ELSEVIER

Acta Oecologica 23 (2002) 213–222

ACTA OECOLOGICA
INTERNATIONAL JOURNAL OF ECOLOGY

www.elsevier.com/locate/actao

Biotic wetland connectivity—supporting a new approach for wetland policy

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Received 14 December 2001; received in revised form 6 March 2002; accepted 7 March 2002

Abstract

Wetlands are key habitats connected physically and socially with processes occurring over a much wider territory. The biotic connection through dispersal mechanisms among wetlands is of primary importance to wetland management and policies. However, traditional wetland conservation approaches are based on the preservation of isolated sites considered to be of special importance (typically owing to their importance for concentrations of migratory waterbirds). Research linking local species richness and bird migration suggests that the effect of wetland loss on regional diversity might be much larger than what would be expected from direct habitat loss. Since the biotic connection among wetlands serviced by waterbirds appears to be more efficient within a limited range, the distribution of wetlands in space is a key aspect determining wetland connectedness even in the absence of direct hydrologic links. Protected areas should thus be defined with regard to waterfowl movements and waterbird migration as functional processes contributing to aquatic species migration and local species richness. This calls for a regional approach to wetland management within a continental context. This paper aims at defining an operational view of the dispersion function of wetlands and its implication for conservation policies. For this purpose, we examined the conservation policies of the Ramsar Convention (the international treaty that protects wetlands) and the European Union (as an example of relevant continental level policy-making) from the viewpoint of bird-mediated dispersal of aquatic organisms. We propose nine specific avenues for the inclusion of bird-mediated dispersal in the policy documents examined. Non-governmental organisations and other organisations working in waterbird conservation should also recognise the importance of their policies for aquatic biodiversity at broader levels and avoid compartmentalising their conservation activities.

Keywords: Wetland policy; Wetland management; Biotic connectivity; Bird dispersal; Biodiversity

1. Introduction

Wetlands are key habitats connected physically and socially with processes over a much wider territory. In the past, wetlands were regarded as unhealthy land to be reclaimed for the benefit of mankind. Wetland destruction by human intervention commenced long ago and has accelerated in recent times. As a consequence, wetlands are among the most degraded of all ecosystems. The relatively recent acceptance of the socio-economic and ecological importance of wetlands in developed countries has not yet succeeded in reversing this trend.

Wetlands were the first major ecosystem to be protected by an international treaty. During the 1960s, European scientists and conservationists recognised the need for such a treaty. The main motivation was to stop the decline of waterfowl populations which was then linked to habitat loss. Similar efforts to preserve wetlands had also been going on for some time in North America (Moser et al., 1993). After several years of international discussions, the text of the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar, Iran, 1971) was finally approved (Matthews, 1993; Ramsar Convention Bureau, 1996). The convention entered into force in 1975, and by 22 November 2001, a total of 130 States had become Contracting Parties, having declared 1108 sites as Wetlands of International Importance (http://ramsar.org/sitelist.doc).

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In this paper we consider 'wetlands' to be defined as in the Article 1 (1) of the Ramsar Convention, i.e., "areas of marsh, fen, peatland, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt, including marine waters, the depth of which at low tide does not exceed six meters". This definition suits our discussion below, although we focus on continental wetlands more than marine waters. The same definition has also been adopted by the European Commission, which groups the wetlands in Europe broadly as marine and coastal wetlands, estuaries and deltas, rivers and floodplains, lakes, freshwater marshes, peatlands and man-made wetlands (CEC, 1995).

From its original focus on wetlands as a habitat for waterfowl, the Ramsar Convention has developed into an international instrument dealing with wetlands from a broader point of view. In particular, since its association with the Convention on Biological Diversity, both bodies are working together on issues of common importance such as impact assessment, inland waters and alien species (Klaphake et al., 2001). In spite of this progressive attitude and numerous achievements since 1975, conservation efforts on the ground have to some extent been marred by the original exclusive focus on special sites, mainly selected by the number of birds in these particular sites. However, the Ramsar Convention has strengthened its focus on fish and other aquatic organisms and communities in recent decades (see http://www.ramsar.org/key_criteria for full details of Ramsar criteria). Extending wetland protection to the whole catchment area and beyond proves to be a difficult endeavour. Even when dealing with highly protected wetlands, powers and interests outside the sphere of conservation make this task extremely difficult (Amezaga and Santamaría, 2000).

In this paper we review recent evidence supporting the need for wetlands policies that go beyond identification and conservation of individual wetland sites. The biotic connection between wetlands maintained by dispersal mechanisms, above all bird-mediated dispersal, appears to have a more important role in sustaining diversity of freshwater organisms than is assumed by current management practices and conservation policies. The same evidence points towards the need to focus on a rich distribution of wetlands in space as much as on maintaining quality sites. This need could become more important in the face of global change and an increase of non-native species invasions. We examine the significance for international wetland protection and, in particular, the development of European environmental policies as an example of continental policy-making.

2. Wetland connectedness

Wetlands are not isolated spaces but, on the contrary, dynamic, complex habitats with biotic and abiotic connections all around. Shaped by natural processes and social practices, they should be conserved by what Ramsar calls wise use, the sustainable utilisation for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem (Davis, 1993).

Among the abiotic connections, those related to the flow and quality of water are, perhaps, the most important ones. Hydrological conditions determine the seasonal fluctuations in the rainfall or inundation patterns, which is particularly important in Mediterranean wetlands (Salathé, 1993). As water depth, flow and intensity define the characteristic flora and fauna (Jordan et al., 1998; Snodgrass et al., 2000; Baldwin et al., 2001; Frederick and Ogden, 2001; Graves, 2001; Timms and Boulton, 2001), wetlands can be extremely sensitive to hydraulic interventions in other parts of the catchment affecting surface or groundwater flow (Salathé, 1993; Suso and Llamas, 1993; Syphard and García, 2001; Chimney and Goforth, 2001). Similarly, changes in water composition and pollution from distant sources can affect severely the viability of wetlands (Cirujano et al., 1996; Chimney and Goforth, 2001). In general, a wetland is dependant on the conditions of the landscape that surrounds it.

The term biotic connections refers to the movements of the biota present in wetlands. Aquatic species such as fish or shrimps, dragonflies, livestock and their herders, small rodents and, above all, migratory waterbirds act as visitor species increasing the diversity of animals that inhabit wetlands (Hails, 1997). However, many aquatic plants and invertebrates lack the mobility to travel directly by their own means from one catchment to another. Since aquatic habitats are ecological islands surrounded by terrestrial environment, the dispersal potential of their biota is likely to influence the composition and functioning of their ecosystem. Potential effects of dispersal include changes in genetic diversity within populations, genetic structure among populations, distribution of species, colonisation/extinction effects on local community composition, and the rates of spread of new and alien species.

3. The importance of bird-mediated dispersal

Many aquatic organisms rely on the passive transport of resting stages for their dispersal (Figuerola and Green, 2002; De Meester et al., 2002). The high dispersal capacity of aquatic organisms is supported by evidence such as the rapid colonisation of new habitats (De Meester et al., 2002), the widespread distribution of aquatic species (Santamaría, 2002), the widespread occurrence of specific genetic lineages in organisms, the rapid spread of exotic species and the observation that dispersal does not limit community composition in isolated ponds (De Meester et al., 2002). Significant potential for dispersal is indicated by the recovery of viable propagules from vectors such as wind, water, aquatic insects and waterbirds (Charalambidou and San-

tamaría, 2002; Figuerola and Green, 2002; Green et al., 2002a; Santamaría, 2002).

Waterbirds appear to be a particularly significant vector, due to their abundance, widespread distribution, the high number and frequency of their movements among lakes and their tendency to show long-distance movements (Green et al., 2002). Evidence for the occurrence and importance of waterbird-mediated dispersal has been reviewed in this volume (De Meester et al., 2002; Santamaría, 2002; Green et al., 2002a; Charalambidou and Santamaría, 2002; Clausen et al., 2002) and elsewhere (Figuerola and Green, 2002), although significant constraints to its potential effects on colonisation (Clausen et al., 2002; Green et al., 2002a), distribution (Santamaría, 2002), community composition (Hobæk et al., 2002) and gene flow (De Meester et al., 2002) have also been pointed out. Although small resting eggs and seeds with adhesive structures may be transported externally, internal transport in the digestive tract seems to be the most significant mode of long-distance dispersal, particularly for large propagules (Figuerola and Green, 2002; Charalambidou and Santamaría, 2002).

There seems to be general agreement that passive transport is likely to decrease in importance as distances get larger. Waterbird-mediated transport is likely to take place on a fairly regular basis over distances ranging from tens to hundreds of kilometers (Charalambidou and Santamaría, 2002), particularly during moult migrations (Clausen et al., 2002) and during winter (Figuerola and Green, 2002; Green et al., 2002a). Transport over larger distances might take place during autumn and spring migrations; while its frequency is likely to be extremely low (Charalambidou and Santamaría, 2002; Clausen et al., 2002; Green et al., 2002a), it might result in quite significant transport due to the enormous numbers of birds undertaking such migrations every year (Scott and Rose, 1996; Rose and Scott, 1997).

The high dispersal capacity of aquatic organisms is probably the underlying process of a commonly observed phenomenon, i.e., the quick colonisation of ‘empty’ aquatic habitats (newly formed waterbodies, restored wetlands and wetlands recovering from perturbations; De Meester et al., 2002). Its effect on the genetic structure of, and gene flow among, populations in older and more stable habitats seems rather limited (De Meester et al., 2002; Santamaría, 2002), particularly for organisms with clonal growth (since early establishing of clones tend to result in strong priority effects; De Meester et al., 2002). An extreme case is provided by cyclical parthenogetic organisms, where the combination of priority effects and local adaptation seems to constrain effectively gene flow among neighbouring populations (De Meester et al., 2002). It is important to note, however, that given the low levels of genotypic variation that characterise many clonal aquatic organisms, especially macrophytes (Santamaría, 2002), low rates of effective migration may result in significant contributions to the maintenance of within-population genotypic diversity.

4. Influence of wetland loss on bird-mediated connectivity

Over recent decades, the total area of well-conserved aquatic habitats has been changing at an increasing rate as a result of man-made habitat loss (desiccation, river regulation and canalisation) and habitat deterioration (pollution, acid rain, eutrophication). Approximately two thirds of all European wetlands have been lost since the beginning of the last century (CEC, 1995). High rates of current habitat loss have been reported for the intertidal and coastal areas of Britain (Davidson et al., 1991) and the United States (Gosselink and Aumann, 1980). It is believed that overall more than half of the world’s wetlands may have been destroyed in the last century (Ramsar Convention Bureau, 1996). Many countries have developed policies that actively promote the disappearance of wetlands, mainly through drainage for development and inadequate agricultural practices (Green et al., 2002b). In Europe, the effect of the Ramsar Convention and the development of more coordinated European policies has had some influence on the course of events. However, this frequently only applies to the protected areas themselves. In most of the countries, the total number of wetlands is still decreasing (Finlayson et al., 1992; Groombridge et al., 1998).

The loss of suitable habitats also has consequences for migratory waterbirds, as it may affect wintering and breeding grounds as well as stop-over habitats. Gradual loss of both wintering and breeding habitats results in increasing rates of population decline of migrants (Sutherland, 1996, 1998a). Loss of stop-over habitats results in a concentration of the migratory waterbirds in the few remaining ones which are in good state of conservation, and in increased mortality during migration when the carrying capacity of the remaining wetlands is exceeded.

The problem could be exacerbated by the effect of climatic change. The migratory birds most threatened by climate change are likely to be shorebirds, ducks and geese (WWF, 1997). Sea-level increase threatens highly valuable coastal areas (Wash and North Norfolk coast, UK; Wadden Sea, the Netherlands, Germany and Denmark; Danube Delta, Romania), and trends towards a drier climate in the Mediterranean basin may eliminate up to 85% of the remaining wetlands (including strategic wetlands like the Coto Doñana, Spain and the Camargue, France). Changes in seasonal dynamics of prey organisms and food plants will influence migratory birds through changing their food resources, while habitat loss would also damage the breeding grounds in the Arctic tundra. There is substantial evidence that climatic change would result in a major distortion of present migratory routes, changes in timing and/or in diet of the waterbirds, and even in a strong decrease in the number of migrants (WWF, 1997; Sutherland, 1998b).

The bean goose (*Anser fabalis*) and greylag goose (*A. anser*), for example, have shortened their migratory

routes in the last few decades ('short stopping'), switching their winter quarters from southern Europe to central Europe (see Madsen, 1991 and Persson and Urdiales, 1995 for *A. fabalis*; and Nilsson and Persson, 1993, 1994 for *A. anser*). Krivenko (1990) also reported major changes in the wintering habits of many Russian waterfowl species, which he related to climatic changes over the last centuries. Other changes in migratory behaviour are reviewed by Sutherland (1998b).

The impact of different human activities has also modified the diet of several migratory species, with the majority of individuals (hundreds of thousands) of some species now feeding in crops and grassland instead of on aquatic organisms. Some of the better known examples, including swans (*Cygnus cygnus*, *C. colombianus bewickii*), geese (*Anser fabalis*, *A. brachyrhynchus*, *A. albifrons*, *A. anser*, *Branta bernicla*, *B. canadensis* and *B. leucopsis*) and ducks (*Anas penelope*, *A. platyrhynchos*), cause important crop damage every year (Madsen, 1991b). As a matter of fact changes in winter food supply owing to agricultural practices are partly responsible for the 'short stopping' in geese reported above.

5. Effect of decreased connectivity on wetland biota

Decrease and change in waterbird migration and diet has consequences not only for the diversity of birds, but also for the diversity of aquatic organisms that rely on bird dispersal. Although wind, flowing water and fish contribute to local transport (i.e., within river catchments), waterbirds are the most important (natural) dispersal vehicle between river catchments and isolated waterbodies (see above). Unfortunately, wetland loss and deterioration has probably already caused a severe reduction in local dispersal, since distances and degree of isolation among wetlands increase through habitat loss.

Since the diversity of aquatic communities depends on the equilibrium between species immigration and local extinction (Cox and Moore, 1993; Colinvaux and Steinitz, 1979; Dodson, 1992), changes in the abundance of wetlands and waterbird abundance, mobility and long-distance migration may be expected to have a major impact on the local diversity of aquatic organisms. The effects of wetland loss on regional diversity is thus expected to be much larger than what would be expected from direct habitat loss per se. These effects could include decreases in local and regional genetic variation, distributional ranges of species, and local species richness. Given that the presence of seed and resting-egg banks may represent a safety net that moderates some of these changes (De Meester et al., 2002), it is expected that the changes outlined above may only become apparent with some delay.

The effect of reduced dispersal will be particularly critical in the wetlands that already suffer decreased species richness. These include wetlands under anthropic stress (due to, e.g., drainage, pollution or eutrophication) and those recovering from it, and above all wetlands in extreme climates such as semiarid areas (due to reduced connectivity) and boreal climatic areas (due to their lower species and genotypic diversity). The latter are among those ecosystems that will be most affected by climatic changes, and the effect of the dis-adjustment of species–environment interactions on the aquatic communities is likely to be stronger since the inflow of new genotypes will be limited by reduced rates of migration.

Wetland policy should also take species invasions into account. Invasion by non-native species is becoming a general problem to virtually all ecosystems and at all continents (IUCN, 1997; Brundu et al., 2001). The problem seems however particularly serious in the aquatic environment, due to the high dispersal capability of many aquatic organisms and the ease with which they become established over large geographic ranges (De Meester et al., 2002; Santamaría, 2002). As a consequence, examples of extensive invasions by aquatic organisms abound in the literature (e.g., Groombridge et al., 1998; see also http://plants.ifas.ufl.edu for extensive information about aquatic plant invasions in North America). The current trend is likely to worsen due to widespread disturbance of environment–species relationships, caused by anthropogenic effects, climatic warming and nitrogen deposition. It is thus likely that species invasions will become a major global disturbance to ecosystem composition and function in the coming decades. Studies that demonstrate that community composition is regulated by competition rather than dispersal suggest that the best way to prevent species invasions is by making sure that existing ecosystems maintain a healthy representation of native species, and newly formed ecosystems are quickly re-colonised by assemblages of local species. Paradoxically, although efficient dispersal may not be readily apparent in undisturbed ecosystems (e.g., owing to priority effects), it may be the key to prevent the perturbation of such ecosystems and their invasion by alien species.

6. Implications of dispersion for wetlands policy

The emphasis in wetland conservation has always been on the preservation of special sites. These sites are largely managed as isolated units. The importance of wetlands for biodiversity is defined in terms of the diversity of species in the protected spaces and, mainly, in terms of the number of seasonal migrant birds stopping over (Hails, 1997). However, the above evidence shows a more complex picture. Birds are not only important per se. They also fulfil a very important functional role as being the main vector maintaining a biotic connection between catchments for aquatic plants and invertebrates.

The biotic connection among wetlands serviced by waterird appears to be more efficient within a limited range. This means that the distribution of wetlands in space is a very important consideration at regional level. Thus, an area rich in wetlands will promote local species richness. The appropriate scale for analysing adequacy of spatial distribution patterns should be determined by how waterbirds use wetlands in a region. Dispersion will have different effects and importance in different regions. Regional species pools can be expected to depend very strongly on the number of wetlands in north and south Europe because these areas are more sensitive to climate change and to changes in migration patterns. It should, however, also be mentioned that the distance between stopping-over places is of crucial importance. Bird-dispersal maintains a long-distance link at the continental scale. There are different degrees of spatial connectivity determined by the different bird migration routes (Lurz et al., 2002).

The important message is that wetland protection should take into account waterbird movements and bird migration as a functional process contributing to aquatic species migration and local species richness. From this point of view, increasing connectivity in critical areas by stopping wetland loss and introducing constructed wetlands (not replacing natural sites) appears ever more important. This functional role requires regional frameworks of management of both protected and non-protected wetlands linked to waterbird movement patterns. The concept of wetlands of international importance should take explicitly into account the existence of continental dispersion processes.

7. Conservation biology and wetlands: evolution of approaches

In conservation biology as a science, there is considerable debate about the relative virtues of conserving individual species (likened to the actors in a play), the ecosystem (the theatre) or ecological processes (the plot). There is currently no consensus about the priorities amongst these options (Simberloff, 1998), but there has been a clear historical shift in emphasis over recent decades from conservation of species towards ecosystems and later towards ecological processes within them. Indeed this trend has been closely linked to the emergence of conservation biology as a discipline from more ‘species centric’ disciplines such as wildlife management (Meffe and Carrol, 1994). These historical trends are clearly visible in the development of the wetland conservation movement, in which the early emphasis was placed on waterbirds (especially wildfowl, i.e., the Anatidae and coots of interest to hunters) followed by a later shift to wetland ecosystems. Thus, one of the leading non-governmental organisations (NGOs) in the field was the International Wildfowl Research Bureau founded in 1948, which changed its name to the International *Waterfowl* and *Wetlands* Research Bureau in 1987, and finally became Wetlands International in 1996. Likewise, the Wildfowl Trust founded in 1946 became the Wildfowl *and Wetlands* Trust in 1989. There has been a clear trend amongst such NGOs to broaden the scope of the ‘species’ to be conserved from wildfowl to all waterbirds and then to all aquatic organisms. In recent years, there has been a growing emphasis on the functions of wetlands (i.e., on some of the ecological processes) in the conservation movement, which is clearly visible in the evolution of Ramsar criteria and other documents over the years (see below). However, the role of bird-mediated dispersal in maintaining aquatic biodiversity at other levels has so far been completely ignored by these organisations, as have many other ecological processes with little direct relevance to human use of wetlands.

8. The Ramsar Convention

The Ramsar Convention (see http://www.ramsar.org/key_conv_e.htm for the full text) is the central element of global wetland policy. Its backbone is the list of wetlands of international importance (the Ramsar List). Each contracting party to the Convention must designate at least one site that meets the Ramsar criteria and ensure the maintenance of the ecological character of each Ramsar site. There is very detailed guidance on how to identify wetlands of international importance (see http://www.ramsar.org/key_criteria). The first group of criteria is about sites containing representative, rare or unique wetland types. The second group is about conserving biological diversity. Among the latter there are criteria based on species and ecological communities and specific criteria based on waterbirds and fish. The criterion 3 (species and ecological communities) refers to wetlands supporting populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region. The recommended interpretation of this criterion (http://www.ramsar.org/key_guide_list_e.htm#v) gives greatest conservation value to hotspots or places maintaining rare species. It would be convenient that this criterion would also be interpreted in a wider sense supporting the maintenance of networks of small wetlands in critical regions, as important landscape components for maintaining biological diversity. Similarly, the specific criteria on waterbirds (5 and 6) refer to total number of birds and percentage of individuals of one species. A new criterion could be introduced referring specifically to chains of wetlands supporting the functional role of bird-dispersal at continental level.

The Convention goes beyond the protection of special sites. Contracting parties commit themselves to include wetland conservation within their national land-use planning, so as to promote the wise use of all wetlands within the territory. Article 3 says that planning should promote the

conservation of listed wetlands "and as far as possible the wise use of wetlands in their territory". Article 4.1 asks to promote conservation by establishing nature reserves on wetlands "whether they are included in the List or not". These provisions should facilitate the approach proposed in this article in the countries that have signed the Ramsar Convention.

However, while the establishment of a list of protected sites is a relatively straightforward activity, the implementation of territory-wide policies is much more problematic. The Ramsar Convention has been encouraging the adoption of National Wetland Policies. Resolution VII.6 of the San José Conference of the Contracting Parties (1999) provides guidelines for developing and implementing these policies (http://www.ramsar.org/key_res_vii.06e.htm). At the time of the conference, 12 countries had reported the adoption of national policies and another 33 had taken steps in that direction. The guidance is quite clear regarding the need to co-ordinate wetland protection "with land, soil, water, air, wildlife conservation and economic development policies in order to secure the wise use of the nation's wetlands". Within this framework, it should be possible to include provisions for the strategic analysis of wetlands patterns in relation to the role of waterbirds in the dispersion of aquatic organisms at regional and continental levels. It remains to be seen to what extent all other policy makers, especially those involved in development issues, will take wetlands policies into account.

The implementation of international agreements on biological diversity may provide the necessary motivation for cross-sectoral co-ordination. The key role of wetlands in biological diversity has been acknowledged by the establishment of Joint Work Plans between Ramsar and the Convention on Biological Diversity (see http://www.ramsar.org/index_mou.htm). A very positive outcome of this collaboration is the River Basin Initiative (Ramsar/CBD) on integrating biological diversity, wetland and river basin management. The regional approach proposed in this paper should be implemented at the level of river basin management plans. However, plans should be drawn at a larger scale allowing the analysis of interbasin connectivity. Resolution VII.18 of the San José Conference gives guidelines for integrating wetland conservation and wise use into river basin management (http://www.ramsar.org/key_res_vii.18e.htm). Section J includes guidelines for the protection and restoration of wetlands and their biodiversity. Guideline J1 recommends the "assessment of the status of wetlands and their biodiversity in each river basin and, where indicated, undertake the actions needed to provide better protection measures". We suggest that a new guideline should be added to the Section J requiring that, in assessing the status of wetlands in each river basin, their role in supporting bird-mediated dispersal should also be considered, taking into account biotic transfer mechanisms between river basins (especially by waterbirds).

9. Wetlands and European Union environmental policy

The European Union can be taken as an example of continental policy making involving multiple states. We can distinguish two strands in European Union wetland policy: the implementation of international agreements signed by the Member States and the environmental legislation contained in the *acquis communitaire*.

All member states of the European Union are signatories to the Ramsar Convention and the European region holds 62% of the Ramsar Sites and 1/3 of the Contracting Parties. As a whole Europe has a global leadership role in supporting the Convention. A recent European regional meeting of the contracting parties acknowledged that the relationship between the EU legal framework and the Ramsar obligations needs to be explored in more detail (http://www.ramsar.org/mtg_reg_europe2001_report.htm).

The European Commission Communication on the Wise Use and Conservation of Wetlands (CEC, 1995) made an explicit reference to this relationship. The communication also signals the interconnectedness of different wetlands as an important fact. It states that "wetlands should not be considered in isolation but as forming a global interconnecting network, often between distant areas" and that "…wetlands serve as dispersal and migration corridors and stepping stones for many species. This favours the colonisation of new habitats and genetic exchange to maintain viable fish and waterfowl population". Bird-mediated dispersal of aquatic organisms other than fish and waterfowl is a new dimension to be added to this framework. The communication mentions specific actions towards policy integration, recommending the development of a strong Community wetland policy, providing policy guidelines and asking for their inclusion in the European Spatial Development Perspective.

The key European policies related to wetlands are nature conservation, water and land use. To this list we can add the recent European Biodiversity Strategy and the related Action Plans. Nature conservation is based on two Directives: the Birds Directive (Council Directive 79/409/EEC) and the Habitats Directive (Council Directive 92/43/EEC). The latter highlights several wetland habitats as conservation priorities. The most important element of the conservation policy is the establishment by the year 2004 of Natura 2000, a network composed of the Special Protection Areas for wild birds and the Special Areas of Conservation for natural habitats and threatened fauna and flora. Wetlands form a large group of the sites of Natura 2000. The aim of Natura 2000 is to contribute towards ensuring biodiversity through conservation of protected sites. The Article 3 (1) of the Habitats Directive states that Natura 2000 is "a coherent European ecological network of special areas of conservation". The Member States are encouraged to improve the ecological coherence by maintaining and developing appropriate landscape features. Thus, Article 10 says that "Member States shall endeavour, where they consider it necessary,

in their land use planning and development policies … to encourage the features of the landscape which are important for wild fauna and flora. Such features are those which, by virtue of … their function as stepping stones (such as ponds or small woods), are essential for the migration, dispersal and genetic exchange of wild species". This is completely coherent with the requirements of bird-mediated dispersal. However, while the designation of special sites is quite clear and compulsory (European Commission, 2000), the Article 10 is left to the judgement of the Member States. This is not very promising taking into account the reluctance to implement these Directives by several Member States (Krämer, 1998; and COM(2001) 162 final on Biodiversity Action Plan, see below). The stated aim of ecological coherence reinforces the view of the Communication on Wetlands (CEC, 1995) that the widest possible classification and designation of wetlands be applied. The findings reported in this paper strongly support both wide classification and development of landscape features.

The Convention on Biological Diversity (CBD) was signed by the Community and all the Member States in 1992. The Council Decision 93/626/EEC concerning the conclusion of the CBD declares that States are responsible for the conservation of their biological diversity. The Commission has developed a European Community Diversity Strategy (Communication COM(98) 42 final). One of the themes of the strategy is the conservation and sustainable use of biological diversity implemented through Biodiversity Action Plans in the areas of conservation of natural resources, agriculture, fisheries and development and economic co-operation. The Action Plan for the Conservation of Natural Resources (Communication COM(2001) 162 final) is the more relevant for our purposes. It states clearly that "as the preservation of biodiversity requires actions not only within designated areas but also across the whole territory, the Action Plan also has a focus on land use related environmental initiatives… and the integration of biodiversity in other sectors". Point 3 of the Plan is about reversing the current trends of biodiversity loss related to management of water, soil, forest and wetlands. Here is where a specific mention to the loss by discontinuity of bird-mediated dispersal should be introduced.

The Plan relies heavily on the new Water Framework Directive (WFD; Directive 2000/60/EC) for the conservation and sustainable use of biodiversity at river basin level. Biodiversity is the central indicator used by the WFD to define what constitutes high and good ecological status. Member States shall aim to achieve good surface water status at the latest 15 years after the date of entry into force of this Directive. Some functional parameters are used as indicators of status, but the dominant ones are structural indicators in terms of categories of organisms. Four trophic layers are identified: phytoplankton, macroalgae and angiosperms, benthic invertebrate fauna and fish fauna. One Action of the Biodiversity Plan is to ensure that the River Basin Management Plans required by the WFD reflect biodiversity concerns by, amongst others, "establishing a string of aquatic ecosystems with restored or improved ecosystem function, which may function as aquatic ecological corridor". It also asks for detailed information to have a better understanding of hydrological and ecological interaction between wetlands, the riverine zone and the aquatic ecosystem in a river basin. There is a conspicuous absence of references to the role of dispersal mechanisms in the maintenance of diversity of aquatic ecosystems in this part of the Action Plan. The actions should include the need to perform functional analyses of bird-mediated dispersal within and between river basins.

One of the essential problems of implementing EU environmental policies encompassing the whole territory is that land use policies are determined by Member States. The European Spatial Development Perspective (ESDP, European Commission, 1999) produced by the Ministers responsible for Spatial Planning in the Member States has been the first attempt to establish common objectives and concepts for the future development of the territory. Within the ESDP, there is an acknowledgement of the need to avoid the isolation of protected areas with a broader land use policy. It is also mentioned that the conservation and development of biodiversity requires the successful development of European ecological networks. Section 2.4.1 specifically refers to the loss of biological diversity and natural areas. This section should include the notion of the functional role of bird-mediated dispersal in maintaining diversity.

10. Value of flyway management plans

For some time, there has been considerable interest in the co-ordination of conservation measures for migratory waterbird populations (especially for the Anatidae exploited for hunting along the whole migratory flyway; Moser et al., 1993). Thus, in 1986 the North American Waterfowl Management Plan came into operation. Since then there have been moves to develop agreements for all types of migratory birds under the Convention of Migratory Species (CMS, or Bonn Convention), and the African–Eurasian Migratory Waterbird Agreement came into force on 1 November 1999, covering 172 species of birds (see http://www.unep-wcmc.org/AEWA/eng/intro.htm). Similarly, an Asia–Pacific Migratory Waterbird Conservation Strategyhasrecentlybeenlaunched(seehttp://www.ea.gov.au/water/wetlands/mwp/2001-2005/index.html).

These agreements have been developed from a 'species conservation' perspective, recognising the need to co-ordinate conservation of declining migratory species between different range countries. The emphasis placed on conservation of waterbirds above other aquatic organisms or ecological processes is partly due to an anthropogenic, emotional response (i.e., humans tend to prefer large, warm

blooded organisms to small, cold blooded ones) and has been heavily criticised for this reason (Herrera, 1989; Montes, 1995). However, the role of such migratory birds in dispersion ironically provides a strong need for such 'flyway management' agreements, and a good reason why non-ornithologists should value them. Unfortunately, the 'waterbird lobby' has so far not recognised the importance of the role of their focal species in aquatic dispersion processes (e.g., there is no mention of this issue in the texts of the above agreements).

Many species of waterbirds have undergone major population declines and are under threat of global extinction (BirdLife International, 2000). These include species like the marbled teal (*Marmaronetta angustrostris*) with migratory movements different to more abundant, sympatric bird species and whose declines have likely had serious consequences for dispersion of other organisms (Green et al., 2002a). There exist numerous single species conservation plans for such species, yet these documents pay no attention to the importance of such species in maintaining populations of other aquatic organisms (Heredia et al., 1996; Schäffer and Gallo-Orsi, 2001). Furthermore, in many cases these plans do not have an operational level equivalent to that of the corresponding migratory flyways. For example, there are international plans whose scope is limited to European countries, even for species like ferruginous duck (*Aythya nyroca*) that migrate outside Europe (Schäffer and Gallo-Orsi, 2001). The use of such political boundaries to define limits of conservation actions for species migrating outside them ignores the significance of the role of birds in dispersing organisms and in wetland processes in general. The fragmentation of wetland conservation organisations along taxonomic lines (e.g., the existence of influential ornithocentric lobbies such as BirdLife International, or IUCN specialist groups for each taxonomic group) is probably one reason for their lack of attention to dispersal processes.

11. Conclusions

Research linking local species richness and bird migration supports the introduction of a new dimension in wetland policy. The biotic connection among wetlands serviced by waterfowl appears to be more efficient within a limited range. This means that the distribution of wetlands in space is a very important consideration at regional level. Protected areas should be defined with regard to waterfowl movements and waterbird migration as functional processes contributing to aquatic species migration and local species richness. Species-oriented conservation programmes focussing on waterbird species (e.g., action plans) should operate at a migratory flyway level and should pay attention to the role of these species in dispersion of other aquatic organisms.

In this paper we propose specific avenues for the inclusion of bird-mediated dispersal in policy documents of the Ramsar Convention and the European Union. These include: (1) Introducing new criteria for identification of wetlands of international importance (Ramsar list), referring specifically to the functional role of bird-dispersal at continental level. (2) Including provisions for the strategic analysis of wetlands patterns in relation to the role of waterbirds as dispersal agents at regional and continental levels in Ramsar guidelines for developing and implementing National Wetland Policies. (3) Adding a new guideline to the River Basin Initiative (Ramsar + Convention on Biological Diversity) requiring that, in assessing the status of wetlands in each river basin, their role in supporting bird-mediated dispersal (particularly biotic transfer mechanisms *between* river basins) is considered. (4) Adding dispersal of aquatic organism other than fish and waterfowl to the explicit reference to wetlands as "dispersal and migration corridors and stepping stones" in the policy framework proposed by the European Commission Communication on the Wise Use and Conservation of Wetlands. (5) Making clear and compulsory guidelines for Article 10 of the Habitats Directive, aimed at encouraging the features of the landscape which are essential for the migration, dispersal and genetic exchange of wild species. (6) Introducing a specific mention to the loss of biodiversity by discontinuity of bird-mediated dispersal in the Biodiversity Action Plan for the Conservation of Natural Resources (European Community). (7) Adding a reference to the functional role of dispersal mechanisms in the maintenance of diversity of aquatic ecosystems to the Action of the Biodiversity Plan aimed at ensuring that the River Basin Management Plans required by the Water Framework Directive reflect biodiversity concerns. (8) Including the functional role of bird-mediated dispersal in the section on loss of diversity of the European Spatial Development Perspective. (9) Acknowledging the role of migratory birds in dispersion to flyway management agreements. Likewise, NGOs and other organisations working in waterbird conservation should recognise the importance of their policies for aquatic biodiversity at other, broader levels, and be cautious of over compartmentalising their conservation activities.

Acknowledgements

Critical comments by M. Klaassen and two anonymous referees are gratefully acknowledged. Funding by European Project 'LAKES: Long distance dispersal of aquatic key species' (European Commission, ENV4-CT97-0585) is also acknowledged. This is publication 2955 of the Centre for Limnology of the Netherlands Institute of Ecology (NIOO-KNAW) and publication 274 of the Centre for Wetland Ecology.

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