United States Department of Agriculture
Natural Resources Conservation Service

CEAP Conservation Insight
Conservation Effects Assessment Project

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WRP Contributes to Amphibian Conservation in Missouri

Summary Findings

- Both abundantly occurring and commonly occurring amphibians use and recruit young on Wetlands Reserve Program (WRP) sites in the Lower Grand River Basin, Missouri. This demonstrates the value of WRP wetlands for conserving and restoring riverine-floodplain amphibians.
- On average, WRP sites did a fair job of providing a range of wetland conditions for members of the amphibian regional species pool. Results also suggest that restored wetland characteristics may not provide optimal habitat during the peak of amphibian breeding and larval development.
- Results suggest that amphibians are breeding and recruiting young into the adult population by responding to micro-topographic conditions within WRP sites rather than larger scale restored wetland characteristics.

Recommendations

- Matching hydrology with landscape setting and managing for seasonal surface water conditions that persist through mid to late summer will increase the number of amphibian species using WRP sites and the probability of population recruitment in north-central Missouri.
- Amphibian habitat requirements vary among species; therefore, providing for all species in a regional species pool requires managing sites that traverse both the longitudinal (downstream to upstream) and lateral (bluff-to-bluff) floodplain gradient.
- Optimum amphibian habitat should be defined at multiple spatial (e.g., within site, site, floodplain) and temporal (e.g., within a season, among seasons) scales such that a diversity of wetlands are present across the landscape representing a combination of wet, drying, or dry conditions as influenced by precipitation amounts, flood events, and drought; this will benefit the full suite of wetland-dependent species.

Background

Globally, amphibians have suffered dramatic population declines in the past 20 years with habitat destruction implicated as the primary cause. Wetland restoration that provides habitat on a landscape scale may buffer amphibian populations from additional stressors and prevent, stabilize, or reverse downward population trends (Semlitsch and Bodie 1998). Amphibians exploit a range of wetlands, from ephemeral to permanent, for a range of life history events. Use of a particular wetland is tied to each species' ability to survive wetland drying and to coexist with predators, primarily fish and aquatic insects (Wellborn et al. 1996). A key element in amphibian conservation, therefore, involves not only protecting existing habitat but also restoring a critical mass of interconnected wetlands that range across the hydrological gradient (Semlitsch 2005).

The Natural Resources Conservation Service (NRCS) Wetlands Reserve Program (WRP) restores wetlands on marginal agricultural land and may improve the spatial arrangement of wetland habitat as well as the temporal variation in wetland conditions (fig. 1). Some wetlands are located near stream channels whereas others are not, and some wetlands may be wet at times when others are dry. This variability in space and time aligns with the life history needs of amphibian communities, as individual species may breed in wetlands at different times and different locations in response to specific wetland conditions.

Floodplain wetland restoration implemented through WRP over the past 2 decades generally followed three design strategies, or approaches, toward wetland development. These strategies reflect an evolution in the thought-process of NRCS biologists and engineers as they gained increased experience with these systems:

1. "***Walk-aways***:" Early designs took a minimalist approach toward wetland restoration, which became dubbed "walk-away" sites. Emphasis was placed on restoring natural vegetation with little focus on restoring hydrology (Heard et al. 2005).
2. "***Maximized hydrology***:" By the mid-1990s, focus shifted toward enhancing habitat for migratory birds by maximizing hydrology (Heard et al. 2005). These efforts focused on providing average surface water depths of 18 inches—the preferred foraging depth of most dabbling ducks (Krapu and Reinecke 1992). These sites were

Figure 1. "Naturalistic" wetland restoration works to mirror remnant floodplain wetland features, providing spatial and temporal hydrologic diversity.

Michael McClure, Mo. Dept. of Conservation designed so water levels could be manipulated to affect plant diversity and encourage growth of seed-producing moist-soil plants. However, because these restored wetlands were located in floodplains, constructed infrastructure created impediments to water movement. As a result, levee scouring and water control structure failures during floods were common. Steep levee slopes were attractive to muskrats, and their burrows caused additional infrastructure failures.

3. "***Naturalistic***:" The latest evolution in wetland design emphasizes a more naturalistic approach to restoration that incorporates both biological and hydrological characteristics of sites. This strategy enhances micro- and macro-topography within wetland pools by taking advantage of landscape structure and mimicking remnant wetland features, thus creating varying water depths and habitats. Naturalistic designs are intended to be "flood-friendly" with broad, wide levees that are lower in stature and less distinctive on the landscape, often measuring less than 2.5 feet in height. Pool water levels are targeted toward shallower depths (8–12 inches) to provide habitat for a wider range of migratory water birds.

The goal of WRP is "to achieve the greatest wetland functions and values, along with optimum wildlife habitat, on every acre enrolled in the program" (NRCS 2012). Functions and values are defined as the hydrological and biological characteristics of wetlands. For this assessment, hydrological wetland characteristics are considered restored if a gradation of wetland conditions ranging from ephemeral to permanent is present on a site. Biological wetland characteristics are considered restored if wetland-dependent species successfully recruit young into the adult population.

Hydrological wetland characteristics are often described in terms of surface water duration, or wetland hydroperiod. Wetland hydroperiod is defined as the length of time and portion of year a wetland holds ponded water. For this assessment, wetland hydroperiod was placed in one of three categories based on definitions described by Tarr and Babbitt (2010):

1. *Ephemeral,* where surface water is present for less than 4 months after ice out (dry by July 1 in Missouri);

2. *Seasonal,* where surface water is present for more than 4 months after ice out but does not persist year-round (water is present after July 1 in Missouri but generally dries by late summer); and

3. *Permanent,* where surface water is present year-round.

Amphibians have species-specific requirements for completing metamorphosis; each species is associated with certain wetland hydroperiods (table 1). If duration of water associated with a wetland hydroperiod is too long (> 12 months), predator communities—particularly fishes—develop, reducing amphibian abundance and species diversity. If water duration is not long enough, wetlands dry up before larvae metamorphose, precluding adult population recruitment (Wellborn et al. 1996). As a result, amphibian species richness is generally lower in ephemeral wetlands due to risk from desiccation and in permanent wetlands due to predation risk,

Table 1. The Lower Grand River Basin amphibian regional species pool and category of wetland hydroperiod associated with each species

Scientific name	Common name	Wetland hydroperiod association
Notophthalmus viridescens	Central newt	permanent
Ambystoma texanum	Small-mouthed salamander	seasonal
Ambystoma tigirnum	Eastern tiger salamander	seasonal
Anaxyrus americanus	American toad	seasonal
Anaxyrus cognatus	Great Plains toad	seasonal
Anaxyrus woodhousii	Woodhouse's toad	seasonal
Acris crepitans	Northern cricket frog	seasonal to permanent
Hyla chrysoscelis- Hyla versicolor complex	Grey treefrogs, Eastern and Cope's	seasonal
Pseudacris crucifer	Spring peeper	seasonal
Pseudacris maculata	Boreal chorus frog	seasonal
Gastrophryne olivacea	Western narrow-mouthed toad	seasonal
Lithobates areolatus	Crawfish frog	seasonal
Lithobates blairi	Plains leopard frog	seasonal to permanent
Lithobates catesbeianus	American bullfrog	permanent
Lithobates clamitans	Green frog	permanent
Lithobates sphenocephalus	Southern leopard frog	seasonal to permanent
Lithobates sylvaticus	Wood frog	ephemeral to seasonal

but generally higher in seasonal wetlands.

Walk-away sites, due to lack of hydrological restoration, are assumed to result in dry to ephemeral wetlands that do not retain water of sufficient duration to ensure successful amphibian recruitment. These sites typically lack hydrological and biological wetland characteristics. Maximized hydrology sites, with pools flooded to a depth of 18 inches, potentially function as seasonal to permanent wetlands. However, landowner interest in drawing surface water off these sites to stimulate waterfowl food-producing moist soil plants may result in ephemeral wetlands that do not retain water long enough for successful amphibian recruitment. This yields sites with hydrological but not biological wetland characteristics. Naturalistic sites contain scattered excavations that are difficult to totally drain, so are assumed to create seasonal to permanent wetland conditions. The inability to completely drain naturalistic sites is likely to result in the presence of some surface water long enough to support amphibian recruitment, exhibiting both hydrological and biological wetland function. Lack of water control capability allows these systems to go through natural wet-dry cycles, which promotes diverse anuran communities due to habitat variability within and among years.

Evaluation Partnership

In 2006, NRCS and the University of Missouri entered into a cooperative agreement to evaluate wildlife habitat values associated with WRP wetlands in Missouri. The first phase of this work, which involved analysis of existing statewide habitat monitoring data, documented wetland restoration mediated habitat improvements for several wetland bird species (Frazer and Galat 2008). The second phase focused on the effects of WRP on amphibian recruitment in north-central Missouri—the topic of this Conservation Insight. Full details on this assessment are described in Mengel (2010). Both efforts were conducted in support of the wildlife component of the Conservation Effects Assessment Project (CEAP).

The objective of this assessment was to measure amphibian species richness to determine if hydrological and/or biological wetland characteristics had been restored in WRP sites representing three restoration design strategies. Amphibians served as indirect indicators of restored wetland function. If WRP sites restored by a particular design strategy had high amphibian species richness, including species associated with wetlands that spanned the gradient from ephemeral to permanent, it would imply that the design strategy successfully restored hydrological wetland characteristics. Likewise, if that same design strategy included a species richness index that represented a higher proportion of species from the local amphibian assemblage, this would imply a higher probability of successful recruitment, thus indicating restoration of biological wetland characteristics. Ideally, to demonstrate that wetland restoration has produced suitable habitats, a design strategy should result in wetland conditions that span a hydrological gradient ranging from ephemeral to permanent and that provide biological wetland conditions enabling successful amphibian recruitment.

Assessment Approach

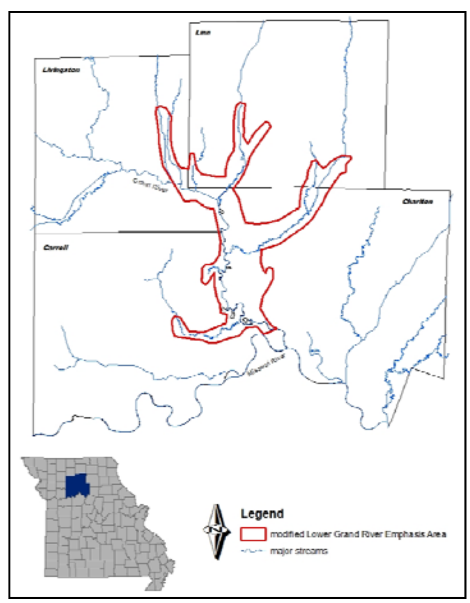
This assessment was conducted in the Lower Grand River Basin (fig. 2) in north-central Missouri. Agriculture is the dominant land use within the basin. The Lower Grand River Basin was targeted because of its former status as a WRP emphasis area and the resulting concentration of WRP easements (over 12,000 acres). Amphibian species richness was determined by sampling 50 randomly selected WRP sites comprising 13 walk-away, 18 maximized hydrology, and 19 naturalistic sites during three primary survey periods from early March through late September 2007 (7 March–4 May; 14 May–9 July; and 23 July–19 September). This time period spanned the period of amphibian breeding and larval development in the Lower Grand River Basin. Three sampling techniques—aquatic funnel-trap surveys, visual encounter surveys (VES), and dip-net surveys—were used to increase the probability of detecting target species.

A regional species pool, defined as the wetland-breeding amphibian assemblage for the Lower Grand River Basin, was identified based on published distribution maps (Table 1) (Johnson 2000). Use of a regional species pool enables estimation of a relative species richness index, the metric used to evaluate hydrological and biological wetland characteristics restored by each of the design strategies. The relative species richness index is determined by the proportion of the regional species pool represented by the species richness estimate.

Two methods were used to determine a relative species richness estimate for each of the sampled WRP sites. The first method, occupancy modeling (MacKenzie et al. 2006), enables spatial and temporal analysis such that relative species richness can be compared among sites and over time. It included data from all three primary survey periods conducted in 2007. This method provides insight into amphibian use of sampled WRP sites over a relatively long field season. The second method, capture/recapture modeling (Nichols and Conroy 1976), was a spatially-based analysis that focused on species richness among sites that included data from only the second primary survey period (14 May–9 July). The second primary survey period overlaps with the peak of amphibian breeding and larval development, so focusing on this survey period provided insight into amphibian use of WRP sites during critical reproduction and recruitment events.

A K-means cluster analysis was performed to evaluate whether wetland de-

Figure 2. Location of Lower Grand River Basin in north-central Missouri



sign strategy accurately reflected restored wetland hydrology characteristics. Hypothetically, sites should group together by design strategy with maximized hydrology and walk-away sites dominated by ephemeral wetlands and naturalistic sites dominated by seasonal wetlands. If so, maximized hydrology and walk-away sites would be associated with low relative species richness estimates and naturalistic sites would be associated with high relative species richness estimates.

Relative species richness was used to assign a site ranking of poor, fair, good, very good, or excellent to reflect the degree to which each sampled WRP site represented the regional species pool (table 2). Prior to the assessment, a predicted abundance and likelihood of detection was determined for each species in the regional species pool. The site ranking was based on the proportion of the regional species pool composed of abundantly, commonly, and rarely occurring species. For example, four species were predicted to be abundant with a very high probability of detection, representing 24 percent of the regional species pool; therefore, if a site had only four species or fewer, it received a poor ranking (≤ 0.24).

The reasoning for this ranking was that wetland restoration on WRP sites should, at a minimum, provide habitat for amphibian species that are abundant and common. However, the true measure of successful wetland restoration is also providing suitable habitat for the full range of wetland-dependent species, including less common species. The drawback to this approach is that it does not account for rare or imperiled species but simply reflects the number of species detected on a site; therefore, a site did not receive a higher ranking if a less commonly encountered species was detected.

Table 2. Wetland restoration efforts on WRP sites in the Lower Grand River Basin

Relative species richness estimate	Site ranking
≤ 0.24	Poor
0.25–0.49	Fair
0.50–0.69	Good
0.70–0.79	Very good
≥ 0.80	Excellent

Findings

Species Richness

Applying the relative species richness metric to the 50 sampled WRP sites indicates that some sites within each design strategy are contributing more to amphibian conservation than others. It also illustrates that the habitat heterogeneity occurring across all sites reduces the relevancy of design strategy as a useful descriptor of wetland restoration efforts. Results from the occupancy method analysis indicate that 74 percent of the sites received a fair rating over the course of the field season and only 14 percent received a poor rating (fig. 3). Results from the capture/recapture method, however, indicate that 42 percent of the sites received a fair rating and 52 percent of the sites received a poor rating for the mid-May to mid-July survey period (fig. 4). The peak of am-

Figure 3. Site rankings based on relative species richness for 50 WRP sites using 2007 occupancy sampling grouped by design strategy, Lower Grand River Basin

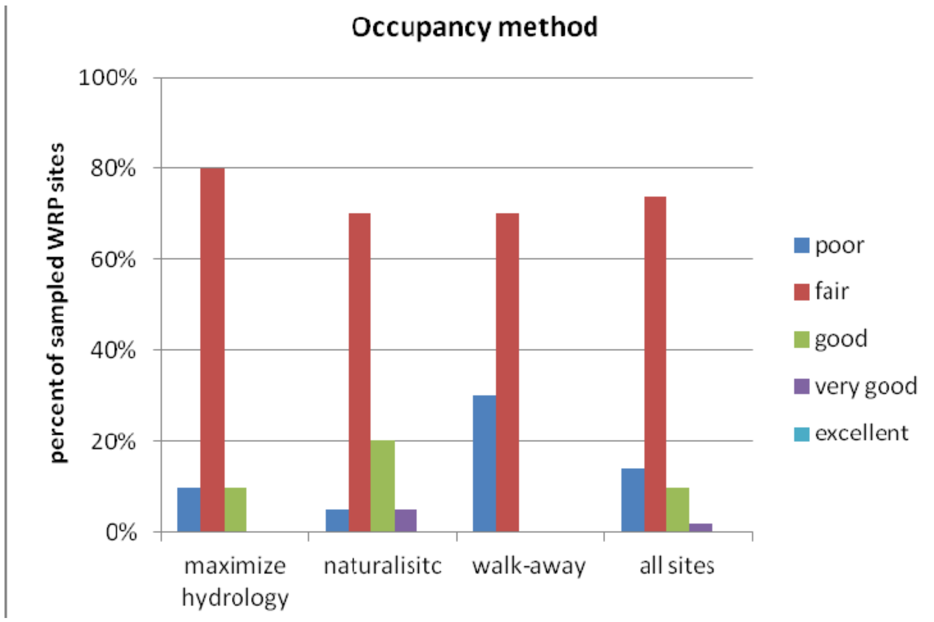
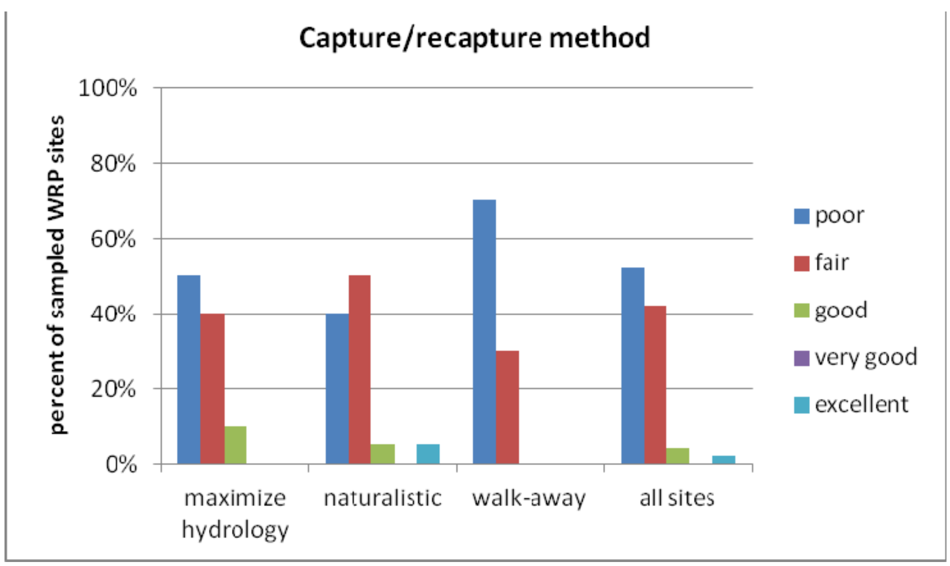


Figure 4. Site rankings based on relative species richness for 50 WRP sites using 2007 capture/recapture surveys grouped by restoration design strategy, Lower Grand River Basin



phibian breeding and larval development occurs from May through July; this is when a higher proportion of species were present on wetland sites. The fact that 52 percent of the sites were ranked poor when the probability of detecting species was greatest indicates that suitable habitat conditions were not present on many of these sites at that time. Because a higher proportion of the regional species pool is associated with seasonal wetlands (table 1), the number of sites with good ratings could potentially be increased by managing for seasonal wetland conditions throughout the time needed for species to complete their life history requirements.

The sampled WRP sites did not group together by design strategy. Instead, although 31 of the 50 sites matched hypothesized conditions, six maximized hydrology sites, two naturalistic sites, and three walk-away sites were wetter than expected, and seven naturalistic sites were drier than expected. Generally, walk-away sites were dry with limited wetland habitat; 70 percent received a poor rating using the capture/recapture method. However, three of the walk-away sites were wetter than expected and received a fair rating by both the occupancy and capture/recapture methods of relative species richness estimation. Alternatively, one of the maximize hydrology sites was also wetter than expected but received a poor rating by both methods.

Hydrology Regime

Observed differences in site rankings appear related to hydrological regime. The year 2007 was relatively warm and dry, with one flood event occurring during the field season. Site conditions were not necessarily reflective of excessively wet or dry conditions due to within year variation. Rather, they reflected local hydrology as characterized by the dominant vegetation community. The walk-away sites were characterized by wet conditions with grassy vegetation, which indicated a relatively dynamic hydrological regime that generally provided suitable habitat for a range of amphibians. The maximized hydrology site was characterized by open water, which indicated static hydrological regime that generally resulted in poor habitat for amphibians. These examples highlight the heterogeneity present within sites that is not adequately captured by applying design strategy as an ecological descriptor.

Overall, WRP in the Lower Grand River Basin has restored hydrological and, to a lesser degree, biological wetland characteristics that provide for abundantly and commonly occurring species in the regional amphibian species pool. These results show the value of the WRP at conserving and restoring river-floodplain amphibians, a particularly important contribution given the sudden, inexplicable declines that have occurred in some amphibian populations in other Midwestern states (Lannoo 2005). These efforts also show a significant contribution toward wetland restoration in north-central Missouri.

Local and Landscape Opportunities

Opportunities exist to increase both the number of species from the regional species pool using WRP sites and increase the probability of successful recruitment by species currently using WRP sites. This can be accomplished by managing for hydroperiods of sufficient duration to enable successful amphibian recruitment and by ensuring that WRP sites occur across the entire gradient of potential amphibian habitats.

Achieving the NRCS goal for WRP requires explicitly defining optimum wildlife habitat and determining whether it can realistically be accomplished on every acre enrolled. Given that the majority of Missouri wetlands are associated with rivers and streams, WRP wetland restoration efforts in the State are, in essence, attempts to restore riverine-floodplain structure and function, including hydrology. However, although habitats may overlap, habitat requirements vary across the range of species and provide for all species in the regional species pool requires sites that traverse both the longitudinal and lateral floodplain gradient. For example, a species adapted to the coarser soils and ephemeral wetlands found at the confluence of the Missouri and Grand Rivers is unlikely to be found upstream along the Grand River in wetlands with finer soils and longer hydroperiods. Similarly, sites located adjacent or close to stream corridors that have a high probability of inundation during flood events and a high likelihood of fish invasion are unlikely to provide optimum habitat for species adapted to life at the floodplain-upland margin where flood water inundation and fish invasions are less likely.

Recognizing that optimum habitat can be defined at multiple spatial and temporal scales that match the landscape setting will contribute to WRP realizing its potential. For instance, optimum habitat at a wetland scale is not the same as optimum habitat at a floodplain scale. Depending on the location of an individual wetland in space and time, providing wetland habitat that accommodates four amphibian species may be optimum for a single site but would be inadequate at a floodplain scale, which should be providing for a much larger proportion of a regional species pool.

Managing for hydroperiods of sufficient duration and ensuring that WRP sites occur across the entire gradient of potential amphibian habitats promotes amphibian recruitment.

The intent of WRP is to convert marginal, flood-prone agricultural lands back into wetlands, so enrollment of lands in north-central Missouri located outside the active floodplain may be impracticable or unrealistic. Whereas it may not be possible to restore riverine-floodplains from bluff-to-bluff on large streams with wide corridors, restoration is possible on smaller tributaries with more restricted floodplains. Similarly, whereas attaining optimum habitat on every acre enrolled in the program may not be an achievable objective, providing optimum habitat for members of a regional species pool within an appropriately defined geography that includes both a longitudinal and a lateral gradient represents a practical objective.

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Seasonal wetland hydrology provided by "naturalistic" wetland restoration of a WRP site in Linn County, Missouri.

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The Conservation Effects Assessment Project: Translating Science into Practice

The Conservation Effects Assessment Project (CEAP) is a multi-agency effort to build the science base for conservation. Project findings will help to guide USDA conservation policy and program development and help farmers and ranchers make informed conservation choices.

One of CEAP's objectives is to quantify the environmental benefits of conservation practices for reporting at the national and regional levels. Because fish and wildlife are affected by conservation actions taken on a variety of landscapes, the wildlife national assessment draws on and complements the national assessments for cropland, wetlands, and grazing lands. The wildlife national assessment works through numerous partnerships to support relevant studies and focuses on regional scientific priorities.

This assessment was conducted under a cooperative agreement between NRCS and the University of Missouri. Primary investigators were Doreen Mengel (Missouri Department of Conservation) and David Galat (University of Missouri).

For more information: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/ceap, or contact Charlie Rewa at charles.rewa@wdc.usda.gov.