Scientific approaches for Designing Ecological Networks: a Case Study for the Faunal Species of Inland Wetlands of Lower Saxony, Germany

Rosa Contreras

Faculty of Marine Sciences. Program of Environmental Sciencies. Autonomous University of Baja California

Introduction

Several methods and tools have been developed to achieve the goals of nature conservation and for the design of ecological networks. In that sense, some frameworks proposed by several authors are applied to all levels of biodiversity conservation. One goal of the ecological networks is to represent and to promote the persistence of biodiversity within a region, however few efforts have concentrated the tools or methods useful to implement such frameworks. In several cases, the focus is on the quantitative area selection methods, others on the focal species approach or just on the species persistence and viability analysis. Nonetheless, when developing ecological networks at broad scales, concentrating the attention in just one of these approaches does not ensure that the most valuable areas for species conservation in wetlands or any other systems are selected. For this reason, the basic step to identify the useful tools to apply for achieving specific conservation goals is to have the scientific background to guide the conservation planning process. Some of the biggest problems to apply more than one of these approaches are the availability of data, the available resources, the financial support and time.

This study compares different approaches of conservation planning that guide the design of ecological networks and identifies different available methods used to support such a design. Moreover, applies different methods for the design of a network for the conservation of faunal species of in-land wetlands of Lower Saxony, following a systematic conservation planning framework. The goal is to concentrate and to compare different methodologies, and to identify its role in the conservation planning frameworks, as well as to identify the lack of information to achieve certain conservation goals in order to direct the future efforts in the collection of data and information of the region, and finally to point in the most urgent local studies.

Background and Literature Review

Throughout the world, scientific conservation planning frameworks have been developed. For example, Margules and Pressey (2000) proposed a framework based on the systematic conservation planning. As well, Groves et al. (2002) developed a framework for conservation planning in terrestrial, freshwater, and near-shore marine environments. Both frameworks have some similarities and can be comparable with the German Nature conservation criteria for the implementation of Article 3 of the Federal Nature Conservation Act on habitat connectivity, which concerns different spatial levels (inter)national, regional and local (Burkhardt et al., 2003; Burkhardt et al., 2004; BfN, 2004).

Because it is impossible to measure all of biodiversity, biodiversity surrogates have to be used. Examples are taxa sub-sets, species assemblages and environmental domains. An achievable goal is to represent at some agreed level, each of the biodiversity features chosen as surrogates (Margules et al., 2002). Selecting conservation areas in an *ad hoc* manner or selecting for the protection of a particular species generally results in the conservation of economically marginal land and unrepresentative reserve networks (Groves et al., 2002; Possingham et al., 2006).

Alternatively, information that is easily understood by policy makers and stakeholders have been introduced. An example is the BIO-SAFE model (a trans-national model), which constitutes an effort to integrate biological indicators with policy- and legislation based biodiversity indicators, i.e. threatened species. BIO-SAFE has been used as a tool for the assessment of impacts of physical reconstruction on biodiversity (De Nooij et al., 2001; De Nooij et al., 2004). As another alternative, many studies have chosen to use complementarity methods where certain species or other biodiversity surrogates are concerned. These have been proved as a more efficient approximation than only using hotspots (Williams et al., 1991).

Focal species identify additional high-value habitats and address the questions: What is the quality of the habitat? How much area is needed? And in what configuration should the components of a reserve network be designed?. Focal species (objective, target, umbrella, keystone, indicator, etc.) are organisms used in planning and managing nature reserves. They are used because their requirements for survival represent important factors to maintaining ecologically healthy conditions. Ultimately, questions about ecological patterns and process cannot be answered without reference to the species that live in a landscape (Foreman et al., 2000).

To promote persistence and the viability of species, a key concept in conservation planning is that of the metapopulation. Indices that may express characteristics of metapopulations with the feature of the landscape network are needed to assess wheter the spatial conditions of a network allow for persistent metapopulations (Verboom et al., 2001). This approach has been integrated into the LARCH model (Landscape Ecological Rules for the configuration of Habitat) (Chardon et al., 2000).

Study Area

Lower Saxony is located in the northwestern part of Germany, it stretches from the East Frisian Isles in the north Sea to the Harz mountains (971 m), the most northern chain of the central German low mountains. The wetlands in Lower Saxony, which are specially represented, are species-rich habitats for flora and fauna. However, as in Central and Western Europe, they have suffered a declination due to habitat fragmentation and other factors (Stähle et al., 1997; Chardon et al., 2000). Because of their declination, The State of Lower Saxony has recognized their protection as a main goal of the nature conservation efforts (Stähle et al., 1997).

Methods

After a literature review three conservation planning frameworks were compared and different methodologies were organized in each of their stages where they could be applied. The three first stages of the Conservation planning framework proposed by Margules and Pressey (2000) were used as a guide of the ecological network design, along with the application of the BIOSAFE Model (De Nooij et al., 2001 and 2004), the Focal Species Approach, the LARCH Model (Chardon et al., 2000) and the Gap Analysis (Possingham, et al., 2006).

Collection of Data Surrogates Selection and Mapping

*Selection of target species:*the term surrogates (Margules and Pressey, 2000) or target (Groves et al., 2002) are used here only to refer the consistent species data available for the design of networks on this study case. For convenience, only the term target will be used. The selection of the target species was defined through different criteria, including the exploration of the Species specific score and the Potential Biodiversity Assessment of the BIO-SAFE Model (De Nooij et al., 2001 and 2004). A total of 34 target species were selected: 19 Odonata, 11 Amphibia and 4 Mammalia. All of them corresponding to the species with the highest priority status of the Habitats Directive and/or the National and State Red lists (Table 1).

Table 1. The target species list (taxonomic group and species scientific name)

DRAGONFLIES AND DAMSELFLIES (ODONATA)	**AMPHIBIANS**
Coenagrion mercuriale	*Bombina bombina*
Ophiogomphus cecilia	*Bombina variegata*
Coenagrion ornatum	*Bufo viridis*
Aeshna viridis	*Triturus cristatus*
Gomphus flavipes	*Pelobates fuscus*
Leucorrhinia caudalis	*Hyla arborea*
Leucorrhinia albifrons	*Rana arvalis*
Leucorrhinia pectoralis	*Rana dalmatina*
Sympecma paedisca	*Rana lessonae*
Ceriagrion tenellum	*Alytes obstetricans*
Erytromma viridulum	*Bufo calamita*
Nehalennia speciosa	
Aeshna subartica	
Aeshna isosceles	**MAMMALS**
Gomphus vulgatissimus	*Castor fiber*
Cordulegaster bidentata	*Lutra lutra*
Somatochlora alpestris	*Myotis dasycneme*
Somatochlora arctica	*Myotis daubentonii*
Libellula fulva	

The digital processing of the target species distribution: a digital map containing all possible species presence records from 1980 to 2006 for each species was obtained. The maps were constructed from paper maps with a cell resolution of approximately 5 X 5 Km from different sources: public government data, books or scientific papers and digital maps and non-published paper maps of the Lower Saxony supplied by members of the department of Landscape Planning and Nature Conservation (Lipski and Reich, personal communication, 5, October, 2006).

*Defining planning units and habitat suitability maps:*a total of 73 biotopes and subtypes were selected with expert advise (Reich, personal comunication 10 june, 2006) from the total biotope types classification available for the State and used as surrogate planning units. The selection of the specific wetland biotope subtypes used for each species was based on literature review and assessed by Reich (personal communication, February, 2007) then a habitat suitability map for each species was elaborated.

Conservation goals

Two conservation goals for the study case were achieved: 1) The design of a wetland biotopes network with representative areas for the conservation of protected and focal species and 2) The proof of the persistence of species in such a network.

Review of existing areas

The selection of representative areas: the network of representative areas for the conservation of protected species was designed based on the Taxonomic group Biodiversity Saturation of the BIO-SAFE model (De Nooij et al., 2001 and 2004. Several concepts of the focal species (co-ocurrence of species, ecological profiles, and species with large area requirements, functional guilds, habitat quality indicator and key stone) were tested to obtain the best suite of species for the representation of both species and biotopes with four network scenarios. Finally the proposed biotopes network for the conservation of target species was obtained with the integration of both approaches (the representation of protected species and the scenario 3 of the focal species).

The viability analysis: the viability analysis of the wetland biotopes network was explored based on the LARCH Model (Chardon et al., 2000). The first step was to determine whether the resolution of the biotope maps was enough to assess the viability of the network. Because the biotope maps are not enough detailed to identify the biotope subtypes, it was decided to choose two specialist species of running waters (*Castor fiber* and *Ophiogomphus cecilia*) as study cases.

The analysis of gaps: a Gap Analysis (Possingham et al., 2006) was conducted to find the gaps of representation, two categories of the Protected Areas considered by the Nature Protection Law "Naturschutzrechtlich geschützte Gebiete" were used (the Biosphere Reserve and Protected Areas), as well as the Habitats Directive Areas and the Main protected areas according to the EU-Birds Habitats Directive (Niedersächsisches Umweltministerium, accesed on line 2007). All these areas were named Protected Areas in this study.

Results

The network of representative areas of in-land wetlands protected species covers an area of 463.75 km^2. The representation of these areas with respect to the surface of the State of Lower Saxony and the biotope types is resumed in Table 2, . All the species are represented by this network, except the odonata species *Somatochlora alpestris*.

Table 2. Area represented by the network of representative areas of in-land wetlands protected species, based on the Taxonomic group Biodiversity Saturation (TBS).

Different spatial levels:	**Percentage cover by the representative areas of wetlands protected species**
State of Lower Saxony	0.98
All the biotope types	9.11
The selected biotope types*	17.91
The selected biotope types with presence of target species	21.85

* It refers to the biotopes which contain wetland subtypes

With the results of the focal species approach, seven of the 34 target species were selected.Four scenarios were proposed: scenario1 with 5 species (*Castor fiber Pelobates fuscus, Hyla arborea, Leucorrhinia pectoralis* and *Ceriagrion tenellum*); scenario 2 adding one more species *Ophiogomphus Cecilia*; scenario 3 with the seven focal species, and scenario 4 only considering the species with the largest area requirements (*Lutra lutra*). Scenario 4 only represents 55.17% of the biotope types with target species presence (Figures 1 and 2). The results of this work revealed that the network of representative areas of protected species, are almost covered for the network designed considering seven focal species which represents all the target species and 38% of the good quality wetland subtypes of Lower Saxony. Table 3 compares the percentage of area necessary for each scenario and their representation in the different systems.

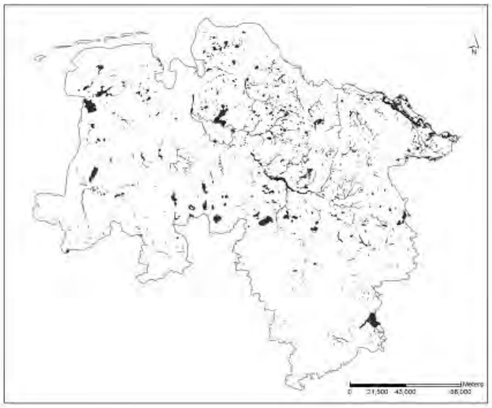

Figure 1. Scenario 3 (the seven focal species)

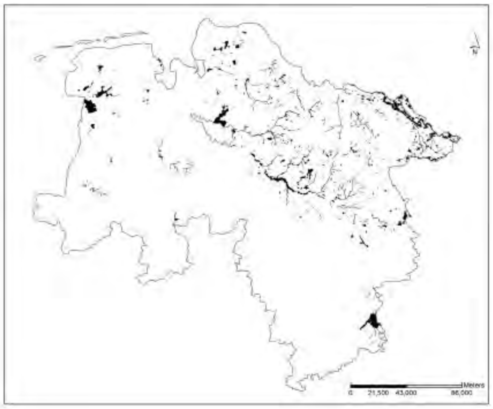

Figure 2. Scenario 4 (the focal species with the largest area requirements)

The final proposed biotopes network for the conservation of target in-land wetland species was designed with the integration of scenario 3 (the seven focal species) and the network of representative areas of in-land wetlands of protected species. When considering only the network of representative areas just the 17.91% of the selected biotope types that contain wetland subtypes is represented while the network of focal species confers more than double (46.36%).

Table 3. Comparative table of representative area per scenario and systems.

	Percentage of area per scenario with respect to different spatial levels:				**Species represented at least in one unit**	**Systems represented by the species**
	State of Lower Saxony	All the biotope types	The biotope types selected*	The biotope types with presence of the target species		
Scenario 1 (5 focal species)	1.66	15.52	30.51	50.59	32 species. *C. ornatum and S. alpestris* are not represented	All the systems
Scenario 2 (6 focal species)	1.78	16.56	32.55	58.98	32 species. *C. ornatum and S. alpestris* are not represented	All the systems
Scenario 3 (7 focal species)	**2.53**	**23.59**	**46.36**	**76.88**	**All the 34 species**	**All the systems**
Scenario 4 (The network of the species of largest area requirements)	**1.82**	**16.92**	**33.28**	**55.17**	**33 species. *Bombina variegata* is not represented**	**3 systems: Running and Standing Waters and Forest**
Proposed network for the conservation of faunal inland wetland species	**2.53**	**23.60**	**46.39**	**76.94**	**All the species**	**All the systems**

*It refers to the biotopes (ERKO) which contain wetland subtypes

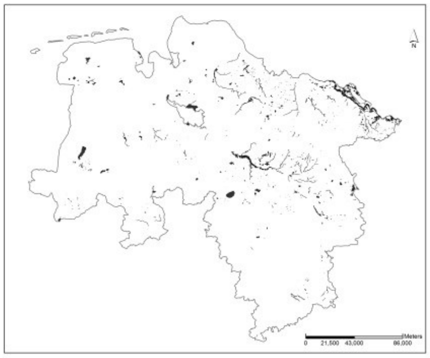

Figure 3. Biotopes network for the conservation of protected species

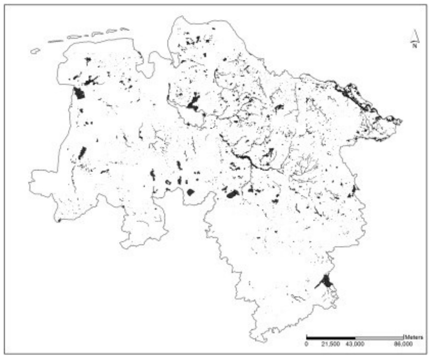

Figure 4. Proposed network for the conservation of faunal in-land wetland species

The resulted gaps of representation for the proposed final network are described in terms of percentage of area no included in the Protected Areas (Table 4). The Figure 5 shows the proposed biotopes network for the conservation of target in-land wetland species of the state of Lower Saxony, and the areas covered and not covered by the Protected Areas, also it is possible to observe how the proposal bring more cohesion to the in-land network of Protected Areas.

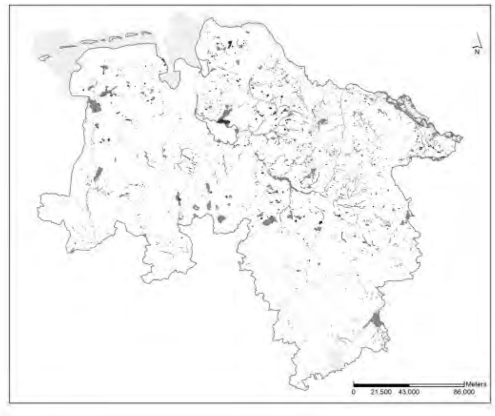

Figure 5. The analysis of gaps in the proposed biotopes network

░ Protected Areas of the State of Lower Saxony
▒ Covered areas of the biotopes network
■ Gaps (not covered areas)

Table 4. The analysis of gaps in the proposed biotopes network

Network	Covered area	Not covered area (gaps)
Proposed Biotopes Network for the conservation of target in-land wetland species	81.1 %	18.9%

Discussion

One of the main differences of the frameworks of Groves (et al., 2002) and Burkhardt (et al., 2003, 2004) and the systematic conservation planning of Margules and Pressey is that they specify and evaluate the ability of conservation targets to persist with a qualitative ranking system that employs criteria such as the following: size, condition and landscape context and each criteria is rated as “very good”, “good”, “fair” or “poor”. Both of them apply this evaluation before and after the implementation of the steps or criteria equivalents to the stage 3 of the Margules and Pressey (2000) framework.

The systematic conservation planning framework recommends some tools or theories for the implementation of stages 1 and 2. However, the specific methods to achieve the representation and persistence of the surrogates for achieving stage 3 (Review existing conservation areas) are not clearly specified.

The results of the viability analysis were only approximation exercises of the proposed method, in which an overestimation of the areas is expected, because the resolution of the species distribution maps is not detailed at a biotope subtype level. Thus a distribution unit can contain several biotope subtypes, including those in which the species is not distributed. The results obtained for both species accumulated overestimations of adding the biotope subtypes that are not used by the species, which is more evident for *Ophiogomphus cecilia*. These results suggest that for network viability analyses a better detail of the spatial data is necessary.

The selected target species of dragonflies and damselflies, amphibians and reptiles and mammals using wetlands in Lower Saxony were restricted to the most threatened species due to the digital availability of data. Despite the biotope types selected as surrogate planning units for the design of the network of representation do not cover the entire state of Lower Saxony, they correspond to the most valuable areas for nature conservation and are the most detailed available units. However, the spatial definition of the biotope subtypes would bring about better approximations.

Conclusions

The Systematic Conservation Planning Framework, in addition to other methods, is a useful guide to: assess networks of representation, carry out viability analysis of the networks, and to identify gaps. However, these results are only a scientific basis on the species approach, and should be integrated with the physical functions of ecological networks and the landscape planning process.

A network confers more protection to the target species when the focal species represent different levels of the habitat scale perception and when the species occur in different biotope subtypes and systems. Whereas a network designed only with species of larger area requirements is less effective to protect both species and biotope subtypes.

The co-occurrence of species and the persistence characteristics are complementary for the selection of focal species. While the habitat quality indicators or keystone species are only characteristics that support the selection of species.

There is a necessity of more detailed units to corroborate whether the focal species are persistent in the network of representation and to evaluate whether these species do really promote the persistence of other target species.

The main lacks of information identified to apply the methodologies are the following: a) the public unavailability of the digital presence records of species and the urban characteristics (“Landesraumordnungsprogramm”); b) the lack of data bases with the characteristics of the species distributed in Lower Saxony, and c) the no delimitation of the biotope subtypes.

Akcnowledgments

I give thanks to the Consejo Nacional de Ciencia y Tecnología (CONACYT), to the Deutsches Academisches Austausch Dients (DAAD), to the Institute for Landscape Planning and Nature Conservation of the Leibniz Universität Hannover, Germany and specially to the Profesor Dr. Michael Reich by the support of my doctoral studies. Also I thank to Jesús Serrano by the kindly comments to the manuscript. And I thank to Dr. José Luis Fermán and to Facultad de Ciencias Marinas of the Universidad Autónoma de Baja California, Mexico by the financial support to attend this Congress.

References

Burkhardt, R., H. Baier, U. Bendzko, E. Bierhals, P. Finck, A. Liegl, R. Mast, E. Mirbach, A. Nagler, A. Pardey, U. Riecken, J. Sachteleben, A. Schneider, S. Szekely, K. Ullrich, U. van Hengel, U. Zeltner und F. Zimmermann. 2004. Empfehlungen zur Umsetzung des § 3 BnatSchG „Biotopverbund‟ - Ergebnisse des Arbeitskreises „Länderübergreifender Biotopverbund‟ der Länderfachbehörden mit dem BfN - . Naturschutz und Biologische Vielfalt 2:1-84.

Chardon, J.P., R.P.B. Foppen and N. Geilen. 2000. LARCH-RIVER: a method to assess the functioning of rivers as ecological networks. European Water Management 3(6):35-43.

De Nooij, R.J.W., D. Alard, G. De Blust, N. Geilen, B. Goldschmidt, V. Huesing, H.J.R. Lenders, R.S.E.W. Leuven, K.M. Lotterman, S. Muller, P,H. Nienhuis and I. Poudevigne. 2001. Development and Application of BIO-SAFE, a Policiy and Legislation Based Model for assessment of Impacts of Flood Prevention Measures on Biodiversity in River Basins. Final Report IRMA-SPONGE project 11. NCR-publication 11-2001. Netherlands Centre for River Studies: Delft.

De Nooij, R.J.W., H.J.R. Lenders, R.S.E. Leuven, G. de Blust, N. Geilen, B. Goldschmidt, S. Muller, I. Poudevigne and P.H. Nienhuis. 2004. BIO-SAFE: Assessing the impact of physical reconstruction on protected and endangered species. River Res. Applic. 20:299-313.

Foreman, D., B. Dugelby, J. Humprey, B. Howard and A. Holdsworth. 2000. The Elements of a Wildland Network Conservation Plan: An Example from the Sky Islands. Wild Earth, Spring 2000. The Sky Islands. Pp.17-30Groves, C.R., D.B. Jensen, L.L. Valutis, K.H. Redford, M.L. Shaffer, J.M. Scott, J.V. Baumgartner, J.V. Higgins, W.B. Michael and M.G. Anderson. 2002. Planning for Biodiversity Conservation: Putting Conservation Science into Practice. BioScience 52(6):499-512.

Margules, C.R. and R.L. Pressey. 2000. Systematic conservation planning. Nature 405: 243-253.

Margules, C.R., R.L. Pressey and P. Williams. 2002. Representing biodiversity: data and procedures for identifying priority areas for conservation. J. Biosci. 27 (4/2): 309-326.

Stähle, B., J. Stefan, E. Schmatzler, U. Rhein und M. Ehlers. 1997. Umweltmonitoring von Zustand und Nutzung der Hochmoore. Auswertung der Satellitendaten für das Niedersächsische Moorschutzprogramm. Niedersächsisches Umweltministerium. 45 S.

Possinghman, H.P., K.A. Wilson, S.J. Andelman and C.H. Vynne. 2006. Protected areas: goals, limitations and design, Pp. 509-551 in M.J. Groom, G.K. Meffe, and C.R. Carroll, eds. Principles of Conservation Biology, 3rd Edition. Sinauer Associates, Inc., Sunderland, MA.

Verboom, J., R. Foppen., P. Chardon., P. Opdam. and P. Luttikhuizen. 2001. Introducing the key patch approach for habitat networks with persistent populations: an example for marshland birds. Biological Conservation 100:89-101.

Williams, P.H., C.J. Humpries and R.I. Vane-Wright. 1991. Measuring biodiversity: taxonomic relatedness for conservation priorities. Australian Systematic Botany 4:665-679.