National Wetlands Newsletter, Vol. 35, No. 5, Copyright © 2013 Environmental Law Institute ® Washington, DC, USA

Wetland Functions: Not Only About Size

With respect to the size and distribution of wetlands, several strategies for analyzing wetland functions are described.

By Paul Adamus

The size distribution of wetlands—that is, the proportions of a watershed's or region's wetlands belonging to various size categories—can significantly influence ecosystem services the wetlands as a whole are able to provide. Consideration of those services is essential if we are to achieve a goal of no net loss of wetland functions, not just a no net loss of acres.

Several human-related factors and policies influence the size distribution of wetlands. These include (a) conservation programs that favor acquisition mainly of larger wetlands, (b) regulations that fail to adequately protect small wetlands, and/or (c) increased use of mitigation banks that tend to replace losses of many small wetlands with created or restored wetlands that are fewer, larger, and at locations distant from where the losses occurred. Beginning at least 20 years ago, Leibowitz et al. 1992 mentioned concerns about cumulative reductions in ecosystem services that might result from shifts in wetland size distributions at landscape scales.

Any framework to assess success of wetland conservation strategies must consider whether many small wetlands are likely to function more, equal, or less than a fewer large wetlands of the same cumulative area. Answering this depends not only on wetland size, but on the range of habitat features present within the large wetland as compared to the range found collectively among the small wetlands. The range is commonly greater among many small wetlands, if only because they are bound to be spread across a larger portion of the landscape and thus are likely to encounter a wider variety of climatic, soil, geologic, and land use conditions.

The answer also depends on specific characteristics of the wetlands being lost, created, restored, or preserved. For example, damages from river flooding that occur downstream from some wetlands can be ameliorated somewhat by removal of water by wetlands higher in the watershed via their processes of evaporation and transpiration. Vegetative transpiration, which occurs primarily along a wetland's edge with adjoining uplands, results in proportionately greater water removals in small than large wetlands due to the greater edge-to-area ratio in small than large wetlands (Millar 1971). However, on an annual basis, greater levels of water removal can occur via evaporation in some large wind-swept wetlands that contain significant extent of open water (Stannard et al. 2013). Whichever process dominates depends as well on antecedent moisture, water regime, seasonal timing, local climate, vegetation density, and other factors.

Often, the richness of plant species (e.g., Weiher and Boylen 1994; Matthews 2004), dragonflies (Oertli et al. 2002), and other groups increases with increasing wetland area. Whether it matters if that area is distributed among several wetlands or concentrated in one has been examined only occasionally (e.g., Peintinger et al. 2003). Where species composition varies little from wetland to wetland, maintaining a region's overall species richness usually can be accomplished more efficiently with fewer large wetlands than with equivalent cumulative area of small ones (e.g., Hecnar and M'Closkey 1997; Florencio et al. 2011; Di Minin and Moilanen 2012; Martinez-Sanz et al. 2012). Many small moderately dispersed wetlands, especially if connected with corridors of intact upland habitat, can reduce risks to the individual animals and plants in any single wetland from local drought, pollution, and some other stressors. On the other hand, large wetlands, because of their larger area-to-edge ratio, usually provide more buffer from disturbances in adjoining uplands, thus protecting wetland water quality and microclimate important to some wetland-interior species (e.g., Baldwin and Bradfield 2005). It also is easier to acquire and manage a single large wetland than an equal area of many small (and likely dispersed) wetlands. Small wetlands tend to be shallower and more prone than large wetlands to drying out or freezing to the bottom completely (e.g., Price 1993). This limits their capacity to support resident fish, but enhances habitat for many other species, such as amphibians that otherwise are often preyed on by fish (Eaton et al. 2005). However, because small wetlands are more likely to contain little or no surface water, this potentially makes their birds more vulnerable to mammalian predators (Willms and Crawford 1989). Presence of numerous small (and thus usually shallow and dispersed) wetlands is not important to all species, but clearly is important to species that tend locally to form metapopulations (Gibbs 1993; Bauer et al. 2010).

Wetland size also potentially affects water purification functions. The greater edge-to-area ratio that is provided collectively by many small wetlands, as well as their typically more dynamic water levels as compared to those of larger wetlands in similar watershed positions, imply a greater interface between typically oxic (upland) and anoxic (wetland) soil conditions. This can increase their denitrification function (Wray and Bayley 2007), and that could be a significant benefit where nonpoint pollution of downslope waters is a concern. Denitrification might also be less in large wetlands because their usually wide expanses of open water generate greater wind and wave action, which aerates sediments. However, that aeration might help keep another nonpoint pollutant, phosphorus, immobilized in sediments. With regard to carbon cycling, because small wetlands are shallower, they generally support greater primary productivity per unit volume, but perhaps also generate more greenhouse gases (Blackwell and Pilgrim 2011).

Because the effects of wetland size are so function-specific and variable, one strategy might be to just maintain a variety of size classes within a landscape. This assumes no preference for any particular wetland size. The strategy would help satisfy the needs of some waterfowl species, for example, that require both small and large wetlands at different points in their life history (Yerkes 2000).

A second strategy might be to analyze and emulate where practical the historical wetland size distribution and spatial pattern. Historical size distributions can be approximated using complex statistical procedures in combination with aerial imagery, topographic analysis, and soils maps (e.g., Miller et al. 2009; Zhang et al. 2009; Hunter et al. 2012; McDonald et al. 2012). However, anticipated climate change or watershed development could suggest that configurations other than what existed historically may be more appropriate if the goal is to maintain adaptive wetlands capable of supporting human needs.

A third strategy might be to estimate, across all wetlands within a watershed or region, factors other than size that predict the functions and benefits that wetlands provide. Such factors are estimated most quickly by identifying biological community type, hydrogeomorphic (HGM) class, and other indicators of wetland functions. Coarse-level classifications of biological communities (e.g., forested vs. emergent) and hydrogeomorphic type (e.g., riverine or depressional) are often used as partial surrogates for functions mainly because they can be estimated quickly from aerial imagery and topographic maps without encountering difficulties of site access. However, although hydrogeomorphic classification is an important first step in approximating the levels of various functions, by itself, it is an insufficient indicator of changes in a watershed or region's balance sheet of wetland functions.

Where spatial data are adequate, more refined estimates of wetland functions as well as ecosystem services (which include consideration of the users of wetland functions) can be obtained at a landscape scale through GIS-based procedures such as NWIplus (formerly LLWW, Tiner 2010). Where site access is possible, even more refined estimates of wetland functions may be obtained by using rapid national-scale methods such as WET (Adamus et al. 1987) and its successor WESP (Adamus et al. 2013) or still better, by using methods tailored to wetlands in a particular state or region (e.g., Hruby 2004; Adamus et al. 2009). Likewise, the information obtained from rapid methods for assessing wetland condition or "health" (e.g., CWMW 2013) or from biotic analyses using integrity indices (e.g., Mack 2007) can characterize with more detail the net changes in biological communities.

As mentioned by Stevenson and Hauer (2002), a framework to assess success of wetland conservation strategies could pair information on wetland functions (from HGM type alone or as augmented with rapid assessment methods) with information on community type (based simply on vegetation form or as augmented with more detailed biological analyses). Trend analyses of the changing statistical distribution of both the size and functions of wetlands would indicate if a policy preference for conserving large wetlands, and/or disregarding the protection of wetlands below a certain size, is ultimately affecting wetland condition and functions cumulatively and at broad scales.

References

Adamus, P.R. et al., Wetland Evaluation Technique (WET), Volume II, Methodology, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi (1987).

Adamus, P. et al., Oregon Rapid Wetland Assessment Protocol (ORWAP): Calculator Spreadsheet, Databases, and Data Forms, Oregon Dept. of State Lands, Salem, OR (2009).

Adamus, P.R. et al., Wetland Ecosystem Services Protocol (WESP), Beta Test Version 1.3 (2013), online: http://people.oregonstate.edu/~adamusp/WESP/.

Baldwin, L.K. & G.E. Bradfield, *Bryophyte Community Differences Between Edge and Interior Environments in Temperate Rain-Forest Fragments of Coastal British Columbia*, 35 Can. J. Forest Res. 580-92 (2005).

Bauer, D. et al., *Are Wetland Regulations Cost Effective for Species Protection? A Case Study of Amphibian Metapopulations*, 20 Ecological Applications 798-815 (2010).

Blackwell, M.S. & E.S. Pilgrim, *Ecosystem Services Delivered by Small-Scale Wetlands*, 56 Hydrological Sci. J. 1467-84 (2011).

California Wetlands Monitoring Workgroup (CWMW), California Rapid Assessment Method (CRAM) for Wetlands, Version 6.1 (2013).

Di Minin, E. & A. Moilanen, *Empirical Evidence for Reduced Protection Levels Across Biodiversity Features From Target-Based Conservation Planning*, 153 Biological Conservation 187-91 (2012).

Eaton, B.R. et al., *Indirect Effects of Fish Winterkills on Amphibian Populations in Boreal Lakes*, 83 Can. J. Zoology 1532-39 (2005).

Florencio, M. et al., *Spatio-Temporal Nested Patterns in Macroinvertebrate Assemblages Across a Pond Network With a Wide Hydroperiod Range*, 166 Oecologia 469-83 (2011).

Gibbs, J.P., *Importance of Small Wetlands for the Persistence of Local Populations of Wetland-Associated Animals*, 13 Wetlands 25-31 (1993).

Hecnar, S.J., & R.T. M'Closkey, *Patterns of Nestedness and Species Association in a Pond-Dwelling Amphibian Fauna*, 80 Oikos 371-81 (1997).

Hruby, T., Washington State Wetland Rating System for Western Washington–Revised. Ecology Publication #04-06-025 (2004), Washington Dept. of Ecology, Olympia, WA.

Hunter, E.A. et al., *Improving Wetland Mitigation Site Identification Through Community Distribution Modeling and a Patch-Based Ranking Scheme*, 32 Wetlands 841-50 (2012).

Leibowitz, S.G. et al., Synoptic Approach to Cumulative Impact Assessment: A Proposed Methodology, EPA 600/R-92/167 (1992), Environmental Research Lab., U.S. Environmental Protection Agency, Corvallis, OR.

Mack, J.J., *Developing a Wetland IBI With Statewide Application After Multiple Testing Iterations*, 7 Ecological Indicators 864-81 (2007).

Martínez-Sanz, C. et al., *Relative Contribution of Small Mountain Ponds to Regional Richness of Littoral Macroinvertebrates and the Iimplications for Conservation*, 22 Aquatic Conservation: Marine & Freshwater Ecosystems 155-64 (2012).

Matthews, J.W., *Effects of Site and Species Characteristics on Nested Patterns of Species Composition in Sedge Meadows*, 174 Plant Ecology 271-78 (2004).

McDonald, C.P. et al., *The Regional Abundance and Size Distribution of Lakes and Reservoirs in the United States and Implications for Estimates of Global Lake Extent*, 57 Limnology & Oceanography 597-606 (2012).

Millar, J.B., *Shoreline-Area Ratio as a Factor in Rate of Water Loss From Small Sloughs*, 14 J. Hydrology 259-84 (1971).

Miller, B.A. et al., *Spatial Distribution of Historical Wetland Classes on the Des Moines Lobe, Iowa*, 29 Wetlands 1146-52 (2009).

Oertli, B. et al., *Does Size Matter? The Relationship Between Pond Area and Biodiversity*, 104 Biological Conservation 59-70 (2002).

Peintinger, M. et al., *Species-Area Relationships and Nestedness of Four Taxonomic Groups in Fragmented Wetlands*, 4 Basic & Applied Ecology 385-94 (2003).

Price, J.S., *Water Level Regimes in Prairie Sloughs*, 18 Can. Water Resources J. 95-106 (1993).

Stannard, D.I. et al., Evapotranspiration From Marsh and Open-Water Sites at Upper Klamath Lake, Oregon, 2008-2010 (2013), U.S. Geological Survey Scientific Investigations Report 2013-5014.

Stevenson, R.J. & F.R. Hauer, *Integrating Hydrogeomorphic and Index of Biotic Integrity Approaches for Environmental Assessment of Wetlands*, 21 J. N. Am. Benthological Soc'y 502-13 (2002).

References continued on page 25