Annual Report

2015 Annual Report on Performance of Iowa CREP Wetlands: Monitoring and Evaluation of Wetland Performance

William Crumpton
Professor

Greg Stenback
Associate Scientist

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Monitoring and Evaluation

A unique aspect of the Iowa CREP is that nitrate reduction is not simply assumed based on wetland acres enrolled, but is calculated based on the measured performance of CREP wetlands. As an integral part of the Iowa CREP, a representative subset of wetlands is monitored and mass balance analyses performed to document nitrate reduction. By design, the wetlands selected for monitoring span the 0.5% to 2.0% wetland/watershed area ratio range approved for Iowa CREP wetlands. The wetlands also span a threefold range in average nitrate concentration. The wetlands thus provide a broad spectrum of those factors most affecting wetland performance: hydraulic loading rate, residence time, nitrate concentration, and nitrate loading rate. In addition to documenting wetland performance, ongoing monitoring and research programs will allow continued refinement of modeling and analytical tools used in site selection, design, and management of CREP wetlands.

Summary of 2015 Monitoring

Monitoring activities were conducted at 17 Iowa CREP wetlands and one mitigation wetland (DD15 north) during 2015 (Figure 1).

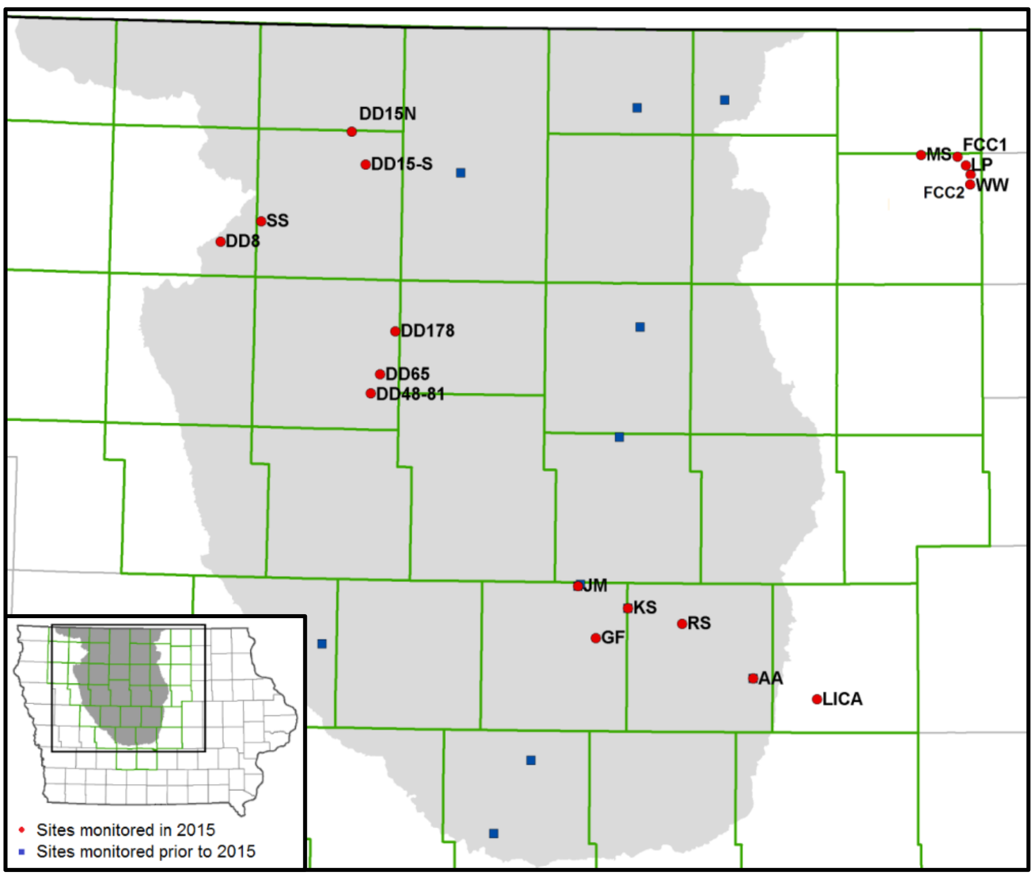

Figure 1. Wetlands monitored during 2015 (red circles, labeled) and wetlands monitored during prior years (blue squares). The shaded area represents the Des Moines Lobe in Iowa.

Wetland monitoring included measurements of wetland inflows, outflows, pool elevation and water temperature and collection of weekly to biweekly water quality grab samples and daily composite samples. Daily composite samples were collected using automated samplers programmed to collect and composite four subsamples collected at six-hour intervals at wetland inflows and outflows when temperatures were sufficiently above freezing to allow the equipment to function properly (approximately April through November). The DD48-81 wetland was drawn down during 2015 for repairs and the outflow from this wetland was not monitored during most of the year, however, both the DD48 and DD81 inflows were monitored for discharge and water quality samples. While the DD8, DD15N and DD178 wetlands were drawn down in April for repairs to their outflow structures, the monitoring results suggest this had insignificant impact on the nitrate removal performance of those wetlands. The outflow from the LICA wetland was briefly altered when the LICA personnel removed the stoplogs on July 11 through about July 13.

A beaver constructed several beaver dams on the JM wetland spillway from April to August. The beaver dams were removed and no evidence of the beaver was noted after August. The six wetlands in Boone, Story and Marshall Counties and the FCC2 and MS wetlands in Floyd County all had a buildup of algae on their spillways several times throughout the year requiring manual removal of the algae to maintain normal pool level elevations.

Wetland inflow and/or outflow stations were instrumented with submerged area velocity (SAV) Doppler flow meters and stage recorders for continuous measurement of flow velocity and stream depth, respectively. The SAV measurements were combined with cross-sectional channel profiles and stream depth to calculate discharge as the product of water velocity and wetted cross-sectional area. Wetland water levels were monitored continuously using stage recorders in order to calculate pool volume, wetland area, and discharge at outflow structures. The pool discharge equations and SAV based discharge measurements were calibrated using manual velocity-area based discharge measurements collected during 2015 and prior monitoring years. Manual velocity-area discharge measurements were determined using the mid-section method whereby the stream depth is determined at 10 cm intervals across the stream and the water velocity is measured at the midpoint of each interval. Velocity was measured with a hand held Sontek Doppler water velocity probe using the 0.6 depth method where the velocity at 60% of the depth from the surface is taken as the mean velocity for the interval. The product of the interval velocity and area is summed over intervals to give the total discharge.

Patterns in Nitrate Concentrations and Loads

Despite significant variation with respect to nitrate concentration and loading rates, the wetlands display similar seasonal patterns and general relationships to discharge. Historically, inflow nitrate concentrations are variable ranging from low to high during the winter. Spring snow-melt often results in increased flow during late February or March but nitrate concentrations in the melt water and associated surface runoff are typically low to moderate. During 2015, inflow nitrate concentrations were generally high during numerous flow events from April through July, with significant flow occurring into September at some sites (Figure 2). Nitrate concentrations generally decline through July and August. Additionally, nitrate concentration during large summer flow events often declines abruptly with peak flows and is thought to be associated with surface runoff having low nitrate concentration; however, nitrate concentrations often rebound within a few days of these high flow events. These nitrate concentration and flow patterns are consistent with those of CREP wetlands monitored in prior years and represent the likely patterns for future wetlands restored as part of the Iowa CREP. A substantial amount of flow occurred during December 2015 at most monitored sites and was accompanied by generally high nitrate concentrations (Figure 2). This late year flow was estimated from nearby USGS river gage data scaled to the each site specific watershed area.

Wetland Performance (Nitrate mass loss and removal efficiency)

Wetland performance is a function of hydraulic loading rate, hydraulic efficiency, nitrate concentration, temperature, and wetland condition. Of these, hydraulic loading rate (HLR) and nitrate concentration are especially important for CREP wetlands. The range in HLR expected for CREP wetlands is significantly greater than would be expected based on just the four fold range in wetland/watershed area ratio approved for the Iowa CREP. In addition to spatial variation in precipitation (average precipitation declines from southeast to northwest across Iowa), there is large annual variation in both precipitation and water yield. The combined effect of these factors results in annual loading rates to CREP wetlands that vary by more than an order of magnitude and will largely determine annual nitrate loss rates for individual wetlands.

Mass balance analysis and modeling were used to calculate observed and predicted nitrate removal, respectively, for each monitored wetland. Wetland bathymetry data were used to characterize wetland volume and area as functions of wetland depth. Wetland bathymetry has been determined by ISU on the basis of wetland construction plans and/or bathymetric surveys. These bathymetric relationships were used in numeric modeling of water budgets and nitrate mass balances to calculate nitrate loss, hydraulic loading, and hydraulic residence time. Wetland water depth and temperatures were recorded at five minute intervals for numerical modeling of nitrate loss.

The monitored wetlands generally performed as expected with respect to nitrate removal efficiency (percent removal) and mass nitrate removal (expressed as kg N ha^{-1} $year^{-1}$). In addition to measured inflow and outflow nitrate concentrations, Figure 2 shows the range of outflow concentrations predicted for these wetlands by mass balance modeling using 2015 water budget, wetland water temperature, and nitrate concentration as model inputs.

Variability in wetland performance is in part due to differences in wetland characteristics and condition and partly due to differences in loading rates and temporal patterns. At a given HLR, differences in wetland condition and in timing of loading can result in significant differences in performance (Figure 3). Mass balance analysis and modeling was also used to examine the long term variability in performance of CREP wetlands including the effects of spatial and temporal variability in temperature and loading patterns. In addition to the calculating the percent mass removal observed for wetlands monitored from 2004 through 2015, the percent nitrate removal expected for CREP wetlands was estimated based on hindcast modeling over the period from 1980 through 2005. The results illustrate reasonably good correspondence between observed and modeled performance and demonstrate that HLR is clearly a major determinant of wetland nitrate removal performance (Figure 3).

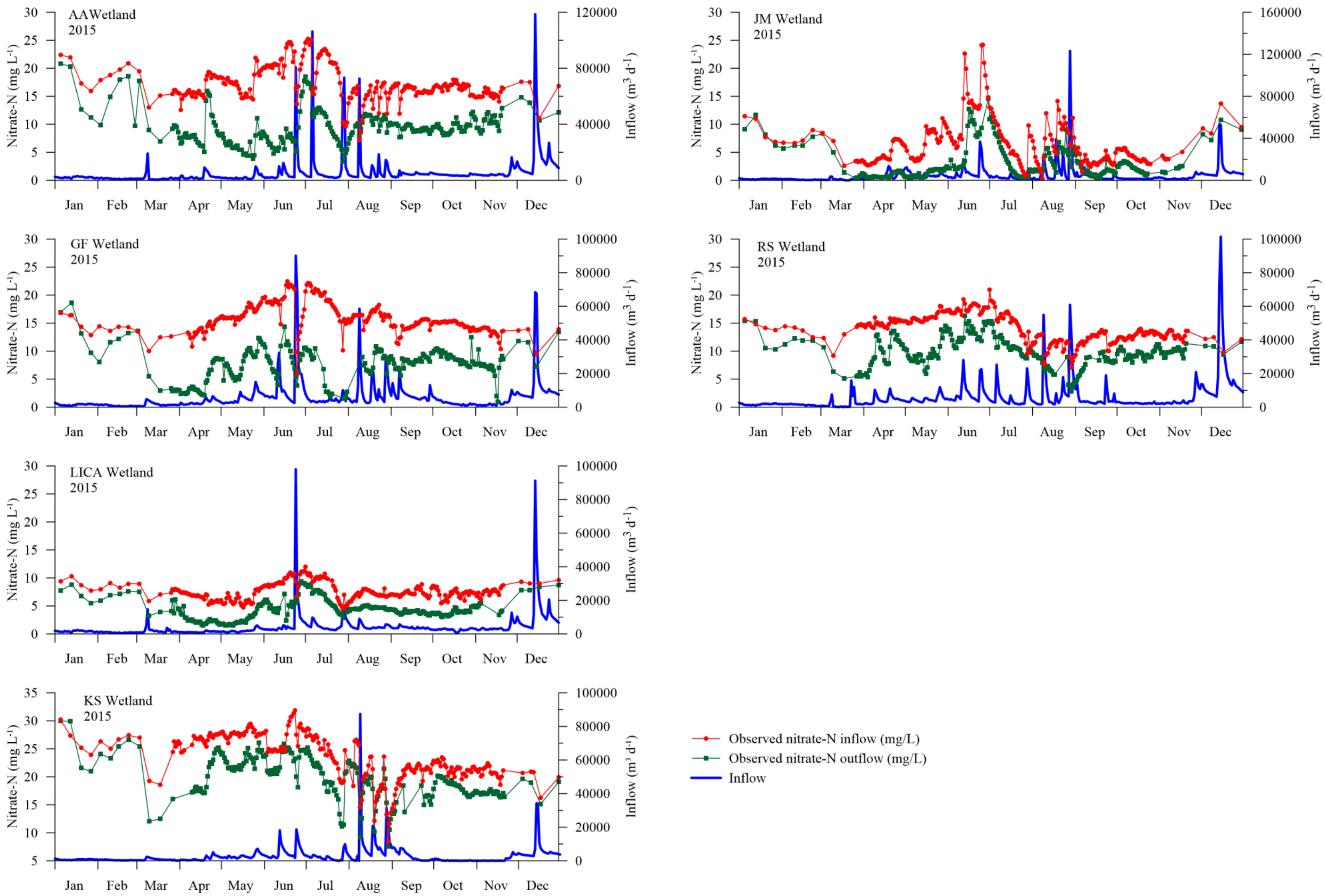

Figure 2. Nitrate concentrations and flows for central Iowa wetlands monitored during 2015.

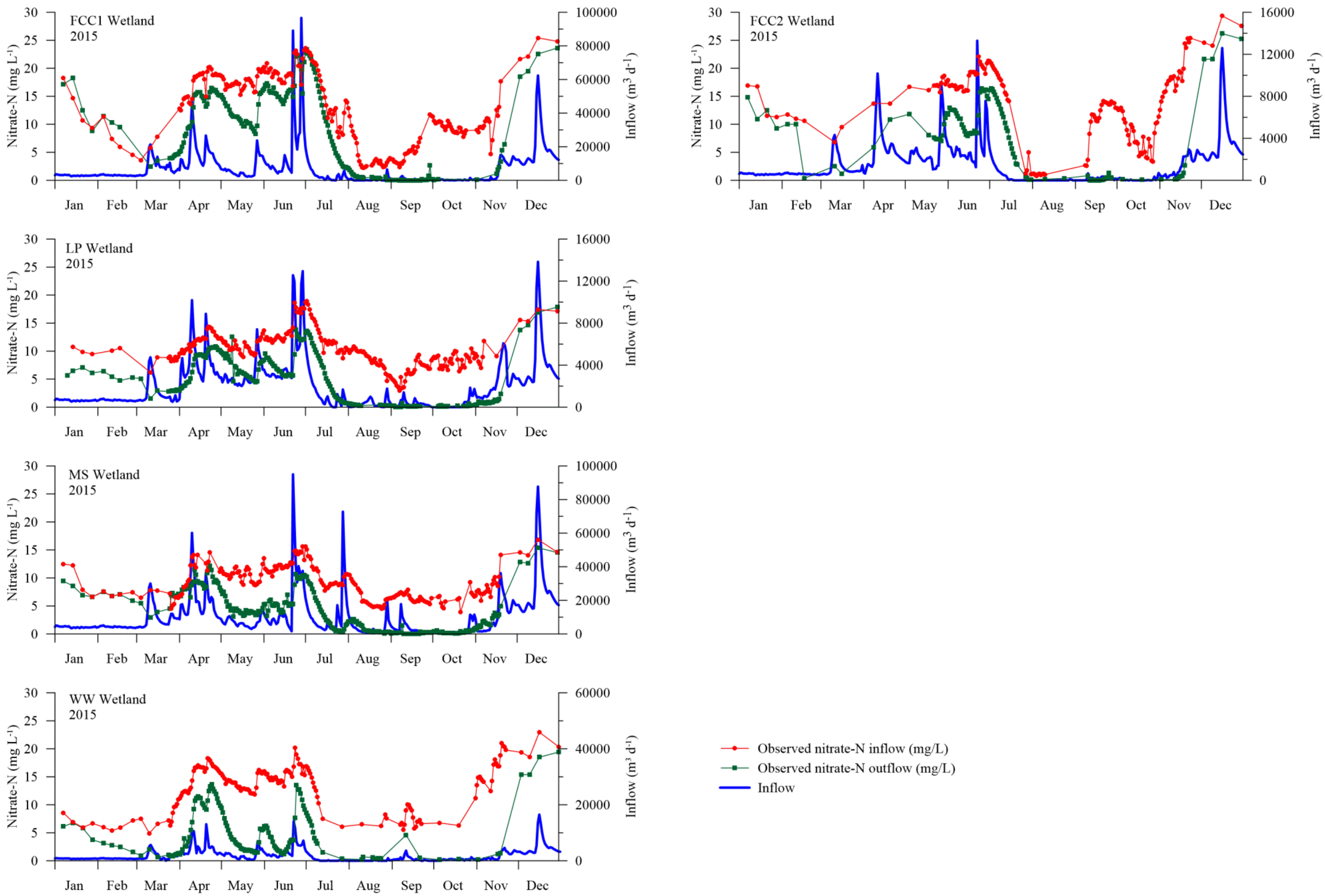

Figure 2 (Continued) Nitrate concentrations and flows for northeast Iowa wetlands monitored during 2015.

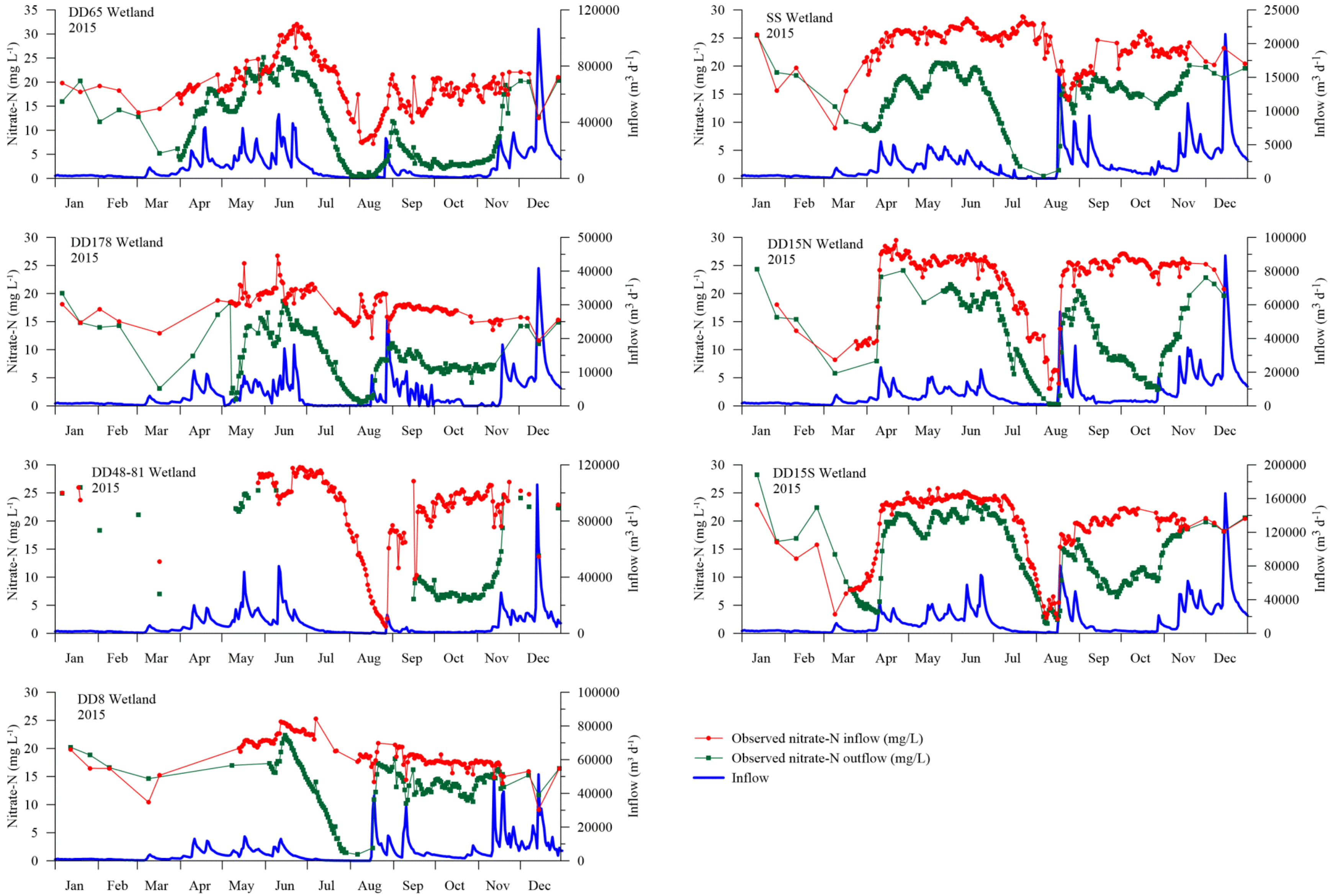

Figure 2 (Continued) Nitrate concentrations and flows for northwest Iowa wetlands monitored during 2015.

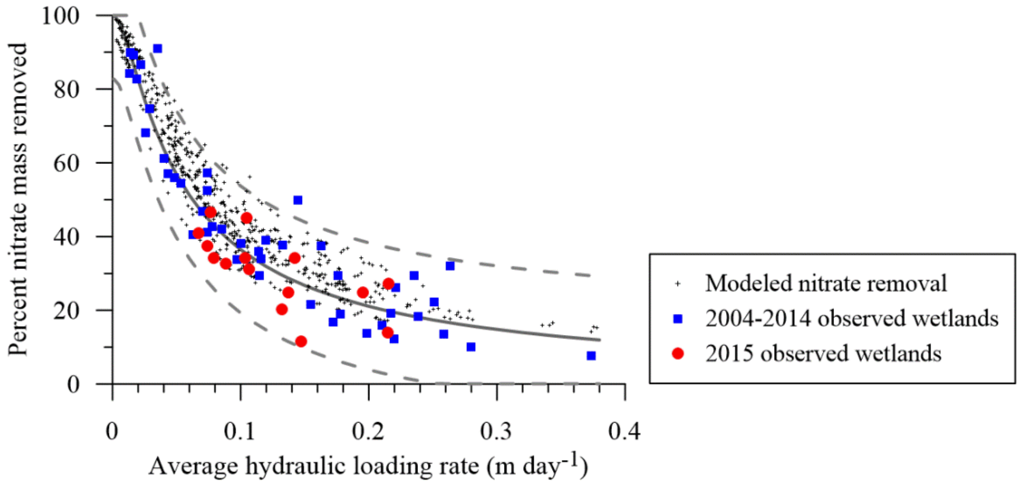

Figure 3. The percent nitrate removal performance for 2015 (red circles) and wetlands monitored during 2004 to 2014 (blue squares). The dashed gray lines indicate the range expected to contain 95% of similar wetlands in Iowa.

Wetland Vegetation Patterns

From 2011 to 2014 thirty-seven CREP wetlands were seeded with an emergent seed mix consisting of 19 species, six of which are deep water species (30-100 cm), and 13 of which are shallow water species (0-30 cm). To evaluate the success of this seeding effort, vegetation surveys were conducted on 47 CREP wetlands during the 2014 and 2015 field seasons. Among the wetland sites in this survey, 12 had been seeded at construction completion, and 12 had been seeded between 3 and 8 years after construction. The 12 older sites had been flooded after construction, but water was temporarily drawn down for the seeding. The remaining 23 surveyed sites had not been seeded and ranged in age from 3 to 12 years (Table 1).

Table 1. Characteristics of wetlands surveyed including the post construction sequence of seeding and water level management (DD=draw down and FP=full pool), age of wetlands when seeded and surveyed, and the total number of surveys for each wetland type.

Seeding and Water Level Management	Age When Seeded	Age When Surveyed	Number Surveyed
Constructed – DD – Seeded – FP	0 years	2-4 years	12
Constructed – FP – DD – Seeded – FP	3-8 years	5-11 years	12
Constructed – FP (Not seeded)	-	3-12 years	23

The vegetation surveys consisted of transects laid perpendicular to the full pool boundary and extending to the emergent edge/open water interface. Approximately 20 transects were taken per wetland. The spacing between transects depended on the size of the wetland, and the length of each transect depended on the extent of the emergent edge. Percent cover was estimated with a 1x1 meter quadrat every five meters along the transect line. A cover class scale was used to estimate percent cover for each species. Plant species were identified in the quadrants, and any additional species found were also noted.

Seeded species presence and establishment

Two species in the fringe area seed mix, Cardinal Flower and Blueflag Iris, were found at seeded sites but only one or two individuals were present. Fringe area seed mix species Bluejoint and Joe Pye Weed were not found at any of the sites. On the basis of details of the seeding strategy from a CREP Field Specialist, the deep water mix of emergent species was found most frequently in its designated seeding band (0.5 to 3 feet deep). However, while the shallow water fringe area mix species were found in their designated seeding band (zero to 0.5 feet deep), they were mostly found in deeper water between 0.5 and 1.5 feet deep.

Seeded species abundance

Comparing vegetation across all sites, a greater abundance of seeded species was found at seeded sites than at non-seeded sites. When we look at the components of the seed mix, the deep water mix was found in relatively the same abundance at both seeded and non-seeded sites, whereas the shallow water mix had greater abundance at seeded sites.

Wetland coverage and diversity

The seed mix did not increase vegetation coverage overall as all surveyed wetlands had similar coverage. When looking at diversity, a measure of number of species and their relative abundance, seeded sites had on average greater diversity. This is most likely due to greater abundance of the shallow water mix at the seeded sites.

Reed Canary Grass

Reed canary grass (an invasive species not present in the fringe or emergent seed mixes) was found at every site, and represented at least half of the vegetation found at 24 of the 47 sites surveyed. Sites where reed canary grass only comprised at most 25% of the vegetation were mostly seeded. Seeding did seem to help avoid quick dominance of reed canary grass.