

1 **Title:** Resolving the Conservation Stewardship Paradox: A Dual-Pathway Architecture for Biodiversity
2 Credits and Stewardship Certificates

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7 **ABSTRACT**

8 Voluntary biodiversity credit markets are expanding rapidly, but their credibility depends on
9 demonstrating that claimed outcomes would not have occurred without intervention. This requirement,
10 additionality, is essential for high-integrity conservation finance and is operationalized through dynamic
11 baselines, ex post issuance, and independent monitoring, reporting, and verification (MRV) of measurable
12 ecological uplift or avoided loss. Yet this outcome-based logic creates a structural problem: territories that
13 have maintained high ecological integrity through long-term stewardship neither generate measurable
14 uplift nor present an independently verifiable trajectory of imminent loss. Successful stewardship thus
15 becomes a barrier to finance rather than a basis for it. We refer to this challenge as the conservation
16 stewardship paradox. To resolve it, we propose a dual-pathway architecture: Pathway I issues outcome-
17 based biodiversity credits where ecological uplift or avoided loss can be rigorously demonstrated against
18 credible counterfactuals; Pathway II issues contribution-based stewardship certificates for high-integrity
19 territories with documented financing gaps, effective governance, and ring-fenced revenues. By
20 separating ecological additionality from stewardship certificate claims, the framework supports both
21 measurable biodiversity gains and the continued maintenance of intact ecosystems without compromising
22 market integrity.

23 **Keywords:** additionality, avoided loss, conservation finance, ecological uplift, Indigenous peoples and
24 local communities, nature markets, outcome-based crediting, protected areas

25 **1. Introduction: Biodiversity finance and the additionality problem**

26 Voluntary biodiversity credit markets face a central credibility challenge grounded in uneven
27 methodological design. Comparative analyses document fragmentation in ecological baseline
28 requirements, monitoring rules and additionality thresholds, and highlight the near absence of rigorous ex

29 post evaluation against credible counterfactuals (Aide, 2024; Wunder et al., 2025). In parallel, an
30 emerging reform agenda has begun to specify the requirements for high-integrity biodiversity credits,
31 emphasizing credible biodiversity outcomes alongside social equity and robust governance (Biodiversity
32 Credit Alliance, 2025). Building on advances in impact evaluation and multi-taxa monitoring, recent
33 studies have sought to operationalize these principles through more rigorous approaches to outcome
34 measurement and attribution (Ford et al., 2024; Wunder et al., 2025; zu Ermgassen et al., 2026). These
35 contributions establish that biodiversity market credibility depends on demonstrating that observed
36 outcomes would not have occurred in the absence of the intervention.

37 Additionality requirements typically condition finance on demonstrable ecological change:
38 measurable improvement against a degraded baseline, or prevented decline against an independently
39 documented threat trajectory (Wunder et al., 2025). Both conditions privilege territories where
40 biodiversity is visibly recovering or actively threatened. Where long-term governance has kept ecological
41 integrity intact, neither condition is routinely satisfiable, not because conservation has failed, but because
42 it has succeeded. This creates a conservation stewardship paradox.

43 To address this problem, we propose a dual-pathway architecture for high-integrity biodiversity
44 finance. One pathway supports outcome-based biodiversity credits where ecological uplift or avoided loss
45 can be rigorously demonstrated against credible counterfactuals; the other supports contribution-based
46 stewardship certificates for high-integrity territories where conservation value lies primarily in
47 maintaining existing ecological condition. The framework makes three contributions. First, it establishes
48 that the stewardship paradox is not an implementation failure or a gap that better monitoring can close,
49 but a structural consequence of applying a single outcome-based logic to conservation contexts where the
50 primary contribution is maintenance rather than measurable change. Second, it separates ecological
51 additionality from financial additionality, assigning each to a different instrument with distinct eligibility
52 criteria and claim rules. Third, it establishes safeguards to prevent stewardship certificates from being
53 converted, implicitly or explicitly, into offsets, compensation claims, or assertions of no net loss.

54 **2. The stewardship paradox**

55 Existing nature markets have demonstrated the cost of weak verification: proponent-defined
56 baselines and insufficient independent oversight have enabled systematic over-crediting, particularly in
57 forest carbon markets (Swinfield et al., 2026; West et al., 2023). The scientific reform agenda for
58 biodiversity credits responds directly to these failures, converging on three requirements for credible
59 outcome-based crediting: dynamic baselines derived from independently monitored control or comparison

60 areas, ex post issuance following verified outcomes, and biodiversity monitoring that extends beyond
61 coarse habitat proxies to include multi-taxa or population-level indicators (Aide, 2024; Ford et al., 2024;
62 zu Ermgassen et al., 2026).

63 For territories facing clear, independently documented external threats, avoided loss can meet this
64 threshold. Where surrounding landscapes show active deforestation, encroachment, or governance
65 fragility, and these pressures are quantified through independent monitoring, preventing biodiversity
66 decline may be credibly attributed to local management. However, avoided-loss crediting remains
67 vulnerable to inflated threat projections, selective site choice, and baseline assumptions that overstate
68 counterfactual degradation (Swinfield et al., 2024; West et al., 2023; Wunder et al., 2025). Credible
69 avoided-loss claims therefore require independently verified threat documentation and credit volumes
70 calibrated to observed landscape dynamics, but even these conditions leave one class of territories
71 systematically unserved.

72 The class of territories that avoided-loss crediting cannot serve are those where long-term
73 governance has maintained ecological stability precisely because management has been effective. Their
74 baselines are stable not because external pressure is absent, but because sustained stewardship and
75 effective governance have kept that pressure from translating into measurable degradation, conditions that
76 depend as much on governance context and tenure clarity as on local management inputs (Fiore &
77 Grabbe, 2025; Schleicher et al., 2019). Under outcome-based crediting, this stability is indistinguishable
78 from a baseline that was never threatened: the instrument cannot credit the absence of a counterfactual it
79 cannot observe. This is not a technical limitation of avoided-loss accounting. It is a structural exclusion
80 built into the logic of additionality itself.

81 The consequences of this exclusion are ecologically significant. Many territories excluded by
82 outcome-based crediting are among the most conservation-critical landscapes on Earth: Indigenous and
83 community-managed lands support vertebrate biodiversity comparable to formal protected areas (Schuster
84 et al., 2019), and more than one-third of the world's remaining intact forest landscapes occur within
85 Indigenous Peoples' territories (Fa et al., 2020). Where Indigenous lands overlap with formally protected
86 areas, the combined effect on forest integrity is greater than either governance type achieves
87 independently (Sze et al., 2022). Effectively managed protected areas hold disproportionate biodiversity
88 value relative to the unprotected matrix, yet their recurrent financing falls systematically below
89 management needs: annual costs for protected-area management have been estimated at USD 76–140
90 billion against current investment of roughly USD 24 billion per year (Coad et al., 2019; Geldmann et al.,
91 2018; McCarthy et al., 2012; Waldron et al., 2020). Outcome-based credits cannot close this gap because

92 they reward measurable change above baseline, not the patrols, monitoring, fire control, boundary
93 defense, and community governance that keep baselines intact. Resolving the stewardship paradox
94 therefore requires a distinct instrument designed specifically for verified maintenance of high-integrity
95 ecosystems.

96 **3. A Dual-Pathway Solution**

97 Existing conservation finance mechanisms (e.g. Payments for ecosystem services; NGO grants,
98 conservation trust funds) provide important support for stewardship but generally offer limited
99 standardization in how that support is verified, tracked, and represented to external audiences (McElwee,
100 2025; Wunder et al., 2025). The stewardship certificate addresses this gap through a framework that links
101 eligibility to independently verified financing needs, restricts revenue use through auditable agreements,
102 records transactions in a spatial registry, and defines the conditions under which buyers may
103 communicate their support. By certifying verified financial support for stewardship, the instrument is
104 designed for non-compensatory use and provides a governance structure for recognizing stewardship in
105 territories where ecological integrity is maintained through long-term management.

106 More broadly, the dual-pathway framework separates outcome-based credit claims from
107 stewardship certificate claims, assigning instruments according to the ecological and financial conditions
108 of spatial units. Each spatial unit is defined as a polygon with broadly consistent ecological condition,
109 management objective, and tenure boundary. This spatially explicit approach allows different parts of the
110 same territory to enter different pathways while ensuring that eligibility, monitoring, and issuance are
111 assessed independently for each unit (Table 1).

112 **3.1. Pathway I: outcome-based biodiversity credits**

113 Pathway I applies in conservation contexts where biodiversity outcomes can be attributed to
114 management interventions through rigorous comparison with a credible counterfactual. This includes both
115 degraded or recovering ecosystems that generate measurable ecological uplift and high-integrity
116 ecosystems where effective management prevents biodiversity decline under independently documented
117 threat conditions. In both cases, credit eligibility depends on demonstrating that observed outcomes would
118 not have occurred in the absence of the intervention.

119 To establish this counterfactual, Pathway I relies on dynamic baselines derived from matched
120 control or comparison sites. These sites are selected to resemble the credited spatial unit in biophysical
121 characteristics, historical land-use trajectories, and exposure to anthropogenic pressures, thereby

122 approximating the most likely trajectory without intervention (Aide, 2024). Where data availability
123 permits, quasi-experimental approaches can further strengthen attribution by separating project effects
124 from broader regional trends and other confounding influences (O’Garra et al., 2025).

125 Outcome assessment extends beyond habitat extent alone and incorporates indicators of
126 biodiversity condition across multiple dimensions. Monitoring should therefore capture changes in habitat
127 structure, vegetation condition, species composition, species diversity, focal populations, and freshwater
128 biodiversity where relevant (Aide, 2024; Ford et al., 2024). Together, these indicators provide evidence of
129 structural, compositional, and functional change in biodiversity systems (Wauchope et al., 2024).

130 Credits are issued only after biodiversity outcomes have been observed and independently
131 verified. Credit volumes are calculated from the difference between observed conditions in the spatial unit
132 and those measured in the dynamic baseline, adjusted for area and monitoring interval, and reduced
133 through conservative deductions for leakage, uncertainty, and non-permanence risk. In avoided-loss
134 applications, additional safeguards are required because outcome estimates depend on assumptions about
135 future decline. Threat trajectories should therefore be derived from independent landscape monitoring
136 rather than proponent projections, and uncertainty deductions should be more conservative than those
137 applied to uplift-based credits (Swinfield et al., 2026; Wunder et al., 2025).

138 The resulting credits represent verified biodiversity outcomes and are issued ex post following
139 independent third-party review (Kim et al., 2025; zu Ermgassen et al., 2026). Continued monitoring
140 remains necessary after issuance. Where subsequent evidence shows that outcomes have not been
141 maintained or that baseline assumptions were materially incorrect, credit volumes and associated claims
142 should be revised accordingly. Consistent with emerging integrity frameworks, these credits are not
143 intended to support offsetting, full ecological compensation, or no-net-loss claims (Arlidge et al., 2018;
144 Wauchope et al., 2024).

145 **3.2.Pathway II: stewardship certificates**

146 Pathway II finances the maintenance of ecological integrity in contexts that outcome-based
147 mechanisms cannot serve. This option is critical because intact ecosystems support a confluence of
148 biodiversity, carbon, and cultural values that degraded systems cannot replicate, making their
149 maintenance an urgent conservation priority alongside efforts to restore already-degraded habitats
150 (Watson et al., 2018). However, where high-integrity territories show neither measurable uplift nor an
151 independently documentable acute threat trajectory, they remain ineligible for Pathway I despite their
152 conservation value (Macreadie et al., 2026). We therefore define a contribution-based stewardship

153 certificate as a non-offset, non-compensatory instrument representing one hectare-year of verified
 154 effective management in a high-integrity spatial unit with a documented financing gap, with revenues
 155 ring-fenced for conservation activities beyond the audited funding baseline. Unlike biodiversity credits,
 156 these certificates do not claim quantified ecological gains; instead, they recognize verified stewardship
 157 contributions.

158 Eligibility for Pathway II is assessed through three components. First, a threat and pressure
 159 analysis documents potential degradation drivers such as surrounding deforestation, encroachment, illegal
 160 extraction, and climate exposure. This establishes that continued ecological integrity depends on active
 161 management and sustained financing (Macreadie et al., 2026). Second, a management effectiveness
 162 assessment evaluates governance capacity, patrol coverage, enforcement, community engagement, and
 163 legal tenure security (Coad et al., 2019; Geldmann et al., 2018). Third, a financial gap analysis documents
 164 the difference between current public or institutional funding and the resources required for effective
 165 long-term management, establishing the basis for the financial additionality test (McCarthy et al., 2012;
 166 Waldron et al., 2020).

167 These three components matter especially for formally protected areas, where states carry legal
 168 conservation obligations. The relevant question is whether those obligations are adequately financed, not
 169 whether they formally exist (Coad et al., 2019; McCarthy et al., 2012). Financial additionality is a
 170 defining feature of Pathway II and ring-fencing is its operational expression (Table 1). Certificate
 171 revenues must be restricted by conservation agreement to activities explicitly absent from the documented
 172 public funding baseline, including ranger programs, ecological monitoring, community governance, and
 173 legal defense of tenure, preventing fiscal substitution in which governments reduce conservation
 174 allocations because private revenues fill the gap (Kedward et al., 2023). Periodic audits should verify that
 175 certificate revenues supplement rather than replace public conservation budgets.

176 **Table 1. Design dimensions distinguishing outcome-based biodiversity credits (Pathway I) from**
 177 **contribution-based stewardship certificates (Pathway II)**

Dimension	Pathway I (Uplift)	Pathway I (Avoided loss)	Pathway II (Contribution)
Conservation context	Degraded or recovering ecosystems	High-integrity ecosystems with independently documented external threat	High-integrity ecosystems where stewardship maintains stable baselines

Additionality logic	Ecological: measurable gain vs. dynamic control-site baseline	Ecological: prevented decline vs. independently verified threat trajectory	Financial: certificate revenues beyond audited public funding baseline
Monitoring requirements	High: multi-taxa indicators; quasi-experimental designs	High: multi-taxa indicators; quasi-experimental designs	Moderate: management indicators; ecological state proxies.
Credit/certificate unit	Quantified biodiversity gain per hectare	Quantified avoided biodiversity loss per hectare	1 hectare under effective management per year × management effectiveness factor
Allowable claims	Quantified biodiversity gain; no offset use	Quantified avoided loss; no offset use	Verified stewardship contribution; no offset use; no no-net-loss claims
Key integrity risk	Baseline gaming; non-additional restoration	Inflated threat projections; high-and-far site selection	Covert use as offset; fiscal substitution of public budgets

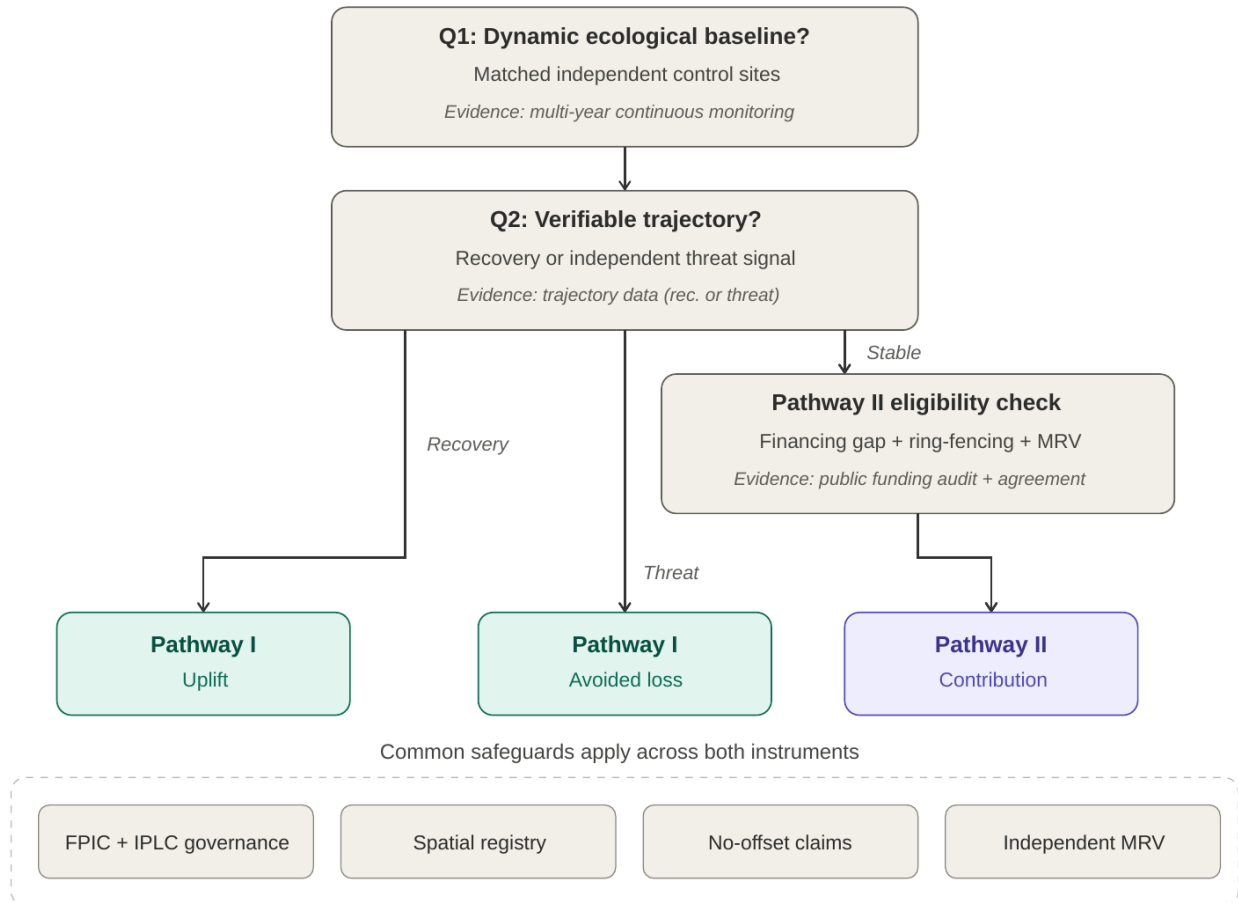
178

179 **3.3.Choosing between pathways**

180 Pathway eligibility is determined by verifiable ecological and financial conditions, not by land
181 tenure category or protected area status. Many conservation landscapes contain zones with different
182 ecological conditions and management objectives, and the same territory may legitimately host both
183 instruments in different spatial units. Where formal management zones already exist, they can serve as
184 candidate spatial units.

185 Figure 1 presents a step-by-step decision framework. The entry question is whether a dynamic
186 ecological baseline can be established from independently monitored control or comparison areas. If so,
187 the second question is whether an independently verifiable trajectory of biodiversity change exists, either
188 recovery from degradation that supports uplift accounting or documented external threat that supports
189 avoided loss. Positive answers to both conditions lead to Pathway I. When long-term stewardship has
190 maintained ecological stability without a documentable acute threat trajectory, the unit of territory enters
191 the Pathway II eligibility assessment, subject to demonstrating a financing deficit and commitment to

192 ring-fencing provisions. In all cases, pathway assignment is the outcome of independent assessment rather
 193 than self-selection by territories or project developers.



194

195 **Figure 1. Decision framework for pathway assignment.** Each spatial unit is assessed independently.
 196 Decision nodes (gray boxes) are sequential gates; italicized text indicates the evidence base required at
 197 each step. Eligible outcomes are coded by instrument family: Pathway I credits (teal) for measurable
 198 ecological gains; Pathway II certificates (purple) for stewardship maintenance. Common safeguards
 199 (dashed container) apply to both instruments and include verified free, prior, and informed consent (FPIC)
 200 with a substantial proportion of net revenues directed to Indigenous Peoples and Local Communities
 201 (IPLC); polygon-level spatial registry; offset prohibition; and independent monitoring, reporting, and
 202 verification (MRV). Spatial units that do not satisfy Q1 or the Pathway II eligibility conditions fall
 203 outside the scope of the framework.

204 **4. Safeguards against misuse**

205 Both pathways share a strict prohibition on offset use, but the enforcement challenge differs between
206 them. Pathway I credits, grounded in quantified ecological outcomes, generate claims that are more
207 specific and easier to verify. Pathway II certificates carry higher greenwashing risk because contribution
208 claims can more easily be reframed in corporate communications as environmental performance rather
209 than financing support. This distinction should be enforced through three linked mechanisms: registry-
210 level claim locks that define the allowable claim for each instrument, independent review of corporate
211 claim use, and standardized public disclosure. These safeguards respond to experience in voluntary
212 carbon markets, where restrictions on offset use were often weakened through marketing and reporting
213 practices, and certification incentives favored credit volume over integrity (García & Moros, 2025).

214 Both pathways require a polygon-level spatial registry that tracks instrument boundaries, claim types,
215 and verification status at the level of individual spatial units. No spatial unit may simultaneously generate
216 claims under Pathway I and Pathway II. Where adjacent zones generate different instruments, their
217 boundaries must be independently audited before issuance. At the national scale, Pathway II certificate
218 issuance must be reconciled with national biodiversity accounting frameworks to prevent double claiming
219 of the same area toward GBF 30×30 targets through both public protected area reporting and private
220 stewardship certificates (Convention on Biological Diversity (CBD), 2022). The registry also records
221 revocation events, ensuring that cancelled credits or suspended certificates are publicly visible and cannot
222 be replaced by claims under the alternate pathway without independent reassessment.

223 Both pathways require the same minimum safeguards where Indigenous peoples and local
224 communities hold rights or governance responsibilities. Free, Prior, and Informed Consent must be
225 independently verified by an entity with a human-rights mandate, not by the issuer or project developer
226 (Dawson et al., 2024; Kim et al., 2025). Revenues must be distributed through transparent benefit-sharing
227 agreements that direct a substantial proportion of net proceeds to custodian communities, supported by
228 accessible grievance mechanisms in local languages. Buyer eligibility should also be restricted:
229 instruments may not be sold to companies whose commercial activities directly affect the territory
230 without explicit community consent. These requirements are essential because biodiversity finance
231 schemes led by external developers have often failed to include affected communities from the outset,
232 with consequences for equity, legitimacy, and conservation outcomes (Dawson et al., 2021).

233 **5. Policy implications and conclusion**

234 The dual-pathway framework advances two linked objectives. Pathway I aligns voluntary
235 biodiversity markets with the scientific standards required for rigorous outcome-based crediting, while
236 Pathway II extends biodiversity finance to territories that such systems cannot serve without weakening

237 integrity standards. This distinction maps directly onto GBF Target 3: areas in active recovery access
238 Pathway I through uplift crediting; areas facing independently documented external threats access
239 Pathway I through avoided loss and uplift; and areas of established integrity maintained through effective
240 governance access Pathway II. Because states shape supply, demand, and site legitimacy even in
241 voluntary markets, National Biodiversity Strategies and Action Plans provide the main policy channel for
242 embedding these distinctions in domestic rules for private finance (Cardona Santos et al., 2023).

243 The equity implications are substantial. A biodiversity finance architecture that conditions
244 eligibility on demonstrable degradation inverts conservation incentives, rewarding contexts of historical
245 failure while penalizing contexts of historical success. The territories most disadvantaged by uplift-only
246 systems are precisely those most critical for GBF Target 3 and central to the livelihoods and rights of
247 Indigenous peoples and local communities (Dawson et al., 2021; Macreadie et al., 2026). Pathway II
248 responds to this by matching the instrument to the conservation function: financing the verified
249 maintenance of ecological integrity where outcome-based crediting cannot operate.

250 The commercial viability of Pathway II rests on a regulatory shift already underway. Corporate
251 reporting frameworks, including the Taskforce on Nature-related Financial Disclosures and the European
252 Corporate Sustainability Reporting Directive, are generating demand for verified evidence of nature-
253 related contributions that is distinct from offset claims. Under these frameworks, a company seeking to
254 demonstrate positive engagement with biodiversity can disclose verified support for the maintenance of a
255 high-integrity territory facing a documented financing gap, without asserting that this support
256 compensates for harm caused elsewhere. Pathway II certificates are designed precisely for this claim
257 category: they are not offsets, and disclosure standards that treat them as such would misapply them. The
258 commercial case therefore depends not on relaxing the offset prohibition, but on regulators and standard-
259 setters explicitly recognizing stewardship certificate claims as a distinct and legitimate evidence category
260 within corporate nature strategies (Kedward et al., 2023; McElwee, 2025).

261 The framework has limitations. The boundary between a documentable threat trajectory and its
262 absence requires independent, context-specific assessment. Financial additionality tests depend on public
263 budget transparency that many national systems do not yet provide (Kedward et al., 2023). Governance
264 capacity for registries, oversight panels, and independent verification remains insufficient at the scale that
265 GBF implementation implies, as current biodiversity credit schemes often lack independent verification
266 and adequate enforcement capacity (Kim et al., 2025; Wunder et al., 2025). These limitations do not
267 weaken the case for separating credits from stewardship certificates; rather, they identify the governance

268 conditions required for biodiversity finance to support both measurable gains and the continued protection
269 of intact ecosystems.

270 **Author Contributions**

271 L.F. and T.M.A. conceived the study; L.F. drafted the manuscript, with critical inputs and revisions from
272 T.M.A. The authors read, revised, and approved the final version of the manuscript.

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282 **Conflict of interest**

283 The authors declare no conflicts of interest.

284 **Data availability statement**

285 Data sharing is not applicable to this article, as no datasets were generated or analyzed during the current
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