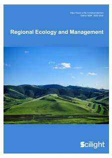
Scilight

Regional Ecology and Management
https://www.sciltp.com/journals/rem



Perspective

Check for updates

From GIS-Based Mapping to Ecological Evidence: Why Ecological Networks Still Need Field Validation

Zechen Wang [1], Sicheng Yan [2], Yanhui Yan [3], Jingeng Huo [4,*] and Yunlong Pan [5]

[1] School of Environment, Beijing Normal University, Beijing 100875, China
[2] Faculty of Geographical Science and Engineering, Henan University, Zhengzhou 450046, China
[3] School of Geography, South China Normal University, Guangzhou 510631, China
[4] College of Architecture and Urban Planning, Chongqing University, Chongqing 400045, China
[5] School of Geography and Environmental Engineering, Gannan Normal University, Ganzhou 341000, China
* Correspondence: Huojg@stu.cqu.edu.cn

How To Cite: Wang, Z.; Yan, S.; Yan, Y.; et al. From GIS-Based Mapping to Ecological Evidence: Why Ecological Networks Still Need Field Validation. *Regional Ecology and Management* **2026**, *1*(1), 9. https://doi.org/10.53941/rem.2026.100009

Received: 24 July 2026
Revised: 17 August 2026
Accepted: 31 August 2026
Published: 3 September 2026

Abstract: Ecological networks are central tools for addressing habitat fragmentation, but research practice has increasingly shifted from organism-center evidence toward GIS-based mapping and structural connectivity modeling. Remote-sensing data, resistance surfaces, circuit theory and ecosystem-service layers now allow visually persuasive networks to be produced over large areas with limited fieldwork. These approaches are indispensable for broad-scale conservation planning, yet they can blur the distinction between potential connectivity and demonstrated ecological function. A mapped corridor is not necessarily a movement pathway, and structural connectivity does not automatically imply dispersal, gene flow, recolonization or population persistence. This perspective argues that modelled corridors should be treated as testable hypotheses unless they are supported by independent biological evidence. We propose a tiered claim–evidence framework that distinguishes structural predictions, species-informed hypotheses, demonstrated corridor use and demonstrated conservation outcomes. Field validation need not be universal or identical across studies; its intensity should be proportional to claim strength, spatial scale and decision risk. Moving from one-off mapping toward an adaptive prediction–validation–update cycle would make ecological networks more credible scientific and conservation tools.

Keywords: ecological network; field validation; structural connectivity; functional connectivity; corridor validation

1. Introduction

Ecological networks emerged from a concrete conservation problem: isolated protected areas and fragmented habitat patches can restrict movement, migration, recolonization and long-term population persistence [1–3]. Connectivity was therefore conceived as an ecological process linking otherwise separated populations and habitats. During the past two decades, however, the operational center of the field has increasingly shifted toward Geographic Information System (GIS)-based network construction. Remote-sensing products, resistance surfaces, circuit-theory models and ecosystem-service layers now make it possible to delineate sources, corridors and priority nodes across very large areas [4–6].

This technical development has strengthened conservation planning, but it has also created an evidentiary ambiguity. After an ecological network is drawn, do organisms actually move through its corridors (Figure 1)? Does gene flow increase? Are road mortality, local extinction risk or barriers to recolonization reduced? A spatial connection that is persuasive on a map may identify where movement could occur without demonstrating that movement does occur or that conservation outcomes improve [7,8].

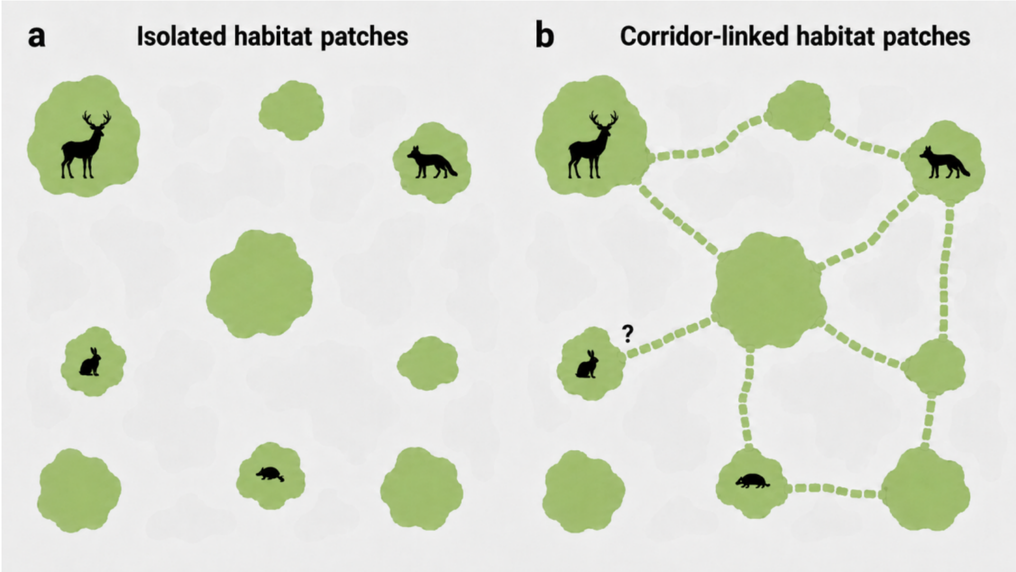


Figure 1. From isolated patches to corridor-linked habitats. (**a**) Isolated habitat patches with animals occurring within separate patches. (**b**) Habitat patches linked by modelled ecological corridors. The question mark indicates uncertainty over whether animals use the corridors as movement pathways.

The distinction matters because structural connectivity and functional connectivity answer different questions. Structural connectivity describes the physical arrangement and continuity of habitat, whereas functional connectivity concerns the realized movement of organisms or the ecological flows enabled by a landscape. Resistance surfaces are designed to represent the expected effects of roads, fences, flooding, disturbance and other landscape features on movement, but they remain models of landscape permeability. Realized connectivity also depends on factors not captured by landscape structure alone, including population density, reproductive output, source-habitat quality and functionality, behavioral state, species interactions and the availability of dispersers. A mapped connection may therefore be meaningful for a wide-ranging carnivore while remaining irrelevant to an amphibian, insect or plant with limited dispersal.

This perspective does not argue against modeling. For regional and national planning, maps are often the only realistic starting point. It instead asks that the strength of connectivity claims be matched to the strength of supporting evidence. Although validation is receiving greater attention, it remains far from a routine component of connectivity research [9,10]. We examine how connectivity became predominantly map based, why structural approaches remain attractive, and how a tiered claim–evidence framework can distinguish exploratory spatial hypotheses from demonstrated ecological connections.

2. From Ecological Processes to Mapped Connectivity

Over the past two decades, the operational center of ecological-network research has increasingly moved toward mapped connectivity. This shift has been enabled by the rapid availability of remote-sensing products, land-cover datasets, digital elevation models, road networks, ecosystem-service layers, and increasingly accessible GIS software. As a result, ecological networks are now frequently constructed through workflows that identify ecological sources, assign resistance surfaces, identify or delineate corridors, and optimize nodes, pinch points, or priority areas. Methods such as morphological spatial pattern analysis, minimum cumulative resistance modeling, graph theory, circuit theory, gravity models, and ecosystem-service integration have made it possible to produce spatially explicit and visually persuasive networks across cities, watersheds, mountain regions, protected-area systems, and national-scale planning units.

This methodological expansion has brought real benefits. It has made connectivity planning more systematic, repeatable, and policy-relevant, especially where field data are scarce and conservation decisions must be made at broad spatial scales. Yet it has also changed the evidentiary basis of the field. A recent bibliometric analysis of ecological-network and ecological-security-pattern research identified 1806 relevant records from 1991 to 2024 and showed that publication output has increased sharply since 2010. The dominant research themes in this expanding literature include ecological-network construction, graph theory, circuit theory, minimum cumulative resistance models, ecological corridors, ecological security patterns, and ecosystem-service integration [11]. These are largely tools for representing potential or structural connectivity rather than direct tests of whether organisms use the mapped connections.

Evidence from systematic reviews points in the same direction. In a review of 142 connectivity studies in European forests, 75 studies (53%) used solely structural approaches, 26 (18.3%) combined structural and functional approaches, and 22 (15%) used functional approaches exclusively. The remaining 19 studies used genetic evidence: 18 (13%) combined genetic methods with other approaches and one (0.7%) used genetic methods alone (Figure 2) [12]. Thus, all five mutually exclusive categories sum to the reported total of 142 studies. This does not mean that structural studies are unimportant. Many conservation problems require maps before they can be acted upon. But it does suggest that ecological-network research has grown faster as a mapping and modeling enterprise than as an organism-center testing enterprise.

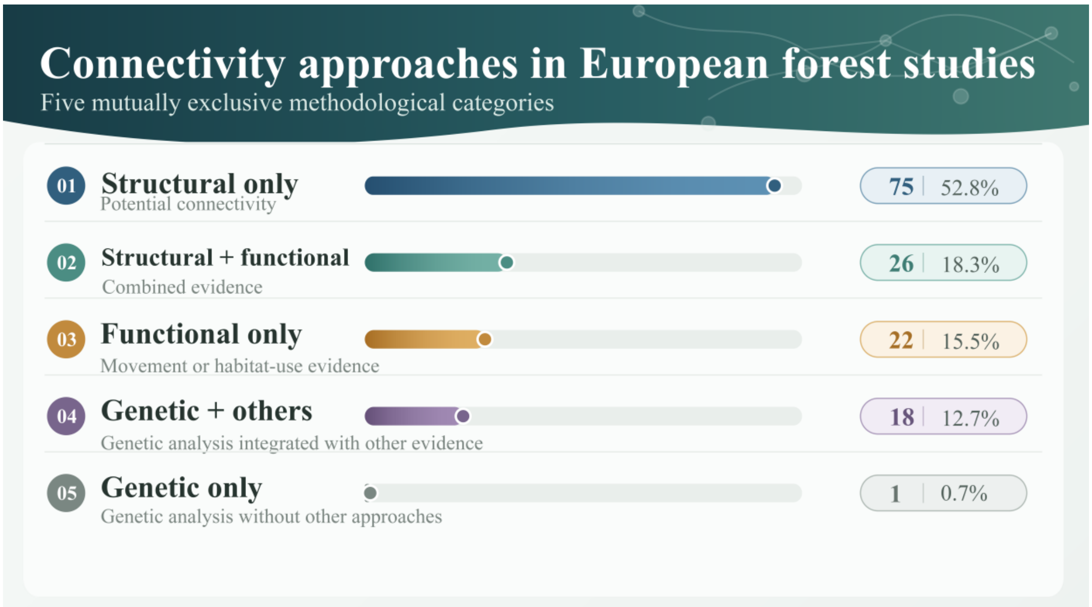


Figure 2. Connectivity approaches used in the 142 European forest studies reviewed by Martínez-Richart et al. [12].

The consequence is that "connectivity" can become ambiguous. A corridor identified by a resistance model may be a useful planning hypothesis, but it is not yet evidence of movement. A network optimized for habitat contiguity, landscape permeability, or ecosystem-service supply may indicate where connectivity could occur, but it does not demonstrate that dispersal, gene flow, recolonization, or demographic rescue is actually taking place. When connectivity becomes a map, the field gains spatial power; it also risks losing sight of the organisms and processes that made connectivity ecologically meaningful in the first place.

3. Why Structural Connectivity Dominates

There are practical reasons why structural connectivity has become so attractive. A mapped ecological network can often be produced within an office-based workflow. Public land-cover products, satellite imagery, digital elevation models, road layers, hydrological data, protected-area boundaries, and ecosystem-service datasets can be downloaded, processed, and combined in GIS. With established software and modeling packages, researchers can delineate ecological sources, construct resistance surfaces, identify least-cost paths, simulate current flow, and rank corridors or pinch points without necessarily collecting new biological data. Satellite remote sensing has greatly expanded the ability of applied ecologists to describe land cover, habitat structure, fragmentation, degradation, and other environmental conditions across broad spatial scales [13]. For large regions, this capacity is indispensable.

By contrast, testing functional connectivity is usually slower, more expensive and less predictable. To know whether organisms actually use mapped corridors, researchers may need telemetry, camera traps, genetic sampling, environmental DNA, mark–recapture or repeated occupancy surveys (Figure 3). These approaches often require field permits, animal-handling approval, species-specific expertise, seasonal sampling windows, equipment purchase and maintenance, local access, trained personnel and repeated visits across months or years. Global Positioning System (GPS) and biologging technologies can provide detailed animal locations and behavioral information, but they depend on devices, power supply, data retrieval systems and species-appropriate deployment [14,15]. Genetic or eDNA evidence may reveal movement or connectivity more indirectly, but it still requires sampling design, laboratory work and careful interpretation. In many cases, the outcome is uncertain: animals may avoid the expected corridor, sample sizes may be small, devices may fail and rare dispersal events may not be observed during the study period.

These constraints do not make broad-scale validation infeasible. A national analysis in Canada tested a 300-m connectivity surface with independently collected wildlife observations [16], and a subsequent assessment used GPS records from 3525 individuals of 17 species across 46 study areas to test predictions for multiple movement processes [17]. Such studies show that large-scale validation can be achieved by reusing existing monitoring data and coordinating collaborations, although taxonomic, geographic and behavioral coverage remains uneven.

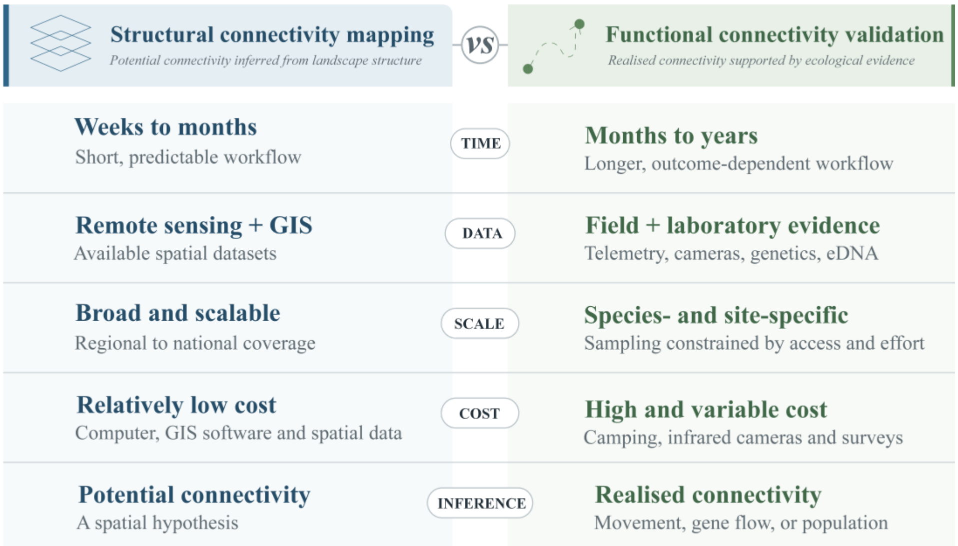


Figure 3. Practical asymmetry between structural connectivity mapping and functional validation.

The difference in research cycle is therefore substantial. A structural connectivity study based on existing spatial datasets may be completed within weeks or months once the workflow is established. A functional validation study may require at least one field season, and often several years, before movement, gene flow, recolonization, or demographic effects can be evaluated. The difference is not only financial; it also concerns time, logistics, disciplinary training, and publication risk. A map-based study can usually guarantee an output: sources, corridors, resistance surfaces, and priority areas. A biological test cannot guarantee the expected result, because the organisms themselves may not behave as the model predicts.

This asymmetry helps explain why ecological-network research has expanded more rapidly as a modeling enterprise than as a testing enterprise. Structural connectivity studies are scalable, visually persuasive, and readily aligned with planning needs. Functional studies are biologically stronger, but they are harder to design, harder to fund, and harder to generalize across regions. The convenience of structural connectivity is therefore understandable. It is not a weakness in itself. The problem begins when this convenience changes the evidentiary standard of the field.

4. A Tiered Claim–Evidence Framework

Ecological-network research does not require a single universal standard of field validation. The appropriate evidence depends on the ecological process being represented, the spatial and temporal scale of analysis and the strength of the claim being made. A structurally identified corridor may be sufficient as a preliminary planning hypothesis, provided that its assumptions and uncertainty are reported clearly. However, claims that a corridor supports movement, gene flow, recolonization, demographic rescue or population persistence require corresponding biological evidence. Existing work provides complementary guidance: Beier et al. [18] outline best practices for producing regional connectivity maps; Creech et al. [10] synthesize available validation approaches; Poor et al. [19] propose a post-hoc corridor-validation workflow; and Zeller et al. [20] demonstrate empirically that model and data choices can change corridor predictions. Our framework addresses a different but related question: not which technical validation method should be selected, but what strength of ecological claim is warranted by the evidence available. It extends beyond model-performance validation by placing mapped predictions, direct corridor use and conservation outcomes on a common reporting ladder. This framing is consistent with the field-wide synthesis of Liczner et al. [21] and with Keeley et al.'s [22] emphasis that validation must align with model objectives, landscape context, spatial resolution and data assumptions. The central principle is not that every network must be tested in the same way, but that evidence strength should match claim strength.

This principle can be applied as an evidence gradient. Networks based solely on landscape configuration or resistance surfaces should be described as potential structural connections. Models informed by species ecology and tested with occurrence, occupancy or habitat-use data can support species-informed hypotheses only when the test data are independent of the data used to build, parameterize or calibrate the model. Reusing the same observations for model fitting and evaluation without a genuine holdout or external dataset is circular and does not constitute validation. The grain, extent and temporal window of the validation data must also be appropriate to the model's resolution and stated objective [10,22]. Claims of actual movement require direct and appropriately designed evidence, whereas claims about gene flow, recolonization or demographic benefit require genetic, population or long-term monitoring evidence. Evidence quality also varies within each level according to independence, replication, sampling effort, detection probability, spatial resolution and the match between the observation and the claimed process. A single road-crossing observation is weaker than replicated telemetry, camera or mark–recapture evidence and may indicate barrier encounter rather than successful movement. Roadkill records can identify mortality risk but cannot by themselves demonstrate successful crossing or reduced mortality; Level 4 therefore requires an outcome design capable of estimating change, such as before–after or control-impact evidence.

Operationally, the gradient can be expressed in four levels. Level 1 comprises structural predictions based on landscape configuration, resistance surfaces, least-cost paths or current-flow models; regional connectivity maps developed under explicit assumptions exemplify this level [18]. Level 2 adds species-specific ecological information and genuinely independent occurrence, occupancy or habitat-use data, allowing a species-informed connectivity hypothesis; Iverson et al. [23] illustrate an independent test of mapped linkages using wildlife occurrence and movement-related datasets. Level 3 requires direct evidence of corridor use, preferably from replicated telemetry, camera detections, mark–recapture, genetic assignment of movement or similarly process-matched observations; empirical tests with dispersal data provide examples [17,20]. Level 4 evaluates conservation outcomes through gene flow, recolonization, survival, demographic rescue, population persistence or demonstrated mortality reduction; genetic evidence that wildlife crossing structures facilitated migration, reproduction and admixture in bears illustrates this level [24]. These levels classify the claim that the evidence can support; they do not imply that every dataset within a level is equally strong (Figure 4).

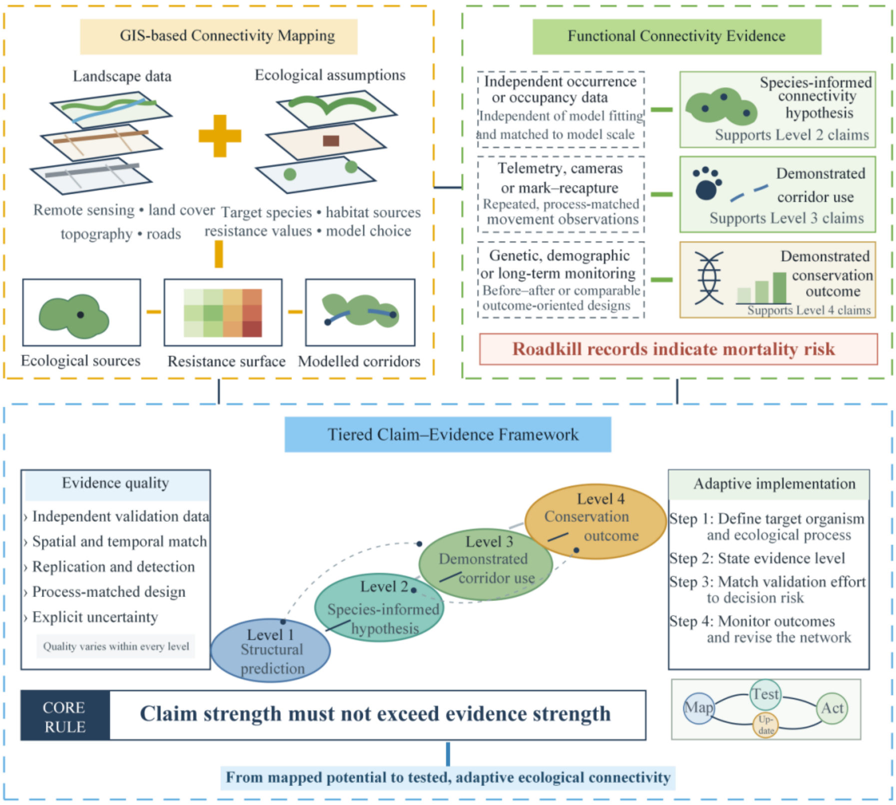


Figure 4. A tiered claim–evidence framework linking structural connectivity mapping to functional connectivity and conservation outcomes.

A claim–evidence standard would make network studies easier to interpret and use. Authors should identify the target organism or ecological process, state whether the network is a structural prediction or a functionally supported connection, and report its principal uncertainty. Reviewers could then assess whether terms such as corridor, movement pathway or functional connection are justified, while planners could distinguish exploratory priorities from demonstrated connections. The governing rule is simple: the strength of a connectivity claim should not exceed the strength of its supporting evidence.

5. Discussion

A tiered framework should not be interpreted as a requirement that every ecological network undergo identical field validation. Validation needs differ with the research question, target organism, spatial scale, data availability and intended decision. A continental assessment designed to identify broad planning priorities cannot be evaluated in the same way as a local wildlife crossing or restoration corridor. Structural models remain legitimate when their purpose is exploratory and their assumptions are transparent. The problem arises when potential connections are reported as functioning corridors or when planning outputs are treated as demonstrated conservation outcomes.

Validation should therefore be proportional to decision risk. Low-risk exploratory studies may rely on sensitivity analysis, alternative resistance surfaces and independent occurrence data. Studies guiding land acquisition, infrastructure mitigation, protected-area design or major restoration investment require stronger evidence because their costs and ecological consequences are difficult to reverse. Validation can also be strategic rather than exhaustive: representative corridors can be sampled, competing models can be tested against independent data, and multiple evidence sources can be triangulated. This approach preserves the scalability of GIS-based planning while reducing the risk of overconfident interpretation.

The science–implementation gap also deserves attention. Reviews of connectivity conservation planning show that producing a technically credible plan does not guarantee implementation or measurable conservation outcomes [25]. Governance, land tenure, infrastructure conflict, local participation, funding and long-term monitoring can determine whether mapped corridors persist outside the publication. Global guidance increasingly recognizes ecological connectivity as a conservation objective, but it likewise emphasizes clearly defined ecological objectives, implementation mechanisms and monitoring [26]. Field validation is therefore one component of a broader accountability chain linking spatial prediction, management action and biological response.

6. Conclusions and Future Directions

GIS-based ecological networks are indispensable for identifying potential connections across fragmented landscapes, but spatial coherence alone does not demonstrate ecological function. The central issue is not whether modeling or field ecology should dominate, but whether the evidence supports the terminology and management claims attached to a network. Distinguishing structural predictions, species-informed hypotheses, demonstrated corridor use and demonstrated conservation outcomes would improve scientific clarity, reviewer evaluation and practical decision-making. Ecological networks remain valuable hypotheses; their conservation credibility increases when those hypotheses are tested.

Future ecological-network research should first establish a minimum reporting standard. Each study should identify the target organism or ecological process, define the spatial and temporal scale, describe how resistance values were derived, distinguish model-building and calibration data from genuinely independent validation data, justify the match between validation resolution and model objectives, report uncertainty and state the evidence level supported by the analysis. Journals and reviewers could use these elements to prevent potential structural connections from being presented as proven movement pathways.

Second, validation should increasingly integrate complementary evidence. Telemetry can reveal individual movement, camera traps and road-crossing records can document repeated use, genetic data can capture intergenerational connectivity, and environmental DNA or occupancy surveys can extend inference to difficult-to-observe taxa. Combining these sources with remote sensing and spatial models will not eliminate uncertainty, but it can reveal where independent lines of evidence converge or conflict.

Third, ecological networks should be treated as adaptive rather than final products. An initial model can identify candidate connections; targeted observations can test those predictions; discrepancies can be used to revise resistance surfaces, corridor locations and management priorities; and subsequent monitoring can evaluate whether interventions improve movement, gene flow, recolonization or population persistence. The next generation of ecological-network research should move from mapping where connectivity might occur to testing when, for whom and with what conservation consequences it actually occurs.

Author Contributions

Z.W.: Conceptualization, writing—original draft preparation, writing—review and editing; S.Y.: Methodology, formal analysis, writing—review and editing; Y.Y.: Data collection, data curation, writing—review and editing; J.H.: Supervision, project administration, conceptualization, writing—review and editing; Y.P.: Validation. All authors have read and agreed to the published version of the manuscript.

Funding

The work was supported by National Natural Sciences Fund Project (No. 42271097; No. 42561144300) and National Key Research and Development Project (No. 2022YFF1303204).

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

The data discussed in this perspective article are derived from previously published studies and publicly available sources. Any additional information supporting the discussion and conclusions of this article will be made available by the corresponding author upon reasonable request.

Acknowledgments

The authors would like to sincerely thank Jiayuan Mao from the School of Geographic Sciences, East China Normal University, for inspiring this work through insightful perspectives, critical discussions, and constructive exchanges of ideas.

Conflicts of Interest

The authors declare no conflict of interest.

Use of AI and AI-Assisted Technologies

During the preparation of this work, the authors used OpenAI ChatGPT (GPT-5.6) to assist with language editing and manuscript revision. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

References

1. Taylor, P.D.; Fahrig, L.; Henein, K.; et al. Connectivity is a vital element of landscape structure. *Oikos* **1993**, *68*, 571–573. https://doi.org/10.2307/3544927.
2. Fahrig, L. Effects of habitat fragmentation on biodiversity. *Annu. Rev. Ecol. Evol. Syst.* **2003**, *34*, 487–515. https://doi.org/10.1146/annurev.ecolsys.34.011802.132419.
3. Haddad, N.M.; Brudvig, L.A.; Clobert, J.; et al. Habitat fragmentation and its lasting impact on Earth's ecosystems. *Sci. Adv.* **2015**, *1*, e1500052. https://doi.org/10.1126/sciadv.1500052.
4. McRae, B.H.; Dickson, B.G.; Keitt, T.H.; et al. Using circuit theory to model connectivity in ecology, evolution, and conservation. *Ecology* **2008**, *89*, 2712–2724. https://doi.org/10.1890/07-1861.1.
5. Zeller, K.A.; McGarigal, K.; Whiteley, A.R. Estimating landscape resistance to movement: A review. *Landsc. Ecol.* **2012**, *27*, 777–797. https://doi.org/10.1007/s10980-012-9737-0.
6. Wang, Z.; Huo, J.; Shi, Z.; et al. Ecological security pattern construction integrating "connectivity–importance–niche" approach under vertical zonation: A case study in Funiu Mountain Area, China. *Ecol. Evol.* **2026**, *16*, e72848. https://doi.org/10.1002/ece3.72848.
7. Beier, P.; Noss, R.F. Do habitat corridors provide connectivity? *Conserv. Biol.* **1998**, *12*, 1241–1252. https://doi.org/10.1111/j.1523-1739.1998.98036.x.
8. Brodie, J.F.; Gonzalez, A.; Mohd-Azlan, J.; et al. A well-connected Earth: The science and conservation of organismal movement. *Science* **2025**, *388*, eadn2225. https://doi.org/10.1126/science.adn2225.

9. Laliberté, J.; St-Laurent, M.H. Validation of functional connectivity modeling: The Achilles' heel of landscape connectivity mapping. *Landsc. Urban Plan.* **2020**, *202*, 103878. https://doi.org/10.1016/j.landurbplan.2020.103878.
10. Creech, T.G.; Brennan, A.; Faselt, J.; et al. Validating connectivity models: A synthesis. *Curr. Landsc. Ecol. Rep.* **2024**, *9*, 120–134. https://doi.org/10.1007/s40823-024-00102-8.
11. Wang, J.; Tang, H.; Guo, W.; et al. Global hotspots and trends of ecological network research (1991–2024): Insights from bibliometric analysis. *Sustainability* **2025**, *17*, 4716. https://doi.org/10.3390/su17104716.
12. Martínez-Richart, A.I.; Zolles, A.; Oettel, J.; et al. A review of structural and functional connectivity studies in European forests. *Landsc. Ecol.* **2025**, *40*, 10. https://doi.org/10.1007/s10980-024-02028-2.
13. Pettorelli, N.; Laurance, W.F.; O'Brien, T.G.; et al. Satellite remote sensing for applied ecologists: Opportunities and challenges. *J. Appl. Ecol.* **2014**, *51*, 839–848. https://doi.org/10.1111/1365-2664.12261.
14. Tomkiewicz, S.M.; Fuller, M.R.; Kie, J.G.; et al. Global positioning system and associated technologies in animal behaviour and ecological research. *Philos. Trans. R. Soc. B Biol. Sci.* **2010**, *365*, 2163–2176. https://doi.org/10.1098/rstb.2010.0090.
15. Kays, R.; Crofoot, M.C.; Jetz, W.; et al. Terrestrial animal tracking as an eye on life and planet. *Science* **2015**, *348*, aaa2478. https://doi.org/10.1126/science.aaa2478.
16. Pither, R.; O'Brien, P.; Brennan, A.; et al. Predicting areas important for ecological connectivity throughout Canada. *PLoS ONE* **2023**, *18*, e0281980. https://doi.org/10.1371/journal.pone.0281980.
17. Brennan, A.; Bowman, J.; Custode, L.; et al. National-scale multispecies connectivity models represent movements for a majority of species tested. *Landsc. Ecol.* **2025**, *40*, 200. https://doi.org/10.1007/s10980-025-02227-5.
18. Beier, P.; Spencer, W.; Baldwin, R.F.; et al. Toward best practices for developing regional connectivity maps. *Conserv. Biol.* **2011**, *25*, 879–892. https://doi.org/10.1111/j.1523-1739.2011.01716.x.
19. Poor, E.E.; Scheick, B.K.; Cox, J.J.; et al. Towards robust corridors: A validation framework to improve corridor modeling. *Landsc. Ecol.* **2024**, *39*, 177. https://doi.org/10.1007/s10980-024-01971-4.
20. Zeller, K.A.; Jennings, M.K.; Vickers, T.W.; et al. Are all data types and connectivity models created equal? Validating common connectivity approaches with dispersal data. *Divers. Distrib.* **2018**, *24*, 868–879. https://doi.org/10.1111/ddi.12742.
21. Liczner, A.R.; Pither, R.; Bennett, J.R.; et al. Advances and challenges in ecological connectivity science. *Ecol. Evol.* **2024**, *14*, e70231. https://doi.org/10.1002/ece3.70231.
22. Keeley, A.T.H.; Beier, P.; Belote, R.T.; et al. Comment on: Functional landscape connectivity for a select few: Linkages do not consistently predict wildlife movement or occupancy. *Landsc. Urban Plan.* **2025**, *253*, 105217. https://doi.org/10.1016/j.landurbplan.2024.105217.
23. Iverson, A.R.; Waetjen, D.; Shilling, F. Functional landscape connectivity for a select few: Linkages do not consistently predict wildlife movement or occupancy. *Landsc. Urban Plan.* **2024**, *243*, 104953. https://doi.org/10.1016/j.landurbplan.2023.104953.
24. Sawaya, M.A.; Kalinowski, S.T.; Clevenger, A.P. Genetic connectivity for two bear species at wildlife crossing structures in Banff National Park. *Proc. R. Soc. B* **2014**, *281*, 20131705. https://doi.org/10.1098/rspb.2013.1705.
25. Keeley, A.T.H.; Beier, P.; Creech, T.; et al. Thirty years of connectivity conservation planning: An assessment of factors influencing plan implementation. *Environ. Res. Lett.* **2019**, *14*, 103001. https://doi.org/10.1088/1748-9326/ab3234.
26. Hilty, J.; Worboys, G.L.; Keeley, A.; et al. *Guidelines for Conserving Connectivity through Ecological Networks and Corridors*; Best Practice Protected Area Guidelines Series No. 30; IUCN: Gland, Switzerland, 2020. https://doi.org/10.2305/IUCN.CH.2020.PAG.30.en.