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Policy analysis

Harnessing biodiversity data to inform policy: Rapid regional audits should underpin Local Nature Recovery Strategies

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ABSTRACT

Nature recovery actions within anthropogenic landscapes typically target small and unrepresentative species subsets, or generic habitat features that are assumed to benefit wider suites of species, despite incomplete understanding of what these species are, or of their autecological needs. These limitations in the evidence underpinning conservation contribute to continuing biodiversity losses.

Experimental evidence shows improved outcomes follow the use of spatially-targeted audits of multi-taxa biodiversity information, allowing actions to be tailored towards the ecological requirements of complete local species pools. We illustrate how this approach could be integrated into environmental policy, with particular reference to the European Union's 2030 Biodiversity Strategy and the UK Environment Act 2021's Local Nature Recovery Strategies (LNRS).

Biodiversity auditing uses existing repositories of species occurrence and functional trait data to group priority species into cross-taxa 'management guilds' that share similar responses to conservation interventions, allowing practitioners to identify and implement regionally-optimized, evidence-based action plans. Where previously implemented, this approach has successfully transformed conservation practices at bioregional scales, increasing the richness and abundance of priority species relative to pre-existing management.

We provide methods for incorporating rapid low-cost biodiversity auditing into local conservation strategies, to ensure these support the widest complement of priority biodiversity. Failure to adopt a data-driven approach risks reproducing previously ineffective paradigms, and thus failing to seize vital chances to reverse declines in biodiversity. We further argue that researchers should prioritize the development of accessible tools to support authorities to incorporate species data into strategic landscape-scale conservation design.

1. The opportunity to recover biodiversity

Despite decades of effort, conservation has not been successful in avoiding accelerating species declines at either global or regional scales (Williams et al., 2020; Hayhow et al., 2019; EEA, 2020). In anthropogenic landscapes that increasingly dominate the world, successful conservation requires locally-tailored management strategies that account for regional differences in species composition, threats and opportunities (Dolman et al., 2012). In the past, local-scale conservation has often relied on interventions targeted either at small sub-sets of species (with uncertain efficacy as biodiversity surrogates or indicators), or at structural features of habitats (with uncertainty on their suitability for locally-threatened biodiversity), while recent rewilding approaches often take a process-led approach without comprehensive analysis of biota (Fuller et al., 2017; Pettorelli et al., 2018).

Goals of conserving and restoring biodiversity must be balanced with food security and other ecosystem service outcomes, therefore, conservation-focused interventions should have maximal efficacy. The success of conservation interventions should be evaluated by their delivery of habitat conditions and processes required by the widest complement of local, threatened, biodiversity (Dolman et al., 2012). In Europe, generalized agri-environment interventions have often failed to benefit rarer threatened biodiversity (Kleijn et al., 2006) while in the UK, actions towards species recovery have so far failed to incorporate

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tailored strategies for 89 % of species listed in the UK Biodiversity Action Plan (Hayhow et al., 2019). Many arthropod groups are particularly under-represented in policies that target rare or endangered species (Duffus and Morimoto, 2022). Habitat-based actions have also been insufficient to stem biodiversity declines, with only 50 % of designated UK Sites of Scientific Importance in favourable condition (Hayhow et al., 2019), and since 1970 more species have shown strong or moderate decreases in abundance (41 %) than increases (26 %; Hayhow et al., 2019).

Crucially, the efficacy of interventions can differ across landscapes (e.g. Batáry et al., 2011; Concepción et al., 2012), reflecting regional variation in the taxonomic and functional composition of biotas. Conservation strategies should, therefore, be locally tailored to meet the ecological needs of their species pools. Comprehensive cross-taxa biodiversity audits in England typically identify 10,000–14,000 species, and 1000–1500 priority species, per ecoregion, the majority of which are plants and invertebrates that have been historically neglected in conservation planning (Dolman et al., 2012; Crowther et al., 2022). Thankfully, the data to assess the distributions and autecological requirements of these 'off-radar' species are widely available, thanks to growing networks of biological recorders and increasingly comprehensive ecological trait databases. Biodiversity auditing is a rapid desk-based method to harness and synthesize these data into region-specific biodiversity inventories that provide cross-cutting manager-friendly guidance (Dolman et al., 2012; POST, 2015; Hawkes et al., 2021a; Crowther et al., 2022). As well as informing local strategy development, the manager-friendly information provided by audits can empower practitioners to implement more effective actions (Hawkes et al., 2021a), and potentially design enhanced monitoring protocols.

Promisingly, many governments are increasingly recognizing the need for strategic local conservation planning. The European Union's 2030 Biodiversity Strategy (European Commission, 2021), includes a proposed Nature Restoration Law (European Commission, 2022) requiring member states to develop national strategies to restore habitats. Similarly, the UK's recent Environment Act (HM Government, 2021) has mandated responsible authorities (e.g. local governments) in England to create and enact bespoke 'Local Nature Recovery Strategies' (LNRS) for habitat creation and improvement, to directly determine actions delivered via agri-environment schemes, biodiversity offsets and other mechanisms. The Scottish Government has also committed to introduce a Natural Environment Bill in 2023 with a further framework to deliver nature restoration with locally targeted outcomes for biodiversity gain (Scottish Government & Scottish Green Party, 2021). Coupled with UK government commitments to bring 75 % of protected sites into favourable condition (HM Government, 2018), and designate 4000 km^2 of new protected areas (Defra, 2020), these have huge potential to help reverse biodiversity losses (Hayhow et al., 2019). However, recent pilots of LNRS in England did not include any provisions for using available species data (Defra, 2021), highlighting the risk that these novel policy tools could miss a key opportunity to harness the wealth of biodiversity information that is available.

In this policy perspective, we propose that biodiversity auditing should be integral to the ongoing development of regionally-targeted conservation strategies within anthropogenic landscapes. Our approach uses both data on species distributions and autecological traits, as such it is simplest to implement in well characterised anthropogenic landscapes, such as those that are common in Europe and North America. We first examine pilot approaches to LNRS in England to demonstrate the need for multi-taxa biodiversity audits. We then show that spatially-explicit regional and supra-regional biodiversity auditing is a straightforward, practical way to improve conservation outcomes at the scale at which practitioners operate. As such, auditing can make an important contribution both to the management of existing semi-natural sites and the design of restoration efforts. We suggest that auditing should be incorporated into planning processes for anthropogenic landscapes globally, and specifically for the EU's 2030 Biodiversity Strategy, as well as formal inclusion in the supplementary advice issued by the UK Secretary of State for LNRS development.

2. Local Nature Recovery Strategies

The UK government has recently piloted LNRS in five Local Authority Areas across England, with the aim of creating management plans that will determine future local decisions on conservation practice and funding, including agri-environment initiatives and 'biodiversity net gain' offsets (Defra, 2021). Here, we consider LNRS as they provide a well-developed example of local strategies and the implications of failing to adopt data-driven approaches to nature recovery policy. Rather than focusing on species data, the piloted LNRS guidance focusses on mapped inventories of statutory Priority Habitats (Fig. 1a; HM Government, 2006, 2018) as a proxy for the resources required by species of conservation concern. In principle, systematic planning tools applied to coarse priority habitats can prioritize restorative actions (Smith et al., 2022), but these approaches suffer from significant shortcomings. Priority semi-natural habitats are usually classified using a combination of plant assemblage composition and human land-use history (Fuller et al., 2017), but different land parcels of the same priority habitat can vary hugely in their vegetation structure, ecological niches and thus their suitability for priority biodiversity (Dolman et al., 2012; Fuller et al., 2017; see examples in Fig. 2). Strategies framed in terms of priority habitat classes without understanding regional biota, do not give effective guidance on how these should be managed. Incorporating an audit approach (Fig. 1b) into the design and management process can greatly increase the numbers of important species that are supported (e.g. Fig. 2). Furthermore, in analyses of multiple landscapes in Eastern England, most priority species occupied multiple semi-natural priority habitats (Dolman et al., 2012), occurring where suitable ecological conditions exist, including in novel land-uses (Fuller et al., 2017). Effectiveness of conservation guidance is simplified and strengthened by integrating the ecological needs of management guilds, cutting across such arbitrary semi-natural habitats.

Piloted LNRS in England were also required to include a Statement of Biodiversity Priorities (Fig. 1a) identifying opportunities for linking, increasing or improving the condition of each mapped priority habitat (i.e. the 'Lawton Principles', Lawton et al., 2010). While the use of both habitat and species data are referenced within the Environment Act, current guidance does not specify how species data are to be used, therefore priority statements are likely to be informed by partial and qualitative information. In the absence of a formal audit, assessors may be unaware of the range of species present and their ecological needs, risking perverse conservation outcomes (Dolman et al., 2012; Fig. 2). Notably, a post-pilot assessment by the Department for Environment, Food and Rural Affairs (Defra) stated: "there is a need for guidance on what data responsible authorities should ideally be seeking to use" (Defra, 2021). At the current time, the LNRS pilots have no plans for monitoring outcomes, which is not explicitly required under the Environment Act.

Currently, the piloted LNRS regulations make no provision for identifying the species that inhabit strategy areas, despite England having among the highest densities of species distributional data (Powney and Isaac, 2015) and functional trait data (Fitter and Peat, 1994; Webb et al., 2017) anywhere in the world, combined with up-to-date conservation status assessments across diverse taxonomic groups. Failure to fully use these data risks perpetuating the shortcomings (Hayhow et al., 2019) of past conservation efforts. Although commitments have been made to protect and restore significant tracts of land (Defra, 2020; HM Government, 2018), simply expanding an ineffective strategy (Hayhow et al., 2019) risks missing an historic opportunity.

3. Biodiversity auditing – a simple solution

Auditing offers a low-cost way to capture regional factors that

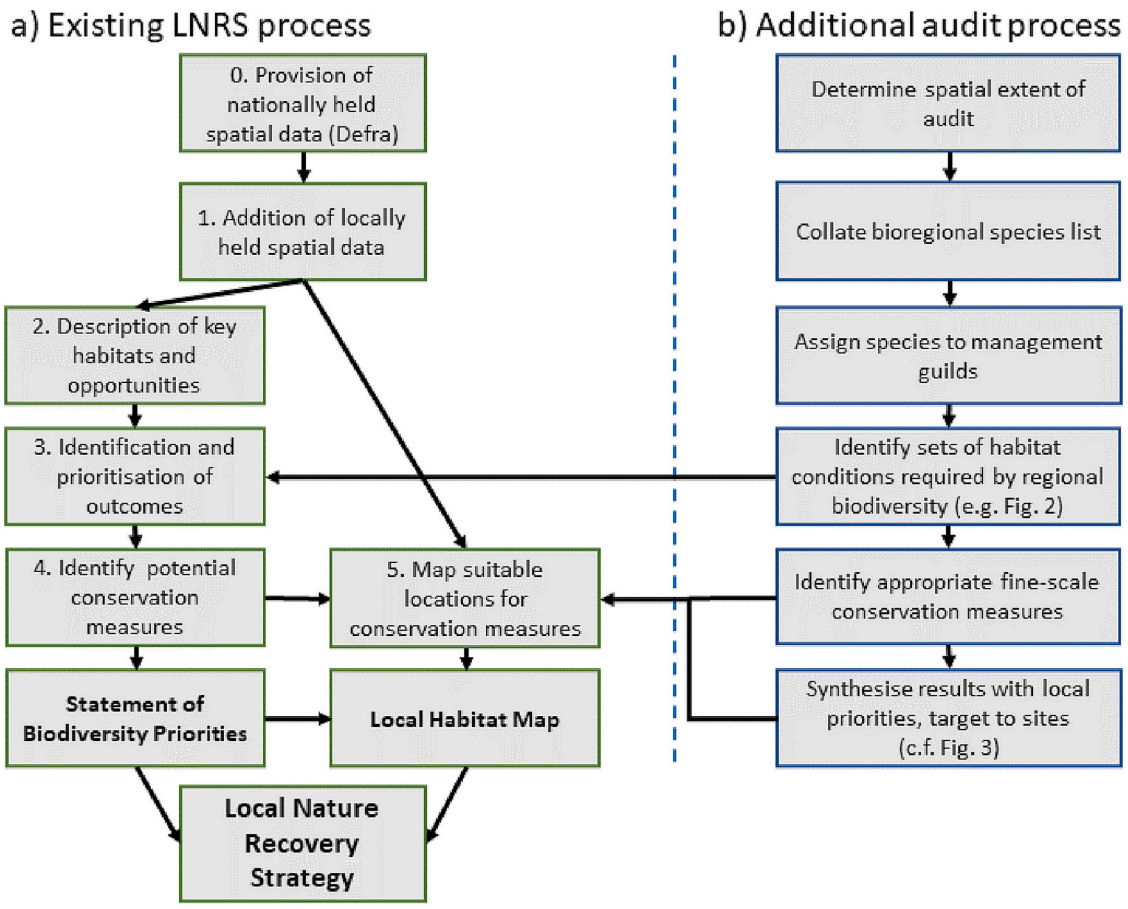

Fig. 1. Schematic showing how the existing process for preparing a Local Nature Recovery Strategy, with steps 0–5 codified from pilots (a), could be guided by the addition of a Biodiversity Audit (b).

strongly influence the optimality of different conservation interventions, using existing biological records and autecological information that are increasingly available for many developed countries (including much of Europe). Auditing first determines the full species inventory for a region (Fig. 1b) using available species occurrence data. Wherever possible data should be harvested from the networks and services that collate and curate it such that validated records from electronic and more traditional sources can be included. In the UK, for example, >127 million species occurrence records are held by the National Biodiversity Network Gateway - these can be augmented by Local Environmental Record Centres (who collate validated records from citizen-science platforms including iNaturalist, and eBird), taxon-specific recording schemes, and local recorder networks. After determining an appropriate timeframe (usually spanning several decades to allow sufficient data) a total regional species list can be collated (see Fig. 1), and the conservation status of each species determined (e.g. from the JNCC master list in the UK; JNCC, 2022) allowing priorities to be identified.

Next, priority species are assigned to cross-taxa 'management guilds' according to their resource requirements and autecological traits, cutting across traditional habitat classifications and focusing on ecological conditions that can be actively managed (Fig. 2). In the UK, this process is now made substantially more efficient by the Pantheon autecological dataset for invertebrates (https://pantheon.brc.ac.uk/; Webb et al., 2017) and Ecoflora for vascular plants (ecoflora.org.uk), providing detailed trait data for 13,000 and 3842 species respectively, with completeness estimates by taxon. Even without such pre-made autecological datasets, it is still practical to create robust management guilds from primary literature, with 80 % of conservation priority plants and invertebrates in Breckland successfully assigned in this way (Dolman et al., 2012). Audits thus develop management guild classes that capture the requirements of a high proportion of a region's species by synthesizing ecological literature, alongside expertise of regional land managers and practitioners, specifically to find the sets of microhabitat conditions that can reliably be created by management action (see Dolman et al., 2012 for further methodological details).

Rapid regional audits of biodiversity data in the UK have consistently identified large groups of priority species to be neglected by existing management prescriptions. In Eastern England, for example, prevailing grazing regimes on coastal grazing marshes were incompatible with requirements of 42 % of priority plant and invertebrate species (Fig. 2b, Crowther et al., 2022); heathland management agreements neglected 83 % of priority species by failing to incorporate physical disturbance (see Fig. 2a); and mechanical fen management neglected the fine-scale topographical variation required by many priority species associated with littoral margins (Dolman et al., 2012; Mossman et al., 2012). In Wales, quantifying the requirements of priority sand dune invertebrates catalysed landscape-rejuvenation (Litt et al., 2021), and in English wood pasture, systematic auditing confirmed the importance of dead wood in supporting 70 % of priority species (Drewitt and Webb, 2017). Outside the UK, audit approaches in Spanish seasonally-dry rivers indicated the importance of local rather than landscape connectivity for the drought resilience of aquatic invertebrate assemblages (Pineda-Morante et al., 2022). Implementing conservation management prescriptions informed by desk-based audits generated two- to three-fold increases in richness of species of conservation concern relative to previous best practices (Hawkes et al., 2021a), and confirmed the efficacy of priority avian surrogate species (Hawkes et al., 2019, 2021b).

The addition of this information can transform local conservation

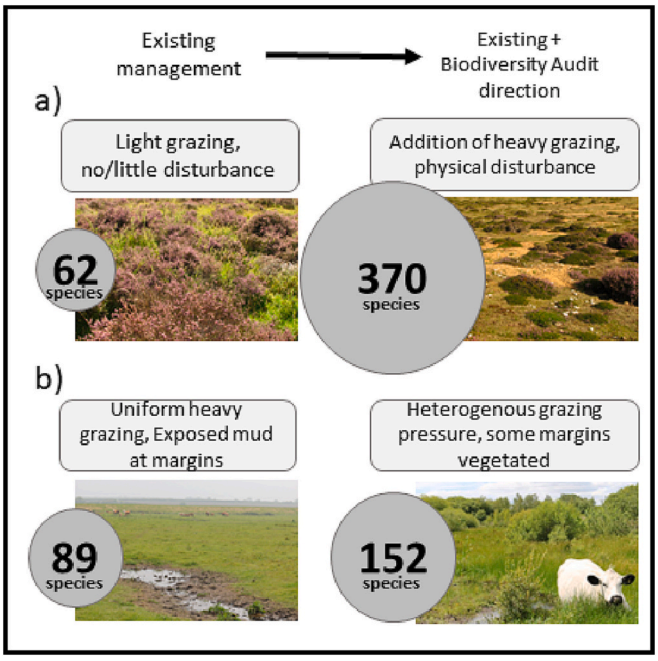

Fig. 2. Contribution of 'Priority Habitats' to biodiversity is substantially increased when habitat management (light grey boxes) is informed by biodiversity auditing. Numbers of invertebrate and plant species of conservation concern (includes nationally rare/scarce, or notable; Red listed (national IUCN criteria), Section 41 Priority Species designated under the Natural Environment and Rural Communities Act (HM Government, 2006; JNCC, 2022)) (circles) supported by prevailing agri-environment prescriptions (left column) are lower than those supported by novel prescriptions informed by local audits (right column) in a) lowland heathland (in Breckland, England; Dolman et al. (2012)) and b) grazing marsh (Norfolk Coast, England; Crowther et al. (2022)).

strategies (Fig. 3). To decide how to manage or restore sites more effectively (Lawton's 'better'; Lawton et al., 2010), an audit determines the fine-scale resources required by the largest numbers of priority species (e.g. vegetation structure, bare ground, hydrological conditions); to prioritize sites for habitat creation or expansion ('bigger', 'more'), auditing quantifies which larger-scale habitat features would most benefit the local species pool; to increase connectivity ('joined' – though crucially, connecting what, to what, with what?), auditing identifies interventions that provide functional connectivity for the largest numbers of regional priorities, given their ecological requirements (Fig. 3).

Auditing can also enhance spatially-explicit approaches to targeted conservation planning. For example, species distribution modelling (SDM) has been used to assess the efficiency of the current protected area network in GB for a wide range of under-recorded taxa (Critchlow 2021, Cunningham et al., 2021), although at relatively coarse spatial scales (10 km2) which limits utility for regional planning purposes. Biodiversity audits allow the identification of management guilds which are more amenable to finer-scale SDMs - for example, in Eastern England, audit-informed fine-scale (100 m) joint SDMs revealed how the current distribution of agri-environment prescriptions could be improved to enhance connectivity for priority guilds comprising both plants and invertebrates (Hawkes et al., 2021c). The prospect of fine-scale SDMs being available for a wide range of priority taxa could significantly extend the taxonomic scope of current regional land-use scenario testing which are often restricted to well-recorded taxa such as birds (e.g. Finch et al., 2021).

Monitoring is a further vital component of conservation practice that should be enhanced by audit information. Since the bioregional species list (Fig. 1) is typically collated from data spanning a multi-decadal period, repeating the audit after interventions will only provide information on new species or identify potentially extirpated species. However, biodiversity audits can be used to identify indicator species or ecological conditions that robustly inform whether a wider suite of priority species (with similar ecological requirements and responses to management) are benefiting from interventions (Hawkes et al., 2019).

4. Priorities for resource development

Improved synthesis and refinement of trait and autecological databases into standardized formats would further simplify auditing across multiple regions. Many autecological traits coded in Pantheon, for example, are highly relevant to management (e.g. responses to grazing/vegetation-volume, hydroseres, structural deadwood elements), but guilding would be further enhanced if Pantheon also coded species responses to physical disturbance, nutrient and salinity tolerance (Panter et al., 2011; Dolman et al., 2012; Hawkes et al., 2021a; Crowther et al., 2022). Integration of habitat-association and micro-site classifications across plant and invertebrate trait databases would simplify and streamline auditing. Inclusion of information from dispersal traits (Pedley and Dolman, 2020; Sarremejane et al., 2020) could allow audits to better quantify the benefits and optimal design of connectivity interventions, but is challenging as species-specific measures of dispersal ability are scarce while it's relation to physiological traits such as body size differs among invertebrate groups (Pedley and Dolman, 2020). Expansion of trait databases to other poorly-studied groups would support more comprehensive auditing; in the Norfolk coastal plain, for example, Fungi comprised 13.7 % of recorded species but were not assigned to management guilds owing to limited autecological information (Crowther et al., 2022). Across the EU and elsewhere in the world, some countries' biota may have poor coverage from existing trait databases developed in another region, highlighting the need to expand trait databases for continent-wide species pools.

The cost-effectiveness of regional auditing could be maximized through coordination at national or international scales, using spatial units defined according to local ecological similarity. In England, an ecologically coherent basis for defining audit units is provided by the National Character Areas dataset (NCAs; Natural England, 2014) that characterises bioregions by climate, geology, soils, land-use history, landscape structure and ecological character. Since LNRS will be defined by the boundaries of responsible authorities, they could be underpinned either by separate consideration of ecoregions within each responsible authority area, or ideally, an over-arching national audit scheme spanning all NCAs, from which responsible authorities could draw. Previous audits have linked species traits to management for major classes of wetland and dry-open ecosystems, expansion of audits to novel landscapes would require successively fewer new ecosystem management complexes, or novel species, to be resolved thus increasing cost effectiveness with cumulative coverage. Previous audits conducted in lowland England typically collated 0.8–1.5 Million species records per ecoregion (Dolman et al., 2012; Crowther et al., 2022); however, even sparser data in remote (e.g. upland) ecoregions will be sufficient to characterise biodiversity composition, particularly as NCA typology can be used to group NCAs with similar biophysical character. Similarly, EU member states may be well placed to coordinate regional audits, while it may be the case that some efficiencies could be generated by developing shared resources and guidance across the EU.

Consolidating a unified national database that classifies all species according to their management needs would facilitate rapid consistent audits and allow easier quantification of which guilds individual regions have a national responsibility to support. Ultimately, the development of standardized datasets and a unified protocol to perform local biodiversity audits would provide a means for transparent, repeatable and cost-effective design of local conservation strategies, and support better monitoring of outcomes across scales.

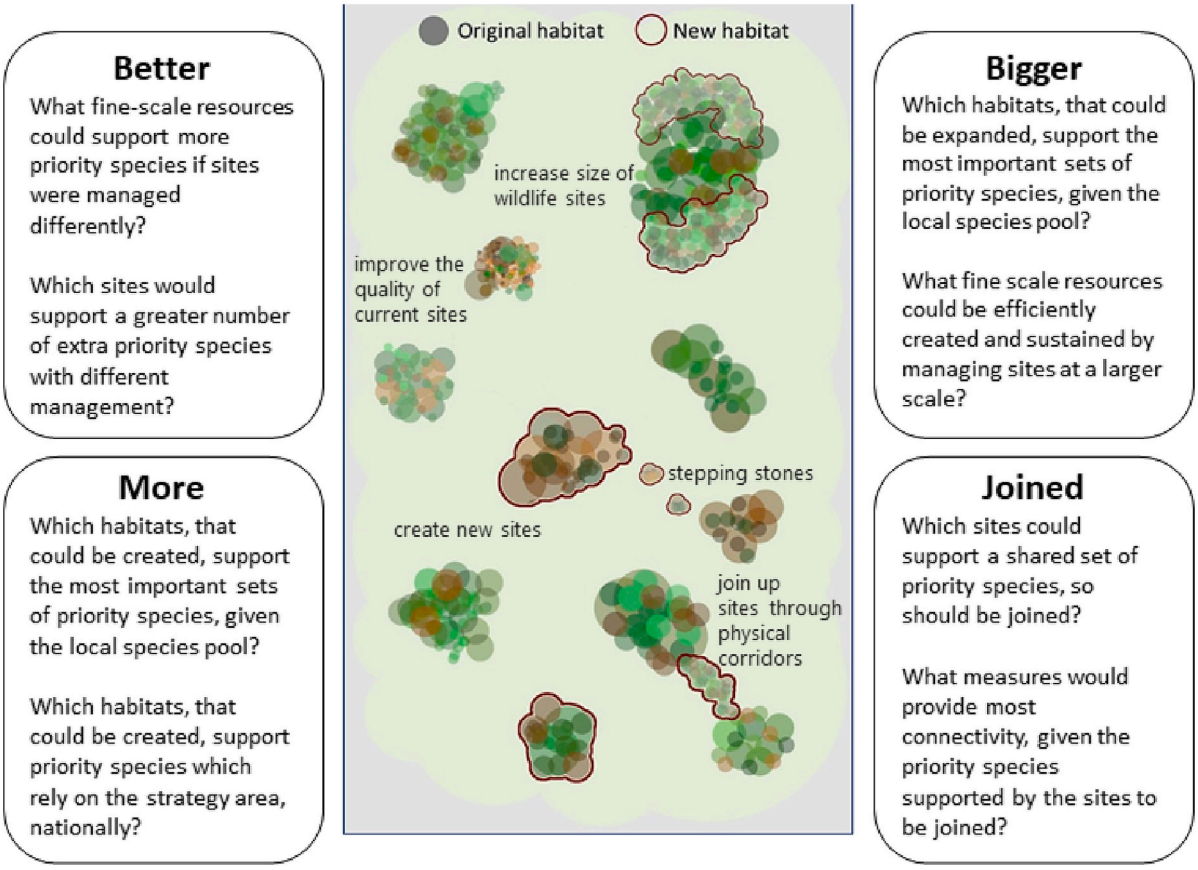

Fig. 3. Schematic showing how the outputs of a biodiversity audit would inform a Local Nature Recovery Strategy, with respect to each of the Lawton Principles that are advocated to conserve, restore and enhance biodiversity by creating resilient ecological networks (Lawton et al., 2010).

5. Conclusion

In the UK, EU and many other regions, the data needed to comprehensively quantify local biotas is abundantly available thanks to a long history of biological recording. By harnessing this resource, conservation strategists and practitioners can improve the likelihood that their actions meet the needs of threatened and priority taxa, particularly plant and invertebrate groups historically underrepresented in planning. Many nations are now actively developing conservation strategies, and we urge policymakers to support biodiversity auditing as a procedural step towards developing effective nature recovery strategies that account for local environmental context and biota to substantially improve outcomes. If widely-adopted, the increasing availability of comprehensive species distribution data and autecological understanding can empower strategic biodiversity planning, and delivery, for many regions worldwide.

Author statement

This original work is not being considered for publication by any other journal and all authors contributed to, and agreed on, the contents of the manuscript. All research not carried out by the authors and sources of funding have been fully cited.

CRediT authorship contribution statement

LPC, JG and PMD conceived the ideas for this policy perspective that were then developed with DS, RH, WP and JW. LPC led the writing of the manuscript with input from DS. All authors contributed critically to the drafts and gave final approval for publication.

Declaration of competing interest

No authors have any conflict of interest with any of the work or analysis presented.

Data availability

No data was used for the research described in the article.

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