Ecological networks and spatial planning in Germany

The concept of ecological networks is enshrined in both German planning legislation and nature conservation laws. The objective of this contribution is to highlight the interfaces of ecological networks and spatial planning in Germany with regard to legal stipulations and conceptual approaches. The paper is illustrated with case studies from Bavaria, the most important German state in the Alpine region.

Ecological network planning in Germany: From "interlinked biotopes" to "green infrastructure"

The notion of ecological networks[1] has acquired a key position in Germany's conservation policies and spatial planning documents. The idea of connecting individual areas and viewing them – together with the surrounding landscape matrix – from a systemic perspective has been discussed by German conservationists and ecologists since the 1980s. They were inspired by international research on the biogeography of islands and the importance of landscape structures for the survival of populations. In 1990 Eckhard Jedicke published a volume (in German) on the theory of ecological networks and different ways of planning these. Still regarded as something of a classic, this book caught the public's attention and triggered a flood of further publications, ultimately resulting in legislation and a vast number of concepts, plans and projects.

There are a number of translations of the term "ecological networks" in German, the most widely used of which is "Biotopverbund" (strictly: "interlinked biotopes"). Other expressions include "Wiedervernetzung von Ökosystemen" ("reconnection" or "defragmentation of ecosystems") and "Grüne Infrastruktur" ("green infrastructure"). These are sometimes used interchangeably with "ecological networks", in other cases as complementary or even umbrella terms. The adoption of the EU Habitats Directive in 1992, which includes provisions for a "coherent European ecological network" of protected areas under the title Natura 2000, led to some confusion about the precise meaning of "coherent" in regard to networks: Is it connectedness in the sense of spatial contiguity, or connectivity as a functional but not necessarily spatial characteristic? Although the Habitats Directive only refers to functional traits, the tension between connectivity and connectedness remains an issue of debate in regard to ecological networks in Germany, especially in the context of spatial planning.

The objective of this contribution is to highlight the interfaces of ecological networks and spatial planning in Germany in terms of legal stipulations, conceptual approaches and practical examples. We mainly concentrate on federal regulations and policies. Where possible, examples are taken from the subnational level, specifically from Bavaria, as Germany's share of the alpine arc is almost entirely covered by this state. We begin by introducing legal requirements for ecological networks and related technical criteria, concepts and strategies.

1. In accordance with the international terminology in conservation biology and landscape ecology, we mostly employ the plural form "ecological networks". Only when referring to a specific ecological network or when quoting from a legal source, we use the singular form "ecological network".

❶ Many decommissioned military training areas such as the Lieberoser Heide south of Berlin represent important core areas within the proposed national ecological network of dry habitats.

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Then we turn to spatial planning, describing how ecological networks are dealt with in statutory spatial planning. A further section looks at how ecological networks are considered in informal, non-statutory programmes and plans. We conclude with a discussion of the current situation and future perspectives.

Requirements for ecological networks in Germany's nature conservation laws

Sections 20 and 21 of the Federal Nature Conservation Act of 29 July 2009 (Bundesnaturschutzgesetz – BNatSchG) form the legal basis for ecological networks. In addition, provisions on ecological networks are also part of the nature conservation acts of the 16 German states (Länder), reflecting the concurrent legislative competence in the field of nature conservation provided in the German constitution (art. 74 para. 1 no. 29 Grundgesetz).

Section 20 para. 1 of BNatSchG states the general principle that a network of linked biotopes (Biotopverbund) is to be created, covering at least ten percent of the area of each state. The classification as a general principle implies that the states are not allowed to make deviating regulations from this aim in their own nature conservation laws (cf. art. 72 para. 3 sent. 1 no. 2 Grundgesetz). The obligation to create ecological networks is conferred upon the states, who are generally in charge of implementing the regulations of the BNatSchG (see art. 83 Grundgesetz). An exception is made for marine areas within the exclusive economic zone and on the continental shelf, where the competence lies with the federation. The aim of securing a minimum of ten percent of the area of each state is binding as a general rule. Exceptions are made for the three city states Berlin, Hamburg and Bremen, which normally possess less suitable areas than the other 13 states.

In accordance with section 21 para. 1 BNatSchG, Germany's ecological network is supposed to serve the enduring conservation of populations of wild fauna and flora, including their habitats, biotopes and communities as well as the preservation, restoration and development of functioning ecological interrelations. It also has the purpose of improving the coherence of the Natura 2000 network. The specific wording in BNatSchG reveals some disparities between Germany's ecological network and the European network Natura 2000. In particular, there is a significant difference regarding the included species and biotopes. Nonetheless, many Natura 2000 sites function as core areas of Germany's national ecological network.

For reasons of efficiency, the ecological network must transcend the inner-German borders between different states. In this respect, sect. 21 para. 2 BNatSchG obliges the states to coordinate with one another. Alongside the sharing of information, this implies the requirement to consult the authorities of neighbouring states when selecting and securing areas located near borders.

The ecological network consists of core areas, linking areas and linking elements (sect. 21 para 3 BNatSchG). The explanatory memorandum to BNatSchG defines core areas as areas which are, due to the presence of animate and inanimate elements, qualitatively and quantitatively suitable to guarantee the sustainable protection of location-typical species, habitats and biotic communities. Linking areas are primarily designed to ensure natural interactions between different populations of flora and fauna, territorial expansion according to their

needs, gene swapping between the populations as well as resettlements or migration processes. While linking elements are supposed to act in a similar way to linking areas, they are much smaller, representing the smallest point-shaped elements such as groves, lynchets, tarns or suchlike (Bundestag printed paper 14/6378, 38).

The legal obligation to establish an ecological network has existed since 2002, yet there is no implementation deadline. Despite intensive efforts in some states, there is still a long way to go before a nationally coherent ecological network is realised. In 2017, one legislative initiative to ensure completion of the network by 2027 failed. Art. 19 of Bavaria's nature conservation act is more ambitious in this regard, setting the year 2023 as a deadline for achieving the ten percent objective. Moreover, by 2027 the Bavarian authorities intend their ecological network to cover 13 percent (and by 2030 at least 15 percent) of the state.

Technical criteria, concepts and strategies for ecological networks

The goal of establishing ecological networks is not only a legal requirement, but also figures prominently in Germany's National Strategy on Biological Diversity (2007). According to this document, designating "protected areas of a sufficiently large size and linking them into functionally coherent systems of interlinked biotopes is of central importance for the conservation of biological diversity". Between 1990 and 2010 the development of such a nationally-coherent system was severely hampered by the lack of nationwide criteria and priorities, leading to a variety of conceptual and spatial approaches in the various states. The federal government and its subordinated Federal Agency for Nature Conservation (BfN) determined to resolve this problem by commissioning a number of research projects to develop guidelines and identify nationally-significant areas for ecological networks.

Initially, the BfN and its research partners defined criteria to ensure the consistent assessment of potential areas for ecological networks. These recommendations, which were published in 2004, focused on:

- Evaluating the stock of natural and semi-natural areas,
- Specifying the need for additional areas, and ultimately,
- Selecting a set of additional areas.

The criteria took account of factors such as location, internal fragmentation, existing ecological features and development potentials.

Subsequently, the BfN devised a comprehensive, spatially-discrete concept for a national ecological network, based on the previously defined criteria (see Fig. ❶).

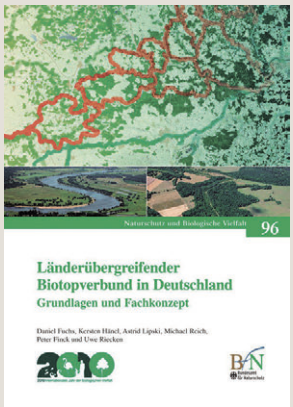
Although data was only available for parts of the territory, the concept includes three maps for ecological networks of:

- Forests,
- Wetlands and dry habitats (see Photo ❶), as well as
- Watercourses.

This concept also encompassed a fourth map on international linkages. In the case of the Bavarian Alps, these are oriented on major watercourses such as the river Inn (see Photo ❷), on forest habitats and on the needs of large migrating mammals.

In 2012 the government also launched a so-called Federal Defragmentation Programme to address the barrier effects of federal trunk roads (see Fig. ❷). Based on a scientific study from 2010 entitled "Nationwide Priorities for Re-Linking Ecosystems: Overcoming Road-Related Barriers", the programme aims to avoid "fragmentation in new road construction and road expansion projects", inter alia by means of integrated spatial planning. Moreover, it proposes defragmentation measures such as amphibian protection systems and green bridges. The programme includes a list of road sections prioritised as highly defragmented, 9 from 93are located in Bavaria. While some measures have already been implemented, a report on the programme's success has been pending since 2017.

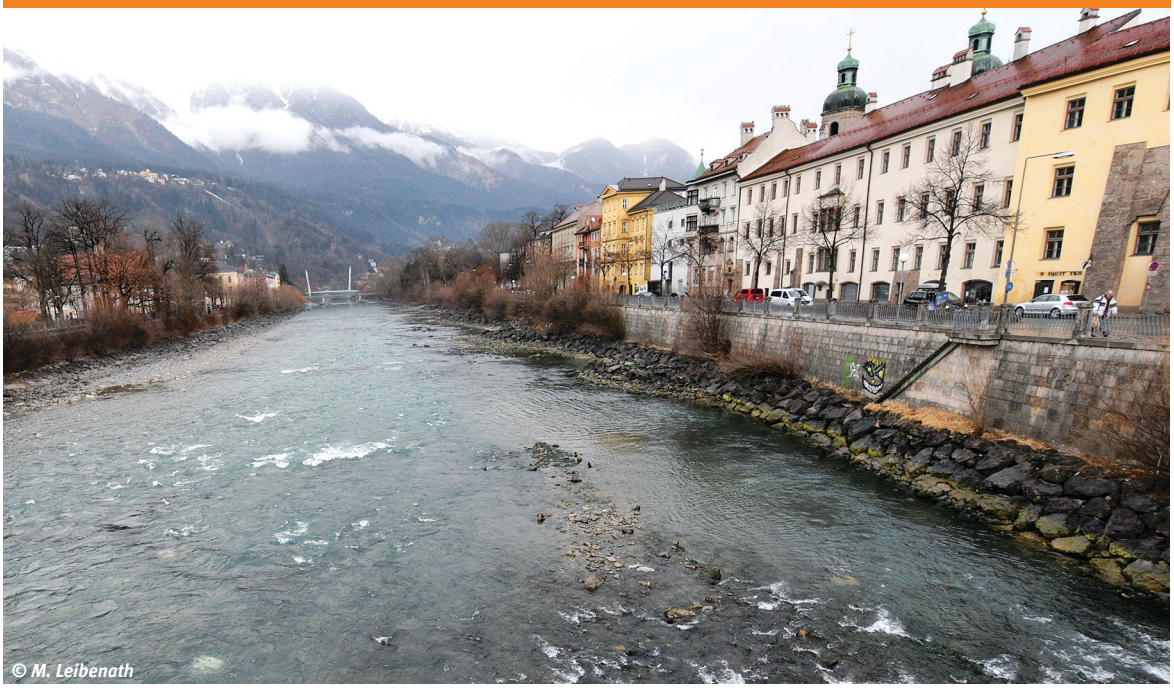
❶ **Cover of the study "A National ecological network in Germany: principles and spatial concept", published in 2010 ***



❷ **Cover of the "Federal Defragmentation Programme" ****

* https://bfn.buchweltshop.de/nabiv-heft-96-landerubergreifender-biotopverbund-in-deutschland-grundlagen-und-fachkonzept.html
** www.bmvi.de/SharedDocs/DE/Anlage/StB/bundesprogramm-wiedervernetzung.pdf?__blob=publicationFile

❷ The river Inn, which runs through the centre of Innsbruck, is regarded as a major international ecological network linkage between Bavaria and Austria.



The BfN finally published a "Federal Green Infrastructure Concept" in 2017. Tying in with the respective EU strategy, the concept aims to ensure that greater consideration be given to conservation issues in the federal government's programmes and plans, mainly by identifying areas of national or international importance. These not only include large protected areas, natural heritage sites and elements of the abovementioned national ecological network, but also undissected functional areas, floodplains and coastal areas.

While Bavaria has developed a "Concept for the Preservation and Restoration of Important Wildlife Corridors along Trunk Roads" (2008), it still lacks a dedicated programme for a spatially-explicit ecological network. This contrasts with some of its neighbouring states, which follow a number of different approaches. For example, Hessen, Saxony and Baden-Wuerttemberg boast relatively recent programmes to develop state-wide ecological networks, including maps for different habitat types and to assist migrating animals. On the other hand, the ecological network concepts of other states are either relatively outdated (e.g. Rhineland-Palatinate), in preparation (e.g. Lower Saxony) or publicly inaccessible (e.g. Saxony-Anhalt).

Integrating ecological networks into statutory spatial planning

The establishment of ecological networks is not merely a question protecting of certain areas but also involves tasks of planning. For example, it can be necessary to close remaining network gaps or resolve spatial conflicts. In this regard, authorities must make use of the instruments of landscape and spatial planning.

Landscape planning

Landscape planning is regulated by sect. 8 ff. BNatSchG as well as by the nature conservation laws of the individual states. It plays a central role in establishing ecological networks. In accordance with sect. 9 para. 3 BNatSchG, landscape plans must contain information about the requirements and measures of nature conservation and landscape management as well as to help designate and protect elements of ecological networks.

Landscape planning comprises four planning levels. At the supra-local level, BNatSchG requires the drawing up of landscape programmes for states (Landschaftsprogramme) as well as landscape master plans for parts of states (Landschaftsrahmenpläne). At the local level, the law distinguishes between landscape plans for the entire area of municipalities (Landschaftspläne) and open space structure plans for parts of the municipal area (Grünordnungspläne), which are frequently optional. Landscape planning documents are solely binding for nature conservation authorities. The designation of an ecological network corridor, for example, only has to be considered by other policy sectors if integrated in the respective spatial planning document.

Basically, ecological networks can be conceived at all planning levels. The supra-local level is of special interest due to the desired national dimension of the ecological network. In practice, the states adopt different approaches and methods in creating their ecological networks: While some states such as Brandenburg, Lower Saxony and Schleswig-Holstein devise ecological networks directly within the broader framework of landscape planning, other states such as Baden-Wuerttemberg, Hessen and North Rhine-Westphalia initially treat ecological networks as a stand-alone issue, only later integrating them into landscape planning documents.

Spatial planning

Spatial planning is subdivided into supra-local spatial planning (Raumordnung) and local land-use planning (Bauleitplanung) (see Table ❶). Due to the statutory nature of its designations, spatial planning is essential to ensure the long-term maintenance of ecological network elements (cf. sect. 21 para 4 BNatSchG).

Supra-local spatial planning is regulated by the Federal Spatial Planning Act of 22 December 2008 (Raumordnungsgesetz, ROG). This is supplemented by the spatial planning acts of the states, which distinguish between two types of cross-sectoral spatial plans: the state-wide spatial development plans and subordinated spatial plans at regional level. At the local level, urban land-use plans have to be established. These are regulated in the Federal Building Code (Baugesetzbuch – BauGB). Urban land-use plans comprise the preparatory land-use plan for the territory of a municipality (Flächennutzungsplan) and the legally-binding land-use plan for parts of the municipal area (Bebauungsplan).

Regarding the obligation to create an ecological network as per sect. 20, 21 BNatSchG, the focus is once again on the supra-local level. Sect. 2 ROG explicitly stipulates "to allow for the requirements of ecological networks" along with other planning principles such as the protection of open spaces, the establishment of a large-scale open space network and the avoidance of landscape fragmentation. Spatial plans must integrate the contents and measures of landscape planning. In this context, the planning authorities also have to consider the requirements of ecological networks in the process of balancing public and private interests.

The ROG specifies various regulations enabling the implementation of ecological networks in spatial planning. The general legal principles of sect. 2 ROG are implemented in the spatial plans by means of planning targets or by (substantiated and regionalised) planning principles, expressed in textual form and in maps with clearly identifiable references to specific territories and material concerns. While the targets are binding stipulations governing the development, spatial structure and the securing of land, planning principles are more flexible.

Ecological networks can be designated as a form of open-space structure and thus a counterpart to settlement structure and infrastructure. Special forms of open space structure are regional green belts (regionale Grünzüge) and small-scale green dividing strips (Grünzäsuren). Networks can be expanded by incorporating areas designated for mitigation and replacement measures to compensate impacts on nature and landscape elsewhere; further, they are improved when mitigation activities are aligned with the aim of interconnecting habitats.

Further important categories for the creation of ecological networks are so-called priority areas and reserved-function areas for nature and landscape. Priority areas (Vorranggebiete) are areas in which priority is given to specific functions or uses, and where other uses with spatial impacts incompatible with the designated priority functions, uses or objectives are excluded. In practice, this category is used to secure core areas of the ecological network beyond already existing strictly protected nature reserves such as national parks and Natura 2000 sites (see Fig. ❸). In contrast to priority areas, the binding force of reserved function areas (Vorbehaltsgebiete) is weaker. For instance, this category may be applied to ecological networks that have been designated by sectoral plans or concepts, but which have not yet been coordinated with spatial planning.

Strengthening ecological networks through non-statutory plans and projects

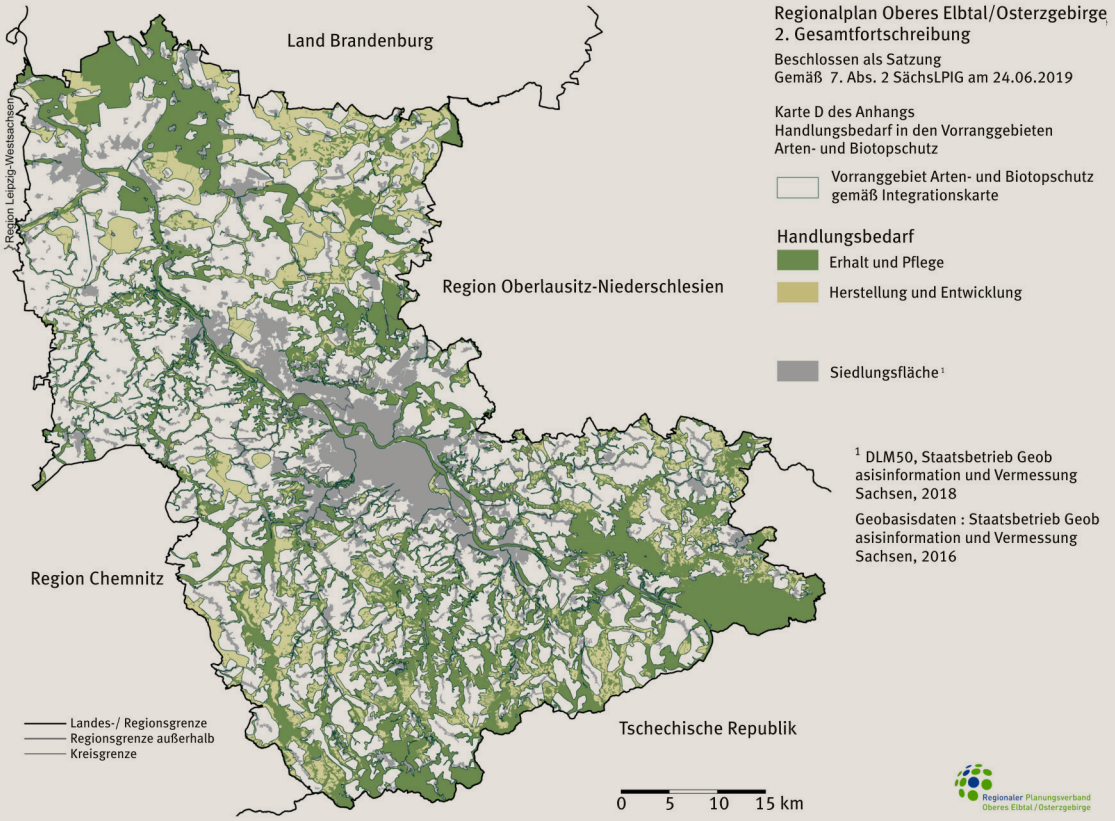
One can hardly avoid noticing the plethora of informal projects and measures related to ecological networks that has evolved in Germany over the past two to three decades. There exist not only large and well-known flagship projects – or better: strategies – such as the European Green Belt along the former Iron Curtain, but also a large number of smaller projects at local and regional level. Alongside governments and other public authorities, many of these are coordinated by environmental non-governmental organisations (ENGOs). The heterogeneity of funding sources, whether private foundations, state-sponsored schemes or EU programmes such as LIFE and INTERREG, deepens the impression of a kaleidoscope of measures to foster ecological networks.

Germany is involved in a number of transnational initiatives to establish ecological networks in the Alps. Probably the most prominent of these is the already mentioned European Green Belt, which stretches from the Baltic Sea through Germany, Austria and Slovenia over the Balkans to Greece. This is an instance of multi-level,

❶ System of spatial planning in Germany.

Planning level	Political / adminis-trative level	Type of comprehensive spatial plan	Accompanying landscape planning document	Scale
Supra-local spatial planning	State (Land)	State development plan Sect. 13 ROG	Landscape programme Sect. 10 BNatSchG	1 : 500,000 - 1 : 200,000
	Region (part of a state)	Spatial plan at regional level Sect. 13 ROG	Landscape master plan Sect. 10 BNatSchG	1 : 100,000 - 1 : 25,000
Local land-use planning	Territory of a municipality	Preparatory land-use plan Sect. 5 BauGB	Landscape plan Sect. 11 BNatSchG	1 : 25,000 - 1 : 10,000
	Parts of municipal areas	Legally-binding land- use plan Sect. 10 BauGB	Green structures plan Sect. 11 BNatSchG	1 : 2,500 - 1 : 1,000

❸ Thematic map from the 2019 spatial plan for the region Upper Elbe Valley/East Ore Mountains (Saxony), in which ecological networks are designated as "priority areas [Vorranggebiete] for the protection of species and biotopes" ("Handlungsbedarf" = "need for action", "Erhalt und Pflege" = "preservation and maintenance", "Herstellung und Entwicklung" = "creation and development", "Siedlungsfläche" = "built-up area")
(source: https://rpv-elbtalosterz.de/regionalplanung/fortschreibung-regionalplan, accessed on 20 February 2020. Reproduced with friendly permission by the Regional Planning Association Upper Elbe Valley/ East Ore Mountains. Copyright « Datenlizenz Deutschland-RPV OEOE-Version 2.0 »).



multi-issue and multi-actor governance, because it integrates pan-European, national and local approaches, addresses ecological, economic and cultural objectives and relies on various forms of cooperation between governments, ENGOs, businesses and other actors. In Germany, the Green Belt initiative is underpinned by a large number of conceptual and practical projects, predominantly funded by the federal government, private foundations and the EU INTERREG programme. Another case in point is the Alpine Convention, with its many and partly overlapping activities such as the platform "Ecological Network" as well as the Ecological Continuum Initiative. These organisational structures form the basis of many transboundary cooperation projects such as Living Space Network (2003-2005), ECONNECT (2008-2011) and, more recently, ALPBIONET2030 (2016-2019), all financed by INTERREG.

Bavaria is renowned for its ecological network programme Bavarian Nature Net (BayernNetzNatur). Since the 1980s, more than 400 projects have been implemented to help establish a state-wide ecological network, although the underlying mechanism is intricate: Each project must reflect the objectives laid down in the Bavarian Programme for the Protection of Species and Biotopes (Arten- und Biotopschutzprogramm), which operates at the level of districts (Landkreise) and includes maps and assessments of important habitats as well as site-specific conservation goals. Most of the projects have been co-financed by the Funds for Nature Conservation (Bayerischer Naturschutzfonds), a state-wide governmental funding scheme. The projects are voluntary and rely on cooperation between landowners, local authorities and – in most cases – other partners, especially from civil society. To gain consideration and funding within Bavarian Nature Net, a project must have an area of at least one square kilometre, refer to an urgent need for action, be coordinated by an appropriate organisation and address clearly-defined aims which can be evaluated. This approach is based on functional rather than spatial coherence: when the results of Bavarian Nature Net are displayed on a map, the observer sees a large number of dots scattered all over the state.

Achievements and challenges

Germany's ecological networks can certainly be regarded as a success story in nature conservation. They owe their existence to a persuasive narrative, namely a

rather gloomy picture of ecological decline caused by habitat fragmentation and degradation. This was linked to scientific findings on population biology and an optimistic vision of connectivity, integrity and some kind of reconciliation between man and nature. The power of this narrative and the manifold struggles of experts and activists at different levels resulted in new legislation, thanks to which the establishment of ecological networks is not only a requirement of nature conservation, but also a mandatory consideration in statutory spatial plans.

Spatial planning can reduce land-use conflicts and facilitate the realisation of ecological networks. It can also help to secure a network over the long term. At the same time, spatial planning is unable to directly induce intended land-use changes by, for instance, converting an intensively farmed field into a high-nature value grassland. That is why implementation programmes such as the Bavarian Nature Net and respective funding schemes are so helpful.

Indicative concepts and strategies are required at national level to achieve coherence in ecological network planning, especially in a federal state such as Germany. This is another domain in which great progress has recently been made: Today any local or regional authority can easily obtain information on whether a specific area is potentially relevant for national or international ecological networks. However, more work needs to be done, as not all states have yet drawn up fine-grained ecological network concepts for their territories.

The oft-cited model of ecological networks as consisting of core areas, corridors, stepping stones and buffer zones is today primarily applied to the development of networks for aquatic species and large mammals. Otherwise, this heuristic (although still used for communication with lay persons) has been largely abandoned in favour of functional criteria as only a few species need large-scale corridors, and a corridor for one species may prove to be a barrier for others. Moreover, conservationists in Germany have always been concerned about the potential risk of neglecting the landscape matrix and ignoring "nature conservation on the entire territory" by concentrating too heavily on a relatively small number of network elements.

In the face of ongoing agricultural intensification, the expansion in built-up areas, climate change and other problematic trends, conservationists are continually challenged to look beyond protected areas and to gain greater influence on other policy sectors such as energy, transport, housing and agriculture. This highlights the fact that ecological networks are not a general panacea but need to be complemented by other approaches, including more holistic visions of landscapes. ■

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