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Global Biodiversity Framework Targets Can Drive Action on Insect Declines, but Lack Robust Indicators to Prove Their Effectiveness

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ABSTRACT

Insects are the most diverse and functionally important animals on Earth. In at least some regions, terrestrial populations are declining. Despite this, insects are often overlooked in conservation policy, and it is difficult to assess how anthropogenic threats and conservation actions affect insect populations. The Kunming-Montreal Global Biodiversity Framework (GBF) aims to reduce pressures on biodiversity, increase conservation efforts, and reverse losses. At the International Congress on Conservation Biology in 2023, we convened a round table of specialist scientists and practitioners in insect ecology and conservation to explore how well the GBF addresses insect declines. We discussed and evaluated: (1) how well GBF targets could deliver for insects, and (2) whether the indicators proposed for monitoring progress would detect changes in the status of insects. We found that although the GBF's targets can drive action for insect recovery, almost none of the indicators can effectively measure progress for insects. We propose four principles to enhance the effectiveness of biodiversity policy for insects, and recommend the establishment of a global working group to develop insect-focused indicators. If implemented effectively, such indicators could provide evidence of whether restoration and conservation actions are putting us on a path to recovery of global biodiversity.

1 | Introduction

Insects are the most diverse group of animals on Earth, with over 1 million named species and up to 4 million undescribed species (Stork 2018). This diversity, coupled with their sheer abundance, means that insects are critical to the functioning of all terrestrial and freshwater ecosystems, acting as pollinators, predators, decomposers and food sources (Noriega et al. 2018). Substantial declines in insect numbers could mean fundamental, even catastrophic, changes to ecosystems, as trophic connections are lost and core ecological functions compromised (Noriega et al. 2018). Current evidence suggests that insect populations are declining, at least in terrestrial ecosystems, in some regions. In large data syntheses, abundance is declining by an average of 1% per year, although freshwater taxa seem to have experienced a phase of recovery in recent decades (Haase et al. 2023; van Klink et al. 2020). Some documented recent declines have been even more alarming than the average trend implies (Hallmann et al. 2020, 2017; Seibold et al. 2019).

Insect declines in terrestrial systems appear to be concentrated among the most abundant species (van Klink et al. 2024)—the same species that make the biggest contribution to ecosystem functions and services (Kleijn et al. 2015). However, rarer species are less frequently captured by standardized monitoring, yet are often identified as vulnerable in Red List assessments, and can deliver unique ecosystem functions (Leitão et al. 2016; Mouillot et al. 2013). Nonetheless, most insect taxa, and vast regions of the world, lack robust population trend data (Dicks et al. 2024). Faced with uncertain scientific evidence and high stakes, the precautionary principle suggests enacting conservation of insects from local to global scales (Harvey et al. 2020).

Despite all of this, insects remain largely overlooked in the international biodiversity debate. The most well-known and widely used biodiversity datasets operable at global scales are heavily focused on vertebrates. For example, the IUCN Red List includes extinction risk assessments for just 1% of insect species, a disproportionate number of which are classed as Data Deficient (IUCN 2025). Just one of the 29 insect Orders, the Odonata (dragonflies and damselflies), has been comprehensively assessed, compared with virtually all vertebrates. Too few insect species have been assessed multiple times for the Red List Index (RLI) to report reliably on changes in insect conservation status through time. Meanwhile, the Living Planet Index (LPI), a high-profile biodiversity indicator, focuses on vertebrate species (McRae et al. 2025), although efforts to include Lepidoptera (butterflies and moths) are underway. Poor representation of insects in global biodiversity datasets risks undermining their usefulness. This is exemplified by the apparent mismatch between findings from the 2022 Living Planet Report (WWF 2022) that freshwater populations have declined by 83% since 1970, and findings that freshwater insect populations are increasing by 11% per decade (albeit with a reliance on data from Europe and North America, with trends difficult to infer for other parts of the world) (Gaume and Desquilbet 2024; van Klink et al. 2020).

The Kunming-Montreal Global Biodiversity Framework (hereafter, GBF) was adopted at the 15th Conference of the Parties of the Convention on Biological Diversity (CBD) in December 2022. It was conceived as a comprehensive plan to reduce pressures on nature, intensify conservation efforts, and remove systemic factors leading to biodiversity loss (e.g., through subsidies). Indeed, the GBF is one of the most ambitious environmental agreements (Hughes and Grumbine 2023). The overarching aim of the GBF is to halt and reverse nature loss by 2030 (Convention on Biological Diversity 2022). The agreement comprises four goals for 2050, and 23 action-oriented targets for 2030, supported by a monitoring framework that defines a set of indicators against which parties to the CBD should report.

In this perspective, we explore whether the GBF and its monitoring framework are fit for the needs of insect conservation and address the concern that insects are excluded from assessment endpoints for the global biodiversity goals (e.g., "Direct drivers of biodiversity loss"—Goal A), precluding any feedback mechanism that could modify the action-oriented targets. We focus on 23 actions for biodiversity conservation and their proposed indicators as laid out in the GBF, and consider whether each can be expected to address insect declines and, if not, what must change for it to do so.

2 | Methods

At the International Congress on Conservation Biology in Kigali, Rwanda, in July 2023, we convened a round table discussion entitled "How to incorporate insects into the Global Biodiversity Framework." The round table was attended by 47 delegates from 18 countries across five continents, with a bias toward Europe and Africa (Africa: 13 delegates; Asia: 4 delegates; Europe: 23 delegates; North America: 6 delegates; Oceania: 1 delegate). All attendees and organizers had a special interest in insects but were from backgrounds in conservation, biodiversity research, or conservation practitioners. All participants of the round table are co-authors of this paper.

During the round table, we first held facilitated group discussions stimulated by the following question: *Why, or how, is conservation fundamentally different for insects than for vertebrates*? This was done in six groups, each with 6–8 participants and one facilitator discussing the same topic. Attendees were allowed to choose which group they joined. After the group discussions, specific ideas were listed one by one, until no group had anything new to add. Ideas were then grouped into themes, from which concise descriptions and summaries of the consequences for insect conservation were derived. These summaries were produced by the core group (a team from the Global Insect Threat-Response Synthesis project, https://glitrs.ceh.ac.uk/, who devised and planned the workshop) and based on transcribed notes from the workshop.

We then focused on the 23 GBF targets. The information supplied to participants (Supporting Information) included the full text of the Targets and the list of headline indicators as defined by the GBF. We worked in the same groups to evaluate: (1) whether each target, if met, could reverse insect declines, or maintain insect populations; (2) whether the proposed headline indicators for each target would be sensitive to changes in the status of insects; (3) what alternative indicators would be better to monitor progress towards each target for insects. Each group considered a subset of three or four targets, with most targets only being assessed by one group (targets 1, 2, 3 and 4 were assessed by two groups). For the first two questions, groups were asked to arrive at one of five possible numbered answers, arranged on a Likert scale from 1 (Not at all beneficial) to 5 (Very beneficial for most insects) for question 1, and 1 (Not at all) to 5 (Comprehensive measurement for most insects) for question 2 (Supporting Information). For the four targets which were assessed by two groups, the groups independently arrived at the same answer to question 1 each time, and at the same answer or 1 point apart for question 2. For the third question, a free text box was used to collect ideas from the groups.

Seven GBF targets (10, 14, 19, 20, 21, 22, and 23; Supporting Information) that were not covered during the in-person conference session were assessed in a subsequent online workshop involving 17 of the participants, working in two groups. This online assessment followed the same format as the in-person round table.

3 | Results

3.1 | Why Do Insects Deserve Special Consideration in Conservation?

We identified nine important reasons why insects are fundamentally different from other taxa, particularly vertebrates, when it comes to understanding their status and planning for conservation actions (Table 1).

3.2 | How Well Could the GBF Targets Deliver for Insects?

Our consensus was that achieving the GBF targets would benefit insects (Figure 1, left). In answer to the question "If this target was delivered globally, would it benefit insects?," we obtained a mean answer score of 3.3 out of 5 across the 23 targets (median: 3), indicating "Moderate benefits to some groups, or limited benefits to most groups." Five targets—"Pollution and water quality," "Nature's contribution to people (ecosystem services)," "Reducing overproduction," "Reducing overconsumption," "Resource mobilization"—were scored 5 "Very beneficial for most insects," while only two—"Use of wild species," "Benefit sharing (genetic resources)"—were scored 1 "Not at all beneficial."

3.3 | Do the Proposed Indicators Measure Change in the Status of Insects?

Our consensus was that insects are poorly served by existing or proposed indicators (Figure 1, right). In answer to the question "How well would the proposed indicators measure progress for insects?," we obtained a mean answer score of 2.4 (median: 2.5) out of 5 across the 16 targets with proposed indicators, indicating "Limited measurement for some groups." None of the proposed indicators were scored as 5, providing "Comprehensive measurement [of progress] for most insects," while four targets scored 1, because we perceived the proposed indicators would "Not [measure progress] at all" for insects. This included two that directly focus on biodiversity conservation: Targets 4 (Species protection) and 5 (Use of wild species).

3.4 | Do the GBF Targets and Proposed Indicators Serve to Address Insect Declines?

Our collective opinion, formed during workshop discussions and represented by our agreed scores (Figure 1), is that the GBF targets support actions at a global scale that have the potential to recover insect populations, but the proposed indicators have limited ability to measure insect responses. The scores we assigned for the two questions were not drawn from the same distribution (Mann–Whitney test: $W = 268.5$, $P = 0.014$; Question 1 rank mean $= 12.0$ ($n = 23$), Question 2 rank mean $= 8.5$ ($n = 16$)). In other words, we might be doing the right things for insect biodiversity, but the proposed indicators will not tell us whether it is working.

TABLE 1 | Why, or how, is conservation fundamentally different for insects than for vertebrates? A summary of key points raised by workshop participants in response to this question.

Feature of insects	Description	Consequences for conservation
Complex life histories	Insects have complex life histories. Species may connect multiple trophic levels or live in different habitat components at different stages of their life cycle. For example, dragonflies and damselflies provide ecological functions in both freshwater and terrestrial environments.	Different life stages may require separate conservation interventions that must be delivered together. Insects that are both herbivorous and carnivorous (e.g., hoverflies) need detailed management of vegetation *and* attention to populations of other animal species.
Very high spatiotemporal variability in populations	Insects have short generation times, high reproductive rates and highly variable populations. Abundance can vary massively between years and times of year. This makes it difficult to quantify trends and creates a need for long time series with high temporal resolution.	Predicting future trends and extinction risk is challenging, making it difficult to set conservation priorities. Existing IUCN Red List Criteria need to be very carefully applied (Fox et al. 2019). Analyses of short time series are not scientifically robust.
Small spatial scale	Insect bodies are small relative to humans, with most falling in the range 1–100 mm in length. The scale at which environmental quality matters to insects is smaller than the scale at which threats can be monitored, and management actions can be planned or implemented.	Management, such as mowing, creates fine-scale homogeneity, damaging insect populations (Konvicka et al. 2008). It can be difficult to set priorities because data on drivers and habitat quality are poorly resolved. Insect conservation tends to focus on general habitat quality, which may not deliver for all species.
Public perception	There are many negative public perceptions of insects. The education system and media neglect insects, and many children are raised to despise them, because of the few species that are dangerous or considered pests, leading to lack of knowledge and lack of care.	There are fewer insect advocates, less research and less conservation action per insect species than for other animal groups (high diversity, low interest). Insect conservation is poorly funded. There are few specific grants or dedicated NGOs, and fewer experts available for citizen science.
Conservation advocacy	Insect conservation tends to be driven by more utilitarian, less emotional motives than for other groups (e.g., insects are conserved for their ecosystem services and food supplies, rather than intrinsic value).	Insect conservation operates more often through improving habitat quality, with an underlying perception that insects do not require specific actions. Conservation focused on service providers may not be what is needed for rare and threatened species (Kleijn et al. 2015).
Sensitivity to change	Being ectothermic, small-bodied and short-lived, insects are sensitive to short-term environmental disturbance. Insect populations can suffer large & immediate consequences from threats such as agri-chemical pollution or extreme weather events. For the same reasons, they can also recover quickly in response to restoration, or removal of threats.	Insects could be "leading indicators," responsive to environmental change and therefore useful for tracking change toward nature recovery. Freshwater arthropod communities are used like this, to indicate water quality, but terrestrial arthropods are not.
Data collection methods	Data collection methods for insects are often subject to high levels of measurement error and incomparable across taxonomic groups. Methods of insect sampling often involve killing individuals, raising ethical issues, and making research difficult when working with rare and threatened species.	Long term monitoring schemes, needed to monitor change and evaluate conservation success, are difficult to design. A variety of methods, and some transport and storage of specimens, is needed. Biases in different data types are not always recognized.

(Continues)

TABLE 1 | (Continued)

Feature of insects	Description	Consequences for conservation
Taxonomic bias	Many groups are hard to identify. Knowledge is biased toward easily identified and charismatic groups (e.g., butterflies). Other groups, for example cicadas or flies, are much less well known and tend to be ignored.	Research and conservation action are taxonomically biased toward certain groups that represent a very small subset of insect diversity, lifestyles and ecological functions.
Population genomics complexity	Diverse mating systems, skewed reproductive success, and polyphenism complicate estimates of effective population size and population genetic structure. Most insect taxa lack reference genomes, functional annotations, and established genomic resources, limiting comparative analysis and adaptive potential inference. High structural genome diversity, cryptic speciation, and unresolved taxonomy obscure species boundaries and conservation units.	Population reconstructions based on effective population size may be inaccurate, undermining extinction risk models. Without reference genomes, population structure and adaptive variation remain poorly resolved for most taxa. Failure to detect cryptic species risks overlooking distinct evolutionary units needing protection. Conservation strategies based on genetic monitoring may miss key trends due to life history heterogeneity and poorly understood dispersal patterns.

Seven of the GBF targets (8, 14, 16, 17, 20, 22, and 23, see Table S1) did not have proposed indicators at the time of our workshop, but indicators have been proposed since. All but one of these newly proposed indicators are counts of the number of countries taking action (for example with relevant policies), and so are unlikely to have been categorized here as anything other than "Limited measurement for some groups." The exception is for Target 22 (land-use change and land tenure in the traditional territories of indigenous peoples and local communities), which may have scored more highly, but we do not think this would change our overall conclusion.

4 | Principles to Enhance the Effectiveness of Global Biodiversity Policy for Insects

Reversing insect declines requires tractable action plans that can deliver for insects. Previous work has outlined a roadmap for insect recovery (Harvey et al. 2020), including no-regret solutions centered on reducing pressures, conserving and restoring habitat and species, and expanding education. By contrast, we propose four guiding principles developed within the workshops to shape action for insects, grounded in the unique characteristics (Table 1) which separate insect conservation from wider conservation efforts.

4.1 | Design Indicators and Metrics That Are Relevant to Insects

Our assessment of the GBF targets indicated that most do not have a proposed metric with which to effectively monitor the progress of insects toward the target. Therefore, we must develop insect-relevant indicators, which may be broadly characterized in one of three ways.

First, insect indicators may be variants of existing metrics for measuring biodiversity change. For example, many countries in Europe (and at EU-level) have indicators on the state of insect populations, such as the European Butterfly Monitoring Scheme (van Swaay et al. 2025) and European Red List assessments (Clausnitzer et al. 2009; Hochkirch et al. 2016; Vujić et al. 2022), that could report against Goal A (Direct drivers of biodiversity loss). The European Commission is in the process of specifying a European Union Pollinator Monitoring Scheme, obligatory under the new Nature Restoration Law (European Union 2024). Member States will have to follow a specified method (Potts et al. 2024) and provide regular reports on the trends of pollinating insects. Similarly, data gathered using new monitoring technologies, such as acoustic monitors for orthopterans or eDNA sampling, will enhance our ability to measure population trends in a comparable way to non-insect taxa (van Klink et al. 2022), with low-cost, automated pipelines currently being developed (Besson et al. 2022). Methods are also being developed to identify proxies for insect diversity in specific systems, such as using total abundance to predict species richness (Marini et al. 2025), biomass as a proxy for abundance (Dunn et al. 2023) or even host plant availability for predicting abundance (Curtis et al. 2015), which may function as lower cost alternatives for monitoring, and could be used to inform measures of Essential Biodiversity Variables (EBVs) (Schmeller et al. 2018). Meanwhile, open-source data analysis pipelines are being used to derive indicators for all members of the Convention on Biological Diversity (CBD) (GEOBON 2025). Such data would be especially useful for measuring progress toward targets 4 (Species protection) and 5 (Use of wild species).

Second, new insect indicators may be derived from newly available data. For example, standardized, non-lethal estimates of insect biomass should be made possible by automated insect monitoring devices deployed at scale (Roy et al. 2024; van Klink et al. 2022), or may even be estimated from weather radar (Bauer et al. 2024; Mungee et al. 2025). Such data would be particularly relevant for measuring ecosystem properties (Goal B). Another new source of data comes from citizen science schemes, which can gather low cost occurrence data from all over the world (Chowdhury et al. 2025; Earthwatch 2024; Reynolds et al. 2025; Targetti et al. 2014). Identification can by guided by recorders, verified by experts, and automated by AI algorithms, and methods

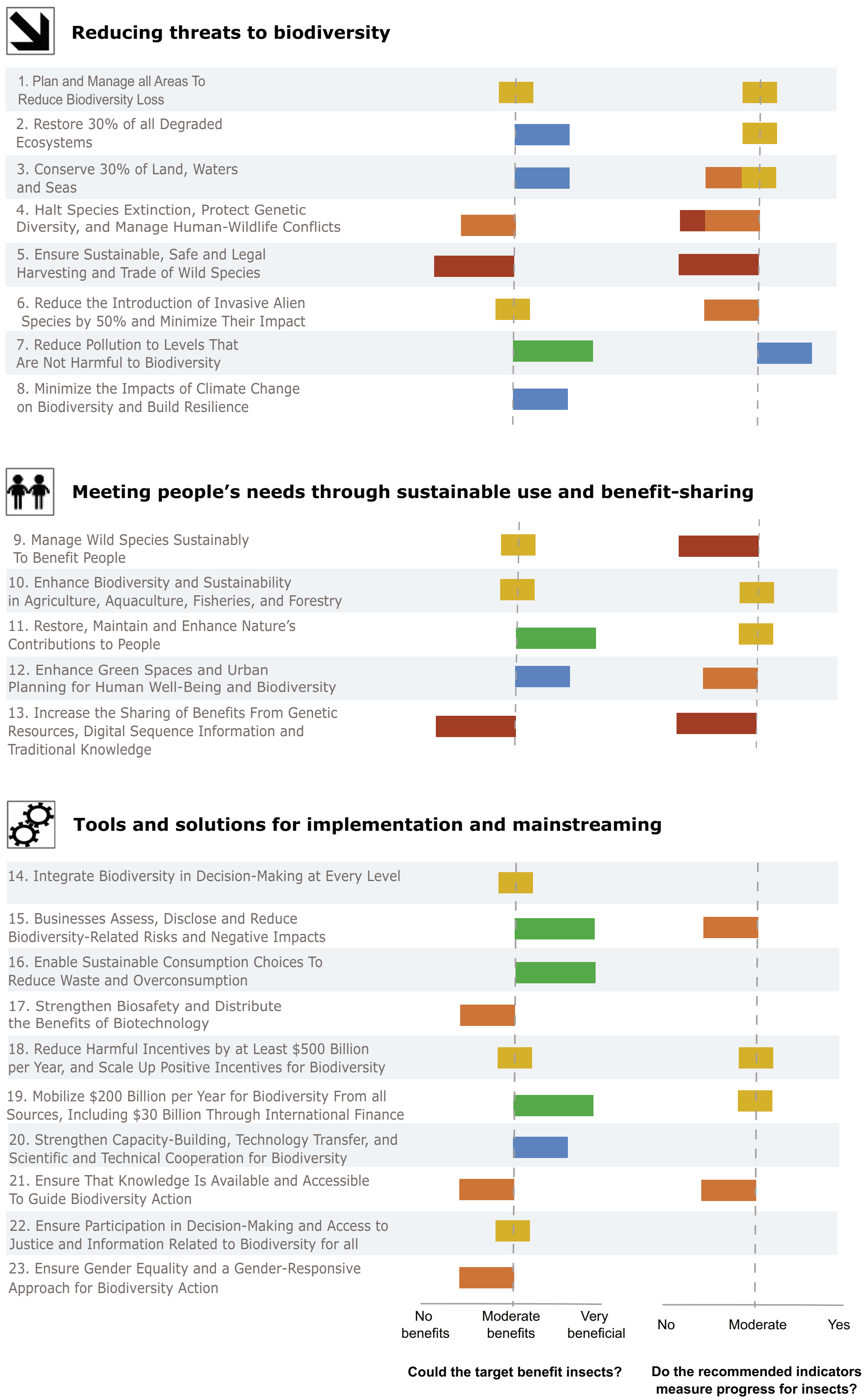

FIGURE 1 | Legend on next page.

for interpreting trends based on ad hoc presence or occupancy data are advancing (Olsen et al. 2020). Focusing monitoring on large and easily identifiable taxa, which may serve as effective proxies for wider insect biodiversity, will widen the appeal of these schemes to a larger audience (Butterflies of India 2025; Chowdhury et al. 2025; Cicadas of India 2025; Moths of India 2025; Odonata of India 2025; Stream Assessment Scoring System 2025). Additionally, lower taxonomic resolutions may be used to predict species richness for groups which are more challenging to identify (Báldi 2003).

Third, insect metrics must capture the fact that insects are exposed to different drivers at different scales compared to other taxa. Global mapping of biodiversity, threats, and extinction risk are often coarse and generic, and do not capture spatial or temporal heterogeneity which is most relevant to insects. Metrics of habitat diversity, connectivity and other indices of spatial structure at a fine spatial scale, and of threat reduction at a fine temporal scale, could be linked to recovering insect population trends through on-the-ground case studies (Landmann et al. 2023; Torresani et al. 2024) or known threat-response relationships (Cooke et al. 2025). This would facilitate the measurement of progress toward targets 2 (restoration), 10 (sustainable production systems), 12 (Green and blue spaces) and 15 (Reducing overproduction).

To maximize their usefulness, such new indicators and metrics should be developed by a working group under the Convention on Biological Diversity, as is underway for Target 6 (Invasive Alien Species) (CBD 2025). If developed and adopted, these approaches would allow progress toward reversing insect biodiversity loss to be measured in a meaningful way.

4.2 | Design Policies and Actions for Insect-Relevant Scales

Some insects are less mobile than vertebrates, and require greater habitat connectivity. Large protected areas are important, but especially for insects, they must be complemented by a network of smaller pockets of habitat that capture the heterogeneity and uniqueness of different parts of different regions (Riva et al. 2024; Riva and Fahrig 2022). However, insects can respond to conservation action at smaller scales than vertebrates. Within human-dominated landscapes, this presents opportunities to bolster insect populations by providing small stepping-stones of habitat, which may not be considered valuable for vertebrates due to their size. For instance, actions to reduce land use intensity and increase landscape heterogeneity outside of protected areas could facilitate insect dispersal and persistence across the wider habitat matrix (Suggitt et al. 2018).

4.3 | Focus on Groups of Species With Similar Responses to Environmental Change or Management

To scale up insect conservation efforts, we need to find ways to protect as many species as possible with a set of broad actions. Rather than attempting to develop and test conservation actions for individual species, the challenge for insect conservation is to define groups of species with similar responses to environmental change that can be conserved together. In this regard, species-focused conservation is akin to clinical medicine, where you treat one person for a particular disease. Insect conservation has to be more like public health, where the aim is to treat the entire community and environment in a way that benefits everyone. Such assemblages may, for example, be habitat-specific, and allow decision-makers and conservation managers to prioritize habitat features that support key groups of species. Alternatively, groups may be defined by their responses to management, enabling an assessment of how broad conservation actions translate into insect biodiversity change. The Biodiversity Audit Approach offers a method for doing this (Crowther et al. 2023).

Species (or groups of species) inhabiting the same ecosystems will also differ in their habitat and conservation requirements. Therefore, identifying groups of species which respond in different ways will be equally important, such that the needs of different groups can be balanced and managed through, for example, the promotion of habitat heterogeneity (Knuff et al. 2020).

4.4 | Use Insects as Indicators of Ecosystem Decline or Recovery, to Incentivize Monitoring

Having short generations means that insects are likely to respond much quicker to conservation action than large-bodied, long-lived vertebrates (Wilson and Fox 2021). This means that insect biodiversity is generally sensitive to changes in the health of the environment and to the effects of conservation actions (Thomas et al. 2009). Indicators based on insect data therefore have enormous potential to act as "leading indicators" that can provide early evidence for recovery (Stevenson et al. 2021). This also makes economic sense, because insect numbers are often proxies for ecosystem services such as pollination, pest regulation and nutrient cycling (Noriega et al. 2018). Indeed, freshwater invertebrates have been used as a key indicator of water quality (which is important for human health as well as biodiversity) in North America for over 40 years (Hilsenhoff 1982), in South Africa since 1994 (Dickens and Graham 2002) and in Europe since at least 2000 (European Union 2000). With legislative targets requiring improvements in water quality, freshwater insect populations in Europe have increased over the last 60 years (Haase et al. 2023;

FIGURE 1 | Our assessment of whether each of the 23 Kunming-Montreal Global Biodiversity Framework targets has the potential to benefit insects (left) and whether the proposed indicators would be able to measure progress toward the target for insects (right). Responses to each question were scored in groups using a Likert scale, from 1 (not at all, red), through 2 (limited benefits/measurement for some groups, orange), 3 (moderate benefits/measurement for some groups, or limited benefits/measurement for most groups, yellow), 4 (moderate benefits/measurement for most groups, blue), to 5 (very beneficial/comprehensive measurement for most insects, green). In most cases, only one group of people scored the target. In the two instances (Targets 3 and 4, question 2) where two groups scored the target and provided different answers, both responses are presented. Targets are sub-divided into three themes as presented in the GBF. The seven targets without indicator scores (question 2) are those for which indicators were only proposed after our workshop (see text).

van Klink et al. 2020), although freshwater insect richness and density declined between 1993 and 2019 in the United States (Rumschlag et al. 2023).

5 | Conclusion

We set out to consider whether the new Global Biodiversity Framework has a chance of addressing insect declines. We expected to find a heavy focus on solutions known to be effective for vertebrates and plants, with indicators of success that could only be measured for these groups. Instead, we concluded that most of the targets in the new framework *could* deliver for insects. We would go even further and say that the GBF has all the components of an excellent strategy to reverse insect decline at scale. In contrast, the indicators currently proposed to measure progress are likely to be insensitive to changes in the status of insects. We therefore recommend a working group is established under the Convention on Biological Diversity to develop indicators specifically for insects. By integrating these actions with other underrepresented taxa, there is an opportunity to identify shared data gaps and common monitoring challenges, and promote composite measures of ecological integrity. Doing so will benefit not just insects and the ecosystem services they provide, but also provide leading indicators of whether restorative actions for nature are putting us on a path to recovery.

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Data Availability Statement

The data associated with this paper were collected during a workshop from which all attendees were invited to be authors of this paper. The data are fully presented in the manuscript, so no additional archiving is necessary.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.

Supplementary Material: conl70025-sup-0001-SuppMat.docx