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Ecosystem Restoration and Human Health: A Scoping Review (2015-2025)

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Ecosystem Restoration and Human Health: A Scoping Review (2015-2025)

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Abstract

Background: Ecosystem restoration, used here as an umbrella term (e.g., rewilding, reforestation, wetland rehabilitation, river re-naturalisation, species reintroduction, soil regeneration), is gaining momentum as a potential nature-based solution with public health co-benefits. However, evidence that specifically links exposure to *restored/rewilded* ecosystems (beyond generic greenspace) to measured health outcomes remains fragmented.

Objective: To map and characterise evidence on associations between exposure to recently restored or rewilded ecosystems and human health and well-being outcomes.

Methods: A scoping review (2015–2025) was conducted following JBI guidance and reported per PRISMA-ScR. Databases searched: PubMed, Scopus, GreenFILE, Environment Complete, and Discovery (last search 06 March 2025). Title/abstract screening was undertaken independently by two reviewers in Rayyan with multidisciplinary consensus resolution; a third reviewer adjudicated persistent uncertainties. Data were charted using a pre-piloted extraction framework and were synthesised thematically; no critical appraisal was undertaken, consistent with scoping methodology.

Results: Included studies (N = *19*) spanned multiple continents and restoration modalities (e.g., forest landscape restoration, natural regeneration, wetland/coastal rehabilitation, species reintroductions). Mental well-being and broader quality-of-life outcomes predominated; physical health outcomes were less common. The overall direction of effect was largely beneficial, with isolated negative perceptions in certain concepts. Framing varied: a subset explicitly examined restoration (more likely to measure biodiversity/quality), while others treated exposure implicitly as access to "natural" areas, often assuming ecological quality.

Conclusions: Restored and rewilded ecosystems appear promising interventions for human health and wellbeing. Furthermore, an integrated approach to human and environmental health has been proposed to aid future research, which should integrate biodiversity/quality metrics with health outcomes, adopt equity-centred designs, and employ longer-term approaches to inform policy and practice.

Introduction

Ecosystem degradation and biodiversity loss are now recognised as fundamental threats to planetary and human health [1]. Globally, one million species face extinction, ecosystems that once acted as carbon sinks are shifting to sources, and the UK is among the most nature-depleted nations in Europe [2]. These environmental shifts shape air and water quality, infectious disease risks, food systems, and opportunities for physical and mental restoration [3]. In this context, ecosystem restoration, including rewilding, has emerged as a potential public health intervention as well as an ecological one [4].

Ecosystem restoration encompasses a spectrum of approaches to returning degraded landscapes to more functional states. Rewilding represents a particularly ambitious form of this, defined by restoring ecosystems so that natural processes can re-establish themselves with minimal human management [5]. It encompasses actions such as reforestation, wetland rehabilitation, species reintroductions, and passive land abandonment [6].

High biodiversity is associated with improved immune function, reduced stress, and healthier living environments [7]. Yet shifting baselines complicate perceptions: each generation accepts degraded ecosystems as "normal," making the need for restoration less visible [8]. This perception gap contributes to the view that rewilding is "radical," when in reality it represents a restorative return to ecological integrity.

Public health also faces the challenges of the social determinants of health, which range from education and employment to environmental quality. Tackling these can reduce health needs, but doing so is conceptually and practically difficult in systems dominated by capitalism. Even nations with socialist frameworks can face inequities in meeting health needs [9]. While the Dahlgren and Whitehead model [10] depicts health as shaped by layered determinants at the individual level, Jaime Breilh reframes this as a process of social determination, emphasising how capitalist development and structural inequities actively produce ill health [11]. the most appropriate framework for this would be that of Barton and Grant's work, which frames ecosystems as an outer core for human health [12].

Contemporary global health threats are intrinsically linked to the complex interplay between environmental, animal, and human systems, a convergence best understood through the One Health framework [13]. While modern healthcare access has expanded, the model remains predominantly reactive and costly, failing to address the upstream drivers of disease or the systemic vulnerabilities of our shared biosphere. By integrating Nature-based Solutions (NbS), we can transition toward a preventive paradigm that fosters

ecological resilience while simultaneously tackling social determinants of health, such as stress, physical inactivity, and social cohesion [14, 15]. These solutions function as critical biological buffers; for instance, restored ecosystems regulate zoonotic spillover risks and mitigate the impacts of climate change, effectively operationalising the One Health approach by recognising that human well-being is inseparable from the vitality of the natural world [13].

Rewilding sits within the NbS spectrum but differs in scale and ambition. Unlike urban parks or therapeutic gardens, rewilding seeks to restore functioning ecosystems and self-sustaining biodiversity [16]. Evidence suggests that biodiverse natural environments support stress reduction, immune regulation, and cardiovascular health, yet most studies examine urban green spaces, not explicitly rewilded landscapes. Theoretical frameworks, including biophilia and human–nature interaction models, propose mechanisms for health benefits, but few empirical studies have directly assessed health outcomes in rewilded contexts.

Access to high-quality green space remains unequal. In the UK, people in the most deprived areas are significantly less likely to live near green space than those in affluent areas, despite evidence that access is associated with better mental and physical health [17, 18]. Globally, similar inequities limit who benefits from ecological interventions. Equitable rewilding therefore has the potential not only to deliver co-benefits for climate and biodiversity, but also to address environmental health inequalities [19]. Potential public health co-benefits include improved air and water quality, soil stability, carbon sequestration, and biodiversity conservation [20–22]. Increased biodiversity in certain contexts can also help regulate disease vectors and support food systems [23, 24].

Conceptual models [25, 26],theories such as nature deficit [27] and the biophilia hypothesis [28] further support the link between biodiversity and human well-being. Anecdotal evidence from projects such as the Knepp Estate suggests that rewilded landscapes can foster relaxation and connection to nature [29]. While not a substitute for empirical research, such engagement underlines the relevance and timeliness of exploring rewilding for public health. This again ties into indigenous practice, and how the Western world may be publishing interventions long held by indigenous populations [30].

Objective

This scoping review aims to map and characterise the evidence on how exposure to recently restored or rewilded ecosystems impacts health and well-being outcomes in human populations. By doing so, it seeks to clarify current knowledge, identify gaps, and inform both future research and policy development at the intersection of ecological restoration and public health.

Methods

Protocol and registration

A formal protocol for this scoping review was not prospectively registered. The study was originally conceived and conducted as a postgraduate student dissertation. Following academic feedback and internal review, the search strategy and synthesis were refined and updated for formal publication to ensure they met the rigorous standards of the JBI evidence synthesis guidance and PRISMA-ScR reporting. The completed PRISMA-ScR checklist and the full search strategy are provided as Supporting Information (S1 file).

Eligibility criteria

Inclusion/exclusion criteria are summarised in Table 1. We included English-language journal articles and relevant grey literature from 2015 onwards that involved human populations and exposure to greenspace/bluespace where restoration/rewilding was explicit or strongly implied (e.g., reforestation, wetland restoration, natural regeneration, species reintroductions). Outcomes included physical, mental, and social health and well-being. We excluded studies without human participants or without relevant exposure.

Table 1: Inclusion and exclusion criteria

Criteria	**Inclusion**	**Exclusion**
Language	English	Languages other than English
Publication Type	Journal articles, grey literature	–
Publication Date	2015 onward	–
Population	Human populations of any age, gender, or ethnicity	Studies not involving human participants
Exposure/Intervention	Greenspace/bluespace with explicit or implicit restoration/rewilding (e.g., reforestation, wetland restoration, species reintroduction, natural regeneration)	Studies without greenspace/bluespace exposure
Outcomes	Health and well-being outcomes (physical, mental, social)	No human health/well-being outcomes

Information sources and search strategy

Databases: PubMed, Scopus, GreenFILE, Environment Complete, and Discovery. The last search was conducted on 06 March 2025. The PubMed strategy included MeSH terms (e.g., Health; Environmental Restoration and Remediation; Residence Characteristics). Full strategies will be provided in the Supporting Information. Core concept blocks included: population (e.g., population, community), restoration/rewilding

(e.g., rewild*, ecosystem restor*, natural regeneration, species reintroduc*), and health outcomes (e.g., health, mental health, respiratory health, well-being). Full search terms in supplementary material (S2 file).

In addition to database searching, a targeted grey literature search was conducted to identify unpublished or non-indexed reports of ecosystem restoration and rewilding interventions with reported human health outcomes. Sources included the World Health Organization (WHO), United Nations Environment Programme (UNEP), UK Department for Environment, Food and Rural Affairs (DEFRA), Public Health England, and relevant NGO repositories (e.g., Rewilding Britain). Searches used combinations of keywords relating to "ecosystem restoration," "rewilding," "biodiversity," and "health."

Selection of sources of evidence

Titles/abstracts and full text screening were independently screened by two reviewers in Rayyan. Conflicts and "maybe" decisions were discussed in a multidisciplinary team meeting. "Maybe + Include" moved to full-text screening; "Maybe + Exclude" were generally excluded unless compelling justification emerged. "Maybe + Maybe" cases were referred to a third reviewer external to the dissertation process for a final decision.

A Venn diagram, Fig 1, illustrates the intersection of studies reporting on health outcomes and referring to the restoration of nature. The review focuses on studies within the red dashed area, specifically those that report health outcomes and nature exposure, and also mention restoration. To ensure that relevant studies were not missed due to inconsistencies in how restoration is reported, the framework was established to guide the inclusion process and categorise studies based on the clarity and centrality of restoration.

This framework focuses on studies that involve both:

- A NbS (exposure to green or blue space), and a health or well-being outcome in a human population, with some reference to restoration or rewilding, whether explicit, implied, or historical.

Studies falling within the following zones were included:

- Area e: Restoration is not explicit and central to the intervention.
- Area d: Restoration is explicit.
- Area c: Restoration is not explicit; however, given that many spaces are managed, ecosystem restoration activities may take place (tree planting in an urban park).

- All included studies were tagged as c, d, or e during screening for flexibility in later analysis.

  Studies falling outside these categories, those not involving health, nature, or restoration meaningfully (areas a, b, f, g), were excluded from the review.

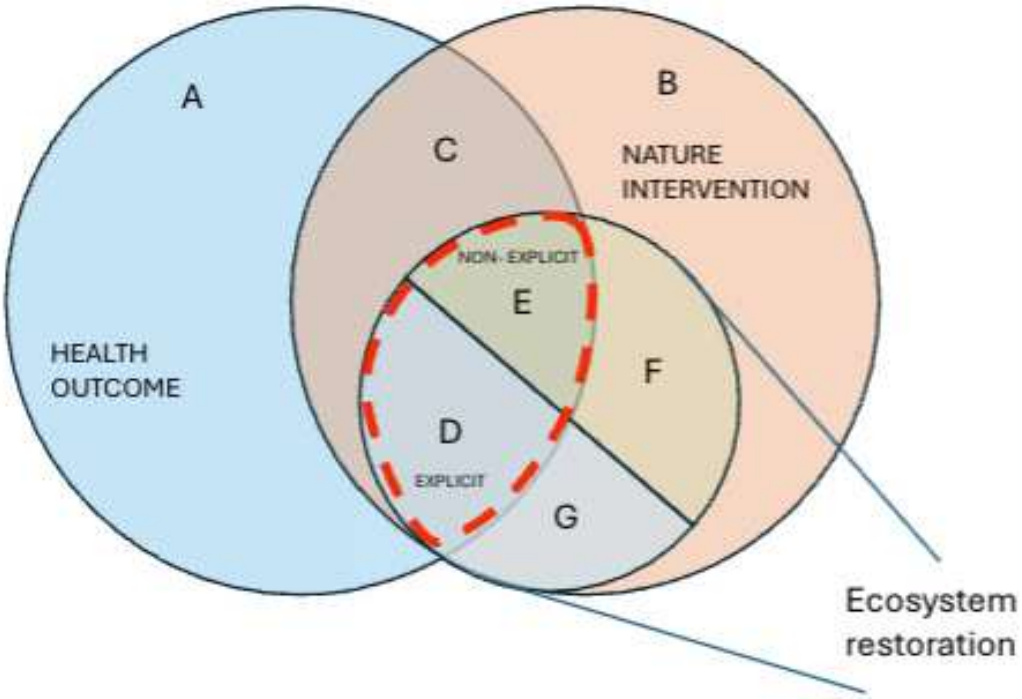


Figure 1: Conceptual framework showing the inclusion logic for the scoping review.

Data charting

Data extraction was performed for all 19 identified articles, which spanned 12 international journals with a primary focus on public health and urban ecology. Of these 19 articles, 14 were dual extracted by at least two reviewers. Extraction was conducted using a standardised framework that captured study ID, design, location, population, intervention details, health outcomes, and key findings or themes.

Synthesis of results

No formal risk-of-bias assessment was performed (scoping review convention). The thematic framework was initially developed by the lead author and subsequently refined through an iterative process of peer-review and consensus building with the senior research team. This collaborative approach ensured the thematic categories were robust, internally consistent, and aligned with the scoping review objectives.

Quality control

Reviewers received a training document outlining the research question, eligibility criteria, screening protocol, and inclusion/exclusion examples. To reduce erroneous exclusion, reviewers used a conservative approach with a "Maybe" option for uncertain cases; all items tagged "wrong intervention" underwent secondary review to avoid loss of implicitly restored contexts.

Ethics

This review synthesises data from publicly available sources; no ethical approval was sought.

Critical Appraisal

In accordance with the scoping review paradigm, no formal critical appraisal or risk-of-bias assessment of the included studies was conducted. While this approach is consistent with mapping the breadth of a diverse and emerging field, the authors acknowledge that the absence of a structured quality assessment may limit the perceived validity and generalisability of the specific recommendations provided. Consequently, these findings should be interpreted as an indicative map of the current evidence base rather than a definitive statement on the clinical or ecological efficacy of the interventions reviewed.

Results

Study selection

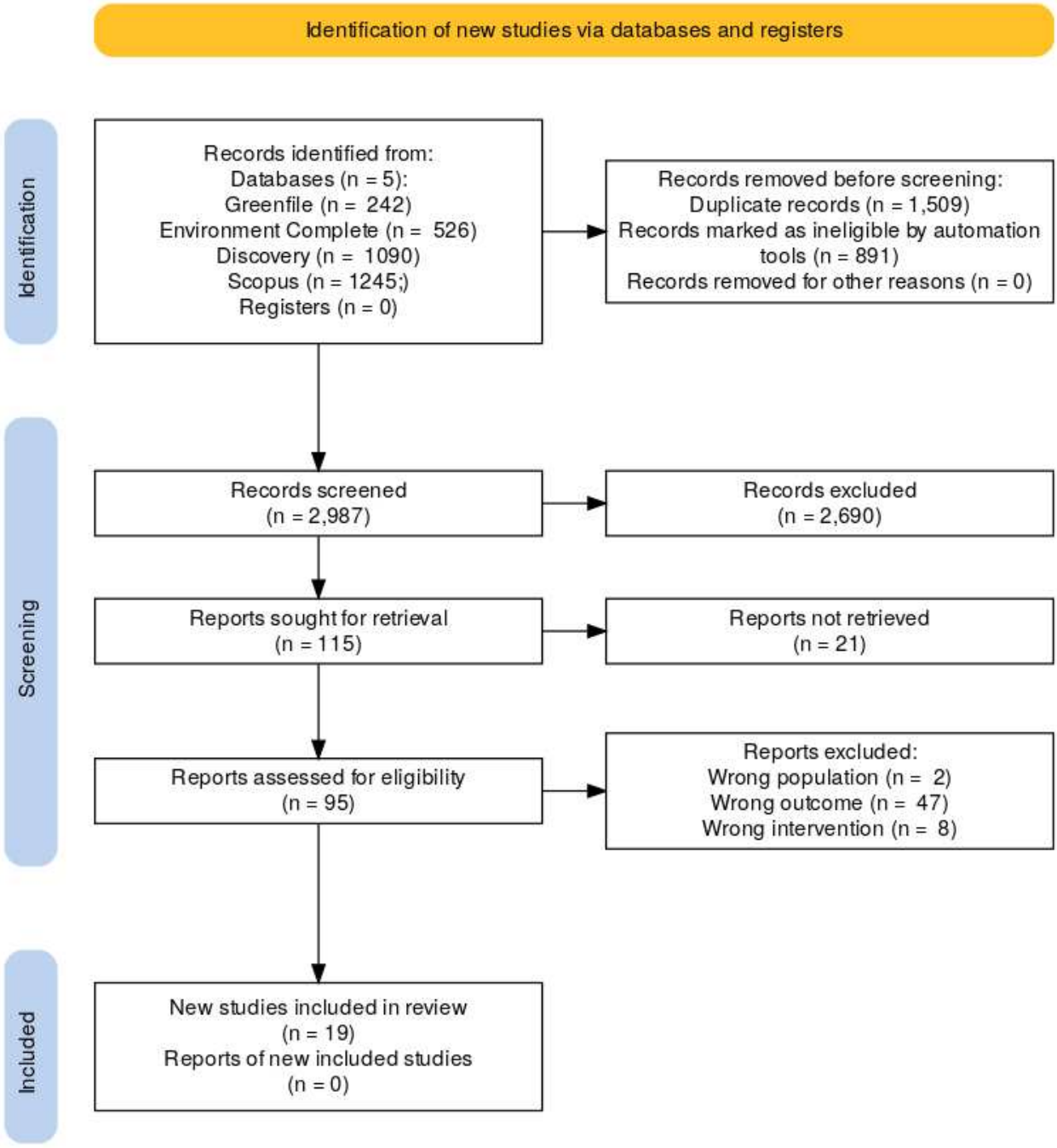


Figure 2: A total of 4496 records were identified; after deduplication, 3013 remained for screening. Following title/abstract and full-text screening, 19 studies were included. Numbers close approximation for exclusion as reasons overlapped.

0.1 Grey Literature

No grey literature sources were identified that reported both a restoration/rewilding intervention and measured human health or well-being outcomes.

Characteristics of sources

Included studies comprised peer-reviewed journal articles; succinct data charting is displayed in Table 2. Restoration types ranged from forest landscape restoration and natural regeneration to wetland/coastal rehabilitation and species reintroductions. Study designs included qualitative case studies, quantitative analyses, and mixed-methods approaches across multiple regions.

Table 2: Impact of Ecosystem Restoration and Biodiversity on Human Health, collated from raw extracted data

Author	**Loc.**	**Intervention**	**Health Outcome**	**Key Mechanism**
Angradi, 2022 [31]	USA	Waterfront revitalisation	Improved mental health; life expectancy	Natural capital amenities
Awuku, 2023 [24]	Ghana	Mangrove restoration	Lower malaria incidence	Biological control
Baceviciene, 2022 [32]	Lithuania	Nature exposure	Enhanced Quality of Life	Nature connectedness
Barrios, 2021 [33]	Spain	Green/Blue asset improvements	Reduced hospital morbidity	Improved air quality
Burra, 2021 [34]	Africa	Bio-control	Reduced adult/infant mortality	Restored crop yields
Duan, 2024 [35]	China	Plant Communities	Physiological recovery	Skin Conductance (SCL)
Grazuleviciene, 2016 [36]	Lithuania	Park walking	Reduced diastolic BP & cortisol	Reduced noise/pollution
Lev, 2020 [37]	USA	Wild Parks	Resilience and flourishing	Interaction with “wild“
Li, 2023 [38]	China	Forest exposure	Psychological restoration	Multi-sensory perception
Liu, 2021 [39]	China	Blue Space exposure	Mitigation of depression risk	Attention restoration
Murage, 2024 [40]	Tanzania	Plant regeneration	Improved respiratory health	Cleaner air; comfort
Pichler, 2025 [41]	Australia	Coastal restoration	Improved social well-being	Agency and solidarity
Poulsen, 2022 [42]	USA	Freshwater access	Reduced perceived stress	Attention restoration

Continued on next page

Table 2 – Continued

Author	Loc.	Intervention	Health Outcome	Key Mechanism
Tieges, 2020 [43]	UK	Canal regeneration	Decreased all-cause mortality	Blue-green access
Tosi, 2015 [44]	Italy	Animal reintroduction	One person injured	Social acceptance
Ullah, 2024 [45]	Pakistan	Forest restoration	Improved well-being	Social cohesion
Vert, 2019 [46]	Spain	Riverside regeneration	Reduced mortality & morbidity (IHD)	Physical activity
Wu, 2022 [47]	China	Forest viewing	Lowered BP and pulse	15-min nature viewing
Young, 2020 [48]	Switz.	Garden access	Stress reduction	Plant species richness

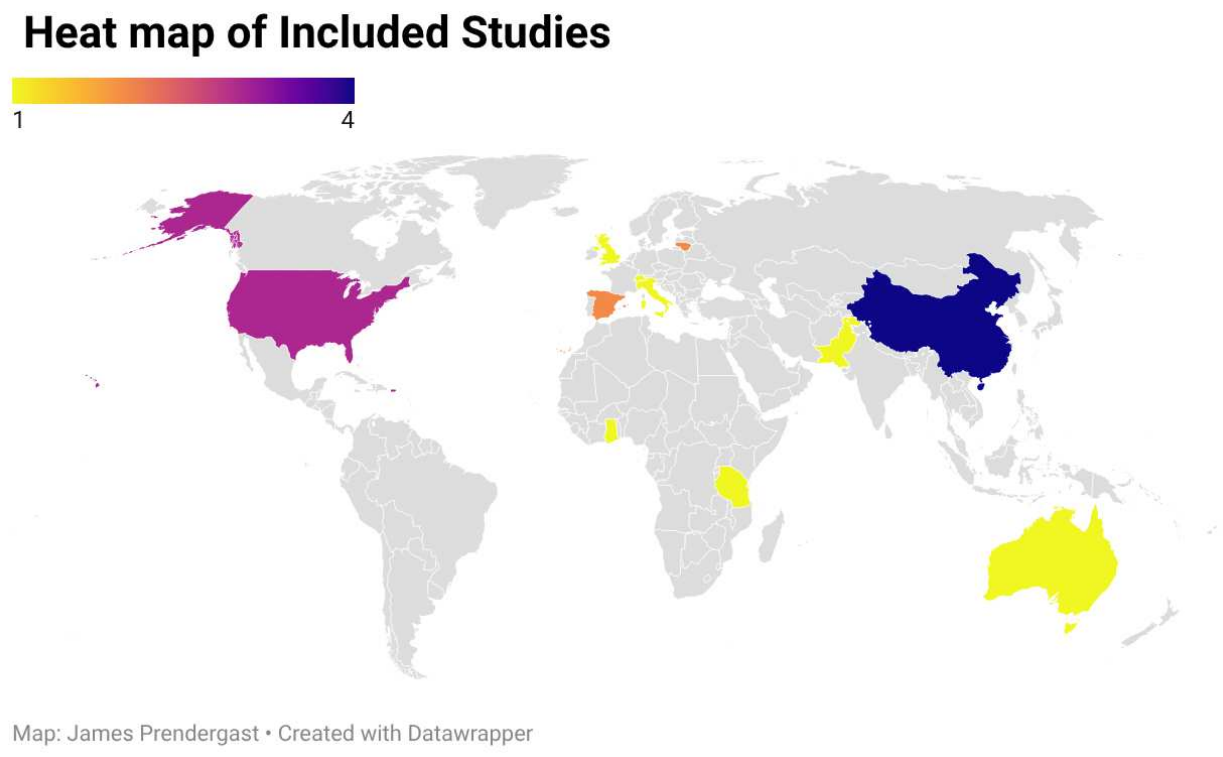


Figure 3: Geographical mapping of literature evidence. Shaded regions indicate countries represented within the scoping review, highlighting a diverse evidence base. Note: This map has been designed using a colourblind-friendly palette.

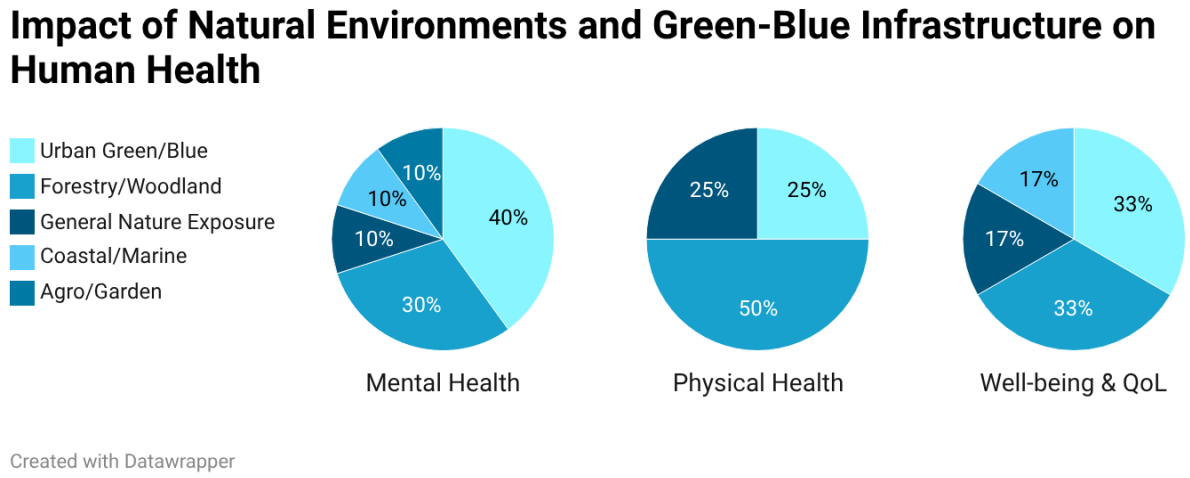


Figure 4: Data summarises N=19 studies investigating how contact with various ecosystems. Values represent frequency of reported outcomes across three pillars: Mental Health (N=12), Physical Health (N=10), and Well-being (N=8). Total mentions (30) exceed study count because 53% of papers (N=10) identified crossover benefits across multiple health categories.

Analysis of the $N = 19$ studies reveals a strong emphasis on Urban Green/Blue and Forestry/Woodland ecosystems as primary drivers of human health outcomes (see Fig 4). While urban environments were most frequently linked to Mental Health (40%), forestry settings emerged as the dominant factor for Physical Health, accounting for 50% of reported outcomes. The data also highlights significant interdisciplinary synergy, with 53% of the papers ($N = 10$) identifying crossover benefits across multiple health pillars.

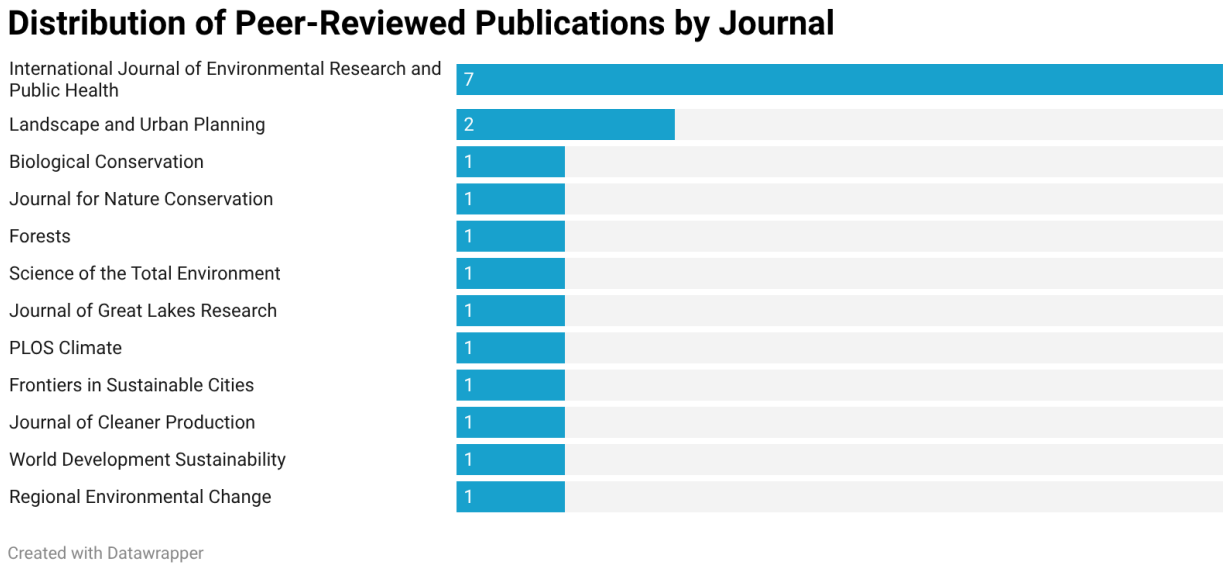


Figure 5: A summary of 19 articles published across 12 international journals, highlighting a core focus on public health and urban ecology.

The research portfolio was distributed across 12 international journals, demonstrating an interdisciplinary approach with a primary concentration in public health and urban ecology (Fig 5). The International Journal of Environmental Research and Public Health served as the leading publication venue, accounting for approximately 37% of the total output ($N = 7$). This was followed by Landscape and Urban Planning ($N = 2$), while the remaining ten journals each represented a single specialised contribution to the dataset (Fig. 5).

Synthesis of results

Thematic analysis identified several interrelated themes. To illustrate the distribution of thematic coverage across the included studies: Access, Biodiversity and health, Community involvement, Economic Benefits, Ecosystem Restoration, Human Health, and Policy and implementation.

Access

Access to natural environments was found to be a critical factor influencing the effectiveness and equity of the studies included [31, 42]. It was highlighted that proximity and ease of access play pivotal roles in shaping how individuals engage with green/blue spaces or restored ecosystems [42].

In urban settings, features such as walking paths, transportation links, and safety considerations significantly affected visit frequency and duration [42, 47]. For instance, Wu et al.'s (2022) research on urban deciduous forests in Chengdu, China, revealed that design elements such as trail width, canopy density, and visibility were intentionally selected to optimise accessibility and user comfort. These environmental design choices were not only linked to increased visitation but also to measurable improvements in emotional states like interest and positive affect [47].

Moreover, socioeconomic and demographic factors further influenced access patterns [39, 42]. Two studies, Poulsen et al.(2022) and Pichler et al.(2025), examined freshwater and coastal blue spaces and found that individuals with higher education, better self-reported health, and more frequent physical activity were more likely to access these environments regularly [41, 42]. In contrast, older adults and those with lower socioeconomic status reported barriers to visitation, underlining the inequitable distribution of health-promoting environmental exposure [41]. Some articles also emphasised that the development of accessible recreational areas, particularly in underutilised or marginal urban spaces, could provide significant non-economic benefits, such as stress relief and social connection [24, 41, 42, 46]. These findings suggest that access should be

viewed as a core public health priority within restoration planning, rather than just a logistical consideration [31].

Biodiversity and Health

The interdependence between biodiversity and human health is a foundational theme emerging from this review. Evidence across studies suggests that ecosystem quality, characterised by habitat complexity and ecological integrity, creates the conditions for biodiversity to thrive, which in turn supports a range of physical, mental, and social health outcomes [35, 38, 45].

Several studies in the review established direct or indirect health benefits from enhanced biodiversity. Environments with diverse plant and microbial life, typically present in high-quality ecosystems, have been linked in the wider literature to immune regulation, particularly in children exposed early to such settings [38]. Within the included studies, one noted community-reported reductions in immune-mediated and inflammatory conditions such as skin, eye, and respiratory health [40]. Additionally, one study provides empirical evidence on how different plant community structures (e.g., single-layer vs. tree-shrub-grass composite) affect health [35].

In the context of ecosystem restoration, the resulting increase in biodiversity acts as a conduit for delivering health co-benefits [34]. Furthermore, increased biodiversity appears to enhance psychological well-being. More complex and ecologically intact environments were associated with greater mental restoration, increased affective engagement, and reduced stress [32, 38]. Research suggests that biodiversity contributes to the quality of nature exposure, not just its presence, and may help explain observed differences in health outcomes between manicured parks and wilder landscapes [37].

Furthermore, some studies explored biodiversity as a proxy for broader ecological integrity, arguing that biodiverse spaces offer more stable and resilient ecosystem services such as water purification, air quality regulation, and climate buffering, all of which indirectly support public health [40, 45]. These services are more likely to be delivered reliably when ecosystem quality is high [40, 45].

Community Involvement

Community involvement seems to be an enabling factor for the success, sustainability, and equity of ecosystem restoration projects. Across the reviewed literature, participatory approaches ranging from co-design and consultation to hands-on restoration were linked to stronger health, social, and ecological outcomes [40, 45].

Many studies described how community engagement enhanced the relevance and uptake of restoration interventions [40, 45]. Where local populations were involved in planning or decision-making, projects tended to better reflect community values, cultural practices, and needs [24, 45]. This often translates into improved perceptions of green spaces, greater stewardship, and sustained environmental use, factors critical for delivering long-term health benefits [45].

Articles also highlighted the psychosocial benefits of participation. Activities like planting, maintaining, or monitoring restored areas were shown to promote a sense of purpose, agency, and belonging, especially among marginalised or underserved groups [40, 41]. Furthermore, community-led restoration also became a vehicle for empowerment and social cohesion, with positive impacts on mental well-being and livelihood security [45].

Importantly, community involvement was as a key determinant of project equity. Without inclusive processes, interventions risked reinforcing existing inequalities, for example, by displacing informal land users or creating green spaces perceived as exclusive [31]. Top-down models, even when ecologically effective, were found to risk social resistance or underuse, thereby undermining public health potential [37, 44].

Studies noted that building trust and legitimacy was vital, particularly when interventions involved sensitive actions like species reintroductions; notably, the only study with a negative health impact led to a change in the community perception of bear reintroductions [44]. Therefore, participatory governance and local leadership were cited as enabling ecological success and social acceptance [44, 45].

Economic Benefits

The theme of economic benefits suggests that ecosystem restoration often produces positive externalities that extend well beyond ecological gains. Several studies noted direct and indirect economic returns associated with improved health outcomes, reduced public spending, enhanced ecosystem services, and local employment or tourism opportunities [24, 40, 45]. However, this was the least discussed theme across the reviewed literature.

One key area of focus was health economics. By improving cardiovascular, respiratory, and mental health outcomes, NbS, particularly those grounded in restoration, may reduce demand on healthcare systems. This was most evident in an urban riverside regeneration study in Barcelona, which estimated an annual reduction in health-related costs of over €23 million and substantial reductions in mortality linked to the

practice of physical activity in the restored area [46]. These findings suggest that ecosystem restoration is a viable candidate for public health investment, with dynamic modelling showing that €1 spent on green infrastructure and restoration policies can produce up to €100 in benefits [33].

In addition, studies pointed to the economic value of restored ecosystem services. These include flood mitigation, carbon sequestration, pollination, and improved water and air quality services that contribute to environmental resilience and long-term cost avoidance [33]. For example, an Africa-wide biological control programme generated an estimated economic benefit of over US dollars 120 billion across 30 years, primarily through crop yield recovery, improved food security, and associated health benefits [34].

Local and regional economies also benefited; cases described rural regeneration where restoration became a catalyst for eco-tourism, job creation, and small enterprise development, including training for beekeeping, guide services, accommodation, and education initiatives [24, 45]. These spillover effects contributed to greater community support and aligned ecological goals with local development priorities [45].

However, the literature also cautioned against viewing restoration solely through a monetised lens. Several studies warned that economic framings can overshadow cultural, spiritual, and intrinsic values of biodiversity [34, 45]. Others noted risks such as land use conflicts or gentrification, particularly when restoration raises local property values without inclusive planning to protect existing residents [31]. One study also highlighted the role of emerging markets and the need for natural capital accounting and defined metrics to track changes in ecosystem structure and services, ensuring that restoration interventions result in equitable outcomes [40].

Ecosystem Restoration

Ecosystem restoration was a central theme across the included studies, representing both a process and a goal. The literature broadly defines restoration as efforts to return degraded landscapes to more functional and biodiverse states, whether through active interventions, such as reforestation, wetland creation, and species reintroduction, or passive processes like land abandonment and natural regeneration [40, 45]. A finding was that restoration activities led to improvements in environmental quality, such as increased vegetation cover, habitat complexity, and biodiversity. These ecological shifts led to a range of health-promoting co-benefits, including cleaner air and water, enhanced recreational spaces, and improved microclimates, particularly cooling effects in urban heat zones [33, 43].

Critically, several studies noted that the "quality" of the restored environment matters. Restoration that prioritised ecological richness and minimal human interference tended to support more robust bio-

diversity and ecosystem services [37]. This nuance was important in distinguishing ecologically restored environments from generic green spaces, where interventions might be limited to aesthetic landscaping or monoculture planting with limited ecological value [37]. Importantly, the literature highlighted that restoration is context-dependent. The success and impact of interventions varied based on geography, governance structures, baseline degradation levels, and community involvement. Moreover, several studies emphasised that restoration should be adaptive and responsive to monitoring data and ecological feedback rather than a fixed or "one-size-fits-all" approach [41, 45].

A further analysis of the included studies distinguished between those where ecosystem restoration was framed explicitly as the central intervention ($N = 7$; 35%) and those where restoration was implicit, occurring in practice but described primarily in terms of nature exposure, access, or amenity ($N = 13$; 65%). While the direction of health outcomes was overwhelmingly positive in both groups, the framing was associated with notable differences in reporting.

Explicit restoration studies, [24, 40, 45], described ecological interventions in detail and, in some cases, measured biodiversity or habitat quality alongside health outcomes. In contrast, implicit studies, for example [32, 38, 42], focused primarily on human health or well-being measures and tended to assume ecological gains rather than directly assessing them. This pattern aligns with the inclusion framework used in this review (Fig 1) and highlights how framing can shape the design and reporting of evidence linking restoration to health.

Human Health

Human health is one of the most evidenced and multidimensional themes across the provided literature. The sources reflect a growing consensus that restored and biodiverse ecosystems positively influence physical, mental, and social health outcomes, especially when interventions directly affect people's lived environments [34, 38, 45].

Regarding Mental health, one study conducted Beijing [38] showed reduced stress and increased engagement in participants exposed to forest environments using EEG data. Tools like the Restoration Outcome Scale (ROS) and Profile of Mood States (POMS) were commonly used to quantify these shifts [38, 47]. Additionally, [42] identified relaxation as a primary benefit of access to water-rich environments, while [32] emphasised the role of nature connectedness and perceived restorativeness as critical mediators in achieving positive psychological outcomes. One study investigated 1,274 respondents and specifically examined depres-

sion risk and four distinct aspects of Subjective Well-being (SWB): life satisfaction, worthwhileness,"happy yesterday" and "anxious yesterday" [39].

Group-based ecological interventions, as seen in community-led coastal restoration, further support mental health by enhancing emotional resilience and reducing ecological grief, particularly through volunteering and hands-on restoration activities [40, 41].

Physical health benefits include improved cardiovascular and respiratory function. [47] and [36] reported significant reductions in blood pressure and stress markers (such as salivary cortisol) in natural environments compared to urban settings, while broader evidence shows that restoration supports chronic disease prevention [38, 43]. One study, [46] linked proximity to restored green/blue infrastructure with lower cardiovascular disease rates and dementia-related disability-adjusted life years (DALYs). Broader findings from [40] and [34] associated ecosystem restoration and a restored ecological balance with lower chronic disease risk and reduced mortality.

Wellbeing was a cross-cutting theme, encompassing psychological and social dimensions beyond traditional health indicators. [40] and [32] documented gains in subjective well-being, including life satisfaction and emotional resilience. Restored environments also supported meaning, identity, and place attachment [37, 48]. Social well-being was enhanced through increased interaction, cultural engagement, and community cohesion triggered by the revitalisation of natural capital [31, 41].

Policy and Implementation

Policy and implementation appeared as a theme to shape the impact of ecosystem restoration initiatives. While the ecological and health benefits of these interventions are increasingly recognised, the translation of evidence into action depends heavily on supportive governance structures, funding mechanisms, and regulatory environments [33, 45].

Across the literature, many studies have highlighted the fragmentation of policy as a major barrier. Restoration projects often fell between environmental, health, and land use domains, resulting in siloed funding, unclear jurisdiction, and limited accountability. This policy disjuncture was particularly evident in urban contexts, where restoration efforts compete with development priorities and must navigate overlapping planning authorities [38, 47].

The importance of long-term, secure funding was also frequently emphasised. Many successful restoration projects relied on short-term grants, pilot programs, or NGO partnerships, which, while helpful for initiation, were insufficient to sustain interventions or measure long-term health outcomes. Several articles argued for the integration of ecosystem restoration into formal policy instruments such as National Biodiversity Strategies, health equity frameworks, or climate adaptation plans, to ensure financial and political continuity [34, 40].

Regulatory support and land use planning were identified as enabling conditions. Projects that benefitted from protected status, favourable zoning laws, or inclusion in green infrastructure plans were more likely to succeed. Conversely, bureaucratic complexity or lack of policy recognition for restoration as a valid land use strategy hindered implementation [33, 46].

Another key insight was the value of inclusive and participatory policy processes. Where communities, local authorities, and stakeholders were involved in policy design and governance, restoration efforts gained legitimacy, improved equity outcomes, and were more likely to align with local priorities. Several studies noted that top-down mandates without community buy-in led to opposition or under use of restored spaces [41, 45].

Finally, some articles advocated for cross-sectoral policy integration. Embedding ecosystem restoration into public health, climate resilience, and economic regeneration agendas was seen as essential to achieving broad impact. Tools like cost–benefit analysis, health impact assessments, and ecosystem service valuation were highlighted as strategies to persuade policymakers and funders of restoration's cross-cutting benefits [24, 31].

Discussion

Summary of evidence

This scoping review examined how exposure to restored or rewilded ecosystems influences human health and well-being across varied interventions, including reforestation, wetland regeneration, species reintroductions, passive rewilding, and green or blue space access.

Using a framework (Fig 1) that classified restoration as explicit, implied, or unlinked, the synthesis identified recurring themes: ecological and public health value, the mediating role of access, biodiversity–health connections, community involvement, economic benefits, and policy context. Ecosystem restoration was found to influence health through psychological, physiological, social, and ecosystem service pathways, though these mechanisms were often addressed in isolation rather than as parts of an interconnected system. When implemented with ecological and social integrity, restoration has the potential to promote health equity, climate resilience, and broader public health goals.

The evidence suggests that restored ecosystems are associated with mental and social well-being benefits. However, biodiversity/ecology metrics are inconsistently measured alongside health outcomes, long-term designs are rare, and economic evaluation is limited. Embedding ecological monitoring with health outcome assessment, adopting equity-first access design, and employing prospective or quasi-experimental approaches would strengthen causal inference and policy relevance.

Access and community involvement were mediators of restoration's health impacts but were often treated reductively. Access was typically equated with proximity or simple design features, overlooking relational and political dimensions such as safety, cultural relevance, and governance. Likewise, community engagement was noted but rarely distinguished between tokenistic consultation and genuine co-production, risking overstated inclusivity.

The wider environmental justice literature shows that disadvantaged groups face barriers of quality, safety, and inclusion even where proximity is comparable [49–51]. Without attention to these dynamics, restoration may reinforce inequalities, yet evidence also indicates that meaningful co-production can yield psychosocial benefits such as belonging and cohesion[52].

Biodiversity and human health were strongly linked in the evidence base, but the connections were often assumed rather than measured. Many studies inferred health benefits from greenness or proximity without

ecological monitoring [48, 53], limiting causal attribution. Standardised biodiversity metrics remain rare [40], and only isolated attempts at ecological–health modelling exist [33].

Health outcomes, while positive, relied heavily on cross-sectional and self-reported data, with limited longitudinal or experimental designs. This restricts causal inference and may overstate short-term benefits. Together, these gaps leave the ecological and health dimensions fragmented, despite evidence that both are essential to understanding restoration's impacts. We also need to consider that the benefits might not come strictly from biodiversity. Because the participants were in a group, the results could be confounded by social connection and physical movement, both of which are powerful drivers of health independent of the environment. Nevertheless, the convergence of findings across diverse designs underscores that ecological quality matters for human health. Future work should therefore prioritise integrated metrics, linking biodiversity and robust health outcomes, to provide more credible evidence for policy and investment.

Policy and governance were repeatedly acknowledged as important but rarely analysed empirically. Most studies pointed to fragmented policy landscapes and short-term funding as barriers [54], yet few examined the political economy of how restoration priorities are set or sustained. Governance was often treated as background context rather than an active determinant of health equity.

Economic evaluation was sometimes used to strengthen the policy case for restoration, with studies citing reduced healthcare costs, ecosystem service benefits, and local employment 45 opportunities [33, 40, 46]. While such evidence can be persuasive for decision-makers, it also risks narrowing restoration's value to monetised outcomes, overshadowing cultural or equity considerations [31, 34].

This review's scoping design was suited to mapping broad evidence but less effective for interrogating governance depth or systematically evaluating economic framings. Interestingly, the lack of grey literature may be due to ecological NGOs lacking health measurement skills, and health lacking ecological measurement skills. A systematic or realist review may have been better positioned to assess how funding mechanisms, valuation tools, and policy integration shape outcomes.

The distinction between explicit and implicit restoration framing has important implications for evidence quality. Both groups reported predominantly positive health outcomes, suggesting that from a health perspective, gains occur regardless of framing. Explicit studies such as Murage, Anton, et al. (2025) and Awuku-Sowah (2023) provided detailed ecological descriptions, including tree-based programmes and mangrove rehabilitation, sometimes with concurrent biodiversity or habitat measures. This supports stronger

attribution of benefits, such as reduced malaria incidence in Awuku-Sowah (2023), to specific activities [24, 40].

Implicit studies, including Li et al. (2023) on urban forest exposure and Poulsen et al. (2022) on freshwater blue space visits, often assumed ecological quality and relied on proximity or self-reported exposure without ecological monitoring [38, 42]. While these frequently used validated health measures, such as psychological restoration scales or WHO-QOL assessments, the lack of ecological data limits causal inference and co-benefit quantification. The only negative outcome, from Tosi et al. (2015) on brown bear reintroduction, occurred in an implicit context where gains were offset by human–wildlife conflict [44]. Integrating the rigorous health metrics common in implicit studies with the ecological monitoring of explicit research would strengthen the evidence base and better inform policy and investment.

Overall, the potential of ecosystem restoration as a holistic public health strategy is evident but underrealised. The included studies reveal a fragmented treatment of social, ecological, and policy dimensions. Future research should adopt interdisciplinary designs with robust ecological and health metrics, participatory methods, and systemic policy analysis [55]. The absence of disaggregated outcome data by socio-economic status in the included studies limits understanding of equity impacts and constrains the ability to incorporate distributional effects into cost-effectiveness models. This limitation is mirrored in the broader evidence base, which also tends to treat population averages as representative, despite well-documented disparities in exposure and benefit distribution [56].

To fully interpret these findings, it is important to consider how they compare with the wider body of evidence and the strengths and weaknesses of that literature. While this review identifies associations between nature-based solutions and improved health outcomes, these findings must be interpreted in light of substantial heterogeneity in study designs and measurement approaches [57, 58]. For example, some included studies used objective environmental exposure metrics, such as NDVI or specific biodiversity indices, while others relied on self-reported access to green space, which may introduce perception bias. This variation complicates the direct comparison of effect sizes and limits meta-analytic synthesis. Furthermore, relatively few of the included studies disaggregated effects by socioeconomic status, despite the broader literature showing that environmental benefits and risks are unevenly distributed [56]. This omission risks obscuring important equity considerations in implementation.

From a policy perspective, the limitations of the mixture of study methods, i.e., small sample sizes and short durations, underscore the need for robust, prospective evaluation of interventions that integrate ecological quality metrics [59]. Without these, public health arguments for biodiversity investment risk being

based on incomplete or overly generalised evidence. The next generation of studies should therefore adopt standardised exposure measures, include socio-demographic stratification, and extend follow-up periods to capture long-term effects. Such advances would enable more precise estimates of health and economic benefits, strengthening the case for integrating ecological restoration into mainstream health policy [60].

The flowchart below (Fig 6) demonstrates how the themes intersect with one another to establish the benefits of ecosystem restoration

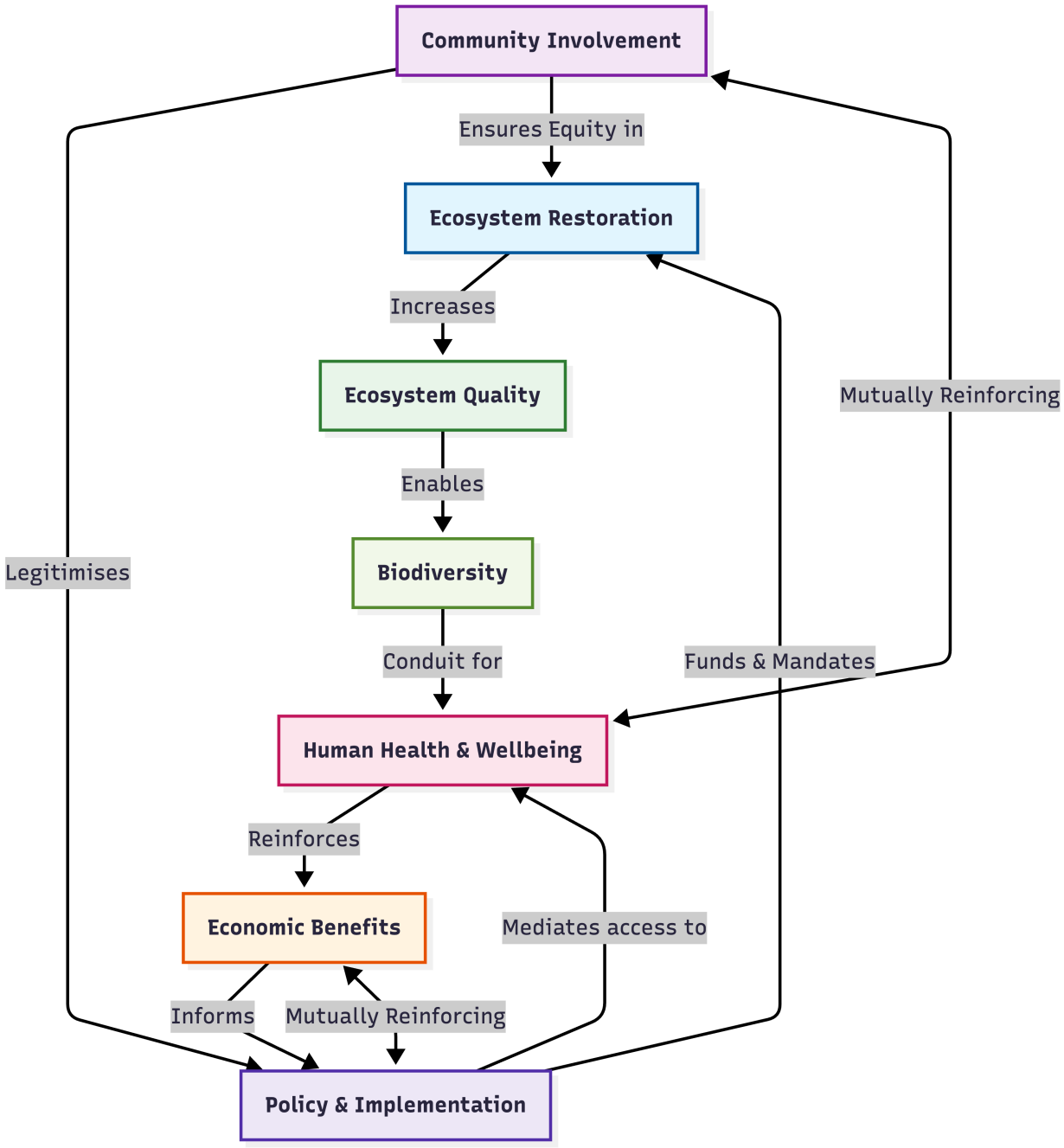


Figure 6: Integrated Conceptual Framework of Ecosystem Restoration and Human Health. This diagram illustrates the systemic interconnections between the seven core themes identified in the review, highlighting how Ecosystem Restoration drives Ecosystem Quality and Biodiversity to deliver Human Health outcomes. It demonstrates the feedback loops where Economic Benefits and Community Involvement reinforce Policy and Implementation to sustain restoration efforts.

Limitations

Several limitations inherent in this scoping review warrant consideration. First, the search was restricted to English-language sources, which may have excluded relevant restoration initiatives and public health data from non-English-speaking regions where ecological restoration terminology differs. Second, the reliance on explicitly reported "restoration" or "rewilding" keywords risks under-representing "implicitly" restored contexts, such as urban parks or managed landscapes where restorative activities occur but are not formally labelled as ecosystem restoration. Third, the significant heterogeneity in study designs and outcome measures precluded a quantitative synthesis or meta-analysis. Fourth, as is conventional for scoping reviews, no formal critical appraisal or risk-of-bias assessment was performed, meaning the findings reflect the extent and nature of the evidence rather than its methodological quality. Fifth, the data extraction process was not completely dual-screened, with 63% being dual extracted; this could reduce the validity of the results by introducing bias. Finally, the targeted grey literature search failed to identify any reports that linked restoration interventions with measured human health outcomes, confirming that health impacts are rarely integrated into current restoration project evaluations. These gaps, combined with a lack of longitudinal and quasi-experimental data, limit the ability to draw robust causal inferences regarding the long-term public health benefits of rewilded landscapes.

While this scoping review follows JBI and PRISMA-ScR protocols by omitting formal critical appraisal, the lack of a risk-of-bias assessment limits the strength of policy-level conclusions, without evaluating the internal validity or confounding factors of the included studies, particularly those with "implicit" restoration framing the reported health benefits should be viewed as indicative rather than causal. Consequently, while these findings provide a strong evidence base for potential co-benefits, further systematic reviews with rigorous quality assessments are required to transition these insights into formal policy mandates.

The HEI (Human-Environment Integrated) Approach: A Proposed Framework

The HEI approach is a conceptual framework (Fig 7 that has been designed to bridge the gap between human health and ecological restoration by aligning with the Ecosystem Services Cascade Model [61]. The process functions as a deliberate sequence:

1. The Primary Catalyst: Ecosystem Restoration The framework begins with Ecosystem Restoration as the essential base layer. Before intervention occurs, practitioners must measure baseline human and ecosystem metrics to establish a starting point for recovery. As the ecosystem is restored, these metrics are tracked continuously to capture the transition from a degraded state to functional recovery.

2. Active Regulation and Measurable Evidence The framework moves from theory to application by treating the environment as an active regulator of health rather than a passive backdrop. This is demonstrated through two distinct pathways:

Active Regulation (Tanzania): Natural regeneration in dry lands created functional structures like windbreakers, which actively regulated dust and reduced the incidence of respiratory and eye diseases.

Measurable Outcomes (North Glasgow): By mapping ecological recovery, such as the creation of accessible green assets along urban waterways, to specific health indices, research observed a 3.12% annual mortality decrease.

3. Deliberate Health Outcomes By positioning Human Health as a deliberate and measurable outcome, the HEI approach addresses the "explicit gap" where 65% of current research treats health only as an implicit by-product. This mapping allows the One Health paradigm to move from a philosophical ideal to a practical roadmap for sustainable development.

4. The Strategic Goal: Equity and Access The framework concludes with a "quality-first" strategy for Equity and Access. To address environmental health inequalities, the HEI approach argues that the most deprived communities must receive the highest quality of restored ecological assets. This ensures a non-negotiable focus on maximising the health-return on environmental investment for those who need it most.

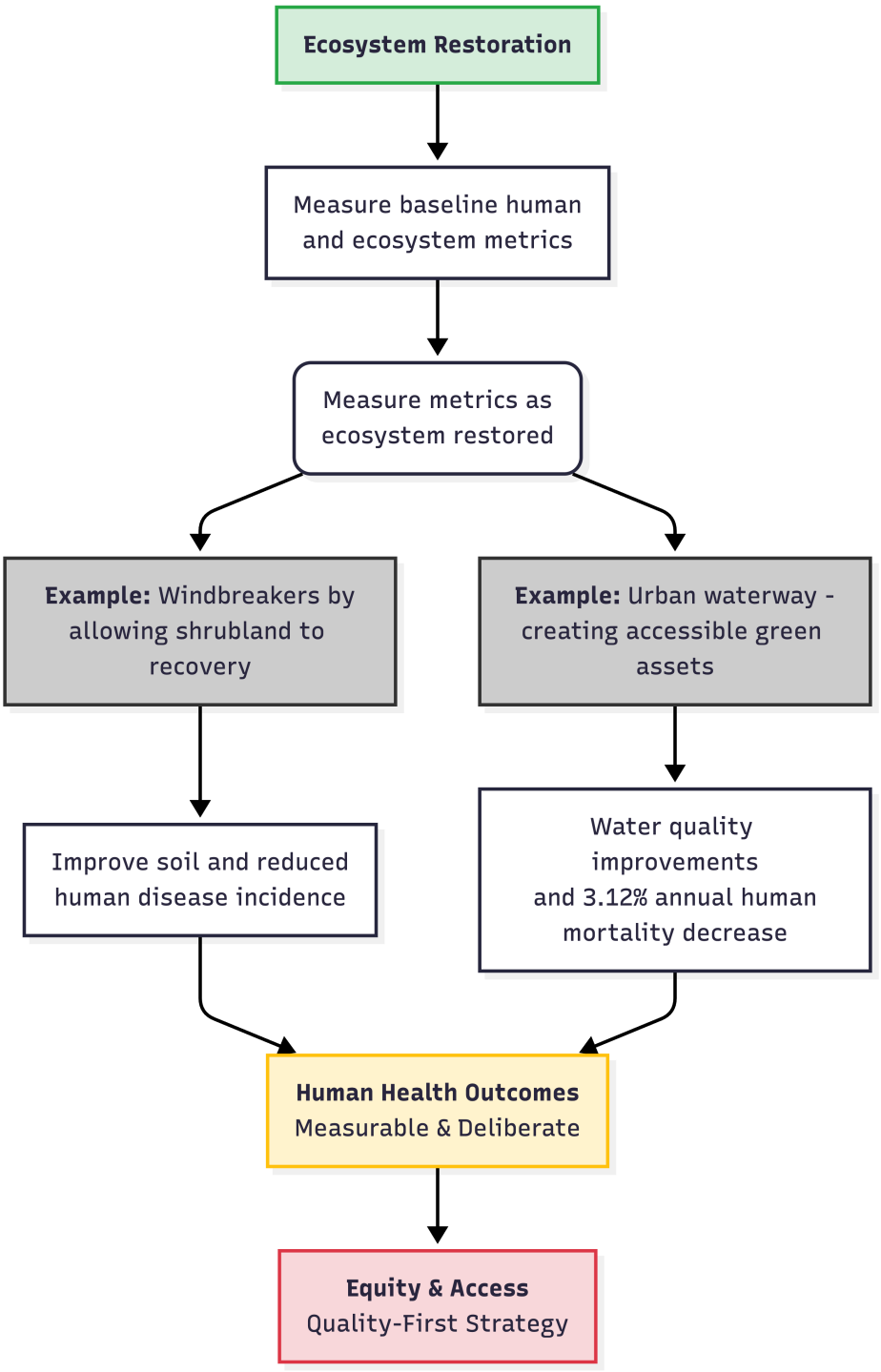


Figure 7: The HEI approach Operational Tool. The figure illustrates the functional cascade between the Environmental and Human domains and how this tool feeds evidence-based metrics into a wider One Health integrated approach.

Recommendations

The scoping review highlights priorities for future work. First, there is a need for further empirical research that directly links ecosystem restoration to health outcomes, particularly through longitudinal and experimental designs that can move beyond the cross-sectional evidence that currently dominates the field. Second, ensuring equitable access and meaningful community involvement should be embedded as core principles of restoration practice, since the evidence indicates that these social dimensions strongly mediate uptake and the distribution of benefits. Finally, biodiversity emerged as an enabling factor that amplifies health gains, suggesting that restoration projects which prioritise ecological quality are more likely to deliver sustained public health impacts. These insights suggest a research agenda that integrates ecological, social, and health perspectives, while also paying closer attention to equity and distributional impacts. In practical terms, practitioners and policymakers should treat rewilding not solely as an environmental intervention but also as a potential public health strategy, embedding biodiversity monitoring and community engagement into project design. Such steps would strengthen the evidence base and ensure that restoration delivers measurable and equitable health benefits in real-world settings.

Conclusion

This scoping review of literature from 2015–2025 demonstrates that ecosystem restoration and rewilding represent a significant yet under-realised frontier for public health. By mapping 19 diverse studies across multiple continents, this research confirms that exposure to restored environments ranging from reforested landscapes to rehabilitated wetlands is associated with predominately beneficial outcomes for mental, physical, and social well-being. Specifically, the evidence highlights that "quality" matters; restoration projects that prioritise ecological richness and biodiversity act as more effective conduits for human health than generic green spaces. A core contribution of this review is the HEI (Human-Environment Integrated) approach, which addresses the current "explicit gap" where much research treats health as an implicit by-product of nature rather than a deliberate objective. By aligning ecological recovery metrics with measurable health indices, the HEI approach provides a practical roadmap to operationalise the One Health paradigm, transitioning it from a philosophical ideal to a functional strategy for sustainable development.

However, for restoration to truly serve as a robust public health intervention, critical gaps must be bridged through improved methodological rigour, ensuring equity-first designs so that deprived communities receive high-quality ecological assets, and breaking down "siloed" governance to embed restoration into national health and biodiversity frameworks. In conclusion, while the field remains fragmented, the convergence of findings underscores that ecological vitality is inseparable from human vitality. If implemented with both social and ecological integrity, rewilding could function as a powerful, preventive nature-based solution that fosters community resilience in an era of unprecedented environmental change. Future efforts should focus on integrating standardised biodiversity metrics with robust health outcomes to provide the credible evidence base required for formal policy mandates and global investment.

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The authors declare no competing interests.

0.2 Author Contributions

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Supporting information

S1 File. Search terms

S2 File. Data extraction full chart

S3 File. PRISMA-ScR Checklist.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- S1filePrismaScRchecklist.pdf
- S2filesearchterms.pdf