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Article

State Conservation Efforts of Seasonal Wetlands along the Mississippi River

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Abstract

Since a 2001 US Supreme Court decision that permanently altered the federal protection of non-navigable waters, scientists and policy-makers have struggled to determine whether state agencies are conserving wetlands and which wetlands no longer receive protection. Subsequent court cases have also made protection of non-navigable waters difficult as the regulatory definition of "navigable waters" continues to change. This study compares regulations and the administrative actions of ten states along the Mississippi River corridor to protect and conserve isolated wetlands. It uses GIS methodology to determine differences in wetland area change for a twenty-year period, and compares past and recent wetland destruction and wetland buffer zone loss using nationally established Land Use/Land Cover (LULC) categories. The results show that conservation of the wetlands and buffer zones have only been successful in places where agricultural area or urban sprawl did not statistically increase. The findings indicate that some biological functions and ecological values of federal wetlands have been conserved by a few state agencies and local governments that have clarified the regulations about small, ephemeral, and seasonal wetlands. The study highlights the need for trustworthy data for sensitive or at risk wetlands so that conservation stakeholders have robust evidence for developing appropriate mitigation policies and implementation strategies.

Keywords: Isolated wetlands, agriculture, urbanisation, federalism, state conservation policy

INTRODUCTION

Environmentalists, scientists, and policy-makers have struggled to identify which wetlands have lost federal protection under the Clean Water Act (CWA) after the provocative Supreme Court decision of *Solid Waste Agency of Northern Cook County (SWANCC) v. US Army Corps of Engineers* in 2001.While some environmentally active state agencies have addressed the gaps left by *SWANCC;* it is difficult to confirm which states have their own dredge and fill permits to protect land as many of the biological functions and ecological values these wetlands provided are or will be unavailable to communities (Comer et. al 2005). Generally, the ambiguity revolving around the idea of "navigable waters" continued in *Rapanos v. United States* (2006) as it was a plurality opinion which allows lower courts to take the narrower opinion because there is no meaningful precedent beyond the specific facts of the *Rapanos* case. Although there was a legal judgment, there was no majority opinion which has resulted in the Army Corp of Engineers to rely upon a Section 401 certification to establish a significant nexus on a case by case basis when seeking to regulate wetlands based on adjacency to non-navigable tributaries to avoid unreasonable applications of the Act by state actions. The lack of action and clarity by some state agencies to elucidate the situation negatively impacts small and seasonal wetlands. Accurate conservation work is necessary because state and non-governmental organisations need to know the extent of the impact and value of wetland areas in their ecosystem to determine what conservation methods are appropriate.

There is some debate among scholars about the responsibility and implementation of state actions to conserve and preserve

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wetlands after court decisions and regulatory conversations. While it might be legally reasonable to agree with Justice Kennedy who essentially says *SWANCC and Riverside Bayview* are still the law since the plurality would have to be more stringent and states must use the weaker standard. However, this logic is not being applied because Chief Justice Roberts thought Kennedy's reading would be applied by all lower courts but some have and others have not as there is confusion and not concurrence. For instance, *Kucana v. Holder (2009)* and *Caucus v. Alabama (2015)* have both cited *Rapanos* but not the navigable waters aspect; leading to a need for better understanding. Current inadequate mapped information and insufficient knowledge makes it difficult to identify those wetlands at risk (Comer et. al. 2005). Specifically, four Courts of Appeals (5th Louisiana and Mississippi; 6th Kentucky and Tennessee; 7th Wisconsin and Illinois, and 8th the remaining four states in this case study covering 80% of the river on one side) have increased the regulatory confusion. The current arguments over the wetland standard are that the 5th and 6th have avoided addressing the "significant nexus" language of *Riverside Bayview Homes* versus the "continuous surface water connection" of *SWANCC*. Moreover the 7th Court of Appeals uses the "significant nexus" as the controlling test to define navigable water and the 8th says either standard can be used.

To explore and propose strategies to address the gaps of conservation and protection programmes, this research study will do an event series analysis of an 80 kilometre wide corridor for a 3,374 kilometre reach of the Mississippi River to determine loss in seasonal wetlands and seasonal wetland buffer zones (terrestrial non-breeding zone - 120m, 400ft, Figure 1). To show the relationship between wetland buffer zones loss, intensification of agricultural practices, and urbanisation encroachment, this proposed research project will provide an in-depth examination of anthropological threats on isolated wetlands in ten states along the Mississippi River without federal environmental protection in the recording years of 2001, 2006, and 2011. It is important to identify the unique habitat of seasonal ponds and non-navigable or isolated wetlands because new state regulations and public administrations are attempting to conserve or preserve with less resources. Utilising GIS allows a spatial analysis of these conservation practices. Final results will be an intersection and difference analysis to identify the best reasons for the loss of vernal wetlands and to serve as a practical indicator of wetland status.

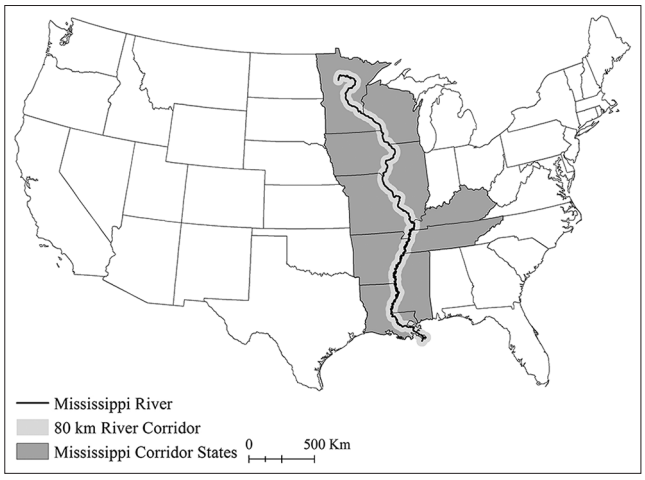

Figure 1
Ten states associated with Mississippi River corridor

This work is critical to understanding the impact of this legislation on wetlands and wetland buffer zones. For example, based on preliminary work, when considering the total wetland area in Missouri between 2001 and 2011, 68% has been negatively impacted by agriculture, 7% by urbanisation, and 25% by other unknown factors. These three factors serve as threats that are negatively impacting ephemeral ponds. However, in Wisconsin, which has developed a state-wide approach that has conservation programmes and protective legislation, the impacts on these ponds are minimal when analysing these same anthropological threats. A full analysis of the states bordering the Mississippi River is necessary as there are certain isolated wetlands, vernal pools, or terrestrial non-breeding zone buffers on a case-by-case basis that are negatively impacted by one or a combination of factors. Overall, this study hypothesizes that state regulations along the Mississippi River to protect vernal pools may impact isolated ecosystems if agricultural output or urban sprawl did not statistically increase. This study will utilise Land Use Land Cover (LULC) data acquired by the Multi-Resolution Land Characteristics Consortium (MRLC), which is a National Land Cover Database (NLCD) for the years 2001, 2006, and 2011. We will perform a buffer analysis (120m, 400ft) on all wetlands located within the Mississippi River corridor and conduct a difference within GIS to determine changes in wetland and wetland buffer areas between the periods of interest. If wetland or wetland buffer area has decreased, the intersect function will be used to determine the main causes, namely agriculture, urbanisation, or other, for the wetland loss. The wetland buffer is the locus of investigation in this study because it best represents the wetland conservation area that is most threatened after the *SWANCC* decision. While some states have attempted some regulatory response to the Supreme Court decision, about two-thirds of the United States has made no attempt to fill the gap left by *SWANCC and Rapanos*. While some could be explained by a lack of political will, most is the result of state actions which can only use the precedents of *SWANNC and Rapanos* to remand a case for jurisdictional language. This work aims at identifying adequate and necessary data to locate sensitive wetland data to allow for more complete decision-making.

Legal Background

Wetlands filter and recharge groundwater, offer necessary habitat for migratory birds, enhance landscape, and hold excess floodwater (Dahl and Allord 1997). Nonetheless, land use in the United States typically prioritises economic gains over ecological benefits as historically millions of acres of

wetlands were destroyed in order to make the land useable for farming and urban development. To preserve wetland acres and functions despite the perceived lost economic values, both regulatory and volunteer programmes are in place. Federal wetland regulation began in 1972 with the Clean Water Act (CWA) and worked in conjunction with incentive programmes to mitigate wetland losses. While rural landowners and urban developers impacting navigable waters of the United States have continued to be regulated under the CWA, legislation focusing on isolated wetlands is missing.

The 2001 U.S. Supreme Court decision *Solid Waste Agency of Northern Cook County (SWANCC) v. U.S. Army Corps of Engineers (ACOE)* created some regulatory confusion for conservation by re-introducing the concept of "significant nexus" as a standard to determine if wetlands are to be part of the waters of the United States. The *SWANCC* decision determined that "isolated waters are waters that are not traditionally navigable or interstate, nor tributaries thereof, nor adjacent to any of these ('Solid Waste Agency,' 2001)." In 1972 when Congress created the Clean Water Act Amendment (CWA) it was to regulate navigable waters so far as they affect interstate commerce. Due to the outcome of the *United States v. Riverside Bayview Homes* (1986) the ACOE regulated intrastate waters, including isolated wetlands, based on the standard of significant nexus to US waters and whether the waters provide habitat for migratory birds. According to the ACOE and the Environmental Protection Agency (EPA), migratory birds fall under the commerce clause because bird watching is a popular activity that generates revenue and supports interstate travel and tourism.

Through the *SWANCC* decision, the Supreme Court concluded that the CWA does not give the ACOE or EPA authority to regulate isolated wetlands, invalidates the Migratory Bird Rule, and scales back wetland protection to watersheds adjacent to or tributaries of navigable waters. The *SWANCC* case is unique in that it clarified the non-existent protection of isolated waters and dismissed the adjacent wetland protections seen in *Riverside Bayview Homes*. While the "significant nexus" language of *Riverside Bayview Homes* is only mentioned once in *Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers;* Justice Kennedy felt that was essentially the rule of *SWANCC*. The regulatory misunderstanding about the standard of "continuous surface water connection" remains today as Justice Scalia spent a lot of time in his interpretation of Rapanos addressing the problems with Kennedy's reliance upon the old nexus standard, which does not control as the Supreme Court held a plurality vote and allows Appeal Courts to use the Kennedy opinion.

Biological Sciences Literature

Vernal pools or isolated wetlands, for biologists, have a significant nexus for both the surrounding upland habitats and the aquatic habitats (Zedler 2003). Heavily fragmented landscapes, habitat isolation, wetland area and wetland buffer loss, and degradation of habitat quality have reduced the populations of pool-breeding amphibians by limiting dispersal success and genetic linkages as well as increasing mortality. Amphibian populations are significant in that they serve as a biological marker for wetland health. This is because they comprise a significant proportion of the vertebrate biomass in forest and wetland ecosystems, and serve as important carnivore and prey species. Society benefits from maintaining biodiversity through wetland preservation because these ecosystems help maintain the well-being of groundwater sources (Epperson, n. d.). In addition, quantifying these ecosystems services as well as determining how these services can be enhanced, maintained, or disrupted can serve as a measure of the health or integrity of an ecosystem itself (Scholes et al. 2010). The increase of heavily fragmented landscapes has now required scholars to determine how these land-use changes might affect wetland habitats (Baldwin and deMaynadier 2009).

Environmental destruction and numerous public health consequences coincide with the loss of wetlands. While these consequences may be diminished with more ecologically rational citizens and through more environmental democracy, the risk associated with the remaining consequences is high, and creative policy solutions are needed. So pervasive is the risk of wetland destruction that it affects every individual on a daily basis in the form of a basic human need—drinking water. Wetlands harbour remarkable filtering capabilities in regards to both biological and chemical contaminants. As the number and quality of wetlands available to filter out pollutants decreases, the potential for those pollutants to be passed onto drinking water sources increases, raising problems with non-point run-off.

Without state or federal protection, these wetlands are vulnerable to drainage for crop production or pressure for development of cities, both of which result in loss of wetland buffer (Sharitz and Gresham 1998). Historically, seasonal pools were destroyed by grazing, but more recently, agriculture continues to play a major role in their degradation and destruction (Keeler-Wolf et al. 1998). In addition, sprawl, or poorly planned land development, has been shown to be a major cause of habitat loss, and therefore amphibian biodiversity (Wilcove et al. 1998; Kirkman et al. 1999; Semlitsh 2003). It is our prediction that without state regulations all small and seasonal wetlands will be lost and in states with progressive wetland regulations, most isolated wetlands will be at risk if agriculture or urban development is needed and encouraged.

Urbanisation is defined as the proportion of the surrounding landscape covered by urban land (Hamer and McDonnel 2008). Urban development changes hydrology via the construction of impervious surfaces, increases runoff, and/or sedimentation with more pollution of wetlands (Hamer and McDonnell 2008). The inevitable threats posed by urban sprawl may be minimised through implementation of the EPA's Smart Growth Program. As local communities aim to attract jobs, foster economic development, and become attractive places for people to live, work, and play (EPA 2009), many governments discover that

their land development codes and ordinances often get in the way of development.

As a result, the EPA's Development, Community, and the Environment Division (DCED) specifically, has created numerous documents over Smart Growth practices in cities, and was the primary driving force for the Smart Growth Program. For example, the federal government offers 'Essential Fixes' that speak to the barriers local governments are most likely to face while implementing smart growth strategies (EPA, 2009). This agency device may help community planners to assess existing municipal codes and city ordinances to create both economically and environmentally sustainable societies (EPA, 2009). It is clear that urbanisation, unless controlled by sustainable management, will continue to pose a threat to small and isolated wetlands nationwide, as humans continue to alter the landscape (Hamer and McDonnell 2008).

The justification that agricultural use will threaten isolated wetlands even if state regulations have been passed to protect them is best summarised by Mitsch and Gosselink: "The reasons that wetlands are often legally protected have to do with their value to society, not with the abstruse ecological processes that occur in wetlands…but are also determined by human perceptions" (Mitsch and Gosselink 2000, 25). The location of the particular wetland by urban and/or suburban population will simply have more political pressures on it. For example, a wetland in a region with moderate urban development will reap the highest benefits because the surrounding population can benefit from its value without disrupting or overwhelming the wetlands functionality. (Mitsch and Gosselink 1993; Mitsch and Gosselink 2000). Despite the known benefits of wetlands in communities, few land planners have incorporated them into the landscape. In addition, when they are used the aesthetic value of mowed vegetation was found to have more value, thus negating the quality and function of the wetland (Tilton 1995).

Wetlands in residential subdivisions are hydrologically altered due to a manicured landscape and increase of impervious surfaces resulting in runoff diverted from the wetland. With these alterations the wetland loses much of its value. Instead, efforts should be made to integrate these habitats into the planned landscapes (Tilton 1995). It is also important to gain public support for the natural wetland and natural vegetation composition which supports wildlife populations. This, in conjunction with public support regarding planning, designing, and implementing communities to make wetlands fully integrated into planned landscapes while maintaining the valuable ecosystem benefits (LaGrange 2005, Tilton 1995).

RESEARCH DESIGN AND STUDY QUESTIONS

The objective of the study is to determine if there is loss of wetland area and buffer zone as a result of *SWANCC, Rapanos,* and the ensuing disorder of the regulatory framework within the 10 states bordering the Mississippi along a river corridor 80 km wide (40 km on each side of the river). Specifically, it is assessed if it is agricultural intensification, encroaching urbanisation or a combination of threats that destroy isolated wetland habitat. It is important to assess the risk that species of potential conservation face by examining the threats on vernal pools and the surrounding critical habitat. Following the SWANCC Supreme Court decision in 2001, the protection of wetlands shifted from Federal to State control or in many instances Federal to no control. The measurement of wetland areas within states (Table 1) bordering the Mississippi River in 2001, 2006, and 2011 determines if the shift in control from Federal to state jurisdiction has impacted wetland protection. The magnitude of loss/gain is unknown, so we ask:

Hypothesis One*: There will be no-net-loss in land area covered by wetlands within an 80 km corridor of the Mississippi River in states that have introduced legislation to prevent and/or mitigate for wetland losses.*

Hypothesis Two: *There will be a net-loss in land area covered by wetlands within an 80 km corridor of the Mississippi River in states that have not introduced legislation to prevent and/or mitigate for wetland losses.*

Hypothesis Three: *In states that have experienced a net-loss of wetland area with new state regulations, it will not be due to an increase in urban sprawl/development, rather an increase in agricultural land use.*

Note all three research questions will determine the magnitude of the negative impacts. Risk will be justified with completion of a Most Different Means Test (Harper 1984). Direct non-human factors would include loss of wetland function over time through severe prolonged drought or wildfire and indirect factors would include climate change and diseases causing extirpation of species.

Data Sources

We acquired land cover data from the Multi-Resolution Land Characteristics Consortium (MRLC), which is a National Land Cover Database (NLCD) made possible by the U.S. Dept. of Interior and U.S. Geological Survey in order to assess 2001, 2006, and 2011 land cover. MRLC is the best source of data for acquiring wetland, agricultural cropland, and urbanisation data because all three layers must be analysed during the same time period and using consistent methods between years for an accurate analysis. The National Land Cover Datasets are a 16-class land cover classification scheme that have been applied consistently at a spatial resolution of 30 metres and are based on the classification of Landsat Enhanced Thematic Mapper. The NLCD provides spatial reference and descriptive data for characteristics of the land surface including wetlands, agriculture, and urbanisation. To subset the needed data, we reclassified land cover to create an agricultural layer, an urbanisation layer, and a wetland layer for all three time periods.

Table 1
Mississippi River States and Recent State Wetland Regulations

States That Introduced Protective/Mitigation Legislation After 2001	States That Have Not Introduced Protective/Mitigation Legislation After 2001
Arkansas, Iowa, Louisiana, Minnesota, Wisconsin	Illinois, Kentucky, Mississippi, Missouri, Tennessee

When reclassifying the agricultural layer, all other land covers were designated as a 1; pasture/hay as a 2; and row crops as a 3.

Similarly, to isolate the urbanisation layer, all other land classifications will be classified as 1; developed/open space as 2; developed/low intensity as 3; developed/medium intensity as a 4; and developed/high intensity as a 5.

For the wetlands data, other land cover was designated as a 1; rivers, streams, lakes, or water bodies that are permanently saturated or covered with water except woody wetlands as a 2; and emergent herbaceous wetlands as a 3.

Due to periodic saturation or coverage with water, woody wetlands, and emergent herbaceous wetlands are the land types identified in the NLCD because they most closely resemble isolated wetlands. The same reclassification procedure was used for all data and was also done with statistical parallelism in order to create an agricultural layer, an urbanisation layer, and a wetland layer.

After reclassifying all layers for each time period, we converted the data from raster to vector (polygon) for storage management ease and data manipulation. Vector data structure produces a smaller file size than raster imagery and allows for the use of specific tools and methods within GIS. After the conversion from raster to vector, we created a 120 m (40ft) dissolved buffer for each region around the wetlands, which serves as the terrestrial non-breeding zone. This buffer is recommended by the Forestry Habitat Management Guidelines for Vernal Pool Wildlife from the Wildlife Conservation Society (Calhoun and deMaynadier 2004). By calculating the area in the attribute tables, an assessment will be made to determine if there has been a loss or gain of total wetland buffer between each of the time periods. Also, wetland area, excluding the buffer in each recording year, were compared by calculating the area in the attribute tables to determine if there has been a loss or gain of wetland habitat. When there was a detected gain in the wetland buffer area, the research design tests if the gain was due to loss of agricultural production, unsustainable urban growth, or other. If there is a loss in buffer zone, however, the procedure then continued to determine if this loss was due to agriculture or encroaching of urbanisation (hypothesis three).

In order to determine where the buffer loss is occurring, we completed a Difference Analysis Test (cf. Yang and Liu 2005; Baldwin and deMaynadier 2009). This allows features or portions of features in the input and updated features (the next year's features) that do not overlap to be written to a new shapefile. This shapefile shows where the loss of wetland buffer has occurred, and is used to solve hypothesis three (encroaching of urbanisation and agriculture). The difference output was intersected with the later dates' agriculture and urban layer (separately) to determine if wetland loss is due to primarily one, both, or other factors.

Pilot Study for entire state of Missouri and Wisconsin

Temporal wetlands in Missouri and Wisconsin were examined first in 1992 and then again in 2006 using the same GIS methods described above. Missouri and Wisconsin were used for the pilot project because they represent the range of state efforts toward protecting these unique habitats. Missouri was selected because it has not passed legislation to address the regulatory hole left by the SWANCC decision. On the other hand, Wisconsin was the first state to pass isolated wetland protection. Wisconsin Act Six was signed into law on 7 May 2001 by Governor Scott McCallum (Christie and Hausmann 2003). This preliminary work questions if Wisconsin was successful in passing legislation to preserve vernal pools while Missouri has lost vernal ponds by not taking the initiative. This analysis was not intended to compare Missouri's efforts to Wisconsin's efforts, but to evaluate how each state has mitigated the threats posed on the potential conservation concern.

Missouri

In 1992, the wetland area was approximately 301,670.892 sq. km. In 2006, the wetland area decreased to approximately 181,187.428 sq. km. Between these two recording years, there is a wetland area loss of 120,483.464 sq. km. In the Missouri wetland, the buffer area was approximately 93,498.900 sq. km in 1992. In 2006, the wetland buffer area decreased to 14,950.584 sq. km. Between these two recording years, there is a wetland buffer loss of 78,548.316 sq. km. As a result, due to buffer loss between pre- and post-SWANCC years, hypothesis one was accepted.

Possible reasons to explain this loss may be due to agricultural practices (hypothesis two) or encroaching of urbanisation (hypothesis three). After completing a difference analysis between 1992 and 2006, we found a total buffer area loss of 81,868.531 sq. km. After intersecting this buffer loss with agriculture, approximately 56,001.766 sq. km out of the possible 81,868.531 sq. km of wetland loss resulted in intensification of agricultural practices. This represents roughly 68.4% of buffer loss due to farming activities such as pasture/hay, row crops, and small grains.

Hypothesis two has been accepted since intensification of agriculture has threatened vernal pool species and their surrounding terrestrial habitat.

Similarly, difference analysis with urban areas shows the area of buffer loss between 1992 and 2006--approximately 5,569.484 sq. km out of the possible 81,868.531 sq. km resulted from encroachment of urbanisation. This represents roughly 6.8% of buffer loss due to development of cities including residential, commercial, and industrial land uses of varying intensities. As a result, hypothesis three has been accepted.

Wisconsin

Between these two recording years, the wetland area increased by approximately 8,059.399 sq. km and wetland buffer increased by 11,741.672 sq. km. With these results, hypothesis one has been rejected. Observations also revealed a coalescing of many of the smaller wetlands in Wisconsin into larger

wetland areas. Further work could be addressed to determine the extent of wetland merging. Based on these results, it would seem that state efforts which have focussed on protecting and expanding wetlands have succeeded in this area.

RESULTS OF MISSISSIPPI RIVER CORRIDOR

Efforts to conserve wetlands have largely been limited to land use regulation and preservation. However, neither of these make an effort to maintain the adjacent terrestrial habitat and connections among pools. Although these pathways may succeed at the conservation of some wetlands, they do not emphasise the functional linkages of multiple wetlands and the wider landscape and the important role these connections play in habitat travel routes (Amezaga et al. 2002; Roe and Georges 2007). For this reason, this multi-state investigation looks at the presence of wetlands along the Mississippi River and establishes baseline data on their location, change through time, and how they have responded to current and past legislation. States within the corridor of interest are as follows:

We expect that states with regulatory actions have succeeded in protecting wetland areas post-SWANCC and those that have not implemented any modes of wetland protection have lost wetland and wetland buffer area over time. Those states without regulations include Illinois, Missouri, Iowa, Tennessee, and Arkansas. Note, as mentioned previously and one of the reasons for this study, policy and legal scholars disagree on which states have responded since *SWANCC* and *Raponos* because the criteria and discrepancy of defining wetlands and determining substantive protections is debated by regulators, land owners, and Supreme Court Justices. For instance, The Illinois Department of Natural Resources may grant authorisation for projects to be constructed within floodways, but whether or not this applies to isolated wetlands or vernal pools is unclear. The Illinois EPA may require anti-degredation documents during approval of projects, but wetlands are not specifically mentioned. Arkansas does require additional permitting, but this state action does not support our categorisation because Arkansas may require a Short Term Activity Authorisation in addition to 401 USACE permit,but there is little evidence that this state effort is for conservation. Similarly, Tennessee has a new general permit program with some vague conditions but it was passed after 2011 and there are no data sources available that confirm adoption of protective or mitigation legislation.

Our classifications will be explored further as this study will offer other reasons for wetland loss and the complex array of issues that impact wetland buffers decreases. These are primarily correlated to urban expansion or increased agricultural land use. In addition, we predict that urban growth and not agricultural development is the largest impact factor on isolated wetlands along the Mississippi River area. This assumption is the result of national trends of unsustainable urban/suburban growth along the river corridor. While states require that 401 permits meet state water standards, this regulatory practice has been a common theoretical idea that has been occurring before SWANCC, which makes wetland public policy complex to discern simple categories like action or no action. For instance, the Missouri wetlands program states on-line that it "will encourage regional planning efforts that lead to protection and restoration of riparian and wetland acres, including development and implementation of green infrastructure plans, stream setback ordinances and investments in trails and greenways." This goal is marked as a priority from 2013-2018 which implies there was a lack of similar programs during the data analysis of 2001-2011 and this symbolic policy mission statement offers no meaningful evidence that agency "encouragement" works for conservation .

Multi-State Results

Between 2001 and 2006, eight states displayed wetland buffer area gain including three of those that introduced legislation and with five that did not. Among those that have introduced legislation and gained wetland buffer area (Wisconsin, Iowa, Arkansas), the gain was primarily the result of agricultural land loss (Table 2). In states that gained wetland buffer area without legislation, the increase was also due primarily to agricultural land loss. Both of the states that lost wetland buffer area in the period between 2001 and 2006 (Minnesota, Louisiana) had introduced protective state legislation following the SWANCC decision of 2001. In Minnesota, the loss of

Table 2
Overall wetland buffer area gain or loss from 2001 to 2006

State	Agricultural area (sq. meters)	Urban development (sq. meters)	Other (sq. meters)	Total Wetland Buffer Area Gain (+) or Loss (-) (sq. meters)
Wisconsin*	-28,118,931.43 (54%)	-4,099,553.60 (8%)	-19,656,722.25 (38%)	+51,875,207.27
Iowa*	-82,212,289.06 (73%)	-9,504,079.17 (8%)	-21,137,684.45 (19%)	+ 112,854,052.68
Illinois	-178,908,423.72 (81%)	-12,467,599.18 (6%)	-28,761,184.49 (13%)	+220,137,207.38
Missouri	-99,693,723.81 (79%)	-9,225,450.57 (7%)	-17,665,282.69 (14%)	+126,584,457.06
Kentucky	-1,683,366.66 (46%)	-77,809.74 (2%)	-1,885,755.26 (52%)	+3,646,931.66
Tennessee	-23,748,110.76 (76%)	-1,840,528.58 (6%)	-5,781,937.17 (18%)	+31,370,576.51
Arkansas*	-70,087,942.54 (81%)	-2,597,552.10 (3%)	-14,303,781.92 (16%)	+86,989,276.56
Mississippi	-144,135,485.07 (72%)	-7,219,237.96 (4%)	-48,370,014.84 (24%)	+199,724,737.87
Minnesota*	+35,835,713.23 (32%)	+52,461,996.93 (47%)	+24,230,690.53 (21%)	-112,528,400.69
Louisiana*	+20,289,755.45 (24%)	+29,780,925.53 (35%)	+36,186,275.96 (41%)	-86,256,956.94

*States that introduced legislation to protect wetlands after 2001. (%) = Indicates percentage of total loss or gain

wetland area was primarily due to urban development, which represented 47% of land use changes resulting from wetland area loss. In Louisiana, the loss was primarily due to reasons other than agricultural encroachment or urban development.

Between 2006 and 2011, five states experienced wetland buffer area gain including four states which had also experienced gains from 2001 to 2006 (Table 3). Agricultural land loss resulted in a majority of wetland buffer area gains for four of the five states (Illinois, Kentucky, Arkansas, and Mississippi). In the fifth state (Louisiana), other land loss reasons accounted for 51% of wetland buffer area gain. Between 2006 and 2011, the loss of wetland buffer area resulted from a disparate combination of agricultural intensification, urban development, and other reasons. Three of the five states (Minnesota, Wisconsin, and Iowa) which experienced wetland buffer area loss have state legislation to protect wetland areas. Of the states that had wetland buffer area losses that do not have legislative protection (Tennessee, Missouri), urban development accounted for the majority of land use changes, making up 60% and 61% of the each state's total wetland buffer area losses respectively.

Between 2001 and 2006, a majority of wetland buffer area loss in states with legislation to protect wetlands was primarily due to urban development (47%) in Minnesota and other reasons (41%) in Louisiana. Agricultural intensification accounted for the smallest percentage of land cover change in Louisiana (24%). Between 2006 and 2011, the loss of wetland buffer area in states with legislation to protect wetlands resulted from a disparate combination of agricultural encroachment, urban development, and other reasons. In Minnesota and Wisconsin, the loss of wetlands due to agricultural encroachment was slightly greater than the loss due to urban encroachment, making up 35% of land cover change in Minnesota and 33% in Wisconsin. In Iowa, urban encroachment displayed 49% of land cover change resulting in buffer area loss.

DISCUSSION

The present regulatory frameworks to protect seasonal wetlands, following the *SWANCC* and *Rapanos* decisions, are inadequate because many no longer fall under protection of the CWA due to minimum size and/or volume thresholds. Those that do fall under the CWA jurisdiction protections are often limited to small terrestrial buffer zones (30 m from wetland edge) and therefore are inadequate for protecting terrestrial habitats required by seasonal wetland breeding amphibian species. If the wetland is deemed a temporary and isolated wetland due to the *SWANCC* decision, the wetland is no longer federally protected, and may or may not be protected by the state. Conservationists should also be concerned with changing from a single wetland landscape to a contiguous approach so that habitats between wetlands are less at risk of being disjointed. Especially challenging has been the rudimentary step of determining the most felicitous approach to agricultural management: command and control regulation or market-based incentives.

One policy approach used by states is voluntary easement programmes like the Conservation Reserve Program (CRP) which offers market-based incentives to take high risk land out of agricultural production. A related programme, the Wetlands Reserve Program (WRP), is also a voluntary easement programme utilised for the conservation of wetlands. Contrary to the CRP which has a main focal point of conserving soil and its overall quality, the WRP endeavours to restore entire wetland ecosystems (Parks and Kramer, 1995). Both programmes can be highly efficient and effective at conserving different aspects of the environment regarding land use; however, they come with limitations.

Administered by the Natural Resource Conservation Service (NRCS), landowners enrolled in the WRP agree to the implementation of a Wetlands Reserve Plan of Operations (WRPO) with a goal to 'restore, protect, enhance, maintain, and manage' the hydrologic conditions of inundation or saturation of the 'soil, native vegetation and natural topography of eligible lands' (Connolly, et al., 2005). In line with all governmental programmes, there are certain enrolment eligibility requirements for the WRP. The land in question must be eligible (presence of hydric soil) as well as the landowner (able to receive farm programme payments). Additionally, sites are ranked using factors of percentage of changed hydrology, native vegetation and proximity to other areas. If the land and landowner meet all specifications, an offer to purchase

Table 3
Overall wetland buffer area gain or loss from 2006 and 2011

State	Agricultural area (sq. meters)	Urban development (sq. meters)	Other (sq. meters)	Total Wetland Buffer Area Gain (+) or Loss (-) (sq. meters)
Illinois	-32,880,571.19 (62%)	-2,998,587.21 (6%)	-17,240,330.86 (32%)	+53,119,489.25
Kentucky	-71,215.89 (13%)	-1.51 (n/a)	-473,119.61 (87%)	+544,337.02
Arkansas*	-11,615,594.77 (81%)	-356,352.19 (2%)	-2,380,718.83 (17%)	+14,352,665.80
Mississippi	-46,860,801.53 (85%)	-1,145,612.30 (3%)	-6,821,108.59 (12%)	+54,827,522.42
Louisiana*	-49,421,511.11 (35%)	-20,049,278.34 (14%)	-72,988,220.58 (51%)	+142,459,010.03
Minnesota*	+124,663,757.06 (35%)	+112,168,614.67 (32%)	+118,449,143.22 (33%)	-355,281,514.95
Wisconsin*	+5,585,258.91 (33%)	+3,026,157.07 (18%)	+8,189,597.44 (49%)	-16,801,013.42
Iowa*	+4,553,788.35 (38%)	+5,482,057.52 (46%)	+1,968,533.32 (16%)	-12,004,379.18
Missouri	+4,747,393.83 (21%)	+13,357,559.41 (60%)	+4,189,339.20 (19%)	-22,294,292.44
Tennessee	+2,331,456.00 (21%)	+6,735,448.04 (61%)	+1,969,304.76 (18%)	-11,036,208.81

*States that introduced legislation to protect wetlands after 2001. (%) = Indicates percentage of total loss or gain

the easement ensues from the NRCS, a survey of the land is conducted, parties go through closing, landowners receive their payment (in one payment or multiple payments depending upon the size and value of the easement) and restoration begins.

There are two choices for restoration. The first involves a high level of participation from the landowner with the landowner performing all restoration to the specifications of the NRCS and is then reimbursed for the costs ensued (T. Wachter pers comm. September 21, 2011). The second approach requires no work from the landowner. In this approach the NRCS uses federal contractors in the form of excavating companies and vegetative specialists to complete all restoration to NRCS specifications (T. Wachter pers comm. September 21, 2011). By offering a choice for the restoration process, the WRP allows landowners to control their level of involvement perhaps creating more appeal for the programme overall.

Significance of Study in Review of Literature

Identifying wetland areas that are threatened by agricultural practices or urbanisation can help states to determine and prioritise wetland restoration and protection. This will help anticipate and mitigate the effects of the habitat loss on species of conservation concern. A third pathway, other than land use regulation and preservation, such as local land-use planning, can be used to complement the existing two pathways, regulatory and preservation efforts. At the non-governmental level where most land use decisions are made; neighbours, planners, and citizens can play an active stewardship role (Klemens 2000; Preisser et al. 2000). As a result, it is essential to provide those playing a role in local decisions with the ability to make ecologically informed decisions to reduce the impacts of sprawl (Calhoun et al. 2005). Implementation of Best Development Practices (BDPs) or recommended strategies for conserving these habitats will enable communities to develop methods to protect these wetland resources (Calhoun et al. 2005).

Previous work on wetland area and location along the Mississippi corridor as a whole and in relation to regulatory frameworks is severely lacking. The work presented here will address the need for a river wide inventory of wetlands, change in wetland area and wetland buffer area, and compare loss in wetland area to present legislation. This work will serve as a baseline of information to begin to explore the complex interaction between legislation and on-the-ground action and restoration. With these questions answered, we can focus on studies that can examine citizen action and on-the-ground response to wetland loss and methods for maintaining and growing wetland area (Guehlstorf and Hallstrom 2011). For example, in Wisconsin, has the increase in wetland area primarily consisted of growing wetlands, merging wetlands, or created wetlands due to mitigation?

Given the US Supreme Court's *SWANCC* and *Rapanos* decisions scientists, conservationists, and resource managers at all levels of government should focus research and resources to determine the courts impact on wetland biodiversity and mitigating any potential impacts (Comer et al. 2005). The Supreme Court's lack of clarity on "significant nexus" in *Rapanos* and its successor cases has created uncertainty over the future extent of CWA jurisdiction and has re-energised public discussion and debate on the appropriate state/federal partnerships as they are applied to protection, conservation, and management of wetlands (Christie and Hausmann 2003). A revised framework that incorporates sound science into public policy in a manner that will ensure the sustained quality of this natural resource is needed. An unknown but potentially significant number and acreage of seasonal ponds have lost federal protection under the CWA, but state regulatory or voluntary incentive programmes have taken place in certain areas. For example, innovative conservation strategies are taking place in Connecticut and Massachusetts that aim to protect the aquatic habitat and the surrounding non-breeding terrestrial habitat. However, of those states along the Mississippi only half have made efforts to fill the gaps created by SWANCC.

Consequences of State Actions

The SWANCC decision increased the risk of loss of previously protected wetlands under the CWA, with some areas suffering a greater degree of wetland loss because vernal pools in these areas make up the majority of what remain as wetlands. Therefore, the scope of the wetlands removed from CWA jurisdiction vary substantially from state to state based on the proportion of the water resources in the state that are legally determined to be 'isolated waters' (Christie and Hausmann 2003). The extent of the waters impacted nationally may be around 20%, but the loss of CWA jurisdiction in individual states may range from less than 10% to more than 60% of the waters within the state (Christie and Hausmann 2003). By narrowing the scope of the CWA, the burdens of protecting the waters are shifted to state governments and non-profit organisations, which complicate the traditional federal-state framework for partnerships. To determine the impacts and propose recommendations for the protection of these areas scientists must assess wetland area losses. The extent of SWANCC's impact is unclear due to the ambiguity of the decision and the subsequent failure of the federal government to provide comprehensive guidance clarifying the extent of the waters affected (Christie and Hausmann 2003). The uncertainty concerning current CWA jurisdiction is further reinforced by the variability in Corps District jurisdictional determinations post SWANCC, for instance little is known after Supreme Court cases like Rapanos and Carabell (Kusler and Christie n. d.). For example, the initial estimates of loss of federal protection were over half the 2.104×10^{10} sq. m of wetlands in Wisconsin, but a later revised estimated reduced the number to 5.26×10^{9} sq. m (Christie and Hausmann 2003). This was just one example assessing the confusion and impacts of the SWANCC decision on biodiversity (Connor et. al. 2005).

A common problem in many of the states is the lack of public knowledge, understanding, and concern regarding the impacts of loss of jurisdiction (Christie and Hausmann 2003).

Many citizens assume that smaller, drier, and more isolated wetlands are less important which leads to their neglect and mismanagement (Beja and Alcazar 2003). For example, farmers usually regard these areas as a nuisance because they decrease yields and interrupt operations. In fact, some farm policy scholars argue subsidy schemes could help farmers be compensated for losses in productivity (Beja and Alcazar 2003). Often times, the economic benefits of retaining these isolated areas are in avoided costs (Christie and Hausmann 2003). Unfortunately, the national reports on losses that may result from the lack of jurisdiction are unlikely to be reported on the national level for some time, forcing states to conduct their own status and trend studies. The national reports are necessary to help track and estimate the extent of wetland loss in the states.

A sustainable approach to this essential natural resource is needed because wetlands and other waters that are 'geographically isolated' from navigable waters are no longer protected by the CWA. These seasonal and isolated wetlands may receive state or local protection through new regulatory or voluntary incentive programmes (Comer et. al. 2005). The efforts that states have made to fill the gaps created by *SWANCC* can be seen in Table 4. Efforts can include extension of water quality programmes to explicitly include isolated and other wetlands, adoption of limited legislation to close the gaps created by SWANCC, and/or adoption of comprehensive wetland legislation.

To protect isolated wetlands, conservation scientists must work with states to promote regulations to protect the wetlands left at risk by SWANCC. This is an approach that has been successful in Wisconsin (Christie and Hausmann 2003). Though their methods may provide less protection than was initially provided under the CWA; some states, like Wisconsin, have made efforts to protect wetlands after the rule change in SWANNC. However, about two-thirds of states, such as Missouri, have taken no action (Christie and Hausmann 2003; Comer et. al. 2005) to fill the gap left by weak definitions of significant nexus and continuous surface water connection. The majority or approximately 67% of states are not mentioned in the chart below because they have not made any effort to protect wetlands left at risk due to SWANCC (Kusler and Christie n.d.).

As discussed in the literature, the most reasonable solution for saving isolated wetlands is with citizen participation. This does not mean the citizens would demand state laws for watershed management or noteworthy wetland mitigation programmes which would include isolated, small or seasonal wetlands. This is naïve and doubtful as there is a dearth of environmental democracy in non-navigable wetlands in the United States because of missing regulatory emphasis, expert science for most ecological oversight, and a generally weak risk-communication of the importance of wetlands for public health. Nonetheless, much can be aided and reformed with prior local site planning, stewardship practices, and partnership programmes on or about wetlands. Most state environmental wetland programmes, which are voluntary and non-regulatory, involve temporary conservation easements or restoration agreements that require extensive work for private landowners (Zinn and Copeland 2001).

Consider the market-based policy structure of banking mitigation. The report offers exact dollar amounts for the incentive programmes as the lowest estimated costs for mitigation was USD 3,000 to USD 4,000 per acre (plus land costs) for non-tidal wetland restoration in Baltimore and the maximum was USD 350,000 per credit (acre) for estuarine wetland in the Norfolk district (ELI, 2006, p. 28). Wetland mitigation efforts can also be broken down by type as a percentage of total acres of mitigation nationwide with the breakdown as follows: restoration, 35.2%; enhancement, 30%; creation, 20.2%; preservation, 14.7% (ELI, 2006, p. 27). The report also shows the distribution of sponsors for approved mitigation banks as follows: private companies (72.2%), state agencies (14.2%), local government (7%), non-profit (5%), and federal agencies (1.7%).

A wetland bank is a natural resource depository or watershed reserve established for the purpose of selling credits, usually in the form of acres, to developers or farmers who need to comply with requirements that are often 16 or more kilometres from the permitted watershed development. City developers and rural landowners who do not have enough land to satisfy the required offsets or do not want to maintain a wetland themselves are increasingly purchasing credits from a wetland mitigation bank. Between 1999 and 2005 the United States went from 46 ACOE permitted mitigation banks to 450 banks with nearly 200 more proposed, and in 2008 the EPA and the ACOE issued revised regulations favouring banking mitigation over other types of compensatory mitigation (USEPA 2009). Whether wetlands are being threatened by agriculture or urban sources, mitigation offers a solution for wetland management issues. Some, however, criticise this programme because it causes disparities by restoring wetlands outside their original area and seems to be successful in cities and not rural areas.

CONCLUSION

The first time series of data analysis, 2001-2006, shows a general increase in wetland buffer area with only two states, Minnesota and Louisiana, showing loss. As seen in the aforementioned tables and charts, in Minnesota this is due to increases in urban area. In Louisiana, this is a result of urban

Table 4

Efforts Made by States to Fill the Regulatory Gaps Created by SWANCC

Extended water quality programs to explicitly include isolated and other wetlands	**Adopted limited legislation closing the gaps created by SWANCC**	**Adopted comprehensive wetland legislation over the last two decades**
Indiana, Nebraska, North Carolina, Ohio, South Carolina, Tennessee, Washington	Indiana, Ohio, Wisconsin	Connecticut, Florida, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Oregon, Pennsylvania, Rhode Island, Vermont, Virginia

development, periphery suburban encroachment, or other reasons. Despite minor decreases, the general increase in wetland buffer area during this time may be due to the standard public policy implementation lag effect whereby the lack of federal regulation has not severely impacted wetland area so shortly after its removal via the Supreme Court decision. In addition, both Louisiana and Minnesota enacted state legislation after 2001 and any loss associated with this time period may also be an implementation delay in economic development on the seasonal wetlands as well.

Specifically, considering the second time series study from 2006-2011, following the *Rapanos* decision, five of the ten states show loss, three of which have enacted legislation to protect wetlands. Unfortunately, for the case of a succinct and concise take-home message, states that have written wetland conservation or banking mitigation legislation have lost wetlands due to a mix of factors. As predicted, however, those without legislation have primarily lost wetland area due to urban influences. An increase in wetland loss after federal legislation removal could indicate that the effects are magnified through time, however. Despite state legislation enactment and enforcement, those states are still experiencing wetland loss during this time which could be due to many factors and variables. Generally, wetland loss is increasing with time along the Mississippi River and it is primarily due to urban influences. Additional data, including but not limited to land cover classifications for more recent periods which are not yet available, could help elucidate patterns in change through time for each of these states.

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