data obtained; and, (iii) degree to which data can be considered transparent.

236

#### 237 3.1.1 France

238 National legislation enabling offsets goes back to the 1970s, although since 2007 (following  
239 the transposition of the EU Birds and Habitats Directives) offsets have begun to be  
240 implemented more widely (Quétier et al., 2014). State agencies are required to give access to  
241 documentation for developments and associated offsets if requested, but do not  
242 systematically place them online. Rather, they meet requests for information by proposing  
243 appointments to consult hardcopy documents (A-C. Vaissière, pers. comm.). There is no  
244 existing national offset database in the public domain, but a new Biodiversity Law (August  
245 2016) requires the government to develop one that will be publicly accessible online. The  
246 public institution CEREMA has been commissioned to develop a single nationwide GIS  
247 database of French offsets, and has so far limited the corresponding data search to protected  
248 species derogations and water law (2012 – 2015).

249

250 At a subnational level, a publicly available offset database exists for the Languedoc-  
251 Roussillon province, containing 87 offset projects (Fig. 2a; DREAL, 2015). Languedoc-  
252 Roussillon has experienced relatively intense offset activity because several large  
253 infrastructure projects received permits after the 2012 publication of official offsetting  
254 guidance, such as the Nîmes-Montpellier railway bypass (construction of 80 kilometres of  
255 high-speed railway line between Nîmes and Montpellier; Quétier et al., 2015). Another  
256 database exists for Provence-Alpes-Côte d'Azur, containing 91 offset projects (2002 – 2014),  
257 but is not publicly available. Local authorities in the Rhône-Alpes province are developing a  
258 database (A-C. Vaissière, pers. comm.). Most provinces have not collated a database of  
259 offset projects, in spite of some offsets actually being implemented. Some provinces have  
260 non-digitized spatial plots of compensatory measures, but these are in the minority and do not

261 use a uniform data entry format, complicating compilation at a national level (S. Hubert, pers.  
262 comm.).

263

264 The 87 offsets in the Languedoc-Roussillon database include compensation for impacts on  
265 234 species and 37 wetland areas, constituting 254 separate conservation actions on  
266 compensatory land (occupying 28.41 km<sup>2</sup>), and 202 accompanying monitoring measures  
267 (DREAL, 2015). The majority of offsets are associated with infrastructure, particularly the  
268 Nîmes-Montpellier railway and A9 motorway, accounting for 59% and 9% of all measures  
269 respectively (Table A.2). Approximately half of all offsets are located within existing protected  
270 areas (Fig. 2a).

271

272 In summary, we could answer questions 1 – 9 (see Methods) for offsets in France, but only  
273 for one province. Offset data in this one province can thus be considered transparent, with  
274 non-transparent reporting in all other provinces (Table 1).

275

### 276 3.1.2 *Germany*

277 Since the enactment of the Federal Nature Conservation Act (*Bundesnaturschutzgesetz*) in  
278 1976, ecological compensation requirements have existed. Amendments to the Act (2002,  
279 2009) facilitating habitat banking allowed “loosening of the spatial and functional connection  
280 between impact and compensation” (Wende et al., 2005; Darbi, 2010). Under the Act, state  
281 governments are responsible for maintaining an offset registry, to avoid double counting and  
282 allow verification of implementation. While all German states do so (BFAD, 2011), individual  
283 registries differ in completeness, data accuracy, and type of data recorded (Wübbe et al.,  
284 2006). Data availability for German offset projects varies dramatically between states (Fig. 3).  
285 Offsets are most obviously found in ‘compensation pools’ or ‘eco-accounts’ (*Flächenpools*  
286 and *Ökokonten*) i.e. habitat banks, rather than tied to specific developments, although the  
287 proportion of each is unknown. The German system includes *Ausgleichsmaßnahmen*  
288 (‘compensation measures’) and *Ersatzmaßnahmen* (‘substitution measures’). The former  
289 involve restoring “impaired functions of the ecosystem” ensuring that “natural scenery has  
290 been restored or re-landscaped ” (Darbi et al., 2010) – they are ‘restoration compensation’,

291 'on-site' (Tucker et al., 2014). Since *Ausgleichsmaßnahmen* involve reversing the impacts  
292 caused by a specific development, they most closely match the remediation category of the  
293 mitigation hierarchy. Conversely, *Ersatzmaßnahmen* are offsets, in that they involve achieving  
294 biodiversity gains in habitats unaffected by the specific development for which they provide  
295 compensation (Albrecht et al., 2014; Tucker et al., 2014). All offsets in Germany are  
296 restoration-based, involving active management e.g. habitat restoration, pond creation.  
297 Protection-based ('averted loss') offsets are not permissible according to the relevant  
298 legislation, and requirements exist for "measures to restore lost functionality" (Herbert, 2015;  
299 Darbi et al., 2016).

300

301 Provincial registries were available online for eight federal states. The remaining state  
302 administrations did not respond or provided no data. Data accessibility is variable, with data  
303 sometimes available for viewing only, or available only upon request (Table A.3). Additional  
304 offset data were also displayed online by compensation agencies (*Flächenagenturen*), service  
305 providers that support offset implementation. Data made available through these agencies  
306 represent a subset of all offset sites, but likely a substantial one. Online spatial data from  
307 agencies exist for nine provinces (Tables 1, A.2).

308

309 We mapped 288 compensation pools in nine of 16 federal states (Fig. 2b). 74 are located in  
310 protected areas, including 29 within Natura 2000 sites. For Baden-Württemberg, data  
311 licensing restrictions stated by the relevant compensation agency meant we were able to view  
312 offset locations, but not analyse the data for reproduction elsewhere. We therefore include the  
313 estimated area occupied by offsets in Baden-Württemberg only (Table 2). Another state  
314 (Mecklenburg-Vorpommern) was noted to contain 179 compensation pools, but no location  
315 data were available. The **minimum** area occupied by the 467 (288 + 179) compensation  
316 pools considered here (spatial information was only available for 38% of projects), plus the  
317 area reported by Baden-Württemberg, was 23.7 km<sup>2</sup>. This is less than some estimates: e.g.  
318 according to Battefeld (2012), in Hessen alone, 191.5 km<sup>2</sup> are recorded in the compensation  
319 registry (see Wende et al., 2015). The majority of habitats in compensation pools were  
320 grasslands or wetlands. Data on German offsets do not generally link compensation pool to

321 specific development projects, so we were unable to determine the proportion of offsets  
322 implemented by sector.

323

324 In summary, data transparency in Germany was highly variable by state, with no offset data  
325 available for some yet sufficient data for answering questions 1 – 6 (see Methods) in others.  
326 Data were only transparent for offsets delivered in compensation pools in Germany, so we  
327 could not answer questions 7 – 9 (associated developments) for any state. Up to half of the  
328 states in Germany could be considered transparent regarding offset data (Table 1).

329

### 330 3.1.3 *The Netherlands*

331 Forest offsets have existed since the Forest Act came into force in 1961, which have been  
332 complemented by offsets for species and habitats of conservation concern in 1998 with the  
333 enactment of the Flora and Fauna Act and the Nature Conservancy Act (van Teeffelen, in  
334 press). These three laws have been merged in 2017 into a new Nature Conservation Act and  
335 applies to Natura 2000 sites, other sites of the National Nature Network and species of  
336 conservation concern. For habitats the provisions have stayed the same, for species they  
337 have been aligned more closely to the EU Birds and Habitats Directives (van Teeffelen, in  
338 press). Since 2007, responsibility for keeping an offset registry has rested with the 12  
339 provinces, to which municipalities are obliged to report on offset project status. No national  
340 database of Dutch offset projects exists. The Netherlands Court of Audit recently concluded  
341 that offsetting practice had improved since 2007, thanks to clarifications of roles and  
342 responsibilities and reduced complexity, but: “Provinces do not have good insight/overview of  
343 the offsetting that has been required through permits. There are no guidelines for registration  
344 leading to gross variations in the process and an inability to compare information across  
345 provinces” (Algemene Rekenkamer, 2014). Information on all offsets in the Netherlands is  
346 ostensibly available online through individual planning permits<sup>3</sup>. Extracting that information,  
347 however, requires going through the documentation on a plan-by-plan basis. This is hindered  
348 by the webportal containing all spatial plans of which only a fraction involve offsetting, and,  
349 because no project list can be generated. Provinces are required to compile overviews of

---

<sup>3</sup> <http://www.ruimtelijkeplannen.nl>

350 offsets projects on an annual basis and monitor offsets, but these overviews are not  
351 commonly publicly available.

352

353 For two provinces, Noord-Brabant and Limburg, a list of offset projects could be accessed  
354 containing offset project names, municipality involved, and dates and phases of  
355 implementation and monitoring thereof. The Noord-Brabant list also mentions area of offsets.  
356 The Noord-Brabant dataset lists 74 projects (2005 – 2014), occupying 551 ha (Provincie  
357 Noord-Brabant, 2014). By sector, infrastructure development generated the most offsets  
358 (33.8%), but recreation and urbanisation were also well represented (Table A.2). Location  
359 data were obtainable for 35 projects (Fig. 2c). The Limburg dataset lists 38 projects (2005 –  
360 2011), totalling approximately 300 ha of offsets (Provincie Limburg, 2012). Progress is being  
361 made in Noord-Brabant with the launch of a webviewer<sup>4</sup>, where impact locations and offset  
362 locations will be projected on a map, further increasing transparency. Offset project details  
363 still have to be looked up in the individual planning permits. Following the research of the  
364 Southern Court of Audit regarding offset implementation, registration and monitoring in Noord-  
365 Brabant and Limburg (Zuidelijke Rekenkamer, 2013; 2014), the Court of Audit of the  
366 provinces Noord-Holland, Zuid-Holland, Utrecht and Flevoland (“Randstedelijke  
367 Rekenkamer”) announced similar studies during 2016/2017, suggesting progress regarding  
368 registration and monitoring of Dutch offsets.

369

370 All offsets in the Netherlands are restoration-based. In line with national guidelines, several  
371 provinces allocate offsets within the National Nature Network, where the government planned  
372 to create additional habitat but has not yet done so due to budget constraints. This should be  
373 accompanied by an extension of the total size of the National Nature Network, to avoid that  
374 offsets are used as a source of funding for protected areas – which could be considered  
375 ‘misuse’ of offsets (Maron et al., 2015; 2016b). Not every province ensured this extension, a  
376 point raised by a regional Court of Audit (Randstedelijke Rekenkamer, 2017). An important  
377 consideration regarding the Netherlands is that space is constrained for offsets, due to high  
378 land-use demand and a strict requirement for equivalence and spatial proximity between a

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<sup>4</sup> <http://kaartbank.brabant.nl/viewer/app/natuurbeheerplan>

379 specific development and the associated offset (Broekmeyer et al., 2012) – an emerging  
380 challenge for offsets more generally (Vanderduys et al., 2016). This has resulted in payments  
381 of in-lieu fees instead of physical compensation, managed by the Dutch National Fund for  
382 Rural Areas (*Groenfonds*), amounting to €145m (2015) (Nationaal Groenfonds, 2015).

383

384 In summary, information on existing offset projects in the Netherlands could be considered  
385 transparent for one province (Noord-Brabant), although information is still scattered. The data  
386 enable us to readily answer questions 1 – 6 for this province. Otherwise, offset data sufficient  
387 to answer all questions in the Netherlands are available in principle, but not transparent  
388 (Table 1).

389

#### 390 3.1.4 *Sweden*

391 Unlike the other countries in this study, aside from mandatory requirements resulting from the  
392 EU Birds and Habitats Directives, there is no specific national NNL requirement in Sweden.  
393 However, the Environmental Code enables regional authorities to demand full compensation  
394 for significant residual impacts through the planning process (Tucker et al., 2014). As a result,  
395 there are numerous examples of individual development projects that have been required by  
396 regional authorities to quantitatively deliver full ecological compensation for impacts, meeting  
397 our definition of offsetting. The nature of this legislative structure means there is no regulatory  
398 requirement for offset databases to be maintained. So, unlike the other three countries we  
399 studied, national experts directed us to online reports containing lists of developments for  
400 which offsets had been required, and we collected information regarding the type of  
401 compensation through planning permissions and environmental impact assessments. Our  
402 findings on offset implementation were compared to findings in an article published by  
403 Persson et al. (2015), who identified Swedish offset projects by surveying 141 officials  
404 “handling nature-conservation cases” for regional authorities. In both the Persson report and  
405 our own dataset, habitats targeted in Sweden are primarily wetlands and stonewalls (i.e. old  
406 dry stone walls constructed to demarcate field boundaries, which now provide important  
407 invertebrate habitat).

408

409 We obtained data on 44 offsets. For all but two, locations of the associated developments  
410 were established, and as associated offsets were required to be in close proximity, these  
411 were used as approximate offset locations (Fig. 2d). One was located in a protected area.  
412 Sectors implementing offsets are overwhelmingly infrastructure or energy (Tables 2, A.1). The  
413 majority of projects implemented involve some proactive management action i.e. habitat  
414 restoration, mainly on public land. Most projects involve active management (68.1%), financial  
415 payment to new or existing conservation activities (13.7%), or the protection of existing  
416 habitat against likely drivers of decline (6.8%). For comparison, Persson et al. (2015)  
417 identified 37 compensation projects (primarily infrastructure development).

418

419 In summary, offset data in Sweden can be considered transparent for the whole country, and  
420 sufficient to enable us to answer questions 1 – 9 (see Methods). But it should be considered  
421 that no one official database exists of offsets in Sweden, so it is only the fact that a relatively  
422 small number of offset projects exist in Sweden that makes these data effectively accessible.

423

## 424 **4.1 Discussion**

### 425 4.1.1 *Data transparency*

426 For all four countries we studied, comprehensive information on offset projects is not yet  
427 systematically collated, digitised and disseminated on a national scale; and cannot be  
428 accessed remotely. There would likely be resource costs associated with improving offset  
429 data transparency. However, a conceptual pre-requisite for offsets is quantitative  
430 demonstration to stakeholders that biodiversity losses and gains associated with a  
431 development are balanced (BBOP, 2012; Bull et al., 2013). Consequently, the cost burden of  
432 monitoring is no argument for non-transparency. While other European countries have  
433 implemented some offsets (e.g. Spain, UK), these four countries are considered leading  
434 practitioners in Europe for offset implementation (Tucker et al., 2014). Comprehensive  
435 assessment of these four nations alone thus likely captures a substantial proportion of all  
436 implemented offsets in Europe.

437

438 For context, consider Australia and the US, which are leading countries on the  
439 implementation of NNL policies worldwide (Bull et al., 2013). Australia collates transparent  
440 online regional datasets on offsetting for most states, including associated developments (e.g.  
441 May et al., 2016). The US is the only country in the world that, to our knowledge, collates a  
442 transparent national dataset on offsetting: the Regional In-Lieu Fee and Bank Information  
443 Tracking System (RIBITS) (Table 1; US ACE, 2015). However, the quality and completeness  
444 of these data are questionable (Robertson & Hayden, 2008; BenDor et al., 2009), and  
445 information on associated developments is not easily extracted from the database (see  
446 Introduction). In general, offset data appear to be more comprehensively transparent for  
447 countries with more mature NNL policies (Australia, Germany, the US; Table 1), and so  
448 availability will perhaps also improve over time for countries with emerging offset policies such  
449 as Denmark, Belgium or the UK (Maron et al., 2016a).

450

451 More broadly, no country in the world records implementation of all stages of the mitigation  
452 hierarchy under NNL policy. Whilst understanding the scale and distribution of implementation  
453 does not automatically enable an assessment of how and where NNL is being used  
454 effectively in practice, the lack of accessible data almost certainly *hampers* efforts to  
455 determine this. Constructing a global picture of NNL implementation, or even offset  
456 implementation, would be an important step towards assessing efficacy for nature  
457 conservation. Nations implementing NNL should ensure that offsets and other NNL measures  
458 are tracked, carefully monitored, and records maintained. The availability of geo-referenced  
459 data would also allow NNL to be linked to landscape-level planning, and strengthen broader  
460 conservation policies – particularly where some degree of flexibility is permitted in NNL  
461 policies (Bull et al., 2015).

462

#### 463 4.1.2 *Tackling barriers to data transparency*

464 Potential barriers to data transparency that we noted include: lack of regulatory requirement;  
465 lack of political will; lack of clarity on requirements or the capacity to meet them; no protocols  
466 for combining sub-national datasets; and, heterogeneity in data formats.

467

468 Concerning a lack of regulatory requirements to compile databases (Sweden), or if there is a  
469 perceived lack of necessity or capacity to fulfil such requirements on the part of authorities  
470 (the Netherlands). Sufficient institutional capacity (e.g. financial and human resources) is  
471 needed to systematically collect, verify, display and maintain offset data (BenDor et al., 2009;  
472 Brown et al., 2014; Maron et al., 2016a; Bull et al., 2017). Placing and enforcing a  
473 requirement upon the original developer to adequately fund monitoring and reporting for any  
474 offsets associated with their developments could overcome this barrier (Maron et al., 2016a).  
475 It is possible that regulatory requirements to monitor and report on offsets could be developed  
476 around existing EU policy, such as the Habitats or EIA Directives, thereby obviating the need  
477 to construct entirely new regulatory obligations (Tucker et al., 2014).

478

479 Other authors have noted that transparency in NNL could be politically unpalatable (Maron et  
480 al., 2016a). In spite of this, the recent introduction of a legal requirement to report offset  
481 implementation appears to be driving more transparent reporting in France, where the on-  
482 going creation of a national offsets database represents a response to concerns about offsets  
483 being a 'license to trash'. Likewise, in the Netherlands, the clarification of offset registration  
484 and monitoring responsibilities (and raised awareness thereof by the Court of Audit) also  
485 appears to be driving transparency at the regional level. We therefore consider it likely that  
486 transparent reporting on offsets, and NNL in general, will only become standard where  
487 reporting is explicitly required and encouraged through policy or legislation.

488

489 When there is no consistent national framework for offset data reporting and collation, it  
490 becomes problematic to combine available offset data collated at sub-national level.

491 Transparent implementation databases are necessary to evaluate whether offsets have likely  
492 enabled delivery of NNL of biodiversity on development projects. For this purpose, the data  
493 should include answers to the questions 1 – 9 asked here (Methods) as a bare minimum,  
494 including extent and type of impacts (BenDor et al., 2009). Preferably, the data should provide  
495 more extensive information on offsets as per categories outlined by Bull et al., (2013; e.g.  
496 equivalence rules, counterfactuals used for evaluation, time lag between development losses  
497 and offset gains, magnitude of multipliers incorporated, etc.). It is insufficient to consider the

498 outcomes of NNL policies at any one scale, and so databases must be designed to allow  
499 analysis from project up to a landscape (e.g. national) scale, where the latter would include  
500 assessments of spatial and temporal redistribution of ecological components (BenDor et al.,  
501 2007; Robertson & Hayden, 2008; BenDor et al., 2009). Due to differences between country  
502 NNL policies and approach to offset implementation, a standard international reporting  
503 framework on offsetting is currently likely unfeasible – but there is a need for countries to  
504 develop coherent national standards for offset data.

505

506 Extracting and analysing information in different formats is problematic. The approach of  
507 listing offset projects online alongside a map of locations (Germany, the Netherlands) was  
508 particularly time-consuming in terms of extraction and analysis, and liable to cause  
509 researchers to introduce uncertainties e.g. in spatial location. Vastly preferable was the  
510 availability of offset data for immediate download in a combination of spreadsheet (.csv, .xcl)  
511 and spatial (.shp, .tif) data formats (France). Consequently, it would be insufficient to consider  
512 only the format in which offset data are to be captured, but not also the format in which they  
513 are displayed and disseminated.

514

515 In seeking to achieve improved offset data transparency, policymakers may already have  
516 specific methods in place for capturing and disseminating the relevant information. Where this  
517 is not the case, however, there are numerous extant databases – designed to capture  
518 information of direct relevance to conservation science and practice – which could serve as  
519 technical models. For instance: in terms of a database designed to collate information from  
520 multiple different sources and of variable types, including automatic data validation and  
521 maintaining traceability to sources, the PREDICTS database provides an excellent example  
522 (Hudson et al., 2014). Equally, in terms of a protocol for updating and maintaining a live  
523 database over a period of decades, as well as disseminating outcomes to the conservation  
524 community, the WDPA is a potential model (UNEP-WCMC, 2017). The largest national offset  
525 database in the world is currently RIBITS, but as mentioned above, the accuracy of this  
526 database has been questioned.

527

528 4.1.3 *Informing controversies around offsetting*

529 Controversies arise around offsets in part due to concerns about the actual conservation  
530 outcomes of NNL policy, and whether these are positive or negative (e.g. Schoukens &  
531 Cliquet, 2016). Again, this highlights the utility of transparent data on implementation, to  
532 inform such concerns.

533

534 The potential misuse of offsets in existing protected areas is a key theoretical controversy for  
535 NNL (Pilgrim & Bennun, 2014), but it has not previously been shown whether this is  
536 widespread practice in countries implementing offsets. Comprehensive versions of the  
537 datasets we collate here would enable such analyses. From our data, we can say that: in  
538 Germany, approximately a quarter of recorded 'offsets' involved activities within protected  
539 areas, in France it was closer to half, whereas in the Netherlands and Sweden the proportion  
540 was zero and < 3% (1 of 44) of projects respectively (Fig. 2). If similar findings were borne out  
541 across a more comprehensive dataset, it would suggest that the proportion of offsets  
542 *implemented* in protected areas is low. In turn, this would imply that concern about regulatory  
543 offsets being misused to support protected areas could in practice be a moot point for certain  
544 countries.

545

546 Similarly, concerns have been raised that offsets too often resort to averted loss measures  
547 that, despite being valid against appropriate counterfactuals (Bull et al., 2014), are considered  
548 open to abuse (Gordon et al., 2015) and poor accounting (Maron et al., 2015). But our data  
549 suggest that most offsets involve active management e.g. habitat restoration. Again, if  
550 developers rarely resort to averted loss, the associated controversy is of little relevance. The  
551 debate around both issues is of course more nuanced – for instance, a greater proportion of  
552 offsets outside of Europe might, and perhaps should, involve existing protected area  
553 commitments if they would otherwise be insufficiently financed (e.g. Hardner et al., 2015). But  
554 our point is that improving transparent reporting of offset implementation would allow more  
555 empirical exploration of such topics, and the opportunity to draw more robust and  
556 generalizable conclusions about offsetting.

557

#### 558 4.1.4 *Limitations*

559 All data were collected remotely, and we did not visit the offset projects themselves for  
560 verification. Nonetheless, since information was generated by public authorities and by  
561 commercial enterprises, it was considered sufficiently reliable for the purposes of our study.  
562 We primarily relied upon experts to confirm the absence of any additional accessible relevant  
563 datasets for each country, and supported this by consulting existing literature reviews (Bull et  
564 al., 2013; Calvet et al., 2015). We accept that it is difficult to prove no additional datasets  
565 exist, however, any available data not uncovered using the process described here would  
566 arguably fail to meet our criteria of 'accessibility', and we can therefore assume they are non-  
567 transparent.

568

569 By seeking at least three contacts in each country, representing a range of interests, we  
570 sought to reduce knowledge and information bias in the responses of experts consulted.  
571 Since we were asking for the existence and location of datasets rather than for any opinion on  
572 NNL or offsetting *per se*, our questions required primarily objective responses. However, our  
573 sample of experts was small, and consequently there may be some bias towards  
574 classification of projects into offsets, or a lack of knowledge about the existence of additional  
575 data. Whilst we acknowledge knowledge bias, other studies corroborate that our approach  
576 resulted in essentially comprehensive data capture for Sweden (Persson et al., 2015), and  
577 greater data capture than studies for other countries (Bennett et al., 2017).

578

579 We have focused here upon biodiversity offsetting, although noting that offsets should always  
580 be seen as part of the broader mitigation hierarchy. Quantitative assessment of the  
581 implementation of other stages of the hierarchy (e.g. avoidance measures) is more  
582 problematic than for offsets, as such measures can be less physically tangible, though  
583 absolutely necessary (Phalan et al., 2017). Ultimately, assuming that avoidance is more  
584 desirable from a biodiversity conservation perspective than offsetting, the implementation of  
585 avoidance measures would be a stronger indicator of NNL effectiveness.

586

## 587 5.1 **Conclusion**

588 To conclude, there is a lack of data transparency obstructing comprehensive assessment of  
589 the actual use of biodiversity offsetting, and the broader implementation of NNL policy. In turn,  
590 this limits progress on important conservation questions related to offsetting, such as what  
591 type of compensation interventions work, and under which circumstances. In Europe and  
592 elsewhere offset datasets are being built at regional and national levels, however, much work  
593 is still to be done, including overcoming technical and political barriers. If and when  
594 comprehensive offset databases are made available, analysts will be able to provide  
595 quantitative insights into NNL practice. Such insights will prove highly informative with regards  
596 to offset implementation globally. Centralised data repositories that enable authorities,  
597 financiers, shareholders and the public to scrutinise the state of implemented offsets will be  
598 an essential step towards ensuring effective NNL.

599

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610

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760 **Table 1:** *Headline summary of data transparency for the four countries studied, with Australia*  
 761 *and US for comparison (Bull & Strange, unpublished data)*  
 762

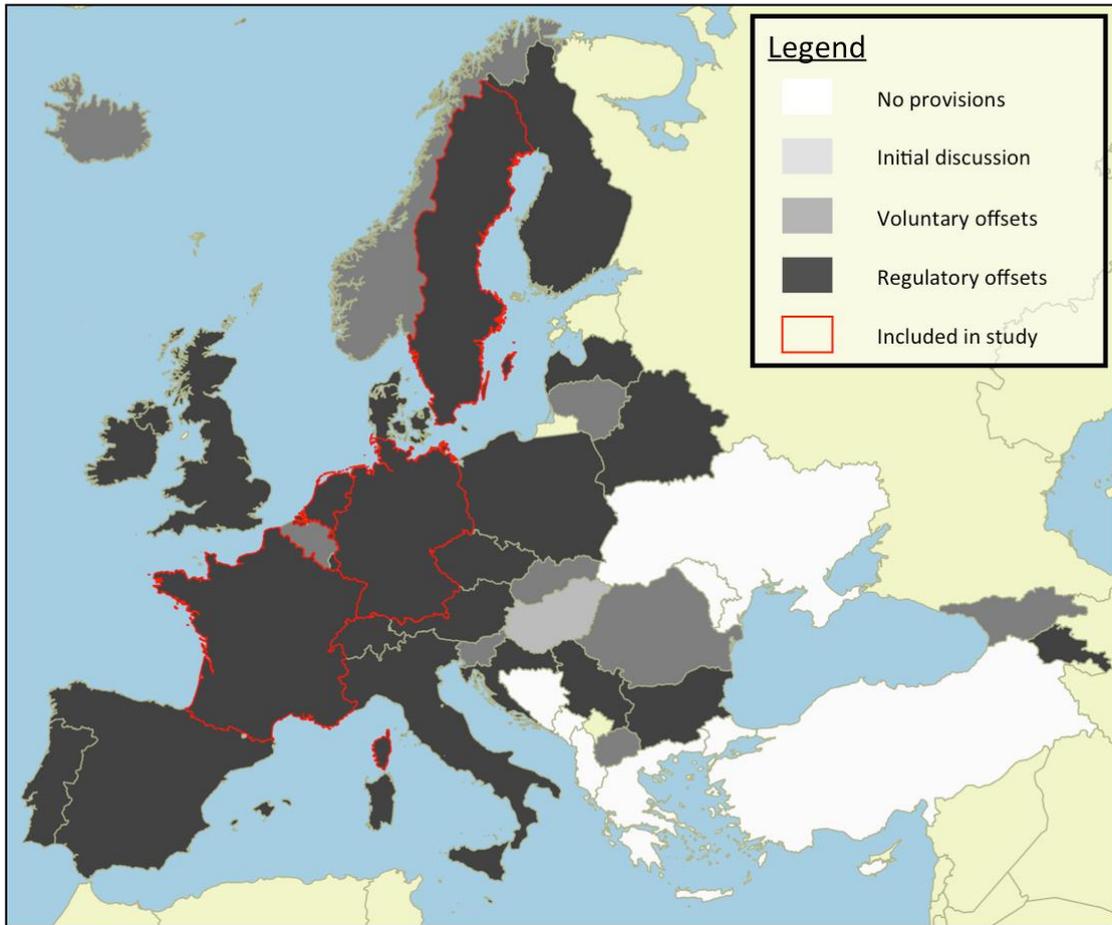
<b>Country</b>	<b>Data available</b>	<b>Data accessible</b>	<b>Regionally collated</b>	<b>Nationally collated</b>	<b>Number of regions covered (of total)</b>
France	Yes	<i>Limited</i>	<i>In progress</i>	<i>In progress</i>	1 (27)
Germany	Yes	Yes	<i>Partial</i>	<i>In progress</i>	9 (16)
Netherlands	Yes	<i>Limited</i>	<i>In progress</i>	<i>No</i>	2 (12)
Sweden	Yes	Yes	<i>No</i>	<i>No</i>	24 (24)
Australia	Yes	Yes	Yes	<i>No</i>	4 (6)
US	Yes	Yes	Yes	Yes	50 (50)

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764 **Table 2:** Data summary for the countries studied, including known offset locations, area  
 765 occupied by offsets, number in protected areas, and main sector implementing offsets  
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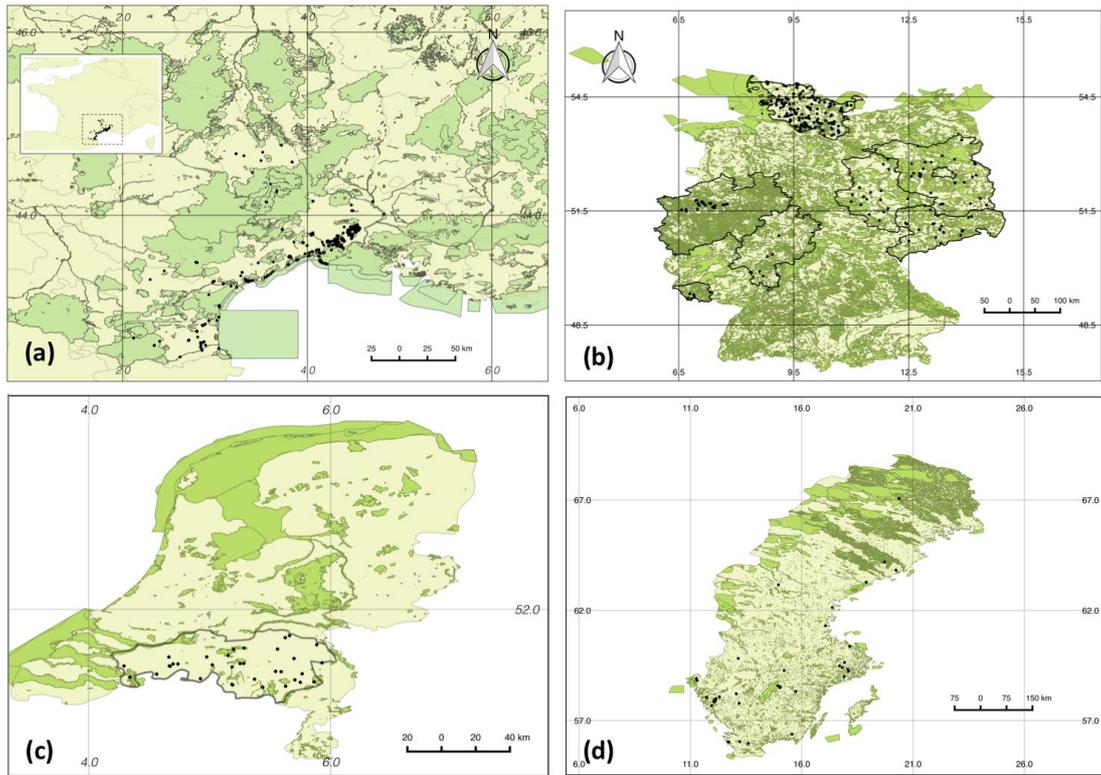
Country	Biodiversity offset locations	Corresponding area (km <sup>2</sup> )	# in Protected Areas	Main sector (%)
France	87 mapped	28.41	~ 40	Infrastructure (>68)
Germany	288 mapped 467 known	23.70 -	74 -	-
Netherlands	35 mapped 112 known	5.51 ~ 8.51	0 -	Infrastructure (33.8)
Sweden	42 mapped 44 known	- -	1 -	Infrastructure (68.2)

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770 **Figure 1:** Map of Europe, showing current biodiversity offset policy status for all countries  
 771 contained within the GIBOP dataset (available at: <https://testportals.iucn.org/offsetpolicy>), and  
 772 according to the classification scheme from the same dataset. The boundaries of the four  
 773 countries included within this study are highlighted in red.



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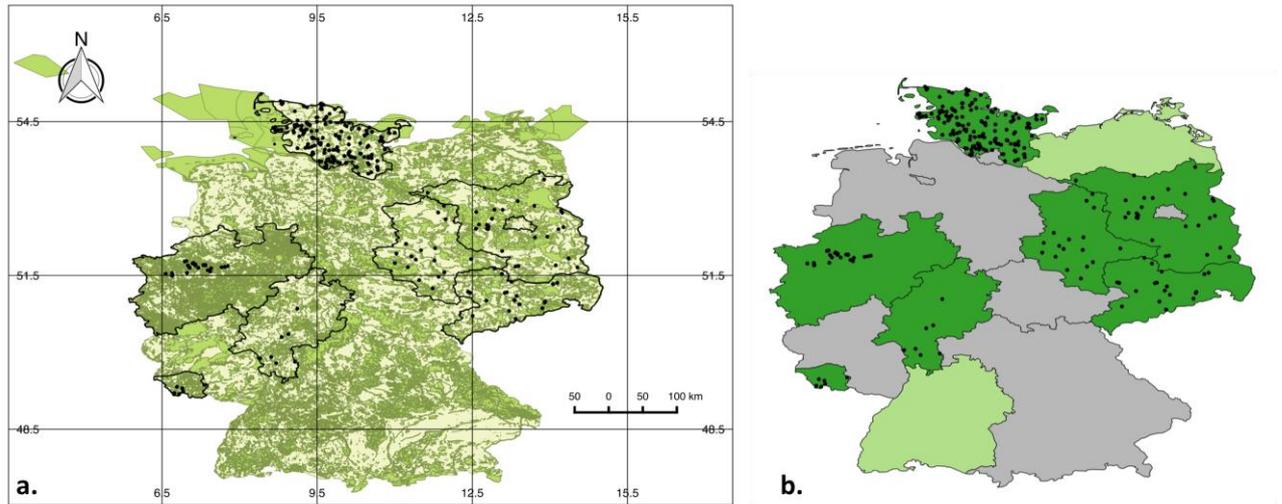
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**Figure 2:** Maps of offset projects (black points) and protected areas contained in the WDPA (shaded green), for the four countries. (a) Languedoc-Roussillon province, France. Inset map of France, showing location of the province. (b) Germany. (c) The Netherlands. Location data available for Noord-Brabant province only, the border for which is marked in black. (d) Sweden.



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781 **Figure 3:** Variability of data transparency by state, for offsets in Germany. (a) Map of  
 782 identified compensation pools, and protected areas (shaded green), as per Figure 2. (b) Dark  
 783 green = states with location data, light green = data on area occupied by compensation pools  
 784 only, grey = no data.