Evaluation of Conservation Practices, with an Emphasis on Habitat Quality and Climate Change, in the Lower Wabash Watershed

Report submitted to Mr. Michael Sertle,
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Executive Summary

For the Fall 2016 capstone class in the School of Public and Environmental Affairs (SPEA) at Indiana University, the Lower Wabash collaborative requested that we gather and assess information for the development of a conservation plan for the Lower Wabash River Watershed. The Lower Wabash Watershed begins south of Terre Haute, Indiana and extends south along the Indiana-Illinois border. The land use in the watershed is predominately agricultural, and runoff from fertilized crop fields supplies excess nutrients to the river. These nutrient loads have negative effects on local and downstream water quality, wildlife, and ultimately the ecosystem. The Eastern Tallgrass Prairie & Big Rivers Landscape Conservation Cooperative (ETPBR LCC) is facilitating conservation planning of the floodplains and associated upland habitats within the Lower Wabash River to address the effects of excess nutrient loading.

Our project purposes were two-fold: first we wanted to evaluate the conservation practices chosen by the ETPBR LCC to determine which practices provide the greatest benefits to wildlife and habitats. Second, we wanted to determine how climate change could potentially shape the conservation plan. To determine the effects of climate change on the conservation plan, we evaluated the climate change effects on the ETPBR LCC conservation practices and developed a scenario plan to determine how the practices hold-up under different possible future scenarios.

The conservation practices chosen by the ETPBR LCC were adapted from the Mississippi River Basin conservation plan. Our first step was to narrow down these practices to those best suited to the Lower Wabash Watershed. Next we used evaluation criteria developed by the Natural Resources Conservation Service (NRCS) to evaluate the soil and water quality benefits of the conservation practices. The NRCS evaluation tool has limited wildlife, habitat, and climate change evaluation criteria, so we developed the following criteria: biodiversity, invasive species, indicator species, flood control, and climate change resilience. We then used these criteria to assess which practices provide the greatest habitat and climate change benefits.

We also compiled information on species and functional groups benefitting from each practice. This information can be used as a baseline to inform decisions when selecting conservation practices for different habitats according to which wildlife groups are benefitted. Focal habitat information was also compiled from the Lower Wabash LCD draft plan to integrate into species distributions.

Climate change creates an uncertain future for conservation plans. Scenario planning is a useful tool that helps managers anticipate and plan for different future situations. Scenario planning is accomplished by pairing two external drivers that will have a significant impact on future conditions, but are unpredictable; therefore, multiple scenarios must be considered. By determining how these scenarios will change the landscape and how they will affect landowners' decisions, we were able to determine which conservation practices will be most relevant and useful under each scenario. Our scenario plan consisted of increased flooding events and increased drought events on one axis, and increased crop prices and decreased crop prices on the other axis.

Results of our conservation practice evaluations suggested that buffer strips, cover crops, and wetland restoration and reforestation provide the greatest habitat and climate change benefits. Wetland restoration and reforestation, drainage water management, and cover crops were found to provide the highest levels of benefits across all criteria. Scenario planning results show that cover crops and drainage water management are beneficial under all 4 possible future scenarios, implying that they are the most versatile practices.

Based on our results, we recommend implementing cover crops and drainage water management on active farmlands, and wetland restoration and reforestation, and buffer strips on marginal lands or inactive farmland. Limitations of our evaluation include simplicity of the scoring system, unweighted scores, and variations within practices.

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1. Introduction and Purpose

Introduction

The Lower Wabash Watershed begins south of Terre Haute, Indiana and extends south along the Indiana-Illinois border (Figure 1.1.1). Because of extensive agriculture in the area, excess nutrients from fertilization make their way to the river, and are carried downstream, and eventually out to the Gulf of Mexico. The occurrence of excess nutrient loading has negative localized effects, as well as negative downstream effects. Local effects include threats to rare species and biodiversity. Downstream effects include a phenomenon, known as Gulf Hypoxia, which threatens wildlife and ecosystems by reducing oxygen to levels that do not support aquatic life in the Gulf of Mexico.

The Mississippi River Basin/Gulf Hypoxia Initiative (MRB/GHI) is a collaborative effort designed to create a framework to promote ecosystem services produced by strategically configured wildlife conservation practices in the Mississippi River Basin (Gulf Coastal Plains, 2016). This initiative is led by seven Landscape Conservation Cooperatives (LCCs), which are regional collaborations of state and federal agencies and nongovernmental organizations. This joint effort of multiple stakeholders is essential in executing large-scale, long-term conservation goals, such as the MRB/GHI. The Eastern Tallgrass Prairie & Big Rivers Landscape Conservation Cooperative (ETPBR LCC) is facilitating conservation planning of the floodplains and associated upland habitats within the Lower Wabash River watersheds as a step-down project within the GHI. Our V600 capstone class at Indiana University is working with the Lower Wabash collaborative to gather and compile information that will be useful for the stakeholders, for the development of a conservation plan for the area. The stakeholders involved in the Lower Wabash collaborative include the US Fish and Wildlife Service, The Nature Conservancy, Natural Resources Conservation Service (NRCS), Ducks Unlimited, Illinois and Indiana Divisions of Fish and Wildlife, and several other federal, state, and NGO partners.

Figure 1.1.1 The Wabash River Watershed, Indiana and Illinois. The Lower Wabash extends from the southern border of Indiana, up to Terre Haute. (from pinterest.com)

Hypoxia occurs when excess nutrients stimulate algal blooms so that the concentration of dissolved oxygen in the water column is depleted, and oxygen-dependent aquatic organisms can no longer survive. Hypoxia has major implications not only for wildlife, but also for the fishing industry and economies that depend on healthy aquatic communities. Runoff from agriculture and municipality outflows transfer excess nitrogen and phosphorus loads into local watersheds, which then flow to regional rivers and eventually the sea. Evidence suggests that the duration and frequency of hypoxic events in the U.S.is increasing. The Ohio River was identified as the greatest contributor of nitrogen and phosphorus to the Gulf of Mexico in the 2008 Gulf Hypoxia

Action Plan (Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, 2008). Further, a 2005 study by the Ohio River Valley Sanitation Commission (ORSANCO) identified the Wabash River, the second largest tributary to the Ohio River, as the largest contributor of nitrogen and phosphorus to the Ohio River. A more recent 2011 study by ORSANCO found that the Wabash River produced an annual load of 138,976 metric tons of nitrogen and 4,646 metric tons of phosphorus, which represents 24.5% and 10.6%, respectively, of the nitrogen and phosphorus loads in the Ohio River (ORSANCO, 2012). For this reason, reducing nutrient loading (runoff) from Midwestern agriculture is a key component to addressing the hypoxia problem downstream.

Floodplains are comprised of "wet" soils, which in their natural state, provide habitat and food sources for a diversity of species and provide water quality improvement by filtering out pollutants. When drained, floodplains can be the most productive agricultural lands. Although most wetlands are privately owned, they are a public concern because of the role they play in improving water quality and as a habitat for wildlife. Riparian vegetation can trap sediments and remove harmful agricultural pollutants such as nitrate-nitrogen, phosphorus, and pesticides before they can enter streams and rivers (Figure 1.1.2). Because of the crucial ecosystem services provided by floodplains and vegetated riparian zones, it is important to maintain or restore them (Evans et al., 1996).

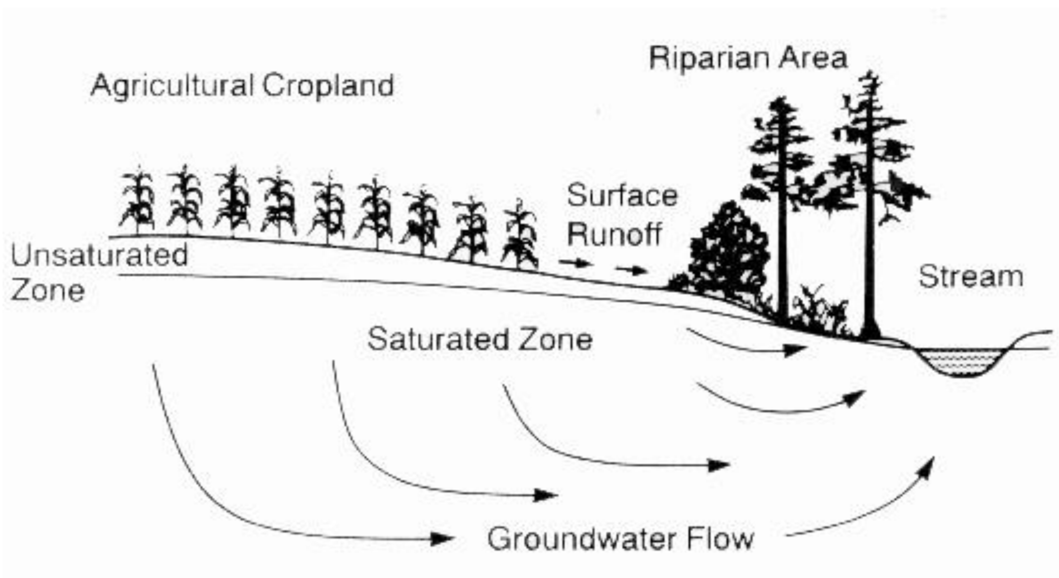

Figure 1.1.2 Riparian vegetation in floodplains can remove agricultural pollutants before they reach streams and rivers (Evans et al., 1996).

Purpose

Our V600 capstone class from the Indiana University School of Public and Environmental Affairs (IU SPEA) is assisting the Lower Wabash collaborative in conservation planning, under a changing climate. Decision makers should consider different potential future climates, to be able to adapt to unpredictable changing conditions, take advantage of opportunities, and mitigate negative impacts. We are also looking into ways to improve decision making, regarding habitat quality and wildlife conservation. Our findings can be applied to other similar areas in LCC to ensure sustainable conservation strategies are implemented on a large scale in light of climate change and other drivers of decision making.

Our project purposes were two-fold: first we wanted to evaluate the conservation practices chosen by the ETPBR LCC to determine which practices provide the greatest benefits to wildlife and habitats. Although the NRCS evaluation tool has several criteria for soil and water quality evaluation, it is lacking in wildlife, habitat, and climate change evaluation criteria, we have developed our own criteria to assess habitat and climate change benefits. In order for landowners and land managers to choose conservation practices effectively, they must understand the level of benefits each practice provides, in terms of the landowners' individual objectives. For example, while some landowners are more interested in soil health benefits, others may be more interested in improving habitat quality; for these distinct objectives, different conservation practices are likely to apply.

Second, we wanted to determine how climate change could potentially shape the conservation plan. By considering multiple potential future scenarios and determining how these scenarios will change the landscape and how they will affect landowners' decisions, we can determine which conservation practices will be most relevant and useful under each scenario.

2. Conservation Practices

The ETPBR LCC investigated various conservation practices to address the landscape-scale conservation goals identified as part of the Gulf Hypoxia Initiative. Twelve conservation practices were selected based on workshops, stakeholder meetings, and input from the Natural Resources Conservation Service (NRCS). The ETPBR LCC published 12 corresponding fact sheets which introduce each practice and provide an overview of the benefits and limitations. Our team utilized these fact sheets and further literature review to narrow the ETPBR LCC's list of conservation practices down to the 7 practices which appear best suited for the Lower Wabash region (Table 2). These 7 practices were selected based on their applicability to the Lower Wabash region land types and land uses. Several of the original 12 practices were specific to the coastal floodplains and wetlands associated with the Lower Mississippi Basin.

Table 2. Twelve conservation practices selected by the ETPBR LCC and their applicability to the Lower Wabash Watershed.

Conservation Practices

Applicable to Lower Wabash	Not Applicable
Wetland restoration and management	Lower floodplain water diversion
Lower floodplain reforestation	Grassland and grazing management
Buffer strips	Biomass production
Cover crops	Prescribed fire
Drainage water management	Lower floodplain vegetative diversity
Two-stage ditches	
Upper floodplain hydrologic restoration	

Many of the ETPBR LCC's conservation practices were selected or developed from the NRCS's Field Office Technical Guide (FOTG) which documents and provides technical specifications for national conservation practices. The NRCS developed the Conservation Practice Effects Summary Tool (CPPE) to tabulate and assess each conservation practice's costs and benefits. The CPPE uses several criteria relating to soil, water, and air quality effects, as well as each practice's effects on plant, animal, and livestock (Appendix 1).

Although the CPPE tool provides useful conservation practice information to planners and managers, there is significant room for expansion regarding the habitat and wildlife criteria used to assess and compare practices. Further, criteria regarding the resiliency and success of practices in future climates could be an important asset to producers and managers operating in future conditions. Section 3 of this paper provides our suggestions for additional criteria that will improve the CPPE's ability to assess conservation practices based on their effects on wildlife, habitat conservation, and future climate conditions. Section 3 also provides an analysis on whether our 7 selected conservation practices meet these new criteria.

3. Evaluation of Conservation Practices

3.1 Introduction

In order for landowners and land managers to choose conservation practices effectively, they must understand the level of benefits each practice provides, in terms of the landowners' individual objectives. For example, while some landowners are more interested in soil health benefits, others may be more interested in improving habitat quality; for these distinct objectives, different conservation practices are likely to apply. In the following three sections, we provide evaluations of 7 conservation practices for soil, water, wildlife, habitat, and climate change benefits, and landowner costs.

3.2 Evaluation of Soil and Water Benefits

As mentioned above, the NRCS has evaluated many of the effects of different conservation practices on soil and water quality. In this section, we will summarize the findings of the NRCS for the 7 selected practices. Because wetland restoration and lower floodplain reforestation typically occur simultaneously, they were tied together as a single practice for the purposes of this evaluation. They will be referred to as wetland restoration and reforestation, hereafter. Descriptions of conservation practices and justifications of the benefits provided by practices can be seen in the appendix (Appendix 2). Please reference included spreadsheet for breakdown of scores.

Soil quality criteria include soil erosion benefits and benefits for degraded soil (for detailed descriptions see Appendix 1). Wetland restoration and reforestation provide the most benefit to soil health by reducing erosion and contributing to soil organic matter. Cover crops also reduce erosion and contribute to soil organic matter, with a slightly lower score. Hydrologic restoration could create adverse effects to soil health by increasing erosion (Figure 3.2.1). However, hydrologic restoration in the Lower Wabash refers to breaking levees, which would likely slow water flow and reduce erosion.

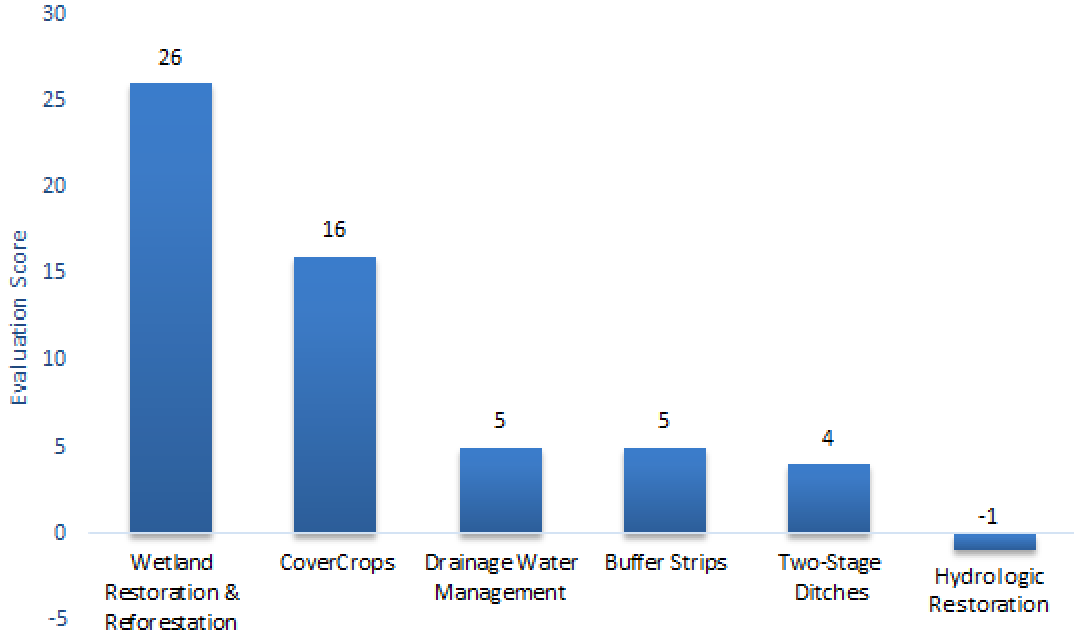

Figure 3.2.1 Soil quality benefits among conservation practices evaluated for Lower Wabash Watershed, Indiana and Illinois, based on NRCS criteria. Practices are shown ranked from highest to lowest soil-quality benefit score.

Using the current NRCS criteria, wetland restoration and reforestation appear to provide the highest benefit to water quality by taking up excess water and nutrients, improving infiltration, and reducing runoff and erosion. Cover crops provide very similar services, with a slightly lower score. Buffer strips provide the fewest water quality benefits (Figure 3.2.2).

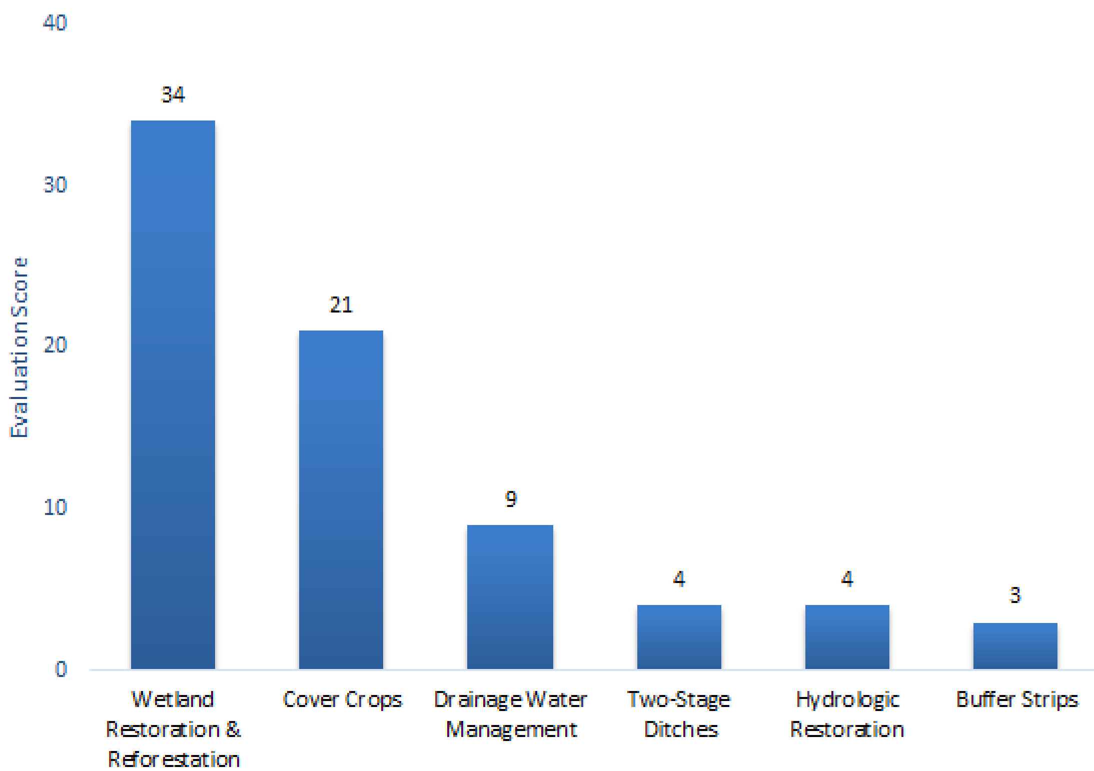

Figure 3.2.2 Water quality benefits among conservation practices evaluated for Lower Wabash Watershed, Indiana and Illinois, based on NRCS criteria. Practices are shown ranked from highest to lowest water-quality benefit score.

3.3 Evaluation of Habitat, Wildlife, and Climate Change Benefits, and Landowner Costs

Methods

Because the NRCS CPPE tool is lacking in wildlife, habitat, and climate change evaluation criteria, we have developed our own criteria: biodiversity, invasive species, indicator species, flood control, and climate change resilience (see descriptions in Appendix 1). We have combined our criteria with the NRCS criteria: food, water, cover, continuity, plant condition, energy efficiency and air quality impacts to perform habitat and climate change benefit evaluations. To quantify our findings, we have scored each metric with 1 for a positive effect, 0 for no effect, and -1 for a negative effect. Areas of uncertainty, where studies are needed were assigned a ‘U’ for unknown.

Results

Buffer strips, wetland restoration and reforestation, and cover crops provide benefits for all 8 of the wildlife and habitat criteria metrics: food, cover, water, continuity, biodiversity, invasive species control, vegetation quality, and presence of indicator species (Figure 3.3.1). Two-stage ditches and drainage water management have 1 unknown variable in terms of wildlife benefits and hydrologic restoration has 2 unknown variables. Unknown variables could shift the total score either direction depending on whether they provide positive or negative impacts.

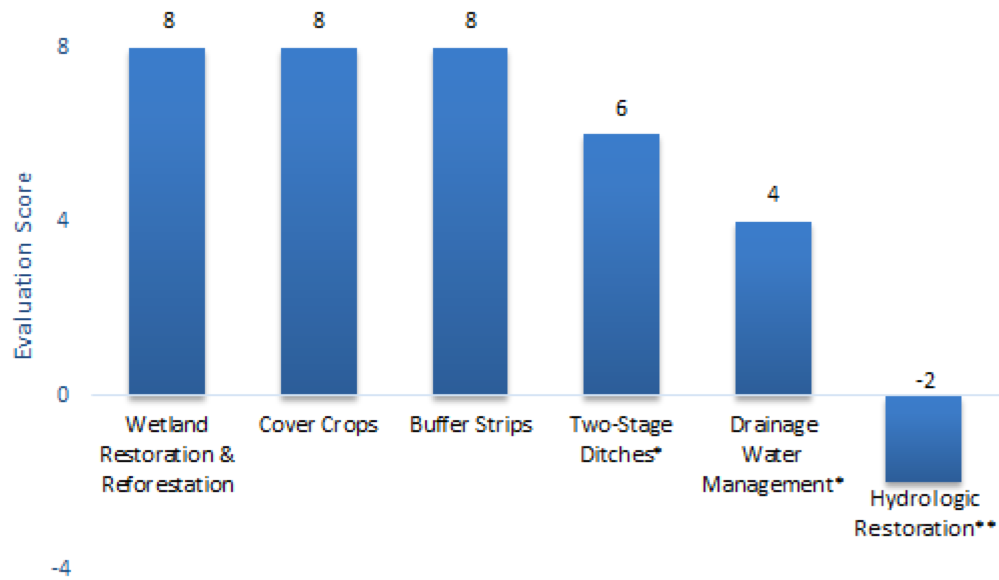

Figure 3.3.1 Habitat and wildlife benefits among conservation practices evaluated for Lower Wabash Watershed, Indiana and Illinois, determined by the proposed criteria we developed. Practices are shown ranked from highest to lowest habitat-quality benefit score. Asterisks denote number of unknown variables.

Buffer strips, wetland restoration and reforestation, and cover crops meet all 4 criteria for climate change mitigation: air pollution reduction, efficient use of energy, flood control, and resilience to climate change. Drainage water management meets 3 of the criteria, excluding efficient energy usage. Hydrologic restoration only meets 2 criteria and two-stage ditches only meet 1 (Figure 3.3.2).

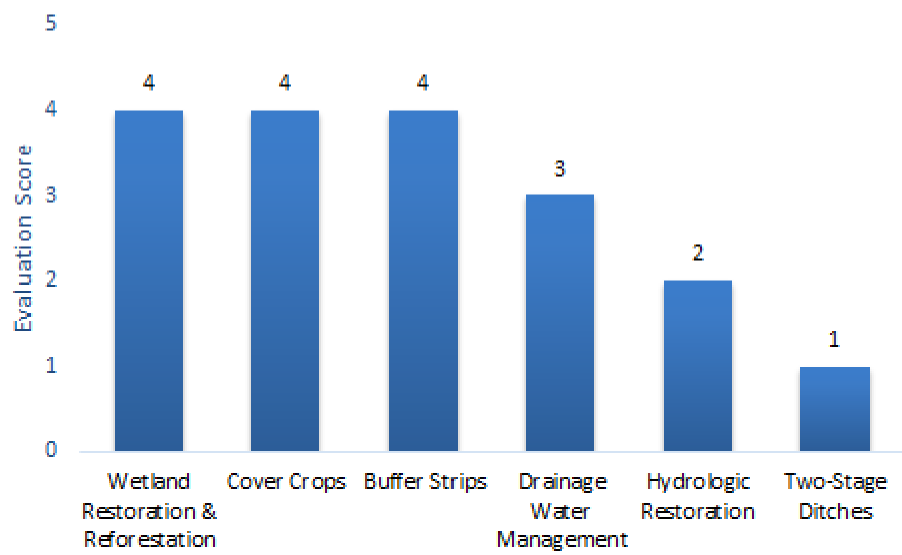

Figure 3.3.2 Climate change benefits among conservation practices evaluated for Lower Wabash Watershed, Indiana and Illinois, determined by the proposed criteria we developed. Practices are shown ranked from highest to lowest climate change benefit score.

We also developed criteria to evaluate landowner cost: price, incentive opportunity, and crop yield. To quantify these criteria, we developed a simple ranking system. For price, subjective observations determined which practices were expensive versus inexpensive. Expensive practices were assigned a ‘ -1’ and inexpensive practices were assigned a ‘1’; practices with incentive programs were given a ‘1’, and practices with no incentive programs were assigned a ‘0’. Practices that decrease crop yield, by taking land out of production, were assigned a ‘-1’, no effect was given a ‘0’, and increase in crop yield, such as making soil more fertile, was given a ‘1’.

According to the criteria chosen, cover crops impose the fewest costs on landowners, followed by two-stage ditches, and drainage water management. Buffer strips and wetland restoration impose higher costs on landowners (Figure 3.3.3). Hydrologic restoration is an expensive practice that will not be implemented by individual landowners, but rather by the Army Corps of Engineers.

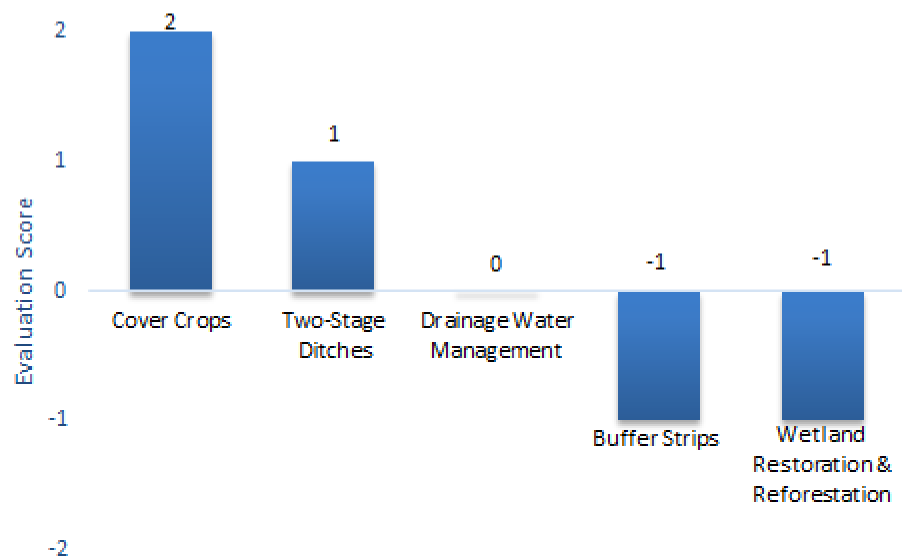

Figure 3.3.3 Affordability of conservation practices evaluated for Lower Wabash Watershed, Indiana and Illinois, determined by the proposed criteria we developed. Practices are shown ranked from lowest to highest landowner costs.

3.4 Overall Evaluation of Conservation Practices

Across all criteria evaluated, it is clear that wetland restoration and reforestation provide the most and highest diversity of benefits (Figure 3.4). Cover crops provide the second greatest benefits across all criteria.

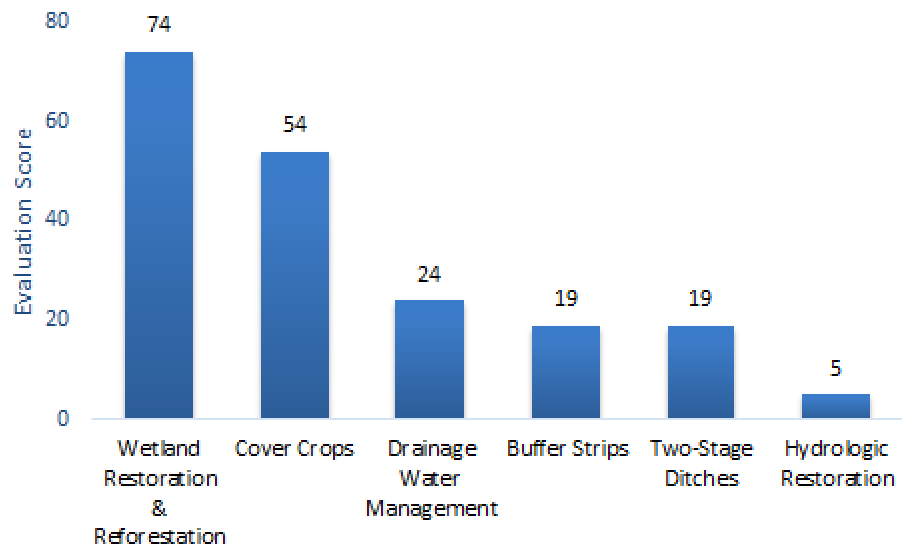

Figure 3.4 Overall benefits among conservation practices evaluated for the Lower Wabash Watershed, Indiana and Illinois, determined by both the NRCS criteria and the proposed criteria we developed. Practices are shown ranked from highest to lowest total benefit score.

3.5 Limitations of Evaluations

We have identified several limitations with our evaluation methods, that we hope can be improved upon in the future. The biggest limitation is the simplicity of our ranking system. Firstly, the scores only identify if a conservation practice provides habitat and climate change benefits, and not how well they provide these benefits. For example, both wetland restoration and two-stage ditches increase habitat continuity, and both received a score of '1', although wetland restoration would clearly provide greater continuity. Secondly, all criteria for habitat and climate change are worth the same amount of points, although some criteria would likely be more valuable than other criteria. For example, increasing biodiversity may be a more valuable criterion for evaluation than providing cover. Lastly, comparing and quantifying conservation practices leaves room for error due to variation within practices. For example, wetland restoration can provide various benefits based on factors such as size, depth, and inundation. Cover crops can provide various benefits based on which plants are chosen, when they are planted, and methods of removal.

3.6 Wildlife Resources

3.6.1 Introduction

Implementing conservation practices is important for restoring ecosystem services. Lands with conservation practices may also provide habitat and food sources for wildlife. Conserving wildlife is critical for ecological, economical, ethical, and aesthetic reasons. Many species are threatened by human-induced impacts, such as habitat loss, degradation, and fragmentation, and the endangered species list continues to lengthen. Climate change may create opportunities for some species to thrive, but will certainly exacerbate the existing threats that wildlife already faces.

There are a total of 859 fish and wildlife species distributed throughout Indiana, where freshwater mussels are the only invertebrates included. This number includes more than 750 species of nongame and endangered species. Due to the large number of individual species, we combined species into “functional groups” as our basic unit for assessing the benefits of the six selected conservation practices. According to Hulot’s research (Hulot and Bern, 2006), species with similar responses or effects to the environment or major ecosystem processes could be defined as belonging to the same functional group. Species in the same functional group are grouped by similar species traits.

3.6.2 Conservation Practice Benefits for Functional Groups

Methods

We documented the species and functional groups which the MRB/GHI LCC factsheets (Table 3.6.2a) identified as benefitting from the selected conservation practices. The majority of habitat and diet information for each species was obtained from the online database “animaldiversity”. Additional species information was collected from the database “natureserve” (see species habitat and diet information in Appendix 3.2). After analyzing the potential ecological benefits, mainly habitat and diet related, for these species and groups, we decided to use functional groups which have similar habitat conditions and food sources as our evaluation units.

Table 3.6.2a Species (their corresponding functional groups) benefiting from conservation practices

Buffer Strips	**Wetland Restoration & Reforestation**	**Cover Crops***	**Water Drainage Mgmnt.**	**Two-stage Ditches**	**Hydrologic Restoration**
Blue-winged teal (Migratory waterfowl)	Blue-winged teal (Migratory waterfowl)	Wheat: (Birds)	American golden plover (Upland birds)	Blackside darter (Small herbivore fish)	Game fish (Medial & large fish)
Belted kingfisher (Migratory waterfowl)	Gadwall (Migratory waterfowl)	Wheat: (Upland birds)	Blue-winged teal (Migratory waterfowl)	Creek chub (Small omnivore fish)	Paddlefish (Large omnivore fish)
Acadian flycatcher (Riparian birds)	(Early life stages of many fish)	Camelina: (Pollinators and other invertebrates)		Johnny darter (Small carnivore fish)	(Waterfowl)
Pheasant (Upland birds)	(Reptile)	Camelina: (Birds)		Sculpin (Small omnivore fish)	(Shorebirds)
Quail (Upland birds)	(Amphibian)			Topeka shiner (Small omnivore fish)	(Wetland birds)
Blackside darter (Small herbivore fish)				Black redhorse (Medial omnivore fish)	
Creek chub (Small omnivore fish)				Pugnose minnow (Small omnivore fish)	
Johnny darter (Small carnivore fish)				River redhorse (Medial carnivore fish)	
Sculpin (Small omnivore fish)				Smallmouth bass (Medial carnivore fish)	
Smallmouth bass (Medial carnivore fish)				American golden plover (Upland birds)	
Copper-bellied water snake (Reptile)				Blue-winged teal (Migratory waterfowl)	
(Mussel)					

***** Wheat and Camelina are crop types used as Cover Crops

Results

Using the MRB/GHI LCC factsheets, and the data on species size, habitat, and diet, we created 14 functional groups under five major animal categories. Please see Table 3.6.2b for information relating functional groups and conservation practices. For the six conservation practices, we found:

1. Buffer strips benefited most of the categories listed, except for invertebrates.
2. Wetland restoration & reforestation benefited birds, fish, reptiles and amphibians.
3. The remaining conservation practices each benefited two categories, but the groups that benefited varied according to each conservation practice.

Cover crops are a broad category, which include many different plant varieties, such as wheat and camelina. Using different cover crop varieties affects different functional groups. A detailed analysis of benefits provided per crop type would be useful and could provide a basis for future study.

Under each species category:

Birds: Buffer strips provided more benefits to upland birds than wetland birds. All other conservation practices provided more benefits to wetland birds.

Fish: Wetland restoration and reforestation benefitted all varieties of fish studied. Two-stage ditches and buffer strips mainly benefitted small and medium fish while hydrologic restoration provided benefits to medium and large fish. The remaining conservation practices did not have a direct influence on fish.

Reptiles and amphibians: Buffer strips and wetland restoration and reforestation provided benefits.

Freshwater mussels: Only buffer strips provided benefits to mussels.

Invertebrates (pollinators): Only cover crops provided benefits to pollinators.

Table 3.6.2b Functional groups benefiting from conservation practices

Type	Functional Group	Conservation Practices					
		Buffer Strips	Wetland Restoration & Reforestation	Cover Crops*	Water Drainage Mgmnt.	Two-stage Ditches	Hydrologic Restoration
Bird	Migratory waterfowl	+	+		+	+	+
	Riparian bird	+					+
	Shorebird			+			+
	Upland bird	+		+	+	+	
Fish	Slow water small fish	+	+			+	
	Flowing water small fish	+	+			+	
	Flowing water medial fish	+	+			+	+
	Flowing water large fish		+				+
Reptile and amphibian	Reptiles and amphibians	+	+				
Mussel	Mussels	+					
Invertebrate	Pollinator			+			

***** Different cover crop types might benefit different functional groups.

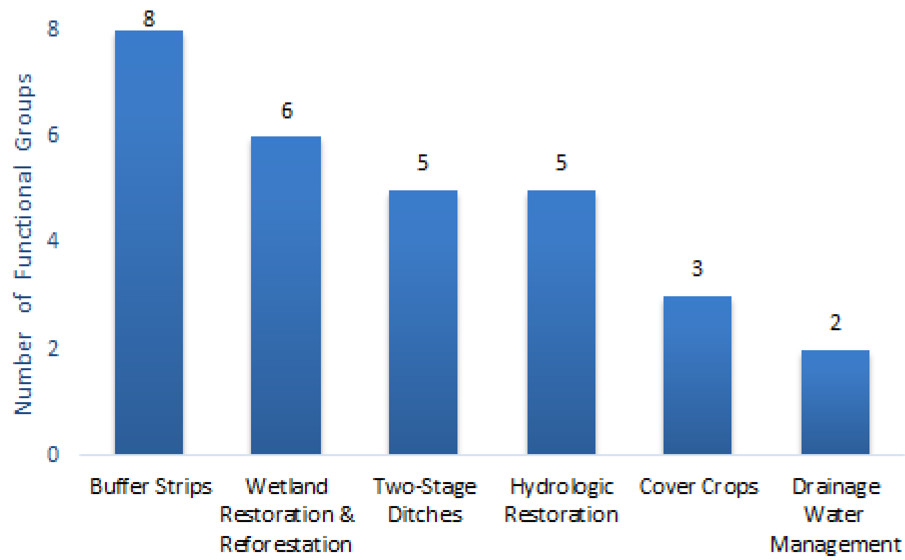

Figure 3.6.2 Number of functional groups benefitted by conservation practices evaluated for the Lower Wabash Watershed, Indiana and Illinois. Benefits were determined by LCC fact sheets and functional groups were determined by our proposed methods. Practices are shown ranked from highest to lowest number of functional groups benefitted.

Summary

Based on our functional group analysis, buffer strips appeared to benefit a greater diversity of species or species types than any other practice. Wetland restoration and reforestation supported the second greatest number of functional groups.

Limitations

A few details of conservation practices (for instance, cover crops plant types) are not discussed, which needs to address in further analysis. Different seasonal effects are not discussed. This information would be highly valuable for migration birds and fish, which needs to address in further analysis, too.

Because of our limited time, and reliance on a single resource, it is possible that not all functional groups that benefit from each practice are documented. We are also missing data for major categories, such as mammals. We are also uncertain if all functional groups should be weighted the same, or if some groups indicate a higher habitat quality than others.

3.6.3 Evaluation of Conservation Practices Wildlife Benefits for Focal Habitats

Method

According to the Lower Wabash LDC draft plan, there are 13 basic habitat types and associated species in our study area: big rivers, oxbows, sandbars/islands, bottomland hardwood forests, emergent marshes, giant cane brakes, vernal pools, scrub-shrub wetlands, spring-fed seeps, mudflat/moist soil/bottomland and hydric agriculture, upland agriculture fields, grasslands, tributaries and streams. We selected six of these habitat types to evaluate the effects of conservation practices based on the degree of conservation practice influence and our focus on agricultural lands.

Big Rivers: paddlefish, mussels, sturgeon.

Mudflat/moist soil/bottomland & hydric agriculture: short-billed dowitcher, lesser yellowleg, pectoral sandpiper, whooping cranes, *duck species (TBA)*, pintails, American golden plover, interior least tern.

Upland agricultural fields: Bobwhite quail, pollinators, America golden plover.

Grasslands: Henslow's sparrow, grasshopper sparrow, pollinators, meadowlark, barn owl, short-eared owls, northern harriers, bobwhite quail, crawfish frog.

Tributaries / Streams: Hellbenders, mussels, invertebrates.

Bottomland hardwood forests: Indiana bat, wood duck, prothonotary warblers, red-shouldered hawk, bald eagle, green tree frogs.

Habitat and diet information for each species was collected predominantly from the online database "animaldiversity". We grouped the species into functional groups for each habitat (See Appendix 3.3), and used the wildlife benefits information from Section 3.6.2 (Table 3.6.2b) to evaluate whether the six conservation practices had a positive effect on each habitat. The evaluations of conservation practices from the focal Habitats wildlife angle is summarized in table 3.6.3a.

Table 3.6.3a Evaluations of Wildlife Benefits of Conservation Practices in 6 Widely Distributed Focal Habitats

Habitat	Functional groups	Conservation Practices Impact to Functional Group					
		Buffer Strips	Wetland Restoration & Reforestation	Cover Crops*	Water Drainage Mgmnt.	Two-stage Ditches	Hydrologic Restoration
Big Rivers	Flowing water large fish		+				+
	Mussel	+					
Mudflat/moist soil/bottomland & hydric agriculture	Shorebird						+
	Migratory waterfowl	+	+	+	+	+	+
	Upland bird	+		+	+	+	
Upland agricultural fields	Upland bird	+		+	+	+	
	Pollinator			+			
Grasslands	Upland bird	+		+	+	+	
	Pollinator			+			
	Upland bird: owls and hawks*						
	Reptiles and amphibians	+	+				
Tributaries / Streams	Reptiles and amphibians	+	+				
	Mussel	+					
	Invertebrates*						
Bottomland hardwood forests	Bat*						
	Migratory waterfowl	+	+	+	+	+	+
	Upland bird	+		+	+	+	
	Upland bird: owls and hawks*						

*Functional groups are not listed as beneficial groups for all the 6 conservation practices in LCC factsheets.

Results

Table 3.6.3b summarizes recommendations for conservation practices for the six focal habitat types:

Big Rivers: Important functional groups for big rivers are large fish and mussels. There are three conservation practices which most benefit this habitat: **buffer strips** benefit mussels, while **wetland restoration & reforestation** and **hydrologic restoration** provide benefits to large fish.

Mudflat/moist soil/bottomland & hydric agriculture: Functional groups of special concern in this habitat are wetland and upland birds. All six conservation practices provide benefits to birds in this habitat. **Buffer strips, cover crops, water drainage management,** and **two-stage ditches** are recommended since they provide benefits to both wetland birds and upland birds. **Wetland restoration & reforestation** and **hydrologic restoration** provide the most benefits for wetland birds.

Upland agricultural fields: Upland birds and pollinators are the important functional groups in this habitat. **Cover crops** are highly recommended since they can benefit both functional groups. **Buffer strips, water drainage management,** and **two-stage ditches** are also recommended for helping upland birds.

Grasslands: Upland birds, pollinators and reptiles and amphibians are the functional groups of special concern for grasslands. Buffer strips and cover crops are both recommended to benefit these species. However, since cover crops might not be used for grasslands, **buffer strips** are the recommended conservation practice. **Water drainage management** and **two-stage ditches** are also recommended for helping upland birds, while **wetland restoration & reforestation** in certain areas benefit reptiles and amphibians. Within the upland birds functional group, owls and hawks do not appear to benefit from the six conservation practices, according to the LCC factsheets.

Tributaries / Streams: Reptiles and amphibians, and mussels and invertebrates are the functional groups of special concern in this habitat. **Buffer strips** and **wetland restoration & reforestation** are recommended.

Bottomland hardwood forests: Upland and wetland birds, as well as bats are the functional groups of special concern in this habitat. All six conservation practices could be used to benefit birds. Conservation practices that may be used near bottomland hardwoods include **buffer strips, cover crops, water drainage management,** and **two-stage ditches**; these benefit both wetland and upland birds. Wetland restoration & reforestation and hydrologic restoration are recommended for benefiting wetland birds. Bats are not considered to benefit from the six conservation practices.

Table 3.6.3b The most recommended Conservation Practices in the 6 Widely Distributed Focal Habitats

Habitat	Conservation Practices Impact to Functional Group					
	Buffer Strips	Wetland Restoration & Reforestation	Cover Crops*	Water Drainage Mgmnt.	Two-stage Ditches	Hydrologic Restoration
Big Rivers	Recommended for mussels	Recommended for large fish	Recommended for large fish			
Mudflat/moist soil/bottomland & hydric agriculture	**Most recommended**	Recommended for wetland birds	**Most recommended**	**Most recommended**	**Most recommended**	Recommended for wetland birds
Upland agricultural fields	Recommended for upland birds		**Most recommended**	Recommended for upland birds	Recommended for upland birds	
Grasslands	**Most recommended**	Recommended for reptiles and amphibians	**Most recommended**	Recommended for upland birds	Recommended for upland birds	
Tributaries / Streams	**Most recommended**	Recommended for reptiles and amphibians				
Bottomland hardwood forests	**Most recommended**	Recommended for wetland birds	**Most recommended**	**Most recommended**	**Most recommended**	Recommended for wetland birds

*Applicability of conservation practices is not discussed in this table. It could be added as next step when considering for picking the most suitable conservation practices.

Summary

Based on our Table 3.6.3b analysis, buffer strips and cover crops works for 4 focal habitat types. Water Drainage Management and Two-stage Ditches are highly recommended for Mudflat/moist soil/bottomland & hydric agriculture, and Bottomland hardwood forests. While Wetland Restoration & Reforestation could be used as a good complement practice to other practices.

Limitations

Because of our limited time, we only discussed 6 conservation practices. Some functions groups are not covered by all these 6 practices. Other conservation practices should also be considered later. For other conservation practices, the same method could be used to selecting potential suitable conservation practices.

The adaptability and applicability of conservation practices in each focal habitat are not discussed in our analysis. It could be addressed as next step analysis.

3.6.4 Further Research Suggestion

The Indiana DNR's website provide fish and wildlife resources information. Rare species are also provided. Special concerns of rare species could be added in conservation practices.

For wildlife benefits listed in LCC conservation practices factsheet, some information mammal species (endangered or species concerned) could also be included. Besides species benefiting from conservation practices, some species might also meet disadvantages by some conservation practices (loss habitat, for instance). The wildlife side effect information is also valuable, and should be taken into consideration when making decision.

4. Climate Change in the Lower Wabash Watershed

4.1 Introduction

Climate conditions and ecosystems are fundamentally interrelated. Climate conditions shape ecosystems and influence the ecosystem services that an area can provide, as well as affect an ecosystem's ability to mitigate and respond to weather events. Changes in future climate conditions are a significant source of uncertainty regarding the success of wildlife conservation practices. Future climate conditions are predicted to reduce the ability of ecosystems to regulate water flows and improve water quality The US Global Change Research Program's (USGCRP) 2014 National Climate Assessment asserts that climate change will impede current conservation goals, and require some conservation plans to reassess their strategies (US Global Change Research Program, 2014).

Projections for the impacts of climate change in the Midwest have predicted that:

- air and water temperatures will continue to rise
- the number of consecutive days over 95°F will increase
- the total number of days with a minimum temperature of less than 10°F will decrease
- the total the number of days below 32°F will decrease
- the freeze-free season (the period of time between the last spring frost and the first fall frost) will increase
- winter, spring, and fall precipitation will increase, and summer precipitation will decrease
- occurrence of dangerous heat events and summer drought will increase
- growing season will be longer
- flooding events will increase
- complex interactions with hydrology, fire, water chemistry, toxicity and other abiotic factors, and may disrupt predator/prey, disease/host, competition, mutualisms, and other interspecific interactions

- heavier rainfall events may degrade water quality by introducing heavy sediment, untreated sewage, and pollutant loads into waterways

These are just some of the future projections and they are shrouded with uncertainty and complex interactions, making future planning a daunting task (Hatfield et al., 2015).

4.2 Climate Change Scenario Planning

As demonstrated above, with climate change, comes much uncertainty. In order for societies to adapt quickly to unpredictable outcomes, scenario planning is a useful tool. Scenario planning is accomplished by pairing 2 external drivers that will have a high impact on future conditions, but are unpredictable; therefore, multiple scenarios must be considered. These drivers are considered external because they are out of the control of the decision maker. The outcome of scenario planning is 4 distinct future scenarios. Conservationists can consider the 4 possible futures to create adaptive management plans.

Under climate change, flooding and drought events are expected to increase. It is difficult to determine exactly when and where these events will occur. To be prepared, we must develop a plan for each scenario. A non-climate driver that will impact landowners' decisions is crop prices. Pairing these 2 drivers created 4 distinct and equally possible scenarios of future conditions in the Lower Wabash region.

The first scenario involves high levels of flooding and low crop prices, the second scenario involves high levels of flooding and high crop prices, the third scenario involves high levels of drought and low crop prices, and the fourth scenario involves high levels of drought and high crop prices. By determining how these scenarios will change the landscape and how they will affect landowners' decisions, we can determine which conservation practices will be most relevant and useful under each scenario.

Scenario 1: High Water, Low Prices

Scenario 1 describes high levels of flooding and low payout for crop production. In this scenario, not only is the land physically unfavorable for growing crops, it is also financially unfavorable. This scenario could motivate farmers to enroll in conservation easement programs, or it could drive up insurance claims and subsidies. Farmers may become interested in diversifying their income by allotting some land for recreational use. Persistent flooding and low prices will likely drive farmers to sell.

If farmers intend to keep their land, wetland restoration, two-stage ditches and drainage water management can act as a sinks for excess water and divert water away from crops. Additionally, restored wetlands and drainage water management can create recreational areas and have the potential to provide additional income. Buffer strips and cover crops can help slow water flow and reduce flood related erosion. Flood tolerant cover crops can be selected for greater benefits. If cover crops are marketable, they could provide a potential income stream. If farmers decide to sell, wetland restoration would be the most beneficial practice, and hydrologic restoration may be beneficial to divert water to other areas.

Scenario 2: High Water, High Prices

Scenario 2 describes high levels of flooding and high payout for crop production. Farmer's decisions may be more heavily shaped by the crop market than climatic conditions. Farmers will be more likely to increase water control practices so they can continue to farm. They may take more risks and ultimately file more insurance claims, or they may receive more subsidies. Farmers will be less likely to sacrifice land for conservation practices, if it could otherwise be used for crop production.

Drainage water management would be very beneficial for scenario 2, because it can remove water from the landscape without sacrificing any available cropland. Cover crops can also be beneficial by slowing water flow and reducing erosion, and they are grown in the off season, so they won't interfere with crop production. Buffer strips are typically implemented in marginal areas that would not be used for crops and therefore would not impede on crop production. Buffer strips would slow water flow and reduce erosion.

Scenario 3: Low Water, Low Prices

Scenario 3 describes high levels of drought and low payout for crop production. Similar to scenario 1, the land is physically and financially unfavorable for growing crops. Likewise, this scenario could motivate farmers to enroll in conservation easement programs, file insurance claims, or receive subsidies. Diversifying income may be more difficult in drought conditions than flood conditions. Farmers may be motivated to sell if these conditions persist.

Wetland restoration and drainage water management would be beneficial under drought conditions, because they can retain water on the landscape for longer. Using drought tolerant cover crops can also help retain water and provide shade, and possibly provide additional income. Hydrologic restoration may be able to divert water to high drought areas.

Scenario 4: Low Water, High Prices

Scenario 4 describes high levels of drought and high payout for crop production. Farmers will be more likely to receive subsidies or file insurance claims than reduce productivity. Similar to scenario 3, farmers will be unlikely to sacrifice land for conservation practices.

Drainage water management can retain water on the landscape and drought tolerant cover crops can help retain moisture in the soil. Both of these practices will allow farmers to utilize all of their land for crop production.

Summary

Buffer strips, wetland restoration, and two-stage ditches are more likely to be implemented when crop prices are low, because landowners will not want to sacrifice land if crop prices are high. Buffer strips may be an exception to this rule, as they are typically created in marginal areas with low crop yields. Cover crops and drainage water management do not interfere with crop yield, so they may be implemented during low or high crop price scenarios.

Hydrologic restoration is not applicable to individual landowners, but may apply if conditions are such that farmers sell their land.

Wetland restoration, hydrologic restoration, and drainage water management would be beneficial during drought events because they would provide a source of water; cover crops help to retain moisture on the landscape and drought tolerant species can be used. Wetland restoration, hydrologic restoration, drainage water management, and two-stage ditches can be beneficial sinks to hold excess water during high flood conditions. Buffer strips and cover crops can be beneficial during flood periods because they help to slow water flow and reduce erosion associated with heavy flow.

Cover crops and drainage water management are beneficial across all scenarios (Figure 4.2.5). Buffer strips are beneficial in high flood conditions, regardless of crop market. Wetland restoration and hydrologic restoration are beneficial during low crop prices, regardless of climatic condition; these practices would therefore be beneficial on public or protected lands, where crop market isn't a factor.

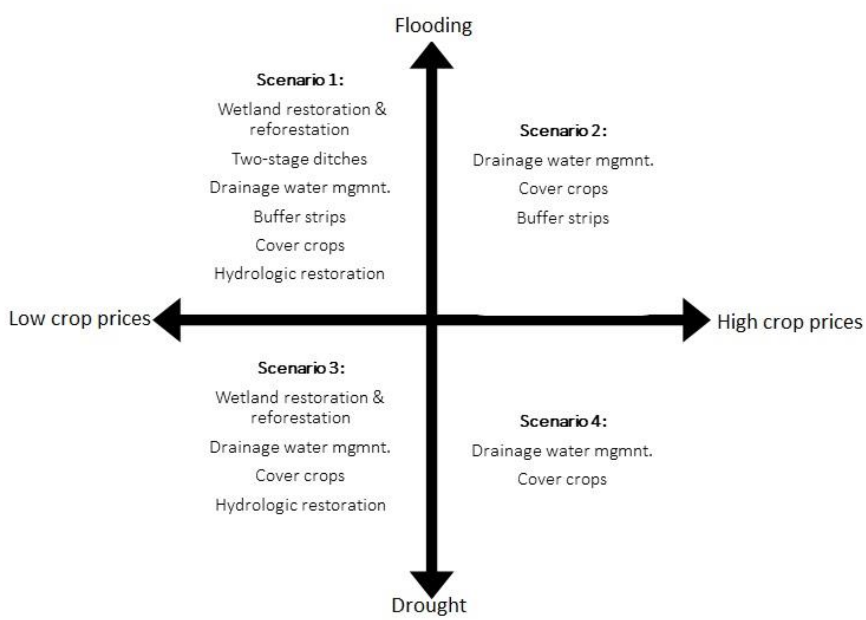

Figure 4.2.5 Evaluation of which conservation practices will be most beneficial under contrasting crop market and climatic scenarios.

5. Final Recommendations

In terms of wildlife and habitat, and climate change benefits, buffer strips, cover crops, and wetland restoration and reforestation provide the greatest benefits. In terms of overall criteria, wetland restoration and reforestation, drainage water management, and cover crops provide the highest levels of benefits. During scenario planning, we found that cover crops and drainage water management are beneficial under 4 distinct possible future scenarios. This implies that they are versatile practices.

Because of the versatility of drainage water management and cover crops, and because of their high scores during evaluation, we recommend that they be widely implemented and promoted in the Lower Wabash Watershed. Wetland restoration and reforestation and buffer strips are also very useful practices that are versatile under climate change and provide high levels of habitat and climate change benefits.

Hydrologic restoration ranked the lowest in many categories, including overall, and also has the greatest amount of unknown factors. Before resorting to hydrologic restoration as a way to manage water levels, it should be studied for habitat effects. It is known to have negative effects on stream species through habitat loss and food web disruption. There is limited information on how it affects biodiversity, or if it promotes invasive species. Hydrologic restoration may have more negative effects than are currently understood, and we urge that it should be used with caution.

If we had to recommend just one practice to farmers, we would recommend cover crops because of the high versatility, high level of benefits, and low costs. If we had to recommend only one practice to conservationists, we would recommend wetland restoration and reforestation because it provides high levels of habitat benefits and mitigation for climate change.

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Appendices:

Appendix 1. Descriptions of Criteria

Appendix 1. Descriptions of criteria used to evaluate conservation practices (modified from NRCS CPPE tool).

Criteria	Description
SOIL	
SOIL EROSION - Sheet, rill, & wind erosion	Detachment and transportation of soil particles caused by rainfall runoff/splash, irrigation runoff or wind that degrades soil quality
SOIL EROSION – Concentrated flow erosion	Untreated classic gullies may enlarge progressively by head cutting and/or lateral widening. Ephemeral gullies occur in the same flow area and are obscured by tillage. This includes concentrated flow erosion caused by runoff from rainfall, snowmelt or irrigation water.
SOIL EROSION– Excessive bank erosion from streams shorelines or water conveyance channels	Sediment from banks or shorelines threatens to degrade water quality and limit use for intended purposes
SOIL QUALITY DEGRADATION - Subsidence	Loss of volume and depth of organic soils due to oxidation caused by above normal microbial activity resulting from excessive water drainage, soil disturbance, or extended drought. This excludes karst / sinkholes issues or depressions caused by underground activities.
SOIL QUALITY DEGRADATION – Compaction	Management induced soil compaction resulting in decreased rooting depth that reduces plant growth, animal habitat and soil biological activity
SOIL QUALITY DEGRADATION – Organic matter depletion	Soil organic matter is not adequate to provide a suitable medium for plant growth, animal habitat, and soil biological activity
SOIL QUALITY DEGRADATION – Concentration of salts or other chemicals	Concentration of salts leading to salinity and/or sodicity reducing productivity or limiting desired use Concentrations of other chemicals impacting productivity or limiting desired use
WATER	

EXCESS WATER – Ponding, flooding, seasonal high water table, seeps, and drifted snow	Surface water or poor subsurface drainage restricts land use and management goals. Wind-blown snow accumulates around and over surface structures, restricting access to humans and animals.
INSUFFICIENT WATER – Inefficient moisture management	Natural precipitation is not optimally managed to support desired land use goals or ecological processes
INSUFFICIENT WATER – Inefficient use of irrigation water	Irrigation water is not stored, delivered, scheduled and/or applied efficiently Aquifer or surface water withdrawals threaten sustained availability of ground or surface water Available irrigation water supplies have been reduced due to aquifer depletion, competition, regulation and/or drought
WATER QUALITY DEGRADATION – Excess nutrients in surface and ground waters	Nutrients - organic and inorganic - are transported to receiving waters through surface runoff and/or leaching into shallow ground waters in quantities that degrade water quality and limit use for intended purposes
WATER QUALITY DEGRADATION – Excess nutrients in surface and ground waters	Nutrients - organic and inorganic - are transported to receiving waters through surface runoff and/or leaching into shallow ground waters in quantities that degrade water quality and limit use for intended purposes
WATER QUALITY DEGRADATION – Pesticides transported to surface and ground waters	Pest control chemicals are transported to receiving waters in quantities that degrade water quality and limit use for intended purposes
WATER QUALITY DEGRADATION – Excess pathogens and chemicals from manure, bio-solids or compost applications	Pathogens, pharmaceuticals, and other chemicals carried by land applied soil amendments are transported to receiving waters in quantities that degrade water quality and limit use for intended purposes. This resource concern also includes the off-site transport of leachate and runoff from compost or other organic materials of animal origin.
WATER QUALITY DEGRADATION – Excessive salts in surface and ground waters	Irrigation or rainfall runoff transports salts to receiving water in quantities that degrade water quality and limit use for intended purposes
WATER QUALITY DEGRADATION – Petroleum, heavy metals and other pollutants transported to receiving waters	Heavy metals, petroleum and other pollutants are transported to receiving water sources in quantities that degrade water quality and limit use for intended purposes

WATER QUALITY DEGRADATION – Excessive sediment in surface waters	Off-site transport of sediment from sheet, rill, gully, and wind erosion into surface water that threatens to degrade surface water quality and limit use for intended purposes
WATER QUALITY DEGRADATION – Elevated water temperature	Surface water temperatures exceed State/Federal standards and/or limit use for intended purposes
WILDLIFE & HABITAT	
INADEQUATE HABITAT FOR FISH AND WILDLIFE – Habitat degradation	Quantity, quality or connectivity of food, cover, space, shelter and/or water is inadequate to meet requirements of identified fish, wildlife or invertebrate species
BIODIVERSITY	The number of different species represented by species richness and species evenness.
INVASIVE SPECIES	Non-native species that have a tendency to outcompete with native species and spread to a degree believed to cause damage to the environment, human economy or human health.
INDICATOR SPECIES	Any biological species that defines a trait or characteristic of the environment. For an example, a species may delineate an ecoregion or indicate an environmental condition such as a disease outbreak, pollution, species competition or climate change. This includes: pollinators, migratory species, intolerant species, endangered and threatened species, and other keystone species.
DEGRADED PLANT CONDITION – Undesirable plant productivity and health	Plant productivity, vigor and/or quality negatively impacts other resources or does not meet yield potential due to improper fertility, management or plants not adapted to site This includes addressing pollinators and beneficial insects.
DEGRADED PLANT CONDITION – Inadequate structure and composition	Plant communities have insufficient composition and structure to achieve ecological functions and management objectives This includes degradation of wetland habitat, targeted ecosystems, or unique plant communities.
DEGRADED PLANT CONDITION – Excessive plant pest pressure	Excessive pest damage to plants including that from undesired plants, diseases, animals, soil borne pathogens, and nematodes This concern addresses invasive plant, animal and insect species

DEGRADED PLANT CONDITION– Wildfire hazard, excessive biomass accumulation	The kinds and amounts of fuel loadings - plant biomass - create wildfire hazards that pose risks to human safety, structures, plants, animals, and air resources
Climate Change Mitigation	
INEFFICIENT ENERGY USE – Equipment and facilities	Inefficient use of energy in the Farm Operation increases dependence on non-renewable energy sources that can be addressed through improved energy efficiency and the use of on-farm renewable energy sources. As an example, this concern addresses inefficient energy use in pumping plants, on-farm processing, drying and storage.
INEFFICIENT ENERGY USE – Farming/ranching practices and field operations	Inefficient use of energy in field operations increases dependence on non-renewable energy sources that can be addressed through improved efficiency and the use of on-farm renewable energy sources.
AIR POLLUTION REDUCTION - Emissions of Particulate Matter - PM - and PM Precursors	Direct emissions of particulate matter - dust and smoke -, as well as the formation of fine particulate matter in the atmosphere from other agricultural emissions - ammonia, NOx, and VOCs - cause multiple environmental impacts, such as: 1) The unintended movement of particulate matter - typically dust or smoke - results in safety or nuisance visibility restriction, 2) The unintended movement of particulate matter and/or chemical droplets results in unwanted deposits on surfaces, 3) Increased atmospheric concentrations of particulate matter can impact human and animal health and degrade regional visibility.
AIR POLLUTION REDUCTION - Emissions of Greenhouse Gases - GHGs -	Emissions increase atmospheric concentrations of greenhouse gases.
AIR POLLUTION REDUCTION - Emissions of Ozone Precursors	Emissions of ozone precursors - NOx and VOCs - resulting in formation of ground- level ozone that cause negative impacts to plants and animals.
AIR POLLUTION REDUCTION - Objectionable odors	Emissions of odorous compounds - VOCs, ammonia and odorous sulfur compounds - cause nuisance conditions

FLOOD CONTROL	Ability to reduce or prevent the detrimental effects of flood waters or high water.
RESILIENCE	The capacity for a socio-ecological system to: (1) absorb stresses and maintain function in the face of external stresses imposed upon it by climate change and (2) adapt, reorganize, and evolve into more desirable configurations that improve the sustainability of the system, leaving it better prepared for future climate change impacts.
Landowner Costs	
PRICE	Price of implementation, including capital costs and other associated costs.
INCENTIVE	Incentive programs, such as WRP, CRP, EQIP.
CROP YIELD	Amount of land available for crops or any other factor that would affect crop yield.

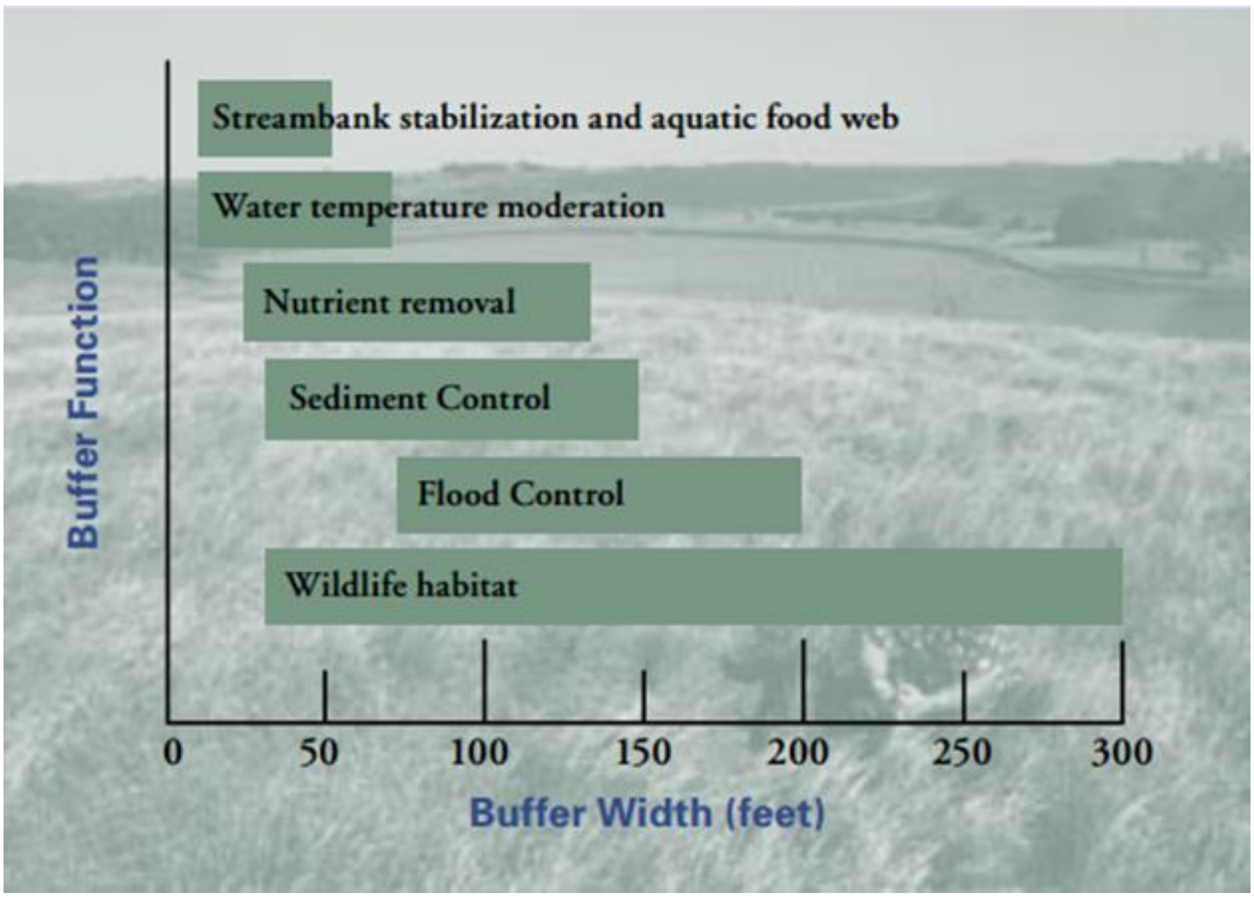
Appendix 2. Descriptions of Conservation Practices

2.1 Buffer Strips

Buffer Strips are land sections along field borders or on the flanks of wetlands or waterbodies where certain types of vegetation are grown to slow and filter overland water flows. Buffer strips are considered a Best Management Practice by state and federal conservation agencies for their simplicity and effectiveness in buffering aquatic ecosystems from surface runoff (Mayer et al., 2005). Basic types of buffer strips include riparian buffers, grassed waterways, filter strips, and contour grass strips. Riparian buffers are lands adjacent to streams or wetlands and planted with trees, shrubs and grasses; filter strips are lands that separate crop fields from streams and exclude trees; grassed waterways are drainage pathways within fields that consist of mowed grass; and contour grass strips occur within fields on sloped areas (Clark and Reeder, 2007).

Buffer strips provide many important benefits to water quality by reducing sediment, nutrient, chemical, and pathogen inputs from surface water runoff into waterways. Water runoff and contaminants are slowed by vegetation along the strip, which then trap sediments and use incoming nutrients as food. Slowing runoff also increases the amount of time that nutrients remain in the strip, allowing microbes in the soil to process and remove nutrients from surface and subsurface flows.

Buffer strips mainly function to improve water quality, but also can provide wildlife habitat or food. Benefits to wildlife are largely dependent on the width, vegetation types, and relative distance to larger habitat areas (Clark and Reeder, 2007). Buffer strips help increase local biodiversity by creating limited habitats and providing wildlife corridors, provided strips are located near existing habitat or connected to a larger network of conservation areas. Wider strips are prefered, as narrow strips may not offer the shelter or habitat preferred by wildlife (Mayer et al., 2005). Buffer strips along streams and lakes benefit aquatic species by creating



shade to reduce water temperatures and improving water quality (ref).
Figure 2.2.1 Recommended conservation buffer strip width for different functions or uses (ISU).

The costs involved with buffer strips are installation and maintenance costs, and land use opportunity costs. The site-specific costs depend on the types of land used for buffer strips and type of buffer strips adopted. Placing buffer strips on marginal lands which consistently flood or have a high risk of erosion both reduces the landowner's opportunity cost, associated with not producing a cash crop on the land used for buffer strips, and improves the effectiveness of the practice.

Three limitations may constrain the use of this conservation practice: a lack of landowner incentives, insufficient landowner awareness of the practices, and limited wildlife benefits. Additional government subsidies may be needed for encouraging participation. Increasing buffer sizes or connecting the buffer strips to existing conservation lands can help increase wildlife benefits.

2.2 Wetland Restoration and Reforestation

Wetland restoration and management practices involve the construction and maintenance of wetlands, which are defined as land "permanently or seasonally saturated and/or ponded with water" (NWI). The wetland types within the Mississippi River Basin include: "emergent marshes, sedge meadows, fens, scrub-shrub wetlands, and forested wetlands (floodplain and flatwood forests)" (reference).

Wetland restoration and management practices primarily benefit wildlife conservation and improve the ecological services provided in an area. Restoring wetlands allows these areas to improve water quality by filtering, impounding, and eventually removing contaminants from flowing waters. For wildlife, it increases local biodiversity, creates habitats, and provides corridors. Restoring and managing wetlands also benefit aquatic species by creating shade to reduce water temperature and providing improved water quality. Wetlands increase the heterogeneity of the landscape, resulting in increased biodiversity, healthy native populations, and reduced invasive species. Ecological services provided by wetlands include flood control, improved water quality, and recharge of groundwater. Wetlands also function as important carbon sinks.

The costs involved with wetland restoration and management are installation and maintenance costs, and land use opportunity costs. The site-specific costs depend on the types and locations of wetlands, the degree of degradation, and available restoration and management technologies. Using historical wetland sites as restoration sites is highly recommended, as the soils and geological formations are already suited for a wetland site (ref).

Several limitations may constrain the use of this conservation practice, including a shortage of interested professionals such as foresters and land managers, a variety of wetland types which may be considered, a scarcity of financial incentives to cover initial costs, and limited planning and mapping abilities over large areas.

2.3 Cover Crops

Definition

Cover crops are plants that are grown during the non-cash crop growing season. Cover crops can be harvested as cash-crops, or strictly grown as cover crops (ETPBR LCC 2016).

Benefits

Benefits vary, depending on which plants are used, but they all provide root biomass, which helps to keep soil, water, and nutrients on the land by anchoring the soil and absorbing water. Many cover crops are useful for weed control and outcompeting invasive species. Some cover crops, such as wheat, have the potential to absorb excess nitrogen and phosphorus from agricultural fields, which greatly reduces the amounts of those nutrients entering the waterways and eventually contributing to the hypoxia problems downstream. Some crops, including wheat, can also provide vital nesting habitat for several species of birds (ETPBR LCC 2016).

Cover crops are beneficial to landowners because they can be grown as a cash crop and, if managed appropriately, can recycle the majority of the nutrients left on the soil from the previous growing season and make these nutrients biologically available for the next growing season. This reduces the amount of fertilizer application necessary for a typical cash crop. Most cover crops more than pay for themselves by increasing yields of the succeeding cash crop and by improving soil and water quality. Regarding climate change, cover crops vary greatly and have differing tolerances, allowing this overall practice to remain robust under the uncertainty of future conditions under climate change (ETPBR LCC 2016).

Although there are several research articles comparing various cover crops and their ability to outcompete invasive species (Perry & Galatowitsch 2003) (Perry et al., 2009), there is much less information available to help quantify the value cover crops add to habitat and wildlife. Preferable cover crop varieties are known to provide food, shelter, and some habitat to wildlife. Future research would be useful in determining which cover crops provide the most habitat value.

Limitations

Cover crops can be detrimental to the landscape if they are tilled or removed with herbicides after their growing season. Implementing no-till, integrated pest management, and comprehensive nutrient management in concert with cover crops will help to maximize conservation benefits. There may also be risks to the landowners if cover crops create a delay in planting of cash crops (ETPBR LCC 2016).

2.4 Drainage Water Management

Definition

Drainage water management refers to the integration of drainage control structures into existing agricultural drainage systems in order to allow farmers to easily retain or drain water out of their fields (Figures 2.4.1 and 2.4.2) (ETPBR LCC 2016).

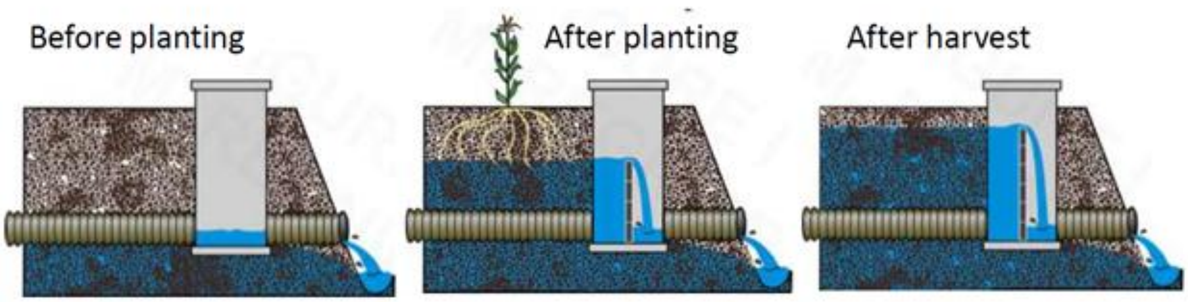


Figure 2.4.1 Drainage water management systems can be manipulated by farmers to control water level on the landscape (from farms.com).

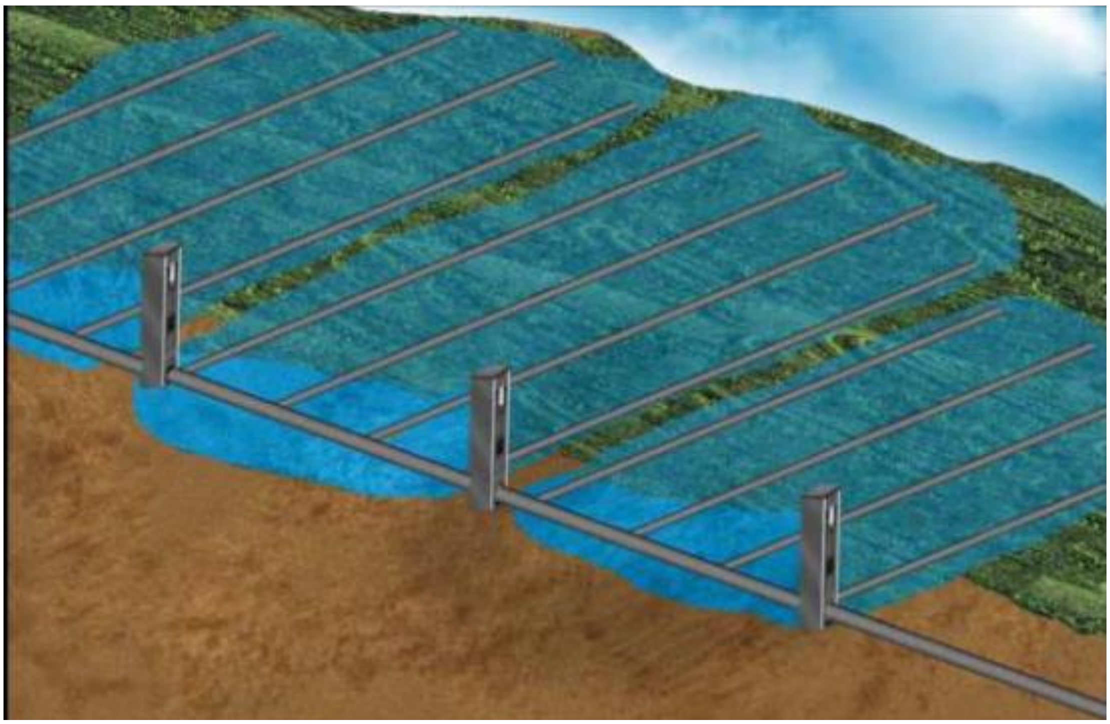


Figure 2.4.2 Drainage water management being used to retain water on the landscape, creating temporary wetlands (from http://www.miwea.org/docs/6B%20Tom%20VanWagner%20Watershed%20Summit.pdf).

Benefits

If used correctly, farmers can prevent water and excess nutrients from leaving their tile lines and polluting larger streams and tributaries. Drainage water management is expected to reduce nitrate and phosphate loads up to 50% or more. Drainage water management could also provide crucial stop-over and staging habitat for migratory birds and waterfowl. Studies have shown an increase in crop yield associated with drainage water management. This technology could also help ameliorate unpredictable precipitation from climate change, especially flooding and drought (ETPBR LCC 2016).

Limitations

Limitations include expensive installation, limitations on where it can be implemented due to slope and configuration of drainage tiles, and the degree of difficulty for farmers to manage it properly. The NRCS has developed maps, showing the suitability of cropland for drainage water management in each county (Figure 2.4.3). The criteria used to determine suitability are soil composition, water table, and slope. Based on the maps, the Illinois side of the Lower Wabash will be much more suited to drainage water management than Indiana (NRCS 2011).

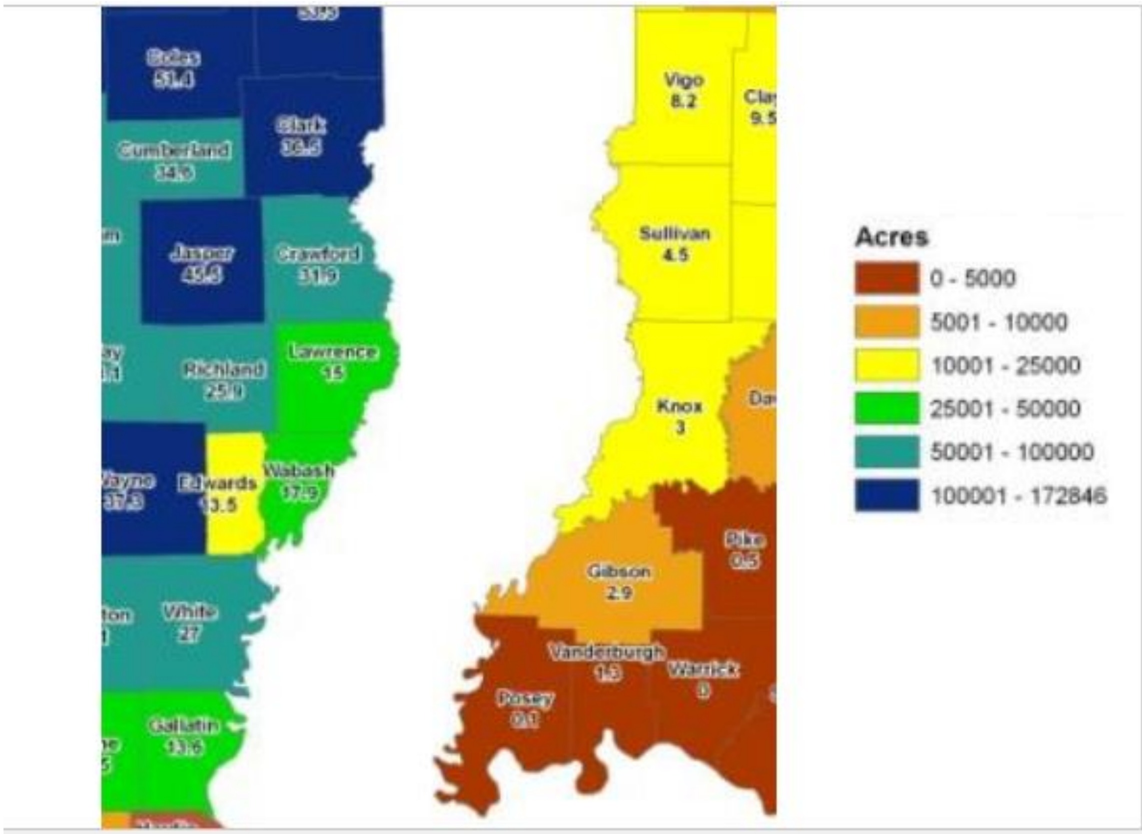


Figure 2.4.3 Suitability of cropland for drainage water management in Lower Wabash counties, based on soil composition, slope, and water table (NRCS 2011).

2.5 Two-Stage Ditches

Definition

A two-stage ditch is a 2-tiered ditch with ledges in a trapezoidal shape, as opposed to the traditional rounded singular ditch (Figure 2.5.1). These ditches are used to help drain agricultural fields (ETPBR LCC 2016).

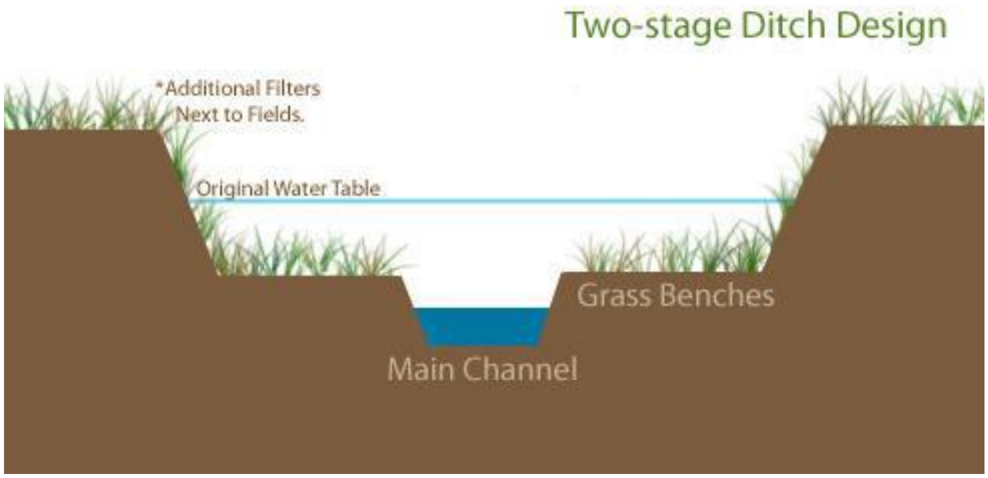


Figure 2.5.1 Two-stage ditches are comprised of 2 tiers, in a trapezoidal shape (from nature.org).

Benefits

Two-stage ditches are more stable than traditional drainage ditches and also provide filtering benefits that can help to reduce the amount of nutrients and sediment entering larger streams and rivers (ETPBR LCC 2016). By reducing stream nutrient and sediment loads and restoring some of the natural hydrology, the two-stage ditch benefits several species of fish (ETPBR LCC 2016). Furthermore, the addition of ledges and the creation of the floodplain inherent to the two-stage ditch design results in increased habitat for migratory shorebirds and waterfowl (ETPBR LCC 2016). Two-stage ditches are covered by the Environmental Quality Incentives Program (EQIP) and increases soil stability and health which could translate to higher crop yields. Additionally, The Nature Conservancy (TNC) has received funding from the Indiana Department of Environmental Management (IDEM) for a wide-scale implementation of two-stage ditches along the Wabash River Watershed (TNC 2016). This may be a good opportunity to study and quantify the value these ditches provide for habitat and wildlife. Regarding climate change, they are more resilient to heavy flow conditions than traditional ditches (ETPBR LCC 2016).

Limitations

Two-stage ditches can reduce available land for crop production. Typically, installation of two-stage ditches is very expensive, requiring significant earth moving and cooperation of multiple landowners along the length of the stream. However, streams may also naturally develop a deeper central channel with side shelves if allowed to revert to this configuration rather than periodically dredging the ditch (ETPBR LCC 2016).

2.6 Upper Floodplain Hydrologic Restoration

Lower floodplain water diversion refers to the large-scale practice of diverting water or sediments from a large river into lower coastal floodplains. Gates or water siphons then regulate the flow through the diversion. Providing a freshwater path from the Mississippi River to its adjacent floodplains is anticipated to reverse coastal wetland loss in Louisiana by reducing the impact of saltwater intrusion and reintroducing vital nutrients to nutrient starved wetlands (Maloney, 2014). Freshwater and sediment diversions are both recommended, as freshwater diversions reduce wetland salinity and sediment diversions increase nutrient loads to wetland plants. These water diversions have the added benefit of directly reducing the nutrient load flowing into the Gulf of Mexico via the Mississippi River, as well as allowing wetlands to store and filter floodwater before releasing it to the Gulf.

Lower floodplain water diversion refers specifically to diversions of a freshwater river to adjacent coastal floodplains, but the NRCS conservation practice ‘diversion’ (code 362, 348) may be applied to leveed sections of the Wabash River to redirect flood waters and reduce nutrient loads in the river. Providing outlets for flood waters will help reduce the impact of predicted increased storm events under climate change and reduce subsequent downstream flooding. As river levees tend to be more concentrated around populated areas, managing water diversions near these towns and cities will help reduce flooding and protect rural farmlands along the river.

Costs associated with water diversion include the construction and maintenance of gates or pumps at the point of diversion. Wetlands serviced or created by these projects will operate under natural processes and be self-sufficient. Locations for these wetlands will need to be acquired or have access permitted. Important considerations and possible limitations of water diversion include thoughtful placement of diversion points with respect to populated areas and available land space.

Appendix 3. Wildlife

Appendix 3.1 Rare Species Distribution in Lower Wabash

In all the 859 species in Indiana, more than 100 of these species are listed as “rare species” in Indiana which attracts special attention. According to 2015 Wildlife Science Report (Indian Department of Natural Resources, 2015), Indiana Rare Species include two kinds of animal species: endangered species and special concern species. Endangered species are defined as “Any animal species whose prospect for survival or recruitment within Indiana are in jeopardy and are in danger of disappearing from the state” (IDNR, 2015). State endangered species are not always consistent with federal endangered species. It works as complements for species protection according to Indiana’s condition, containing more species than USWFS listed. Special concern species are defined as “Any animal species requiring monitoring because of known or suspected limited abundance or distribution, or because of recent change in federal status or required habitat” (IDNR, 2015). Endangered species in Indiana are legally protected by Indiana Nongaming and Endangered Species Conservation Act (IC 14-23-34). But special concern species are not protected by this law.

Since gaming species are permitted for licensed hunting, most of them are not included as “rare” species. But in 2015, two gaming birds also added into the list as special concern species because of population declining in Indiana state.

We organized a list with all these “rare species”, and several species not included as “rare” but with specially sections in Indiana Department of Natural Resources official site, the data are from Indiana Department of Natural Resources official site (http://www.in.gov/dnr/fishwild/2356.htm).

Multiple sources are used to confirm the distribution areas of these species. For keeping the data uniform, the distribution information are mainly based on USGS National Gap Analysis Program (GAP) -- Core Science Analytics and Synthesis (http://gapanalysis.usgs.gov/gap-analysis/). Several other datasets are chosen as complements only if the Gap database not containing/not completing the species information. By analyzed the overlap of species distributions with the 14 counties in Lower Wabash Areas: Clay, Daviess, Dubois, Gibson, Greene, Knox, Martin, Orange, Pike, Posey, Sullivan, Vanderburgh, Vigo, and Warrick, species appeared in Lower Wabash counties are chosen for further analysis.

The “rare” species distribution information is listed in below: totally 7 categories (invasive species included).

“Special Protected (SP), Special Concern (SC), State Endangered (SE), Federal Threatened (FT), Federal Endangered (FE), Federal Candidate (FC), Exotic/introduced (X)” (DNR).

1. Amphibians: (done)

ORDE	FAMILY	GENU	*SPECIE*	COMMO	STATU	Distribut	Distributi	Distribution	Link

R		S	*S*	N NAME	S*	ed in Lower Wabash	on data sources	in Lower Wabash counties	
Caudata	Cryptobranchidae	Hellbenders	*Cryptobranchus alleganiensis*	Hellbender	SE	Yes	GAP	ALL	http://gapanalysis.usgs.gov/species/data/download/#choose (then download range)
	Proteidae	Mudpuppies and Waterdogs	*Necturus maculosus*	Common Mudpuppy	SC	Yes	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Amphibians/amudpx/MapServer
	Ambystomatidae	Mole Salamanders	*Ambystoma laterale*	Blue-spotted Salamander	SC	No	other sources (berkeley mapper from UC Berkeley)		http://berkeleymapper.berkeley.edu/index.html?tabfile=http://amphibiaweb.org/tmpfiles/628576&configfile=http://amphibiaweb.org/tmpfiles/bm_config_576253.xml&ViewResults=tab&sourcename=AmphibiaWeb+Species+Map:+Ambystoma+laterale&amphibiaweb=true&label=1&opacity=0.50&pointDisplay=pointMarkers
			Ambystoma talpoideum	Mole Salamander	SE	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Amphibians/amosax/MapServer
			Ambystoma barbouri	Streamside Salamander	SC	Yes	other sources (berkeley mapper from UC Berkeley)	Dubois	http://berkeleymapper.berkeley.edu/index.html?tabfile=http://amphibiaweb.org/tmpfiles/352356&configfile=http://amphibiaweb.org/tmpfiles/bm_confi

									g_137843.xml&ViewResults=tab&sourcename=AmphibiaWeb+Species+Map:+Ambystoma+barbouri&amphibiaweb=true&label=1&opacity=0.50&pointDisplay=pointMarkers (distribution)
			Hemidactylium scutatum	Four-toed Salamander	SC	Yes	GAP	Greene, Sullivan, Daviess, Martin, Orange	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Amphibians/aftsax/MapServer
			Pseudotriton ruber	Red Salamander	SE	No	other sources (berkeley mapper from UC Berkeley)		http://amphibiaweb.org/cgi/amphib_query?where-genus=Pseudotriton&where-species=ruber
			Aneides aeneus	Green Salamander	SE	Yes	other sources (berkeley mapper from UC Berkeley)	Orange	http://amphibiaweb.org/species/3934
Anura	Hylidae	Treefrogs	*Acris crepitans*	Northern Cricket Frog	SC	Yes	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Amphibians/ancfrx/MapServer;
			Hyla chrysoscelis	Cope's Gray Treefrog		Yes	IDNR; other sources (berkeley mapper from UC Berkeley)	ALL	http://www.in.gov/dnr/fishwild/3341.htm
			Hyla versicolor	Eastern Gray Treefrog		?		Co. H. versicolor is found in	

								northern Indiana, not known south of Indy.	
			Hyla cinerea	Green Treefrog		Yes	IDNR	All	http://www.in.gov/dnr/fishwild/3336.htm
			Pseudacris triseriata	Western Chorus Frog		Yes	IDNR	All	http://www.in.gov/dnr/fishwild/3332.htm
			Pseudacris crucifer	Spring Peeper		Yes	IDNR	All	http://www.in.gov/dnr/fishwild/3330.htm
	Ranidae	True Frogs	*Lithobates areolatus*	Crawfish Frog	SE	Yes	IDNR	? Southwestern and west-central Indiana. Isolated population in the southeast region. Very uncommon. Endangered in Indiana.	http://www.in.gov/dnr/fishwild/3342.htm
			Lithobates pipiens	Northern Leopard Frog	SC	NA	GAP		http://www.in.gov/dnr/fishwild/3335.htm
			Lithobates blairi	Plains Leopard Frog (Plain's Leopard Frog)	SE	?	IDNR	? Poorly known. Species of special concern.	http://www.in.gov/dnr/fishwild/3334.htm
			Lithobates catesbeianus	American Bullfrog		Yes	IDNR	All	http://www.in.gov/dnr/fishwild/3344.htm
			Lithobates	Green Frog		Yes	IDNR	All	http://www.in.gov/dnr/fishwild/3337.

			clamitans						htm
			Lithobates palustris	Pickeral Frog		NA	IDNR	Statewide except northwestern prairie and lower Wabash valley. Not common.	http://www.in.gov/dnr/fishwild/3333.htm
			Lithobates sphenocephalus	Southern Leopard Frog		Yes	IDNR	West-central and southern Indiana.	http://www.in.gov/dnr/fishwild/3331.htm
			Lithobates sylvaticus	Wood Frog		Yes	GAP	All	http://www.in.gov/dnr/fishwild/3329.htm https://www.arcgis.com/home/webmap/viewer.html?url=https%3A%2F%2Fgis1.usgs.gov%2Farcgis%2Frest%2Fservices%2FNAT_Species_Amphibians%2Fawofrx%2FMapServer&source=sd
	Bufonidae	True Toads	*Anaxyrus americanus*	American Toad		NA	IDNR		http://www.in.gov/dnr/fishwild/3345.htm
			Anaxyrus fowleri	Fowler's Toad		Yes	IDNR	All	http://www.in.gov/dnr/fishwild/3338.htm
	Scaphiopodidae	North American Spadefoots	*Scaphiopus holbrookii*	Eastern Spadefoot		Yes	IDNR	Southern third of state. Occur in flood plains of lower Wabash and	http://www.in.gov/dnr/fishwild/3339.htm

								White rivers and in barrens or relic prairies of Harrison Co. Species of Special Concern.	

2. Birds: (done)

ORDER	FAMILY		*SPECIES*	COMMON NAME	STATUS*	Distributed in Lower Wabash	Distribution data sources	Distribution in Lower Wabash counties	Link (disntributiom)
Anseriformes	Anatidae	Waterfowl: Ducks, Geese, and Swans	*Cygnus buccinator*	Trumpeter Swan	SE	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/btrusx/MapServer
Pelecaniformes	Ardeidae	Bitterns, Herons, and Egrets	*Botaurus lentiginosus*	American Bittern	SE	Yes-Summer	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bambix/MapServer
			Ixobrychus exilis	Least Bittern	SE	Yes-Summer	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/blebix/MapServer
			Ardea alba	Great Egret	SC	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bgregx/MapServer
			Nycticorax	Black-crowned Night-Hero	SE	Yes-Summer & Year Round	GAP	Green, Sullvan, Clay, Owen-summer; other places-	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bbcnhx/MapServer

				n				year round	
			Nyctanassa violacea	Yellow-crowned Night-Heron	SE	Yes-Summer	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bycnhx/MapServer
Accipitriformes	Pandionidae Osprey	Osprey	*Pandion haliaetus*	Osprey	SE	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bosprx/MapServer
	Accipitridae	Hawks, Eagles, and Kites	*Ictinia mississippiensis*	Mississippi Kite	SC	Yes-Summer	GAP	Green, Sullivan, Lawrance, Martin, Daviess, Knox, Gibson, Pike, Dubios, Warrick	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bmikix/MapServer
			Circus cyaneus	Northern Harrier	SE	Yes-Winter & Year Round	GAP	Green, Sullivan, Clay, Owen-year round;	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bnohax/MapServer
			Accipiter striatus	Sharp-shinned Hawk	SC	Yes-Winter & Year Round	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bsshax/MapServer
			Haliaeetus leucocephalus	Bald Eagle	SC	Yes-Winter & Year Round	GAP	Martin, Dubios, Orange - year rounde;	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bbaeax/MapServer

								other places-winter	
			Buteo lineatus	Red-shouldered Hawk	SC	Yes-Year Round	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/brshax/MapServer
			Buteo platypterus	Broad-winged Hawk	SC	Yes-Summer	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bbwhax/MapServer
Gruiformes	Rallidae	Rails, Gallinules, and Coots	*Laterallus jamaicensis*	Black Rail	SE	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bblrax/MapServer
			Rallus elegans	King Rail	SE	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bkirax/MapServer
			Rallus limicola	Virginia Rail	SE	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bvirax/MapServer
			Gallinula galeata	Common Gallinule	SE	Yes-Summer	other sources (Birds of North America from Cornell Lab)	ALL	https://birdsna.org/Species-Account/bna/species/comgal1/introduction;JSESSIONID=A013C173B1AC650C0E051424292E4018
	Gruidae	Cranes	*Grus canadensis*	Sandhill Crane	SC	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_

									Birds/bsacrx/MapServer
			Grus americana	Whooping Crane	SE, FE	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bwhcrx/MapServer
Charadriiformes	Charadriidae	Plovers	*Pluvialis dominica*	American Golden-Plover	SC	Yes-Summer	GAP	ALL	http://gapanalysis.usgs.gov/species/data/download/# (download range)
			Charadrius melodus	Piping Plover	SE, FE	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bpiplx/MapServer
	Scolopacidae	Sandpipers and Phalaropes	*Tringa solitaria*	Solitary Sandpiper	SC	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bsosax/MapServer
			Tringa melanoleuca	Greater Yellowlegs	SC	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bgryex/MapServer
			Bartramia longicauda	Upland Sandpiper	SE	Yes-Summer	GAP	Clay	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bupsax/MapServer
			Arenaria interpres	Ruddy Turnstone	SC	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/brutux/MapServer
			Tryngites subrufic	Buff-brea	SC	No	GAP		http://gapanalysis.usgs.gov/species/data/download/#

			ollis	sted Sandpiper					(download range)
			Limnodromus griseus	Short-billed Dowitcher	SC	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bsbdox/MapServer
			Phalaropus tricolor	Wilson's Phalarope	SC	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bwiphx/MapServer
			Calidris canutus rufa	Rufa Red Knot	SC	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/breknx/MapServer
	Laridae	Gulls, Terns, and Skimmers	*Sternula antillarum*	Least Tern	SE, FE	Yes-Summer	GAP	Posey	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bletea/MapServer
			Chlidonias niger	Black Tern	SE	Yes-Summer	GAP	Martin, Dubios, Pike, Owen, Green, Orange, Crawford, Spencer, Perry,	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bbltex/MapServer
Strigiformes	Tytonidae	Barn Owls	*Tyto alba*	Barn Owl	SE	Yes-year round	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bbanox/MapServer

	Strigidae	Typical Owls	*Asio flammeus*	Short-eared Owl	SE	Yes-Winter & Year Round	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bseowx/MapServer
Caprimulgiformes	Caprimulgidae	Nighthawks and Nightjars	*Chordeiles minor*	Common Nighthawk	SC	Yes-Summer	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bconix/MapServer
			Antrostomus vociferus	Eastern Whip-poor-will	SC	Yes-year round	other sources (Birds of North America from Cornell Lab)	ALL	https://birdsna.org/Species-Account/bna/species/whip-p1/introduction
Falconiformes	Falconidae	Falcons and Caracaras	*Falco peregrinus*	Peregrine Falcon	SC	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bpefax/MapServer
Passeriformes	Laniidae	Shrikes	*Lanius ludovicianus*	Loggerhead Shrike	SE	Yes-Winter & Year Round	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bloshx/MapServer
	Troglodytidae	Wrens	*Cistothorus platensis*	Sedge Wren	SE	Yes-Summer	GAP	Green, Sullvan, Lawrance, Martin, Daviess, Knox, Gibson, Pike, Posey	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bsewrx/MapServer
			Cistothorus palustris	Marsh Wren	SE	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bmawrx/MapServer

	Parulidae	New World Warblers	*Helmitheros vermivorum*	Worm-eating Warbler	SC	Yes-Summer	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bwewax/MapServer
			Vermivora chrysoptera	Golden-winged Warbler	SE	Yes-Summer	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bgwwax/MapServer
			Mniotilta varia	Black-and-white Warbler	SC	Yes-Summer	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bbwwax/MapServer
	Emberizidae	Sparrows	*Ammodramus henslowii*	Henslow's Sparrow	SE	Yes-Summer	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bhespx/MapServer
	Icteridae	Blackbirds and Orioles	*Sturnella neglecta*	Western Meadowlark	SC	Yes-Winter	GAP	Posey, Gibson	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bwemex/MapServer
			Xanthocephalus	Yellow-headed Blackbird	SE	No	GAP		http://gapanalysis.usgs.gov/species/data/download/# (download range)
	Cardinalidae Tanagers, Cardinals,		*Piranga rubra*	Summer Tanager		Yes-Summer	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bsutax/MapServer

	and Grosbeaks)								
Galliformes	Phasianidae	Turkeys, grouse, pheasants, and partridges	*Bonasa umbellus*	Ruffed Grouse	SC	Yes	GAP	Greene, Orange, Perry	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/brugrx/MapServer

3. Fish: (Not done)

ORDER	FAMILY		*SPECIES*	COMMON NAME	STATUS *	Distributed in Lower Wabash	Distribution data sources	Distribution in Lower Wabash counties	Link
Petromyzontiformes (Class Petromyzontida)	Petromyzontidae	lampreys	*Ichthyomyzon fossor*	Northern Brook Lamprey	SE	No	NSE		http://explorer.natureserve.org/servlet/NatureServe?searchName=Ichthyomyzon+fossor+
Acipenseriformes (Class Actinopterygii)	Acipenseridae	sturgeons	*Acipenser fulvescens*	Lake Sturgeon	SE	YES	NSE	Martin (18101), Porter (18127), Posey (18129)*, , Vigo (18167)*	http://explorer.natureserve.org/servlet/NatureServe?sourceTemplate=tabular_report.wmt&loadTemplate=species_RptComprehensive.wmt&selectedReport=RptComprehensive.wmt&summaryView=tabular_report.wmt&elKey=104232&paging=home&save=true&startIndex=1&nextStartIndex=1&reset=false&offPageSelectedElKey=104232&offPageSelectedElType=species&offPageYesNo=true&post_processes=&radiobutton

									=radiobutton&selectedIndexes=104232&selectedIndexes=777781&selectedIndexes=777776&selectedIndexes=777773&selectedIndexes=798155&selectedIndexes=798164&selectedIndexes=798167&selectedIndexes=798173&selectedIndexes=798177
Lepisosteiformes (Class Actinopterygii)	Lepisosteidae	gars	*Atractosteus spatula*	Alligator Gar	EX				
Clupeiformes (Class Actinopterygii)	Clupeidae	herrings	*Alosa alabamae*	Alabama Shad	EX				
Cypriniformes (Class Actinopterygii)	Cyprinidae	carps and minnows	*Clinostomus elongatus*	Redside Dace	SE				
			Hybopsis amnis	Pallid Shiner	SE				
			Notropis anogenus	Pugnose Shiner	SC				
			Notropis ariommus	Popeye Shiner	EX				
			Notropis dorsalis	Bigmouth Shiner	SC				
			Rhinichthys cataractae	Longnose Dace	SC				

	Catostomidae	suckers	*Catostomus*	Longnose Sucker	SC				
			Moxostoma lacerum	Harelip Sucker	EX				
			Moxostoma valenciennesi	Greater Redhorse	SE				
Siluriformes (Class Actinopterygii)	Ictaluridae	North American catfishes	*Noturus stigmosus Northern Madtom*	Northern Madtom	SE				
Salmoniformes (Class Actinopterygii)	Salmonidae	trouts and salmons	*Coregonus artedi*	Cisco	SC				
			Coregonus clupeaformis	Lake Whitefish	SC				
			Coregonus nigripinnis	Blackfin Cisco	EX				
			Coregonus reighardi	Shortnose Cisco	EX				
			Coregonus zenithicus	Shortjaw Cisco	EX				
Percopsiformes (Class Actinopterygii)	Percopsidae	trout-perches	*Percopsis omiscomaycus*	Trout-perch	SC				
	Amblyo	cavefishes	*Amblyop*	Hoosier	SE				

	psidae		*sis hoosieri*	Cavefish					
			Typhlichthys subterraneus	Southern Cavefish	EX				
Scorpaeniformes (Class Actinopterygii)	Cottidae	sculpins	*Cottus cognatus*	Slimy Sculpin	SC				
Perciformes (Class Actinopterygii)	Centrarchidae	sunfishes	*Lepomis symmetricus*	Bantam Sunfish	SE				
	Percidae	perches and darters	*Ammocrypta clara*	Western Sand Darter	SC				
			Crystallaria asprella	Crystal Darter	EX				
			Etheostoma maculatum	Spotted Darter	SC				
			Etheostoma proeliare	Cypress Darter	SC				
			Etheostoma tippecanoe	Tippecanoe Darter	SC				
			Etheostoma variatum	Variegate Darter	SE				
			Percina copelandi	Channel Darter	SE				
			Percina evides	Gilt Darter	SE				

			Percina uranidea	Stargazing Darter	EX				
			Percina vigil	Saddleback Darter	EX				
	Elassomatidae	pygmy sunfishes	*Elassoma zonatum*	Banded Pygmy Sunfish	SC				

4. Fresh Mussels: (Not done)

ORDER	FAMILY	GENUS	*SPECIES*	COMMON NAME	STATUS*	Distributed in Lower Wabash	Distribution data sources	Distribution in Lower Wabash counties	Link
Unionoida	Margaritiferidae	Cumberlandia	*monodonta s*	pectaclecase	EX, FE				
	Unionidae	Cyprogenia	*stegaria*	fanshell	FE				
		Epioblasma	*flexuosa*	leafshell	EX				
		Epioblasma	*obliquata*	catspaw					http://explorer.natureserve.org/servlet/NatureServe?searchName=obliquata+obliquata+
		Epioblasma	*obliquata perobliqua*	white catspaw	FE				
		Epioblasma	*personata*	round combshell	EX				
		Epioblasma	*propinqua*	Tennessee riffleshell	EX				
		Epioblasma	*sampsonii*	Wabash	EX				

				riffleshell					
		Epioblasma	*torulosa rangiana*	northern riffleshell	FE				
		Epioblasma	*torulosa*	tubercled blossom	FE				
		Epioblasma	*triquetra*	snuffbox	FE				
		Fusconaia	*subrotunda*	longsolid	SE				
		Hemistena	*lata*	cracking pearlymussel	EX, FE				
		Lampsilis	*abrupta*	pink mucket	FE				
		Lampsilis	*fasciola*	wavyrayed lampmussel	SC				http://www.in.gov/dnr/fishwild/8685.htm
		Leptodea	*leptodon*	scaleshell	EX, FE				
		Obovaria	*retusa*	ring pink	EX, FE				
		Obovaria	*subrotunda*	round hickorynut	SE				
		Plethobasus	*cicatricosus*	white wartyback	FE				
		Plethobasus	*cooperianus*	orangefoot pimpleback	FE				
		Plethobasus	*cyphyus*	sheepnose	FE				
		Pleurobema	*clava*	clubshell	FE				
		Pleurobema	*cordatum*	Ohio pigtoe	SC				
		Pleurobema	*plenum*	rough	FE				

				pigtoe					
		Pleurobema	*rubrum*	pyramid pigtoe	SE				
		Potamilus	*capax*	fat pocketbook	FE				
		Ptychobranchus	*fasciolaris*	kidneyshell	SC				
		Quadrula	*cylindrica*	cylindrica rabbitsfoot	SE, FT				
		Quadrula	*fragosa*	winged mapleleaf	EX, FE				
		Simpsonaias	*ambigua*	salamander mussel	SC				
		Toxolasma	*lividus*	purple lilliput	SC				
		Venustaconcha	*ellipsiformis*	ellipse	SC				
		Villosa	*fabalis*	rayed bean	FE				
		Villosa	*lienosa*	little spectacle case	SC				

5. Mammals: (Not done)

ORDER	FAMILY		*SPECIES*	COMMON NAME	STATUS*	Distributed in Lower Wabash	Distribution data sources	Distribution in Lower Wabash counties	Link
Soricomorpha	Soricidae	shrews	*Sorex fumeus*	Smoky shrew	SC	Yes	GAP	Orange, Lawrance, Green	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Mammals/msmshx/

									MapServer ;
			Sorex hoyi	Pygmy shrew	SC				
	Talpidae	moles	*Condylura cristata*	Star-nosed mole	SC				
Chiroptera	Vespertilionidae	evening and vesper bats	*Myotis austroriparius*	Southeastern myotis	SC				
			Myotis grisescens	Gray myotis	FE, SE				
			Myotis leibii	Eastern small-footed myotis	SC				
			Myotis lucifugus	Little brown myotis	SC				
			Myotis septentrionalis	Northern long-eared myotis	SC				
			Myotis sodalis	Indiana myotis	FE, SE				
			Lasionycteris noctivagans	Silver-haired bat	SC				
			Perimyotis subflavus	Tri-colored bat	SC				
			Nycticeius humeralis	Evening bat	SE				
			Lasiurus borealis	Red bat	SC				
			Lasiurus cinereus	Hoary bat	SC				
			Corynorhinus	Rafinesq	SC				

			rafinesquii	ue's big-eared bat						
Lagomorpha	Leporidae	rabbits and hares	*Sylvilagus aquaticus*	Swamp rabbit	SE					
Rodentia	Sciuridae	squirrels	*Spermophilus franklinii*	Franklin's ground squirrel	SE					
	Geomyidea	pocket gophers	*Geomys bursarius*	Plains pocket gophers	SC					
	Cricetidae	New World rats, mice, voles	*Neotoma magister*	Allegheny woodrat	SE					http://www.in.gov/dnr/fishwild/3385.htm
Carnivora	Mustelidae	weasels, badgers, otters	*Mustela nivalis*	Least weasel	SC					
			Taxidea taxus	Badger	SC					http://www.in.gov/dnr/fishwild/3384.htm
				Black Bear	Listed in IDNR Web					http://www.in.gov/dnr/fishwild/8500.htm
				Bobcat	Listed in IDNR Web					http://www.in.gov/dnr/fishwild/3380.htm
				Coyote	Listed in IDNR Web					
				Mountain Lion (Cougar, puma, catamount, panther)	Listed in IDNR Web					

				Bats	Listed in IDNR Web				http://www.in.gov/dnr/fishwild/8450.htm

6. Reptiles: (Not done)

ORDER	FAMILY		*SPECIES*	COMMON NAME	STATUS*	Distributed in Lower Wabash	Distribution data sources	Distribution in Lower Wabash counties	Link
Testudines	Chelydridae	Snapping Turtles	*Macrochelys temminckii*	Alligator Snapping Turtle	SE				http://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Reptiles
	Kinosternidae	Mud and Musk Turtles	*Kinosternon subrubrum*	Eastern Mud Turtle	SE				
	Emydidae	Box and Water Turtles	*Clemmys guttata*	Spotted Turtle	SE				
			Emydoidea blandingii	Blanding's Turtle	SE				
			Terrapene carolina	Eastern Box Turtle	SP				
			Terrapene ornata	Ornate Box Turtle	SE				
			Pseudemys concinna	River Cooter	SE				
Squamata	Natricidae	Harmless Live-Bearing Snakes	*Thamnophis butleri*	Butler's Gartersnake	SE				
			Thamnophis proximus	Western Ribbonsnake	SC				
			Nerodia	Copper-	FT**,S				

			erythrogaster neglecta	bellied Watersnake	E				
			Clonophis kirtlandii	Kirtland's Snake	SE				
	Colubridae	Harmless Egg-Laying Snakes	*Opheodrys aestivus*	Rough Greensnake	SC				
			Opheodrys vernalis	Smooth Greensnake	SE				
			Cemophora coccinea	Scarletsnake	SE				
			Tantilla coronata	Southeastern Crowned Snake	SE				
	Xenodontidae	Robus Rear-Fanged Snakes	*Farancia abacura*	Red-bellied Mudsnake	SC				
	Crotalidae	Pit Vipers	*Agkistrodon piscivorus*	Cottonmouth	SE				
			Sistrurus catenatus	Massasauga	FC, SE				
			Crotalus horridus	Timber Rattlesnake	SE				

7. Invasive species: (Not done)

ORDER	FAMILY		*SPECIES*	COMMON NAME	STATUS*	Distributed in Lower Wabash	Distribution data sources	Distribution in Lower Wabash counties	Link
birds									
Anseriformes	Anatidae	Waterfowl: Ducks, Geese, and Swans	*Cygnus olor*	Mute Swan	X	No	GAP		https://gis1.usgs.gov/arcgis/rest/services

									/NAT_Species_Birds/bmuswx/MapServer
Galliformes	Phasianidae	Pheasants, Grouse, and Turkeys	*Phasianus colchicus*	Ring-necked Pheasant	X	Yes-year round	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/brnepx/MapServer
Columbiformes	Columbidae	Pigeons and Doves	*Columba livia*	Rock Pigeon	X	Yes-year round	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bropix/MapServer
			Streptopelia decaocto	Eurasian Collared-Dove	X	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/beucdx/MapServer
Psittaciformes	Psittacidae	Parakeets	*Myiopsitta monachus*	Monk Parakeet	X	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bmopax/MapServer
Passeriformes	Sturnidae	Starlings	*Sturnus vulgaris*	European Starling	X	Yes-year round	GAP	ALL	https://gis1.usgs.gov/arcgis/re

									st/services/NAT_Species_Birds/beustx/MapServer
	Fringillidae	Finches	*Haemorhous mexicanus*	House Finch	X	Yes-year round	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bhofix/MapServer
	Passeridae	Old World Sparrows	*Passer domesticus*	House Sparrow	X	Yes-year round	GAP	ALL	https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bhospx/MapServer
			Passer montanus	Eurasian Tree Sparrow	X	No	GAP		https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/bhospx/MapServer
fishs									https://gis1.usgs.gov/arcgis/rest/services/NAT_Species_Birds/betspx/MapServer
Petromyzontiformes	Petromyzontidae	lampreys	*Petromyzon marinus*	Sea Lamprey	X				

(Class Petromyzontida)									
Clupeiformes (Class Actinopterygii)	Clupeidae	herrings	*Alosa pseudoharengus*	Alewife	X				
Cypriniformes (Class Actinopterygii)	Cyprinidae	carps and minnows	*Carassius auratus*	Goldfish	X				
			Ctenopharyngodon idella	Grass Carp	X				
			Cyprinus carpio	Common Carp	X				
			Hypophthalmichthys molitrix	Silver Carp	X				
			Hypophthalmichthys nobilis	Bighead Carp	X				
			Scardinius erythrophthalmus	Rudd	X				
	Cobitidae	loaches	*Misgurnus anguillicaudatus*	Oriental Weatherfish	X				
Siluriformes (Class Actinopterygii)	Ictaluridae	North American catfishes	*Ameiurus catus*	White Catfish	X				
Osmeriformes (Class Actinopterygii)	Osmeridae	smelts	*Osmerus mordax*	Rainbow Smelt	X				
Salmoniformes (Class Actinopterygii)	Salmonidae	trouts and salmons	*Oncorhynchus kisutch*	Coho Salmon	X				
			Oncorhynchus	Rainbow	X				

			mykiss	Trout						
			Oncorhynchus tshawytscha	Chinook Salmon	X					
			Salmo salar	Atlantic Salmon	X					
			Salmo trutta	Brown Trout	X					
Mugiliformes (Class Actinopterygii)	Mugilidae	mullets	*Mugil cephalus*	Striped Mullet	X					
			Menidia beryllina	Inland Silverside	X					
Gasterosteiformes (Class Actinopterygii)	Gasterosteidae	sticklebacks	*Gasterosteus aculeatus*	Threespine Stickleback	X					
Perciformes (Class Actinopterygii)	Moronidae	temperate basses	*Morone americana*	White Perch	X					
			Morone saxatilis	Striped Bass	X					
	Gobiidae	gobies	*Neogobius melanostomus*	Round Goby	X					
Freshwater Mussels										
Veneroida	Corbiculidae	Corbicula	*fluminea*	Asian clam	X					
	Dreissenidae	Dreissena	*polymorpha*	zebra mussel	X					
		Dreissena	*bugensis*	quagga mussel	X					
Mammals										
Rodentia	Muridae	Old World	*Rattus*	Norway rat	X					

		rats and rats	*norvegicus*							
			Mus musculus	House mouse	X					

Appendix 3.2 Species Traits and Corresponding Functional Groups

Type	Common Name	*SPECIES*	Habitat*	Breeding Habitat*	Diet*	Common Name	Functional Group
Bird	Blue-winged teal	*Anas discors*	Freshwater habitats include shallow ponds and seasonal and permanent wetlands. They often use both temporary and permanent ponds.	Breeding season, nesting habitat includes wetland areas within grasslands, such as shallow marshes, sloughs, flooded ditches, and temporary ponds.	Primary Diet: carnivore, herbivore; Animal Foods: insects, mollusks, aquatic crustaceans, other marine invertebrates; Plant Foods: leaves, seeds, grains, and nuts, algae, phytoplankton	Blue-winged teal	Migratory waterfowl
	Gadwall	*Anas strepera*	Marshes, sloughs, ponds, and small lakes with grasslands in both fresh and brackish water as breading habitats.	Meadows and upland habitats	Primary Diet: omnivore; Animal Foods: amphibians, fish, insects, terrestrial non-insect arthropods, mollusks Plant Foods: leaves, seeds, grains, and nuts, algae	Gadwall	Migratory waterfowl
	Wood duck	*Aix sponsa*	Same with teal and gadwall	Same with teal and gadwall	Same with teal and gadwall	Wood duck	Migratory waterfowl
	Belted kingfisher	*Megaceryle alcyon*	The habitat of belted kingfishers requires a body of clear water, often surrounded by forest, that features nearly vertical exposed earth for digging burrows in which it nests.	Typically encompasses 800 to 1,200 meters of shoreline.	Primary Diet: carnivore; Animal Foods: birds, mammals, amphibians, reptiles, fish, insects, mollusks, aquatic crustaceans; Plant Foods: fruit	Belted kingfisher	Migratory waterfowl
	Acadian flycatc	*Empidonax viresce*	Wetlands: marsh, swamp; riparian	No-breeding here	Primary Diet: carnivore (insectivore);	Acadian flycatc	Riparian bird

	her	*ns*			Animal Foods: insects, terrestrial non-insect arthropods; Plant Foods: fruit	her	
	American Golden-Plover	*Pluvialis dominica*	Temperate, grassland areas	No-breeding here	Diet is influenced by local abundance of prey and temperatures. Breeding season: terrestial snails, insects and insect larvae, seeds, freshwater crustaceans, and insect larvae. Nonbreeding season: terrestial earthworms, insects and insect larvae, berries, seeds, and freshwater fish.	American Golden-Plover	Shorebird
	Common pheasant	*Phasianus colchicus*	Normally grassland and farmland habitats. Also appears in wetland (marsh) areas	In grass, shallow depression in the ground in a well covered area	Primary Diet: omnivore; Animal Foods: insects, terrestrial non-insect arthropods; Plant Foods: seeds, grains, and nuts, fruit	Common pheasant	Upland bird
	Quail		Same with pheasants	Same with pheasants	Same with pheasants	Quail	Upland bird
Fish	Blackside darter	*Pleurobema clava*	In streams and small rivers, in well oxygenated riffles with coarse sand and gravel and little silt.		Primary Diet: planktivore, detritivore; Plant Foods: algae, phytoplankton; Other Foods: detritus, microbes; Foraging Behavior: filter-feeding	Blackside darter	Shalow water small herbivore fish
	Johnny darter	*Etheostoma*	Temperate, freshwater regions;	A stationary object of at least 25 cm in	Primary Diet: carnivore	Johnny darter	Slow water benthic

		nigrum	benthic, lakes and ponds, rivers and streams	diameter, such as a log, rock, or even trash under which spawning occurs.	(insectivore, eats non-insect arthropods); Animal Foods: insects, aquatic crustaceans		small carnivore fish
	Topeka shiner	Notropis topeka	Pond-like areas or isolated portions of streams that begin to evaporate during dry weather. Optimal pond habitat tends to be cool and clear with an abundance of vegetation and soft, muddy bottoms. Optimal stream habitat tends to have a flow rate of about 1.5 m^3 per second with mostly gravel bottoms.	Spawn in pools over gravel and rubble substrates alongside green sunfish and orangespotted sunfish. Defend small territories, less than 0.25 m^2, near sunfish nests	Primary Diet: omnivore; Animal Foods: fish, insects, aquatic crustaceans; Plant Foods: seeds, grains, and nuts; Other Foods: detritus	Topeka shiner	Slow water small omnivore fish
	Sculpin		Rivers, submarine canyons, kelp forests, and shallow littoral habitat types, such as tidepools		Primary Diet: carnivore, omnivore; Animal Foods: terrestrial vertebrates, amphibians, fish, insects, mollusks; Plant Foods: leaves, roots, and tubers	Sculpin	Flowing water benthic small omnivore fish
	Creek chub	*Semotilus atromaculatus*	Require flowing water for spawning and are often found in small headwater creeks, small streams, and agricultural ditches over gravel and sand substrates.		Primary Diet: carnivore, omnivore; Animal Foods: terrestrial vertebrates, amphibians, fish, insects, mollusks; Plant Foods: leaves, roots, and tubers	Creek chub	Flowing water small omnivore fish
	Pugnose shiner	*Notropis anogenus*	Clear vegetated lakes as well as similar habitats in pools and runs of	Densely vegetated shallow water with a maximum depth of 2m	Primary Diet: carnivore (eats eggs, insectivore, vermivore),	Pugnose shiner	Flowing water small omnivore fish

			low gradient streams and rivers. They are extremely intolerant to turbidity.		herbivore (algivore), omnivore (detritivore); Animal Foods: eggs, insects, terrestrial worms; Plant Foods: algae		
	Small mouth bass	*Micropterus dolomieu*	Cooler lakes and ponds, rivers and streamsrivers, with rocky or sandy substrates	Small, round nest	Primary Diet: carnivore (piscivore, insectivore, eats non-insect arthropods, planktivore); Animal Foods: amphibians, fish, insects, aquatic crustaceans, zooplankton; Plant Foods: phytoplankton	Small mouth bass	Flowing water medial carnivore fish
	Black redhorse	*Moxostoma duquesnii*	Moderately sized rivers and streams, 25 to 130 m wide, up to 1.8 m in depth, and with generally moderate to fast currents.		Benthic-feeder; Primary Diet: omnivore; (insectivore), herbivore (algivore); Animal Foods:aquatic insects; Plant Foods: microcrustaceans, and alga; Other Foods: detritus	Black redhorse	Flowing water medial omnivore fish
	River redhorse	*Moxostoma carinatum*	Found in only the largest rivers of the Ohio and Lake Erie drainage systems. They are typically found in deep pools with moderate current over bedrock or gravel substrate. River redhorse are	Migrate into smaller streams and spawn at night at the top and bottom ends of shallow riffles.	Benthic-feeder; Primary Diet: carnivore; Animal Foods:mussels, snails, crustaceans and immature aquatic insects.	River redhorse	Flowing water medial carnivore fish

			intolerant of pollution and turbid (murky) water and are an indicator of good water quality. They feed on larval insects, small mollusks, snails, and other aquatic invertebrates.				
	Paddlefish	*Paddlefish*	Brackish freshwater; large rivers with deep water (greater than 6 meters) and slow moving currents (less than 5 cm/s).	Areas with sand or gravel bars	Primary Diet: planktivore (herbivore); Animal Foods: insects, aquatic crustaceans, zooplankton Foraging Behavior: filter-feeding	Paddlefish	Flowing water large omnivore fish
Reptile and amphibian	Copper-bellied water snake	*Nerodia erythrogaster*	Semi-aquatic, using both terrestrial and freshwater aquatic habitats. Aquatic habitats include ephemeral ponds or temporary pools, permanent lakes and ponds, swamps, bogs, marshes, small rivers, and riverine sloughs. Terrestrial habitats used as travel corridors, aestivation sites, hibernation sites and occasional feeding sites, including forests, grasslands, and scrublands. Sometimes in agricultural land.	Flooded forest wetlands with less than 15 cm of standing water, ponds near the shoreline. Woody debris was observed near the breeding site.	Primary Diet: carnivore (eats terrestrial vertebrates, piscivore); Animal Foods: amphibians, fish, carrion, aquatic crustaceans	Copper-bellied water snake	Semi-aquatic snake
Mussel	Mussel		Freshwater like lakes, ponds, rivers,		Filter feeders; feed on plankton and	Mussel	Mussels

			creeks, canals. Some live in water; some live on exposed shores in the intertidal zone, attached by means of their strong byssal threads to a firm substrate.		other microscopic water creatures which are free-floating in water		
Shrimp	Palaemonetes shrimp	*Palaemonetes paludosus*	Habitat Regions: temperate freshwater Aquatic Biomes: lakes and ponds, rivers and streams, brackish water		Filter-feeding; Primary Diet: carnivore (insectivore), herbivore (algivore); Animal Foods: insects, zooplankton; Plant Foods: algae, phytoplankton; Other Foods: detritus	Palaemonetes shrimp	Shrimp

*These descriptions are mainly from original website with light edition. Only for appendix backup, cannot directly use since copyright. (The data sources are “ADW” http://animaldiversity.org/ and “natureserve” http://explorer.natureserve.org/).
**Species Types are from LCC Conservation Practices Factsheets

Appendix 3.3 Species and Corresponding Functional Groups for Focal Habitat

Habitat	Species Groups	Functional groups
Big Rivers	Paddlefish	Flowing water large fish
	Sturgeon	Flowing water large fish
	Mussels	Mussel
Mudflat/moist soil/bottomland & hydric agriculture	Short-billed dowitcher	Shorebird
	Lesser yellowleg	Shorebird
	Yellowleg	Shorebird

	Pectoral sandpiper,	Shorebird
	Whooping cranes	Migratory waterfowl
	Duck species (TBA)	Migratory waterfowl
	pintails	Migratory waterfowl
	American golden plover	Upland bird
	Interior least tern (FE)	Shorebird
Upland agricultural fields	Bobwhite quail	Upland bird
	Pollinators	Pollinator
	America golden plover	Upland bird
Grasslands	Henslow's sparrow	Upland bird
	Grasshopper sparrow	Upland bird
	Pollinators	Pollinator
	Meadowlark	Upland bird
	Barn owl	Upland bird: owls and hawks
	Short-eared owls	Upland bird: owls and hawks
	Northern harriers	Upland bird: owls and hawks
	Bobwhite quail	Upland bird
	Crawfish frog	Reptiles and amphibians
Tributaries /	Hellbenders	Reptiles and

Streams		amphibians
	Mussels	Mussel
	Invertebrates	Invertebrate
Bottomland hardwood forests	Indiana bat	Bat
	Wood duck	Migratory waterfowl
	Prothonotary warblers	Upland bird
	Red-shouldered hawk	Upland bird: owls and hawks

*From LCC Lower Wabash draft plan

Appendix 4. Table of Land Use Data

Appendix 4. Table of land use data to be used for future GIS analysis, to determine where practices can be utilized (NRCS CPPE tool).

Conservation Practices	Land uses									
	Crop	Forest	Range	Pasture	Protected	Farmstead	Developed Land	Water	Other	Associated Ag. Land
Drainage Water Management	X			X		X			X	X
Contour Buffer Strips	X									
Prescribed Burning	X	X	X	X	X				X	X
Cover Crop	X	X	X	X	X				X	X
Dam, Diversion	X	X	X	X	X	X	X	X	X	X
Two-stage Ditches	X	X	X	X	X	X	X	X	X	X
Wetland Restoration	X	X	X	X	X			X	X	X

Appendix 5. Other Available Data

Appendix 5. Other available data which will be useful to stakeholders, in Lower Wabash cooperative.

Water data for the Lower Wabash River basin is available from several sources. The Indiana Department of Environmental Management (IDEM) has macroinvertebrate data for the Lower Wabash River watershed from years 1993, 1996, 1997, and 2009 (McMurray, 2016). Fish community and habitat data is also available through IDEM for years 1999, 2004, 2009, and 2016 (Gaston, 2016). The Ohio River Valley Sanitation Commission (ORSANCO) collects stream data from a monitoring station downstream of New Harmony, Indiana; this monitoring station has collected samples since 1988. ORSANCO also provides datasonde, algae, and nutrient data from their Wabash River Project, which was conducted in 2011 and reauthorized in 2012 (ORSANCO, 2016). A USGS gage station located on the Wabash River at Mt. Carmel, IL provides flow volumes representative of 86.5% of the Wabash River watershed (ORSANCO, 2012).