the Kennedy opinion and consistent with the science, in restoring protections to these geographically remote or isolated waters. In fact, we think they really are *not* protected and continue to be at risk under this guidance. So, that includes the prairie potholes, the playa lakes of southern Colorado, New Mexico and west Texas, very important waters for groundwater recharge, as well as for drinking water and migratory birds.

There is demonstrated evidence that this current situation has undermined enforcement of Clean Water Act pollution safeguards due to the uncertainty and confusion and delay. We believe that rulemaking is needed to strengthen the Clean Water Act's legal and scientific foundation, and that it will provide greater long-term certainty for landowners and protection for streams, wetlands, and other waters. ■

CONSERVATION

Reservoir Management and Wetlands

Many natural lakes have been converted to reservoirs by placing water-control structures at their outlets. Water-level regulation plans typically seek to provide power generation, reduce damage from flooding, provide reliable water supplies, and support recreational activities. Water management often involves winter drawdowns to create storage capacity in anticipation of spring runoff and maintenance of stable water levels during other seasons to protect shoreline developments. The annual changes in water levels seldom resemble those of natural systems. Fluctuations in water levels are especially important in shallow wetlands, where even small changes can shift large areas from being flooded to being exposed, and vice versa. Thus, reservoir management likely impacts hydrology-dependent wetland habitats (developed over eons under natural water-level patterns). Evidence is mounting to support that conclusion, but more public awareness is needed.

Water levels in Rainy Lake and Namakan Reservoir in Voyageurs National Park, Minnesota, have been regulated since 1909 and 1914, respectively. The range of mean annual fluctuations under natural conditions was about 1.9 meters (m) for Rainy Lake and 1.8 m for Namakan Lake, but regulation changed them to 1.1 m and 2.7 m, respectively. Studies were conducted that compared plant communities in these reservoirs to nearby unregulated Lac La Croix along elevation contours with specific water-level histories. The unregulated lake supported structurally diverse plant communities at all depths, while transects that were never dewatered in Rainy held only four submersed aquatic taxa and transects in Namakan that were unnaturally dewatered in early winter were dominated by rosette and mat-forming species. The regulation plan was changed in 2000, primarily to reduce the fluctuation in Namakan Reservoir. Follow-up studies suggest that little change in plant communities occurred at Rainy, while changes at Namakan caused it to resemble Rainy more closely at shallower depths and Lac La Croix at greater depths. Some recovery may occur when extreme fluctuations are reduced, but continued compression of the range of fluctuations allows no recovery.

Lake Ontario became a reservoir around 1960, when the St. Lawrence Seaway began operation. The range of annual fluctuations under the current regulation plan was compressed from about 1.5 m to 0.7 m by the late 1960s, and low water levels during the growing season no longer occur, even in years with reduced water supplies. Studies of historical air photos showed that the sedge/grass meadow marsh prominent at upper wetland elevations prior to regulation had been greatly reduced and mostly replaced by cattails following regulation. Sedges and grasses have a competitive advantage over cattails in naturally occurring low-water-level years because they are tolerant of drier soils. When low lake levels no longer occur, the larger cattails can survive and invade upslope. A new regulation plan for Lake Ontario is currently under development that may reintroduce more natural lake-level fluctuations.

The Voyageurs and Lake Ontario examples are not unique in North America, although the effects of regulation on wetland habitats have not been studied as thoroughly at other sites. Lake Superior has operated as a reservoir since 1914. Regulation likely raised overall water levels, but the range between highs and lows was not reduced greatly. Little research has been focused on the impacts of regulation, but potential new regulation plans for Lake Superior are currently being developed. Canadian prairie great lakes are now reservoirs also. The natural range of fluctuations in Lake Winnipeg was reduced from 2.7 m to 1.2 m when hydroelectric operations began in 1975, and cattail invasion has accelerated in Netley-Libau Marsh at the southern end of the lake. The range of water-level fluctuations in Lake Manitoba was reduced from 1.8 m to 0.3 m when regulation began in 1961. Studies conducted at Delta Marsh documented cattail invasion in response to regulation there also.

"Citizens, and especially wetland scientists, should be aware of the potential impacts to wetlands related to reservoir management actions and know that changes in regulation plans can be made."

China Lake in Maine has been regulated for more than 150 years. Lake levels were raised as much as 1.2 m above estimated natural levels, and the natural fluctuation range of about 1.6 m has been reduced to 0.6 m during the past 20 years. Rather than peaking in late spring and then decreasing, lake levels are held at full pool until mid-autumn, with no low water years. Field studies found cattail invasion of both wet meadow and peatland habitats, with massive peat loss from flooded peatlands.

In 1827, a dam was constructed downriver from the natural outlet of Sebago Lake in

Maine, but little regulation of water levels occurred until the dam was raised 1.5 m in 1878. Continuous lake-level records, beginning in 1910, show typical summer growing season peaks of about 81.3 m mean sea level, but periodic summer peaks often at 79.7 m or lower. In response to potential power shortages, an attempt was made in 1986 to increase winter production by holding back more water during the summer. This plan was dropped after a few years, but the history of natural outflows had ended. In 1997, a new regulation plan was adopted that reduced the range of fluctuations, has not allowed growing season peak levels to drop below 80.9 m, and also extends the full-pool season. Despite obvious visual indications of impacts, studies conducted to evaluate effects of the new regulation plan on wetland habitats were not designed to assess the response of plant communities at the elevations that were affected. However, perhaps as a result of continued public outcries about declining water quality, a proposal to return to the pre-1986 regulation plan is now under serious consideration.

Citizens, and especially wetland scientists, should be aware of the potential impacts to wetlands related to reservoir management actions and know that changes in regulation plans can be made. Impacts should be documented when identified, studies should be pursued when possible, and opportunities for intervention should be monitored. Many reservoirs require periodic Federal Energy Regulatory Commission (FERC) relicensing or permit renewals, opening the door for input into management of public resources. Such actions may call for detailed studies to identify and quantify impacts, and they may allow for recommended changes in regulation plans. Supporting data should derive from carefully designed studies that relate plant community response to changing water depths (incorporating lag times), typically along transects that follow elevation contours with specific water-level histories. Data collected with improper hydrologic reference and lacking an unregulated control lake will likely be insufficient to convince planners that changes are needed. A carefully selected control lake can also serve as a target, reminding us all that the best option for a wetland is usually a return to hydrology that is as close to natural as possible. ■

-Douglas A. Wilcox

Dense stands of cattail replaced sedge/grass meadow marsh in wetlands of Lake Ontario following regulation of water levels. Photo courtesy of Douglas Wilcox.

MITIGATION

Report From the Field: Mitigation News From the Annual Society of Wetland Scientists Meetings

The 2011 annual Society of Wetland Scientists (SWS) meeting took place during the first week of July, in conjunction with the Wetland Biogeochemistry Symposium and the European-based WetPol, the International Symposium on Wetland Pollutant Dynamics and Control. The conference was held in Prague, Czech Republic, only the second time that the SWS has held its annual meeting outside of the United States. The meeting was truly international, but much of the focus of the sessions was on topics familiar to wetland practitioners here, including the role of wetlands in delivering ecosystem services, understanding how hydrology shapes the structure and function of wetlands, and best practices for wetland restoration and mitigation. Many of the papers delivered at the meeting focused on the importance of soils in mitigation success, and the factors that control hydric soil development in created and restored wetlands. It was apparent that this is an active area of research, and several themes emerged from the presentations at the meeting.

Hydric soils are part of the physical foundation of wetlands, acting as a substrate for plant growth, microbial activities, and the processes that result from plant-microbe interactions, such as plant litter decomposition. Soil properties influence ecosystem processes and the biota that reside there. Many factors affect the development of hydric soils in mitigation wetlands, including the hydrology at the site, the types of organisms that are present (particularly plant and microbial communities), topography, climate, and parent material. Globally, wetland soils are also important reservoirs of carbon, holding an estimated 20% of the carbon in the biosphere, and highly organic soils can accumulate as much as 30-40% carbon per