

1 Challenges and pathways for matching corporate value-chain 2 biodiversity losses and gains

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18 Keywords: biodiversity gains, impacts, corporate, claims, value-chain, compensation, biodiversity credit

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20 **1. Abstract**

21 In the context of ambitious global biodiversity goals, the need to compensate for the impact of
22 corporate activities is no longer restricted to direct impacts but extends to the entire value-chain
23 of corporates. This is challenging, considering the substantial uncertainties involved in
24 measuring corporate value-chain biodiversity losses and gains, which render their comparison
25 difficult. Corporates run the risk of taking inadequate action and making compensatory
26 statements that are not supported by equivalent losses and gains, potentially exacerbating loss
27 of biodiversity instead of supporting its recovery and leading to reputational and financial risks.
28 Here, we highlight uncertainties that pertain to the metrics used for biodiversity loss and gain
29 measurements and approaches that can be used to match these metrics. We then suggest a simple
30 framework for corporates to evaluate the risk of making a compensatory claim, based on the
31 level of uncertainty on value-chain biodiversity impacts, to reduce the risk of making
32 inappropriate statements.

33 **2. Addressing value-chain impacts on nature**

34 Compensation of corporate – referring to businesses and companies – value-chain impacts on
35 nature has existed for years in the realm of the climate, where carbon offsetting has been used
36 to help achieve goals such as carbon neutrality and Net Zero (Hale et al. 2022; Trouwloon et al.
37 2023). However, whilst there are examples of individual effective carbon offsetting projects
38 (West et al. 2023; Malan et al. 2024), rigorous evaluation of the schemes overall has revealed
39 concerning shortcomings. Assessments that allowed proper quantification of additionality,
40 leakage and impermanence – in a way that was not (and still largely is not) standard practice in
41 carbon credit design (Balmford et al. 2023; Swinfield et al. 2024) – identified that several
42 leading initiatives were often overestimating the carbon benefits from their projects (West et al.
43 2020, 2023; Greenfield 2023). Today, a contribution approach is gaining traction, whereby
44 carbon credits can still be purchased, but are not used to offset emissions. Corporates can simply
45 state they have contributed to mitigating climate change, either through the purchase of these
46 credits, or funding of projects that have climate benefits, whether proven yet or not (Blanchard
47 et al. 2024). Ideally all carbon mitigation and adaptation projects would have robust and proven
48 carbon benefits, but when used to compensate for residual emissions, the importance of robust
49 outcomes becomes higher, to avoid deepening the climate crisis and negatively impacting
50 corporates. Indeed, the consequences of green-washing are understood as a real risk (Flood
51 2023): while engaging in corporate social responsibility (CSR) activities, including pro-
52 environmental actions, can benefit a firm (Albuquerque et al. 2019), false claims can raise
53 reputational, regulatory or even litigation risks (Kitzmueller & Shimshack 2012; Setzer &
54 Higham 2022).

55 Biodiversity globally is in decline, while carbon emissions continue to increase (Richardson et
56 al. 2023). Corporates could play a major role in halting or reversing biodiversity loss by learning
57 from mistakes made in the carbon realm and developing robust biodiversity strategies to
58 mitigate their impacts on nature (Folke et al. 2019). Biodiversity offsets of direct and local
59 impacts have been used for decades in such strategies, either as part of regulatory schemes or
60 on a project-by-project basis (Damiens et al. 2021; Maron et al. 2025). As with carbon, whilst
61 there have been examples of effective biodiversity offsets (Devenish et al. 2022), evaluations
62 have identified that many have failed to meet their objectives of delivering no net loss (NNL)
63 or net gain of biodiversity (zu Ermgassen et al. 2019; Josefsson et al. 2021; zu Ermgassen et al.
64 2023). Alignment between offset quantification and recognised ecosystem accounting methods
65 is also lacking to ensure standardised practice (Czucz et al. 2025). Furthermore, if corporates
66 want to reach ambitious biodiversity goals aligned with global goals and contribute to Nature
67 Positive (Locke et al. 2021), they should measure and compensate not only for their direct

68 impacts, but also for more diffuse impacts occurring throughout their value-chain (Milner-
69 Gulland et al. 2021; Panwar 2023), e.g. in upstream supply chains, after application of the
70 mitigation hierarchy (Maron et al. 2023). Biodiversity credits – units of commodified
71 biodiversity gain (Wauchope et al. 2024; Wunder et al. 2025) – could be a lever to scale-up
72 ecosystem restoration and biodiversity conservation (Antonelli et al. 2024), and provide an
73 avenue for value-chain level offsetting (Wunder et al. 2025). However, despite the recent
74 development of promising methods to increase credit robustness (Swinfield et al. 2024), the
75 science supporting biodiversity credits is struggling to keep up with the momentum for their
76 use.

77 Experience with carbon offsets and local biodiversity offsets of direct impacts show that
78 matching of losses and gains is challenging (Kujala et al. 2022). Underlying such matching is
79 the concept of ecological equivalence: losses and gains should be comparable in their type,
80 condition, location and possibly timing, on top of their quantity (achieving at least NNL)
81 (BBOP 2012). Beyond ecological aspects, equivalence in location is an important consideration
82 as biodiversity can provide many local values and services (zu Ermgassen et al. 2020). More
83 generally, social outcomes caused by compensatory activities to impacted communities need to
84 be considered too (Griffiths et al. 2019a, 2019b). When considering the entire value-chain,
85 compensation of biodiversity impacts comprises extra layers of complexity, in particular due to
86 the change of scale from local to potentially global, and the difficulty of demonstrating
87 equivalence (Maron et al. 2023). International offsetting through the use of biodiversity credits
88 is not supported by the International Advisory Panel on Biodiversity Credits (IAPB 2024).
89 Furthermore, value-chain impacts can be the largest portion of many corporates' impacts on
90 biodiversity and nature (Bull et al. 2022; Peura et al. 2023; Finance for Biodiversity Foundation
91 2024). There is thus a potential large demand for avenues that could allow compensatory gains
92 to help address these impacts. However, just as for carbon, making inaccurate statements on
93 biodiversity benefits and compensation actions entails reputational risks (zu Ermgassen et al.
94 2025), and has risks for biodiversity itself if compensatory actions are insufficient or
95 inappropriate responses to the losses. Scientific guidelines for setting targets, designing
96 offsetting strategies and corresponding claims can help mitigate these risks (“Combat corporate
97 greenwashing with better science” 2023; Simmonds et al. 2024; Science Based Targets
98 Network 2024), but are currently limited for value-chain impacts. Below, we highlight various
99 sources of uncertainty in corporate value-chain biodiversity loss and gain measurements – with
100 a particular focus on mismatches of the metrics used –, suggest avenues for reducing uncertainty,
101 and provide a simple framework to guide corporates to take robust actions to address their
102 value-chain net biodiversity impacts.

103 **3. Sources of uncertainty when measuring losses and gains**

104 Some of the uncertainties in corporate loss and gain measurement will not be resolved in the
105 foreseeable future; true impacts on biodiversity can never be fully quantified, since inherently
106 nature does not respond in expected ways, and yet undiscovered species are by definition
107 unknown, so impacts on them can also not be measured. The spatial distribution of species and
108 ecosystems on Earth is also imperfectly known (Cazalis et al. 2022), and the dynamic nature of
109 biodiversity makes it unlikely that it will ever be perfectly mapped out. We do not further
110 discuss these uncertainties, and focus below on those for which there are avenues for
111 improvement.

112 *3.1. Uncertainties in loss measurements*

113 Estimates of corporate value-chain impacts are often hindered by limited data availability on
114 corporate activities (White et al. 2023) and the complexity of global value-chains (Bromwich
115 et al. 2025). Corporates do not always know precisely where negative impacts are happening
116 beyond direct operations, due to poor supply chain traceability (zu Ermgassen et al. 2022). In
117 addition, some of the negative effects of their activities are diffuse. For example, GHG
118 emissions contribute to global climate change, which affects all biodiversity, while pollution of
119 flowing freshwater can affect biodiversity far from the initial point of pollutant emission
120 (Verones et al. 2020). Hence, assessments of loss may need to make assumptions about the
121 locations of impacts.

122 Even if each location was known, measuring biodiversity loss at each point of the value-chain
123 is unfeasible at present for many corporates. Thus, corporates frequently use globally applicable
124 modelling approaches to estimate biodiversity loss, in corporate impact assessment and
125 reporting contexts (De Ryck et al. 2024). Some approaches model community-level impacts.
126 An example is the GLOBIO model (Schipper et al. 2020) which estimates how biodiversity will
127 change due to changes in a given pressure (such as land use or climate change), based on
128 underlying pressure-impacts relationships between pressures on biodiversity and the abundance
129 of species in the ecosystems, using the metric Mean Species Abundance (Hawkins et al. 2023).
130 This metric is used in several corporate biodiversity impact assessment tools (CDC Biodiversité
131 2023). Other approaches model species-level impacts, such as the Species Threat Abatement
132 and Restoration metric (STAR) (Mair et al. 2021), which combines information on species
133 threat status, area of habitat and exposure to threats from the IUCN Red List, and can be used
134 by corporates to help assess impacts (TNFD 2023). Whilst making use of the best available data,
135 these approaches can be highly uncertain, with taxonomic biases and data gaps in the underlying
136 datasets (Hawkins et al. 2023). Further, for value-chain assessments, approaches that use
137 species-specific location data need to be paired with location data from corporate activities,

138 which is often limited. Measurements made using such modelling approaches thus inherit the
139 models' inherent uncertainties (Bromwich et al. 2025).

140 *3.2.Uncertainties in gain measurements*

141 Biodiversity gains do not materialise instantly or linearly (Schipper et al., 2016): after pressure
142 reduction or implementation of restoration actions, time is needed for species to colonize the
143 habitat or for populations and ecosystems to recover (Jones et al. 2018; Pedersen et al. 2023;
144 Chen et al. 2023). Gains can be projected ex-ante – the measurement is a projection of the
145 expected gain – or measured ex-post – at a point chosen in time after the restoration or
146 conservation actions have been implemented. Ex-ante projections are no replacement for the
147 ongoing monitoring evaluating whether biodiversity is changing in alignment with the ex-ante
148 projection (Maron et al. 2012; Jones et al. 2018; Swinfield et al. 2024). Such monitoring is not
149 always possible however, especially over extended periods.

150 Gains are usually measured based on site-level biodiversity data, which are therefore more
151 representative of changes in biodiversity on-the-ground than metrics obtained through
152 modelling approaches used to measure losses in value-chains. However, they are still associated
153 with uncertainties. In the offsetting context, the metrics often used focus on ecosystem extent
154 and condition (Marshall et al. 2020; Duffus et al. 2024). For example, the habitat hectares metric
155 is calculated as habitat extent multiplied by a score of its condition, established by scoring
156 components such as tree cover or the presence of weeds (Parkes et al. 2003). In crediting
157 schemes, multiple metrics on species, populations and ecosystems are often used, combined
158 into a single value (Wauchope et al. 2024). For example, the methodology developed by Plan
159 Vivo combines species richness, species diversity, taxonomic dissimilarity, habitat health and
160 habitat spatial structure (Plan Vivo & Pivotal 2023).

161 Some metrics in leading schemes, such as England's Biodiversity Net Gain policy – which
162 renders achieving a net biodiversity gain of 10% mandatory in development projects
163 (Parliament of the UK n.d.) – have been shown to have limitations in terms of how
164 representative they are of different components of biodiversity (zu Ermgassen et al. 2021;
165 Duffus et al. 2024). Metrics in emerging crediting schemes run also the risk of misrepresenting
166 some aspects of biodiversity affected in projects, such as those that are not quantifiable, or by
167 allowing fungibility between contrasting biodiversity components (Wauchope et al. 2024).

168 Credible counterfactuals are also typically lacking to prove that actions designed to cause
169 biodiversity gains truly cause the expected uplift (Maron et al. 2015). There is a lack of
170 standardised biodiversity 'control' data to establish appropriate counterfactuals or baselines
171 (Wauchope et al. 2024). This contrasts with the abundance of remote sensing data for

172 estimations of the counterfactual in the context of forest carbon offsets (Swinfield et al. 2024).
173 Therefore, evaluations of biodiversity outcomes per se are rare (Wauchope et al. 2022), and are
174 often based on proxies such as changes in land cover (Jones & Shreedhar 2024; Wunder et al.
175 2024).

176 **4. Reconciling differences in metrics for losses and gains**

177 While sources of uncertainty hinder corporates' ability to make strong statements about their
178 negative and positive biodiversity impacts, the issue of differences in the metrics used for losses
179 and gains is also challenging. Metrics for value-chain losses and site-level gains are usually
180 incompatible: they measure different components of biodiversity, are expressed in different
181 units, and have differing levels of uncertainty. Gain metrics usually interface more directly with
182 nature and have higher resolution and ecosystem specificity. Comparing losses and gains
183 expressed with different metrics comes with the risk of making compensation efforts that are
184 challenging to verify, inadequate, or poorly targeted.

185 One option to aid comparison of corporate value-chain losses globally and local biodiversity
186 gains would be to identify and utilise metrics that can measure both. As an example, MSA is
187 commonly used for loss evaluations using modelled values, and can also be quantified based
188 on local measurements, if abundance data for multiple species, and ideally taxa, are gathered
189 for both disturbed or restored and natural reference sites. In fact, such local abundance data
190 underpin the pressure-impact relationships required to calculate modelled MSA (Schipper et al.
191 2020). More comprehensive surveys across different activities, pressures and geographies
192 would allow estimation of more granular MSA values, which could in principle be used to
193 estimate site-specific gains. However, at present, models are too generic to allow for context-
194 specific assessments of biodiversity changes at a site level, making comparison of losses and
195 gains challenging. Such improvements would require vastly more comprehensive and detailed
196 datasets reporting changes in species abundance under different management scenarios in
197 different geographic contexts (Kuipers et al. 2023). The Nature Positive Initiative is developing
198 guidance on state of biodiversity metrics that can be used by corporates, to assess both increases
199 and decreases in ecosystem extent and condition, as well as population sizes and species
200 extinction risk (Nature Positive Initiative 2025). Application of these metrics requires location-
201 specific data (Nature Positive Initiative 2025). If corporates can obtain all required data, this
202 could facilitate matching losses and gains. Quantifying losses and gains at site scales with
203 identical metrics thus appears theoretically feasible in the future, if based on sufficiently
204 detailed biodiversity outcome data. This would avoid extending the uncertainties from the loss
205 measurement to that of the gain. However, even with this data and metric in place, it would still

206 be advisable to utilise multiple metrics to reduce the risk of not evaluating impacts on certain
207 facets of biodiversity (Durand et al. 2024).

208 Another option could be converting between one metric of biodiversity to another to allow
209 losses and gains to be matched. This has been attempted, in particular by Rossberg et al. (2024)
210 who showed how one could convert estimates of PDF to changes in extinction risk, using a
211 number of approximations. Rossberg et al. (2024) also propose using changes in extinction risk
212 (represented by the Biodiversity Impact Credit metric) as a metric to measure losses and gains
213 in biodiversity. However, converting corporate impacts – using approaches that rely heavily on
214 modelling – to measures of changes in the state of biodiversity, conceals large assumptions and
215 uncertainties made by the corporate impact measurement tools, adding large uncertainties into
216 the estimates of losses without necessarily making these explicit. This could introduce risks in
217 using these metrics as the basis for comparing losses and gains.

218 Finally, monetary valuation can be seen as a common metric for biodiversity losses and gains
219 (Díaz et al. 2015). Once losses are properly quantified, avoided, reduced and locally abated as
220 much as possible (Maron et al. 2023), monetary valuation can provide an estimation of the unit
221 cost of restoring biodiversity (TEEB 2010). This could guide a corporate monetary contribution
222 compensating for the total loss it has measured. However, such an approach adds uncertainty
223 and masks incomparability between losses and gains, since valuing biodiversity is difficult and
224 uncertain (OECD 2002; TEEB 2010). Further, it is only a proxy for biodiversity outcomes.
225 Implementation of restoration or conservation actions does not guarantee that biodiversity gains
226 will occur (Bullock et al. 2011; Sutherland et al. 2021), increasing uncertainty even more.

227 **5. Towards robust corporate biodiversity impact statements on compensatory actions**

228 At present, measuring and matching gains and losses for value-chain impacts is challenging,
229 representing a difficulty for corporates wanting to address their impacts on nature. To reduce
230 uncertainty, corporates can work to obtain better data on impacts using state of nature metrics,
231 at the granularity level appropriate for their biodiversity objectives, resources and for the
232 biodiversity that is affected (Nature Positive Initiative 2025). They can also work to improve
233 transparency in their value-chains (Gardner et al. 2019). It is also essential that the statements
234 corporates make regarding net impacts are aligned with the robustness of the data and
235 measurements they have available, considering the previously highlighted risks associated with
236 making claims that then expose corporates to reputational or litigation risk. This section seeks
237 to guide how corporates can compare value-chain losses and gains, and suggests appropriate
238 wording and principles for different forms of uncertainty. For example, if purchasing a

239 biodiversity credit to address value-chain losses, can that credit be stated as compensation or is
240 the data too uncertain?

241 *5.1. General good practice*

242 If compensatory claims were to be scientifically-credible, and before making such statements,
243 corporates would first need to ensure that the actions they wish to make claims about have been
244 performed in accordance with the mitigation hierarchy (Milner-Gulland et al. 2021; Maron et
245 al. 2023). They would then need specify the nature and magnitude of the losses and gains –
246 using metrics that support the statements made – as well as the uncertainty around those
247 measurements. If a statement is made about impacts on a specific species for example, the
248 metrics used for losses and gains must reflect impacts on that specific species. The period over
249 which impacts are counted must also be specified. This period can begin at the start of
250 operations, or at a baseline year where impact measurement started, or can represent a given
251 year of operations. Corporates must specify how gains are monitored over time, and what the
252 counterfactual scenario is (to justify that gains occur). Beyond biodiversity itself, guidance has
253 been written on how to leave people at least no worse off as a result of offset implementation
254 (Griffiths et al. 2019a). Such guidance should be followed for projects generating gains, in
255 particular by conducting social monitoring to evaluate the impact of a project on people
256 (Griffiths et al. 2019a) and involving those affected in decision-making (BBOP 2012).
257 Legitimate engagement with local stakeholders is essential, as local buy-in is critical to social
258 and economic success of a project (Löfqvist et al. 2023).

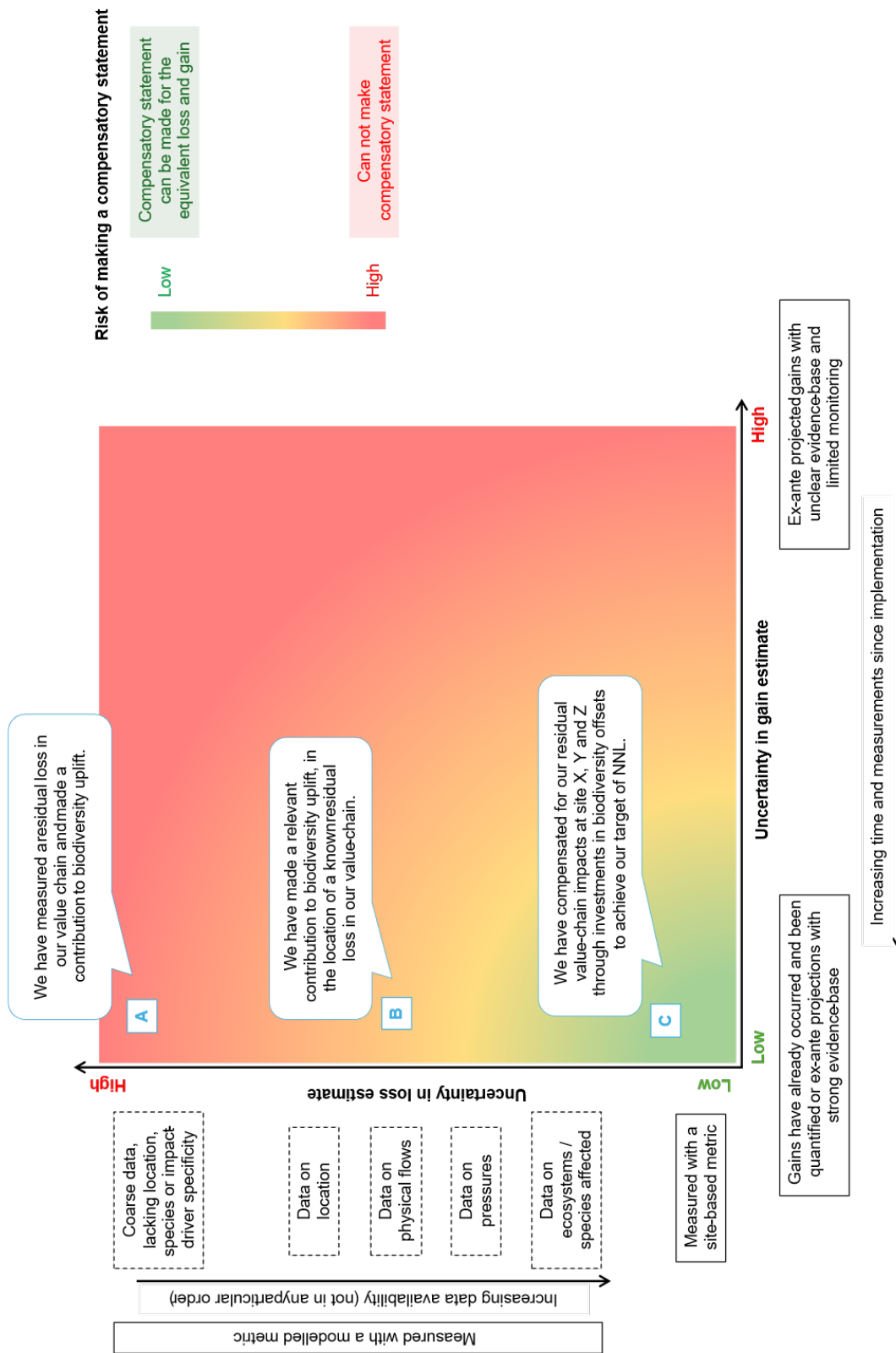
259 *5.2. Framework*

260 We suggest a framework to guide corporates in making compensatory statements about their
261 value-chain impacts on biodiversity (Figure 1). This framework indicates the level of risk
262 associated with a compensatory claim, as a function of the level of uncertainty in the gain and
263 loss measurements. Depending on these levels of uncertainty, corporates can better understand
264 the likelihood that the action on gains is adequately compensating for their value-chain losses,
265 and therefore the risks associated with making different kinds of statements. Gains that have
266 already happened (e.g. through habitat banking) and been quantified, or those for which the ex-
267 ante projections have a strong evidence-base, are on the lower end of the uncertainty spectrum,
268 while those that have only been projected through poorly supported ex-ante measurements are
269 the most uncertain. The level of certainty of the gain increases as time since the action elapses,
270 and monitoring of biodiversity outcomes is robustly and successfully performed. For losses,
271 those measured using site-based data are the least uncertain, while those measured with
272 modelled metrics have a higher level of uncertainty, depending on the quality of the corporate
273 input data. For example, if corporates only have financial data to estimate value-chain impacts,

274 evaluations of losses with modelled metrics will be highly uncertain. Use of more precise data,
275 for example on transformed or raw material use, or on pressures (e.g. ha of land use) or physical
276 flows (e.g. GHG emissions) (CDC Biodiversité 2021), can reduce the level of uncertainty of
277 the loss evaluation. The more precise and site-specific the data is when used to evaluate the
278 losses, the less uncertain the loss estimate becomes. Because it can be challenging to evaluate
279 which category of uncertainty a particular loss and gain falls into, we suggest taking the most
280 conservative approach – that is, assuming the most uncertain category until more evidence
281 suggests otherwise.

282 When uncertainty in the gains is high, it is likely that they are not matched appropriately to
283 losses. In this case, compensatory statements should be avoided completely. When uncertainty
284 is low for gains but high for losses, compensatory statements should be avoided for the same
285 reason. However, in this case the corporate can make a statement about its generic contribution
286 to a conservation/restoration action leading to the gains, without claiming that they compensate
287 for the biodiversity loss. As the level of uncertainty decreases for losses (still considering more
288 certain gains), risks associated with compensatory statements are reduced. If the level of
289 uncertainty of the loss is medium, but it can still be attributed to a dominant driver or it affects
290 a specific species or ecosystem, and if the (low uncertainty) gain alleviates that dominant driver
291 or benefits the same species or ecosystem (i.e. losses and gains are equivalent), then the
292 company can make a statement about a relevant contribution in terms of a particular
293 driver/taxon/ecosystem, although still without claiming compensation. Finally, if both loss and
294 gain uncertainty is low, and equivalency can be shown, then a compensatory claim can be made
295 with a low level of risk.

296 The significance of the biodiversity impacted should also be considered, that is the
297 irreplaceability and vulnerability of the affected area and species, respectively. Pilgrim et al.
298 (2013) have argued that the more irreplaceable and vulnerable the biodiversity affected, the
299 stronger the evidence required proving that biodiversity will not be worse off after an offset.
300 Similarly in our framework, the higher the irreplaceability and vulnerability of biodiversity
301 affected, the riskier a compensatory claim becomes. This would change where the red area lies
302 in Figure 1.



303

304 **Figure 1. Framework to evaluate the level of risk associated with a corporate value-chain level claim of**
 305 **biodiversity impact compensation. A, B and C refer to fictitious value-chain impacts and associated claims**
 306 **that could be made, illustrating corporate application of the framework. The colour scale is provided as an**
 307 **illustration: the size of the red area will look different depending on the irreplaceability and vulnerability**
 308 **of affected biodiversity.**

309

310 To illustrate the use of this framework, we describe its application to three types of value-chain
311 impacts for a fictitious agrifood company, in a case where the company has low uncertainty
312 gain measurements. If the company purchases a big piece of equipment, the impacts will likely
313 be poorly known and diffuse, since the equipment may be made from multiple composite parts
314 manufactured in many different parts of the world, brought together via a complex network of
315 different supply chains that may be challenging to track back to source and acquire an accurate
316 quantification of impacts.

317 In the first case, the agrifood company obtains an approximate estimate of the biodiversity loss
318 due to this purchase, measured with a modelled metric and using a corporate impact assessment
319 tool. It can then make a generic contribution to a low uncertainty conservation/restoration
320 project, without claiming that it offsets the impact of their purchase (case A, Figure 1). As a
321 second example, if the company imports cattle feed from a known location but with otherwise
322 limited information on the impacts, the company can contribute to conservation/restoration in
323 the vicinity of the location where the feed is produced – potentially in collaboration with other
324 businesses sourcing from the landscape. The area restored by the company’s action could be
325 commensurate to the estimated area needed to grow one year’s worth of the feed, or the money
326 contributed to restoration/to purchase credits could be commensurate to the cost of the feed.
327 The company can make a statement about this investment, stating that the contribution is in a
328 relevant location compared to one of their impacts, without claiming compensation (case B,
329 Figure 1). Finally, if the company converts land at a known location to pasture for cattle grazing,
330 it can purchase credits from a restoration project close to their pastures, in the same ecosystem
331 as the pastures, over a similar area of land, and targeting any specific species impacted by the
332 original land conversion. In this case, they can more confidently make a compensation
333 statement (case C, Figure 1). Such precautionary statements can contribute to more robust
334 tracking of corporate progress towards positive contributions to nature.

335 **6. Conclusion**

336 In practice, due to uncertainty and assumptions at multiple levels of the measurement processes,
337 perfect information is impossible to obtain for corporate biodiversity losses and gains. Limited
338 data availability, complex value-chains, diffuse impacts and modelling uncertainties affect loss
339 measurement, while gains can be challenging to track over time, imperfectly captured by
340 available metrics and often without credible counterfactuals. These uncertainties should not
341 discourage value-chain impact measurements, which remain an essential part of corporate
342 journeys towards biodiversity strategies that contribute to a ‘Nature Positive’ future. Collection
343 of more data and use of best practice can help reduce some of this uncertainty. Corporates

344 seeking to compensate for value-chain impacts will, however, likely often still be confronted
345 with the challenge of wishing to make robust statements in the absence of perfect data. The
346 imperative to apply the mitigation hierarchy cannot be overstated: whatever the biodiversity
347 objectives, corporates should first apply the steps of avoiding, reducing and restoring, for
348 impacts occurring throughout their value-chain. Once they have done this, they should carefully
349 evaluate the level of uncertainty around the losses they induce and the gains they have
350 contributed to, and tailor the ambition of their claims to these uncertainties, for example by
351 using the guiding framework we propose here.

352 **7. Acknowledgements and Funding**

353 The authors thank Marc Barré, Jean-Christophe Benoit, Camille Brussier, Arthur Campredon,
354 Gaëlle Jardinier, Matthieu Rivet and Patricia Zhang, for their thoughts shared during an internal
355 workshop at CDC Biodiversité and on a draft version of this paper. MD acknowledges funding
356 from *l'Association nationale de la recherche et de la technologie* (ANRT, France) as part of a
357 Cifre research agreement between AgroParisTech and CDC Biodiversité [grant no. 2022/0474].
358 TBW and TB were funded by the Leverhulme Trust as part of the Leverhulme Centre for Nature
359 Recovery, University of Oxford (RC-2021-076).

360 **8. Conflict of interest**

361 MD is an employee at CDC Biodiversité as part of a Cifre research agreement between
362 AgroParisTech and CDC Biodiversité. TBW and TB receive income from consultancy services
363 to companies related to biodiversity impact assessment and biodiversity strategy design. None
364 of the companies or clients of 'Wild Business' or 'The Biodiversity Consultancy' had any role
365 in the study design, analysis, or conclusions drawn in this paper. All authors declare no conflict
366 of interest in carrying out this work.

367 **9. Author contributions**

368 **Margaux Durand:** Conceptualization, Investigation, Writing - Original Draft, Funding
369 acquisition

370 **Thomas B. White:** Conceptualization, Investigation, Writing - Review & Editing

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373 **Vincent Martinet:** Conceptualization, Investigation, Writing - Original Draft, Supervision,
374 Project administration

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