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Considerable environmental bottlenecks for species listed in the Habitats and Birds Directives in the Netherlands

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ABSTRACT

Many habitats and species have their existence threatened, especially in densely populated areas such as Western Europe. To stop the decline of biodiversity, the Natura 2000 network is being set-up. The ultimate objective is to get all habitat types (of Annex I of the Habitats Directive) and species (of Annexes II, III and IV of the Habitats Directive and Annex I of the Birds Directive) in a favourable conservation status. In the Netherlands a national ecological network has been set up for this purpose which includes the designated Natura 2000 sites. The current amount of atmospheric nitrogen deposition, acidification and desiccation were compared with limit values per habitat type for nitrogen deposition load, soil pH and spring groundwater table respectively and subsequently presented together in one map. Fragmentation was tested for 80 species.

For two-third of the examined natural surface the critical load for nitrogen deposition is exceeded, desiccation is present in over 90% of the area of groundwater dependent nature. Problems with acidification are less pronounced. Fragmentation is present causing regional problems for up to six species. When the four pressures are combined, about two third of the areas suffer from at least one pressure. Many areas suffer from a combination of nitrogen deposition and desiccation.

We conclude that environmental and spatial conditions are insufficient to meet the biodiversity target set by the European Union for the Natura 2000 network, habitat types and species.

1. Introduction

Biodiversity is declining, both on the global and the European level (Butchart et al., 2010; Chapin et al., 1998; Dobson, 2005; Smith et al., 2000; Swift et al., 1998). One of the most important actions to preserve and restore Europe's biodiversity is the creation of a Europe-wide ecological network of nature conservation areas – called the Natura 2000 Network (HD issued in 1992, CD 92/43/EEC). This network, established under the Habitats Directive (92/43/EEG) and Birds Directive (2009/147/EG), will accommodate threatened and valuable habitats and species in all EU member states. Conservation measures should be taken to appropriately manage Special Areas of Conservation (SAC's) and Special Protection Areas (SPA's). Natura 2000 sites should be big enough or connected to other suitable sites within and between member states in order to sustain healthy (meta-) populations of the protected species. The ultimate objective of the European Union is to get all habitat types (of Annex I of the Habitats Directive) and species (of Annexes II, III and IV of the Habitats Directive and Annex I of the Birds Directive) in a favourable conservation status; the Habitats and Birds Directives are intended to prevent the decline of the population size of any of these listed species and the deterioration of any habitat type.

The main pressures that are commonly recognized as causing biodiversity loss are habitat loss and fragmentation, nutrient loading and pollution, the effects of invasive alien species, climate change and unsustainable use of land (Balmford et al., 2005; Chapin et al., 2000; Cook et al., 2006; Galloway et al., 1984; Hanski, 1994; Hogg et al., 1995; Lameire et al., 2000; Mack et al., 2000; Thomas et al., 2004). Of these pressures loss of suitable habitat and fragmentation, desiccation, eutrophication and acidification are considered the most important pressures for biodiversity in the densely populated Netherlands (Bruinderink et al., 2003; De Vries et al., 2009; Heijmans et al., 2008; Hettelingh et al., 2009; Lammers and Zadelhoff, 1996; Wamelink et al., 2009a), the study area of this paper. Acidification and eutrophication due to nitrogen deposition as well as desiccation due to lowering of the groundwater level are mostly associated with unsustainable land use resulting from intensified agricultural and industrial practices (Galloway et al., 1984, 2008; Van Ruijven and Berendse, 2010). Where acidification due to industrial activities has dropped dramatically,

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nitrogen deposition and the related acidification and eutrophication are still increasing on a European and global scale (Galloway et al., 2008). Nitrogen deposition levels in the Netherlands used to be very high, up to 60 kg/ha/y, and have presently decreased to 30–40 kg/ha/y. Eutrophication in Natura 2000 sites is not only due to nitrogen deposition but has several causes such as increased nutrient levels in ground water and surface water and mineralization of organic soil. This paper focuses on nitrogen deposition and not on nitrogen availability because it is the most important source of nutrient input on the national and international scale. Both eutrophication and acidification have well known negative impacts on soil conditions and plant biodiversity (De Vries et al., 2010; Hettelingh et al., 2009; Wamelink et al., 2003, 2009a). Desiccation is strongly related to agricultural activities needing a low groundwater table and excessive use of water irrigation, causing drought stress in nearby natural areas (Elmore et al., 2003; Moore, 2002; Van Ruijven and Berendse, 2010). This is a large bottleneck for wetlands, peatlands, bogs and other water related habitats, especially for small and isolated sites in intensively used agricultural areas.

Many vulnerable species will be at risk of population decline or local extinction if these pressures persist. So, unless we successfully mitigate the impacts of these pressures on biodiversity, the decline of natural areas and biodiversity is expected to continue (De Vries et al., 2009; Heijmans et al., 2008; Lewis et al., 2004; Sverdrup et al., 2012; Wamelink et al., 2009b).

Of a different magnitude and also directly influencing the persistence of populations survival is fragmentation of the natural landscape. Although the total natural area has increased by nature development projects on agricultural land since the National Ecological Network (NEN) has been introduced in 1990, lack of natural habitat and its fragmentation are still a major threat to biodiversity. Due to loss of spatial cohesion population survival is under pressure and species may become extinct (Beier and Noss, 1998; Hanski, 1994; Opdam et al., 2003).

In this paper the major goals are (1) to quantitatively identify which of the four pressures, acidification, desiccation, nitrogen deposition and habitat fragmentation are the most important bottlenecks, (2) to investigate how they influence the conservation status at these sites, and (3) to investigate how they influence the European biodiversity policy targets. The focus of this research is not only on the N2000 sites but on all natural areas, because the latter also contribute to the Birds and Habitats Directives; they also help to preserve the designated species and habitats and to get them in a sustainable state. To give an overview results are presented in one graph together to be able to assess the quality of the habitats of the four different pressures together.

2. Materials and method

2.1. Overview of the method

The present environmental conditions and spatial cohesion of all natural terrestrial and water areas in the Netherlands were evaluated, but limited by available data. For nitrogen deposition we have critical loads for estuaries and marine areas, thus they were included in the analysis. For soil pH and groundwater table we have no data for the water bodies, hence they were not included. For the combined maps we therefore did not include the marine waters, since they were only examined for critical load of nitrogen deposition. For the environmental conditions we chose three abiotic parameters, nitrogen deposition, spring groundwater table and soil pH. These parameters are indicative for the pressures eutrophication, desiccation and acidification, respectively. Evaluation was carried out based on limit values per habitat type. For nitrogen deposition the limit value is represented by the 'critical load', for mean spring groundwater table (MSL) the limit value is represented by the minimum tolerable groundwater level, and for soil pH the limit value is represented by the minimum tolerable pH (cf. van Dobben et al., 2006; Wamelink et al., 2011). For each habitat type combined with MSL and pH a range of occurrence was estimated, based on field measurements (Wamelink et al., 2011, 2012). This gives limit values for each vegetation type; within the limits a vegetation type can in principle occur, outside this range it cannot. We tested MSL and pH only one sided, both for the lower limits, so the pH and MSL can be too low, but not too high.

The present abiotic values per site were derived from the present nitrogen deposition in the Netherlands (Velders et al., 2010) and for MSL the actual groundwater table (Van der Gaast et al., 2009). Soil pH was inferred from vegetation relevés (following Wamelink et al., 2005). Limit values (i.e., 'no effect levels') of nitrogen deposition, MSL and soil pH were assigned to each site on the basis of the habitat type present at that site. Subsequently, the limit values of these parameters were confronted with their actual values to determine if the estimated field value exceeded the set limit values for the habitat type.

The spatial cohesion of ecological networks for species of the Habitats and Birds Directives were evaluated with the model LARCH (Opdam et al., 2003, 2008; Verboom and Pouwels, 2004). Model parameters per species can be found in Pouwels et al. (2008, http://edepot.wur.nl/45743) and Pouwels et al. (2007, http://edepot.wur.nl/22177) annex 2. Model parameters are:

1. Local population Distance (m): the distance between 2 habitat locations within which they will be clustered into one local population.
2. Network Distance (m): the distance between 2 local populations within which they will be clustered into 1 network population.
3. Network Step Stone Size: the minimum number of RUs for a habitat location to be considered a network cluster candidate.
4. Key Patch (–): the species' minimum number of reproductive units needed to form a key population.
5. MVP factor (–): the multiplication factor for the minimum area needed to form a network population when the strongest local population is a minimum viable population.
6. NW + KP factor (–): the multiplication factor for the minimum area needed to form a network population when the strongest local population is a key population.
7. NW7KP factor (–): the multiplication factor for the minimum area needed to form a network population when the strongest local population is a small population.

Also needed are a habitat quality map, with varying quality per species and vegetation type combination and a density factor (RU/100 ha) for population species.

Based on actual species distribution data and the spatial configuration of ecosystems, viable meta-populations were identified. A viable population is defined as a population that has a high probability to survive for a long time (e.g. over 95% in a period of 100 years, Opdam et al., 2003). Subsequently, for 80 species the spatial bottlenecks were analysed. These 80 species cover over three quarters of all species from Annex II and IV of the Habitats Directive and Annex I of the Birds Directive in the Netherlands. For the other one quarter of the species no or not reliable enough data are available to parameterise the model.

Calculations were done for grid cells of 250 m × 250 m and for each grid cell the dominant vegetation type, if more than one was present, was used. Below the habitat map and method to determine the environmental and spatial bottlenecks are described in more detail.