Ecological Connectivity

Guidance for revised National Biodiversity Strategies and Action Plans and implementation of the Kunming-Montreal Global Biodiversity Framework

Offered by the IUCN WCPA Connectivity Conservation Specialist Group, in cooperation with IUCN WCPA Transboundary Conservation Specialist Group

Introduction: Well managed and effectively connected protected and conserved areas are an essential part of solving the two largest crises facing the world today: climate change and biodiversity loss. While protected areas are the cornerstone of area-based conservation, they are insufficient in isolation and efforts to address these challenges must foreground ecological connectivity. The global importance of connectivity and transboundary conservation was highlighted in 2021 as the UN General Assembly adopted Resolution 75/271 "Nature knows no borders: transboundary cooperation a key factor for biodiversity conservation, restoration and sustainable use". More recently, outcomes of both CoP-15 to the Convention on Biological Diversity (CBD) and CoP-27 to the UN Framework Convention on Climate Change (UNFCCC) express the need for significant protected area growth *and* connectivity as crucial for maintaining biodiversity while providing an opportunity for species to adapt to climate change.

At CoP-15, the 196 Parties to the CBD adopted the Kunming-Montreal Global Biodiversity Framework (GBF) as decision 15/4 on 18 December 2022. This milestone agreement, along with its Global Monitoring Framework, now serves as the strategic plan for the Convention for 2022-2030. As countries move towards implementation of the GBF through revised or updated National Biodiversity Strategies and Action Plans (NBSAPs), ecological connectivity is an essential piece of the puzzle. The purpose of this document is to provide guidance for connectivity and transboundary conservation and along with resources, tools and examples, towards developing feasible, effective NBSAPs.

Ecological connectivity has been defined as the unimpeded movement of species and the flow of natural processes that sustain life on Earth.[1] Well-connected ecosystems support a diversity of ecological functions such as migration, surface and sub-surface hydrology, nutrient cycling,

[1] CMS (2020). *Improving Ways of Addressing Connectivity in the Conservation of Migratory Species,* Resolution 12.26 (REV.COP13), Gandhinagar, India (17-22 February 2020). UNEP/CMS/COP13/ CRP 26.4.4. https://www.cms.int/sites/default/files/document/cms_cop13_res.12.26_rev.cop13_e.pdf.

pollination, seed and larval dispersal, range shift, genetic diversity, and disease resistance. Connectivity largely shapes species richness, food web structure and most ecological functions, processes and ecosystem services, both on land and at sea. Its conservation is thus essential for managing healthy and productive ecosystems, mitigating fragmentation, conserving biodiversity and building resilience to human activities and climate change across all biomes and all spatial scales. In terrestrial, freshwater, and marine ecosystems, we must maintain, enhance, and restore ecological connectivity to the greatest extent possible. In 2020, Hilty et al.[2] provided guidelines for conserving connectivity through planning and implementing ecological corridors and networks. Considering that corridors and networks often span international boundaries, it is important to take into regard transboundary conservation principles and processes, guidance on which is outlined in Vasilijević et al. (2015).[3] In this document, we provide updated, detailed guidance for applying these principles to the goals and targets of the GBF.

The GBF emphasizes the fundamental contribution that ecological connectivity makes to healthy functioning ecosystems and species' diversity and resilience, and their benefits to people, by including connectivity in a number of goals and targets to be advanced globally by the 196 signatory countries. These include:

- **Goal A**, as a fundamental requirement for ecosystem functioning;
- **Target 1**, as a key criterion for achieving "participatory, integrated and biodiversity inclusive spatial planning", especially for determining which areas to establish as protected and conserved areas, where to delineate ecological corridors and networks, and/or as areas of priority for restoration;
- **Target 2**, as a part of maximizing the benefits and outcomes of restoration for entire landscapes and seascapes;
- **Target 3**, to achieve 30x30 objectives of land, freshwater, and marine areas being effectively protected, conserved, and managed, especially in areas of particular importance for biodiversity (including corridors);
- **Target 12**, for increasing benefits from "green and blue spaces" in urban/densely populated areas; and
- **Target 14**, for ensuring "the full integration of biodiversity and its multiple values into policies, regulations, planning and development processes, poverty eradication strategies, strategic environmental assessments, environmental impact assessments and, as appropriate, national accounting within and across all levels of government and across all sectors…"

[2] Hilty, J., Worboys, G.L., Keeley, A., Woodley, S., Lausche, B., Locke, H., Carr, M., Pulsford I., Pittock, J., White, J.W., Theobald, D.M., Levine, J., Reuling, M., Watson, J.E.M., Ament, R. and Tabor, G.M. (2020). "Guidelines for conserving connectivity through ecological networks and corridors". Best Practice Protected Area Guidelines Series No. 30. Gland, Switzerland: IUCN. https://doi.org/10.2305/IUCN.CH.2020.PAG.30.en.

[3] Vasilijević, M., Zunckel, K., McKinney, M., Erg, B., Schoon, M., Rosen Michel, T. (2015). Transboundary Conservation: A systematic and integrated approach. Best Practice Protected Area Guidelines Series No. 23, Gland, Switzerland: IUCN. xii + 107 pp. https://portals.iucn.org/library/sites/library/files/documents/PAG-023.pdf

Ecological connectivity is thus a central component of the GBF and should figure prominently in revised NBSAPs, financing, and implementation efforts across all sectors at national and subnational levels. To guide effective consideration of ecological connectivity, the Connectivity Conservation and Transboundary Conservation Specialist Groups offers the following guidance:

General considerations

1. **Respecting local communities and Indigenous Peoples' rights:** Broad and inclusive collaboration in connectivity conservation is of critical importance. Collaborative approaches to on-the-ground conservation or restoration of ecological corridors bolsters communal property and local rights and reinforces the concept that ecological corridors and networks also connect people to nature. Free Prior Informed Consent should be used to ensure local communities and Indigenous Peoples are engaged and participating in proposed connectivity projects. Connectivity and transboundary conservation usually requires cooperation across political and administrative boundaries and among people and institutions at all levels of society.

2. **Spatial planning:** In line with Target 1 of the GBF, effective ecological corridors and ecological networks for conservation[4] should be identified and established, and integrated into comprehensive spatial planning processes. Ecological corridors…
   - Are not a substitute for protected areas or other effective area-based conservation measures (OECMs).
   - Should be identified and established in areas where connectivity is required with the aim of building effective ecological networks for conservation.
   - Should have specific objectives for the general conservation of biodiversity and ecosystem functioning in addition to the maintenance of identified ecosystem services and socio-economic benefits.
   - Should be governed and managed to achieve stated objectives and to achieve global conservation and sustainable development goals.
   - Should be informed by considerations of functional genetic diversity, and based on ecosystem-based approaches when possible, considering species interactions across food webs.
   - May exist in places with a range of human intervention, from degraded areas with restoration potential to wildlands.

[4] Oppler, G., Woodley, S., Hilty, J., Laur, A. and Tabor, G. 2020. *Guidelines for conserving connectivity through ecological networks and corridors*. IUCN WCPA Technical Note Series No.3, Gland, Switzerland: IUCN WCPA. 4pp. https://www.iucn.org/sites/default/files/2022-08/03_iucn_wcpa_technical_note_series_no._3.pdf.

- So long as their conservation objectives are supported, may include compatible human activities that practice sustainable resource use, minimize conflict, and promote human-wildlife coexistence.
- Should be differentiated from non-designated areas by specific uses that are allowed or prohibited.
- Facilitate transboundary collaboration and knowledge sharing between all relevant jurisdictions.
- Are not necessarily static and can vary in their geographical location and characteristics over time.

3. **Information needs:** Planning should incorporate multiple datasets, including conservation datasets (e.g., Protected Areas, Key Biodiversity Areas, Ramsar sites), datasets of Indigenous territories and land tenure, local and Indigenous knowledge, up-to-date science-based information on species distribution, biodiversity hotspots and key pathways for ecological fluxes and genetic exchanges (e.g., ocean currents, migration routes, etc.), records of established and planned infrastructure projects, productive or economic corridors and aspects of institutional capacity that affect the feasibility of a connectivity/transboundary initiative. The Diagnostic tool for transboundary conservation planners (Vasilijević, 2020) of the WCPA Transboundary Conservation Specialist Group can be used to gather relevant information on institutional aspects.[5] The resulting spatial analysis should allow decision makers to select areas for protected and conserved area expansion, and connectivity and/or transboundary conservation and restoration projects that have the greatest potential for success—thereby allocating resources most wisely.

3. **Designing, implementing, and monitoring ecological corridors:** Corridors must be established in a context-sensitive manner and, when needed, regularly adapted to reflect changes in connectivity through time. Specific tasks required for planning and designing ecological corridors and transboundary conservation initiatives include description of the landscape and seascape and their biodiversity; identification of focal species and ecosystems/habitats and indicators of their status; modeling and mapping of structural and functional connectivity, including at the land-freshwater and land-sea interfaces; prioritizing areas and/or habitat types for implementation; and developing an effective implementation plan (allowing for adaptation to connectivity changes in time). Specific tasks required for implementing ecological corridors include identification of threats and pressures; assessment of governance and policies; evaluation of social and economic factors; identifying opportunities and prioritizing actions, and creation of adaptative and global governance frameworks enabling the adoption of relevant, integrated and harmonized policies at international, national, and subnational levels. Finally, effective corridors require a monitoring, evaluation, and adaptive management plan.

[5] Vasilijević, M. (2020). Diagnostic Tool for Transboundary Conservation Planners. Suggested questions to determine feasibility for transboundary conservation. IUCN WCPA Transboundary Conservation Specialist Group. https://www.tbpa.net/page.php?ndx=22

4. **Transboundary corridors:** In many cases, national level planning of corridors will need to take into consideration transboundary aspects at the international scale, including sometimes across realms. Planning, designing, implementing and monitoring transboundary corridors between protected and conserved areas in neighboring countries and national waters is critical for maintaining the connectivity and long-term survival of wide-ranging species. Planning of transboundary corridors require cooperation and coordination between different agencies and actors of all the concerned neighboring countries. Vasilijević et al. (2015) provide guidance on establishing effective transboundary conservation processes.

5. **Connectivity indicators:** There is a need for developing new, more integrative, connectivity indicators (especially at the community or ecosystem levels) that can help decision makers with analyzing and monitoring the connectivity of their landscapes/seascapes. Connectivity aspects to measure include the stepping-stone value of habitat fragments, the climate adaptation potential of corridors (elevation/North-South connection), migration pathways (e.g., the Critical Site Network and the Eurasian African Bird Migration Atlas), and socio-economic values. Given the difference in the environmental characteristics and the general drivers and rules of functional connectivity between realms, specific connectivity indicators have to be developed to robustly infer connectivity at sea and at the land-sea interface.

5. **Development:** Poorly planned development represents one of the greatest threats to ecological connectivity. It is essential to foremost avoid and otherwise mitigate at the earliest planning stages the fragmenting forces of human development, especially infrastructure, such as roads, railways and canals; shipping lanes, dredging and marine construction, agriculture; natural resource extraction; and other environmentally destructive activities in protected and conserved areas, and other high biodiversity areas.

6. **Migratory species action plans:** Countries should establish national action plans in their NBSAPs for migratory species (e.g., birds and migratory fish). Countries should consider the diversity of species that undertake some form of migration within their life cycles, and the resulting diversity in their contribution to overall connectivity within and across realms.

7. **Linking landscapes and seascapes:** Whole-watershed connectivity is an emerging area of interest that could be used to guide connectivity planning because it considers surface and sub-surface hydrology, nutrient cycling, land use, wildlife migration, and land-freshwater-sea interactions. Marine connectivity is critically important to biodiversity conservation and complex given the unique tenurial conditions, the impacts on the marine realm that originate in the terrestrial and inland water realms, and the need for much more data to improve connectivity modeling techniques and understand the implications for people and biodiversity. It is important to consider the intrinsic differences in connectivity patterns between realms and adapt action plans to the specific characteristics of terrestrial, freshwater and marine environments and the specific dispersal strategies of their respective species. In particular, the importance of vertical connectivity at sea for many ecosystem services provided by the ocean (including carbon sequestration, oceanic productivity, etc.) is just beginning to be acknowledged.

8. **Country-wide connectivity examples:** Canada's National Program for Ecological Corridors and Tanzania's Wildlife Corridor Assessment, Prioritization, and Action Plan are two excellent examples of national programs to support maintaining and improving connectivity that other countries may follow and learn from. From the transboundary conservation perspective, there are myriad examples from around the world that can be drawn on to follow and learn from. Tanzania's case noted here is one of these examples that provide a valuable input in transboundary corridor design and implementation.

9. **Funding:** The Global Environment Facility (GEF) is the leading public finance mechanism for implementation of the GBF in countries of need. In early 2023, the CBD Secretariat began publishing a compilation of decisions by the Conference of the Parties (CoP) relevant to each target of the GBF that is intended to guide Parties to access funding in the eighth replenishment of the GEF Trust Fund (GEF-8, July 2022 to June 2026). In this information note, the Center for Large Landscape Conservation (CLLC) and the Connectivity Conservation Specialist Group (CCSG) provide a selection of this guidance relevant to the connectivity and infrastructure-related provisions of GBF. Other mechanisms for funding connectivity conservation include private philanthropy and regional public-private partnerships (e.g., The Eco-Corridors Fund). Furthermore, the enhanced ecosystem functionality of well-connected landscapes and seascapes may serve to generate sustainable financial support at local scales, thereby countering dependency on external donors.

10. **Adaptive Management:** As climate change advances, ecosystem characteristics will also change – sometimes dramatically—and current models of ecosystem management may prove more or less effective. Setting up adaptive management systems will ensure that practitioners in connectivity and transboundary conservation can learn from mistakes and apply new knowledge to improve.

Specific guidance for implementing connectivity conservation to fulfill GBF Goals & Targets:

Goal / Target Text	Recommended approaches, actions, and tools
GOAL A: *The integrity, connectivity and resilience of all ecosystems are maintained, enhanced, or restored, substantially increasing the area of natural ecosystems by 2050; Human induced extinction of known threatened species is halted, and, by 2050, extinction rate and risk of all species are reduced tenfold and the abundance of native wild species is increased to healthy and resilient levels; The genetic diversity within populations of wild and domesticated species, is maintained, safeguarding their adaptive potential.*	• Identify, characterize, and map ecosystems at a variety of scales, drawing upon a variety of forms of knowledge, including local and traditional. • Maintain, enhance, and/or restore connections between interconnected ecosystems within and across realms through conservation of ecological corridors and management of networks of protected and conserved areas. • Recognize the areas and habitat types that are critical for long-distance migratory species. • Foremost avoid and otherwise mitigate at the earliest planning stages the fragmenting forces of human development, especially infrastructure, agriculture, natural resource extraction, and other environmentally destructive activities in protected and conserved areas, as well as areas with high levels of biodiversity and other conservation values. • Cooperate across boundaries and among people and institutions at all levels by building capacity and promoting collaboration, e.g., by organizing joint meetings or webinars, conferences, or transdisciplinary trainings, where technical expertise, knowledge, and information can be shared and advanced. • Strengthen the infrastructure and capacity for monitoring and reporting to biodiversity informatics platforms at national and international scales (e.g., via the Global Biodiversity Information Facility (GBIF)). Encourage the local and global public sharing of biodiversity data gathered from scientific institutions, experts and citizen scientists.
TARGET 1 (SPATIAL PLANNING): *Ensure that all areas are under participatory integrated biodiversity inclusive spatial planning and/or effective management processes addressing land and sea use change, to bring the loss of areas of high biodiversity importance, including ecosystems of high ecological*	• Use appropriate methodologies (i.e., Systematic Conservation Planning) to assess the existing protected area network for representativeness and structural and functional connectivity. • Perform a gap analysis, spatial prioritization analyses, and validation using appropriate indicators of ecosystem integrity, connectivity and resilience. Consider the presence of Key Biodiversity Areas (KBAs).

integrity, close to zero by 2030, while respecting the rights of indigenous peoples and local communities	• Design effective ecological networks for conservation, including PAs, OECMs, KBAs, and ecological corridors.
	  ○ Define the study area and the core areas in the network.
	  ○ Use connectivity models to identify optimal movement paths among core areas.
	  ○ Consider and identify the potentially negative effects of improved connectivity on geographically isolated populations, including those that may have benefited from barriers of anthropogenic origin. In these circumstances, the removal of connectivity barriers can pose severe risks to those species or populations (e.g., by increasing their exposure to exotic competitors or predators) or may spread invasive species, parasites or other disease.
	  ○ Identify and prioritize populations with traits likely to confer resilience to climate change and other threats.
	  ○ Consider natural and climate change-modified disturbance regimes in corridor planning. For example, corridor restoration in landscapes increasingly prone to wildlife may benefit from selection of less-flammable plant species.
	  ○ Delineate corridors and design ecological networks using connectivity model outputs and considering jurisdictions with potential for effective management.
	  ○ Seek and incorporate feedback and regular knowledge updates from local rightsholders and other interested parties on connectivity and optimal network design.
	• Address the impacts of linear infrastructure on ecological connectivity through:
	  ○ Spatial analyses of existing and planned LI threats on biodiversity.
	  ○ Fine-scale road ecology analyses and assessments to identify priority sites for wildlife crossing improvements, assess feasibility, and develop site and species-specific recommendations.
	  ○ Promoting and implementing nature-based solutions to climate change, such as planning for the managed or staged retreat of LI that hinders the natural inland migration of coastal ecosystems in response to rising sea levels.
	• Incorporate ecological corridors and networks into spatial planning at levels of government and across sectors.

TARGET 2 (RESTORATION): *Ensure that by 2030 at least 30 per cent of areas of degraded terrestrial, inland water, and coastal and marine ecosystems are under effective restoration, in order to enhance biodiversity and ecosystem functions and services, ecological integrity and connectivity.*	• Approach the relationship between restoration and connectivity from the dual standpoint of 'Connect to Restore and Restore to Connect.' ○ Connect to Restore: ecological connectivity maximizes restoration success. Landscape connectivity can have positive ecological effects on the performance of restoration projects. Ecological connectivity modifies the distribution, abundance, and diversity of animals and plants across landscapes and potentially improves the ecological function of restored habitats, promoting the self-maintenance of those ecosystems. Therefore, when planning restoration projects, it is vital to consider which aspects of connectivity are key to ecosystem functioning. Maintaining, and if needed, restoring them will ensure long-term success of the restoration project. ▪ Hydrological connectivity is particularly important, not only along streams but in the entire watershed, and similarly in marine environments. Understanding and managing hydrological connectivity at the watershed scale is fundamental for maintaining ecological functions in both landscapes and seascapes. ○ Restore to Connect: restoration efforts can be an important opportunity to enhance connectivity. Targeted restoration to enhance connectivity is an opportunity to restore wildlife movements and ecological processes. It is key for maintaining genetic diversity within populations, decreasing the risk of extinction due to shortages of breeding individuals, allowing animals and plants to recolonize suitable habitat areas after local extirpation has occurred, and bolstering ecosystem resilience to climate change. As such, it is ideal to build connectivity considerations into existing and proposed restoration activities. Restoration activities should be planned carefully and avoid introduction of non-native species, parasites and other disease.
TARGET 3 (CONSERVATION): *Ensure and enable that by 2030 at least 30 percent of terrestrial, inland water, and of coastal and marine areas... are effectively conserved and managed through ecologically representative, well-connected and equitably governed systems of protected areas*	• Organize and conduct Connectivity and/or Transboundary Conservation Workshops to initiate processes for planning, implementing and monitoring ecological corridors and ecological networks for conservation at regional, national and international scales. • Consider that connectivity assessments and their integration in relevant environmental conservation policies and management plans may rely on a variety of approaches, depending on landscape/seascape conditions, focal species,

and other effective area-based conservation measures.	existing governance, policies, and social and economic factors at the international, national and subnational levels. Harmonizing approaches and integrating them within and across realms is needed to efficiently incorporate connectivity knowledge into planning, implementing and monitoring of ecological corridors and ecological networks for conservation. • Prioritize corridors based on various spatial analyses to assess conservation values and threats. • Identify KBAs across multiple taxonomic groups and identify the connectivity required to maintain these globally significant populations of species or ecosystems. • Develop a monitoring, evaluation, and adaptive management plan for all ecological corridors. • Ensure transboundary conservation governance approaches are utilized for effective and efficient implementation and monitoring of transboundary corridors. This includes efficient sharing of knowledge (i.e., in open, digitized formats) and cooperative management between neighboring countries.
TARGET 12 (URBAN AND DENSELY POPULATED AREAS): *Significantly increase the area and quality and connectivity of, access to, and benefits from green and blue spaces in urban and densely populated areas sustainably, by mainstreaming the conservation and sustainable use of biodiversity, and ensure biodiversity-inclusive urban planning, enhancing native biodiversity, ecological connectivity and integrity, and improving human health and well-being and connection to nature and contributing to inclusive and sustainable urbanization and the provision of ecosystem functions and services.*	• Protect urban wildlife habitats and preserve ecological connectivity by allowing native plants to grow naturally, with minimal pest control and chemical spraying, and replacing monocrop lawns with diverse assemblages of native plants. • Protect wetlands in urban areas, even if small in size, to help protect habitat for a range of biodiversity, especially migrating birds. • Protect riparian networks in urban areas which deliver co-benefits for ecological connectivity, flood and drought mitigation, climate change resilience and urban green space for recreation and enjoyment. • Promote partnerships between industry and conservation. One such initiative in China is called “Biodiversity Conservation in Our Neighborhood (BCON)”. In one BCON example, fish farmers in Hubei province refrain from using chemical disinfectants to kill "unwanted fish and shrimp" in their ponds during winters. This allows migratory birds that have traveled long distances to feed on the fish during the winter. Farmers only disinfect the ponds after the migratory birds have flown away the following spring.

TARGET 14 (VALUATION): *Ensure the full integration of biodiversity and its multiple values into policies, regulations, planning and development processes, poverty eradication strategies, strategic environmental assessments, environmental impact assessments and, as appropriate, national accounting, within and across all levels of government and across all sectors, in particular those with significant impacts on biodiversity, progressively aligning all relevant public and private activities, fiscal and financial flows with the goals and targets of this framework.*	• Assess existing relevant government policies and update policies to incorporate ecological connectivity in all forms of environmental assessments. • Develop national biodiversity information platforms and capacity to manage it and permit its integration into land use planning at all levels. • Identify and prioritize opportunities to develop, coordinate and implement new government funding at all jurisdictional levels to support ecological connectivity conservation. • Build diverse partnerships to advance connectivity priorities by engaging with key leaders at all levels and all sectors. When feasible, establish a coordination group of policymakers, scientists, practitioners, funders, and other relevant institutions to collaboratively plan and implement connectivity conservation projects.