A practical analysis of ecological continuity on diverse territorial scales
Example of a method employed prior to the French ecological-network project

The Environmental agency in the Franche Comté region discusses here the method tested during early programmes for ecological continuity.

Some French departments and regions started work on ecological networks and ecological continuity before the Grenelle agreements decided to create the French National ecological network. For some of them, the preparation of their Service plans for rural and natural areas (SSCENR [1]) led them to launch a mapping phase for ecological networks as early as 1999.

Following an initial SSCENR map drafted in 1999, the Franche-Comté region continued in 2002 with discussions on the notions of green infrastructure (DIREN *et al.*, 2002), ecological continuity (Vedovati et Vanpeene, 2005), fragmentation (Lethuillier, 2007), mapping of a regional ecological network (Ponchon, 2006; Coulette, 2007; Frochot, 2009) and good practices to maintain ecological continuities (Strub, 2008). This document sums up those discussions which highlighted the methods that must be set up jointly with the local stakeholders to encourage widespread adoption of ecological networks. The goal of the joint discussions is to produce actual efforts in the field to restore and maintain ecological networks. This proposal to define methods and terminology in view of analysing ecological continuities was put forward by the regional environmental agency (DREAL) and validated by the regional scientific council for natural heritage (CSRPN) of the Franche Comté region in January 2008 (Collectif, 2008).

Goal of the discussions between DREAL and local stakeholders

The DREAL approach comprises the following steps:
- mobilise organisations and stakeholders;
- set up a shared framework for discussions;
- run a diagnosis with a report on the current status;
- set priorities and prepare concrete projects for implementation.

This approach includes a proposal for a method designed for use on all scales of work and precision. The idea is to analyse terrestrial ecological continuities [2] via a single set of questions (systematically raised) whatever the project conditions. In responding to each of the questions, the lead times, available means, existing knowledge, desired precision, size of the studied territory, type and progression of the project for which the study is carried out, etc. are all factors taken into account in selecting the best

1. Article 23 of law 99-533 voted 25 June 1999 on territorial planning and sustainable development, modifying law 95-115 voted 4 February 1995 on territorial planning and development.

2. The meaning here is that of a link, in a very general sense, between two environmentally similar environments. The term comprises both corridors and travel routes.


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❶ Each landscape has got its own functions which provide precious evidence to locate ecological corridors.

suited tools and sources (bibliographic analysis, spatial analysis, travel-cost modelling, expert advice, analysis of environmental fragmentation, field inventories, etc.). No particular techniques are recommended, all potential approaches and sources of information must be brought into play. Only one thing is considered certain, that is that the real knowledge is in the field and all hypotheses and assumptions must be confronted as early as possible with a trip to the field and/or expert advice.

The issues of aquatic biological continuities (aquatic travel, continuities along and across rivers) are not analysed here.

Major principles behind this approach

Five major principles guided the discussions in view of proposing this framework for an effective and operational method.

Vary the scales used for analysis and diagnostics

Even in a local project, it is necessary to widen the scope to determine the importance (local, regional, national) of the detected continuities. Conversely, vast projects require very local checks in important sectors (major constraints or the habitat of high-value species) on the functioning of an ecological continuity.

Reason in terms of (eco)-landscape units rather than administrative borders

Each landscape (and landscape unit) functions in its own way and provides precious clues to where continuities are located (tree lines, valley bottoms, etc.).

Start by mapping environments, then address the needs of flag species

In that selection of target species is always difficult, this method proposes systematically addressing the continua, then filling out the diagnostics with information on the needs of flag species if any exist in the studied territory.

Assign ecological continuities to three levels

These continuity levels depend on the available knowledge or the targeted degree of detail. The levels are 1) important sectors (there is a particular issue for ecological continuity), 2) travel routes (it is possible using arrows to indicate where continuity occurs) and 3) corridors (ecological continuity is clearly identified and can be precisely mapped).

Produce topical maps and launch the participative process using the maps

Maps of the inventory and protection perimeters, continua, territorial fragmentation, etc. are all information sources that should be used to better understand how ecological networks function in a given territory. It is on the basis of these maps and the participative process allowing the territorial stakeholders to pull the information together that an overall summary map can be drawn up presenting their shared commitments and projects.

A four-step process

It was possible to devise a four-step process based on the stated principles (see table ❶) and the discussions held. Prior to the recommendations made for the National eco-

❶ A four-step process

Steps	Goals	Detailed goals	Available tools/means
1.Large-scale characterisation of studied zone and of its role (potential or demonstrated) in ecological continuity	Present the studied territory, its characteristics and its ecological role in particular. On this scale, the goal of this first step is to isolate the main, known issues for continuity in the studied zone (environments, species, major obstacles, etc.). The continua and large environmental units listed here must systematically be studied: forests, wetlands, extensive agriculture, thermophilic environments, links between cities and nature, migration and nesting aspects for birds, Chiroptera, etc.	• Positions and use (analysis of each continuum/large environmental group). • Landscape atlas/diagnosis (large landscape units and their relations, overall functioning of landscape). • Territorial fragmentation (main obstacles, both natural and artificial). • Environmental issues (inventory and protection perimeters). • Presence or absence of flag species.	• Analysis of habitat spatial continuity and fragmentation (Corine Land Cover, maps (1:25 000 to 1:100 000) from the National geographic institute, other data sources). • Landscape atlas/diagnosis, organisation of hydrographic network and of topography. • Local bibliography and existing maps (service plans, Pan-European ecological network, regional guidelines for management and conservation of wildlife and habitats, maps of migratory flows, fragmentation, etc.). • Discussions with stakeholders and experts.
2. Summary and justification of methods selected to analyse by continuum on the scale of the studied territory	One or more overall diagrams may be produced at this point. The initial large-scale assessment identified the major issues that will justify the methods selected for more precise analysis on the scale of the studied territory (target species, responsibility levels, etc.).	• Selection of continua (and any associated flag species) for which the studied territory bears significant responsibility. • Selection of sectors requiring more in-depth analysis. • Suitable level of detail and competencies required for diagnostics and detailed maps.	
3 - For each continuum, on the scale of the studied territory: 3.1. ZMapping of core areas and extension zones	Detailed analysis serves to refine any assumptions made, but also to reveal any continuities or local aspects that should be maintained.	• Location of target flag species. • Location of high-value environments in the studied continuum.	• Inventories. • Maps of inventory and protection perimeters. • Bibliography. • Local technicians and experts. • Studied territory.
3.2. PMapping of main obstacles		• Potential obstacles and their permeability. • Potential or certain breaks in ecological continuity.	• Bibliography (mortality data, collisions, existing installations for fauna, traffic volumes, etc.). • Studied territory. • Local technicians and experts.
3.3. Mapping of ecological continuities		• Indicate ecological continuities (existing or potential) and their functions as important sectors, travel routes* or corridors.	• Spatial analysis (with or without modelling). • Bibliography. • Local technicians and experts.
3.4. Technical validation		• Under ideal conditions, this phase serves to technically validate the local diagnosis.	• Local technicians and experts (associations, State agencies, scientists, etc.), studied territory.
4. Summary, discussions, integration of results and action	• Map summing up the issues for ecological continuity. • Translation into operational terms. • Distribution, adoption by stakeholders.	• Identification of priorities for action and work.	• Participative process tailored to the studied territory, using the various analysis results (overall diagrams, maps of each continuum, etc.).

* Mapping technique for ecological continuities when precise mapping of corridors is not possible.
The zone must be large enough for future determination of the corresponding functional corridor(s) and its/their buffer zones.

logical network, this process made it possible to develop acceptance of the conservation issues in ecological networks and to propose projects through a participatory approach.

Proposal for method application to two projects

The two examples below illustrate how the method could be applied to two projects, one large in scale and the other more local. These examples are purely informative in nature and are not intended as detailed solutions to be applied directly (in particular, use is not made of all the potential bibliographical and cartographic data).

Example 1. Large-scale (regional) linear-infrastructure (rail) project

In this case, the project would take place over a significant period of time and have a major impact on ecological continuities. It would thus be possible to adapt the various study steps to the different project phases (see table ❷).

Example 2. Small town, near a major centre, planning (PLU, local urbanisation plan) to extend a residential subdivision and set up a special development zone

The project has the potential to significantly impact ecological continuities (urbanisation). But the diagnostics must be carried out over a short time span and with limited means (see table ❸). The town was recently the site of a development project (the design studies are available). Studies for the ecological network were carried out in the framework of the SCOT (local development plan) currently being set up.

Feedback on the method

In 2008, DREAL launched a work group to set up efforts to solve conflicts concerning infrastructure and fauna. The proposed method was used in part in setting up this work group and a certain number of practical lessons were drawn from the analysis of how the "National ecological network infrastructure" group functioned.

❷ Example 1. Large-scale (regional) linear-infrastructure (rail) project

Steps		
1. Large-scale characterisation of studied zone and of its role (potential or demonstrated) in ecological continuity		**Use of the existing maps and bibliographic data** For a large infrastructure project, the existing data must be consulted very early in the project, even before decisions on the general itinerary zones. This type of analysis may reveal important reasons to maintain connectivity between the mountain ranges (Vosges, Jura, Alps), i.e. issues on the European scale, based notably on a forest continuum, significant wetlands and rivers that structure the landscapes and are host to Natura 2000 sites, and the presence of flag species (lynx, etc.).
2. Summary and justification of methods selected to analyse by continuum on the scale of the studied territory		The project (a large, fenced infrastructure with secondary installations and easements) is likely to have a major impact on connectivity for all continua which must therefore be analysed in detail. Any breaks in continuity in Vosges-Jura links would constitute international issues. Maintaining connectivity in the valleys and wetlands is also a major responsibility of the region. Overall diagrams presenting connectivity issues are a means to detect, along the project route, the particularly sensitive sectors. The overall diagrams may be of great use during the discussions and analysis in view of selecting the general itinerary zones.
3 - For each continuum, on the scale of the studied territory	3.1. Mapping of core areas and extension zones	This step requires an even higher level of detail, notably when the general itinerary zones have been selected. The precision of maps must increase in step with the progress made in the project (preliminary design documents, detailed documents, etc.) and can thus take place in a number of successive studies. Given the vast scale of the analysis, the core areas may be determined using the inventory and protection perimeters and the Corine Land Cover, with further data on the position of the selected target species. Forest environments inside the inventory and protection perimeters (not including ZNIEFFs (high-value ecological zones)) may be considered core areas. Other forests are potential extension zones. For continuity mapping, a travel-cost modelling approach may be a suitable means, on this scale and for this continuum, to make a number of assumptions that will have to be validated (experts, studied territory).
	3.2. Mapping of main obstacles	
	3.3. Mapping of ecological continuities	
	3.4. Technical validation	
4. Summary, discussions, integration of results and action		The translation into operational terms for an infrastructure project consists mainly of determining the installations for animals (passage ways, landscaping work, etc.). These installations may be decided in step with the successive studies for issues of both national and local importance. The discussions for this type of project may consist of determining and validating the planned attenuation and compensation systems with the responsible agencies and experts (scientists, associations, hunting federations, ONCFS (national agency for hunting and wildlife), the CETE technical centres, etc.). A general map presenting the continuities taken into account, the importance of the various issues and the selected attenuation/compensation measures must be available to assist in the discussions. The validated map may be used to inform the general public as well as local stakeholders for inclusion in concerned projects (land development, urbanisation, etc.)

The topic (How to deal with a disagreement?) is more motivating for stakeholders than the theory of ecological networks. The system of workshops with technical assistants to work on a precise agenda was very effective. The best study scale was that of a project combining the local level, strong involvement by all stakeholders and solid knowledge on the functioning of the environment.

The experience gained showed that there is no point in setting up a very large, comprehensive group, it is better to start with a core group of motivated people that will grow on its own as the meetings go by. In the end, the group comprised 26 organisations including some that DREAL was not in the habit of meeting, e.g. infrastructure managers (highways, rail, electricity), State services (environment, agriculture, industry), local governments (region, department), environmental-protection associations, hunting associations, etc.

The diversity of the groups brought together, even though it can result in opening up old wounds, is a key factor for project success and to achieve effective implementation of the decided work programme. It makes it possible to discuss internal data from each organisation and to draw attention to their work, as well as to establish dialogue between groups. However, this project made clear the difficulty of readily sharing unprocessed data and finally opted to share experiences as a more pragmatic means to advance.

The diversity of stakeholders also made it possible to discuss the mixing of biodiversity-preservation issues with many other territorial-development policies and the many threats weighing on biodiversity and ecological continuity (infrastructure, urbanisation, etc.), but also the many possible synergies (landscapes, amenities, flood risks, public safety, etc.).

The establishment of a common language, with the necessary terminology, was a step that took a great deal of time, but was indispensable in creating a project shared by all.

When a scientist acts as mediator, he or she ensures the mixing of cultures and rigor during discussions, and encourages greater confidence between stakeholders.

The regional level (in the regional ecological-continuity plans) in the National ecological network and its local application in development projects (infrastructure, urbanisation, PLUs and development projects) could make good use of this very pragmatic approach in that it has shown its effectiveness in the Franche Comté region. ■

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❸ Example 2. Small town, near a major centre, planning (PLU, local urbanisation plan) to extend a residential subdivision and set up a special development zone

Étapes		
1. Large-scale characterisation of studied zone and of its role (potential or demonstrated) in ecological continuity		Use of the existing maps and bibliographic data. Local studies are also used (various project preliminary studies, studies for the SCOT, etc.).
2. Summary and justification of methods selected to analyse by continuum on the scale of the studied territory		Examination of the existing publications and documents (step 1) will guide decisions in terms of the method selected. **Example.** No high-value species (priority 1, 2 or 3 in the regional guidelines for management and conservation of wildlife and habitats) have been noted on town territory. But the SCOT project mentions a periurban green-zone project that could concern the town. The previous development project highlighted lines of trees that were to be preserved. There is also an isolated piece of wetland near a wetland forest. The overall diagram for this project would centre on the landscape (landscape units) and overlap onto neighbouring towns. It would include the three main assumptions that must be checked, 1) the potential implication of the territory in the green belt set up by the SCOT (an issue exceeding the limits of the town), 2) networking (connectivity) of the tree lines preserved by the previous project studies and 3) possible connection of the wetlands to the nearby forests (more local issue).
3 - For each continuum, on the scale of the studied territory:	3.1. Mapping of core areas and extension zones	The design office for the PLU must include in its study a section on ecological continuities to check on site the assumptions made in step 2. There is no point (no relevance) in this mapping step to undertake modelling or spatial analysis. Visits in the field and discussion with local stakeholders and experts are sufficient. The discussions with local stakeholders revealed the desire of the local hunting association (ACCA) to maintain and even plant new hedges on the property of volunteers. The hunting associations, environmental technicians of local governments and of State services familiar with the sector, environmental-protection associations, etc. should all be consulted to obtain their opinion and validate the project.
	3.2. Mapping of main obstacles	
	3.3. Mapping of ecological continuities	
	3.4. Technical validation	
4. Summary, discussions, integration of results and action		For a PLU, the translation into operational terms can take on a number of different forms. The Rhône-Alpes DIREN funded a study on the PLU for Saint-Martin-d'Uriage that developed a number of interesting ideas on incorporating continuity in PLU zoning and regulations*. Other means may also be used, e.g. creation of protected wooded zones, reinforced protection of hedges, no urbanisation in sensitive zones, support for market-garden farming and periurban agriculture near the green belt, etc. The diagnosis on ecological continuities and the plan of action proposed via the PLU will be transmitted and made available to the concerned groups of towns and local governments.

* For feedback on integration of ecological corridors in PLU zoning and regulations (June 2008), see http://www.rhone-alpes.ecologie.gouv.fr/include/publi/pdf/rapport_stmartin_duriage_juillet2008vdef.pdf

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