



Conserving Prairie Pothole Wetlands and Surrounding Grasslands: Evaluating Effects on Amphibians

Natural Resources Conservation Service
Conservation Effects Assessment Project

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Summary Findings

The maintenance of viable and genetically diverse populations of amphibians in the Prairie Pothole Region of the United States depends on upland as well as wetland over-wintering and landscape level habitat features.

Prairie pothole wetlands provide important amphibian breeding habitat while grasslands surrounding these wetlands provide foraging habitat for adults, overwintering habitat for some species, and important connectivity among breeding wetlands.

Grasslands surrounding wetlands were found to be especially important for wood frogs and northern leopard frogs, while croplands dominated habitat utilized by Great Plains toads and Woodhouse's toads.

Habitat suitability mapping highlighted (1) the influence of deep-water overwintering wetlands on suitable habitat for four of five anuran species encountered; (2) the lack of overlap between areas of core habitat for both the northern leopard frog and wood frog compared to the core habitat for both toad species; and (3) the importance of conservation programs in providing grassland components of northern leopard frog and wood frog habitat.

Currently, there are approximately 7.2 million acres (2.9 million hectares, ha) of habitat in the PPR identified as suitable for amphibians. WRP and CRP wetland and grassland habitats accounted for approximately 1.9 million acres (0.75 million ha) or 26 percent of this total area.

Continued loss of amphibian habitat resulting from an ongoing trend of returning PPR conservation lands to crop production, will likely have significant negative effects on the region's ability to maintain amphibian biodiversity. Conversely, increases in conservation wetlands and surrounding grasslands on the PPR landscape have great potential to positively influence the region's amphibian populations.

Introduction

Habitat alteration related to land-use change has been implicated as a primary causal factor in the decline of amphibian populations worldwide (Houlahan et al. 2000, Alford et al. 2001). In the Prairie Pothole Region (PPR) of North America, this land-use change has been related to the conversion of vast areas of wetlands and grasslands to lands dedicated to cultivated crop production (Tiner 1984, Dahl 1990, Euliss et al. 2006). While the loss of wetland and grassland habitats in the PPR has been extensive, the effects on amphibians are largely unknown.

In an effort to increase our knowledge of amphibian populations in the PPR and to quantify the benefits of conservation programs on this important component of PPR ecosystems, the Conservation Effects Assessment Project (CEAP – Wetlands) funded several research efforts focused on PPR amphibians. These efforts included the development of a conceptual model identifying key drivers, stressors, and ecological effects influencing the maintenance of viable and genetically diverse amphibian populations (Mushet et al. 2012a), development of habitat suitability maps for several species within an intensively surveyed block of the PPR landscape (Mushet et al. 2012b), amphibian occupancy modeling of seasonal wetlands throughout the drift plain of the PPR (Balas et al. 2012), and incorporation of information learned into a geographic information system (GIS) modeling system allowing for the quantification of the effects of conservation programs (e.g., Wetlands Reserve Program (WRP), Conservation Reserve Program (CRP) on amphibians across the PPR (Mushet et al. 2014).

This Science Note provides an overview of these amphibian research efforts conducted through CEAP-Wetlands in the PPR. More detailed information can be found in the peer-reviewed publications emanating from individual efforts.

A Conceptual Model to Facilitate Amphibian Conservation (Mushet et al. 2012a)

The landscape of the PPR is changing as a surge in agricultural production to meet an ever-growing demand for food, fiber, and energy has facilitated a shift in traditional land use. Simultaneously, as land-use trends shift and pressure on agricultural landscapes mount, amphibian populations face numerous threats including habitat destruction, chemical contaminants, disease outbreaks, wetland sedimentation, and the synergistic effects of these perturbations (Semlitsch 2000), demonstrating a need for models that will aid amphibian-focused conservation planning. In a step towards meeting this need, a conceptual model depicting elements critical for amphibian conservation in the PPR was developed (Mushet et al. 2012a). The model identifies key drivers and stressors, and links them to ecological effects on specific attributes important for the maintenance of viable and genetically diverse amphibian populations.

In creating this conceptual model, a compromise between model generality and model realism was needed to address both broad-scale ecosystem drivers applicable to an entire region and fine-scale details needed to identify important connections. Using a two-

stage process, a successful tradeoff between model generality and model realism was identified. The backbone of this two-stage approach was the creation of a model depicting generalized relationships among habitat components and key life-history attributes (fig. 1). Next, major drivers influencing habitat components were identified and linked to life history attributes through the identification of ecosystem stressors and their effects. In this second stage, we utilized the definitions of ecosystem drivers, stressors, effects, and attributes described by Ogden et al. (2005). The result of this two-stage process is the conceptual model presented in figure 2.

Precipitation patterns, a major

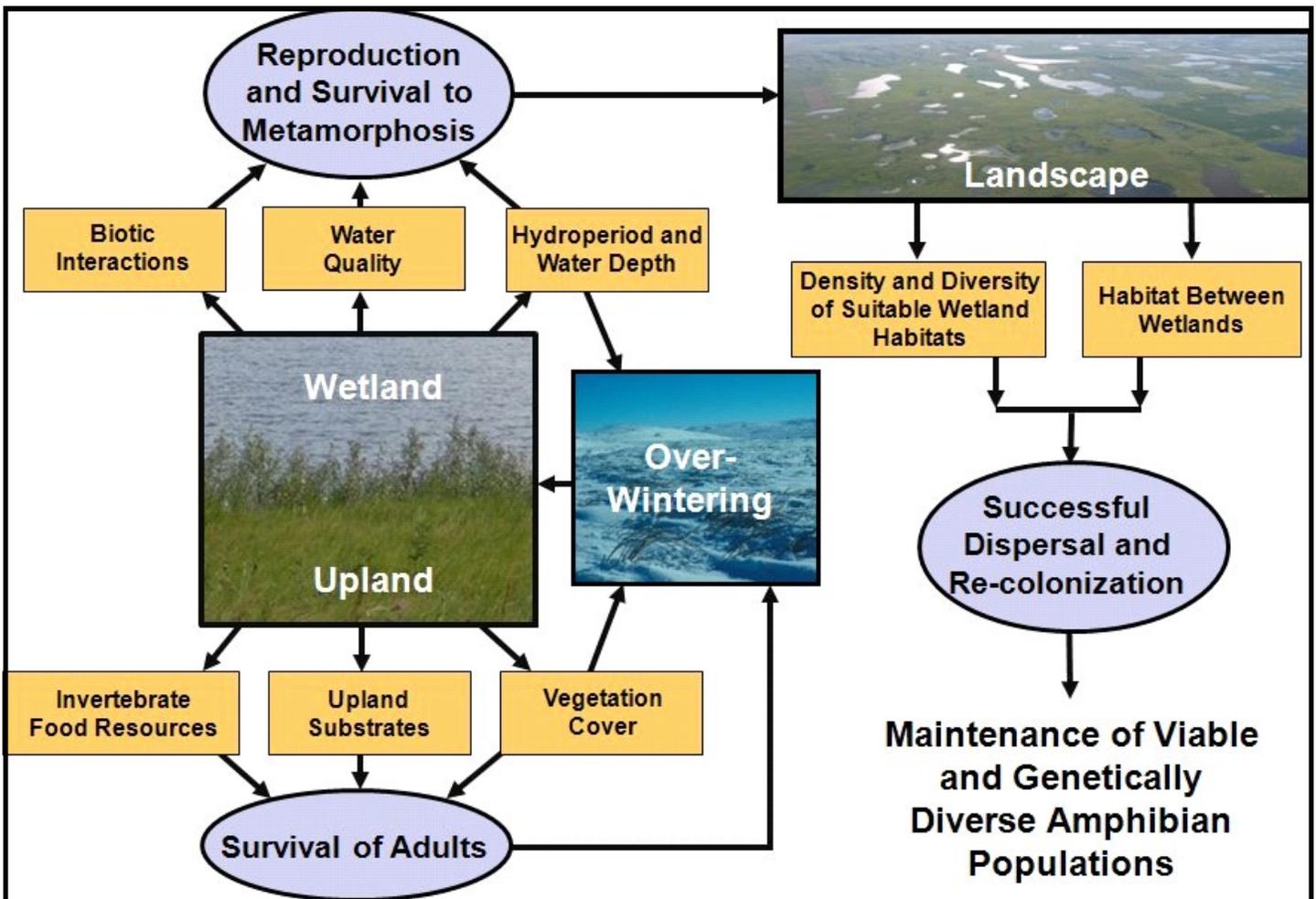
component of the climate cycles driver of PPR amphibian populations shown in figure 2, cycle on roughly a 10- to 20-year basis within the region. This cycle varies between periods of drought (Woodhouse and Overpeck 1998) and periods of deluge (Winter and Rosenberry 1998), both of which act upon amphibian populations. During periods of drought, wetlands of the PPR tend to have shortened hydroperiods, decreased wetland water depths, and in some cases, complete desiccation of the wetland acting to increase inter-wetland distances.

Conversely, periods of deluge are often characterized by effects such as lengthened hydroperiods, increased

water depths, and decreased inter-wetland distances. The interplay between the extremes of both drought and deluge and their effects can influence amphibian life history attributes including reproduction and survival to metamorphosis, successful dispersal and recolonization, and the survival of adults.

The effects derived from the stressors associated with the other main driver affecting amphibian populations in the PPR--economic incentives for crop production--influence amphibian life history attributes in ways similar to effects of the region's climate cycles. As an example, stressors such as wetland drainage are similar to those of droughts and influence some of the same

Figure 1. A generalized model depicting linkages among habitats (photos), life history attributes (ovals), and ecosystem components (rectangles) maintaining viable and genetically diverse amphibian populations in the Prairie Pothole Region of North America. *From Mushet et al. 2012a.*



amphibian life history attributes. Likewise wetland excavation and impoundment share similar effects to those of the deluge portion of natural climate cycles. However, stressors associated with agricultural crop production affect not only variation in hydroperiod, water depth, and interwetland distance, but also produce effects associated with increased sediment transportation from uplands to wetlands, and increased exposure to agricultural chemicals. These effects can influence reproduction and survival to metamorphosis and survival of adult amphibians, key life history attributes of amphibians, including reproduction and survival to metamorphosis and survival of adult amphibians.

The effects of stressors related to both climate cycles and economic incentives for crop production can also work together in a synergistic manner to increase susceptibility of amphibians to disease and pathogens. In an ever changing environment and landscape, a continuous flux among these stressors and their effects plays out on varying landscape and time scales to influence the maintenance of viable and genetically diverse amphibian population in the PPR.

Development of Habitat Suitability Maps (Mushet et al 2012b)

Ecogeographical GIS layers describing key environmental features were used in

conjunction with amphibian call survey data to identify relationships among environmental variables and suitability of habitats for amphibian species. Using an ecological niche factor analysis method implemented through the Biomapper program, habitat suitability for five anuran species was quantified within a 196 km² study area. Amphibian call surveys conducted over a two year period identified northern leopard frogs (*Lithobates pipiens*), wood frogs (*Lithobates sylvaticus*), boreal chorus frogs (*Pseudacris maculata*), Great Plains toads (*Anaxyrus cognatus*), and Woodhouse's toads (*Anaxyrus woodhousii*) occurring within the study area. Focusing on these five species,

Figure 2. A conceptual model relating key drivers to ecological attributes important for maintaining populations of amphibians in the Prairie Pothole Region of North America. Global climate change, displayed as a cloud overarching the entire model, has the potential to affect both major drivers and therefore all stressors and related effects influencing life history attributes of amphibians. *From Mushet et al 2012a.*

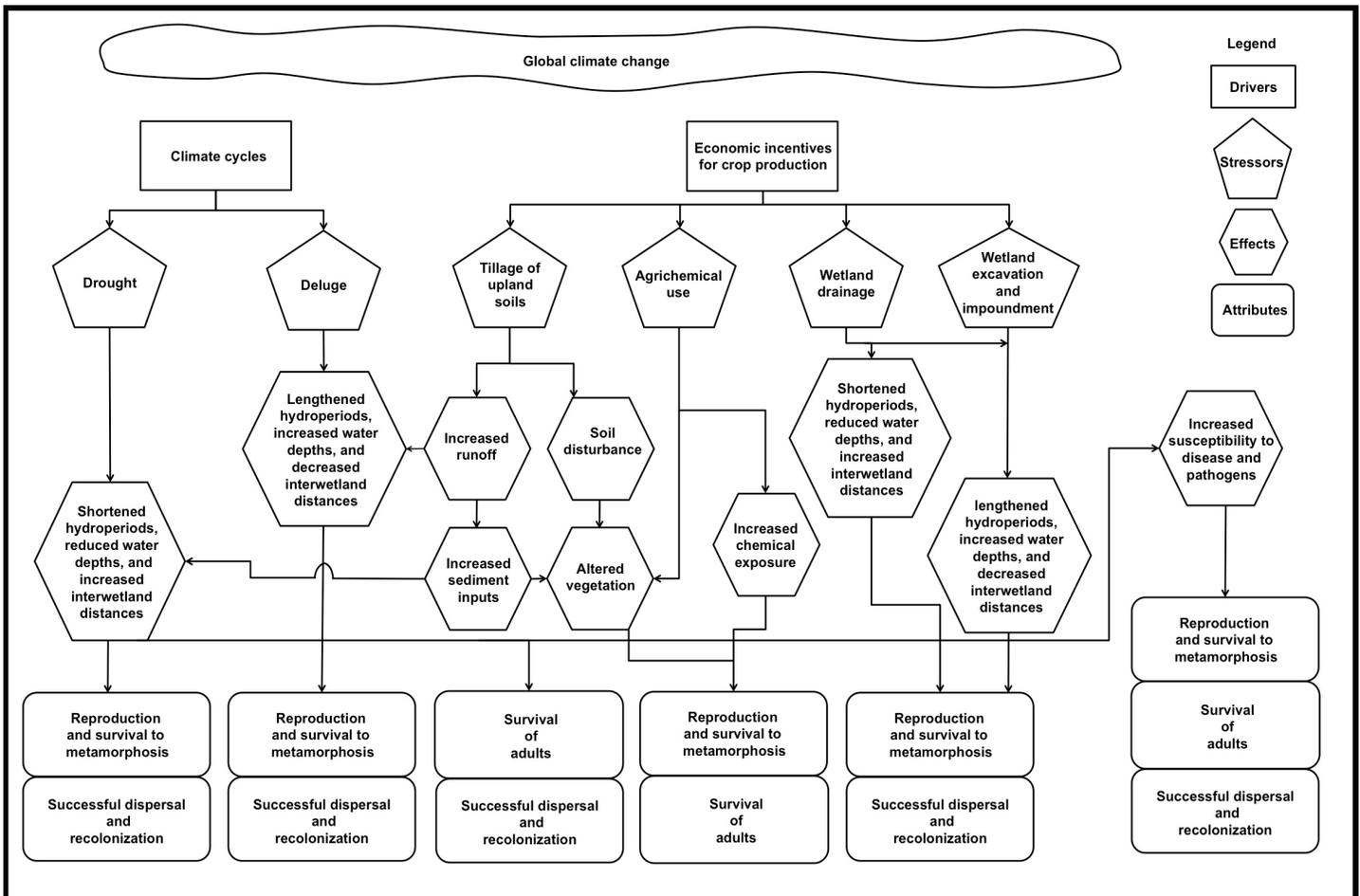
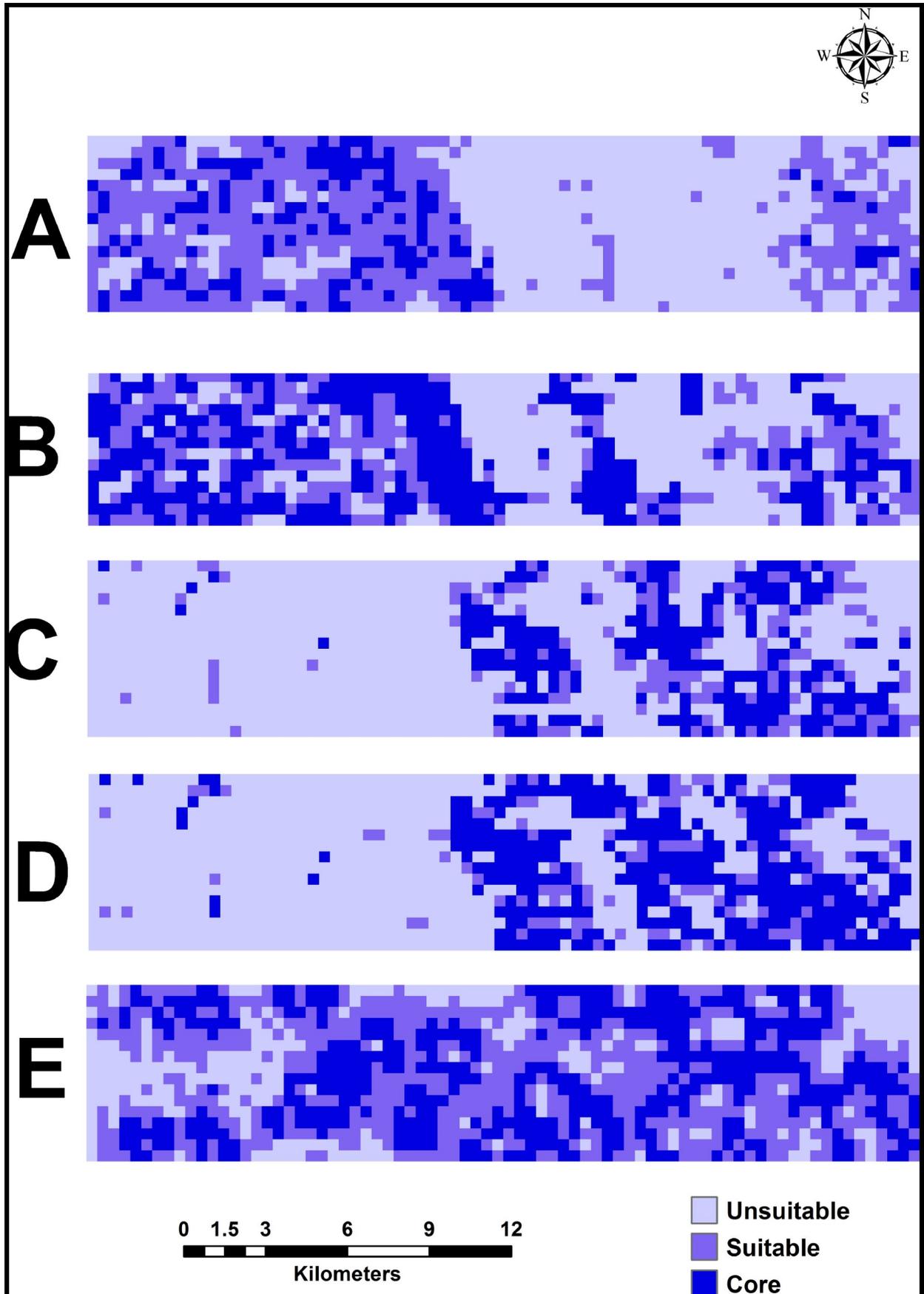


Figure 3. Amphibian habitat suitability maps for the A) northern leopard frog, B) wood frog, C) Great Plains toad, D) Woodhouse's toad, and E) boreal chorus for a 196 km² study area within the Prairie Pothole Region of North America. From Mushet *et al.* 2012b.



habitat suitability maps developed for each species revealed differing patterns of core and suitable habitat.

The use of ecological niche theory (Chase and Leibold 2003) offers a way of estimating how environmental changes, such as the loss of conservation grasslands, affect the suitability of a landscape for a species of interest (Hirzel et al. 2008). Nine ecogeographical GIS layers were created, each detailing a different aspect of the study site environment (percent grassland, distance to trees, etc.). These ecogeographical GIS layers were used in conjunction with species occurrence layers developed from call surveys to perform ecological niche factor analyses and generate habitat suitability maps.

The habitat suitability maps generated utilizing the Biomapper program varied by anuran species (fig. 3). Variances between suitable and core habitats for each species revealed close ties to grassland areas for some species such as northern leopard frog and wood frog, yet also indicated that other species, in particular both toad species, were linked to cropland areas. Echoing these results, marginality factor scores and specialization factor scores showed that northern leopard frog, Great Plains toad, and Woodhouse's toad all had relatively high marginality values, indicating that suitable habitat for these species was relatively marginal in comparison to habitat conditions globally available across the study site. Boreal chorus frogs and wood frogs both had relatively lower marginality values, indicating that their suitable habitat was closer to average conditions. Similar results were also encountered within specialization scores, indicating that boreal chorus frogs and wood frogs had a lower degree of specialization than the northern leopard frog, Great Plains toad, and Woodhouse's toad.

Habitat suitability maps for the different anuran species encountered in this effort

revealed varying patterns of core and suitable habitats. Analysis of these varying patterns between species indicated the following significant findings: (1) the influence of deep-water overwintering wetlands on suitable habitat for all species encountered except the boreal chorus frog; (2) the lack of overlap between areas of core habitat for the northern leopard frog and wood frog compared to the core habitat for both toad species; and (3) the importance of conservation programs in providing grassland components of northern leopard frog and wood frog habitat. Conservation programs are an important source of suitable habitat for anuran species utilizing grasslands, such as the northern leopard frog.

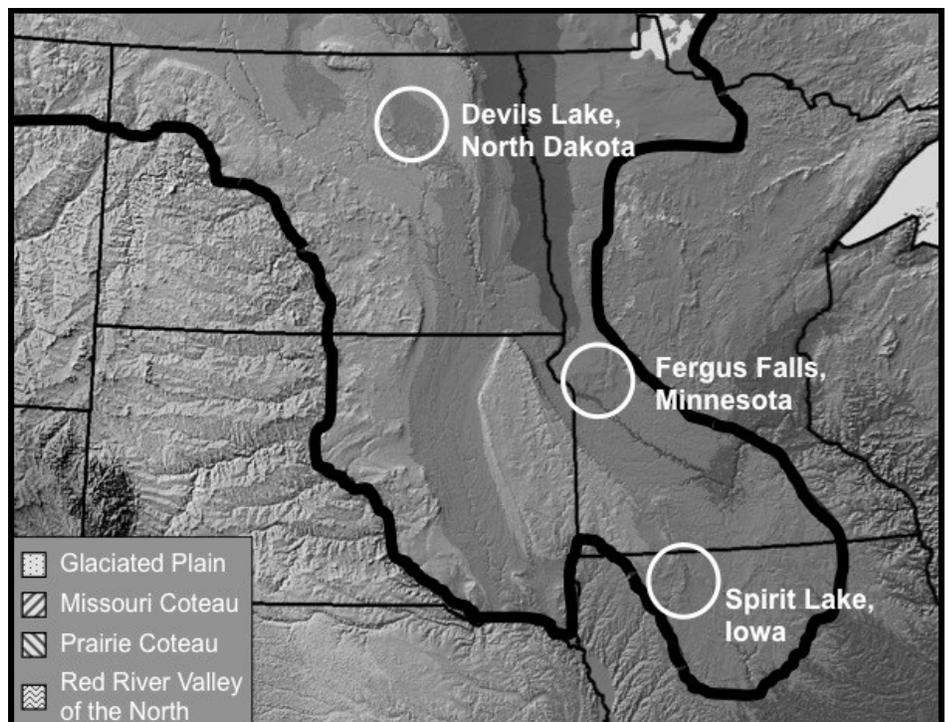
However, study results also indicate that for species such as the Great Plains toad, cropland habitats form a significant component of their utilized habitat. However, little is known about the water quality of cropland wetlands and their potential effects on reproduction and population viability in these highly modified habitats. The great differences

in habitat types identified in this research effort as being suitable to various anurans highlight the need for ecosystem-based conservation and management approaches (Christensen et al. 1996) that consider the habitat requirements of multiple species; a management plan focusing on just an individual species would likely have unintended consequences on other species in an area. This consideration lends itself to an ecosystem-based approach in which the entire area is considered as an interconnected system. Such an approach will likely be required to ensure that conservation and management decisions favor the widest possible set of species utilizing an area.

Amphibian Occupancy Modeling of Seasonal Wetlands (Balas et al. 2012)

Vast tracts of upland croplands have been returned to perennial vegetative cover (i.e., conservation grasslands) under a variety of U.S. Department of Agriculture programs in an attempt to mitigate ecosystem damage associated with extensive landscape alteration.

Figure 4. Location of three study sites (white circles) within the Northern Glaciated Plain ecoregion of the Prairie Pothole Region. *From Balas et al. 2012.*



Using automated call surveys, aquatic funnel traps, and visual encounter surveys, this study evaluated the influence of upland land use (cropland, conservation grassland, and native prairie) on amphibian occurrence within seasonal wetlands across the Glaciated Plain of the PPR. Focusing on three upland land uses (cropland, conservation grassland, and native prairie) surrounding seasonal wetlands, survey were conducted at each of three study locations within the Glaciated Plain of the PPR, located in general proximity to Devils Lake, North Dakota; Fergus Falls, Minnesota; and Spirit Lake, Iowa (fig. 4).

Through the use of automated call surveys, aquatic funnel traps, and visual encounter surveys, a total of eight species of amphibians were identified within the selected seasonal wetlands of the study sites. Species-specific occupancy models were developed for both adult and larval amphibians using PRESENCE[®] software. Amphibian species included the American toad (*Anaxyrus americanus*), Canadian toad (*Anaxyrus hemiophrys*), boreal and western chorus frogs (*Pseudacris* spp.), gray treefrogs (*Hyla* spp.), northern leopard frog, tiger salamander (*Ambystoma tigrinum*), and wood frog.

The study found that with few exceptions, occupancy by amphibians of seasonal wetlands within croplands was less than that of similar wetlands within conservation grassland and native prairie settings. Adult and larval northern leopard frogs, tiger salamander larvae, and wood frog larva occurred in native prairie wetlands most frequently whereas chorus frog larvae and adult tiger salamanders occurred most frequently in conservation grassland wetlands. Adult American toads, Canadian toads, and gray treefrogs had similar occupancy rates among cropland, conservation grassland, and native prairie wetlands. Results of this effort suggest that conservation

programs can improve habitat for many amphibian species, help maintain critical hydrologic processes that can moderate drying conditions, and ultimately reconnect fragmented amphibian habitats.

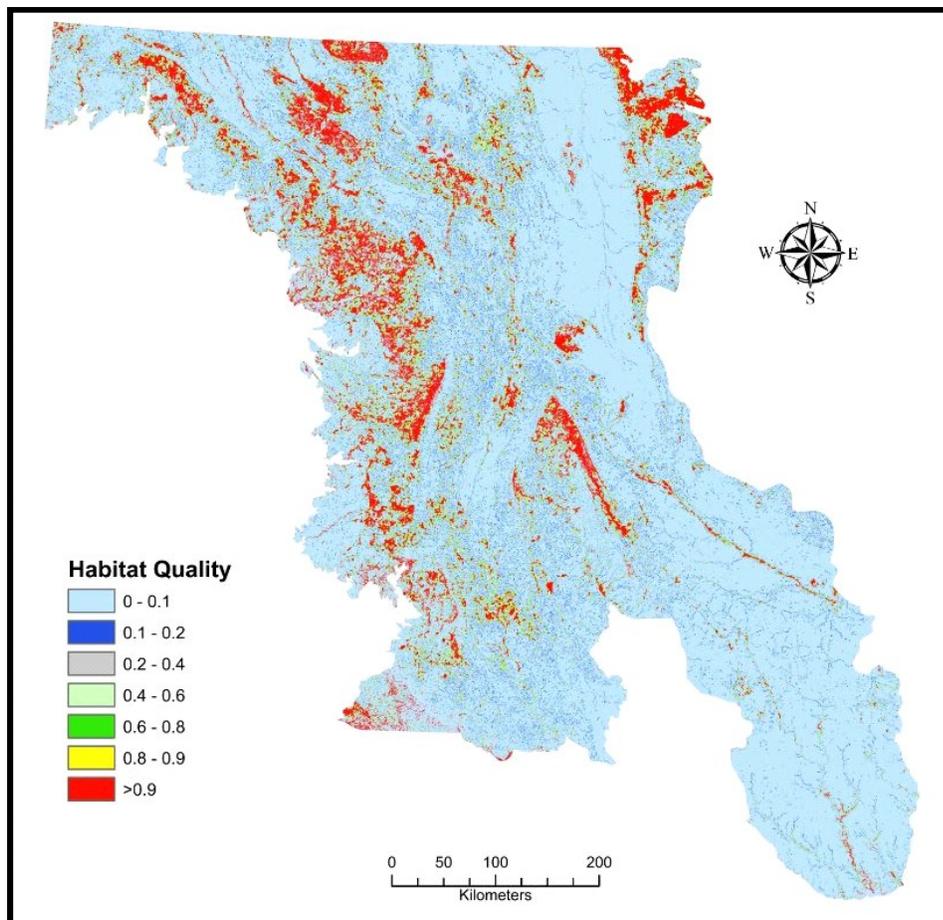
Quantifying Conservation Program Effects on Amphibians Using InVEST (Mushet et al. 2014)

CEAP – Wetlands is utilizing the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) modeling suite (Natural Capital Project 2013) to synthesize knowledge gained through the aforementioned studies to support environmental decision-making and understanding. The InVEST biodiversity model was used to quantify amphibian habitat throughout the PPR in relation to both CRP and WRP conservation lands. Threshold values, relational distances, and tolerance values were derived from CEAP –

Wetlands studies and the current body of knowledge and utilized to parameterize the InVEST model. Model simulations identified suitable amphibian habitat on both the current landscape and under various plausible futures representing incremental losses or gains of conservation lands. By comparing the output maps of suitable habitat (fig. 5) correlated with its input scenario, this modeling effort was able to quantify changes in amphibian habitat across various landscape scales.

Drawing primarily from the research efforts previously summarized, this modeling effort centered on quantifying the benefits of conservation lands for amphibians. U.S. Department of Agriculture Conservation Reserve Program and Wetlands Reserve Program lands account for large portions of the PPR landscape meeting the criteria defining suitable amphibian habitat. Currently, there are

Figure 5. Amphibian habitat quality in the Prairie Pothole Region of the United States, From Mushet et al, 2014



approximately 7.2 million acres (2.9 million hectares, ha) of habitat in the PPR identified as suitable for amphibians. WRP and CRP wetland and grassland habitats accounted for approximately 1.9 million acres (0.75 million ha) or 26 percent of this total area.

Model scenarios depicting the conversion of CRP and WRP lands from conservation grasslands to agricultural crop production yielded results indicating significant losses in suitable amphibian habitat throughout the PPR.

For some scenarios, the quantity of amphibian habitat was found to not decrease significantly hinting at variables outside of land use contributing to amount of available amphibian habitat on the landscape. Current persistent wet conditions throughout the PPR were thought to be a contributing factor. With large amounts of agricultural croplands too wet to till and plant, greater amounts of suitable amphibian habitat was believed to exist, effectively masking the losses to CRP and WRP sustained by grassland to cropland conversion. This evidence seems to reaffirm the emphasis on climatic conditions and shifts while also raising the question of what happens to amphibian habitats and populations when climatic conditions cycle back to dryer conditions and there is still a decreased amount of conservation lands available across the PPR landscape.

Declining amphibian populations, the large variance among habitats identified as suitable for individual amphibian species, decreases in the amount of conservation lands on the PPR landscape, and the need to balance crop production with the benefits received from ecosystem services is becoming clearer each day. Research and modeling efforts such as those highlighted here identify the advantages of rooting research efforts within current research knowledge bases. In doing so, modeling

efforts can more accurately and precisely analyze probable future landscapes. These modeling efforts provide a vehicle for modeling plausible landscape changes and their effects on ecosystem services across a variety of landscape scales. In particular, results from our InVEST model simulations indicate the ability of conservation lands to benefit amphibians by providing suitable habitat. InVEST modeling results have also allowed for the identification of areas and regions that may be more beneficial to amphibian populations and therefore provide focal points for conservation efforts in an effort to maximize ecosystem services, mainly through providing suitable amphibian habitat. Additionally, by incorporating other ecosystem services into the modeling effort, a more holistic understanding of the effects and outcomes of conservation programs and practices will result.

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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 wetlands are affected by conservation actions taken on a variety of landscapes, the wetlands national assessment complements the national assessments for cropland, wildlife, and grazing lands. The wetlands national assessment works through numerous partnerships to support relevant assessments and focuses on regional scientific priorities.

This CEAP Science Note was written by David M. Mushet and Jordan L. Neau, U.S. Geological Survey, Northern Prairie Wildlife Research Center, Jamestown, ND. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

For more information: <http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/ceap>, or contact Bill Effland at william.effland@wdc.usda.gov.

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