OptiFlux: when biological and spatial data are crossed to reduce effects of linear infrastructure on wildlife

Adil Baghlia a, *, Philippe Thiévent b

a Ecologist Engineer, EGIS Environnement, 11 avenue du Centre - CS 30530 Guyancourt 78286 France
b Manager of CDC Biodiversité 102, rue de Réaumur Paris 75002 France

Abstract

R&D activities at Egis Environnement (a civil engineering-based environmental consultancy) facilitated the development of OptiFlux, a spatial analysis tool designed to predict and visualize the effects of implementing a linear infrastructure upon wildlife habitats. It also tests the relevance of positioning fauna passages to ensure the restoration of habitat connectivity and therefore allows the optimization of the number and location of potential fauna passages. OptiFlux makes use of habitat quality maps which correlated with ecological requirements of each studied species. The concept is based on the evaluation of the spatial distribution of wildlife in their natural habitats. It also allows the evaluation of the impact of a project that modifies landscape structures and contributes to territory fragmentation. OptiFlux is a project optimization instrument which helps in the decision-making process. Major applications are:

- Identification of routes with the least impact on wildlife population fluxes and their habitats,
- Optimization of the number and location of fauna passages for the benefit of wildlife and reduction of the conflict points between infrastructures (road, highway, railway) and ecological networks,
- Simulation of the positive effects of the proposed fauna passages or biotopes (amphibian ponds, for example) for a better choice of installations and for a better reconnection of the fragmented habitats.

Keywords: ecological networks; environmental design; fragmentation; infrastructures; Optiflux

1. Introduction

Wildlife needs to move across large areas of landscapes searching for food, nesting sites and mates. For several centuries, the north-western part of Europe has always been under an increasing anthropogenic pressure: urbanization, industrialization, intensification of infrastructure, agriculture, watercourses modifications, etc. One of the consequences of this pressure is landscape fragmentation which threatens biodiversity. The process of fragmentation is connected to many different factors, of which the direct loss and isolation of natural habitat are the most important.

* Corresponding author. Tel.: +33-1-30484959; fax: +33-1-30484485.
E-mail address: adil.baghli@egis.fr.

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Linear transport infrastructures such as highways or high speed line railway have a significant impact on the environment and may affect wildlife species with large home ranges and decrease genetic variability across populations. Their geometry is not so much a cause of destruction of animal habitats, but rather it acts more as a barrier between fragments [1]. If we consider linear infrastructure as a barrier in landscapes, it is important to study biological fluxes between landscape features before deciding the final route of such infrastructures.

2. Concept

The OptiFlux concept, (a mathematical assessment software) is based on an evaluation of the spatial distribution of an animal population according to its ecological requirements. It requires knowledge of landscape ecology principles, such as habitats (the quality of the environment in relation to the species ecological requirements) and ecosystem functioning (the natural habitat role in the species ecology, feeding, breeding, migration, etc.).

It is also based on the resistance of the natural environment to an animal species presence: frequentation or avoidance of a natural habitat, the death rate and the energy spent in migrating within this natural habitat.

Knowledge about species biology is fundamental. This knowledge conditions the assignment of the resistance coefficient given to every type of habitat [2]. It results in the MCR (Minimal Cumulated Resistance). The MCR gives weighted distances that are not the shortest possible but that reflect the resistance of the habitat crossed. These MCR would also give a “weighted cost”.

The dispersion equation would have the following form: MCR = Dij x r where:
- Dij = covered distance between i and j in different habitats
- r = resistance coefficient of every crossed habitat

If r = 1, then Dij = Dmax, if r=100, then Dij = Dmax/100

Dispersion rates are meaningful only if resistance has biologic reality. The OptiFlux process will therefore give the user a quantitative assessment of the resistance of an existing habitat, and conversely identify those areas where dispersion across the potential linear construction will be greatest. Resources can therefore be targeted to maintain or improve the connectivity of these locations and optimize biological function of existing ecosystems.

3. Advantages

OptiFlux provides a preliminary approach for a rapid identification of the critical areas to be taken into account for design and estimation of the infrastructure. However it does not eliminate the need for expertise and verification of the results obtained by a field biologist. It is also a project optimisation instrument, helping in the decision making process, concerning the necessity and relevance of the improvements retained. Finally, OptiFlux is a tool that allows the user to model potential future scenarios, and identifies project risks and allows comparisons of alternative versions of a project.

4. Applications

4.1. Small mammal case: the European mink (Mustela lutreola)

The European mink (hereafter referred to as “mink”) is a small territory species (25 ha). Its territory is closely linked with wet habitats that mink almost never leave. For this reason, it is necessary to use a detailed database, such as Corine Biotope. In our case study, we have used an existing and customized database, constructed to study habitat quality. This was created from aerial photography and site visits for verification. The following map (Fig. 1) shows likely the migration of the European mink [3].
The results obtained with OptiFlux have been controlled by a French mink expert, and it appears that they are coherent with the known species distribution.

It is shown that the distribution of the species, obtained using OptiFlux, overlaps the areas obtained by the expert. In addition, OptiFlux is capable of automating certain applications such as the identification of small streams which may otherwise have been missed by the expert during the digitisation of habitats. OptiFlux is also capable of highlighting waterbodies to facilitate the identification of possible passageways between different channels of water.

4.2. Large mammal case: the Red Deer (Cervus elaphus)

As the Red Deer occupies a large territory (2000 ha), it is necessary to use a database such as Corine Land Cover. Fig. 2 shows a large territory extending on approximately 300 km. The Red Deer habitat appears in green, while favorable habitat for daily migration appears in yellow, and the dispersion, in brown.

In Fig. 3, the infrastructure crosses this territory from one side to the other. It is a fenced carriageway that constitutes an impassable barrier for Red Deer. A Simulation of the impact of this infrastructure is shown.

The potential fragmentation of Red deer habitats due to the construction of a deer-fenced motorway initiates a search for mitigation measures to reduce fragmentation of the species. In this example, OptiFlux enabled the identification of three sites where the installation of a wildlife crossing would be required to maintain functional connectivity for deer through the infrastructure.
OptiFlux is used to locate the best position for fauna passages. When three fauna passages are installed, the connectivity and function of existing habitats is almost totally conserved.

Thus, at a study stage of a new project, simulations on OptiFlux show the optimum locations for fauna crossover passages and therefore ensure the efficient restoration of significant biological corridors. This is particularly useful if, for financial reasons, not all of the crossover passages can be implemented.

5. Conclusions

The innovative aspect of OptiFlux is its automated diagnostic approach, which is based on the combination of spatial and biological data, on large territories and at the initial stages of the project. OptiFlux provides a preliminary approach for a rapid identification of the critical areas to be taken into account to design infrastructures and estimate their costs. However it does not eliminate the need for expertise and verification of the OptiFlux results made by a competent field biologist.

OptiFlux is a project optimisation instrument, which helps in the decision-making process, concerning the necessity and relevance of the improvements retained.

There are three direct applications for the tool:
- Identification of routes having the least impact on wild animal population fluxes and their habitats;
- Optimisation of the number and location of fauna passages for the benefit of wild animals, and reduction of the points of conflicts between infrastructures (road, highway, railway…) and biological corridors;
- Simulation of the positive effects of the proposed fauna passages or biotopes (amphibian ponds for example), for a better choice of installations and for a better re-establishment of habitat connectivity habitats.
References