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Toward the Full Operationalization of the Dark Diversity Concept in Environmental Impact Assessments: A Call to Revise International EIA Standards

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ABSTRACT

Environmental impact assessments and related safeguard standards are key tools for mitigating the ecological damage of development projects; however, they predominantly evaluate what is observed during baseline surveys. This approach, which is inherently constrained by imperfect detectability, seasonality, and uneven sampling effort, leads to a chronic underestimation of an ecosystem's true biotic potential, with direct consequences for the mitigation hierarchy (avoidance, minimization, restoration, and offsets) and for strategies that aim to meet the "no net loss" of biodiversity target. This paper proposes the systematic integration of "dark diversity", that is, the set of species ecologically suited to a site but currently absent, into the EIA framework. Assessing a habitat's ecological "completeness" (observed diversity relative to dark diversity) reveals its true level of degradation and restoration potential, helping to distinguish systems that are simply complex to detect from those that are impoverished or constrained by dispersal and establishment barriers. This approach provides a more robust and precautionary baseline, allowing for the design of mitigation and compensation measures based on an ecosystem's full potential, not just one part. We outline pragmatic pathways to operationalize dark diversity in EIA practice, combining existing occurrence data, co-occurrence approaches, and emerging tools (e.g., eDNA and niche modeling) to guide targeted supplementary surveys, impact evaluation, and measurable restoration objectives.

1 | Introduction

Biodiversity is rapidly declining worldwide, with development pressures (including infrastructure expansion) identified as one of the major drivers (Western 2001; Narain et al. 2023; Fonda, Bullegas, et al. 2026). Projects such as roads, dams, and power plants contribute to this decline through habitat fragmentation, species displacement, and increased wildlife mortality (Fonda, D'Amico, et al. 2026). Because built infrastructure is a major source of carbon emissions and biodiversity loss (zu Ermgassen et al. 2022), a variety of policies have been developed to manage trade-offs between new infrastructure and environmental goals (Rampling et al. 2024). In this context, environmental impact assessments (EIAs) are a critical pillar in global regulatory frameworks, intended to anticipate and mitigate the ecological consequences of development projects (Fonseca 2022; Fonda, Petrillo, et al. 2026). The mitigation hierarchy, endorsed in EIA processes by many countries following the Convention on Biological Diversity (Rio de Janeiro, 1992), is the standard framework for minimizing biodiversity impacts from development projects (Bergès et al. 2020; BBOP 2012). It involves a sequential approach; avoiding, reducing, and offsetting impacts, with the aim of achieving "no net loss" of biodiversity (Bull et al. 2016). However, in practice, EIAs tend to focus primarily on specific, legally protected species, habitats, and protected areas (International Finance Corporation 2019). Such focal taxa, frequently already threatened, may also be rare due to small or declining populations, limited distributions, or habitat specificity (Rabinowitz et al. 1984; Crisfield et al. 2024). As a result, their likelihood of going undetected is particularly high in the context of expedited or under-resourced assessments, which can materially compromise the effectiveness of impact assessment and mitigation strategies (e.g., Dias et al. 2025). Consequently, longstanding concerns persist regarding EIA effectiveness across jurisdictions, with recurrent critiques that EIAs often fail to deliver their intended biodiversity safeguards (Liu et al. 2008; Williams and Dupuy 2017; Nita et al. 2022; Paudel et al. 2025).

International standards, such as the International Finance Corporation's Performance Standard 6 (IFC PS6) (International Finance Corporation 2019) and the World Bank Environmental and Social Framework (ESS 6) (ESF 2016), explicitly mandate the identification and protection of biodiversity, particularly in areas of high ecological value. These guidelines aim to achieve "no net loss" or even "net gain" of biodiversity (Morley et al. 2021). Although it is essential to acknowledge that large-scale development projects, especially those related to renewable energy, play a critical role in advancing global sustainability, their implementation should not occur at the expense of biodiversity, which is equally vital for a healthy planet. Yet, despite these commendable objectives, many EIAs consistently fall short (Nita et al. 2022). The primary deficiency lies in their reliance on limited, often one-off, biodiversity surveys constrained by budget and time. Current EIA practice commonly relies on short-term baseline surveys and standardized species lists, including rapid biodiversity assessments (Gurung et al. 2022). In hyper-diverse tropical and subtropical ecosystems, such baselines can systematically under-record biodiversity, particularly for rare, cryptic, or seasonally inactive taxa (Sutherland et al. 2004; Gardner et al. 2008). When observed lists are treated as complete baselines, this bias can propagate through impact prediction and the mitigation hierarchy, undermining avoidance decisions, restoration targets, and offset equivalence. A further, well-established limitation of biodiversity baselines is imperfect detectability; the probability of recording a species is rarely 1 and varies across taxa, seasons, habitats, observer expertise, and survey methods (Bacaro et al. 2009). Where feasible, EIA baselines should therefore adopt designs and analyses that explicitly address detectability (e.g., repeated visits, multi-method sampling, and detection-corrected models), and should combine complementary approaches such as camera trapping, acoustic monitoring, and environmental DNA. However, even robust detectability-aware designs may not fully close the gap between recorded assemblages and ecologically expected communities in under-sampled regions; this motivates complementary approaches that formalize expectations about suitable-but-absent species.

In this perspectives article, we synthesize evidence from a targeted, non-systematic scan of the dark diversity literature and of applied EIA and mitigation hierarchy practice, complemented by the authors' professional experience in biodiversity baseline design, impact evaluation, and offset planning. Our aim is both conceptual and operational: to clarify why species absence matters for EIAs and to propose an implementable workflow that can be embedded within existing international standards and national regulations. To make these implications tangible for practitioners, we also discussed a brief worked example illustrating how incorporating dark diversity can change inference relative to an observed-only baseline.

2 | The Problem: Assessments Built on Partial Data and Unrecognized Gaps

Particularly in biodiversity hotspots like the Amazon, the Himalayas, or Southeast Asia, where endemism and species turnover rates are exceptionally high, standard, short-term biodiversity surveys often fail to capture the full biotic potential of a site and, by extension, its site-specific species pool (Gardner et al. 2008). Here, the "absence of evidence" is routinely, and consequentially for decision-making, mistaken for "evidence of absence" (sensu Alderson 2004). This issue is exacerbated for rare, elusive, cryptic, or seasonally inactive species, which are often missed despite their ecological suitability and potential presence. Crucially, these "unrecognized gaps" can reflect two partly overlapping processes: (i) imperfect detection and incomplete sampling, where species are present but not recorded and (ii) genuine ecological absence (i.e., dark diversity), where species are ecologically suitable and belong to the site-specific species pool yet are currently missing because of dispersal and establishment constraints, habitat degradation, or biotic interactions.

Distinguishing between these processes is essential for EIA decision-making, because they imply different mitigation and monitoring priorities. When observed species lists are treated as complete baselines, the mitigation hierarchy can be implemented against an underestimated reference condition, with downstream consequences for impact prediction, restoration targets, and offset equivalence. This increases the risk of flawed mitigation strategies, inadequate compensation for unavoidable impacts, and ultimately a failure to achieve stated "no net loss" objectives (Pilgrim et al. 2013; Bacaro 2025). Recent reviews highlight persistent challenges in biodiversity offsetting, including inconsistent assessment methodologies and insufficient governance, often failing to achieve "no net loss" (Maron et al. 2025). The current frameworks, while striving for comprehensive assessment, remain vulnerable to these limitations of survey-based baselines, particularly in complex and understudied ecosystems, and therefore require practical refinements that explicitly account for both expected-but-unobserved components of biodiversity and imperfect detectability.

3 | Integrating Dark Diversity Into Environmental Assessments

To overcome this fundamental limitation of survey-based baselines, we propose that EIAs and strategic environmental assessments (SEAs) systematically integrate the concept of dark diversity. In this context, "dark diversity" refers to the set of species that are ecologically suitable for a site but currently absent, while occurring within the surrounding region or broader species pool (Pärtel et al. 2011). Dark diversity has been identified as a useful tool for practical biodiversity management (Lewis et al. 2017; Moeslund et al. 2017). This concept, originally rooted in macroecology and community assembly theory, is increasingly recognized across diverse taxa and ecosystems for its ability to provide a more nuanced understanding of habitat quality, colonization constraints, and ecological recovery potential (Ronk et al. 2015; Lewis et al. 2017; Bacaro 2025). Importantly, this definition is conceptually distinct from imperfect detectability. Species may be missing from checklists either because they were not detected despite being present, or because they are genuinely absent despite suitable conditions; dark diversity formalizes the latter component by anchoring expectations to a site-specific species pool. Dark diversity could also help us learn more about red-listed species and the susceptibility of communities to invasive species (Moeslund et al. 2017). Empirical applications illustrate the policy and management relevance of the approach, including guidance for conservation and restoration planning (Moeslund et al. 2017), the use of environmental DNA to reveal hidden components of regional species pools (Boussarie et al. 2018), and recent global evidence of impoverishment in natural vegetation detected through dark diversity (Pärtel et al. 2025). Interpreting patterns from various prioritization frameworks facilitates a more informed identification of areas most at risk of biodiversity loss. For example, the substantial overlap between global biodiversity hotspots and "crisis ecoregions" (sensu Hoekstra et al. 2005) offers a broad-scale indication of particularly vulnerable regions whose degradation or loss would contribute significantly to global biodiversity loss (Lewis et al. 2017).

Integrating dark diversity into EIAs offers a precautionary, decision-relevant complement to observed baselines by making expected-but-absent species explicit and linking completeness deficits to mitigation-hierarchy choices, particularly in rapidly changing or under-sampled regions.

Traditional metrics used in EIAs, such as irreplaceability and vulnerability indices, offer valuable insights but are inherently limited, as they do not account for the discrepancy between a site's observed biodiversity and its potential biodiversity. In this regard, the dark diversity framework provides a critical complement. For instance, the "completeness index" proposed by Pärtel et al. (2013) and defined as the logarithmic ratio between observed and dark diversity, can offer a quantitative measure of how ecologically intact a given habitat or region is in relation to its species pool. When applied within the EIA process, this index allows for the identification of sites where biodiversity is not only currently high, but also near its ecological potential, that is, sites of high completeness. Such areas, particularly when they also exhibit high levels of irreplaceability and vulnerability (Brooks et al. 2006), merit strong conservation prioritization and careful avoidance of residual impacts.

4 | Operationalizing Dark Diversity in EIA Practice

Importantly, completeness and dark diversity can be assessed using standard ecological and taxonomic records, and can therefore be integrated with relative ease into EIA baseline surveys and impact evaluations. Their inclusion would provide a more comprehensive understanding of ecosystem quality and restoration potential, thus improving the scientific foundation for decision-making within the mitigation hierarchy. A practical workflow begins by defining a site-specific species pool for each habitat unit considered in the assessment, moving beyond local observations alone. This involves leveraging a combination of established knowledge with available data streams. Global platforms such as the Global Biodiversity Information Facility (GBIF) (Luo et al. 2021), the IUCN Red List, the Integrated Biodiversity Assessment Tool, and the Red List of Ecosystems provide essential spatial and occurrence data that support the identification of both observed and potentially present species and ecosystems. Advanced methods for data collection, such as environmental DNA, and for data analysis, such as ecological niche models, can significantly enhance information on species that are present but difficult to detect, and help predict their distribution based on environmental variables (Elith and Leathwick 2009; Sahu et al. 2023). Integrating these tools with local ecological knowledge and historical data as well as with expert judgment further refines species pools and improves our understanding of past and present community composition (Jarzyna et al. 2025).

As a simplified illustration of how making an expected pool explicit can change EIA inference relative to an observed-only baseline, two complementary lines of evidence are useful. In an EIA-focused synthesis of terrestrial mammal baseline surveys for mining projects in Minas Gerais (Brazil), Dias et al. (2025) report that baseline checklists recorded on average 11.6 species (range 1–22), while 37 species were identified as potentially occurring in the broader region (i.e., a regional pool proxy and an upper bound that must be filtered to the focal habitat unit to derive a site-specific pool). If the observed checklist is interpreted as a complete baseline, an observed-only baseline could therefore understate receptor sensitivity; importantly, Dias et al. (2025) show that a substantial share of this gap is consistent with imperfect detection (species present but not recorded), which directly supports more detectability-aware designs and targeted supplementary surveys before key mitigation-hierarchy decisions are made. A closely related, but conceptually distinct, step is required once detectability has been addressed; estimating the expected-but-absent component (dark diversity) and using it to interpret ecological completeness. In high-altitude Himalayan plant communities, Wani et al. (2023) estimated regional species pools and dark diversity under contrasting disturbance regimes and found consistently higher dark diversity and lower completeness in disturbed sites. For example, in alpine grasslands, natural sites had 23 observed species and an estimated dark diversity of 21.52 (pool 44.53; completeness index 0.066), whereas disturbed sites had 12 observed species but higher dark diversity (23.43; pool 35.43; completeness index −0.669); similar patterns were reported in forests (natural: observed 25, dark 26.08; disturbed: observed 16, dark 29.07). For EIA practice, the added value is straightforward. Observed-only lists indicate that disturbed sites are species-poor, but dark diversity and completeness show how far the system is from its expected potential. This information can change decisions across the mitigation hierarchy. It supports stronger avoidance where completeness is high, it helps target restoration toward reducing completeness deficits, and it frames offsets around measurable progress toward the expected pool, rather than observed richness alone.

To generate these metrics in practice, EIAs can estimate site-specific species pools and the expected-but-unobserved component using methods that fit available data and time constraints. Where autecological information is limited, dark diversity can be estimated using methods derived from species co-occurrence patterns, that is, co-occurrence-based approaches (e.g., hypergeometric, favorability, and Beals-type indices) that estimate probabilistic site-specific species pools and allow dark diversity to be quantified as the expected-but-unobserved component of local assemblages (Carmona and Pärtel 2021). Combining dark diversity outputs with trait information can help diagnose why species are missing, whether due to dispersal limitation, disturbance sensitivity, competitive exclusion, mutualistic dependencies, or other establishment barriers, and thereby generating testable and operational hypotheses for mitigation and restoration planning.

By systematically comparing observed species with this site-specific species pool, it becomes possible to estimate the completeness of a community (Pärtel et al. 2013).

Communities or areas with low observed richness but high dark diversity indicate a pronounced completeness deficit, that is, a substantial gap between realized and site-specific potential diversity. In many settings this pattern is more consistent with colonization credit (species are suitable but have not yet recolonized) or persistent dispersal and establishment barriers. Dark diversity should therefore be treated as a diagnostic signal to be interpreted alongside land-use history, habitat trajectories, and (where available) detection-corrected monitoring data (Lewis et al. 2017; Gavriel et al. 2025).

Within the EIA framework, this metric offers critical insights for evaluating ecosystem integrity and resilience. It enables practitioners to move beyond mere species inventories and toward a deeper understanding of a habitat's full biodiversity potential. Routinely incorporating dark diversity assessments into EIA procedures can help identify habitats that have been substantially degraded, where species are absent not because of unsuitable conditions but due to dispersal limitations, historical land use, or other ecological barriers. This, in turn, supports the identification of knowledge gaps, prompting targeted supplementary studies during the EIA process to determine the specific ecological or anthropogenic drivers behind species absences. Such analyses are essential not only for characterizing baseline conditions more accurately but also for informing the design of more effective mitigation and offset measures (Bezombes et al. 2018). In particular, restoration and offset strategies can be directed toward enhancing habitat conditions and connectivity to promote the return or persistence of species identified as part of the dark diversity (Bergès et al. 2020; Fonda, D'Amico, et al. 2026; Fonda, Petrillo, et al. 2026), thereby enhancing functional and phylogenetic recovery and ensuring more robust "net gain" outcomes (Rampling et al. 2024; Maron et al. 2025). Therefore, biodiversity offsets should not be based solely on currently observed species, but on the full ecological potential of a site, as revealed through the lens of dark diversity. This approach allows for more forward-looking and ecologically grounded conservation outcomes, aligned with the long-term objectives of the mitigation hierarchy. Embedding dark diversity in EIAs aligns with the precautionary principle, a cornerstone of international environmental law, enshrined in the Rio Declaration (The Precautionary Principle in Biodiversity Conservation and Natural Resource Management) (Cooney 2004). This principle mandates taking action to prevent serious or irreversible harm, even in the face of scientific uncertainty. By acknowledging and quantifying dark diversity, we explicitly recognize the uncertainty inherent in current biodiversity assessments and proactively address the hidden dimension of biodiversity risk before irreversible decisions are made. It allows us to "see in the dark" and identify sites that, despite appearing degraded, still retain significant ecological memory and potential for recovery, areas that might otherwise be overlooked or dismissed in conventional evaluation systems. This proactive stance is essential for genuinely safeguarding biodiversity in the face of complex environmental challenges.

5 | Conclusion

The integration of dark diversity into EIAs represents a necessary and timely advancement in the way we assess, mitigate, and offset biodiversity loss. This paradigm shift—moving from an exclusive focus on observed presence to an informed consideration of species absence—does pose certain technical and institutional challenges. These include limitations in regional data availability, uneven taxonomic expertise, and the complexity of integrating diverse data sources such as environmental DNA, GBIF records, and ecological niche models. In addition, practitioners must explicitly distinguish between species that are missing from checklists because of imperfect detectability and those that are genuinely absent despite suitable conditions; dark diversity contributes primarily to the latter by anchoring assessment to a site-specific species pool and by quantifying ecological completeness. However, these challenges are not insurmountable. International funding institutions, environmental consultants, and developers already invest considerable resources in biodiversity baseline modeling. Incorporating dark diversity metrics should be viewed not as a disruptive overhaul, but as a logical and necessary evolution, enhancing the resolution and predictive power of existing assessment frameworks. Crucially, this integration is compatible with (rather than a substitute for) detectability-aware survey designs and monitoring; together, these approaches reduce both false absences (undetected presence) and unrecognized completeness deficits (suitable-but-absent species).

Pilot studies across representative ecoregions, potentially supported by biodiversity trust funds or corporate environmental responsibility programs, are essential to demonstrate operational feasibility, refine analytical methodologies, and foster local capacity. Such pilots should explicitly compare alternative pathways for estimating species pools (e.g., expert-based and database-driven approaches, niche models, and co-occurrence-based approaches that estimate probabilistic site-specific species pools) (Carmona and Pärtel 2021), and evaluate how dark diversity metrics influence avoidance decisions, restoration targets, and offset equivalence. Most importantly, the routine consideration of dark diversity must be embedded within the core guidance documents and standards that shape global conservation practice, such as IFC PS6, the World Bank's ESS6, and the IUCN's policy frameworks. These standards play a critical role in defining what constitutes acceptable environmental due diligence in development finance. To uphold the principle of "no net loss" of biodiversity, it is imperative that these protocols evolve to recognize that true ecological integrity cannot be assessed without accounting for what is absent, but ecologically expected. By making expected-but-missing components explicit, dark diversity can shift EIAs from purely descriptive baselines toward more diagnostic and testable assessments, where completeness deficits generate operational hypotheses (e.g., dispersal, establishment, and disturbance sensitivity) that can be targeted through mitigation and restoration.

To meet accelerating biodiversity loss and climate change, EIAs must move beyond what is simply observed and documented and account for species absences that signal both past degradation and recoverable potential. Failing to do so risks undermining restoration targets, misdirecting compensation, and compromising global conservation commitments. Ultimately, operationalizing dark diversity in EIAs means defining a site-specific species pool, quantifying ecological completeness, and translating completeness deficits into clear decision points within the mitigation hierarchy, from targeted supplementary surveys and avoidance to measurable restoration objectives and offset design.

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References

Alderson, P. 2004. "Absence of Evidence Is Not Evidence of Absence." *BMJ* 328: 476–477.

Bacaro, G. 2025. "Shades of Grey: A Continuum of Biodiversity Understanding From Dark to Bright Diversity." *Ecology and Diversity* 2, no. 4: 10012.

Bacaro, G., E. Baragatti, and A. Chiarucci. 2009. "Using Taxonomic Data for Assessing and Monitoring Biodiversity: The Tribe Still Fighting?" *Journal of Environmental Monitoring* 11: 789–801.

Business and Biodiversity Offsets Programme (BBOP). 2012. *Guidance Notes to the Standard on Biodiversity Offsets*. BBOP.

Bergès, L., C. Avon, L. Bezombes, et al. 2020. "Environmental Mitigation Hierarchy and Biodiversity Offsets Revisited Through Habitat Connectivity Modelling." *Journal of Environmental Management* 256: 109950.

Bezombes, L., S. Gaucherand, T. Spiegelberger, V. Gouraud, and C. Kerbiriou. 2018. "A Set of Organized Indicators to Conciliate Scientific Knowledge, Offset Policies Requirements and Operational Constraints in the Context of Biodiversity Offsets." *Ecological Indicators* 93: 1244–1252.

Boussarie, G., J. Bakker, O. S. Wangensteen, et al. 2018. "Environmental DNA Illuminates the Dark Diversity of Sharks." *Science Advances* 4: eaap9661.

Brooks, T. M., R. A. Mittermeier, G. A. B. da Fonseca, et al. 2006. "Global Biodiversity Conservation Priorities." *Science* 313: 58–61.

Bull, J. W., A. Gordon, J. E. M. Watson, and M. Maron. 2016. "Seeking Convergence on the Key Concepts in 'No Net Loss' Policy." *Journal of Applied Ecology* 53: 1686–1693.

Carmona, C. P., and M. Pärtel. 2021. "Estimating Probabilistic Site-Specific Species Pools and Dark Diversity From Co-Occurrence Data." *Global Ecology and Biogeography* 30: 316–326.

Crisfield, V. E., F. Guillaume Blanchet, C. Raudsepp-Hearne, and D. Gravel. 2024. "How and Why Species Are Rare: Towards an Understanding of the Ecological Causes of Rarity." *Ecography* 2024: e07037.

Cooney, R. 2004. *The Precautionary Principle in Biodiversity Conservation and Natural Resource Management*. IUCN.

Dias, A. M. S., C. Cook, A. P. Paglia, and R. L. Massara. 2025. "Imperfect Detection of Terrestrial Mammals in Environmental Impact Assessment (EIA) Baseline Surveys May Compromise Decision-Making and Mitigation Measures." *Environmental Impact Assessment Review* 112: 107850.

Elith, J., and J. R. Leathwick. 2009. "Species Distribution Models: Ecological Explanation and Prediction Across Space and Time." *Annual Review of Ecology, Evolution, and Systematics* 40: 677–697.

zu Ermgassen, S. O. S. E., M. P. Drewniok, J. W. Bull, et al. 2022. "A Home for All Within Planetary Boundaries: Pathways for Meeting England's Housing Needs Without Transgressing National Climate and Biodiversity Goals." *Ecological Economics* 201: 107562.

ESF. 2016. *World Bank Environmental and Social Framework*. World Bank.

Fonda, F., F. Bullegas, F. Petruzzellis, and G. Bacaro. 2026. "Assessing the Impact of Linear Infrastructure on Landscape Connectivity: A Worked Example From South Sudan and Uganda." *Biodiversity and Conservation*, *in press*.

Fonda, F., M. D'Amico, F. Petruzzellis, et al. 2026. "Rethinking Road Mitigation Priorities Through Detection-informed Interpretation of Roadkill Data and Road Crossability." *Biological Conservation* 313: 111619. https://doi.org/10.1016/j.biocon.2025.111619.

Fonda, F., M. Petrillo, and G. Bacaro. 2026. "A Framework for Assessing Forest Habitat Connectivity Loss and Optimising Reforestation Efforts on the Example of a Hydropower Project." *Environmental Management* 76, no. 2: 52. https://doi.org/10.1007/s00267-025-02351-7.

Fonseca, A., ed. 2022. *Handbook of Environmental Impact Assessment*. Edward Elgar Publishing.

Gardner, T. A., J. Barlow, I. S. Araujo, et al. 2008. "The Cost-Effectiveness of Biodiversity Surveys in Tropical Forests." *Ecology Letters* 11: 139–150.

Gavriel, T., E. Azzurro, L. Benedetti-Cecchi, et al. 2025. "Using Dark Diversity to Disentangle the Effects of Protection and Habitat Quality on Species Diversity." *Biological Conservation* 305: 111096.

Gurung, D., O. Katel, T. Tobgay, et al. 2022. *Protocol for Rapid Biodiversity Assessment*. Royal Society for Protection of Nature.

Hoekstra, J. M., T. M. Boucher, T. H. Ricketts, and C. Roberts. 2005. "Confronting a Biome Crisis: Global Disparities of Habitat Loss and Protection." *Ecology Letters* 8: 23–29.

International Finance Corporation. 2019. *Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources*. IFC.

Jarzyna, M. A., L. Ohyama, E. P. Economo, et al. 2025. "Emergence and Dynamics of Regional Species Pools." *Global Ecology and Biogeography* 34: e70046.

Lewis, R. J., F. de Bello, J. A. Bennett, et al. 2017. "Applying the Dark Diversity Concept to Nature Conservation." *Conservation Biology* 31: 40–47.

Liu, Y., M. Mahmoud, H. Hartmann, et al. 2008. "Chapter Nine Formal Scenario Development for Environmental Impact Assessment Studies." In *Developments in Integrated Environmental Assessment, Environmental Modelling, Software and Decision Support*, edited by A. J. Jakeman, A. A. Voinov, A. E. Rizzoli, and S. H. Chen, 145–162. Elsevier.

Luo, M., Z. Xu, T. Hirsch, et al. 2021. "The Use of Global Biodiversity Information Facility (GBIF)-Mediated Data in Publications Written in Chinese." *Global Ecology and Conservation* 25: e01406.

Maron, M., A. von Hase, F. Quétier, L. J. Sonter, S. Theis, and S. O. S. E. zu Ermgassen. 2025. "Biodiversity Offsets, Their Effectiveness and Their Role in a Nature Positive Future." *Nature Reviews Biodiversity* 1: 183–196.

Moeslund, J. E., A. K. Brunbjerg, K. K. Clausen, et al. 2017. "Using Dark Diversity and Plant Characteristics to Guide Conservation and Restoration." *Journal of Applied Ecology* 54: 1730–1741.

Morley, J., G. Buchanan, E. T. A. Mitchard, and A. Keane. 2021. "Implications of the World Bank's Environmental and Social Framework for Biodiversity." *Conservation Letters* 14: e12759.

Narain, D., L. J. Sonter, A. M. Lechner, J. E. M. Watson, J. S. Simmonds, and M. Maron. 2023. "Global Assessment of the Biodiversity Safeguards of Development Banks That Finance Infrastructure." *Conservation Biology* 37: e14095.

Nita, A., S. Fineran, and L. Rozylowicz. 2022. "Researchers' Perspective on the Main Strengths and Weaknesses of Environmental Impact Assessment (EIA) Procedures." *Environmental Impact Assessment Review* 92: 106690.

Pärtel, M., R. Szava-Kovats, and M. Zobel. 2011. "Dark Diversity: Shedding Light on Absent Species." *Trends in Ecology & Evolution* 26: 124–128.

Pärtel, M., R. Szava-Kovats, and M. Zobel. 2013. "Community Completeness: Linking Local and Dark Diversity Within the Species Pool Concept." *Folia Geobotanica* 48: 307–317.

Pärtel, M., R. Tamme, C. P. Carmona, et al. 2025. "Global Impoverishment of Natural Vegetation Revealed by Dark Diversity." *Nature* 641: 917–924.

Paudel, K., E. Ghimire, and J. Phelps. 2025. "The Pending Promises of Mitigation Measures in Environmental Impact Assessments: A Typology and Evaluation of Nepal's Hydropower Projects." *Environmental Management* 75: 1084–1098.

Pilgrim, J. D., S. Brownlie, J. M. M. Ekstrom, et al. 2013. "A Process for Assessing the Offsetability of Biodiversity Impacts." *Conservation Letters* 6: 376–384.

Rabinowitz, D., J. K. Rapp, and P. M. Dixon. 1984. "Competitive Abilities of Sparse Grass Species: Means of Persistence or Cause of Abundance." *Ecology* 65: 1144–1154.

Rampling, E. E., S. O. S. E. zu Ermgassen, I. Hawkins, and J. W. Bull. 2024. "Achieving Biodiversity Net Gain by Addressing Governance Gaps Underpinning Ecological Compensation Policies." *Conservation Biology* 38: e14198.

Ronk, A., R. Szava-Kovats, and M. Pärtel. 2015. "Applying the Dark Diversity Concept to Plants at the European Scale." *Ecography* 38: 1015–1025.

Sahu, A., N. Kumar, C. Pal Singh, and M. Singh. 2023. "Environmental DNA (eDNA): Powerful Technique for Biodiversity Conservation." *Journal for Nature Conservation* 71: 126325.

Sutherland, W. J., A. S. Pullin, P. M. Dolman, and T. M. Knight. 2004. "The Need for Evidence-Based Conservation." *Trends in Ecology & Evolution* 19: 305–308.

Wani, S. A., R. Ahmad, F. A. Dar, et al. 2023. "Estimating Dark Diversity and Regional Species Pool in the High-Altitude Himalayan Habitats." *Biodiversity and Conservation* 32: 2981–2999.

Western, D. 2001. "Human-Modified Ecosystems and Future Evolution." *Proceedings of the National Academy of Sciences* 98: 5458–5465.

Williams, A., and K. Dupuy. 2017. "Deciding Over Nature: Corruption and Environmental Impact Assessments." *Environmental Impact Assessment Review* 65: 118–124.