Copyright © 2000 Environmental Law Institute. All rights reserved. Reproduction in whole or in part without written permission from the copyright holder is prohibited. The *National Wetlands Newsletter* is a bimonthly publication of the Environmental Law Institute®, 1616 P Street NW Suite 200, Washington DC 20036. To subscribe, call 800-433-5120, write orders@eli.org, or visit http://www.eli.org/bookstore/nwn.htm.

Size Does Matter: The Value of Small Isolated Wetlands

While the regulatory landscape values larger wetlands over smaller ones, the ecological landscape presents a different view. Research in Carolina bays shows that small isolated wetlands play a crucial role in the biodiversity of wetland-dependent species, especially for amphibians.

by Raymond D. Semlitsch

Federal wetland protection and regulation are biased against small isolated wetlands. Why does this bias exist? Too often, decisionmakers assume that a small wetland is unimportant or less valuable than a larger wetland, because they assume that "larger" means "better." Small wetlands, however, are extremely valuable for maintaining the biodiversity of a number of plant and animal species. Furthermore, healthy populations of many species depend on not just a single wetland but a landscape densely covered by a variety of wetlands.

Ecologists describe the value of small isolated wetlands by their aggregate role in protecting wetland-dependent species through "source-sink dynamics." More variable than larger wetlands, each small wetland in an area may fluctuate in the number of individuals of a species it contains; at times a wetland may act as a "sink" when the population of a species dies out locally from that wetland, or it may be a "source" that produces surplus individuals, which can colonize a nearby sink wetland. Populations of a species that are spread over a number of locations are referred to as "metapopulations," and this source-sink dynamic is crucial to the regional survival of species. A metapopulation of a wetland-dependent species depends on the abundance and proximity of wetlands, rather than a critical size threshold. The disappearance of small wetlands from an area that relies on source-sink dynamics could result in the loss of ecological connectedness and potentially collapse the metapopulations of wetland-dependent species, causing many local extinctions. This is particularly detrimental to wetland-dependent amphibians, which are suffering global population declines.[1]

Raymond D. Semlitsch is a professor of ecology with the University of Missouri in Columbia. His research focuses on amphibian conservation and community dynamics in wetlands.

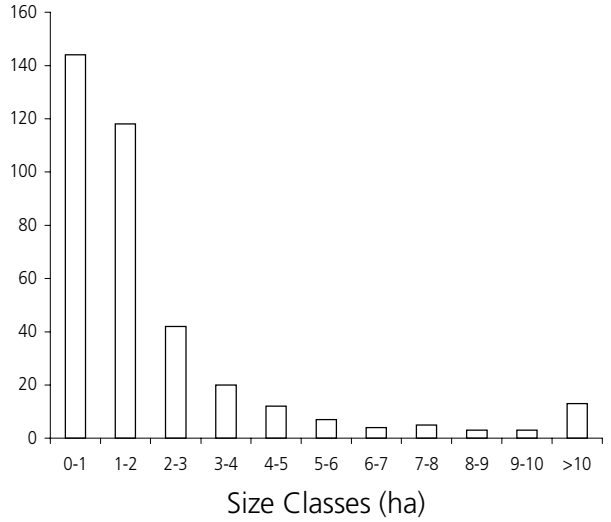
Small isolated wetlands like this cypress swamp in the Atlantic Coastal Plain of South Carolina are habitat for myriad wetland-dependent amphibians. Photo by R.D. Semlitsch.

The Carolina Bays

The density and size distribution of wetlands are the two attributes that together describe the prevalence of wetlands in the landscape, and therefore how frequently they might be encountered and subsequently colonized by plants and animals. We analyzed the abundance of 371 isolated depression wetlands known as Carolina bays that are distributed on the southeastern Atlantic Coastal Plain of South Carolina. In the apparently undisturbed Carolina bay

Editor's note

This is the second of a three-part series on small isolated wetlands. The first article appeared in the November-December 1999 issue.



Isolated depression wetlands known as Carolina bays in South Carolina tend to be small and numerous, with most smaller than 4 hectares. Reprinted by permission of Blackwell Science, Inc.

landscape, wetlands are close together and generally small. They are distributed at a density of 0.476/km^2 and range in size from 0.2 to 78.2 hectares, with many more small bays than large ones.[2] In fact, 46.4 percent of all Carolina bays are 1.2 hectares or smaller, and 87.3 percent are 4.0 hectares or smaller.

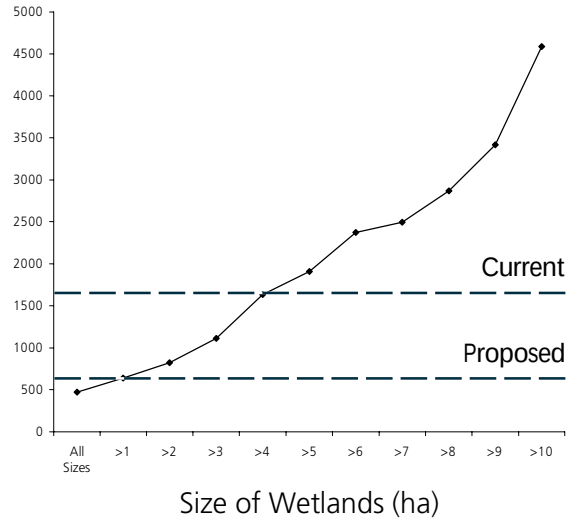
These small wetlands are crucial for maintaining the regional biodiversity of the Carolina bays. For example, during a 16-year monitoring study of a half-hectare area called Rainbow Bay, my colleagues and I documented 27 species of frogs, toads, and salamanders—one of the highest species diversities known for amphibians in this region.[3] In addition, we also recorded the breeding activity of 41,776 females and the production of 216,251 metamorphosing juveniles during the same period. Other small wetlands in the same area contained similar numbers of amphibian species. The numbers suggest that the levels of species richness found at Rainbow Bay are not uncommon for the area, and when combined with other studies from the southeastern United States, they indicate that small wetlands in this area contain high levels of diversity. This is comparable or possibly higher than estimates for wetlands an order of magnitude larger in size.

In an area like Rainbow Bay, the loss or alteration of any wetland, large or small, would reduce the total number of sites at which wetland-breeding amphibians could reproduce and successfully recruit juveniles into the breeding population. The loss of small wetlands, however are most keenly felt. The juvenile amphibians serve as source populations for other wetlands, and juvenile recruitment is higher in wetlands that seasonally dry out (generally the smaller ones) than in permanent wetlands (generally the larger ones).[4] Therefore, in the event of natural causes leading to local extinctions in a pond, the loss of surrounding small wetlands could suppress recolonization by dispersing juveniles from other locations.

Our study of Carolina bays illustrates the ecological damage to an area when the density of small wetlands is reduced. We suggest that as the distance between wetlands increases, the potential for migration and recolonization by amphibians decreases, and consequently, the chance of recolonization by source populations from nearby wetlands also decreases.[5] Furthermore, many pond-breeding salamanders, and possibly many frogs and toads, are faithful to the ponds from which they hatched and do not emigrate long distances.[6] For example, the maximum dispersal distance for wood frogs, measured by gene flow over multiple generations, is only about 1,126 meters;[7] because of the limited dispersal ability of these animals, any increase in distances between wetlands through wetland destruction impedes their recolonization. In Carolina bays, we found that if all wetlands smaller than 1.2 hectares (the U.S. Army Corps of Engineers' proposed new protection threshold) were removed, their loss would dramatically increase the nearest-wetland distance from 471 meters to 666 meters. Loss of all wetlands smaller than current Corps protection thresholds (4.0 hectares) translates to an increase in the distance to 1,633 meters—beyond, for example, the maximum dispersal distance of wood frogs. Thus, along with the direct loss of wetlands as breeding habitat, regional fauna also likely would suffer indirectly because of reduced recolonization following local population extinctions. Some examples of such effects may already be surfacing in the western United States.[8]

The biodiversity value of a wetland is, therefore, intimately tied to its position on the landscape with respect to other wetlands. For

continued on page 13



In a simulation, Carolina bays were removed sequentially by size, and the average nearest-neighbor distance between bays was recalculated after each size class removal. The average distance between wetlands increases as wetlands are removed. Dashed lines indicate current and proposed regulatory size thresholds. Adapted from Semlitsch and Bodie 1998, fig. 2.

SIZE DOES MATTER, continued from page 6

example, a 1.0-hectare wetland isolated by 500–1,000 meters may have more biological value than a 1.0-hectare wetland with neighboring wetlands just 50–100 meters away. Its location, regardless of its size, becomes the most important attribute—the more isolated wetland has greater potential to act as a stepping-stone to connect other more distance wetlands.

Pitcher plants (*Sarracenia* spp.) are among the many species that depend on small isolated wetlands in some natural landscapes like this one in North Carolina. Photo by R.D. Semlitsch.

Ecologically Sensitive Regulation Is Needed

A regulatory bias that allows small isolated wetlands to be removed from the landscape potentially changes the metapopulation dynamics of the species in remaining larger wetlands. Loss of these wetlands can reduce the number or density of individual animals dispersing, and it can increase the dispersal distances among wetlands.

Small isolated wetlands are not expendable if the goal is to maintain present levels of biodiversity. Although recently proposed changes to the Corps' nationwide permit program would reduce the threshold size for permitting wetland conversions from 4.0 to 1.2 hectares, both the current and proposed regulations still inadequately maintain the biodiversity of wetland flora and fauna, and would be especially detrimental to wetland-dependent amphibians. This is especially disheartening in light of the many reports of declining amphibian populations worldwide, and in particular, because of rapid habitat loss across the United States.[9]

To protect ecological connectedness and source-sink dynamics of species populations, wetland regulations should focus not just on size but also on local and regional wetland distribution. At the very least, wetland regulations should protect wetlands as small as 0.2 hectares—the lower limit of detection by most remote sensing—until additional data are available to directly compare diversity across a range of wetland sizes.

Equally important, regulatory agencies should scrutinize proposals for the potential value of the site before issuing permits that result in their loss. Evaluation of species richness of sensitive groups such as amphibians as well as nearest wetland distances would greatly help in this decision.

Finally, mitigation practices also should take source-sink processes into account when permitted to offset wetland losses. For example, loss of many small wetlands should not be replaced with one large wetland, based on cumulative size—20 1-hectare wetlands do not equal one 20-hectare wetland. New research should analyze the relationship of biodiversity to wetland size, spatial distribution, and connectedness, and how the loss of wetlands at a regional level affects metapopulation processes. ■

References

[1] Adapted from R.D. Semlitsch and J.R. Bodie, "Are small, isolated wetlands expendable?" *Conservation Biology* 12 (1998): 1129–1133.

[2] Semlitsch and Bodie, 1998.

[3] R.D. Semlitsch, D.E. Scott, J.H.K. Pechmann, and J.W. Gibbons, "Structure and dynamics of an amphibian community: evidence from a 16-year study of a natural pond," in *Long-term Studies of Vertebrate Communities*, eds. M. L. Cody and J. A. Smallwood, (Academic Press, San Diego, 1996), pp. 217–248.

[4] J.H.K. Pechmann, D.E. Scott, J.W. Gibbons, and R.D. Semlitsch, "Influence of wetland hydroperiod on diversity and abundance of metamorphosing juvenile amphibians," *Wetlands Ecology and Management* 1 (1989): 3–11.

[5] J.H. Brown and A. Kodric-Brown, "Turnover rates in insular biogeography: effect of immigration on extinction," *Ecology* 58 (1977): 445–449.

[6] R.D. Semlitsch, "Biological delineation of terrestrial buffer zones for pond-breeding salamanders," *Conservation Biology* 12 (1998): 1112–1119.

[7] See, for example, K.A. Berven and T. A. Grudzien, "Dispersal in the wood frog *(Rana sylvatica)*: implications for genetic population structure," *Evolution* 44 (1990): 2047–2056.

[8] See for example, C.A. Drost and G. M. Fellers, "Collapse of a regional frog fauna in the Yosemite Area of the California Sierra Nevada, USA," *Conservation Biology* 10 (1996): 414–425.

[9] C.K. Dodd, "Imperiled amphibians: a historical perspective," in *Aquatic Fauna in Peril: The Southeastern Perspective*, eds. G. W. Benz and D. E. Collins, special publication 1 (Southeast Aquatic Research Institute, Lenz Design and Communications, Decatur, Ga., 1997), pp. 165–200.