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► To cite this version:

Mathieu Perrin, Nathalie Bertrand, Sylvie Vanpeene. Ecological connectivity in spatial planning: from the EU framework to its territorial implementation in the French context. *Environmental Science & Policy*, 2022, 129, pp.118-125. 10.1016/j.envsci.2021.12.011 . hal-04290249

HAL Id: hal-04290249

<https://hal.inrae.fr/hal-04290249v1>

Submitted on 22 Jul 2024

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Title

Ecological connectivity in spatial planning: from the EU framework to its territorial implementation in the French context

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Abstract

Against the background of widespread biodiversity loss, the issue of ecological connectivity has become increasingly important in recent decades at EU level. This growing attention can be observed in particular in biodiversity strategies or certain directives, in the establishment of key programmes or in the mobilisation of various types of funds. However, there is currently no EU framework that explicitly obliges member states to address the issue or to achieve certain objectives in this field. This article first shows how ecological connectivity has gradually emerged as a spatial planning issue, in particular through national/federal and/or regional legislative developments, in different countries (Germany, Italy and France). A focus on the French context and its Green and Blue Network Policy then depicts the implementation challenges observed in spatial planning at the regional, sub-regional and local levels. The paper highlights the difficulty of establishing a standardised framework for ecological connectivity, which implies considering the complexity of wildlife in spatial planning procedures in which potentially divergent interests intersect.

Keywords

Biodiversity policy; Ecological connectivity; Ecological network; Spatial planning; European Union; France; Germany; Italy

1. Introduction

The generalised loss of biodiversity, observed and confirmed by numerous studies (Mace et al., 2005; IPBES, 2019), has become a concern at European level. In 2011, the European Union thus set the need to "*halt the loss of biodiversity and the degradation of ecosystem services*" as the main target in its Biodiversity Strategy to 2020 (European Commission, 2011). This was in line with the commitments of the 1992 Convention on Biological Diversity and the 2010 Nagoya Protocol listing 20 objectives to be pursued over the decade to combat biodiversity loss.

This decline concerns the extinction of species but above all the drastic reduction in the populations of species that were once very common. For example, a 15% decline in the populations of common birds

was observed in France over the period 1989-2019 (CRBPO, 2020) as well as a 39% drop in the European Grassland Butterfly Indicator over the period 1990-2017 (Van Swaay et al., 2019). This loss of biodiversity reflects a relative failure of traditional nature protection policies that are based on lists of species and protected habitats to be preserved (e.g. Birds and Habitats Directives) and protected areas (nature reserves, national park core areas, etc). These provisions are effective in ensuring the protection of large preserved spaces of remarkable nature and the preservation of heritage species. However, they have proved to be limited in preserving ordinary biodiversity, which is subject to pressure from land conversion and intensive agricultural practices leading to the fragmentation and isolation of environments favourable to species.

The inadequacy of traditional nature conservation policies to halt biodiversity loss has led to increasing attention being paid to ecological processes in public policies (Bonnin, 2008). This trend happened in the wake of developments in the scientific field, particularly in population and landscape ecology, knowledge of species and their needs, modelling of ecological networks and identification of key areas for connectivity (Albert et al., 2017).

The idea of preserving networks of sites enabling the completion of species' life cycles (reproduction, rearing of young, feeding, resting and wintering), the dispersal of individuals (particularly that of young adults to reach new territories and contribute to genetic mixing) and adaptation to global changes (including possible modification of the species range) has therefore gradually emerged in Europe. In particular, there was the ambition in 1995, with the Pan-European Biological and Landscape Diversity Strategy, to map the Pan-European Ecological Network in every states by 2006. This deadline was not met, but the preservation of ecological connectivity has become a major challenge. The European Union is relatively active in this field through explicit references to the need for ecological connectivity in its Biodiversity Strategies and implicit references in the 1979 and 2009 Birds Directives and 1992 Habitats Directive. It also promotes the concept of green infrastructure and project funding at macro- and interregional level (e.g. LIFE, ERDF, Interreg programmes).

This ambition has been reinforced in the EU Biodiversity Strategy for 2030 adopted in 2020, in particular by the following statement: “*Member states will then have until the end of 2023 to demonstrate significant progress in legally designating new protected areas and integrating ecological corridors. On this basis, the Commission will assess by 2024 whether the EU is on track to meet its 2030 targets or whether stronger actions, including EU legislation, are needed.*” (European Commission, 2020). However, there is currently no explicitly binding EU framework to preserve ecological functionality. Member states are free to establish the legal framework and pursue the desired policy on ecological connectivity (Sobieraj and Zacharczuk, 2016). Many countries have adopted legislation to this end, issued guidelines, funded research, developed operational programmes and provided support to regional and local authorities.

One of the key fields of action for the implementation of ecological networks is spatial planning. This is consistently considered as strategic since it offers a potential for approaching the issue from a comprehensive (combination of sectoral policies influencing connectivity), multi-scalar perspective (consideration for connectivity at different spatial scales) and in relation to other land-use related issues (conflicts with uses on the same or neighbouring areas). Spatial planning remains a field of public intervention that is poorly integrated at the European level and over which the European authorities have little influence. This can be explained by significant differences in spatial planning cultures between countries and by the fear among member states of concurrent powers over an activity that offers control over space and is therefore generally considered sovereign (Faludi, 2000, 2003, 2010).

The article thus outlines the frameworks and processes established in spatial planning for taking into account ecological connectivity and implementing ecological networks. Part 2 reports - through a comparative analysis of the French, German and Italian contexts - on the diversity of the legal frameworks in force, with varying degrees of involvement by the central/federal states and the

voluntarism of certain regions that has contributed to the increase in importance of the issue. Part 3 details the Green and Blue Network Policy established in the French context and how this concept is supposed to be implemented through the spatial planning system. Part 4 points out different factors that influence the implementation of this Green and Blue Network through subregional and local spatial planning processes, and thus explains the heterogeneity observed between planning areas.

2. The rise of ecological connectivity as a spatial planning issue in the German, Italian and French contexts

Ecological connectivity is not only a matter of spatial planning. However, this field of public action has been adopted as a privileged angle to address the issue in most European countries and regions. Consequently, the way in which ecological connectivity aspects are dealt with depends to some extent on the specific features of each environmental policies, but also on spatial planning cultures and the distribution of competences in this domain, which vary from one country to another (Perrin et al., 2019).

2.1. A more or less decisive involvement of the central/federal states

A first major difference lies in the capacity of the German states and Italian regions to adopt laws and thus participate in defining the framework, in particular in terms of spatial planning or biodiversity protection. This feature can be explained by a relatively old federalist tradition in Germany (since 1919, despite breaks in the process). In Italy, it follows a more recent regionalist turn (from the 1970s and intensified in the 1990s). The dynamics are therefore relatively different between the two contexts.

A vertical (between the federal government and the states) and horizontal (between the states) coordination effort has been observed in the area of law-making and policy-making on the German side, especially since the 2006 reform. The first outline of a federal framework for ecological connectivity emerged in 1992 at a Conference of Ministers for Spatial Planning following the adoption of a resolution calling for the establishment of an ecological network through spatial planning. The concept was supposed to be functionally coherent and to cover about 15% of the total undeveloped area of the country. This resolution was not binding and was followed unevenly by the states (Leibenath, 2011; Hänel, 2015). It was not until 2002 and an amendment to the Federal Nature Conservation Act that the states were obliged to develop a network of interlinked biotopes (*Netz verbundener Biotope*), also known as a biotope network (*Biotopverbund*), covering at least 10% of the country's land area (von Haaren and Reich, 2006). No deadline has been legally set to achieve this objective, despite an unsuccessful attempt in 2017. At the same time the federal government and its Federal Agency for Nature Conservation (BfN) have been funding research projects since the beginning of the 2000s. The aim has been to establish guidelines and identify areas to be included in biotope networks with a view to harmonising the different initiatives and methods developed in the various states.

In Italy, the central government has gradually been relieved of most of its prerogatives in spatial planning (Prenger-Berninghoff, 2016). Although the state remains the guarantor of environmental protection, its intervention sometimes appears limited, especially when considering the activism that the regions can sometimes demonstrate in this field (Rochette, 2010). Thus, there is no legal obligation at the national level to address ecological connectivity issues through spatial planning, as the relevant standards are adopted in regional legislations. However, the State has played a certain role in ensuring that the issue is better taken into account in the country. In 1999, the Nature Conservation Service of the Ministry of the Environment published an Interim Report of the Sectoral Working Group "*National Ecological Network*" offering a definition of the concept of ecological network and identifying a number of useful measures for the emergence of such a structure at the national level

(Ministero dell' Ambiente, 1999). Following this report, a national ecological network was mapped (Boitani et al., 2003). In addition, the Italian National Institute for Environmental Protection and Research (ISPRA) has monitored the inclusion of ecological connectivity issues in regional legislative frameworks and spatial planning processes at regional and local levels (Guccione and Schilleci; 2010).

On the French side, legislative power is concentrated at the national level. The first legal recognition of the concept of ecological networks dates back to the Framework Law for the Planning and Sustainable Development of the Territory of 1999, which introduced regional schemes for collective services. However, what did give rise to a more ambitious and operational legal framework around the concept of the Green and Blue Network (*Trame Verte et Bleue*) was the Grenelle Environment Round Table in 2007. This event paved the way for the adoption of the Programming Act for the Implementation of the Grenelle Environment Agreements (2009), of the National Commitment to Environment Act (2010) and of the National Guidelines for the Preservation and Restoration of Ecological Connectivity (decree n°2014-45 of 20 January 2014). This regulatory framework establishes the Green and Blue Network, made up of core areas (*réservoirs de biodiversité*) connected by ecological corridors (*corridors écologiques*), as a concept aimed at maintaining or restoring the ecological continuum. According to the National Guidelines, the latter has to be ecologically functional, in particular in view of the variety and quality of milieus, of their degree of fragmentation, as well as of the interactions between milieus, between species and between species and milieus. However, considerable leeway has been left to the regions and to the planning bodies at lower levels to establish their methodology for designing this Green and Blue Network (Sordello et al., 2017; Amsallem et al., 2018) - particularly through processes that can bring together a variety of stakeholders from e.g. scientific, technical, management, associative and political circles (Charvolin et al., 2011) - and transposing it from a cartographic and regulatory perspectives into spatial and urban planning documents. In other words, pragmatism has largely prevailed during the implementation process of the concept.

2.2. The legislative and operational contribution of leading regions

In the three considered countries, some regions played a pioneering or even leading role in addressing ecological connectivity. Initiatives have been launched through the adoption of legislative provisions or the launch of ambitious policies at the regional level, sometimes even before the establishment of a legal framework, be it incentive or restrictive, at the national or federal level.

On the German side the services of the State of Rhineland-Palatinate carried out a programme for the large-scale planning of biotope networks in collaboration with the Rhineland-Palatinate Society for Nature Protection and Ornithology from 1987 to 1999 (Rheinland-Pfalz - Landesamt für Umwelt). This work contributed to landscape planning processes at the district level and was groundbreaking as at that time there existed neither the EU Habitats Directive nor a real framework at the German federal level.

In Italy, the first more or less explicit references to connectivity and/or ecological networks were introduced in regional legislation on spatial or urban planning in the late 1990s (Guccione and Schilleci, 2010: 13-20; Todaro, 2010: 124-131). For example, the Region of Liguria established (Regional Urban Planning Law of 04-09-1997, n. 36) that the Territorial Plans for Provincial Coordination must "*identify those parts of the provincial area likely to ensure organicity and unity from the point of view of ecological regeneration, with the aim of protecting and conserving the environment [...]*". The Basilicata Region specified (Regional Law on Land Protection, Governance and Use. 11-08-1999, n.23) that territorial and urban planning should consider, among other things, a naturalist-environmental system, established on the basis of landscape and environmental geomorphological units, corridors of environmental connectivity, as well as areas of fragmentation of morphological-environmental connectivity. Furthermore, the Law of General Regulations on the Land

Protection and Use amended by the Emilia-Romagna Region in 2000 (L.R. 24-03-2000, n.20) stated that the Territorial Plans for Provincial Coordination must "*include guidelines and directives for the realisation [...] of ecological networks as well as areas for regeneration and environmental compensation.*"

On the French side, the Nord-Pas-de-Calais Regional Council launched projects to restore an ecological network (*trame écologique régionale*) as early as 1993, in partnership with the decentralised department of the Ministry of the Environment (Conseil Général du Nord, 1995). Other initiatives followed, notably the development of a regional policy established as part of the 2000-2006 State-Region Planning Contract (*Contrat de Plan Etat-Région*). The policy aimed at recovering brownfields in a former mining district from an environmental perspective and, to this end, laying the foundations for the implementation of a green and blue network. From 2003 onwards, the Alsace-Lorraine region launched a green network policy essentially focused on the connection of natural areas by means of ecological corridors. Initially tested on the Vosges plain and foothills, the programme has then been spatially extended to the whole region with considerations for connections with neighbouring German (Baden-Württemberg, Rhineland-Palatinate) and French (Lorraine) areas. This policy included the funding of projects aimed at protecting the existing green network or developing new corridors and integration of the green network concept into spatial plans.

3. Integration of ecological connectivity in the French spatial planning system

3.1. The beginnings of ecological networks in France

At the national level, the first project of a network of ecological connectivity appears in the Law of 25 June 1999 on Guidelines for the Spatial Planning and Sustainable Development of the Territory (LOADDT) (art. 23) via the so-called Collective Services Scheme for Natural and Rural Areas (SSC-ENR) drawn up under the responsibility of the regional prefects with the support of the decentralised services of the French State and the regional councils by carrying out 20-year foresight study. It "*sets the guidelines for their sustainable development, taking into account all the activities that take place there, their local characteristics as well as their economic, environmental and social function*" with "*a balanced management of these areas*" (LOADDT Law). Its aim was to provide a "*desirable way of managing the territory*" based on the multifunctionality of spaces. This national structure constitutes Annex VII of Decree No. 2002-560 of 18 April 2002. It was developed at regional level as a preparatory step for establishing the State-Region Planning Contracts, which are 5/6-year regional development programmes jointly funded by national, regional authorities and - to a lesser extent - other territorial bodies. Documents such as the Regional Scheme for Spatial Planning and Territorial Development (SRADT), the ancestor of the current Regional Scheme for Spatial Planning, Sustainable Development and Territorial Equality (SRADDET), had to be compatible with these Collective Services Schemes. Some regions have drawn up such SSC-ENR (e.g. Lorraine, Nord-Pas-de-Calais and Burgundy). For example, the Nord-Pas-de-Calais SSC-ENR took advantage of the concept of a biological corridor in answer to ecological, economic and socio-economic issues. The Lorraine SSC-ENR identified key components of the green network, aquatic components and connections between these key components and those to be created or rebuilt.

At the beginning of the 2000s, local authorities identified ecological infrastructures or networks. The Isère department developed its Isère Departmental Ecological Network (REDI) in 2001, making it known and taken into account by the elected municipal representatives. The Alsace region initiated a Green and Blue Network Policy in 2003. Regional natural parks and intermunicipal structures have also mapped green and blue networks at their respective levels.

The need to develop a national Green and Blue Network was stressed during the national meetings on environmental issues (*Grenelle de l'Environnement*) held in 2007. The concept would be implemented in a top-down manner. Thus, the Green and Blue Network would first be outlined through regional planning with the Regional Schemes for Ecological Coherence (SRCE), then specified through strategic spatial planning on a subregional scale with the Schemes for Territorial Coherence (SCoT) and ultimately refined on a supramunicipal/municipal scale through Local Urban Plans (PLU/i) specifying land-uses and the associated regulations. Additionally, development projects must also preserve ecological connectivity (Vanpeene, 2019).

It is worth noting the legislative effort run during this period at the intersection of the planning and ecological fields. The Green and Blue Network established by the two Grenelle laws (see 2.1) is the first object relating to the protection of the environment included in both, the Environmental Code and the Urban Planning Code, of which article L110 included (now in article L101-2 of the Urban Planning Code after recodification) "*the conservation, restoration and creation of ecological connectivity*" as an objective. The French legislation explicitly states that the Green and Blue Network is a spatial planning instrument. This wording probably reflected the intention of ensuring the implementation of a concept that would otherwise remain essentially a matter for ecologists and of making elected officials as well as spatial/urban planners accountable for their decisions in a context of accelerated land consumption. It thus reflected a rising concern for what would be then enshrined in the Act for the Biodiversity, Nature and Landscapes Recovery (2016) as the ecological solidarity principle, that is to say the need of taking into account "the interactions of ecosystems, living beings and natural or built environments" in any public decision having a significant environmental impact.

3.2. Conditions and difficulties of transposition to the different spatial scales

The abundance of pre-existing local initiatives with varied identification methods and mapping configurations explains why the State promulgated a method to be applied by the regions but has only imposed compliance with criteria through the adoption of national guidelines. As a result, the technical choices made by the regions for the identification of the Green and Blue Network, the political compromises and the cartographic representations have given rise to varied SRCE maps.¹

The development of the Green and Blue Network at different planning levels raises questions about the interconnection of spatial scales. Moving from the SRCE (map scale 1/100,000) based on a spatially imprecise land-cover database (Corine Land Cover) to the SCoT (1/50,000 to 1/25,000) and then to the Local Urban Plan (1/10,000) that can draw on detailed land-use data involve implementation challenges. Stakeholders sometimes fail to understand that it is necessary to redefine the Green and Blue Network for each document (and scale) and not just to transpose the concept by zooming in on the document of higher level. Nor is it easy to justify the differences between the networks defined at different scales (for example using finer data, because species with different movement capacities are considered).

Moreover, the principle of subsidiarity does not allow higher-level documents to be spatially precise, as they must leave room for local urban planning. Similarly, the SCoT cannot provide too specific guidance to local planning authorities in terms of preserving the Green and Blue Network and therefore usually confines itself to broad principles. Each document therefore plays both, the role of a safeguard (not to omit a major connectivity issue at the higher level) and of providing information for the preparation of the lower-level plan.

To these difficulties linked to spatial scales, comes also a time lag as the different schemes and plans advance at their own pace and over several years; a lower-level document is sometimes almost finished when the higher-level document has not yet validated its guidelines for the establishment of

¹ For a concise overview: <https://inpn.mnhn.fr/programme/trame-verte-et-bleue/carte-nationale>

the Green and Blue Network. To avoid this discrepancy, some SRCEs (e.g. Rhône-Alpes) have integrated detailed elements present in the Green and Blue Networks of SCoTs or regional nature parks, although the method adopted for the SRCE did not allow for providing this detail everywhere. Other SRCEs have stuck to homogeneous results in terms of precision throughout their planning area and are therefore in contradiction with pre-existing SCoTs from the time of their elaboration.

The implementation of the already complex Green and Blue Network Policy was further disrupted in 2016 by the merger between regions (Law no. 2015-29 of 16 January 2015), which saw the number of regions decrease from 22 to 13, and the integration of the SRCE into a new comprehensive scheme, namely the Regional Scheme for Spatial Planning, Sustainable Development and Territorial Equality (SRADDET) (Law no. 2015-991 of 7 August 2015). This change has given rise to different concerns. Some fear that ecological connectivity, which was until then addressed at the fundamental issue in a sectoral document, may thus receive reduced attention in this new comprehensive scheme. There are also doubts regarding the legal force given to the provisions included in the document. On the one hand, the SRADDET involves a higher degree of legal enforceability if compared to the pre-existing SRCE. The subregional spatial plans have not only to take into account (*prise en compte*) the objectives but must also satisfy (*compatibilité*) the rules established in this new comprehensive regional scheme. On the other hand, the map of the ecological continuum contained in the document is no longer legally binding, thus providing more latitude to spatial planning authorities for designing the Green and Blue Network at the subregional level. An assessment of how the elements of the SRCE were integrated into the SRADDETs has not yet been made. Nevertheless, the announcement of the abolition of the SRCE and the difficulties for state and regional services to reorganise after the merger have not made it any easier to apply the Green and Blue Network concept at local level.

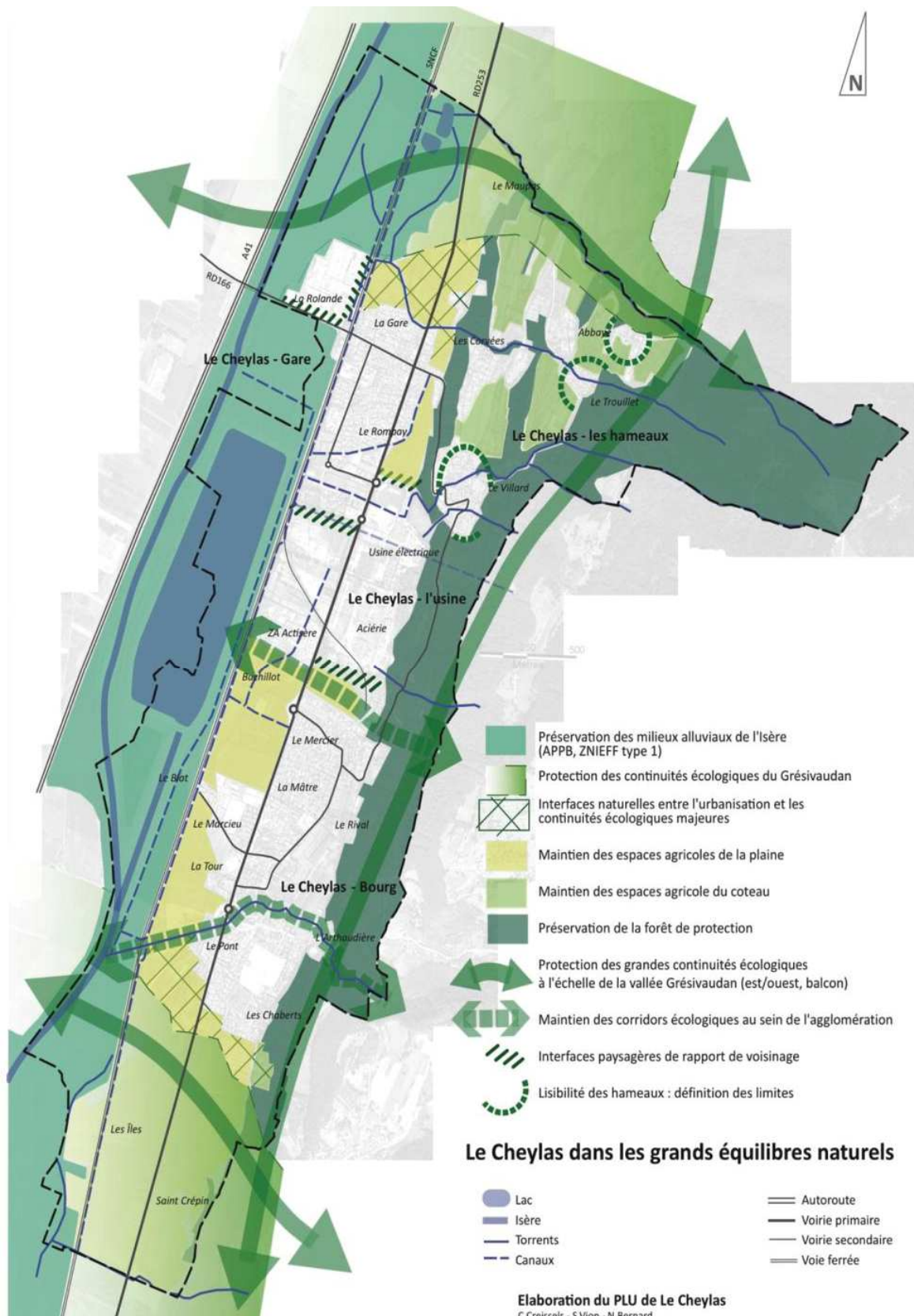
4. The territorial implementation of the Green and Blue Network: a feedback of experiences

The transposition of the Green and Blue Network concept has been undertaken in very disparate ways, be it through strategic spatial planning with the Schemes for Territorial Coherence (SCOT) on a subregional scale, urban planning with the Local Urban Plans (PLU) or the planning of territorial projects of the Regional Nature Parks (PNR). In some contexts, it has resulted in innovative experiments in terms of the inclusion of the green network in the spatial project. Here we will distinguish four factors of its territorial implementation.

4.1. The exploitation of ecological data in spatial planning

The capacity of planning authorities and regional/local communities to exploit ecological data and understand the functionality of ecosystems is a first factor of the implementation of green networks. New contents such as inventories of local biodiversity, principles of landscape ecology or methodological elements aimed at defining the networks are increasingly considered in planning processes and seen in the presentation report of urban plans. For example, the SCoT of the Greater Gap Area (southern part of the French Alps) took advantage of the local high-level skills in spatial and environmental engineering (such as the ecological expertise of the Urban Planning Agency of the Greater Grenoble Area that prepared the document as well as that of a national park present in the area). Its Green and Blue Network was elaborated on the basis of expert views, with a map of natural habitats and a map of plant patches and faunal data. The document has given significant attention to areas for their ecological functionality, in particular to those that contribute to the connection between mountainous massifs. Moreover, ambitious planning requirements have been enshrined in the document in order to secure the Green and Blue Network and its spatial components.

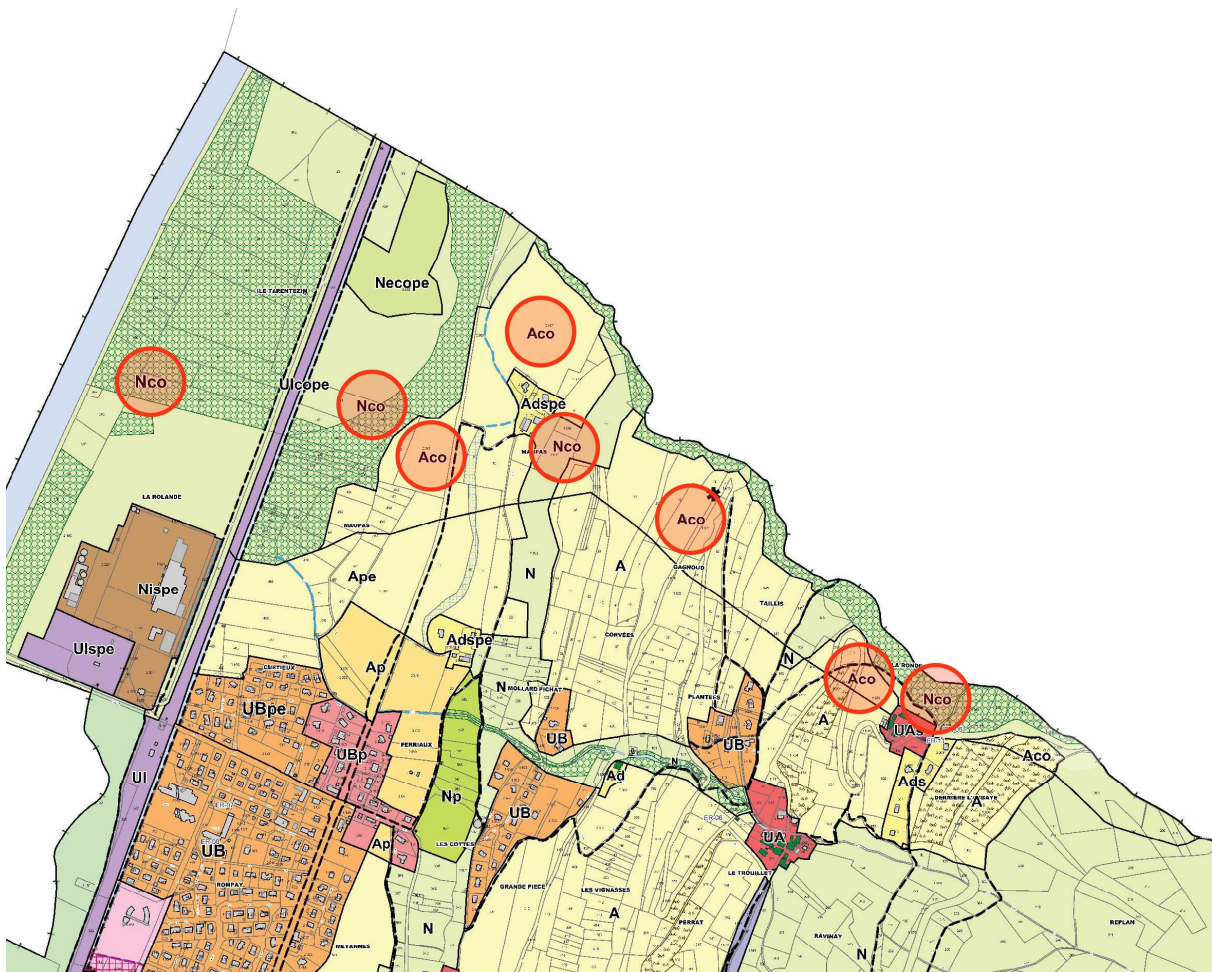
Urban planning documents such as the PLUs include information on biodiversity and ecological connectivity through their maps (see Map 1). The biodiversity issue was addressed in a new way, moving away from a simple approach of protecting environments or species, to becoming part of an integrated and territorial approach.



Map 1: Strategic map included in the 2014 PLU of Le Cheylas municipality (Grenoble urban area, northern part of the French Alps) (in: Perrin et al., 2019). The map identifies the ecological connections of municipal (wide green dotted arrows) and supramunicipal (wide green continuous arrows) interest as well as the buffer areas between urban areas and the main ecological connections (green cross-hatching).

4.2. The transposition of strategic guidelines into planning requirements and regulations

The transposition in the PLUs of strategic guidelines into planning requirements and regulations is particularly sensitive. Depending on the contexts, the results vary according to local compromises between different (economic, social, environmental) interests. At this supramunicipal or municipal planning level, the inclusion of the green network in land rights results in regulatory zoning. Certain networks are specified in the zoning map using the indices "Aco" (agricultural zone with wildlife corridor) or "Nco" (natural zone with wildlife corridor) in order to set up specific zone rules and regulations (see map 2). Another method consists in superimposing landscape components of the green network to be protected over the functional zones. A rarer method is closer to a project approach using urban development instruments such as integrated development areas (Planning and Programming Guidelines (OAP), Article L-151-6 and -7 of the Urban Planning Code); this helps to reinforce a valorisation of planning by the project and not only by the rules.



Map 2: Land-use map (detail) included in the 2014 PLU of Le Cheylas municipality (Grenoble urban area, northern part of the French Alps) (in: Perrin et al., 2019). It shows through the addition of red circles the transposition of the northern wildlife corridor into zoning regulations:

“Aco” (*agricultural zone with wildlife corridor*), “Nco” (*natural zone with wildlife corridor*), “UIco” (*business zone with wildlife corridor*) implying some specifications regarding building regulations, landscape compositions, wildlife-permeable fencing, etc.

These zonings may be accompanied by more restrictive rules, for example in terms of constructability. However, they remain variable from one municipality to another, with more or less significant impacts on the network functionalities. Nevertheless, there is a certain tendency to offer through the legislative framework more provisions (e.g. the possibility of including "*areas of ecological connectivity*" in urban planning documents introduced by the Law for the Recovery of Biodiversity, Nature and Landscapes of 2016) and reinforce the constraint (e.g. increased limitation of land consumption, particularly in relation to the objectives of maintaining biodiversity and preserving or restoring ecological connectivity, following the promulgation of the Ordinance on the Modernisation of the Schemes for Territorial Coherence of 2020) in order to better take into account the issues of ecological connectivity in urban planning documents.

4.3. The concerted preparation of urban planning documents

Urban planning documents are drawn up through concertation mechanisms. This concertation takes place at different levels (Cadoret and Beuret, 2009) in which the Green and Blue Network is sometimes imperfectly integrated. While its technical integration in the plan is essentially a matter for urban planning practitioners (see 4.2.), the width of ecological corridors can vary, resulting from compromises between naturalist recommendations and other planning issues (Cormerais and Bertrand, 2014). The multi-stakeholder compromises established locally in planning processes can thus generate risks inherent to a certain simplification of ecosystem functioning. This tends to induce a process focused on the (moreover negotiated) spatial delimitation, little able of ensuring the functional connectivity expected for such networks. Concertation enables local stakeholders to be made aware of the issues and to share a cognitive framework that is essential for understanding and taking on board the challenges of ecological connectivity. Thus, the elaboration of the urban planning documents also provides an opportunity to spell out the green network and to raise the awareness of a wide range of stakeholders in the local community, such as elected officials and planning technicians. The ecological network of the department of Isère (REDI) established in 2001 did not allow a complete appropriation of the issue of ecological connectivity by municipalities. On the other hand, the European project Corridor of life (2009-2015) - at the scale of the Grésivaudan valley (Grenoble urban area, Isère department) - allowed a better understanding of the challenges related to the Green and Blue Network at the municipal level, enabling the dissemination of information and communication on REDI. The concertation aimed at producing rules and the search for consensus on perimeters and rules are more conflictual and often seized by local public actors. There is therefore a tendency to institutionalise concertation on the regulatory aspects (and therefore fundamental to the implementation of municipal action) of ecological corridors.

4.4. Limitations of spatial planning in terms of ecological network management

Zoning regulations are certainly part of a concern to maintain or even restore the ecological functions of the network and may in this sense introduce specific provisions, such as the permeability of fences to wildlife or the hedgerow protection). However, spatial planning remains limited when it comes to the management of the areas that make up the Green and Blue Network. Other levers need therefore to be emphasized to ensure land-uses that will favour the expected ecological functionality.

These are, in particular, contractual arrangements aimed at maintaining or restoring ecological connectivity on a specific area (such as the so-called Green and Blue Contracts in the Auvergne-Rhône-Alpes region), measures favouring the agricultural transition towards more environmentally

friendly practices (such as agri-environmental measures) and land interventions by public bodies (control of land ownership and use via rural leases with environmental clauses such as for the protection of water catchment areas). Institutions such as Regional Nature Parks (PNR) can play an important role in the network management. As an example, the Verdon PNR developed its Green and Blue Network with a consideration of the management practices likely to maintain and/or develop a good ecological functionality, especially in agricultural and pastoral areas. These various measures rely on different decision-making levels, different sources of funding and timescales. The latter can be more or less relevant to the pursued objective. In particular, the 3-year Green and Blue Contracts would not by themselves enable sufficient concertation to plan the management of the areas making up the networks (Delclaux, 2020). Finally, the emergence of certain topics favours a more integrated approach to ecological connectivity. For example, discussions on local food systems and food planning contribute to better coordination between spatial planning and other sectoral levers.

5. Conclusion

Although there is no strict binding framework at the European Union level to address ecological connectivity, numerous initiatives show that it exists a real ambition in the field: the signature of international conventions, the adoption of directives on biodiversity with certain considerations for this issue, the promotion of new concepts such as the green infrastructure, the financing of projects at macro-regional and inter-regional scales, and the inclusion of specific objectives within its biodiversity strategies. Thus, the EU has played a significant role in the dissemination of the topic and in the emergence of projects addressing this concern. However, its involvement differs quite widely from the one it traditionally had in matters of biodiversity policy, notably through the establishment of strict standards imposed on member states and transposed into national/federal law.

This lack of a strict framework explains, at least partly, the diversity of approaches observed between the different countries. For example, there is a real heterogeneity in the definitions and concepts established in each country, or even region, to address the issue of ecological connectivity, with some approaches favouring ecological functionality while others emphasise spatial and landscape continuity. Not to mention the fact that linguistic considerations most certainly influence the way of addressing the issue, since the terms used to evoke it differ from one language to another and sometimes even between countries in the same linguistic area (Perrin et al., 2019). The diversity can also be explained by the spatial planning cultures and systems in force in the different countries. This is a public policy field over which the EU still has relatively little control and yet relatively central to the development of ecological networks.

Similarly, there are quite marked differences between regions - including in a French context of unitary tradition - or even at lower levels. In particular, it is worth noting the influence of some factors on the quality of the acknowledgement of connectivity issues, such as exchanges between biodiversity specialists and spatial planning professionals, the sensitivity of elected officials and the public involved in planning processes and negotiation efforts between the many parties concerned.

In other words, ecological connectivity seems to be an issue for which it is difficult to establish a standardised and standardising policy framework. Several factors may explain this, notably its complexity compared to other biodiversity policies (taking into account ecosystem functioning rather than simpler criteria such as habitat features or presence/absence of species), its data and expertise requirements (territorial inequalities in terms of quantity/quality of available data and expertise), its geographical relativity (difficulty or even impossibility of establishing universally valid connectivity indicators and targets), its multiscale nature (heterogeneous connectivity requirements between species), its political and legal touchiness (consideration of biodiversity issues on often privately held land, devolved to other socio-economic functions and no longer only on areas with a high protection status).

Thus, ecological connectivity, like other contemporary environmental challenges, undoubtedly reveals the limits of a spatial planning system organised historically in the French context according to a top-down logic and therefore the relevance of the territorial turn operated in the country at the turn of the 21st century (Scherrer et al., 2008; Novarina and Zepf, 2009). Furthermore, it can be seen that the mutual feedback principle officially established in the German spatial planning system and involving simultaneous top-down and bottom-up co-ordination between planning levels is to some extent in practice in the French context. The methods and developments of the Green and Blue Network at a lower scale are regularly taken up and integrated at a higher level. In particular, this adaptation provides a partial, and therefore insufficient, response to one of the inherent limitations of spatial planning, namely its relative inability to address dynamic processes, in this case ecological processes. The long periods of elaboration and validity of spatial planning documents, as well as the inertia between the moment when an issue is considered in a reference document and the moment when it is transposed in the documents legally required to consider its content, can induce anachronistic planning decisions in the face of on-the-ground realities that evolve much more rapidly.

The introduction of the issue of ecological connectivity into the political agenda is likely to have an impact, not yet fully grasped, on the way of approaching among other things: (a) public action in environmental matters and the organisation of this action at different levels, (b) the relationship between administrative and/or planning bodies of higher and lower levels, (c) the place of spatial planning and its scope of action or, alternatively, its degree of integration with other sectors of public action, (d) the interaction between strategic planning, regulatory planning and operational approaches, (e) the link between planning and projects.

Declaration of Competing Interest

The authors report no declarations of interest.

Acknowledgements

This article is amongst other things the result of researches funded by the French Ministry for the Ecological and Inclusive Transition (PLACE Project) and the Laboratory of Excellence Innovation et Territoires de Montagne (EXEmPLE Postdoctoral Research). The authors would like to acknowledge the helpful suggestions from reviewers.

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