Appendix 2

We here describe the data of wetlands and dispersal distances that we used to construct the network model of wetland connectivity.

Wetland data

Our analysis includes all wetlands in Stockholm County present in the National Swedish Wetland Survey (abbr. VMI), which was performed by the county authorities under supervision from the Swedish Environmental Protection Agency (Gunnarsson and Löfroth 2009). It includes 641 wetlands with a mean area of 23.1 ha (22.8 ha standard deviation), in total 148 km^2 or 2% of the county's land area, which is low compared to Sweden in general. The VMI mapped wetlands based on aerial photography and defined wetlands as sites where at least half the vegetation is hydrophilic (including also periodically flooded shores with sparse vegetation). This is similar to the definition of the Ramsar Convention with the exception that areas with permanent water cover, like open lakes and coastal marine areas, are not considered as wetlands in the VMI. The wetlands are divided into four classes relating to conservation values, based on field surveys in around 20% of the objects, in addition to the aerial photography (SCAB 1997). We include all four classes in our analysis, also the lowest category that holds almost 10% of the county's wetlands and includes gravely degraded wetland habitats. The classification is however coarse and uncertain, and it is not unambiguously imperative to landscape-ecological planning. For example, local authorities might permit the development of a degraded wetland area with regard to its low conservation values. Alternatively, they might try to restore the degraded wetland if it seem important from a landscape-ecological perspective, for example regarding its location in relation to other wetlands. In addition to restoring the ecological integrity of the specific wetland, such restoration effort could enhance the connectivity of the wetland system.

Wetland connectivity

The flows of groundwater and surface water are key to the ecological integrity of wetland systems, yet a considerable proportion of the spatial biotic connections in wetland systems are not strongly related to hydrology. Among those are the dispersal processes of fauna over land, and seed dispersal by wind, humans and other animal vectors (Morris 2012; Soomers 2012; Verhoeven et al. 2008). The potential for dispersal depends on the spatial distribution of wetlands – also in the absence of direct hydrological links – and this has implications for landscape planning and conservation (Amezaga et al. 2012). The distances between wetlands condition the chance of dispersal success, which in turn affects the survival of a species and their ability to relocate and recolonize in response to habitat changes and local population dynamics (Bergsten et al. 2013). Connectivity is critical especially to those species whose maximal dispersal distance limits them to colonize only the nearest wetlands, if any (Hanski 1999). More rare, long-distance dispersal events are crucial to population spread and to maintenance of genetic connectivity (Nathan and Muller-Landau 2000). Insufficient long-distance dispersal of native species because of habitat fragmentation is one of the main threats to global biodiversity (Trakhtenbrot et al. 2005). 41% of the world's amphibian species are threatened (Frost 2013) and the largest potential to halt this decline comes from landscape-scale conservation plans that manage connectivity patterns (Cushman 2006). Amphibians have previously served as indicators of biological diversity in Stockholm Municipality (Löfvenhaft et al. 2004) and their interaction with the landscape make them sensitive to fragmentation (Joly et al. 2001; Sjögren 1991; Vos and Chardon 1998). Their distribution depends largely on juvenile dispersal, yet less studied than adult movement (Edenhamn 1999). Löfvenhaft et al. (2004) suggested amphibian studies as complementary tools for spatial planning in Stockholm, to reveal the impact of land-use changes on spatial and temporal habitat continuity. Spatially explicit population models and network models of

amphibian populations have both been proven useful to predict and evaluate consequences of land-change scenarios (Ribeiro et al. 2011; Rustigian et al. 2003; Zetterberg et al. 2010).

Sjögren (1991) found a highly elevated risk of local extinction of the pool frog *Rana lessonae* when inter---wetland distances exceeded 1 km, despite rare dispersal events up to 15 km (in Austria, Tunner 1969 cited in Sinsch 1990). Reports of the maximum dispersal distance of the common toad *Bufo bufo* range from 1.6 km (Sinch 1988) to 1.9 km in Sweden (Reading et al. 1991) and 3 km in Switzerland (Heusser 1969 cited in Sinsch 1990). Previous research in Stockholm Municipality has used 2 km as a maximum spring migration distance for the common toad (Löfvenhaft et al. 2004; Mörtberg et al. 2006). A third amphibian species of conservation interest in Stockholm County is the crested newt *Triturus cristatus*, for which Halley et al. (1996) used 1 km as maximum dispersal distance in a population viability study. Recent restorations of wetlands in southern Sweden have improved the situation of previously regionally endangered amphibians (Nyström & Stenberg 2006; Tranvik & Bjelke 2010). These include the fire-bellied toad *Bombina bombina*, the natterjack toad *Epidalea calamita* and the tree frog *Hyla arborea*, with respective maximal dispersal distances of 1.7 km, 2.6-4.4 km (Smith and Green 2005) and 1.6–12.6km (Edenhamn 1999).

To capture the range of distances outlined above, we here apply 1, 2, 3, 4 and 5 km as inter-wetland threshold distances to assess connectivity. Using the measure described below we analyze the total connectivity values over the distance range 1-5 km. Unless otherwise clearly stated, the terms “wetland connectivity” or “ecological connectivity” hereafter in this paper refer to inter-wetland connectivity in this distance interval. Our analysis range of 1-5 km also corresponds to the review of Smith and Green (2005, see figure 3 therein) on dispersal distances of 53 anuran species, where 44% of 102 references reported maximum movement distances over 1 km, with only some exceptional examples over 8 km. Although specifically selected for amphibians in the region, the 1-5 km range includes some other processes that connect wetlands. For example, human individuals like bird watchers may walk from one wetland to another within 5 km. There are also non-amphibian species potent to disperse up to maximally 5 kilometers. For example, the common shrew *Sorex araneus* is found in many biotopes but prefers wet forests and meadows and can disperse maximally up to 5 km (Tegelström and Hansson 1987). Soomers (2012) studied wind dispersal of the common reed *Phragmites australis* and found that most seeds were carried shortly (6 m medium dispersal) but with some long distance events over 1 km. Many wetland plants depend on assisted dispersal, for which water birds and furry animals are the most significant dispersal vectors (Amezaga et al. 2002; Clausen et al. 2002; Soomers 2012). The movements of wetland birds within and between catchments shape the dispersal pattern of many hydrophilic plants (Amezaga et al. 2002; Figuerola and Green 2002; Haig et al. 1998;). Wichmann (2009) demonstrated that seeds that were dispersed by wind maximally 250 m were carried by walking humans up to 10 km (cf. Auffret and Cousins 2013). We stress that our method requires that the interpatch distance be carefully considered when mapping the ecological connections. The precision of network-based connectivity models can be further enhanced by incorporating matrix data, i.e., of the land use between the patches of the focal resource, such as elevation data, the road network or observed dispersal events.

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