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Northern Prairie Wildlife Research Center

EFFECTS OF CONSERVATION PROGRAMS ON AMPHIBIANS IN SEASONAL WETLANDS OF THE PRAIRIE POTHOLE REGION'S GLACIATED PLAIN:

FY2005 Progress Report

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Report to:
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Human perturbations have altered the health and sustainability of modern ecosystems. In the prairie pothole region (PPR) of the United States (Figure 1), an area of considerable value to wildlife and agriculture (Euliss et al. 1999), the primary human perturbation has been land development to facilitate agricultural production. In response to concerns regarding the fate of fish and wildlife habitat and various ecosystem functions (e.g. water quality, sediment and chemical filtration, erosion, nutrient transport, floodwater retention, ground-water recharge, and biological diversity), private and governmental entities have implemented numerous conservation programs to restore basic ecosystem services within the modern agricultural landscape. Although evaluations of these programs to verify and quantify environmental services and benefits are lacking, recent reporting requirements established by the federal government have stimulated interest in developing protocols to monitor and evaluate land-use practices implemented under various federal conservation programs.

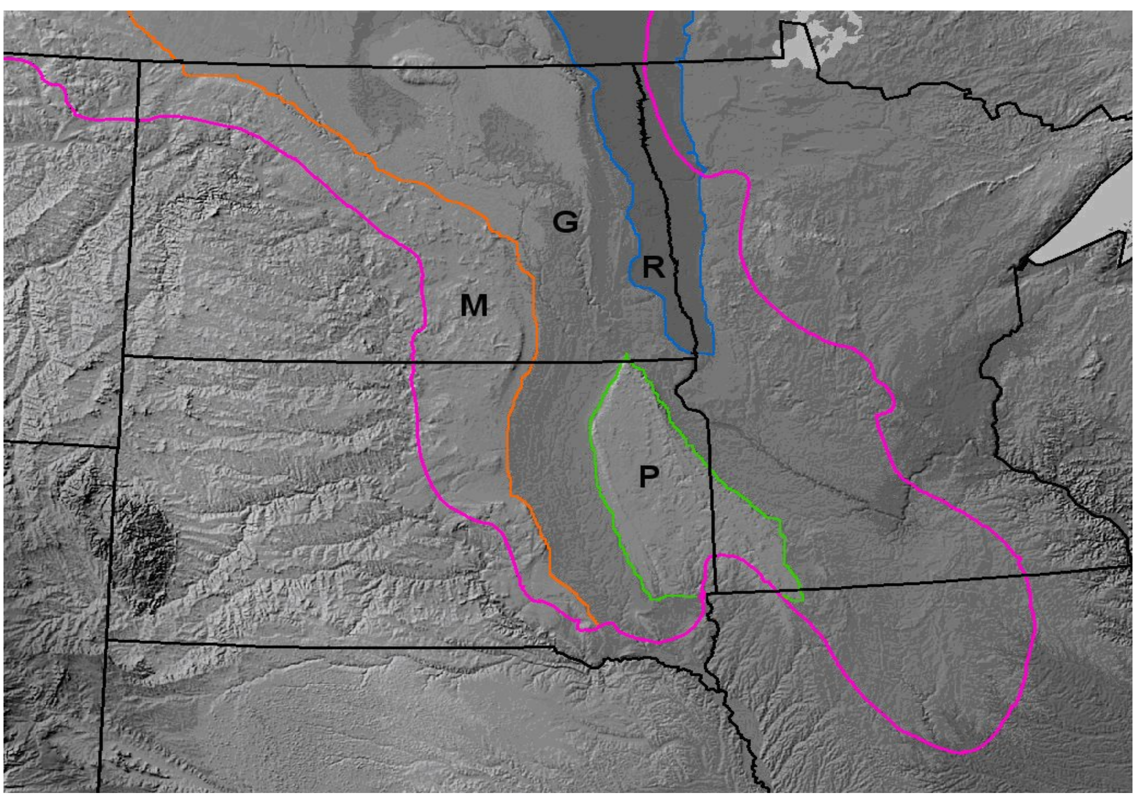

Figure 1. The prairie pothole region of the United States: (M) Missouri Coteau, (G) Glaciated Plains, (R) Red River Valley, and (P) Prairie Coteau.

Land-use changes that destroy or degrade critical habitat have been linked to amphibian population declines in the southern (Gray et al. 2004a) and northern (Larson et al. 1998, Lannoo et al. 1994, Lannoo 1998, Knutson et al. 1999) Great Plains. Destruction (e.g. wetland drainage) includes the direct loss of habitats important for reproduction, migration, dispersal, and other biological events, whereas degradation includes excessive sedimentation, the transport of agrichemicals (i.e., fertilizers, pesticides, and herbicides) to wetlands, and the loss of structural cover important to reduce amphibian exposure to sunlight, associated desiccation rates, and predation. To better understand the nature of these influences on amphibians, we partnered with the United States Department of Agriculture Natural Resources Conservation Service (NRCS) and Farm Services Agency (FSA) to explore potential methods of assessing the impacts of conservation programs on amphibian communities in the PPR. Our objective was to evaluate amphibian communities along a land-use disturbance gradient and along the natural climate gradient of the PPR and provide an initial assessment regarding the effect of conservation programs on amphibians of the Glaciated Plains. This progress report describes accomplishments in the first year of this three-year effort

CURRENT STATE OF KNOWLEDGE

In 2005, we performed a review of the scientific literature relating to amphibians of the PPR. The goal of this review was to review the current state of knowledge relative to amphibians of the prairie pothole region and develop a clearer understanding of the potential influences of conservation programs on their populations. Our literature review revealed that a great deal is already known about the amphibians of the PPR. Semlitsch (2000) provided an extensive review on the principles for management of aquatic-breeding amphibians and concluded that "most of the critical elements required to begin managing amphibians are known." Similarly, most of the critical elements required to begin quantification of the potential effects of conservation programs on their populations also are known. Here we provide a brief overview of the knowledge determined to be key to the quantification of conservation program effects in the PPR. Additionally, we describe a draft conceptual model developed from this knowledge that details habitat processes that ultimately influence the maintenance and regional diversity of amphibian populations.

Extreme Variability Necessitates a Focus on "Suitable Habitat" Rather Than on "Head Counts"

The northern Great Plains is well known for its extremely dynamic continental climate (Kantrud et al. 1989). Large variations in temperature and precipitation that typify the region result from complex interactions among air masses that originate from polar, Pacific, and Gulf of Mexico sources (Borchert 1950, Bryson and Hare 1974). Variations in temperature and moisture content of these competing air masses lead to great seasonal and annual differences in precipitation and evaporation rates. Additionally, long-term cycles between periods of drought (Woodhouse and Overpeck 1998) and deluge (Winter and Rosenberry 1998) can dominate the climate of the region. These wet/dry climate cycles can persist for 10 to 20 years (Duvick and Blasing 1981, Karl and Koscielny 1982, Karl and Riebsame 1984, Diaz 1983, 1986). Prairie wetlands can be completely dry during periods of drought or can flood to depths beyond the tolerance limits of most emergent vegetation during periods of deluge (Winter and Rosenberry 1998).

The great annual variation in habitat conditions results in equally great annual variation in amphibian communities that can occur with no corresponding change in anthropogenic activities. This natural variation in biotic populations has made the development of biotic indicators of wetland integrity very problematic (Micacchion 2002, Wilcox et al. 2002, Tangen et al. 2003, Euliss and Mushet 2006). Figure 2 displays the natural variation that occurred in tiger salamanders (*Ambystoma tigrinum*) populations in eight wetlands at the Cottonwood Lake Study Area in Stutsman County, North Dakota, over a 12-year time period (N. H. Euliss, Jr. and D. M. Mushet, unpublished data). The Cottonwood Lake Study Area is a relatively undisturbed complex of prairie wetlands and no changes in land-use or management practices occurred at the site during the study period. Even in regions of lower climatic variability, amphibian populations fluctuate widely from year to year independent of anthropogenic influence. Semlitsch et al. (1996), studying a Carolina Bay wetland, highlighted the natural yearly variation in five salamander and eight anuran species over a 16-year period. They found that juvenile production for all species was episodic and

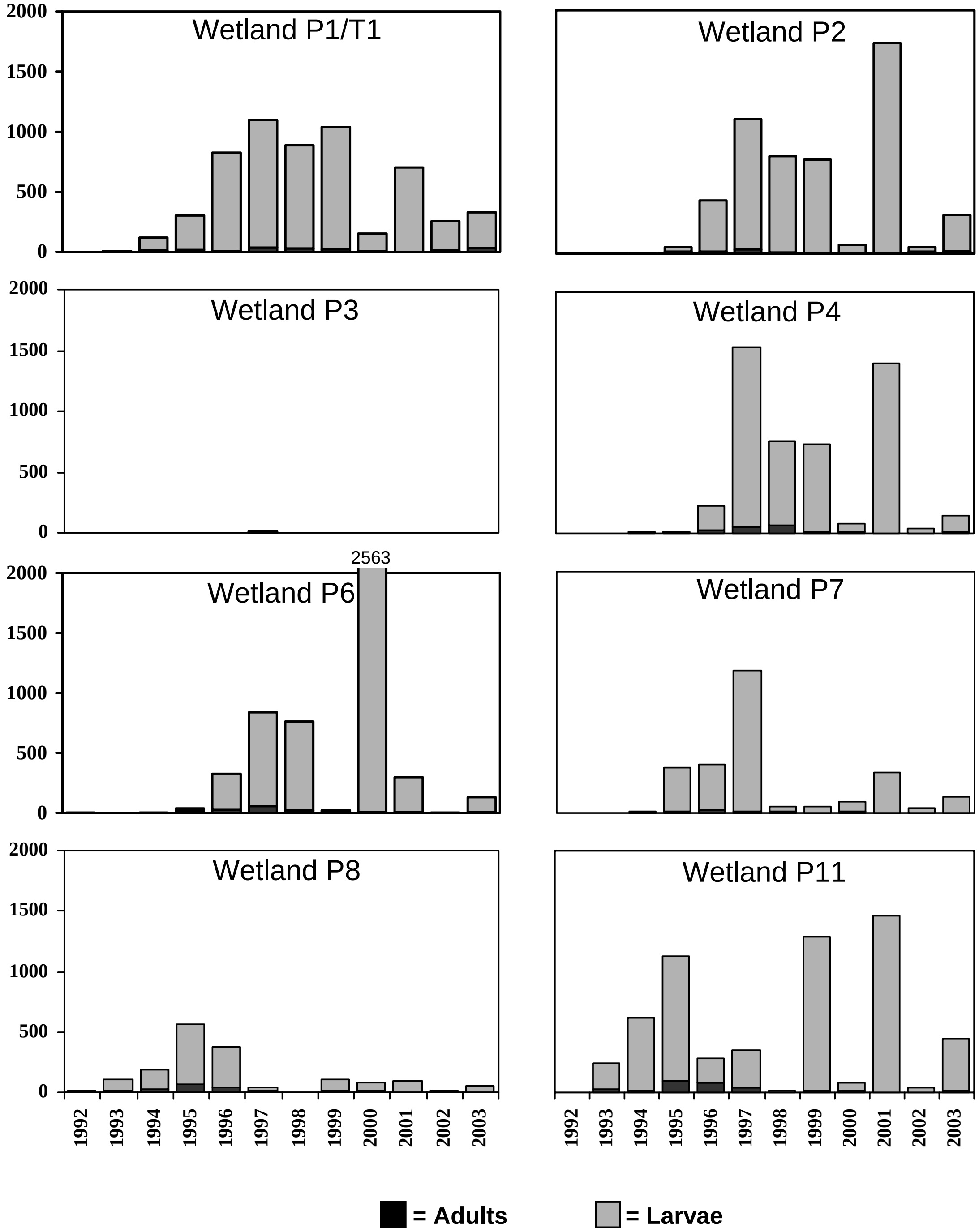

Figure 2. Number of tiger salamanders captured in eight wetlands at the Cottonwood Lake Study Area, Stutsman County, North Dakota, 1992-2003.

contributed to wide fluctuations in breeding population sizes among years. Similarly, great variability in natural amphibian communities has been well documented by others across a wide range of geographic regions and climatic conditions (e.g. Blair 1961, Tevis 1966, Heyer 1973, 1979, Shoop 1974, Gill 1978, Wiest 1982, Berven and Grudzien 1990, Dodd 1992).

Given the great natural variation that occurs in the larval and adult populations of amphibians among years, amphibian numbers do not provide a reliable measurement of the effect of conservation programs on amphibians. Low numbers of amphibians or even extirpations of a species in a wetland in any given year does not provide an indication of the contribution of that wetland to the long-term maintenance and regional diversity of amphibian populations. In a subsequent year, this same wetland may host an explosive breeding event of great importance to the maintenance of a region's amphibian populations. Thus, a focus on identifying "suitable habitat" (both aquatic and terrestrial) and how conservation programs affect the quantity and quality of "suitable habitat" on the PPR landscape will likely lead to a more meaningful measure of the effects of conservation programs on amphibians than a focus on population size during any given year. Euliss et al. (2004) highlight the natural variability of the prairie pothole region in their "Wetland Continuum" concept. Their concept details how the abiotic and biotic components of prairie wetlands naturally fluctuate over time in response to continuously changing climatic conditions. Their concept also highlights the role that having a variety of wetland types on the landscape plays in ensuring that suitable habitat for individual species will likely occur (although at varying spatial locations) during any given year.

Wetland Processes

With the exception of mudpuppies (*Necturus maculosus*) in the Red River, all PPR amphibians have complex life cycles which require both aquatic and terrestrial habitat components in the landscape (Wilbur 1980). Thus, the quality and quantity of both the aquatic and the terrestrial habitat are important for the maintenance and regional diversity of amphibian communities. However, in the highly agricultural PPR, both habitat components have been greatly impacted by human use. In the PPR of the United States, over half of the wetlands have been drained or filled (Tiner 1984, Dahl 1990, Dahl and Johnson 1991) and most terrestrial habitats have been converted to agricultural production.

The aquatic (wetland) habitat is used primarily for mating, egg survival, and larval growth. Thus the primary output desired from the aquatic environment is the production of large numbers of juveniles necessary to maintain adult breeding populations, rescue local populations, and recolonize areas where populations have become extinct (Gill 1978). Wetland hydroperiod, competition, and predation work in concert to influence the amphibian productivity in wetlands (Pechmann et al. 1989, Semlitsch et al. 1996). Both extremely temporary wetlands (with hydroperiods of less than 30 days) and permanent wetlands (with hydroperiods greater than 1 year) are used by fewer amphibian species than wetlands with intermediate hydroperiods (Heyer et al. 1975, Wilbur 1980, 1984). If a wetland dries too quickly, larvae may be killed before metamorphosis can occur. Likewise, if a wetland is too permanent, it may become populated with predators (especially salamanders and fish) which can reduce or eliminate larvae that lack mechanisms to deter predators (Heyer et al. 1975, Caldwell et al. 1980, Woodward 1983, Morin 1986, Kats et al. 1988, Lawler 1989, Hews 1995, Kats and Dill 1998, Tyler et al. 1998, Euliss and Mushet 2004). Thus, amphibian populations can be greatly impacted by predation (Petranka 1983, Bradford 1989, Bradford and Graber 1993, Bronmark and Edenhamm 1994, Skelly 1996, Azevedo-Ramos et al. 1999). Interspecific competition for food resources can reduce larval growth and developmental rates, lengthening the aquatic portion of their lifecycle and increasing vulnerability to desiccation or predation (Collins and Cheek 1983, Wilbur 1987, Newman 1989, Pfennig 1990, Wilbur and Fauth 1990). Wellborn et al. (1996) further describe how amphibian communities in wetlands are structured through the interactions of hydroperiod, competition, and predation.

Semlitsch (2000) states that “an effective management plan must maintain or restore an array of natural ponds that vary in hydroperiod from 30 days to 1-2 years to insure that all local species have sites where the probability of reproductive success is high, even in extremely dry or wet years.” This statement is consistent with the conceptual model presented by Euliss et al. (2004) detailing how naturally occurring wetlands vary both spatially and temporally on the prairie landscape thereby providing a mosaic of habitat types at any point in time. Thus, in efforts to maximize benefits to amphibian populations, quantification of the ability of conservation programs to maintain or restore such an array of wetlands on the landscape would be an essential component of any strategy to measure the conservation program benefits to amphibian populations.

Wetland sedimentation (Gleason and Euliss 1998) and contamination (Hanson et al. 1994, Freemark and Boutin 1995, Boone and Semlitsch 2000, Bridges and Semlitsch 2000, Hayes et al. 2002) can also have a significant impact on wetland biota. Filling of wetlands by sedimentation can alter natural wetland volumes and hydroperiods (Luo et al. 1997) and thus affect amphibian communities. Additionally, sedimentation can influence the composition of the plant and invertebrate communities of wetlands through the burial of seeds and eggs (Gleason et al. 2004). Both organic and inorganic chemicals have a great potential to negatively impact wetland amphibian communities (Rand 1995). Thus conservation efforts that reduce the amount of sediments and/or agricultural chemicals entering wetlands will likely have a positive influence on amphibian communities.

Upland Processes

Adult and newly metamorphosed juvenile amphibians are highly dependent upon surrounding terrestrial habitats. Adults live in the terrestrial habitat for much of the year (Madison 1997, Semlitsch 1998) and enter the aquatic habitats primarily for mating and egg laying. Thus, survival of the adults in the terrestrial habitats is a key component to ensuring a viable population of adults to reproduce in the aquatic habitats (Semlitsch 2000). Several factors related to the production of agricultural crops can greatly impact the suitability of habitat surrounding wetlands and thus the survivability of adults in these terrestrial habitats. Terrestrial juvenile and adult amphibians may be exposed to harmful levels of herbicides and insecticides in terrestrial habitats from chemical applications to agricultural fields (Semlitsch 2000). Additionally, cultivation can reduce live and detrital vegetation that function as foraging, retreat, and burrow sites for amphibians (Dodd 1996, deMaynedier and Hunter 1998, Herbeck and Larsen 1999, Naughton et al. 2000) and can affect the composition of the native plant and ultimately the invertebrate communities in the terrestrial habitat altering natural food web dynamics. Thus, conservation and agricultural programs that result in reduced applications of herbicides and insecticides, and lower disturbance to the terrestrial plant and animal communities will likely have benefits to the amphibian communities.

Landscape Processes

The two primary factors influencing metapopulation dynamics of amphibians are the number of juveniles dispersing from wetlands and the probability of them successfully reaching a new breeding habitat (Hanski and Gilpin 1991, Sjogren 1991, Gibbs 1993). The amphibian species that occur in the PPR are well adapted to the dynamic habitat conditions that characterize the region. A critical adaptation is their ability to produce a large number of dispersing juveniles when conditions are favorable. However, wetland drainage has substantially reduced the number and density of wetlands in agricultural landscapes (Tiner 1984, Dahl 1990, Dahl and Johnson 1991), with a negative impact on amphibian metapopulations (Findlay and Houlahan 1997, Knutson et al 1999, Kolozsvary and Swilhart 1999, Lehtinen et al. 1999, Gray et al. 2004b). Conservation programs that increase the number of wetlands on the landscape subsequently increase the number of areas where amphibians can successfully reproduce and juveniles can successfully be recruited into the breeding population. These juveniles also are the dispersers that provide for mixing of genetic material, found new populations, or recolonize areas where populations have been eliminated. Increases in wetland numbers also result in reduced inter-wetland distances thereby increasing the likelihood that dispersal will be successful. Successful dispersal is especially important in the PPR as populations frequently become extinct in many wetlands during recurring periods of drought. Semlitsch et al. (1996) and Dodd (1993, 1995) reported that even in wetlands undisturbed by agriculture or development, reproductive failure occurs in many years, thus increasing the probability of local extinctions.

The terrestrial habitats also play a key role in influencing the probability that dispersing juveniles will reach other breeding habitats and thus provide gene flow, found new populations, and recolonize areas where populations have become extinct (Semlitsch 2000). Although little information is available on the dispersal of amphibians through terrestrial habitats, it is likely that conservation programs that maintain continuous natural habitat cover between neighboring wetlands would reduce risks to predation, desiccation, and starvation.

Draft Conceptual Model

Here we provide a draft conceptual model (Figure 3) in which we have attempted to capture key factors important in the maintenance of viable populations and regional diversity of amphibians in the PPR. The reader is cautioned that this is a preliminary draft of our model and will likely be changed significantly as this project proceeds. However, we provide this initial draft as a means of visually depicting the habitat processes discussed above and clarifying their combined roles in influencing amphibian populations of the region. The draft conceptual model consists of the three basic factors that influence the regions amphibian populations; 1) the probability of survival from egg to metamorphosis, 2) the probability of adult survival and reproduction, and 3) the probability of successful dispersal. We also depict key habitat features that influence each of the above three factors. Thus naturally vegetated, undisturbed uplands with low use of agrichemicals will contribute to high probability of breeding adults surviving. If these adults reproduce in wetlands with natural hydroperiods, low sedimentation rates, and low levels of contaminants, then there is a high probability that larvae will survive to metamorphosis and enter the local breeding population or disperse. If there is a high density and diversity of wetland habitats on the landscape with natural vegetation covering the areas between wetlands, it is likely that dispersing juveniles will successfully recolonize areas where extinctions have occurred or will found new populations. All of these factors contribute to the continued maintenance of viable populations and regional diversity of amphibians. Our draft model reveals that quantification of the effects of conservation programs can be based on quantifying the effects of specific features that contribute to the probability of adult survival, larval survival, and successful dispersal. Figure 4 identifies process models and other currently available or obtainable information that potentially could be used to make the connections between the effects of conservation programs and the maintenance of viable populations and diversity of amphibians in the PPR.

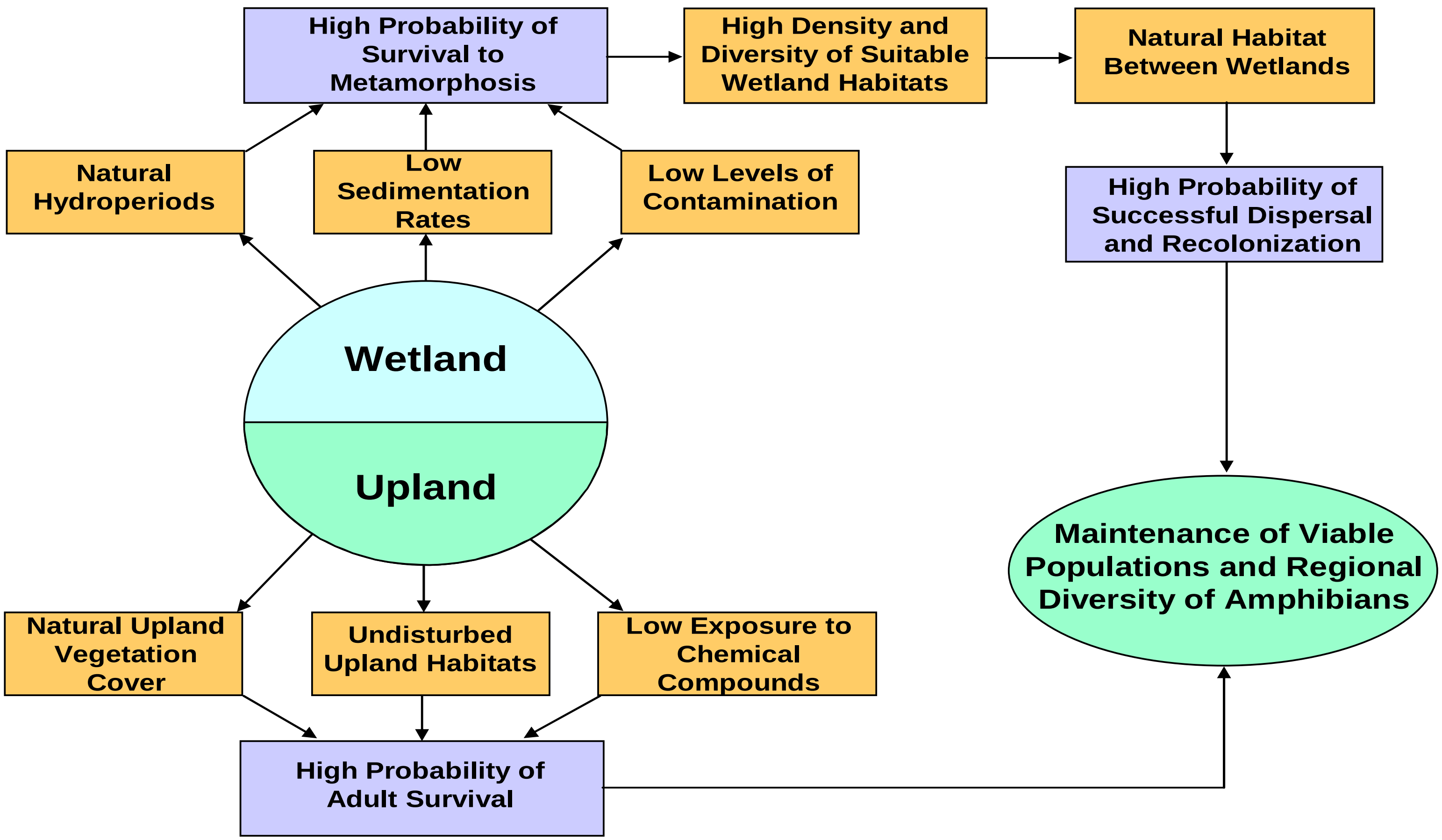

Figure 3. A draft conceptual model depicting habitat features that influence the maintenance of viable populations and diversity of amphibians in the prairie pothole region of the United States.

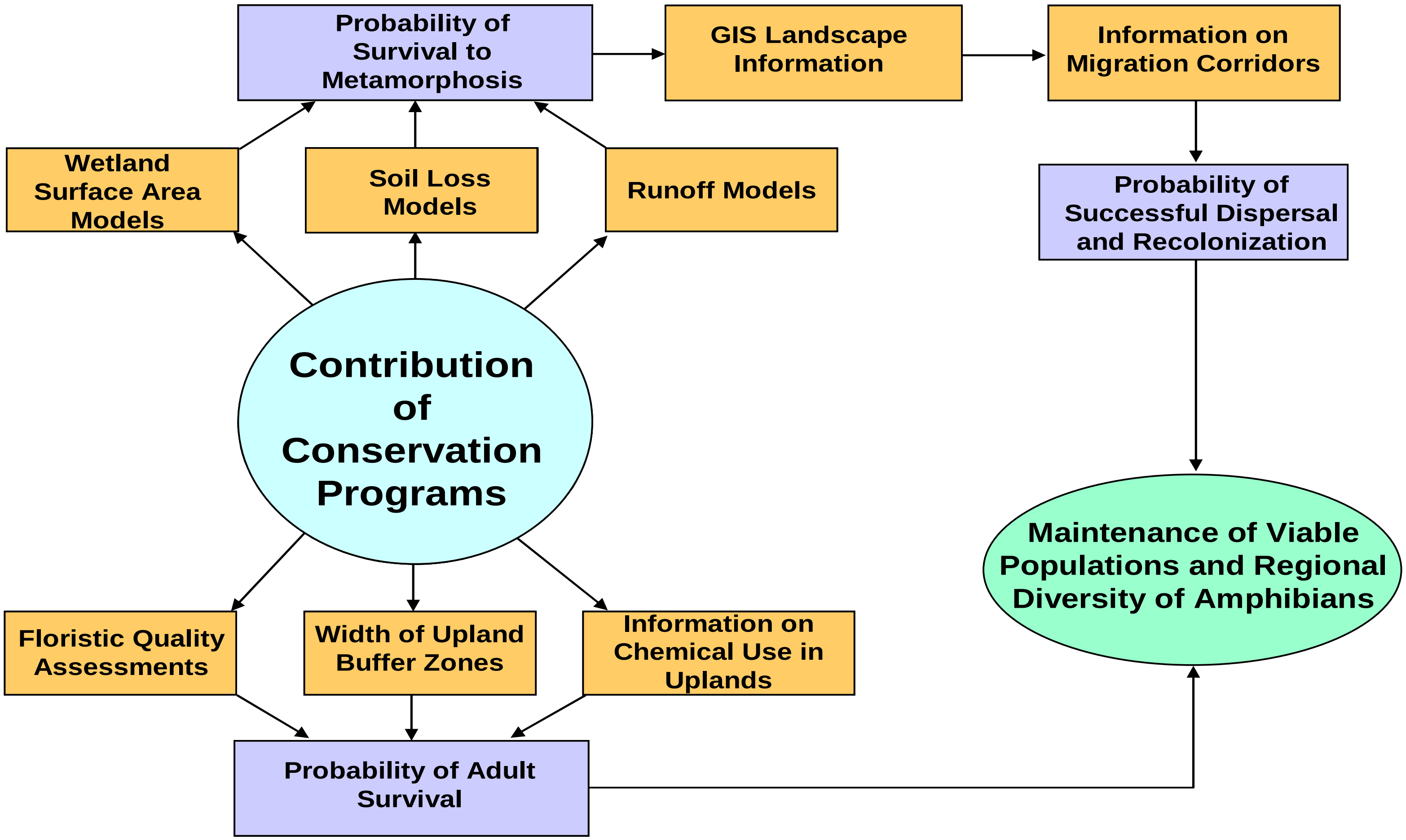

Figure 4. Currently available models and obtainable information that potentially can be used to quantify conservation program effects on the maintenance of viable populations and diversity of amphibians in the prairie pothole region of the United States.

FY2005 FIELD WORK

In FY 2005, we followed the procedures outlined in the study plan for this project to sample the amphibian communities of 40 seasonal wetlands in the PPR. Twelve of the wetlands were drained/farmed wetlands, 16 wetlands were formerly drained/farmed wetlands that had been restored and placed in a conservation program, and 12 wetlands were reference wetlands (i.e., non-drained wetlands in native prairie). The wetlands were distributed among three sampling locations in the northern, central, and southern portions of the Prairie Pothole Region Glaciated Plains (Figure 5). We sampled each wetland six times in 2005 with visual encounter surveys (Heyer et al. 1994), amphibian funnel traps (Mushet et al. 1997), egg mass surveys (Crouch and Paton 2000), and automatic recorders (Bowers 1998, Heyer et al. 1994) to document as much of the amphibian diversity at each site as possible.

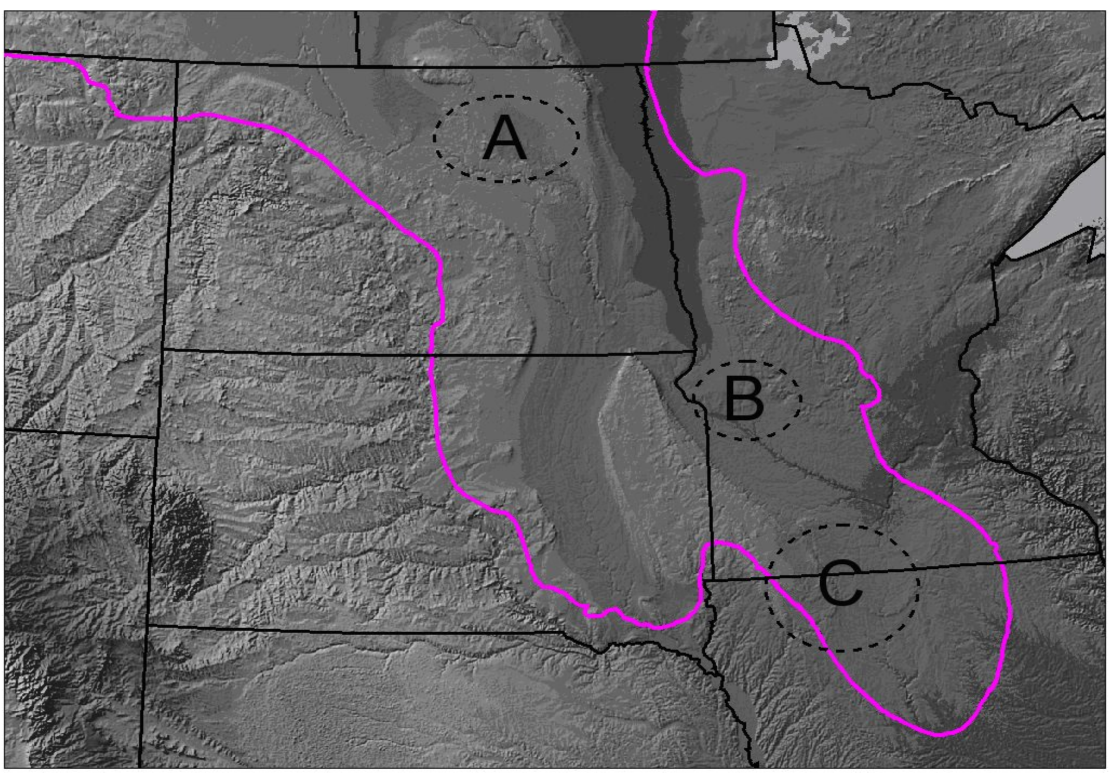

Figure 5. Areas of wetland site selection in the PPR of the United States. (A) Devils Lake, ND, (B) Morris, MN, and (C) Spirit Lake, IA.

Data from our 2005 sampling have produced the following **preliminary results**:

- **Eight amphibian species were present in the wetlands sampled in 2005.**
    - northern leopard frog (*Rana pipiens*)
    - chorus frog (*Pseudacris maculata/triseriata*)
    - wood frog (*Rana sylvatica*)
    - gray tree frog (*Hyla versicolor/chrysoscelis*)
    - tiger salamander (*Ambystoma tigrinum*)
    - Canadian toad (*Bufo hemiophrys*)
    - Great Plains toad (*Bufo cognatus*)
    - American toad (*Bufo americanus*)

- **Anurans:**
    - ***Frogs had a higher rate of occurrence in the sampled wetlands than did toads.***
        - Northern leopard frogs had the highest frequency of occurrence, being found in 75% of the wetlands, followed by chorus frogs (70%), wood frogs (45%), and gray tree frogs (13%).
        - American, Canadian, and Great Plains toads occurred in 23%, 10%, and 5% of the wetlands, respectively.
- **Salamanders:**
    - ***Tiger salamanders were found in 40% of the wetlands sampled.***

- **Species-habitat relationship:**
    - ***Half of the species sampled occurred at a greater frequency in restored wetlands (N=16) than in farmed wetlands (N=12).***
        - Northern leopard frogs and chorus frogs had greater occurrence in wetlands in conservation programs (94% and 88%, respectively) versus those currently being farmed (42% and 33%, respectively). Wood frogs also occurred more often in the conservation program wetlands (44%) than the farmed wetlands (25%), but the differences were not as great.

        - American toads were founded in 44% of the conservation program wetlands but not in a single farmed wetland.
        - Canadian toads and Great Plains toads occurred more often in farmed wetlands (17% for each) than in conservation program wetlands (0% and 6%, respectively).
        - Grey tree frogs were only found in a single conservation program wetland and a single farmed wetland.

- **Potential differences among the three Glaciated Plains regions sampled**:
    - ***Farmed wetlands provided habitat for amphibians in the northern Glaciated Plains while they did not in the southern portion.***
        - In North Dakota, leopard frogs, wood frogs, and chorus frogs occurred in both farmed and conservation program wetlands.
        - Amphibians were entirely absent from the farmed wetlands sampled in Iowa.
    - ***Wetlands sampled in the central Glaciated Plains supported the highest amphibian diversity.***
        - Wetlands sampled near Morris, MN had the greatest diversity of amphibians (7 species, versus 5 for ND and 4 for IA).

PLANS FOR FY2006

In FY2006, the amphibian communities of all wetlands sampled in 2005 will be re-sampled, and environmental and landscape data will be analyzed to obtain a better understanding of habitat use/non-use in the PPR. These data will be used to create models identifying suitable habitat for amphibians. We will also further explore the development of models and mapping methodologies (e.g., Hirzel et al. 2002) that potentially can be used to quantify the influence of conservation activities on amphibian communities in the PPR. Additional funding was secured from the USGS to extend field sampling through 2007. This extension will greatly increase the overall value of this research effort to FSA, NRCS, and

USFWS. Additionally, amphibian community and environmental data from USGS long-term work at the Cottonwood Lake Study Area, near Jamestown, ND, will be used to explore the natural variation in amphibian communities in relation to the dynamic climate cycles of the region.

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