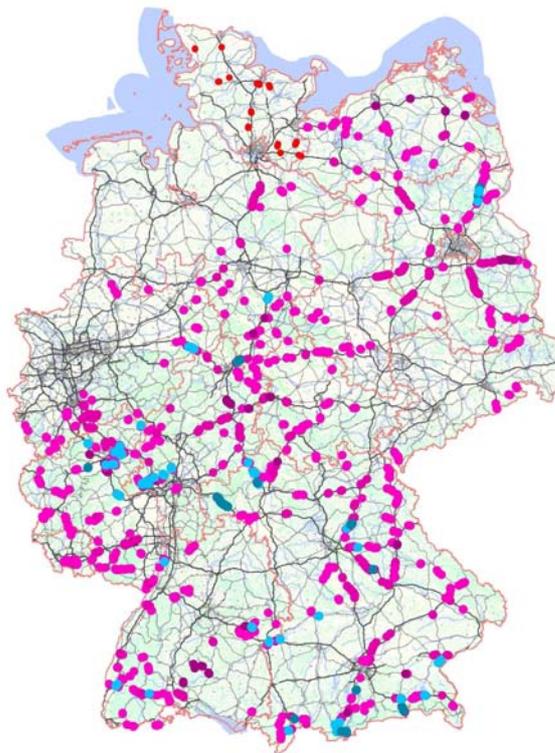


Nationwide Priorities for Re-Linking Ecosystems: Overcoming Road-Related Barriers



Summary

H. Reck, K. Hänel, A. Huckauf, March 2010



*„Until 2020 transportation infrastructure will
no longer significantly impair the habitat connectivity system.“*
Concrete vision B 2.8 of the National Strategy for Biological Diversity

Project Realisation:



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ECOLOGY CENTRE
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für ökologische
Raumentwicklung

Suggested citation

Complete report: Hänel, K. & Reck, H: Nationwide Priorities for Ecosystem Connectivity (Bundesweite Prioritäten zur Wiedervernetzung von Ökosystemen) – Final report of the R & D project (Abschlußbericht zum F+E-Vorhaben) FKZ 3507 82 090, 325 p. – with contributions by Huckauf, A. & Reck, H.: Connectivity Concepts in the Neighbouring Countries (Wiedervernetzungs-konzepte in den Nachbarstaaten), 32 p., Herrmann, M. & Klar, N.: (1) Preliminary Investigation of the Permeability of the Road Network (Vorer-mittlung der Durchlässigkeit des Verkehrsnetzes), 26 p. and (2) Exemplary On-site Assessment of Priority Sections (Beispielhafte Vor-Ort-Prüfung prioritärer Abschnitte), 19 p. – as well as supplementary reports by Schumacher, J. & Schumacher, A.: Legal Basis for the Interconnection of Habitat Corridors in National and International Law (Grundlagen für die Vernetzung von Lebensraumkorridoren im nationalen und interna-tionalen Recht), 47 p. – and
Walz, U. & Stratmann, L.: Planning Expertise on Overcoming Road-Related Barriers (Planungsexpertise zur Überwindung straßenbedingter Barrieren), 148 p.

Contents

Ecological Reasons, Legal Requirements and Spatial Environmental Planning	4
Objective and Preliminary Work Concerning Spatial Prioritisation for Mitigation	5
Approach and Products	6
What Are Habitat Networks?	7
Overview of Results “Habitat Networks”	10
Priorities for Overcoming Barriers between Dry Biotopes, Wet Biotopes, and “Valuable” Forest Biotopes	11
Priorities for Overcoming Barriers in the ”Network for Larger Mammals“	15
Further Specification of Measure Priorities: Bio-Geographical Representation and Transnational Habitat Corridors	18
Existing Deficits and Updating	20
Further results: Comparative presentation of the concepts of European countries and of the German <i>Länder</i>	22
Appendix 1: Notes on Selective Habitat Mapping in Germany and the GIS-Algorithm “Habitat-Net”	
Appendix 2: Synopsis on Central European Defragmentation Approaches	

Ecological Reasons, Legal Requirements and Spatial Environmental Planning

Ecosystem connectivity makes a decisive contribution to the preservation of biodiversity. To protect indigenous species so effectively that people can experience them in their natural habitats, it is necessary

1. to strengthen threatened populations and to stabilise them by re-establishing the exchange of individuals between isolated populations (population network, maintaining genetic diversity);
2. for migrating species and mobile key species (bioengineers) to be able to change habitats (among other things, a sufficient number of migration corridors must remain); and
3. to re-enable spatial adaptation processes to natural and anthropogenic landscape dynamics – also in order to mitigate or to avoid adverse effects of climate change (maintaining sufficient dispersal movement).

According to these functional requirements, international societal goals have been formulated. Germany has confirmed these goals in its national law: by ratifying international conventions on the conservation of biodiversity and on the protection of migrating species, by implementing European Directives on the protection of threatened species and their habitats, and – above all – by taking the ecosystem approach of the German environmental laws both at national and state level and appropriate assignments for landscape planning, environmental impact management or area protection.

Connectivity projects at national or state or *länder* level serve to fulfil obligations to protect biodiversity, which are binding under international law. Both the legal obligations concerning connectivity and the meaning and the possibilities spatial environmental planning has for its realisation are discussed in two separate expertises, which are part of this project:

1. the “Planning Expertise on Connectivity” (“Planungsexpertise zur Wiedervernetzung“, Walz & Stratmann 2009) and
2. the report on “Legal Basis for the Connectivity of Habitat Corridors in National and International law” (“Grundlagen für die Vernetzung von Lebensraumkorridoren im nationalen und internationalen Recht“, Schumacher & Schumacher 2009).

Objective and Preliminary Work Concerning Spatial Prioritisation for Mitigation

By now, the German traffic network, especially the network of busy roads, has become so dense that lasting conservation of biodiversity is no longer possible without specific crossing aids to overcome the barrier “road“. Crossing aids are, however, often rather expensive, and they are efficient only if they are embedded in remaining habitat networks and combined with an optimal development of the corresponding surroundings. Therefore, the German Federal Agency for Nature Conservation commissioned the Ecology Centre Kiel and the Department of Ecological Site and Vegetation Science of the University of Kassel to identify, in a rule-based manner, priority sites for measures to overcome road-related barriers, which will serve as basis for a connectivity concept for biodiversity in the Federal Republic of Germany.

The result is the first integrative (geographical) information system for habitat networks, which encompasses the complete biological diversity and identifies local points of conflict throughout Germany on the basis of landscape-related habitat topology. The project, on the one hand, corresponds with the biotope connectivity planning of the *länder* and on the other hand with the initiatives of nature conservation associations (in particular WWF, NABU, BUND, and DJV¹; cf. position paper “Wildtierkorridore jetzt!“ (Wildlife Corridors Now!, Berlin, February 2008) as well as information available from the nationwide project “Lebensraumkorridore für Mensch und Natur“ (Habitat corridors for man and nature), “NABU-Bundeswildwegeplan“ (NABU Federal plan for wildlife paths), “BUND-Rettungsnetz Wildkatze“ (BUND Wildcat safety net), and the projects FKZ 805 82 025 and FKZ 804 85 005: “UZVR, UFR + Biologische Vielfalt: Landschafts- und Zerschneidungsanalysen als Grundlage für die räumliche Umweltplanung“ [Undissected Areas (> 100 km²) With Low Traffic Density, Undissected Functional Areas + Biodiversity: Landscape and Fragmentation Analysis as Basis for Spatial Environmental Planning] and “Länderübergreifende Achsen des Biotopverbunds“ (Biotope Connectivity Axes on Federal Level). Along the national border, the most important habitat corridors/habitat networks correspond with connectivity systems of neighbouring countries.

¹ World Wide Fund for Nature, Nature and Biodiversity Conservation Union, Friends of Earth Germany, German Hunters Association

Approach and Products

Against the background of European connectivity concepts and a comprehensive study on the permeability of the German road network (Herrmann & Klar, 2009),

1. potentially functional habitat systems (**habitat networks** for species of dry biotopes, wet biotopes, and „valuable“ forest biotopes) have been identified as well as a separate corridor system for larger mammals;
2. **conflict areas** have been determined (conflicts with traffic routes arise especially in places where busy roads cut through habitat networks; in Germany, habitat networks are intersected in about 30,000 instances by federal roads frequented by more than 1000 vehicles per day); and
3. the urgency of mitigation measures has been assessed. The **prioritisation of connectivity measures** is essentially based on how intense the bisection is (traffic density, presence of crossing opportunities) and how effective the measure would be regarding biodiversity conservation (size of the bisected habitat systems and location with respect to connectivity axes of large-scale or national importance).

The criterion of geographical representativeness and the location of points of conflict e.g. on corridors that are of particular importance for regional planning **have not been taken into consideration** in the prioritisation. This can be done as a subsequent step in the selection process of measures to be funded (see below).

The analyses have been carried out as a foundation for **small-scale planning**. Large-scale planning needs to be adjusted to supplementary data, if available (i. e. to data that is not available (or at least not in standardised form) for the whole country: comprehensive biotope type maps, nationwide, hierarchically structured biotope connectivity plans, wildlife registers etc.). The planning of individual measures (determination of exact position and dimension, shaping of the surroundings, and hinterland connection) usually requires supplementary on-the-spot investigations.

The **habitat networks** and the underlying nationwide data compilation on the occurrence and the location of biotopes worth protecting are available as digital data record² and can, thus, be used for impact assessment of newly planned traffic routes or settlement projects.

² Exception: The Land Hessen did not provide the necessary data in time.

What Are Habitat Networks?

Habitat networks are systems of similar, neighbouring habitats that are particularly worthy of protection and potentially in close functional relation to each other. They represent functioning ecological interrelations.

Thanks to the data of the selective biotope mapping of the *länder*, additional landscape information, and the GIS algorithm „Habitat-Net“, habitat networks could be identified on a large scale for the whole of Germany (Appendix 1 and BfN projects FKZ 805 82 025 and FKZ 804 85 005). The habitat networks have been developed separately for species of dry, wet, and forest biotopes (see Fig. 3ff.), differentiating between different distance classes (narrower and wider functional areas, see below), which also defines particularly suitable development areas.

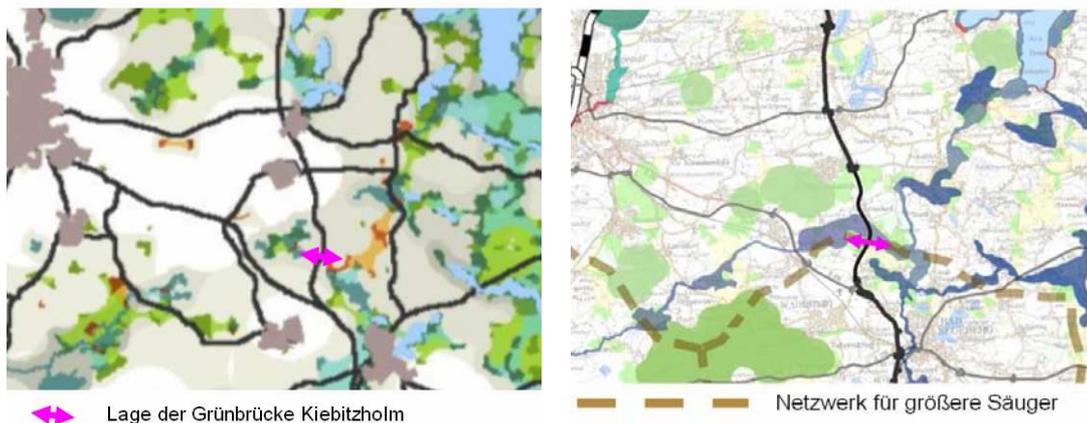


Fig. 1: Habitat networks and integrated network for larger mammals in comparison to the location of the wildlife overpass Kiebitzholm over the A 21

Left: Location of the wildlife crossing Kiebitzholm in comparison to habitats worth protecting, habitat networks (functional areas), standing waters, settlement areas, and existing roads southwest of the Plöner See (cf. Fig. 7).

Right: Location of the wildlife overpass relative to the „network for larger mammals“.

Functional Areas (“Funktionsräume”, FR) are systems of functionally connected habitats that are hierarchically interconnected according to distance classes and land use in between. Depending on the distance class (e. g. 100, 250, 500, 1000, or 1500 m), on the one hand they reflect metapopulation systems for species of different mobility, on the other hand dispersal axes for stenotopic species and buffer zones for sensible biotope

types. Functional areas of the distance class 500 m (FR 500) show spatial connections of habitats which usually are up to 500 m apart (or, in case of adjacent very large habitats, up to 1000 m), with no settlement areas in between.

Undissected Functional Areas (UFAs) („Unzerschnittene Funktionsräume“, UFR) are sub-areas of habitat networks or so-called “ecological networks”, which are bounded by transport infrastructure with a significant barrier effect, but not dissected themselves. UFAs are defined with respect to certain requirement types of species. To be considered are the individual mobility of the requirement type and the impact of the barrier regarding the requirement type (e. G: traffic density of > 1000 motor vehicles / day for small animals, traffic density > 5.000 up to 10.000 motor vehicles / day for large mammals).

In one fundamental aspect, the use of UFAs differs from the methods hitherto used on the landscape scale or the indicators of landscape fragmentation (undissected areas > 100 km² with low traffic density or effective mesh size)³: Not the whole landscape is taken into consideration, but certain priority habitat systems of species groups, which have previously been determined to be “functional units”. In contrast to the above-mentioned approaches, it is, thus, possible to visualise specific ecological connections on an aggregate level in a comprehensible manner and to describe them using concrete spatial relationships.

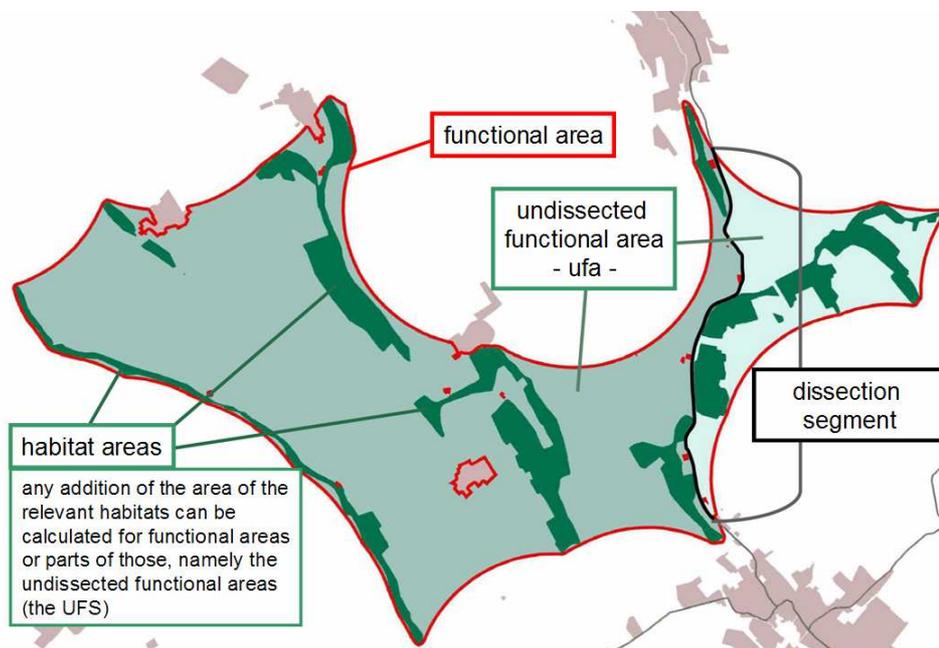


Fig. 2: Terms used in connection with undissected functional areas (from: Hänel 2007)

³ Lassen 1990, Jäger 2002

Habitat Network for Larger Mammals / Federal Mammal Network (“Bundesnetz Säuger”)

Whereas metapopulation systems and dispersal or adaptation processes of stenotopic (and usually small) species to climate change are well represented on a small scale through the habitat networks of biotopes that are particularly worthy of protection, the connectivity of stable habitats for large migrating or threatened mammals (the Federal mammal network) is oriented towards the forest network and follows expertises on different large mammals like lynx, wild cat, red deer, and others. It shows where the dissection of connecting axes has to be avoided.

The **impact of fragmentation** can be assessed practically through the *fragmentation index* (FI). The FI has been developed to quantify the degree of fragmentation of habitat areas (COST OFFICE 2006: 50f.). If a habitat (A), which is considered homogeneous in itself, is dissected into two parts (A_1+A_2), it can be postulated that the fragmentation impact is largest in case of a median cut ($A_1=A_2$). The same holds true for the area sums of valuable biotopes in functional areas. The basic idea when using the FI is that the ability of species to survive generally increases with the size of the population, which depends on the available habitat area. This assumption is given preference over the possibility that in case of a median cut through very large functional areas, viable populations may remain on both sides. In contrast, the impact of fragmentation is considered relatively low if the cut is located close to the edge so that only a small part is cut off. This relation can be expressed by the formula $4 \times A_1 \times A_2 / (A_1 + A_2)$. [The factor 4 has been added so that in the worst case of a median cut the figure of the original size of the undissected area is maintained ($4 \times A_1 \times A_2 / (A_1 + A_2) = A_1 + A_2$); in all other cases, the figure of the index is smaller than the area sum of the sections and also depends on their size ratio.]

Overview of Results “Habitat Networks”

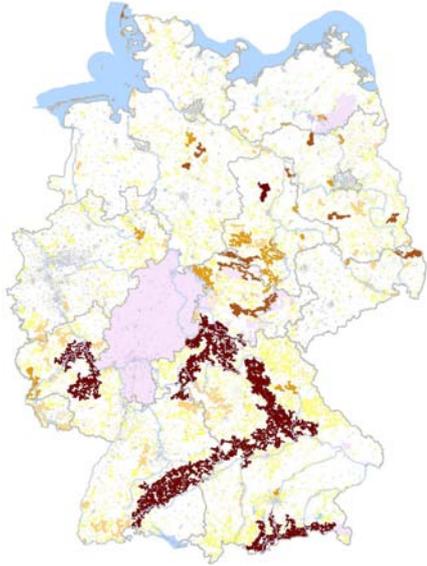


Fig. 3: Habitat network „Dry Biotopes“



Fig. 4: Habitat network „Wet Biotopes“



Fig. 5: Habitat network “Valuable” Forest Biotopes (forest biotopes that are particularly worth protecting, historic ancient woodlands, plots with mainly indigenous tree species)

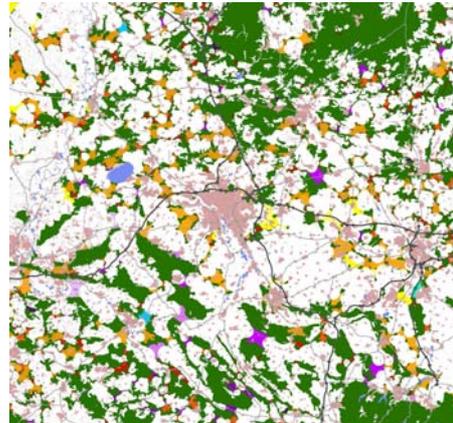


Fig. 6: Details on the forest habitat network (all shrub biotopes and forests) – clipping Hannover/ Lüneburg Heath /Harz; green: forests and the like, red-orange-yellow/violet: different types and classes of functional areas

Figures from reports to the projects FKZ 805 82 025, 804 85 005, FKZ 3507 82 090, 08 85 0400



Fig. 7: Aggregated habitat networks (biotope systems of forest, wet, and dry biotopes); the red frame indicates the clipping used in Fig. 1.



Fig. 8: Network for silvicolous larger mammals ("Federal mammal network"); suitable corridors between large undissected woodlands and connectivity axes to target areas in The Netherlands and Denmark

Priorities for Overcoming Barriers between Dry Biotopes, Wet Biotopes, and "Valuable" Forest Biotopes

At first, points of conflict between habitat networks and roads are presented starting from a traffic density of 1000 motor vehicles per day. At higher traffic densities, small (flightless) animals may already suffer heavy losses. However, different mitigation measures can be taken locally: special culverts e. g. for amphibians or optimisation of invertebrate donor populations.

Roads with a traffic density above 10,000 motor vehicles per day can be crossed by only few species without special crossing aids. Even large mammals suffer heavy losses if they have to cross such roads regularly. Therefore, special connectivity measures have priority, if important habitat systems (larger functional areas with a high share of biotopes that need to be protected) are dissected by roads with a traffic load of more than

10,000 motor vehicles per day and if this causes large parts of the habitat system to be cut off. Depending on the extent to which these criteria are fulfilled, a ranking list of connectivity demand based on nationwide standardised criteria can be prepared in an automatically way⁴.

The **first selection criterion** is, thus, the allocation of fragmentation intensity (here: DTV > 10,000 motor vehicles per day) to a conflict section (= section in which a habitat network is cut).

The **second and third selection criteria** are the area sums of the biotopes in the functional areas in question: in core zones on the one hand and in larger connectivity areas on the other. For this, functional areas are assigned to 5 different classes using a statistical method (“natural breaks“). The importance of a functional area is the higher and the connectivity measure the more promising, the larger the sum of the corresponding biotope areas is. Here, the importance for the large-scale connectivity (FR 500 through FR 1500) is taken into consideration as well as the fragmentation of core areas (FR 100 through FR 250).

E. g. FR 1500: Systems of dry habitats that are functionally connected on a large scale are represented by the so-called functional areas 1500 (FR 1500). They reflect spatial connections between habitats that are usually up to 1500 m apart (or, in case of adjacent very large habitats, up to 3000 m), with no settlement areas in between (details are given in Appendix 1). A functional area is the more important, the more habitat area it comprises. As a rule, this “integrative biotope area sum” correlates with the size of the functional area.

E. g. FR 250: Systems of closely neighbouring dry habitats, which would interact if they were not fragmented, are represented by so-called functional areas 250 (FR 250). These “core areas” reflect habitat complexes in which the individual habitats are usually up to 250 m apart (or, in case of adjacent very large habitats, up to 500 m), with no settlement areas in between. The FR 250, too, have been divided into classes of importance with the help of “natural breaks”. The FR 250 are always a subset of the FR 1500.

A conflict section within the habitat net of dry biotopes is (in case of DTV > 10,000) assigned to priority class 1 (highest priority) if it dissects a coherent area of highest national importance (FR 1500, importance class 5 = class of largest areas or class of high-

⁴ Here, the fact that the average size of habitat systems in the lowlands of north Germany (“Norddeutsches Tiefland”) (or corresponding Länder) is different from that in the low mountains of south-west Germany (“Südwestdeutsche Mittelgebirge”) is not taken into account. The same holds true for the fact that in mountainous areas, roads are relatively more often crossable than in lowland regions because of large valley crossings or tunnel stretches. **If the different natural land units or Länder were to be represented in the same way in the priority determination**, the bio-geographical representativity would have to be considered as well. Additionally, the location on internationally important axes to be developed in the framework of habitat connectivity on federal level may be used as (also additional) criterion of differentiation – or the location on special axes for the development of habitat corridors, which have been determined on Länder level.

est importance) and within this area additionally a “core area” of national importance (FR 250, importance class 4 or 5).

The **forth selection criterion** describes the size of the separated parts of the functional area. If essential parts of an extensive habitat complex (FR 1500) are cut off by the corresponding road, re-linking is considered particularly urgent; if only small remnants are affected, it is considered less urgent⁵. With the help of the fragmentation index it is possible to remove such fragmentation sections from the priority list that concern the cutting off of only small fractions of the area. For priority determination, the fragmentation index, too, has been assigned to different classes with the help of “natural breaks”.

The location of a road relative to the closest biotopes that are particularly valuable and worthy of protection has been regarded as a supplementary distinctive feature. If the road borders more or less directly on relevant habitats, the construction of a crossing aid is likely to be immediately successful. If the road is further away, a crossing aid can only be successful if suitable habitat structures are created to lead the species towards the constriction in the biotope network. At such sections of the road, the construction of crossing aids is useful only if a complementary hinterland connection is created at the same time or can be expected in the foreseeable future (i. e. if the environmental planning for the surroundings has been ratified).

⁵ In individual cases, there might be specific local characteristics / particular protective goods that justify a deviation from the ranking lists set up according to the (above-mentioned) rules when putting the concept into practice.

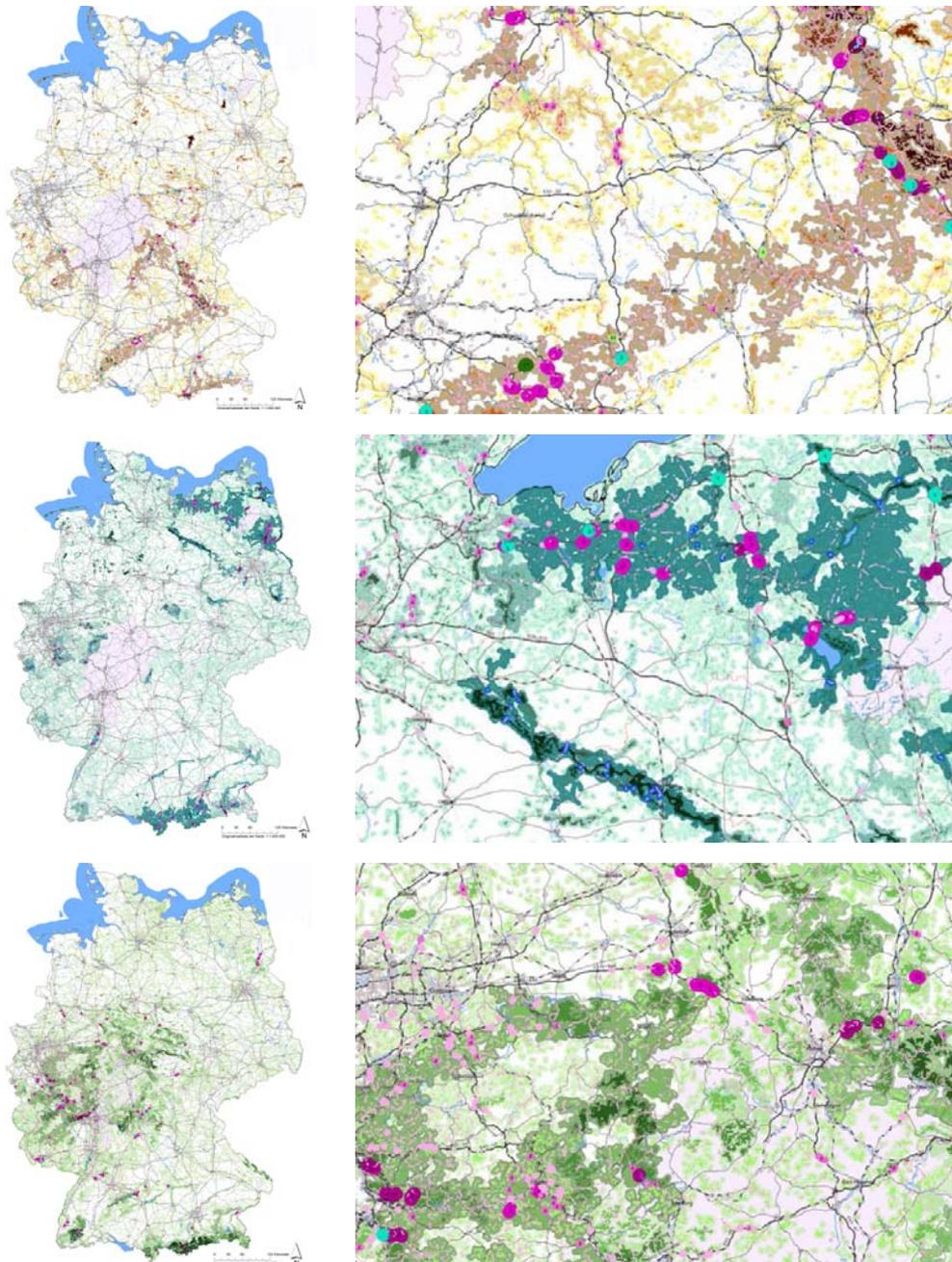


Fig. 9: Map clippings with sections of high connectivity priority; top: dry habitats, centre: wet habitats, bottom: forest biotopes (details are given in separate large-scale maps). Since priorities have been given on the basis of federal standardised criteria, according to which the size of remaining biotopes that are particularly worthy of protection plays an important role, low mountain areas are overrepresented (see also comments on regionalisation).

Priorities for Overcoming Barriers in the "Network for Larger Mammals"⁶

Connectivity measures in the "Federal Mammal Network" have priority, if corridors of national importance located between extensive coherent forest areas or the forest areas themselves are dissected by roads with a traffic load of more than 30,000 motor vehicles per day, provided that target species (here: lynx, wild cat, wolf, moose, red deer, chamois) are currently affected.

Depending on the extent to which these criteria are fulfilled and the size of the corresponding forest areas that are cut off, a ranking list of connectivity demand can be set up⁷.

The **first selection criterion** is the assignment of a conflict section (= section in which the coherent forest areas are cut) to the fragmentation intensity (here: DTV > 30,000 motor vehicles per day to identify the priority area of measures⁸ and DTV > 10,000 to 30,000 motor vehicles to identify further points of conflict that are particularly problematic for mammals).

The **second criterion** registers if, which and how many of the above-mentioned target species occur in the corresponding area and how important the areas are (distinguishing between established populations and re-immigration areas).

As a **third criterion**, the size of the section cut off from the coherent woodland area is used. If a road cuts off essential parts of otherwise coherent forest systems (so-called undissected functional areas ("Unzerschnittene Funktionsräume", UFR), e. g. through a median cut, re-linking is considered most important; if only small remnants are affected, the measures are, in comparison, of secondary importance⁹. With the help of the fragmentation index (FI), a priority list is drawn up. For this, the individual indices (FI) calculated for the local points of conflict have been assigned to different classes using "natural breaks". It should be noted that "extensive coherent forest areas" have been

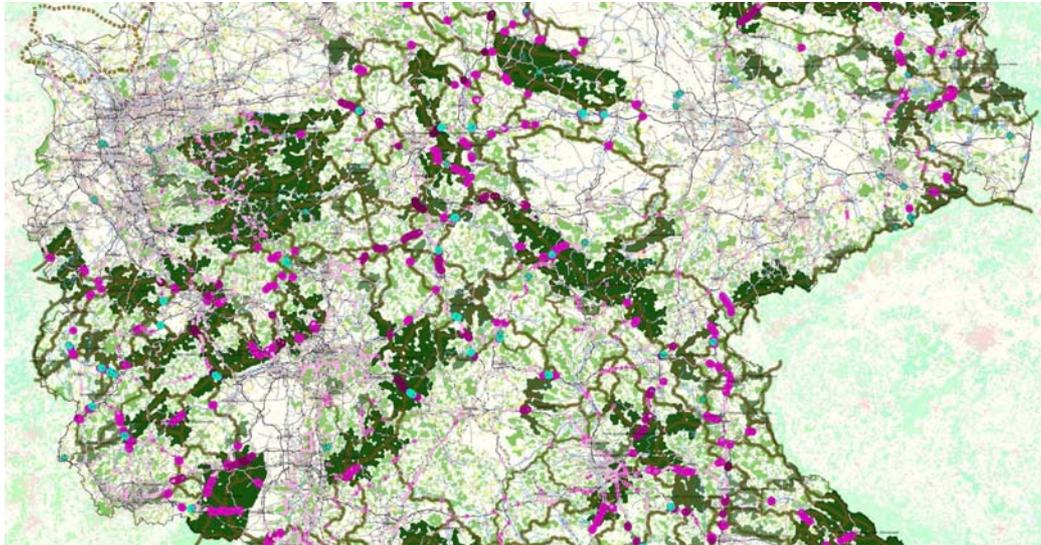
⁶ Large and medium-sized mammals, which can be particularly supported by connectivity of extended forest ecosystems.

⁷ Here, the fact that extended coherent woodland areas and the most threatened target species do not occur (at all or in wide areas) in the lowlands of north-western Germany ("Nordwestdeutsches Tiefland") (or the corresponding Länder) has not been taken into account. Additional (best suitable development) corridors are shown, so that interconnections with the Netherlands and Denmark (which are, from an international point of view, worth aiming for) or connectivity of the red deer habitats in north-west Germany can be considered **complementary** in the priority determination. In this way, priority determination can be specifically extended, augmenting the rule-based selection by individual solutions, which take regional characteristics into account.

⁸ Crossing aids including game warning systems.

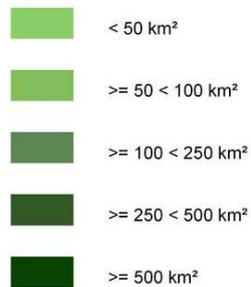
⁹ In individual cases, there might be specific local characteristics / particular protective goods that justify a deviation from the ranking lists set up according to the (above-mentioned) rules.

identified by combining woodlands and suitable semi-open habitats (such as mire complexes, military training areas, and post-mining landscapes) and assigned to 5 different size classes with limits of 50, 100, 250, and 500 km². All areas above 100 km² were considered to be of national importance and should be connected through corridors. The course of these corridors has been iteratively determined against the background of a model-based generated “network of woodlands” (which includes additional suitable habitat types, see above), coordinated with authors of transregional or nationwide connectivity concepts, and improved. Settlement areas and traffic infrastructure that are difficult to cross have been avoided, if possible.



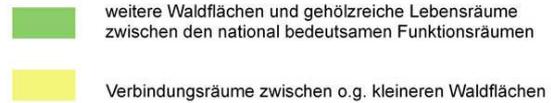
National bedeutsame Funktionsräume

national bedeutsam: Räume $\geq 100 \text{ km}^2$

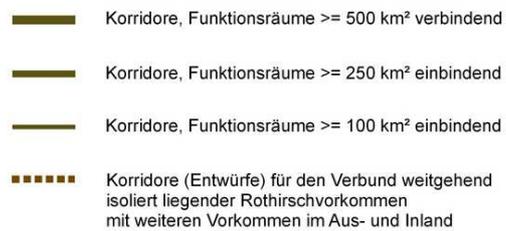


Netzwerk der Wälder

hinterlegt, erarbeitet mit HABITAT-NET (HÄNEL 2007)



National bedeutsame Korridore



Prioritäre Abschnitte zur Wiedervernetzung

in Klassen (Klasse 1 - 4 auch als Beschriftung in Karte), ab Klasse 4 ist eine noch nicht näher geprüfte Vorauswahl dargestellt



Fig. 10: Clipping of the network for larger mammals with sections of connectivity priority and caption examples.

Further Specification of Measure Priorities: Bio-Geographical Representation and Transnational Habitat Corridors

One of the major outcomes of the project is the priority list of measures for overcoming barriers. On a federal scale, it identifies the most important sections for measures to be taken in the existing road net.

Due to scale and information, this list cannot provide a final selection, but only an elaborate **pre-selection** for the implementation; it can also be used as **test criterion** for the implementation of proposed measures derived on the basis of supplementary methods.

Pre-selection means that it should be possible to change the ranking order of measure requirements on the basis of additional criteria, which could not be applied in a rule-based nationwide way in the framework of the “Research & Development Project”, or of new information (see below). Pre-selection is a suitable frame concept under the premise that / provided that even in case of limited implementation the best possible success should be reached and under the premise that the implementation of 100 measures is a significant, albeit not finally sufficient contribution to the conservation of biodiversity. How many large-scale measures in relation to all the points of conflict in the existing network will be sufficient to preserve the biological diversity in the long run depends on the further development of our landscape and e. g. on standards in maintaining traffic routes or the development of the conservation area system: the necessary amount of crossing aids is always a product of the degree of fragmentation, landscape quality, landscape dynamics, and the aspired level of biodiversity conservation.

Test criterion means that measures proposed independently can be well-founded on local knowledge; they should, however, also fulfil the criteria the nationwide selection is based upon: to interconnect habitats of high quality within habitat corridors of supraregional importance.

Steps in the process of measure planning are therefore:

- I. further specification of measure proposals (well-founded alteration of the ranking of proposed measures and addition of particular points of conflict¹⁰, if applicable) and
- II. on-site analysis.

¹⁰ On roads that have been constructed in the meantime, but not been included in the federal database so far, or at priority points of conflict that are not recognisable from the federal data set. [Both cases should be exceptions, because in case of recent road construction measures, the impact assessment and regulation is usually sufficient, and the vast majority of biotopes worth protecting have been recorded in digital form and (with exception of the data of the Land Hessen) made available for the project. However, several positive developments especially in wetlands and extended pasture landscapes resulted in an increase of the surface area of biotopes in need of protection all across Germany and in new areas being added.]

ad I:

The ranking of the required measures was carried out independent of the **geographical representation** and independent of the **länder-specific target planning**.

As a result, priorities are, from a statistical point of view, overrepresented in the low mountains. At the same time, the road network can be more “permeable“ in these regions than in extensive flat landscapes because of tunnels and viaducts.

One possibility to fulfil the criterion of representation is to draw up separate ranking lists for the different bio-geographical regions or *länder* and to assign measures according to the area size, provided the basic conditions („test criterion“, see above) are fulfilled.

Länder-Specific Target Planning / Target Corridors

The target planning of many *länder* points out those habitat corridors (to be developed) that are most important from the *länder* and/or the federal point of view and the most important links to habitat networks of neighbouring countries (Schleswig-Holstein, for example, can serve as gateway for the dispersal of species into and from Scandinavia).

The planning objectives of the *länder* on the one hand and the prioritisation used in the designation of biotope connectivity axes of federal importance on the other can be taken into consideration in the prioritisation of connectivity constructions. One possibility to further develop the prioritisation in a manner that is differentiated accordingly is to initially focus the measures on the axes of federal importance. In doing so, the different requirement types have to be considered, and basic conditions („test criterion“, see above) should again be fulfilled. The Natura 2000 network is already very well represented within the designated priorities. With regard to the connectivity of biocoenoses of certain biotope types, however, the location of priority sections of conflict in or along Natura 2000 areas can add additional weight in the process of binding site selection.

Scope of the Priority Determination

The above-mentioned suggestions on priority determination concern the existing road net. As for the handling of newly planned fragmentations, we refer to the suggested guidelines in Reck et al. (2007) (<http://medienjagd.test.newsroom.de/empfehlungen-fuerquerungshilfen.pdf>).

ad II:

On-site, insurmountable obstacles or existing crossing aids that are not recognisable on a federal scale may make it necessary to discard a measure that has been given priority in the preselection process in favour of another conflict that might appear secondary in comparison, but is still of importance. Applying the principle of proportionality, a cost-benefit analysis has to be made, because measures of similar urgency might differ con-

siderably in costs e. g. for geological reasons. Also, it is cheaper to put measures into practice along road sections that currently are in the process of technical remediation rather than along stretches that have already been completed.

Another important criterion for financial contributions to crossing aids is the possibility to design the surrounding environment. Adequate environmental design and hinterland connection can significantly enhance the positive effects of crossings aids. Crossing aids should preferably be constructed in conflict sections that are either already connected to the hinterland or where such connections can be realised through suitable environmental design.

Firstly, the implementation, thus, requires an on-site inspection (an aptitude test, which takes the guidelines of the corresponding spatial planning and the cost assessment into account) and secondly, in case of a positive result, a feasibility assessment, which also includes the environmental design.

In the framework of the R&D project, 15 rule-based determined priority conflict sections have been examined by M. Herrmann & N. Klar to see if essential aims of connectivity can be reached. The result proved all controlled sections suitable also from the local point of view. However, 2 of the 15 sections checked contained bridges across valleys sufficient in size to allow exchange of individuals between the habitats affected by fragmentation. Further crossing aids would therefore have no priority here at all. In one case, additional barriers in the surroundings call the effectiveness of one singular crossing aid in the priority section into question. At several examined sections, the construction of a crossing aid can only be recommended if a suitable environmental design is possible as well.

Existing Deficits and Updating

Deficits

In the framework of the project, a data set on habitat networks has been established which makes the results of the selective biotope mapping of the *länder* available nationwide (with the exception of the Land Hessen), together with additional large-scale landscape data currently available (CORINE land cover 2000, digital landscape models, information on the occurrences of larger mammals, and maps of traffic volume). Some limitations in the interpretation arise from the fact that

- the digital data on some conservation areas do not identify included valuable biotopes,
- valuable biotopes could only be generally integrated in military training grounds,
- larger biotope complexes belonging to rather different biotope types have in some cases been marked as uniform areas in the selective biotope mapping,

- (especially in structure-rich landscapes) not all relevant biotopes have been mapped and some mappings should be updated urgently.

Connectivity priorities on the permeability of running water bodies have not been determined in the present study. As to terrestrial habitats, mesophile grassland might possibly be under-represented.

Since no supraregional concept based on data on current land use and development planning is perpetually valid without updating, the mentioned deficits can be remedied iteratively.

For the update, new methods for analysing remote sensing data might be included (result: area-wide current data on biotope quality and land use) as well as the permanently improved landscape planning of the *länder* (especially the biotope connectivity planning and high-resolution site suitability/soil maps, if applicable); however, our knowledge about the importance of wildlife mobility keeps growing, and the prognosis of future traffic volume is also changing. Permeability models (models on the impact of barriers and the area affected by crossing aids) should be improved in order to enable a better estimation of the necessary number of crossing aids. Investigations on the necessary number and size of crossing aids within extensive conflict sections are of particular importance, as well as investigations on the relevance of cumulative fragmentation, and the fragmentation effect of high-speed rail links.

The data on the main target group, the populations of fragmentation-sensitive species, is improving, and will then be available for an update.

Updating / Information System “Re-Linking”

On the basis of several research and development projects of the Federal Agency for Nature Conservation and numerous preparatory and accompanying projects in connection with fundamental methodological studies, a GIS-based national information pool on the subject of “Connectivity” has been established.

With the help of the information pool, not only the conflicts between habitat network and traffic network can be addressed, but also several other fields of application. Without going into detail (cf. Hänel 2007: 303ff.), the following most important fields should be mentioned:

- Support of supra-regional biotope connectivity and landscape planning
- Support of environmental planning (securing the function of connecting areas)
- Strategic environmental assessment (e. g. traffic route planning / road planning)
- Broadening of the UZVR¹¹ concept (relation: biodiversity – UFA)

¹¹ UZVR: unzerschnittene verkehrsarme Räume (undissected areas > 100 km² with low traffic density)

- Support of the concept of habitat corridors / connecting axes
- Analyses of connectivity within the NATURA 2000 network
- Establishment of spatial relations to neighbouring countries

Regarding the subject of „connectivity across roads“, the various integrated information can now and in the future serve as basis for a coordinated and systematic national procedure.

The information pool and its potential could be specifically useful to further develop the presented concept into an information system and into an instrument for the implementation of the National Strategy for Biodiversity (Nationale Strategie zur Biologischen Vielfalt, see e. g. “Konkrete Vision B 2.8”) – also with regard to the above-mentioned further potential (see example of The Netherlands below).

From this, an advisory and partly coordinating function could accrue for the theme specific co-operation between the federal institutions involved¹², the *länder*, and other participants (“service function”)

With the help of the information system, it would be possible to take on the task of comprehensive monitoring, i. e. recording and presenting the success of connectivity measures for the „connectivity across roads“. In connection with monitoring, it would be imperative to update the foundation of the system (updates with respect to traffic densities, supplementation of the biotope mapping, distribution of species), because the more outdated the data basis, the lower the quality of the derived statement.

Further results: Comparative presentation of the concepts of European countries and of the German *Länder*

Connectivity concepts exist in nearly all countries neighbouring Germany. They have been described for the purpose of comparison (see Appendix 2). They differ from each other in pursuing national and/or regional approaches. Some concepts propose transnational measures. International approaches are e. g. the “Pan European Ecological Network”, the “Green Belt” project, the “Alpine Network of Protected Areas”, and the “Alpine-Carpathian Corridor”. The “Infra Eco Network Europe” has become established as an information platform.

The individual national concepts or programmes differ from each other with respect to the chosen planning scale, the binding character, and the focus: integrative concepts consider the diversity affected by fragmentation as a whole, whereas some concepts

¹² e. g. the Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, BMU); the Federal Agency for Nature Conservation (Bundesamt für Naturschutz, BfN); the Federal Ministry of Transport, Building, and Urban Development (Bundesministerium für Verkehr, Bau und Stadtentwicklung, BMVBS); and the Federal Highway Research Institute (Bundesanstalt für Straßenwesen, BAST)

follow a sectoral approach, focussing e. g. only on large mammals. Another difference is whether concrete programmes to overcome barriers in the existing transport network are already agreed upon or if there are merely suggestions concerning this topic so far. They all have in common that overcoming barriers or overcoming the fragmentation of habitats is considered to play an important role in biodiversity conservation.

There are federal initiatives for overcoming barriers in Germany as well as *länder* - specific concepts, which are partly based on nationwide habitat connectivity concepts and sometimes on individual analyses. In summary, the following items may be pointed out:

- Nationwide, there is no connectivity concept regarding the supraregional road network with respect to more than one ecosystem type / species group. Only the NABU Federal plan for game paths (NABU Bundeswildwegeplan, HERRMANN et al. 2007), which, however, focuses (only) on larger mammals, identifies points of conflict and priorities for the remediation of the transport network.
- There are different corridor plans, also mostly focussing on larger mammals, to interconnect areas of national and international importance.
- There is an urgent need for ecosystem-based connectivity concepts with respect to the supraregional road network.
- Accordingly, a joint appeal has been launched by the associations NABU, DJV, and BUND in 2008 („Berliner Forderung“, BUND, DJV, NABU 2008).

In four *länder* (Mecklenburg-Western Pomerania, Bavaria, Hesse (as plan of the BUND), and Baden-Württemberg) there have been *länder* -wide concrete concepts with conflict analyses or suggestions for the remediation of the transport network with respect to habitat connectivity until 2009. These concepts are mainly sectoral, concerning large or medium-sized mammals or a single habitat type. In Baden-Württemberg, the analyses were extended to the interconnection of threatened habitat types of the open landscape (on wet, medium, and dry sites).

The habitat connectivity planning of the *länder* usually lacks the element of large-scale corridors with respect to larger mammals (Mecklenburg-Vorpommern or the Rhineland-Palatinate are exceptions). Other *länder* -wide analyses e. g. regarding further requirement or ecosystem types and the influence of linear barriers do not exist.

Acknowledgement

We are grateful to C. C. Casper for improving the English