Nelson Institute for Environmental Studies
UNIVERSITY OF WISCONSIN–MADISON

Flood Resilience in the Coon Creek Watershed

2020 WATER RESOURCES MANAGEMENT PRACTICUM REPORT

PREFACE

Water Resources Management (WRM) is a Master of Science degree program housed within the Nelson Institute for Environmental Studies at the University of Wisconsin-Madison. WRM graduate students complete 45 credits of interdisciplinary coursework across categories such as the natural sciences, engineering, social sciences, planning, and water management. Instead of conducting individual research, students participate in a collaborative practicum that extends across their two years in the program. The WRM practicum concentrates on a relevant water management issue facing a local community, and students form partnerships with organizations and institutions to develop project objectives and ultimately deliver management recommendations.

The 2019-2021 WRM practicum focused on the watershed of Coon Creek in Monroe, La Crosse, and Vernon Counties, Wisconsin. This report serves as documentation of the cohort's project: "Flood Resilience in the Coon Creek Watershed." Six students participated in the practicum. They are: Rajpreet Grewal, Cathryn Herlihey, Jackson Parr, Robert Rosner, Rachael Sodeman, and Kayla Wandsnider.

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2019-2021 Water Resources Management Master's Cohort
Rajpreet Grewal | Cathryn Herlihey | Jackson Parr | Robert Rosner | Rachael Sodeman | Kayla Wandsnider

EXECUTIVE SUMMARY

In August 2018, severe rainfall fell over the Coon Creek Watershed in Wisconsin's Driftless Region, resulting in the failure of three dam structures and inundating the area with floodwater. The watershed, marked by high ridges and low valleys separated by steep slopes, is projected to experience more frequent and severe rainfall and flood events under a changing climate. As the location of the first demonstration site for the Soil Erosion Service, the Coon Creek Watershed has a storied history in leveraging the landscape and its people to promote change. Resilience to future flood events will continue to demand such change.

Six graduate students in the Water Resources Management Program at the University of Wisconsin-Madison's Nelson Institute for Environmental Studies took an interdisciplinary approach to analyze different ways to improve flood resilience in the Coon Creek watershed. Their research explored five different but overlapping areas of interest that culminated in tailored recommendations, including: Public Perspectives on Flooding, Flood Management Institutions, Effects of Land Use and Infiltration, Economics of Land Use and Management, and Community Resilience.

PUBLIC PERSPECTIVES ON FLOODING

The project team conducted 26 long-form and semi-structured interviews with watershed managers, public officials, and residents of the Coon Creek Watershed. Interview topics included experiences with flooding, climate change, preferred flood management options, flood insurance, and more. A thematic analysis of interview transcripts suggests that people living and working in the Coon Creek Watershed have a strong sense of place and connection to the landscape, and that flooding takes a large mental and emotional toll that hardly relents in the months after a flood. However, there were differences in how those interviewed perceived the cause of flooding, climate change, and who is responsible for flood recovery. These contrasting opinions often aligned with one's personal experience with flooding.

FLOOD MANAGEMENT INSTITUTIONS

Flood preparation, response, and recovery involves a complex web of local, state, federal, and non-governmental actors. This complexity creates challenges for municipalities and the general public trying to engage in flood response. There is also inherent tension between levels of government. Higher levels of government have more resources, but local governments and their residents are closer to the problems and better understand the impact and feasibility of proposed solutions. This is particularly true of small, rural municipalities such as those in the Coon Creek Watershed. Often having just a few people on staff and limited time, small communities struggle to participate in programs such as federal disaster aid and mitigation grants, or assist willing landowners in conservation-minded land practices.

Recommendations

1. **Create a Joint Powers Board among jurisdictions comprising the Coon Creek Watershed.**

EFFECTS OF LAND USE AND MANAGEMENT ON INFILTRATION

A largely rural landscape with significant agricultural land use on steep slopes prone to runoff, the farming community in the Coon Creek Watershed has outsized influence on how the landscape is managed. Once a place of small farms and diverse crops tied strongly to dairy production, economic pressures have pushed more of the landscape toward large corn and soy operations as the number of dairy farms declines. In some cases, those changes have reduced the landscape's ability to hold on to rainfall. The watershed has seen a loss in the acreage under contour strip cropping, which contributes to greater runoff. Similarly, infiltration tests in the watershed determined that perennial cover such as pasture under a managed grazing program allows significantly more infiltration of rainfall than annual crops such as corn and soy. The move toward corn and soy and away from more perennial crops will therefore contribute to more runoff.

Recommendations

1. **Restore and maintain contour strips and grassed waterways.**
2. **Promote and implement perennial pasture in the watershed.**
3. **Inform local farmers on the impact of conservation practices on runoff generation.**
4. **Provide more funding for technical staff to help farmers implement management practices and land use changes.**

ECONOMICS OF LAND USE AND MANAGEMENT

Agricultural management practices such as contour strip cropping, cover crops, and managed grazing may improve infiltration

and reduce runoff, but changing land management often comes with upfront costs to the producer. A Monte Carlo analysis of these three land management practices suggests that public investment may be required to induce changes on private land. However, the adoption of managed grazing programs found that, in most cases, the benefits of adopting a managed grazing program will offset the costs and be a net gain for the producer. Still, recognizing the value of reducing flood risk and damage to areas downstream may be cause to invest in these practices with private landowners.

Recommendations

1. **Expand the program goal of the producer-led watershed protection program to include improvement of infiltration in addition to improvement of soil and water quality.**
2. **Develop a separate program within the Department of Agriculture, Trade and Consumer Protection (DATCP) specifically targeted at improvement of infiltration and flood resiliency.**

COMMUNITY RESILIENCE

Residents of the Coon Creek Watershed often rely on their strong sense of place and community fabric to respond and recover after a flood event. Analysis of interviews and related literature found six important themes within the community's approach to flood resilience: flood awareness, local ties and volunteerism, distribution of information, disconnect between those flooded and not flooded, confusion of institutional roles, and lack of support. Maintenance of the existing social capital within the Coon Creek Watershed, and its expansion through improved communication and institutional support, will be important for future flood events.

Recommendations

1. **Develop a comprehensive website or alternative central database for disaster preparedness-related information.**
2. **Create a comprehensive disaster preparedness and response plan which involves stakeholder participation.**
3. **Coordinate a systematic approach for managed retreat.**

ACKNOWLEDGEMENTS

The 2019–2021 Water Resources Management master's degree cohort would like to thank those who guided us through this process. They offered their expertise, answered our questions, created networks of resources and contacts, and donated their time to provide valuable input and feedback on this report. We would especially like to acknowledge our partners in the Coon Creek Watershed. Specifically, we would like to thank Bob Micheel (Monroe County), Matt Hanewall (La Crosse County), and Ben Wojahn (Vernon County) who provided us with the local knowledge and networks that we depended on for this research. Funding was made possible by La Crosse County and Monroe County. We would also like to thank Steve Becker at the Natural Resources Conservation Service.

This interdisciplinary research relied on a variety of experts from the many fields we explored, including Dan Wright (Civil & Environmental Engineering), Caroline Gottschalk-Druschke (English), Stephen Ventura (Soil Science), and Adena Rissman (Forest & Wildlife Ecology) at the University of Wisconsin–Madison. Paul Juckem from the U.S. Geological Survey also provided his past research and present insight on infiltration and rainfall in Coon Creek. We were also fortunate to learn about the region's history, challenges, and the foundations of flood policy from Marcy West (Kickapoo Valley Reserve), Haley Briel (ASFPM), Michelle Staff (WDNR), and Rob Davis (WDNR).

We would also like to thank the landowners in the Coon Creek Watershed who offered their land for our fieldwork, including Tucker and Becky Gretebeck, Chris Peterson, and Thomas Chirko.

We also offer our gratitude to the dozens of residents in and around the Coon Creek Watershed that we spoke to throughout this project. We asked about their beliefs, experiences, trauma, community relationships, and more, which they graciously offered in addition to their time.

Finally, we would like to thank our advisor, Eric Booth (Agronomy and Civil & Environmental Engineering, UW–Madison), whose expertise on this project was only eclipsed by his passion. He provided relentless valuable feedback, endured late night meetings, chauffeured across ridges and valleys, and gently nudged us toward deadlines. This report would not be before you today without his help or the help of the others listed here.

In addition, we extend thanks to the Nelson Institute for Environmental Studies' Strategic Communications team for their expertise and guidance in writing, editing, graphic and web design, to produce a final report.

Water Resources Management Practicum, 2022. Flood Resilience in the Coon Creek Watershed. 2020 Water Resources Management Practicum, Nelson Institute for Environmental Studies, University of Wisconsin–Madison. Madison, Wisconsin. May 2022

Photo by David Mark.

INTRODUCTION

The Coon Creek Watershed is a 90,000-acre watershed located in the Driftless Area of southwestern Wisconsin, which spans Vernon, Monroe, and La Crosse counties, and empties into the Mississippi River. The Driftless Area is defined by a complete lack of glacial deposits in southwest Wisconsin and northwest Illinois, bound to the west by glacial deposits approximately aligned with the Mississippi River (Carson et al. 2019). The lack of glaciation resulted in the steep, rolling topography for which the region is well known. Streams carved the landscape, resulting in low valleys, steep slopes, and high ridges hundreds of feet above the Mississippi River they empty into. Flooding has indelibly shaped both the physical and cultural landscape, created by the unique geology and topography. More recently, human impacts and development have continued to shape the watershed.

The Paleoindian Tradition (12,000-6,000 B.C.) marks the first human presence in the region followed by the Archaic Tradition (8,000-500 B.C.). The Woodland Tradition (600 B.C.-200 A.D.) is characterized by plant cultivation and the erection of burial mounds. The Mississippian Tradition beginning in A.D. 1050 saw a growth in settled agrarian villages growing primarily corn. By 1300 A.D., the Oneota culture dominated the Driftless Area, creating sedentary villages sustained by intensive agriculture. In the 1600s, eastern pressures, including disease and the hunt for bison hides, likely resulted in the last of the Oneota in the region.

Although it is still debated in archeological circles, many argue that the Ho-Chunk people are ancestral to the Mississippian and Oneota cultures (Tronnes, 2017). The Ho-Chunk people have long called Wisconsin their ancestral and sacred homeland. Known through oral history tradition, the first contact between the Ho-Chunk people and Europeans occurred in 1634 (Rykken, 2017). This marked a drastic change in history which resulted in the forced removal of the Ho-Chunk people from the area. In the 1660s, an active fur trade evolved between the French and the Ho-Chunk people (Rykken, 2017). This declined in the early 1800s with more Euro-Americans moving to Wisconsin. A Treaty of Peace and Friendship was signed in 1816 between the Ho-Chunk and the United States Federal Government marking the first of 11 such treaties (Rykken, 2017). Treaties like these and others subjected the Ho-Chunk people to a brutal effort by the United States Federal Government to forcibly remove them further and further west, away from encroaching Euro-American settlement. This was first pushed by lead mining and then agricultural settlement. The Treaty of 1832 was a second land concession for the Ho-Chunk including all lands south and east of the Wisconsin River (Rykken, 2017). This Treaty was the first to call for the removal of the Ho-Chunk people west of the Mississippi River. The Treaty of 1837 was a land concession of the area north of the Wisconsin River and called for the removal of the Ho-Chunk people within eight months. This ultimately led to the division of Ho-Chunk people into "Abiding" and "Non-Abiding" factions, with the "Non-Abiding" faction resisting removal over the years (Rykken, 2017). In 1863, a special act of Congress approved the removal of the Wisconsin Ho-Chunk to a reservation in South Dakota. The Winnebago people of Wisconsin, the "Abiding" faction, officially relocated to the Omaha reserve in Nebraska in 1865 (Rykken, 2017). Although the Federal Government tried to remove the Wisconsin Ho-Chunk people repeatedly, many returned, finally receiving special legislation to stay on 40-acre homesteads (Wisconsin Historical Society). Today, the Ho-Chunk people have reclaimed over 2,000 acres in twelve Wisconsin counties (Wisconsin Historical Society).

Europeans remained in the region intermittently to extract natural resources but settled in the region more permanently in the early 1800s. By the 1850s, more than 50 percent of the basin was in agricultural production (2011 Water Quality Management Plan Update). Wheat was originally the most common agricultural product in the region, with its repeated planting resulting in depletion of soil fertility. By the 1900s, dairy had become the largest agricultural sector in the region for a variety of reasons, including to help replenish the depleted soils. But as dairy continued to grow in the early 1900s, farmers began clearing trees from the landscape, including the steep hillsides, to make more room for livestock. The more intensive livestock production compacted soils and, without the vegetation, rainfall carved gullies into the barren hillsides and eroded soil from the ridges down to the valley floor. Floodplain sedimentation rates for tributaries in the Upper Mississippi River basin were between 2-20 mm/year (Belby et al. 2019). A decrease in infiltration, causing lower baseflow, turned streams from perennial to intermittent. Deep, cold-water creeks filled with brook trout became shallow and warm.

The region's unique topography, as well as agriculturally driven soil loss, drove what was then known as the United States Soil Erosion Service (SES) to pilot an erosion control project in the Coon Creek Watershed. A historical marker on Highway 14 just east of the Village of Coon Valley denotes the significance of the project as the nation sought to mitigate many concerns that deteriorated the value of the Mississippi River and the agriculture in its basin. "Coon Valley, in short, is one of the thousand farm communities which, through the abuse of its originally rich soil, has not only filled the national dinner pail, but has created the Mississippi flood problem of its own future continuity," wrote conservationist Aldo Leopold in 1935.

The project brought the Civilian Conservation Corps (CCC) to the watershed to construct infrastructure such as terraces and grassed waterways to reduce erosion. SES agents simultaneously aided in land management practices such as eliminating livestock grazing on the steep slopes, contour plowing, strip cropping, and stabilizing gullies (2011 Water Quality Management Plan Update). Though the project ended in 1940, the land management practices remained and were quickly adopted throughout the Driftless Area (Johansen 1969). The land management changes have been credited with improved hydrologic trends such as reduced flood peaks and increased baseflow in the region (Trimble & Lund 1982; Krug 1996). Between 1934 and 1982, erosion in the watershed had been reduced by at least 75 percent (Trimble 2009). However, repeated floods also encouraged the construction of a series of dams throughout the watershed in the 1960s. There are 14 dams in the watershed that are large enough to be listed in the National Inventory of Dams (NID), which is maintained by the Army Corps of Engineers (ACE). Dams listed in the NID must meet at least one of the four following criteria:

1. **High hazard potential classification - loss of human life is likely if the dam fails**
2. **Significant hazard potential classification - no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns**
3. **Equal or exceed 25 feet in height and exceed 15 acre-feet in storage**
4. **Equal or exceed 50 acre-feet storage and exceed six feet in height**

All of the dams in the Coon Creek Watershed were constructed between 1960 and 1965, which further contributed to flood management in the region. Note that the hazard classification is unrelated to the structural integrity or condition of the dam. Hazard classifications are only related to loss of life and downstream damages in the event of dam failure.

Despite the recent legacy of conservation, agriculture in the region has reverted to less conservation-driven methods since the 1980s. Acreage previously dedicated to more infiltration-encouraging pasture, alfalfa, and hay has been replaced with increasing corn and soy planting (Hart 2008).

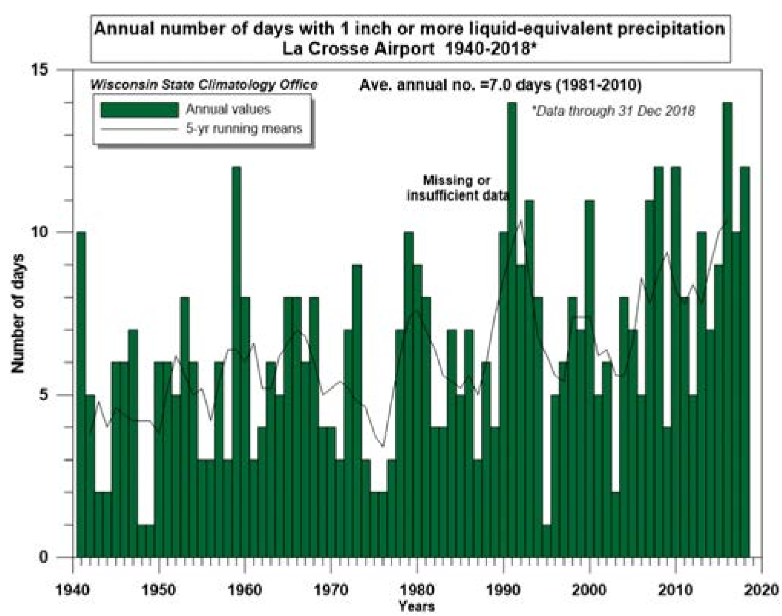


Figure1: The rain gauge at the La Crosse airport shows that the number of days with greater than one inch of precipitation is rising.

In aggregate, these changes have likely reduced the infiltration capacity of the watershed, resulting in rainfall that more rapidly runs off into the valleys. This increased runoff contributes to flashy and severe floods in the valley floors.

Meanwhile, the severity and frequency of rainfall is increasing. The nearest National Weather Service (NWS) rain gauge located at the La Crosse airport shows a highly variable, but steadily increasing number of days in a year with one inch or more of rainfall (Figure 1). Wright et al., (2020) found rainfall in the Coon Creek basin has become more severe in the past few decades compared to the 20th century, resulting in an increase in the estimated 100-year and 500-year rainfall. This increase is primarily driven by climate change and will likely continue to increase with a warming climate (Villarini et al., 2013). This increase in rainfall has led to a subsequent increase in extreme floods in recent years. For example, long term trends in peak discharge in the neighboring Kickapoo River at La Farge reveal how large floods decreased following the implementation of better land management practices in the 1940-1960s followed by a recent uptick in extreme flooding since 2008 (Figure 2). This increase in flooding is likely a consequence of increased precipitation driven by climate change. Additionally, potential land use and land management changes that decreased the watershed's infiltration potential may have also increased flood events. While climate change is the main driver of extreme floods, the role of land use and management in the recent increase in flood events is still in question. For example, Juckem et al. (2008) investigated the influence of climate and land management on hydrology of the Kickapoo River watershed in the Driftless Area. The study found that the timing of hydrologic change was influenced by precipitation changes, while the magnitude of hydrologic change in baseflow and stormflow was more affected by land management changes. Our study can complement these findings by considering the effect of recent flood events in the area, like the 2018 event, and recent land use and management changes on the hydrology of the Coon Creek Watershed.

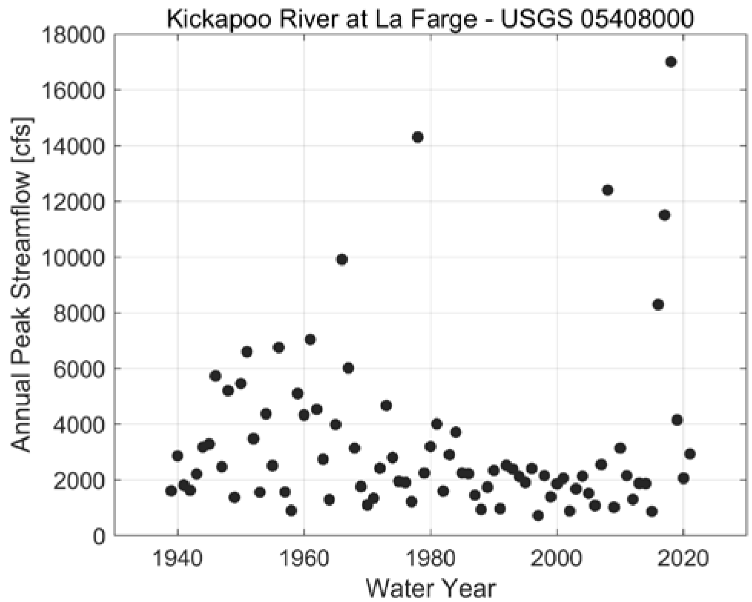


Figure 2: Peak streamflow readings taken on the Kickapoo River at La Farge show a number of significant flood events occurring since 2008. (Data available from U.S. Geological Survey)

Students visited the breached dam sites in the Coon Creek Watershed with Monroe County Conservationist Bob Micheel in 2019. Photo by Eric Booth

Students touring the Coon Creek Watershed with Monroe County Conservationist Bob Micheel in 2019. Photo by Eric Booth

AUGUST 2018 EVENT

In August 2018, within 48 hours, severe rainfall throughout southwest Wisconsin resulted in the breach of five large dams, the evacuation of hundreds from their homes, and millions of dollars in damage. Starting around 9 p.m. on Monday, August 27, up to twelve inches of rain fell in portions of the Coon Creek Watershed. In the early morning hours of Tuesday, August 28, three dams in the watershed breached, sending a torrential wave of water and debris barreling down the valley, washing away almost everything in its path.

News reports detail stories of emergency responders evacuating people in darkness and pouring rain, road washouts restricting escape routes, and homes lifted off their foundation and washed downstream.

"The breach process was not only rapid, but complete," wrote the Natural Resources Conservation Service (NRCS) in its assessment of the dam breaches.

That assessment determined the primary cause of the failure to be weakness in the foundation geology where the dams met the hillsides, compounded by extreme runoff. Rainfall and runoff seeped into the sections where the dam was anchored and eroded its connection to sandstone in the hillsides.

Governor Scott Walker issued a state of emergency for six counties on Tuesday, August 28, before the rain had even stopped falling. The Federal Emergency Management Agency (FEMA) declared a federal emergency on October 18, and approximately $21 million in aid was provided to the state and its residents.

In the aftermath, residents and local officials discussed the causes of the flooding and how to move forward. Groups such as the Monroe County Climate Change Task Force took a long-term approach to adapt to increased frequency and severity of rainfall. NRCS launched a watershed planning study to determine the future of the dams that breached. The study is expected to be complete in December 2022, more than four years after the August 2018 floods.

Meanwhile, residents have pointed to everything from changing land use to the construction of a new bridge in downtown Coon Valley as the cause of the floods. In public meetings, they criticize the speed of the government in delivering solutions. Monroe County, where all three breached dams are located, stabilized the dam sites but has not reconstructed them as they wait for the NRCS to develop its plan and recommendations. Some people believe the dams are the only solution to prevent flooding; others think the dams caused the 2018 catastrophe and lead to excessive risk to properties immediately downstream of them.

All of the breached dams were constructed in the early 1960s and engineered to have a useful life of 50 years. The NRCS anticipates there are several more dams in the region that have not breached, but are also beyond their useful life and similarly anchored to the landscape in a way that makes them susceptible to failure. An analysis of the structural integrity of remaining dams is an ongoing process as part of the watershed study. But dams are expensive to construct and maintain, which has officials considering other ways to manage floods, including increased infiltration on the landscape, improved planning and zoning, and limiting damages to structures and threats to vulnerable populations that are susceptible to flooding.

NRCS PLAN-EIS

The NRCS, in partnership with La Crosse, Monroe, and Vernon counties, are developing a Watershed Project Plan-Environmental Impact Statement (PLAN-EIS) for the Coon Creek Watershed and neighboring West Fork Kickapoo Watershed in the wake of the 2018 flood events and corresponding dam breaches of the NRCS-constructed dams. The NRCS has jurisdiction to govern this watershed planning process under the Watershed Prevention and Flood Protection Act of 1954 and the Flood Control Act of 1944, which also authorized construction of the earthen dams as a result of the original watershed plan. In addition to a watershed plan, the preparation of an EIS was needed as the project has significant or regional impacts on the environment. This EIS process for public comment and input is required by the National Environmental Policy Act of 1969 (NEPA). The goal of the EIS is to identify and evaluate alternatives for flood prevention or damage reduction in the Coon Creek and West Fork Kickapoo watersheds.

Currently, the NRCS has created a planning page for the PLAN-EIS, which provides a project history and current updates on the status of the planning process. In September 2020, the NRCS and its contracted engineering firm held public scoping meetings for each watershed as a part of the public comment process. The website also provided an opportunity for virtual comment and the entire preliminary commenting process closed in October 2020. A secondary public scoping process occurred in June and July 2021. The end goal of the project is to select one viable alternative for the watershed based on input from the counties and other watershed stakeholders. The PLAN-EIS is expected to be completed by December 2022 with a selected action and the following implementation of this action (requiring additional funding, design, and construction) would require a Section 404 Clean Water Act permit before any actual implementation can occur.

Flood Resilience

The variety of approaches to flood resilience demonstrates the need for an interdisciplinary approach. Therefore, for the purposes of this report, we adopt the definition of resilience from Marchese et al. (2018) as, "the ability of a system to prepare for threats, absorb impacts, recover, and adapt following persistent stress or a disruptive event". The following sections contribute to this holistic understanding of flood resilience.

PUBLIC PERSPECTIVES ON FLOODING

Resilient communities leverage the opinions of their residents to inform policy decision. This section identifies the demographic characteristics of the region and the ways in which the public interacts with flood events and water resources institutions. This will effectuate improved policy decisions and trust between residents and watershed managers.

FLOOD MANAGEMENT INSTITUTIONS

Resilient institutions prevent, prepare, adequately respond, adapt, and recover after a flood event. This is only possible within the framework and policies set by institutions. This section will explore dissonance between policies of the institutions and the physical and social needs and realities surrounding flood mitigation and response.

EFFECTS OF LAND USE AND MANAGEMENT ON INFILTRATION

This section will identify ways to increase infiltration on the watershed's landscape in order to reduce and slow runoff during extreme rain events. This is achieved by identifying the effect of land use and land management practices on infiltration in the watershed. Then, based on these observations, we provide recommendations to stakeholders to develop a system that better retains water on the landscape, which reduces runoff and flooding during extreme weather events.

ECONOMICS OF LAND USE AND MANAGEMENT

Resilient communities recognize the economic impacts and resource limitations of changes on the land and within a community. Although we may determine the best land use and management practices to reduce flood impacts, producers have limited resources and face other challenges. This section will review the changing economic landscape of the region and model the costs of changing land use practices and management.

COMMUNITY RESILIENCE

Community resilience relates to how a community has developed strategies of adapting to disaster. It includes current infrastructure, community initiatives, and long-term preventative actions to meet current and expected increased flooding due to climate change. Community resilience recognizes that flood resilience is specific to a community's local needs and existing systems. It also involves awareness of why and how flooding is happening on a large scale and cognizance of how flooding can be prevented. Community resilience fills gaps left by policies and institutions intending to protect communities from flooding.

PUBLIC PERSPECTIVES ON FLOODING

Introduction

Flood events are personal and traumatic, involving a variety of stakeholders that may all contribute to improve flood resilience. This section will review the people that live and work in the Coon Creek Watershed while drawing on other literature about the public's relationship with and behavior surrounding flooding. It will then offer an analysis of 26 interviews conducted with residents and watershed managers to better understand the potential communication gaps between those parties and offer insight into how those gaps can be bridged to better effect flood resiliency.

Demographics of Coon Creek

Approximately 5,282 people live in the Coon Creek Watershed making up 2,055 households, according to the 2014-2018 estimates of the American Community Survey (ACS). The Coon Creek population skews older. Twenty percent of residents in the watershed are older than 65, compared to 19 percent in the neighboring West Fork Kickapoo and 17 percent in Wisconsin. The median age of 44.2 is also higher than those geographies. People in the Coon Creek Watershed also have a higher median household income than the state average. The median household income is $65,615, which is higher than Wisconsin ($60,185) and much higher than the population in the West Fork Kickapoo ($53,295). The population in the watershed has lower levels of higher education than the state average, with 16 percent of residents obtaining a bachelor's degree compared to 19 percent in Wisconsin.

Photo by David Mark.

In terms of housing, a very high number of housing units in the watershed (83 percent) are owner-occupied, compared to 66 percent in the rest of the state. Of all homes in the watershed, 56 percent have a mortgage. This can be important given almost all mortgages are backed by the federal government and therefore require the owner to obtain flood insurance if they are within the 100-year floodplain. Data from the NYU Furman Center

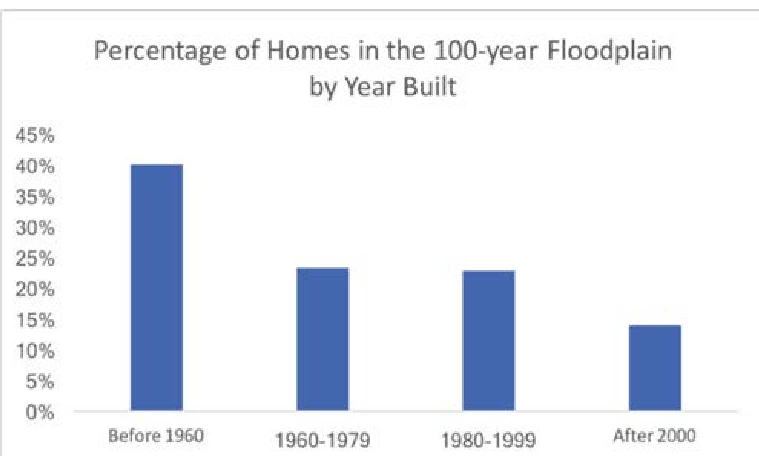
RAINFALL ANALYSIS

Engineers predict rainfall intensity when designing structures, but most of these designs today are based on data from the mid-20th century (Wright et al. 2019). Rainfall prediction has advanced with the help of RainyDay, a software program which uses recent rainfall data to predict rainfall intensity-duration-frequency relationships in specific areas, and by taking into account the space-time structure that rain events can have (Wright et al. 2019). RainyDay was designed to couple remote sensing data for rainfall with Stochastic Storm Transposition (SST) to model rainfall-driven hazards, including floods and landslides (Wright et al, 2017).

Predicting rainfall involves looking at three key components; duration, intensity, and space-time structure, all of which are interrelated. But in the past, space-time structure, the "when" and "where" rainfall would occur, was generally neglected due to its complexity, leading to less sophisticated representation in hazard modeling. Although neglected in the past, space-time structure plays a key role in determining how hazardous certain storms might be in different areas. Short-term rainfall in a small area could pose a threat to somewhere such as a narrow mountain valley or urban area but could be harmless in large river systems (Wright et al, 2017). Applying the RainyDay modeling system allows for hazard modeling to be done under nonstationary conditions, similar to what is being seen nowadays with increased rainfall magnitude and intensity.

As a complement to this report, Wright et al. (2020) used RainyDay to estimate updated rainfall statistics (e.g., 100-year, 24-hr rainfall) for the Coon Creek region. In general, rainfall amounts estimated using SST are more severe than the more traditional methods.

(collected at the census tract level) shows that 3.2 percent of housing units in the Coon Creek watershed are within the 100-year floodplain, which includes 3 percent of the watershed population. The homes in the 100-year floodplain are older (Figure 3), with 40 percent built before 1960 compared to just 14 percent built since 2000. This is similar to the watershed as a whole, where 39 percent of homes were built before 1960. However, a higher percentage (19 percent) of homes across the entire watershed were built after 2000, suggesting that people building new homes are less likely to build in the 100-year floodplain. Additionally, 20 percent of homes in the 100-year floodplain are occupied by renters, compared to 15.4 percent across the entire watershed, suggesting that renters are more likely to live within the 100-year floodplain. Although federally backed mortgages require the owners to obtain flood insurance if they are within the 100-year floodplain, homeowners who have paid off their mortgage or financed their homes through different means such as succession of property through an in-family loan, are not required to obtain flood insurance. On the other hand, homeowners who are outside of the 100-year floodplain may choose to purchase flood insurance even though they are not required to do so. Throughout the entire watershed, 3.2 percent of homes are in the 100-year floodplain. Therefore, we would expect that at least 3.2 percent of homes in the watershed also have flood insurance, given the requirement to have flood insurance for a federally backed mortgage within the 100-year floodplain. However, only 3.03 percent of homes have earthquake or flood insurance. This suggests there are at-risk homes without flood insurance. This gap is compounded if, as Wright et al. (2020) suggested, the true 100-year event is becoming more common or the 100-year event surpasses the floodplain currently delineated by FEMA. Note, however, that these findings combine census data generated through an algorithm by the Environmental Systems Research Institute (ESRI) with data of census tracts from the NYU Furman Center; therefore, the overlap may be imperfect. Census tract data from the Furman Center may capture some households that are immediately adjacent to, but outside of, the Coon Creek Watershed.



Homes in the 100-year floodplain tend to be older, which could raise concerns for structural stability. Source: NYU Furman Center

Literature review

The data presented above are not necessarily leverage points for increasing flood resilience, but they can provide insight into how residents experience and respond to flood events. In this section, we draw on a variety of literature of the general public's experience with flood events and other disasters to understand the conditions and perceptions that watershed managers will need to navigate to support community flood resilience. Although there is no existing literature specific to residents of Coon Creek, this analysis uses the best available literature and considers its external validity to the watershed.

The available literature demonstrates a consensus that the public's awareness of flood risk increases with their experience of flooding. If someone has experienced flooding in the past, they are more aware that it may happen again in the future. Awareness of flood risk increases the longer someone has lived in an area (Burningham et al., 2008) and older populations tend to have a higher awareness of flood risk (Kellens et al., 2011). Existing literature also points to a correlation between awareness of flood risk and higher socioeconomic status and higher education levels (Shao et al., 2017). These findings may or may not explain the disparity between the percentage of homes in the floodplain (3.2 percent) and the number of homes with flood insurance (3.03 percent). The population in Coon Creek, with its older average age and higher average income than the state average, may have a greater level of flood awareness, especially given the watershed's history of frequent flooding. That awareness of flooding, however, may not lead to the purchase of flood insurance; there are many compounding factors that contribute to the decision to purchase flood insurance. It is critical to note that these data collected on the watershed-scale do not fully capture the nuances of flood events as they relate to the literature presented here. For example, there is abundant evidence that households in poverty tend to be in more flood-prone areas, even if demographics for the larger area do not suggest flood vulnerability.

Atreya et al. (2013) found that the housing market discounts floods over time, or "forgets" the floods. In their research, property values in the 100-year floodplain declined immediately after a flood event, but returned to pre-flood value four to nine years later. They also found the number of active flood insurance policies jumps after a flood event, but then recedes over time. The recession of perceived flood risk could also be explained by the finding of Zhai & Ikeda (2008) that people perceive flood risk in a multi-risk context. In other words, the presence of other risks reduces the amount of resources someone is willing to put toward flood risk reduction. As years pass by without severe flood events, households with limited financial resources may discontinue paying flood insurance premiums to allocate those resources to other more pressing uses. Although this may also be true of residents in the Coon Creek Watershed, there has hardly been a long enough gap in flood events to trigger

Photo by David Mark.

"forgetfulness", as many in the watershed said they have dealt with some type of flood event in the majority of years of the past decade.

Flood awareness goes hand in hand with mitigation, and mitigation costs money. In theory, an individual who is able, would be willing to pay any amount up to their perceived potential loss during a flood event. If a person had unlimited funds, knew for certain that a flood would occur next year, and that the flood would result in $10,000 worth of damages, they would be willing to pay up to $9,999 to stop that flood from happening. However, probability, perception, politics, and the ability to pay muddy the waters.

In a study in Milwaukee, Clark et al. (2002) found that people are more willing to pay for flood risk reduction if they experience greater levels of flood risk, but they do not support projects that expand to include reduction in the risk to the environment because they do not see those benefits directly. Zhai et al. (2006) found, "willingness to pay for flood control measures may increase with per capita income, individual preparedness, and/or experience with flooding, but may decrease with distance from a river, acceptability of flood risk, and provision of environmental information."

The idea that people who experience floods or live near a river are more willing to pay for flood risk reduction can pose two challenges related to collective action. First, as discussed in a later section on land use, slowing water on the ridges of the watershed will be an important action to mitigate flood events. However, landowners on the ridges, by definition, live far away from the creek and are less likely to directly experience flood events. Second, flood management projects such as dams are costly and will require public funding. Differences in flood experience and proximity to the creek could bifurcate support for the project, with people who do not experience flood events opposing a tax increase that would exceed their perceived damages.

Given the existing government involvement in flood management in the region through the ongoing Watershed Project Plan and Environmental Impact Statement (PLAN-EIS), the public perception of government is also important. Lave & Lave (1991) and Terpstra & Gutteling (2008) found that residents believe flood management is a government function. However, residents' willingness to support flood management projects hinges on the perceived efficacy of the government. Akbar & Aldrich (2015) found that the damage suffered by flood victims is directly related to a person's faith in political leadership, and people view disaster damage as the result of ineffective leadership. Similarly, people are more likely to seek out information on flood events if they perceive government failure in flood management (Griffin et al., 2008). Spegel (2017) found that residents are more willing to support a high cost flood management option if they trust their government to execute it well. This presents a potential challenge in the case of dam failure and reconstruction.

Dam failures result in significant downstream damage, which Akbar & Aldrich (2015) would suggest results in a perception of government failure. The reconstruction of the dams, which is a costly option, would be executed by the government that people now perceive ineffectively managed the dam, making it difficult to gain public support under Spegel's analysis. In public forums discussing the PLAN-EIS and future flood management in the watershed, residents did express concern over adequate maintenance and funding for the dams if they are reconstructed. However, in the interviews discussed below and the institutional analysis, we find that people tend to be more trusting of local levels of government, which may help navigate this challenge as local governments are more representative of local interests. Therefore, if the public perceives the local government to be the primary flood management actor, they may be more supportive of flood management projects.

Finally, Spegel (2017), Griffen et al. (2008), and Terpstra & Gutteling (2008) all found a notion of private and personal responsibility for flood management, despite residents believing such management was primarily a government function. A survey from Terpstra & Gutteling (2008) found that people view disaster preparedness as an equal responsibility between themselves and the government, even if "flood protection" was the government's responsibility. If people do feel their government is ineffective, Griffen et al. (2008) found that people view themselves as being more efficacious in dealing with flood events.

Finally, there is growing literature exploring the mental health impacts of flooding. Those who experience flood events report higher levels of depression, anxiety, and post-traumatic stress disorder (Waite et al., 2017). If a flooded individual also experiences utility disruptions, their poor mental health outcomes are even greater (Waite et al., 2017). People who are displaced from their homes due to flooding also report higher depression, anxiety, and post-traumatic stress disorder (Munro et al. 2018). French et al. (2019) also found that repeat flood victims may experience slightly higher levels of reported poor mental health. This may be important in considering health equity, as individuals who lack the means to relocate may be more susceptible to repeat flood events.

None of the literature cited here took place in the Coon Creek Watershed, and we do not present it here as completely representative of residents in Coon Creek. Rather, it provides some context and considerations for understanding the way people perceive, experience, and respond to flooding. The following analysis of interviews conducted in the watershed serves as a ground-truth of the literature presented here to better understand the unique and specific nature of the region.

Methodology

A team of three interviewers conducted 26 semi-structured interviews between May and October of 2020 with managers and members of the public who live or work in the Coon Creek Watershed. Interview subjects were identified through online research, participation in events related to flooding in the watershed, recommendations from watershed managers, and recommendations from other interviewees. Interview subjects were divided into three groups: General Public (n = 8), Watershed Managers (n = 12), and Public Officials (n = 6). Individuals were categorized as watershed managers if they had some expertise in flood management or the natural resources in the watershed and could contribute to policy implementation in a professional capacity. Individuals were categorized as public officials if they were elected to their positions or work in a capacity to contribute to policy, but lack the technical expertise related to flooding and natural resources. Individuals were categorized as the general public if they did not have professional or technical expertise related to flooding or natural resources and could not directly influence policy. Table 1 describes characteristics of the interviews.

Table 1

Interviews with Watershed Managers	12
Interviews with Public Officials	6
Interviews with General Public	8
Average Length of Interviews	44 minutes
Longest Interview	1 hour, 7 minutes
Shortest Interview	21 minutes

The semi-structured interview format followed approximately 20 pre-determined questions. In general, there were 14 questions asked of all interviewees, with an additional four to seven questions asked depending on the individual's interview category. Questions were selected to develop an understanding of several themes related to flooding and flood management in the Coon Creek Watershed, including:

- **Misunderstandings between the general public and watershed managers concerning proper flood management**
- **Challenges in flood response at different levels of government**
- **Preferred flood mitigation strategies**
- **Personal and collective responsibility to mitigate flood impacts**

Interviews were conducted over the phone or using a video conferencing software. Interview recordings were transcribed using a professional transcription service. The research team then randomly assigned transcripts to review. We identified codes associated with anticipated themes. For example, codes of "climate" and "global warming" were grouped together. Codes such as "trauma", "psychological", and "scared" were grouped together. The codes were then aggregated into nine themes, which are each described in this section. These themes served as a ground-truthing for topics identified in the literature review. The interview questions can be found in Appendix III.

Results

SPATIAL INFLUENCE

Literature reviewed above demonstrated the relevance of spatial influence in terms of an interviewees' willingness to pay for mitigation measures, the degree to which they experience flooding, how they feel about rebuilding the breached dams, and how people experience community. We hypothesized that proximity to the creek would lead to divergent opinions of support for rebuilding the dams. Those in favor of funding dam reconstruction and more expensive flood mitigation measures would generally live in close proximity to or within the floodplain and have been more impacted by the flooding than those who lived further away either on a ridge or out of town.

To reiterate what was found in the literature review from Zhai et al. (2006), "willingness to pay for flood control measures may […] decrease with distance from a river […]". However, when asked if they would support a high cost option that reduced flood risk, or maintain current risk at no additional cost, interviewees generally supported the idea of higher cost flood mitigation measures. Additionally, the vast majority agreed that they would also support most forms of flood mitigation measures as a whole. The replacement of the breached dams was the one polarizing issue. Across all groups, it seemed there were opinions ranging across the spectrum from strongly in favor to strongly against and even a strong abstention. Interestingly, these opinions did not seem to be spatially influenced without a trend from those who lived within the floodplain or outside of it.

One community member that was particularly affected by the floods expressed that the dams should not be rebuilt. The interviewee said that the river should be left to shrink and swell naturally which would prevent catastrophes, like the one in 2018, from happening again. Another community member who lives in the Village of Coon Valley said the dams need to be rebuilt, explaining that the creek should be straightened, and levees should be put up along the banks to swiftly carry the water downstream and prevent flooding.

The issue of flooding in the Coon Creek Watershed is so severe, that even community members who lived in towns outside of the floodplain understood the importance of flood mitigation measures and would be willing to pay for a project that would be more expensive up front but more protective in the long run. One person put it this way, "I live here, so I want to have the money dumped in. And it's not even just for me. I think about the towns below us. […] We have neighbors that their place is an absolute disaster and it's condemned."

Spatial influence is also an important factor when understanding who people identify with as their community or if there is a spatial factor in feeling a responsibility to warn others about potential flooding. When asked this specific question, "Do you think people on the ridge feel responsible for the flooding in the Valley?", one community member who lived in the floodplain responded, "No, they didn't even know that we flooded down here when it was raining that night because they had absolutely no idea that it was flooding in the valley, that the dams broke."

HERITAGE

Interviewees articulated strong and multi-generational ties to the Coon Creek watershed land and location. "Our communities of people that have endured flooding for generations, to some degree, having been prepared to deal with the fact that the river is going to flood, it is going to come up quickly and hopefully it's going to go down quickly. And that's part of the sociology of their whole family and generations." Another interviewee said, "we're all just trying to live here. We're all just trying to make a better life for ourselves and our families here… it's the love of the culture and history that we share that makes it important to continue to keep going." One interviewee spoke of homes as multi-generational and integral to their family and family history. "That's what people don't understand. These are these people's homes that they raise their families in."

Photo by David Mark.

This history includes the watershed as a relevant boundary for cooperation. One interviewee noted the regions' "history of convening groups and topics to sort of serve as the table for folks to gather around to have these meetings where we're all working in this watershed." The community is widely aware of its role in the first Soil Conservation Service Watershed Project site. Interviewees mentioned the importance of land use both in its historical role and the relevance to current flooding. "In Wisconsin something in the order of, I've forgot exactly but I want to say lost a half a million acres of pasture and hay and we've gained about a half a million acres in row crops and that played out here strongly. And that so the history would say that we went [backwards] in terms of quality of stewardship."

COMMUNITY

Community was described by interview participants as resoundingly important in the Coon Creek Watershed. The Coon Creek Watershed is not a singular community but instead a geographical area that contains individuals who each belong to many overlapping communities defined not only spatially but also by shared interests and values. Strong community ties are both a highly prized feature of the culture and a functional aide in flood resilience.

Interview participants noted strong community ties as a defining characteristic of the region. One interviewee spoke of the community's response to the unexpected passing of a mailman. "You will see mailboxes up and down the road with flowers, ribbons, everything tied to them just in support of his family. I mean, that's how people are here. And you don't find that anywhere else." The interviewees told numerous stories of Coon Creek community members generously giving time, resources, and finances to each other.

Interviewees described this community support as a main tool in flood recovery. This included physical cleanup of private and public spaces, financial and material donations, and prepared foods to feed both those who had been flooded and volunteer workers. One interviewee articulated that "just being a resident of the community makes you personally responsible for help [cleaning up] at least." Another interviewee said, "The community is a lot tighter now because of the flooding." Word of mouth news was also articulated as an important step in understanding and navigating government disaster recovery programs after a flood.

While these examples display how the strength of the community ties were amplified after the disaster, flooding also has had enduring negative impacts on the community. Interviewees noted the loss of all businesses and homes in a portion of Chaseburg close to the creek referred to as Lower Chaseburg. Lower Chaseburg had included a popular bar that functioned as an important place for community gathering. One interviewee noted, "I'm sure there are some people have just up and left the community." Interviewees also suggested that, while immediate assistance to those who were flooded was generous, important, and impactful, there is a dichotomy of understanding for some people between those who have been flooded and those who have not. "I have friends that I can't talk to because they really have no idea the impact that it made on us."

Many interviews demonstrated an understanding that the community is connected through the watershed itself, "realizing that we're all in, we'll have our role to play in making it better, not focusing on the negative, but rather on the solutions where we can all come together and help." However, interviewees also noted that not all residents of the watershed understand the hydrological relationship and expressed a desire for improved community-wide understanding of flood management techniques. A watershed manager said, "We need more landowners talking to landowners, farmers talking to farmers about what works, and that's both regionally and larger scale. It's not just about having money. It's not there aren't things that people can implement on their own that I think a lot of people are willing to. But it's still a very shotgun approach instead of targeted where we need it most. There's currently nothing like that. There's no way to deal with that, to address that, there's no shared liability. So… it is every individual landowner." In this manner, community ties are seen as a potent strength in pursuing effective flood management.

TRAUMA, EMOTIONAL TOLL

Interviewees articulated the emotional toll and trauma of repetitive flooding in the region. "People [are] losing their homes and having to shutter their businesses or just all the stuff that just impacts people's livelihoods, their businesses and their homes, which for many people is everything they have. Yeah, I don't know. I don't know how many times people can go through that."

There is a lasting or even constant fear of the dangers of future floods. "There's certainly a lot of anxiety around just personal safety and property safety because of flooding," said one interviewee. "If there's a heavy rainstorm, you know, they wake up and they start looking around and waiting for the inevitable to come." Another interviewee said, "You're not sleeping, because in many of the cases that happened in the middle of the night, so you woke up to something very, very devastatingly different."

This fear is made worse through repetitive flooding events. "My husband had bulldozed for six days straight and then it happened again and we were stranded again and it literally broke my back that next day. I could not believe everything we had done. I was in the bathroom sobbing because I'm like, I can't do this again."

The degree to which flooding impacted one's home, property, and sense of safety varied. "You know, people in your community, there's more of a lasting remembrance of this life, whereas people who aren't directly affected, you know, it's in their minds for a little bit and then it kind of goes away," said an interviewee. "It's the people that live within a few miles from us that are in the valley [who] know how it feels. To me, that's my community when it comes to flooding because nobody, nobody [else] understands."

Although available literature suggests that residents may "forget" floods after a long enough period of time, or shift their investment in risk aversion to other concerns, many residents experience flood events frequently enough for ever-present awareness. These statements also align with the literature stating spatial proximity to a flood event or waterbody increases flood awareness.

One of the breached dam sites in the Coon Creek Watershed. Photo by Eric Booth

With dams breached and their likelihood of being rebuilt, relocated, or removed unanswered, there is an amplified sense of fear and exhaustion regarding unknown impacts of flooding and flood management moving forward. One watershed manager discussing the ongoing PLAN-EIS study noted, "With a community that's been devastated, I understand why they don't like to hear that there's one point six million dollars being spent to just study, just start to decide."

FLOOD INSURANCE

Structures located within the 100-year floodplain that have a federally-backed mortgage are required to have flood insurance. Flood insurance is also available to anyone, regardless of their relationship to the floodplain, although it may be financially infeasible. One interviewee described it this way:

"Insurance is nothing more than a bet. It's a wager. So, you're wagering, when you put your money in, you're wagering that you're going to have a flood."

Interviewees generally viewed flood insurance as a good option, particularly for people living within the floodplain, but recognized that it is often too expensive for the people who need it most.

"It's a very pricey product...for a lot of people, it's cost prohibitive, the cost of it is too high."

One interviewee who experienced significant damage to their property during the August 2018 flood event said flatly, "I wouldn't be able to afford [flood insurance]." The high cost of flood insurance is partly due to challenges in risk pooling that are inherent in flooding. Insurance usually benefits from having a large pool of people with varying levels of risk, leading the lower-risk individuals to subsidize the high-risk individuals. However, in the case of flood insurance where the people who purchase it almost all live in the high-risk 100-year floodplain, those purchasers face high premiums due to the pool being relatively high-risk. This fact contributed to the creation of the National Flood Insurance Program, which has itself struggled with financial solvency described in the institutional analysis section of this report.

One manager also discussed the issue of moral hazard in flood insurance, or the tendency for people to act in a higher-risk way because insurance reduces the costs if something goes wrong. In the case of flood insurance, this may result in people building or rebuilding homes in higher-risk areas because they are insured against a flood.

"You deal with a flood… and get insurance to rebuild again. At some point you have to stop doing that," said one interviewee. However, there are many reasons why an individual may choose to remain at the location of their flooded property, including the inability to relocate due to income constraints or employment. Repetitive flood properties that are granted multiple flood insurance claims have been criticized for their contribution to the fiscal challenges in the National Flood Insurance Program (Pew, 2016).

On the other hand, interviewees suggested that flood insurance payouts are difficult to secure unless the flooding is very severe, and when the payouts do occur, they are often far less than the true cost of reconstruction or rehabilitation. Flood insurance payouts can also be less than a property owner still owes in their mortgage. As one interview said, "Some people got $32,000 and didn't have a house, and they owed $150,000 on their house."

CLIMATE CHANGE

Climate change is a politically volatile topic in the United States. In Wright et al.'s (2020) analysis of rainfall in the Coon Creek Watershed, summarized earlier in this report pg. 6, there was strong evidence that severe and more frequent rain events are occurring due to anthropogenic effects. This trend is global in scale and is exacerbating flood events across the country. The vast majority of those we interviewed acknowledged climate change was occurring. In fact, 10 out of 12 watershed managers, 3 out of 6 public officials, and 5 out of 8 members of the public explicitly mentioned climate change or global warming as a possible cause of recent extreme weather events. Some interviewees spoke directly to the fact that the phrase climate change was too political to describe the situation even though they believed it was the cause. Others did not mention it or possibly explicitly left it out of their response. Mentions of climate change as well as a lack-there-of are important data points because it attempts to reveal an understanding of the attitudes in the region.

One interviewee said, "I have my personal thoughts, which is global climate change, but that is not a phrase that I feel is very useful for me to use. It's too politically sensitive and I don't have time to get into that argument, so extreme weather events is a phrase that I'm comfortable using".

Climate change tends to be a sensitive topic in some locations so we wanted to provide the interviewees with the opportunity to bring up the phrase themselves. The interview question, "Have you noticed flooding changing and if yes, what is causing the change?", attempted to breach the subject without mentioning "climate change" explicitly in order to evoke a response, unbiased by the question and to get a sense of the mindset in different communities across the watershed. Many responses spurred reactions pointing specifically to climate change as the impetus for change. Others (31 percent), did not mention climate change at all, but provided responses indicating a trend in increasing rainfall and storm intensity.

According to a report from Duke University (Bonnie, 2020), opinions on climate change are polarizing between rural and urban/suburban communities. People in rural areas tend to be more skepticalof climate change than urban/suburban areas and more reluctant to talk about it. Even with such a small sample size, we found that there do appear to be differences in how people engage with or react to the term climate change. We found both sides of the story. The most significant example of this came out when interviewing different watershed managers who were working to mitigate climate change. They stated that while working with the public, they needed to use different tactics, expressions, and reasoning to get the same job done. They did the same work between different counties but had to use different labels in order to be effective.

In another interview, one member of the public recognized a change in precipitation trending with a change in temperatures, but lacked a mention of climate change. They said, "We know temperatures are increasing, the amount of precipitation is increasing. The frequency between events is getting tighter. But the main thing is that rainfall intensity where we used to get one or two inches overnight, we get one or two inches in 20 minutes." Another response mentioned global warming, however in a different context than most of the other interviewees. "There is talk that is related to global warming. I don't know why the weather patterns change that drastically. I personally think that some of the problems [relating to weather] in this country actually come from other countries."

Some interviewees noted that the changes in rainfall accompanied many other factors contributing to flooding. Some included changing land use and land management practices, dams on the Mississippi River, and reconstruction of the creek. Many people mentioned flooding as the fault of bridge reconstruction over State Highway 14. For example, "...land use[s] changed. Less conservation, less animals on the landscape, [...] means less hay, less contour strips. More pavement, more concrete [...] decreases infiltration and increases runoff. And so, our rain [and flooding] events are more intense."

The general trend throughout the interviews from those who mentioned climate change was a similarity of responses across watershed managers, the public, or public officials. Those who were willing to participate in our research often had climate change in their vocabulary and used it. One interviewee said, "We've had two 50-year rain events in the last 10 years, and within the last 15 years, I think we had one, one-hundred-year rain event. So, climate change is, in my view, has driven the severity of rain events." However, there was a sense that most understood that climate change is driving these abnormal precipitation events, but they knew that it was a loaded term and had some reservations using it.

DISTRIBUTION OF RESOURCES

In the Institutions section of this report, we discuss challenges related to the fiscal capacity for local governments to fund flood resiliency initiatives. Those findings were borne out in the opinions of residents and flood managers. There is an understanding that local governments - both municipalities and counties - lack the resources to implement significant flood resilience programs, including buyouts, supplementation of land management practices, and dam maintenance.

One watershed manager said, "A lot of towns have been dealing with the burden of managing and trying to upgrade their infrastructure, and they just simply don't have the budgets."

One town board member discussed the fiscal challenges in recovery after flood events, as towns finance the repair of washed-out roads through traditional public financing such as loans and bonds as they wait for reimbursement from FEMA that can take years to receive.

"It's been very financially stressful for the communities, especially for the municipalities that have roads and bridges to repair and replace," said one interviewee.

Another said, "If money was not an object, I would go with that one [higher cost and better resilience], but the reality is the money is not there."

When it comes to the reconstruction of dams, federal funding will be required given the cost of the structures and limited budgets of local governments. As an example, adjusted for inflation, the unfinished La Farge dam project in 1970 was expected to cost $38 million (Anderson n.d.), nearly 350 percent of the amount Vernon County residents paid to the county in property taxes in 2020 (Vernon County Board of Supervisors, 2020).

At the same time, residents and managers recognize fiscal constraints at the federal level.

As one interviewee noted, "We cannot think, oh, we can build anything, and the feds will pay for it."

The ongoing PLAN-EIS is a useful example supporting this statement. The federally funded watershed planning project will work with local communities on their preferences for watershed management, but also consider the federal government's interests. The decision arising from that plan will be implemented with federal funding if it is made available.

Even in the event of federal funding for projects, residents and managers are still concerned about the ability for local governments to fund operations and maintenance into the future. During dam construction in the region in the 1960s, local governments were tasked with financing ongoing maintenance and repairs. It is likely that any new dam constructed in the region would follow a similar model.

Asked what should be included in the calculation of costs and benefits of dam reconstruction, one resident said, "There should definitely be maintenance… It should be in the budget."

The budget would be that of the county and local governments, which already face fiscal constraints.

DISTRIBUTION OF RESPONSIBILITY

Distribution of responsibility fell into two categories based on the questions that were asked. First, who is responsible for responding to flood events and second who is responsible for preventing future flood events. In both cases the majority of interviewees felt that it is everyone's responsibility to both respond to and prevent flooding. One member of the public responded, "I think our communities have shown that whether you're a private citizen or a landowner, a farmer, a business owner or someone from the county agencies, state agencies, everybody has a part to play."

Even though many responses from the general public stated the importance of everyone's involvement in flood management, most only mentioned that prevention of floods fell upon managers, policymakers, the state or federal government. There were only limited statements indicating that any one individual could do something to prevent flooding. Watershed managers and public officials expressed the opposite point of view. The overwhelming response from them was that "Landowners should be the ones most responsible for mitigating [flooding], for employing better land use management strategies and overhauling the landscape so that there are more buffers, more small dams, and more water infiltration."

In terms of who is responsible for responding after a flood event, most interviewees place great importance on immediate local responsiveness to flood events. They highly revered their communities' ability to come together and provide support for those

Water inlet at one of the breached dam sites in the Coon Creek Watershed. Photo by Eric Booth in need. Others expressed that there is a need for collaboration between local, state, and the federal government in order to deal with pre- and post-disaster response strategies. Some people felt that the State of Wisconsin needed to be more helpful and provide more resources for mitigating and responding to flood impacts by "provid[ing] more technical and financial assistance…, creating additional funding streams, a general need for resiliency coordination."

In every interview the Federal Emergency Management Agency (FEMA) and the Department of Natural Resources (DNR) were brought up as the main governmental organizations responsible for flood response, especially in terms of rebuilding and recovery efforts. Their involvement was a polarizing topic. Some interviewees asserted that FEMA was an invaluable resource. "They really helped us out. FEMA was, I can't say enough good things about FEMA. [In regard to the bailout program] they helped them pay with moving expenses … And those guys were really, really easy to work with. All of our homeowners got paid a fair price. We were happy with the program."

Others expressed that FEMA is not and cannot be the only resource for flood response and mitigation efforts. Many of the attitudes towards the DNR were that they are a necessary evil. They do good things, but "the Department of Natural Resources or FEMA gets so involved with this [flood recovery] that it's going to be difficult." Some reasons for this feeling include the process of filing paperwork, working with FEMA employees, and requesting FEMA funding. Many feel it is cumbersome and redundant, especially for a small community where there is limited staff to do the work of documenting flood impacts. One public official said, "Everybody wants to say FEMA. But, you know, if we look at our world today in the United States with everything going on... we've got to depend on our fire department, law enforcement… neighbor helping neighbor."

Another topic that surfaced was that fewer and fewer people have a connection to the land and understand the impacts further downstream. This led to the thought that ridgeland landowners may not understand their responsibility to those in the valleys. In other words, there is a disconnect between seeing rainfall in the uplands and realizing its impact in the valley below, or that the ability for water to infiltrate in the upland areas has a direct effect on the severity of flooding in the lowland areas. The change in land use over the past few decades directly affected this dynamic.

ROLE OF EXPERIENCE

Much of the literature described earlier in this section suggests that past experience with flood events is a primary indicator of an individual's flood awareness. This was generally borne out in interviews.

Broadly, one local official said, "Unless you have been through a flood, I don't think you can understand how much damage can be done."

Another local official said his municipality purchased more barricades to stave off water in future events. The official said, "The experience has probably been our biggest help. When you go through three or four floods in three years, that's what really helps."

In the Village of Coon Valley, officials said the creekside park has flooded in 2017, 2018, and 2019. Devastating floods in both 2007 and 2008 similarly caused millions of dollars in damages. Many interviewees have lived or worked in the watershed long enough to experience each of these events and others that occurred earlier.

In some cases, the recurrent events induce people to take actions they otherwise would not take in the event of a single flood. One watershed manager interviewed said her parents still live in the house along Coon Creek that she was raised in.

"The last couple of floods they had a lot of water in the basement… they had to take everything out of the basement. Years ago, they said, 'Well maybe we should try to lift the basement' and said, 'Oh no, this will pass.'" The couple began the process of lifting their basement in 2020 after the more recent and recurring floods.

However, frequent experience also generated a helpless feeling in some interviewees. One watershed manager who also lives on the Coon Creek said all of the events, "kind of blend together".

"I don't know what the answer is but people are sick of flooding."

Experience also plays a role in higher-level response. One watershed manager cited the frequency of events as a reason for improvement in intergovernmental communication and organization.

The manager said, "As more of these events happen, our response time is better… I think we're all learning how to better collaborate. We're becoming more and more efficient all the time."

As Atreya et al. (2013) suggested, people can "forget" floods after approximately four to nine years. Large flood events in 2007 and 2008, followed by the dam breaches and subsequent flooding in 2018 interspersed with smaller nuisance flood events indicate there is not enough time between events to "forget" the flood. In some cases, this frequency results in improved governmental and individual response. In others, it results in trauma, fatigue, and helplessness.

Conclusion

This section does not offer specific recommendations on policy or program improvement, but rather provides a lens into the way residents and watershed managers in the Coon Creek Watershed experience floods and prioritize flood mitigation strategies. In some cases, the themes identified through these interviews aligned with existing literature from around the world, suggesting that there are some universal truths when it comes to the public's experience with floods. For example, we identified a connection between spatial proximity to flood events and an individual's awareness or perception of flood risk. We also identified the psychological trauma of flooding for many residents that reflects the growing literature on mental health and flooding. Additionally, we found a type of organizational learning, whereby residents and local governments that suffered repeated flood events became more proficient at managing the response and recovery.

There are also statements that are inconsistent with what we would expect from available literature, particularly in the perception of government. Although other studies found flood protection and mitigation to overwhelmingly be the responsibility of the government, residents and watershed managers in Coon Creek felt a collective approach of individual responsibility is necessary. Additionally, flood victims recited varied experiences with different levels of government. Some had positive experiences with federal agencies, while others preferred working with more local governments. These differences may reflect inconsistencies in program delivery and the uniqueness of each flood event for each individual property owner.

Finally, perceived causes of increased flooding and preferred mitigation also varied widely. Although some interviewees attributed the increased frequency and intensity of floods to climate change, others pointed to land use changes and infrastructure. These differences resulted in varied preferences for mitigation, including advocating for land management practices identified in this report, reconstruction of dams, and the channelization of waterways. Watershed managers and policymakers should be aware of these differences in perceived causes and preferred mitigation strategies to improve communication and watershed education for residents.

Photo by Vijaya Narasimha.

FLOOD MANAGEMENT INSTITUTIONS

Introduction

Federal, state, and local governments all play an important role in flood management and response. Over time, all institutional levels have participated in flood response efforts for the Coon Creek Watershed. The institutional responsibilities vary with the level of government but generally include developing flood regulations, providing funding for infrastructure and disaster response, facilitating buyout programs, providing assistance programs and grants when applicable, and more.

Local municipalities are the first to feel the impacts of a flooding event and need to develop infrastructure, regulations, and emergency responses to be prepared for flooding events. Responsibilities then transition to the state level where additional emergency response can be deployed in addition to resources and funding. Some specific state institutions include Wisconsin Emergency Management (WEM) in Wisconsin's Department of Military Affairs, which provides emergency response on the ground, and the Wisconsin Department of Natural Resources (WDNR), which is involved in floodplain management, planning, and mapping. These floodplain maps are then used for floodplain management, flood insurance rating, and flood insurance requirements. Another state-level institution is the Wisconsin Department of Health Services (DHS) who has developed a Flood Resilience Scorecard (FRS) and the Risk Assessment Flood Tool (RAFT) with the purpose of providing local governments, health departments, and citizens with information on how to prepare and respond to a flood event.

Federal government institutions include the Federal Emergency Management Agency (FEMA) and the Natural Resources Conservation Service (NRCS). FEMA develops floodplain maps which are used in the National Flood Insurance Program (NFIP), as they are the basis for NFIP regulations and flood insurance requirements (FEMA, 2021). FEMA also offers mitigation funding programs such as Building Resilient Infrastructure and Communities (BRIC). NRCS, housed in the United States Department of Agriculture, acts primarily to provide technical and financial assistance to farmers and private landowners. Additionally, non-governmental organizations (NGOs) play a role in flood management. These organizations provide more on-the-ground, quick reactions to disasters. In the August 2018 flood event, there were responses from neighbors, students, and volunteers from the greater region helping dig out homes and provide other disaster response.

Because of the complex nature of the landscape, this section focuses on identifying some of the complexities surrounding the institutions at play in the Coon Creek Watershed. There are many institutions that play a role in managing flooding. The following is a brief introduction to these institutions. This is not an exhaustive list and there are many other institutions that play a role in flood management.

The WDNR is a state institution that works with businesses and citizens to promote, preserve, and enhance Wisconsin's natural resources. They partner with federal and local organizations to develop resource management strategies and programs. They also provide many flood related tools and resources including flood prevention and coping, mitigation, and floodplain management and mapping. This agency plays a large role in preparation for a flood and aims to provide a more streamlined way to access resources that people need in relation to flooding response and recovery.

WEM is the lead state agency involved with emergency management, categorized into four main phases: mitigation, preparedness, response, and recovery (WEM, 2020). This agency is a division under the Wisconsin Department of Military Affairs (DMA), which provides effective and crucial military and emergency management to the state. WEM is heavily involved in the emergency phase of a flood disaster.

NRCS, an agency within the United States Department of Agriculture (USDA), works to develop conservation solutions and programs for the health and long-term sustainability of agriculture. They provide technical and financial assistance to producers who employ conservation practices such as grassed waterways, stream restoration, and managed grazing.

FEMA is a federal agency involved with emergency management, inclusive but not limited to flooding emergencies. Their mission is to help people before, after, and during disasters (FEMA, 2021). Their general goals as an agency, as outlined by their 2018-2022 Strategic Plan, are to: build a culture of preparedness, ready the nation for disasters, and reduce the complexity of FEMA (FEMA, 2018). In order to build a culture of preparedness, FEMA has set out objectives which are: incentivizing investments that reduce risk, closing the insurance gap, helping people prepare for disasters, and learning continuously from past disasters and experiences (FEMA, 2018). For their second goal, to ready the United States for disasters, their specific objectives are to: organize the BEST (Build, Empower, Sustain, and Train) scalable and capable incident workforce, enhance intergovernmental coordination, posture FEMA and communities to provide lifesaving and life sustaining equipment, commodities, and personnel, and improve continuity and resilient communications capabilities (FEMA, 2018). The third goal, to reduce the complexity of FEMA, is further divided into specific objectives which are to: streamline the disaster survivor and grantee experience, mature the National Disaster Recovery Framework, develop systems and business processes that allow FEMA employees to rapidly and effectively deliver the agency's mission, and strengthen grants management, increase transparency, and improve data statistics (FEMA, 2018). They have a number of grants, tools, and other resources to aid response and preparation for disasters.

In terms of flooding, FEMA offers flood insurance, provides flood maps, and has a role in floodplain management. The National Flood Insurance Program (NFIP) is managed by FEMA and provides insurance to property owners, renters, and businesses. Floodplain management is undertaken by multiple groups who carry out management functions such as zoning, building codes, enforcement, education, and others. FEMA has minimum floodplain standards for communities who participate in the NFIP but suggests adopting higher standards. FEMA provides tools and resources to help guide communities, government officials, individuals, and others through NFIP requirements while implementing higher standards of floodplain management. (FEMA, May 11, 2021.) Lastly, FEMA maintains and updates data through flood maps and risk assessments (FEMA, June 22, 2021). These programs provide regulatory products such as a flood insurance rate map database and flood insurance study reports and non-regulatory products such as flood risk maps, flood risk reports, and a Flood Risk Database (FDR) (FEMA, Nov. 16, 2020). Flood maps help lenders determine insurance requirements and help communities develop strategies for reducing their flood risk.

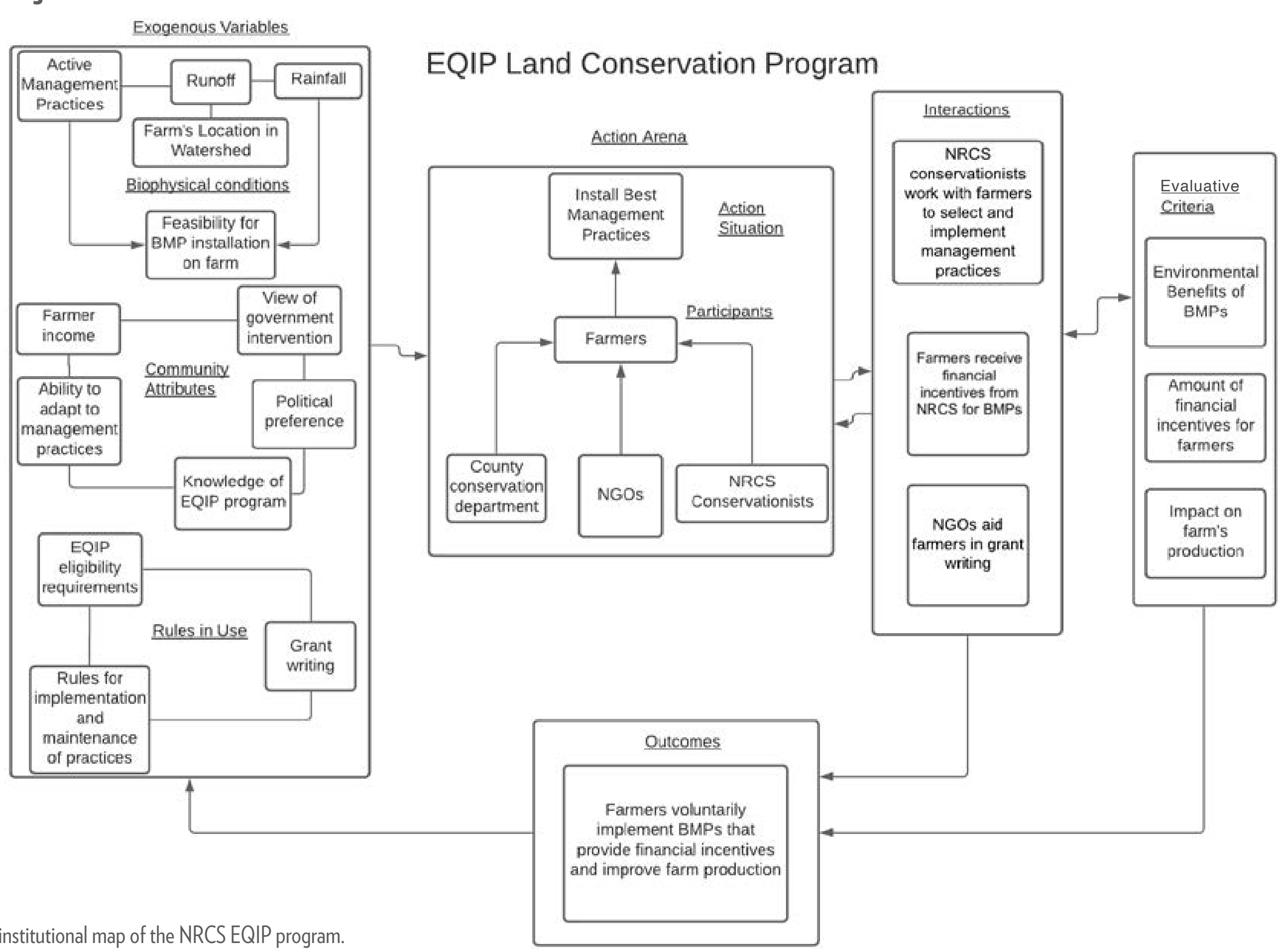
Methodology

Institutional mapping is used to help understand the existing distribution of power, focusing on the key actors and their interactions, where power is located, who is able to influence decisions, who makes decisions, and the source of funding (McFadden et al, 2010). Institutions are generally defined as either formal or informal systems of rules which define the institutional boundaries (McFadden et al, 2010). In order to map the institutional landscape of flood management, we used the Institutional Analysis and Development Framework (IAD). This framework, developed by Elinor Ostrom, maps out four key elements: "(1) actor's preferences regarding certain actions and outcomes, (2) the way actors acquire, process, and use information, (3) the decision criteria actors use regarding a particular course of action, and (4) the resources that an actor brings to a situation" to analyze that social space (McFadden, 2011).

Institutional Maps

Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP)

Figure 4



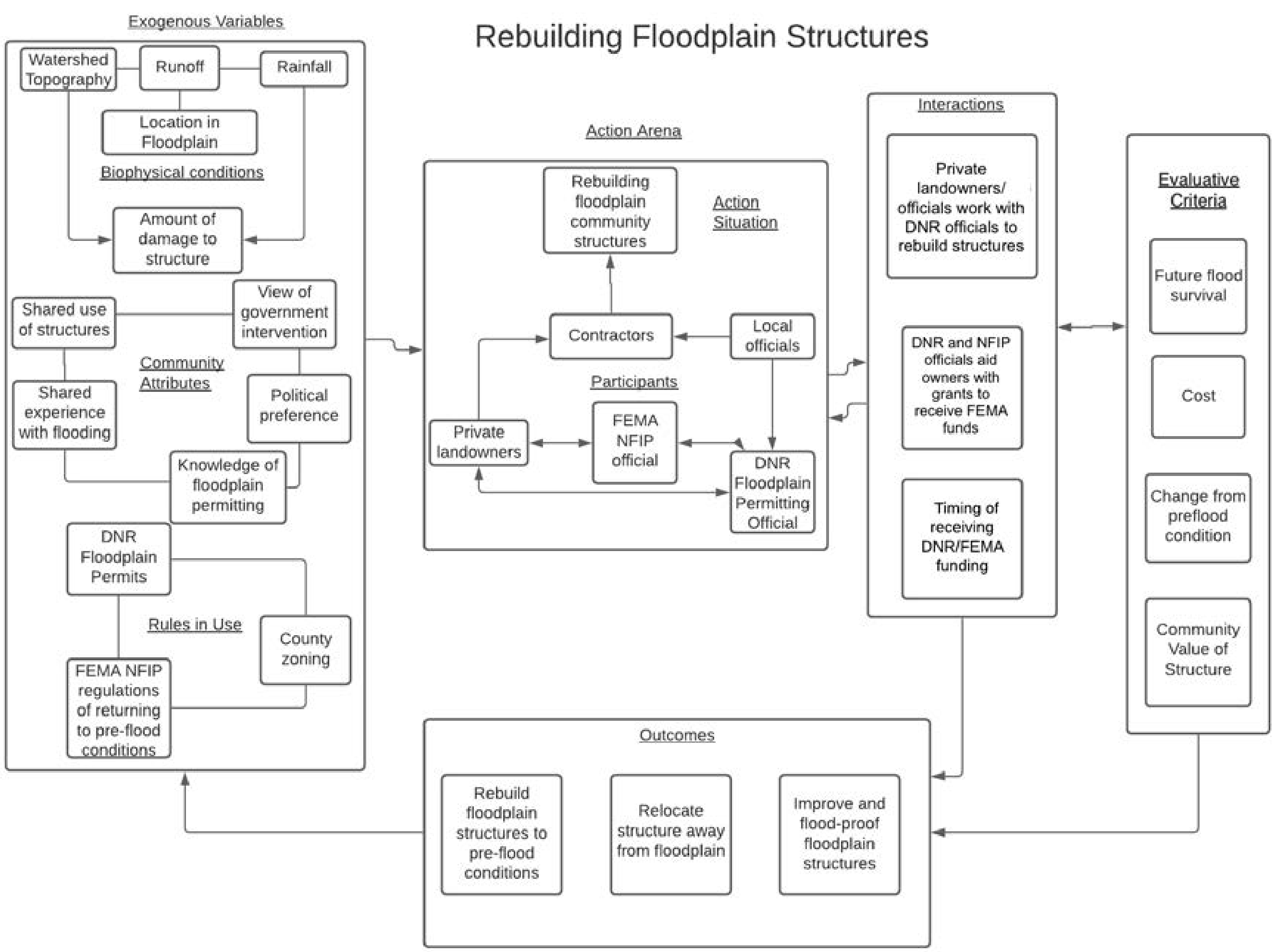
An institutional map of the NRCS EQIP program.

The NRCS currently runs the EQIP program to provide financial and technical assistance to farmers interested in installing conservation practices. However, the program often fails to approve many applications due to the sheer number of requests and lack of funding (Basche et al., 2020). A state-run program by the WDNR could supplement EQIP and help fund and install management practices for farmers throughout the state. Since it would be voluntary, the success of the program would depend on the farmers to implement management practices and reduce nonpoint source pollution. Increased funding and staffing would also be required to implement the program.

In contrast to the voluntary incentive approach, a producer-pays approach compensates farmers for best management practices, while penalizing farmers for nonpoint source pollution. This program could also promote flood resilience by reducing the amount of runoff as a co-benefit. Implementation would take some explicit management tools to measure and set nonpoint runoff goals and compensate farmers for achieving these goals (Shortle et al., 2012). Farmers that fail to meet these goals would be financially penalized for the amount of runoff that exceeded the goal. This program goes beyond the implementation of management practices and actually evaluates their effectiveness in reducing runoff. However, this program would require an immense amount of funding and staff to develop tools to measure runoff on farms on a state or county level and enforce penalties and incentives. The program could be run from the state level but would require collaboration at the county level and may require federal support. Despite these barriers, it would likely ensure an increase in management practices and subsequent reduction in runoff and flooding.

REBUILDING FLOODPLAIN STRUCTURES

Figure 5



An institutional map of the process to rebuild floodplain structures.

When local stakeholders are faced with the complex task of rebuilding floodplain structures, they have to navigate the bureaucracy of FEMA's National Flood Insurance Program (NFIP) and DNR floodplain permits. From interviews with watershed stakeholders, many residents had navigated this bureaucracy when replacing pedestrian bridges, gazebos, and other floodplain structures after the 2018 and other recent flood events.

The NFIP provides funding for rebuilding structures in the 100-year floodplain following flood events. It can also provide funds to people with NFIP insurance outside the floodplain. However, payments from this program typically only represent that which is required to return the structure to pre-flood conditions and no more. This forces stakeholders to determine whether to rebuild the structure to pre-flood conditions and risk destruction from future floods or seek additional funds to flood-proof the structure to withstand future events. Oftentimes, stakeholders lean toward rebuilding the structure to pre-flood conditions as it is fully funded and they do not want to bear the additional costs of flood proofing. For example, a local stakeholder in the watershed explained their experience with repetitive rebuilding of walking bridges following recent flood events:

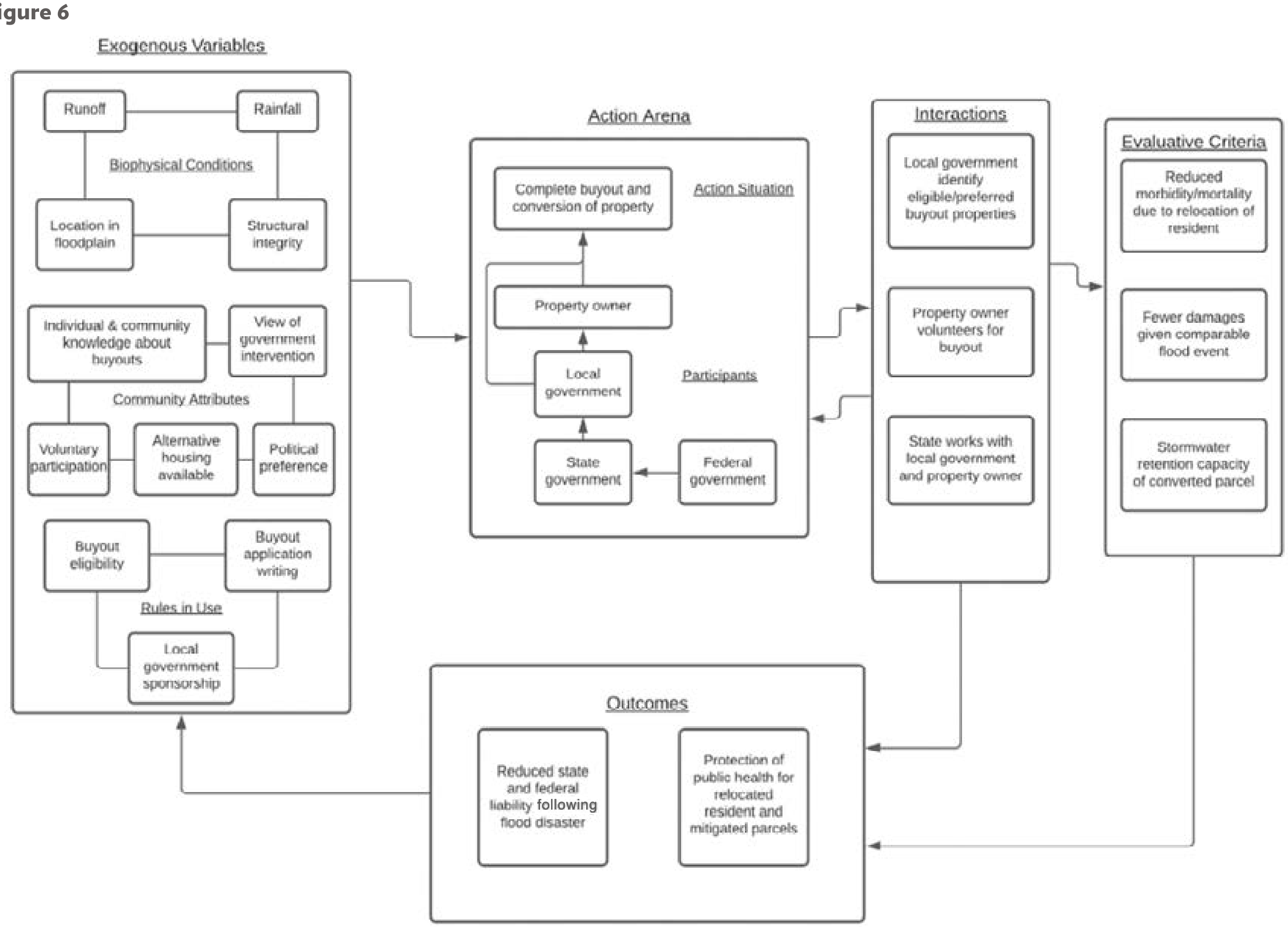
"We got seven of the nine bridges repaired in 2017 and 2018. We lost them all again. Well, of course, we couldn't [get] the funding for those through FEMA because we never got the permit.... We get a permit in 2018. All is well then, the 2019 flood, then and we lost bridges again"

The stakeholder also noted a lack of resources and expertise preventing them from flood proofing the bridges:

"We're now very good at building bridges, but we don't want to keep rebuilding bridges.... They also have ideas for what we need to do (about the bridges). But again, if they change the permit, I have to have an engineer behind it. I don't have an engineer." This stakeholder also had to navigate WDNR floodplain permitting for rebuilding bridges and needed review from WDNR staff to rebuild the bridges. Private bridges returned to pre-flood conditions are expedited in the review, which also leads stakeholders to prefer this route. This involvement of state and federal agencies in rebuilding floodplain structures illustrates the bureaucratic complexity that has to be navigated by affected stakeholders and how they often select the most reactive solution to most effectively navigate this bureaucratic web.

BUYOUT PROGRAMS

Figure 6



An institutional map of the process to complete a buyout of flood-prone structures.

Beginning in the 1920s, private insurance companies ceased providing flood insurance. They no longer considered it profitable as the only purchasers of flood insurance are those in the floodplain who are more likely to make claims (FEMA 480). In the 1960s, severe floods damaging uninsured homes prompted congress to create the National Flood Insurance Program to aid homeowners that are prone to flooding. As the federal government became the insurer, it accrued that liability. But the NFIP was not intended to deal with extreme weather events, and the relative frequency of such events in recent history has caused financial instability in the program (Laporte, 2019). After Congress cancelled $16 billion in debt in 2017, the program still owed more than $20 billion to the U.S. Treasury as of 2019, buoyed by $4 billion in annual revenue through premiums and fees (Horn et al., 2021). The NFIP has a borrowing capacity of $30.425 billion that is eclipsed by just a few extreme weather events.

Public park and baseball fields in Coon Valley where repetitive flood damages occur, shown in 2019. Photo by Eric Booth

In order to reduce the liability suffered by the NFIP, FEMA also administers grants to fund buyouts. If a property is costing the NFIP more in insurance payouts than it receives in premiums, it is a good candidate for a buyout to lower the program's overall liability. Two of these programs, Flood Mitigation Assistance and Building Resilient Infrastructure and Communities, are significantly underfunded based on demand. In the 2020 application year, 1,227 grant applications sought approximately $4 billion in funding from a $700 million budget.

The WDNR also administers the Municipal Flood Control Grant Program, which can fund acquisition and removal of floodplain structures.

Problems plague the programs as they are chronically underfunded. They are slow-moving, with a median of five years from application to the buyout (Weber & Moore, 2019).

The variety of funding sources available for buyouts, the requirement of all levels of government in the application, and the length of time from an application to a buyout raises concerns over the institutional complexity of the program, particularly for individuals and municipalities that may lack the capacity to overcome administrative burden and participate fully in the program.

Discussion

The institutional framework related to flood events and mitigation is highly complex, evidenced by the fragmentation represented in the institutional maps above. This complexity and fragmentation is intimately understood by people in the region who have dealt with or overseen flood response or mitigation. In interviews conducted for this report, residents who directly experienced flooding cited delays and confusion at most levels of government involved in recovery.

"Truthfully, the state needs to do a whole lot more. People want to rely on FEMA. And it's pretty complicated to go through a FEMA funding request. They have a pretty high bar as far as the type of documentation they require."

"I'd rather go to the dentist and get your teeth pulled than work with FEMA. I mean, they're good people. But they've got so many damn loopholes."

Watershed managers and government officials felt misdirected when seeking clarity and approvals for actions they felt would improve flood resiliency.

"A lot of the brunt of the public's frustrations is we very often have to explain, 'Sorry, that's not us. That's the DNR. That's not us. That's FEMA. That's not us. That's zoning.' Which is very confusing for folks when they just want a solution."

The complexity of the institutional framework contributes to these challenges, but so do other factors that are more narrowly related to the Coon Creek Watershed. The following sections discuss some of the additional challenges that communities in the Coon Creek Watershed may face when trying to navigate the waters of flood recovery and resilience, including intergovernmental interactions, challenges for small municipalities, and differences in government scales.

INTERGOVERNMENTAL INTERACTIONS

Disaster recovery is a shared responsibility across all levels of government, but it is highly local given spatial proximity and knowledge of the disaster event and the community in which it takes place. Emergency response is fragmented and follows a federalism approach, whereby a local disaster declaration must be echoed by the state before it is taken up at the federal level. This multi-step approach naturally delays federal involvement in flood response.

Upon initiation of the recovery process, local officials are tasked with determining whether and/or how to rebuild, while state and federal officials provide technical assistance and funding during recovery. In other words, "The most effective disaster response and recovery efforts are locally developed and executed, state/tribal/territorially managed, and federally supported" (OIA, 2018). The reliance that local governments and individuals have on federal funding for recovery, either through grants or flood insurance, provides an opportunity for the federal government to institute its own policies on recovery. These policies may complement or compete with policies preferred by local governments (Crow & Albright, 2019) and its citizens. For example, in order to be eligible for the NFIP and other flood-related programs, states must administer floodplain management programs and standards that are then enforced by local officials.

Flood response is often limited by the administrative capacity, resources, and technical knowledge of local government officials (Crow & Albright, 2019). This has led many scholars to look at improving disaster-related outcomes through the lens of organizational learning at the local level. Crow & Albright (2019) found that greater organizational learning by local governments following flood events can increase resource flows from state agencies and form more collaborative intergovernmental relationships. Unfortunately, one of the best tools for organizational learning is experience, and although flood events can contribute to this learning (Thompson, 2016), learning would ideally take place independent of repeated catastrophic flood events. Crow & Albright (2019) suggest this learning can be facilitated at the state level by improving processes for disaster recovery and bringing together disaster-affected local governments to collaborate. However, communities in the Coon Creek Watershed have suffered repeated flood events, suggesting they have undergone an abundance of organizational learning.

Rubin & Barbee (1985) suggest local governments have improved their capacity for emergency management and no longer need to be supplanted by private organizations or higher levels of government with the exception of providing funding. However, the provision of funding has become a critical liability for the federal government, resulting in an existing debt of more than $20 billion, even after Congressional cancellation of $16 billion in 2017 (CRS 2019). The Congressional Research Service (2019) estimates that the federally mandated floodplain regulations result in $1.87 billion in annual savings for the NFIP. This incentive for the federal government to regulate away risk further entrenches the federal government with local decision making.

Further, interviews with local public officials suggest that, in the absence of oversight from more technically proficient levels of government, localities may compete with adjacent local governments to reduce their own risk of flooding at the expense of other property owners downstream, similar to competition between levee districts in the Mississippi River basin during 20^{th} Century flood events.

CHALLENGES FOR SMALL MUNICIPALITIES

Local communities are bearing the responsibility for increasingly repetitive flood problems and the same holds true for the rural Coon Creek Watershed. The watershed is located mostly in rural Vernon and Monroe counties and is home to the municipalities of Stoddard, Chaseburg, and Coon Valley, all with populations of less than 1,000 people. The nature of these small, rural communities puts local and county decision makers at a disadvantage as they have less resources and funding for flood management and recovery. This section will examine the challenge for rural, small town flood management in general and examine the specific challenges faced by the municipalities in the Coon Creek Watershed.

Consoer and Milman (2018) examined the decision-making process involved in flood mitigation in rural municipalities of Western Massachusetts by determining factors that affect choosing flood mitigation measures and the opportunities and constraints faced in implementing them. The study found that the institutional and physical characteristics of these municipalities lead them to prioritize structural over nonstructural flood mitigation measures. In a physical context, municipal officers noted the dynamic nature of rivers were better controlled with structural mitigation and that there was no room for nonstructural mitigation, such as wetland restoration or land conversion, in the small, constrained towns. Institutionally, municipal officers indicated that institutional fragmentation and limited local capacity restricted implementation of flood mitigation and reinforced a structural mitigation approach. In particular, responsibility for flood mitigation is often split between the public works and the land conservation departments of municipalities, where public works handles structural approaches while land use planning and conservation develops nonstructural mitigation. However, the study noted that small municipalities often are only staffed by a highway administrator and lack both resources and knowledge for nonstructural mitigation. Furthermore, the study discovered that implementation of these measures is often inhibited by state and federal regulations and by barriers to accessing state and federal assistance programs. Given these barriers, small municipalities often opt for reactionary and ancillary flood mitigation, which leaves them vulnerable to future flood events. In the end, Consoer and Milman (2018) recommend that government policies and programs should be crafted to the specific situation where flood mitigation occurs, especially the rural characteristics of small municipalities.

Similarly, Brody et al. (2010) found that the organizational capacity of local decision makers is a significant factor contributing to the implementation of structural and non-structural flood mitigation approaches. In this case, organizational capacity refers to not just the number of staff working on the plan, but the ability to anticipate flooding, make educated decisions, and implement efficient policies. This includes the financial resources, staffing, technical expertise, leadership, and the commitment to information sharing and flood protection (Brody et al. 2010). In this way, organizational capacity factors in funding, technical expertise, and the ability of the local decision makers to work together to achieve a common goal. Brody et al. (2010) found this organizational capacity is as important or more important than past flood experience, geophysical conditions, and the state of planning. Although rural local municipalities, like those in the Coon Creek Watershed, often lack substantial funding and other resources, they can foster a culture of information sharing, communication and flexibility to increase their organizational capacity and improve flood response.

For example, a local official noted their frustrations with the number of regulations and permits from the WDNR in slowing flood recovery: "You run up against all these roadblocks and you shouldn't have to deal with that when you're trying to deal with getting your town back to being able to have traffic flow through it and residents be safe and those kinds of things. So, I just think a lot of their regulations are just kind of overbearing."

The same official also noted that the inability of WDNR and FEMA to effectively work together slowed flood recovery: "I think they [FEMA and WDNR] need to work together. I think they butt heads too much… [FEMA] were almost appalled at what we had to go through to get a permit, because every time they would tell us to do something, we said, well, we got to check with the DNR chief."

These comments illustrate the barriers faced by the local governments in the Coon Creek watershed in receiving funding and progressing the flood recovery process. However, the community can work to improve its organizational capacity to better tackle the regulatory barriers to flood response and recovery from state and federal agencies. Further barriers faced by stakeholders in the Coon Creek Watershed are discussed in the public perspectives section of this report.

DIFFERENCES IN GOVERNMENT SCALES

Despite the fact that immediate disaster response is inherently local, that does not necessarily make local governments the most well-equipped or appropriate administrator of response and recovery. However, given that flood events occur over a limited area, it may also be inappropriate for larger units of government to aid in response and recovery. The concept of fiscal equivalence suggests that the jurisdiction reaping the benefit of a policy or public spending should be the same jurisdiction that pays for it. In other words, fiscal equivalence would argue that federal monies collected from across the country should not be used in such a narrow jurisdiction as the Coon Creek Watershed.

Due to simple proximity, the level of government primarily responsible for immediate disaster response is the local level. In a survey of perceptions of reliance on different groups following a disaster, 73 percent said they would rely on their own household in the first 72 hours after a disaster, while 51 percent said they rely on fire, police, and emergency personnel (FEMA 2014). Just one third (34 percent) relied on state or federal help in the first 72 hours after an event. Local governments are often the administrators of fire, emergency services, and basic public infrastructure that may be compromised in a flood event. Limitations on mobility due to compromised transportation networks can further delay the availability of external help (Pregnolato, 2017).

Photo by David Mark.

However, beyond 72 hours, local governments lack the administrative and fiscal capacity to recover from floods, particularly in the Coon Creek Watershed. The Village of Coon Valley, among the largest municipalities in the watershed, operates with four employees. Many surrounding townships have a single clerk employed. In interviews conducted for this report, local public officials said they lack the staff to process the paperwork associated with flood recovery. Counties are better equipped to administer recovery given larger resource bases and a greater level of technical expertise. Waugh (1994) suggests county governments should be the primary administrator of emergency management for several reasons:

"They are geographically close to environmental problems; have larger resource bases than municipalities; have ambiguous administrative structures that encourage inter- and intra-governmental cooperation; are local agents of state administration; have close administrative ties to state agencies; provide forums for local-local cooperation; and serve as general-purpose local governments representing local interests."

States have an even larger fiscal and administrative capacity to assist in flood recovery but may lack local knowledge required to effectively administer recovery. Although the state functions as a conduit between local and federal governments for disaster aid, its primary role is aiding local communities in setting and enforcing standards that align with federal standards, which allow communities to participate in disaster recovery programs such as the NFIP.

The federal government and FEMA provide the majority of financial relief in disaster recovery but are even further removed from local knowledge and conditions on the ground. Federal involvement in recovery is intended to step in only where state and local resources become exhausted.

The large role the federal government plays in financing disaster recovery runs counter to the concept of fiscal equivalence, or the theory that the population voting on and financing a public good should be the same as that affected by the provision of that public good, otherwise the quantity provided will not be economically efficient. Such a theory would be hard pressed to justify federal spending on a dam project in a single part of the country since few taxpayers would see any benefit from the project. Fiscal equivalence attempts to strike the balance between taking advantage of local knowledge and ensuring adequate financial and administrative capacity.

Recommendations

Flood management and mitigation in the Coon Creek Watershed faces a variety of challenges described above. Rurality and lack of resources makes it difficult to fund or implement measures that will reduce flood impacts. Limited administrative capacity restricts a community's ability to develop and coordinate proper flood mitigation or recover after flood events. The arbitrary nature of jurisdictional boundaries relative to watershed boundaries results in institutional fragmentation and disrupts coordination. However, these limitations share similar foundations related to limited resources or small economies of scale, and inadequate coordination to collectively implement solutions. To address these foundational limitations, the governing bodies in the watershed should consider developing a Joint Powers Board (JPB) that is authorized to carry out specific flood mitigation policies and practices.

JOINT POWERS BOARD

The joint exercise of power through intergovernmental agreement takes place with variation across the United States. It is constructed by state statutes and therefore differs by state. Generally, "A [JPB] is a group of legally distinct and independent entities [that] enter into an agreement for joint exercise of power. The agreement establishes operational constraints, the composition of the governing board, funding arrangements, staffing, financial provisions, and the duration of the authority" (Stava et al., 2006). Because of the broad nature of the JPB, they have been used for a variety of applications. Advantages of the JPB include the "broad array of financial arrangements possible, can add members over time, benefit from exercising power of another agency through the [JPB], share system management, share operators" (AWWA Strategic Management Practices Committee of the Technical & Educational Council, 2012).

Under Section §92.12 of the Wisconsin Statutes, Intergovernmental Cooperation, created first in 1981, "If a problem of soil or water conservation is defined in part by drainage basin boundaries beyond a single county's borders or otherwise transcends these borders, the respective counties, cities, villages, towns and public agencies with natural resource responsibilities may enter into mutually binding agreements and contracts containing, but not limited to, provisions for mutually enforced and administered regulatory ordinances and cost-sharing distribution arrangements" (Intergovernmental Cooperation, 2019). "The parties can specify matters such as the work to be done, how payment shall be made, who has responsibility for reviewing the work, and the duration and termination of the agreement" (UW Extension Local Government Center 2000). In the case that the cooperating municipalities have varying powers under law, under the contract of joint exercise of power, each municipality can act only to the extent of its own previously established powers (Intergovernmental Cooperation, 2019), meaning the board can only act with the authority of its least powerful member (LWM n.d.).

In Wisconsin, this statute has been implemented in order to "produce less expensive and more efficient local government services." (UW Extension Local Government Center, 2019) This can occur through consolidation of services such as local health departments, fire departments, law enforcement, and emergency services. Notably, there are currently no JPBs specifically related to flood management in Wisconsin.

Co-operative governing across the watershed could result in more effective flood mitigation efforts than could be coordinated by each entity alone. By demonstrating a coordinated and effective plan for the watershed as a whole, there also may be greater chances of obtaining funding for mitigation grants through the DNR, WEM, FEMA, and similar mitigation funding organizations. It is possible that cooperation and shared resources defined by the watershed boundaries could result in more comprehensive and less burdensome mitigation planning.

In early 2021, La Crosse, Monroe, and Vernon Counties were considering the creation of a JPB by the name of the Coon Creek Cooperative Agreement.

BEST PRACTICES FOR A JPB

Table 2 provides details on the structure and authority of a JPB in the Coon Creek watershed. All three counties that constitute the watershed - La Crosse, Monroe, Vernon - should be a formal party to the intergovernmental agreement. Lower levels of government, including cities, villages, and towns, should not be formal parties to the agreement, given that they may lack certain powers afforded to counties, and §92.12 dictates that the JPB may only have the authority of its least powerful member. Therefore, a JPB consisting of only counties will maintain all powers and authorities of counties. However, limiting formal JPB membership to counties may generalize nuances that are important to distinct communities within each county. In order to maintain the full power of counties within the JPB while representing the interests of the most flood-affected communities, the JPB should prioritize informal participation by municipal officials in the board's agenda through consistent communication and consultation.

Membership on the board should consist of a variety of stakeholders but prioritize county officials who speak for the separate county boards from which the JPB began. Given the importance of agriculture to the economy in the region, and agriculture's potential role in mitigating flood impacts, the farming community should be represented on the board. The board should also include at least one at-large member, who is a resident in the watershed. Given the exclusion of cities, villages, and towns from the intergovernmental agreement, the JPB may wish to include a representative from a village or town in the watershed. Finally, the JPB may wish to allocate more membership positions to individuals in Vernon County, given that the majority of the watershed area and flood impacts take place in Vernon County.

Table 2

JPB Characteristics	Personnel and Activities	Notes
Jurisdictions	La Crosse, Vernon, Monroe Counties	Lower levels of government should not be a formal party due to limitations it would place on the board's power per § 66.0301
Board Membership	County officials, agriculture and industry representatives, at-large watershed residents	Vernon County may have a great proportion of board members given its larger share of the watershed. County officials are members of county Soil and Water Committees
Necessary Authority	Education, outreach, research, grant writing, emergency management communications	
Additional Authority	Lobbying, zoning, buyouts and land acquisition, taxation	These powers may be politically unfeasible
Oversight	County Soil and Water Conservation Committees	May provide JPB with some authority that does not need committee approval. Could categorize authorities and necessary approvals.
Funding	Non-expense operations (staff time, county supervisor per diem) funded by county general funds. Additional projects funded through grants.	Grant matching may require additional expenditures

EFFECTS OF LAND USE AND MANAGEMENT ON INFILTRATION

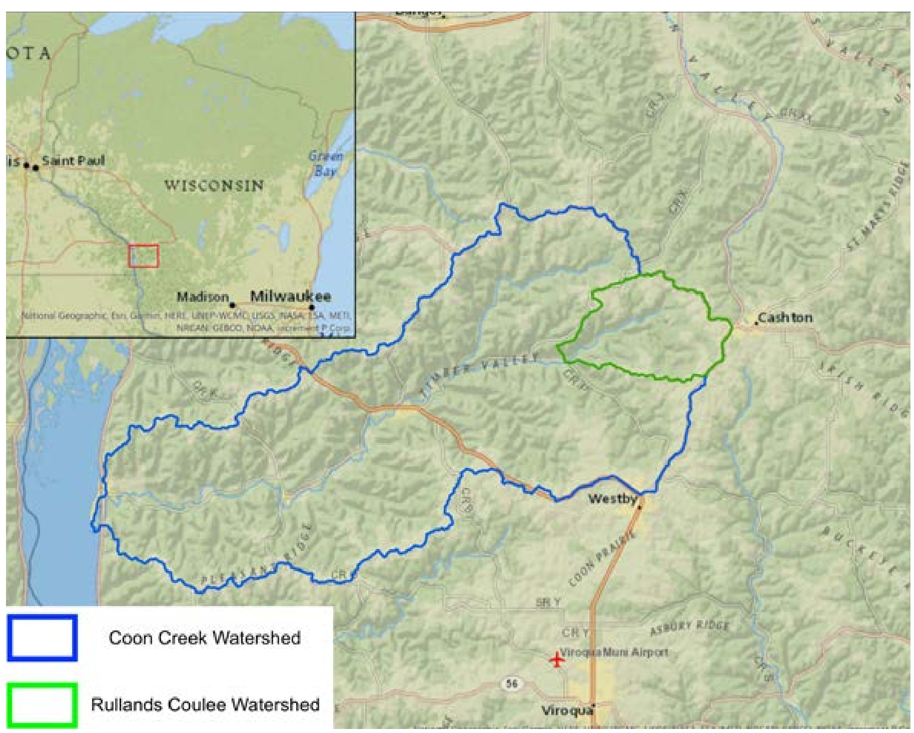
Introduction

The Coon Creek Watershed is found in the Driftless Area of southwestern Wisconsin, where the landscape is broken into flat ridgetops, steep slopes, and narrow valleys. The topographic relief of the Driftless Area is much larger than the glaciated portions of Wisconsin and can exceed 500 feet from ridgetops to the valley bottoms (Juckem, 2003). The watershed is typical of most Driftless Area basins as its surface watershed has very distinct boundaries with adjacent riverine systems (Figure 7). The La Crosse River Watershed and Mississippi River form the northern and western boundaries, while the Kickapoo River and Bad Axe River Watersheds respectively form the eastern and southern boundaries. There are no naturally occurring lakes in the watershed, but numerous spring-fed ponds are found in the basin. Groundwater discharge contributes to a large amount of streamflow in the watershed. Curtis (1966) used manual hydrograph separation techniques to estimate that baseflow accounts for 60-77 percent of total flow in a typical Driftless Area stream. Using the same methods, Curtis estimated that groundwater contributed roughly 75 percent of all streamflow in Coon Creek based on discharge measurement from the watershed demonstration project.

The unique topography and variable geology of the watershed have a large impact on the hydrology and runoff potential of the watershed. Although the glaciers did not cover the Driftless Area and deposit glacial drift, the thickness of surface deposits, such as ridgetop loess and valley alluvium and colluvium, was strongly influenced by weathering processes due to climatic conditions during Pleistocene glaciations (Knox 1977, Hunt 1999). Geologically, the watershed's ridge tops are covered by reddish-brown clay known as the Rountree Formation with a thin veneer of loess lying above the clay layer (Hole 1982, Frolking 1982, Frolking et al. 1983, Knox et al. 1990, Evans 2003). Colluvium and alluvium deposits of varying thickness cover most of the hillslopes and valleys in the basin. This physiographic makeup is extremely influential on the watershed's ability to generate and retain runoff.

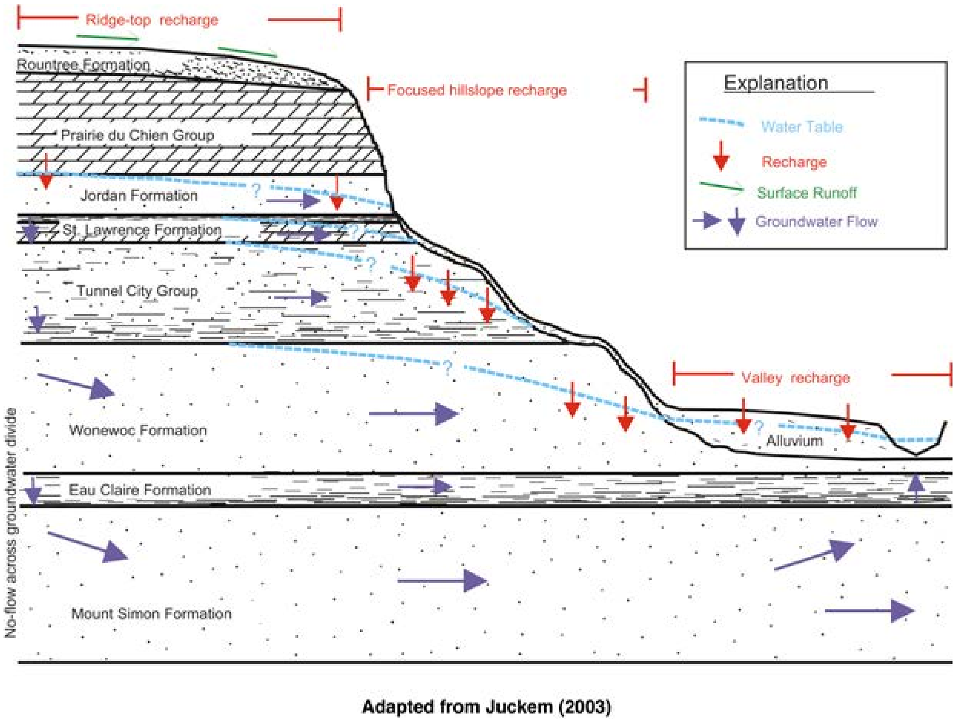
All water within the watershed drains into Coon Creek and the unique landscape paired with the geology often accelerates the runoff process and decreases infiltration. The clay and silt makeup of the ridgetops is characterized as hydrologic soil groups B and C (Soil Survey) with a moderate to high runoff potential and low saturated hydraulic conductivity and infiltration rates. This makes the ridgetops less receptive to rain events and causes surface runoff in extreme rain events once the ground is saturated. Juckem (2003) confirmed this theory in the watershed by measuring very low infiltration rates on the ridgetops. This runoff drains onto the steep hillslopes, which are covered by a thin colluvium deposit above fractured bedrock that allows for infiltration of some runoff. The hillslopes in the watershed can have high infiltration rates and groundwater recharge due to their geology and predominantly forested land cover (Curtis 1966, Olson 1994, Juckem, 2003). While the hillslopes can have high infiltration rates, their steep nature causes water to quickly move into the valley bottoms, which limits their infiltration potential. In general, the infiltration rates in the watershed's valley bottom are lower than on the hillslopes (Juckem, 2003) and overland flow on hillslopes and in valleys typically converges into channels that quickly convey runoff into the stream channel (Figure 8). Juckem (2003) found that infiltration rates on hillslopes were larger than the valleys and ridges regardless of the land use practice (Figure 9). This unique physiographic makeup of the watershed illustrates the flood-prone nature of the watershed as the flattest areas are covered by fine-grained soils with low infiltration rates. Given the flood-prone nature of the landscape, it is necessary to determine how land use and land management practices affect infiltration in the watershed.

Figure 7



A map of the Coon Creek Watershed and location of Rullands Coulee subwatershed.

Figure 8



A cross sectional image of the Coon Creek Watershed with the flow of runoff and groundwater. Modified from Juckem (2003).

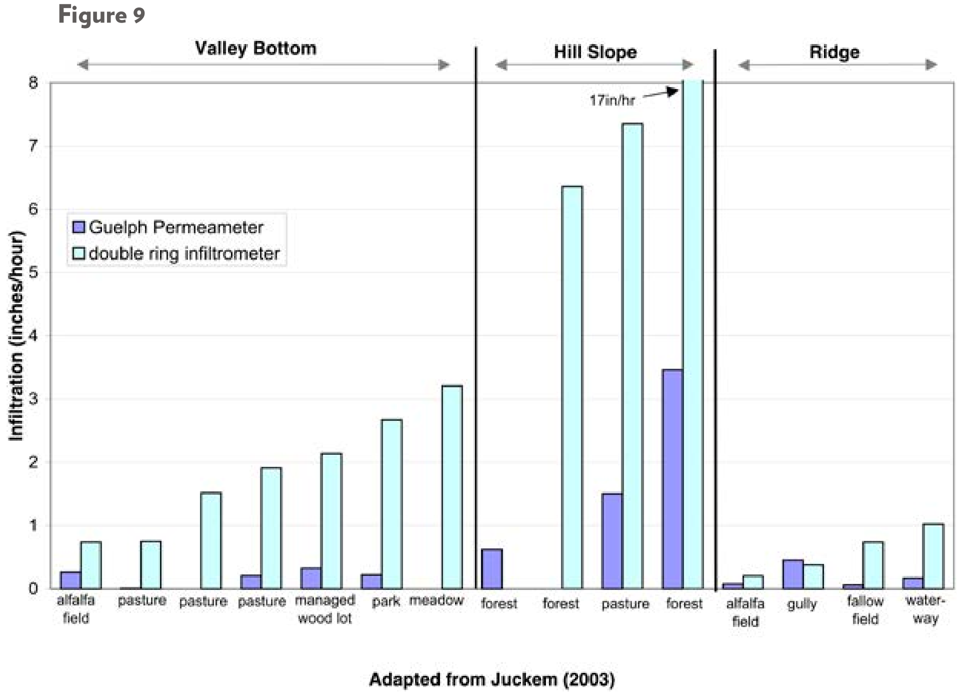
LAND USE AND INFILTRATION

Land management and land use intensity affect infiltration in the Coon Creek Watershed because of their influence on soil structure and erosion potential. Specific land management practices are often dictated by climatic, environmental, social or economic factors. In 2016, land cover in the upper Coon Creek Watershed was 48 percent forest, 27 percent pasture/hay, 20 percent cropland, four percent developed, and one percent other (2016 NLCD dataset), with the majority of forested land cover occurring on hillslopes.

The impact of land use has been examined for various land uses common to the watershed. For example, Alaoui et al. (2011) found that in a temperate Switzerland climate forested land promotes high infiltration and reduces surface runoff due to high saturated hydraulic conductivity and porosity of the soil. In addition, forest soil has high root water uptake that enhances forest soil's available storage capacity and reduces surface runoff. Forest infiltration rates were higher than grassland infiltration rates due to higher conductivity, porosity, and root uptake (Alaoui et al., 2011). Zhao et al. (2013) found that grasslands had higher infiltration rates than cropland due to an increase in macroaggregates and organic matter, which improves grassland soil structure. Furthermore, conversion to cropland has been shown to decrease infiltration rates in some areas due to decreased soil porosity and organic matter content, which has a negative impact on infiltration (Sun et al., 2018). Juckem (2003) illustrated the influence of land use on infiltration in the Coon Creek Watershed. For a given topographic area (ridge, hillslope, valley), infiltration rates were inversely related to land use intensity, where cropland has a high land use intensity while forests have low land use intensity. This finding is consistent with a similar study in the region (Sun et al., 2018).

Data from the United States Census of Agriculture further details land use changes in the watershed. Given data limitations, we show data for Vernon County, which is likely representative of land use changes throughout the watershed. Figure 10 shows three categories broadly: Total Cropland, Non-cropland in Farms, and Land Not in Farms. The figure demonstrates that, although the proportion of land used for cropland has stayed approximately the same throughout the century - approximately 40 percent of land area - there has been growth in the Land Not in Farms. This growth has primarily come out of the non-cropland farm acreage, a category which could include farm buildings, pasture, forests, or fallow fields. The loss of non-cropland acreage to non-farm uses could have a

Figure 9



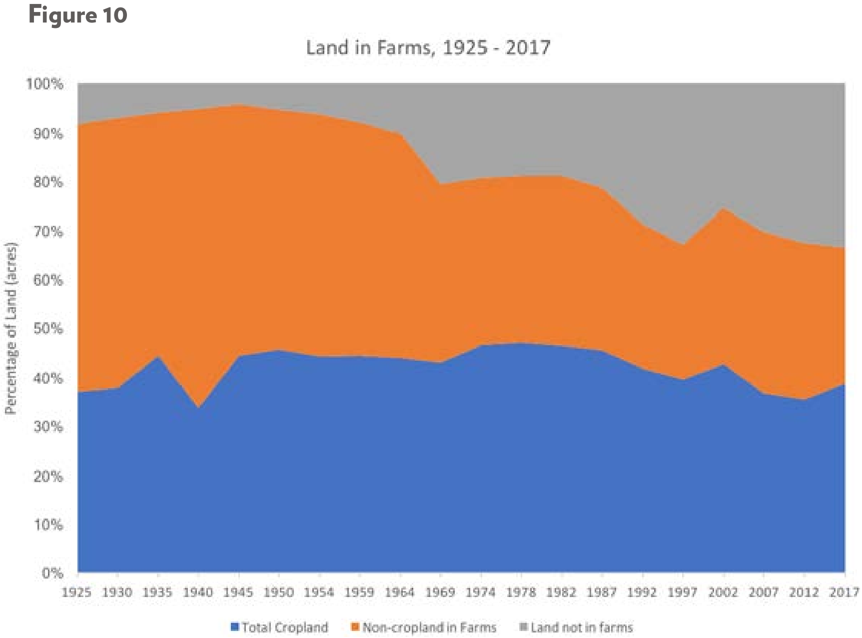
A comparison of infiltration rates on different land uses across different physiographic categories of the Coon Creek Watershed. Modified from Juckem (2003).

Contour strips in Wisconsin. Photo by Jim Klousia.

Specifically analyzing cropland provides a narrower lens into landscape changes in the watershed. Figure 11 shows the percentage of total cropland and pasture in a given year that is planted with a variety of crops, including: corn, soybean, small grains, alfalfa, other hay (excluding alfalfa), woodland pasture, cropland only used for pasture, other pasture, and other agricultural products such as berries and vegetables. There are several important takeaways from this figure. First, the amount of acreage in corn has seen a gradual increase since the first half of the century, rising from less than 10 percent of acreage to more than 20 percent. This represented an addition of approximately 37,000 acres (seven percent of total acreage in Vernon County) since 1925. Second, soybeans were nearly non-existent in the watershed until the 1990s. For most of the 20th century, soybeans accounted for a few hundred acres each year. By the 2017 Census of Agriculture, 39,000 acres of soybeans were being planted. Taken together, these traditional row crops - corn and soybeans - grew from less than 10 percent of cropland to nearly 40 percent. A portion of this growth was taken out of small grains (wheat, oats, and barley), which once made up approximately 10 percent of cropland acres but are hardly seen on the landscape today. Third, alfalfa plantings grew significantly during the mid-20th century, but decreased after about 1990. Uncommon on the landscape in the early part of the century, by 1987 plantings of alfalfa commanded more than 90,000 acres, or approximately 22 percent of cropland acreage. Note that initially, the absence of alfalfa acreage was substituted by other hay varieties. The initial growth of alfalfa simply took the place of other hay plantings. However, since that peak in 1987, alfalfa plantings have declined both in the absolute and relative number of acres. This coincides with the decline of dairy in the region during the past few decades, which is further explored in the Economics of Land Use section later in this report, as alfalfa and other hay varieties represent important sources of forage for dairy cattle. Finally, the boom of corn and soybeans through the last century has reduced acreage in pasture. Taken together, woodland pasture, cropland used only for pasture, and other pasture accounted for more than 50 percent of acreage

variety of implications. If non-cropland acreage is being converted into developed uses such as roads, residential properties, and commercial buildings, that could have a deleterious effect on infiltration capacity of the watershed. On the other hand, if a farm's fallow grassland is taken out of farm use and reforested, that may improve infiltration capacity. However, reforestation of agricultural land is a relatively uncommon practice in the region.

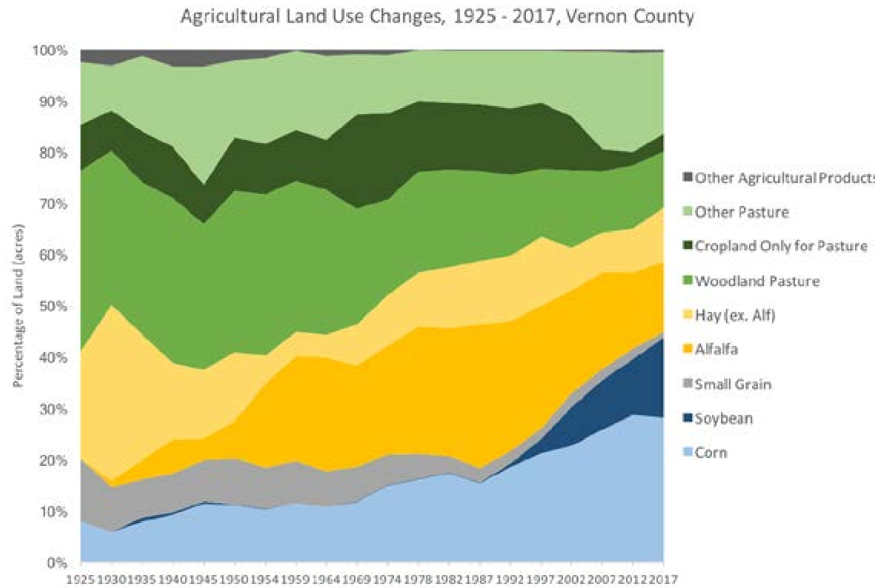
Figure 10



Change in Vernon County land use 1925 – 2017. Source: United States Census of Agriculture in the early and mid-20th century. Today, pasture makes up around 35 percent of acreage. Within the pasture categories, woodland pasture has seen the most significant decline. From a peak of 162,000 acres in 1930, only 27,000 acres are currently in woodland pasture as of the 2017 census. Although research has shown that high density, unmanaged pasture can reduce infiltration (Sartz, 1984), there has been a recent interest in the capacity of managed intensive rotational grazing to improve soil health and encourage greater infiltration.

Juckem's (2003) finding that infiltration rates are inversely related to land use intensity suggests that the increase in traditional row crops such as corn and soybeans, paired with the relative loss of pasture acres could be resulting in changes to agricultural land use that tend to reduce infiltration rates in the watershed.

Figure 11



Change in crop variety as a percentage of total cropland in Vernon County, 1925 – 2017. Source: United States Census of Agriculture.

LAND MANAGEMENT PRACTICES AND INFILTRATION

While the effects of land use on infiltration have been investigated in the watershed recently, the effect of land management practices on infiltration has not been recently examined in the watershed. The Coon Creek Watershed has a rich history of land management practices as the home of the first watershed demonstration project in the nation, where the CCC implemented various land management practices including contour strip cropping, reforesting hillslopes, and stabilizing gullies. In fact, Trimble (2009) investigated the change in peak discharge in the neighboring Timber Coulee subwatershed to determine the change in runoff response of the watershed from arrival of European settlers in 1850 to present day (Figure 12). Trimble (2009) found that there was an initial sharp increase in discharge after European settlement as the natural forest and prairie landscape converted cropland, which led to decreased infiltration rates, more runoff, and large peak discharges during storm events. However, the watershed demonstration project changed this trend by installing management practices to promote more infiltration, reduce runoff, and reduce peak discharge in the watershed. Trimble's (2009) work illustrates the significant positive impact that the management practices of the demonstration project had on reducing peak discharge, streambank erosion, and flooding in the watershed.

However, in recent decades, changes to the watershed may be undoing past conservation practices. For example, agriculture in the watershed has gone away from contour strip cropping due to an increased demand for corn, soy, and other factors, such as the use of larger farm equipment that can be difficult to navigate through contour strips and terraces. This removal of terracing and contour strip cropping also illustrates the move from small dairy farms to large confinement operations and corn and soy commodity farming. Many farmers are also converting conservation reserve program land in the watershed back to cropland, which allows them to take advantage of government subsidies for biofuels, particularly corn-based ethanol. In the end, if loss of conservation land continues, it could threaten the fragile land balance in the watershed sustained since the 1930s (Hart 2008). Therefore, it is necessary to investigate the effect of land management practices on infiltration in the watershed.

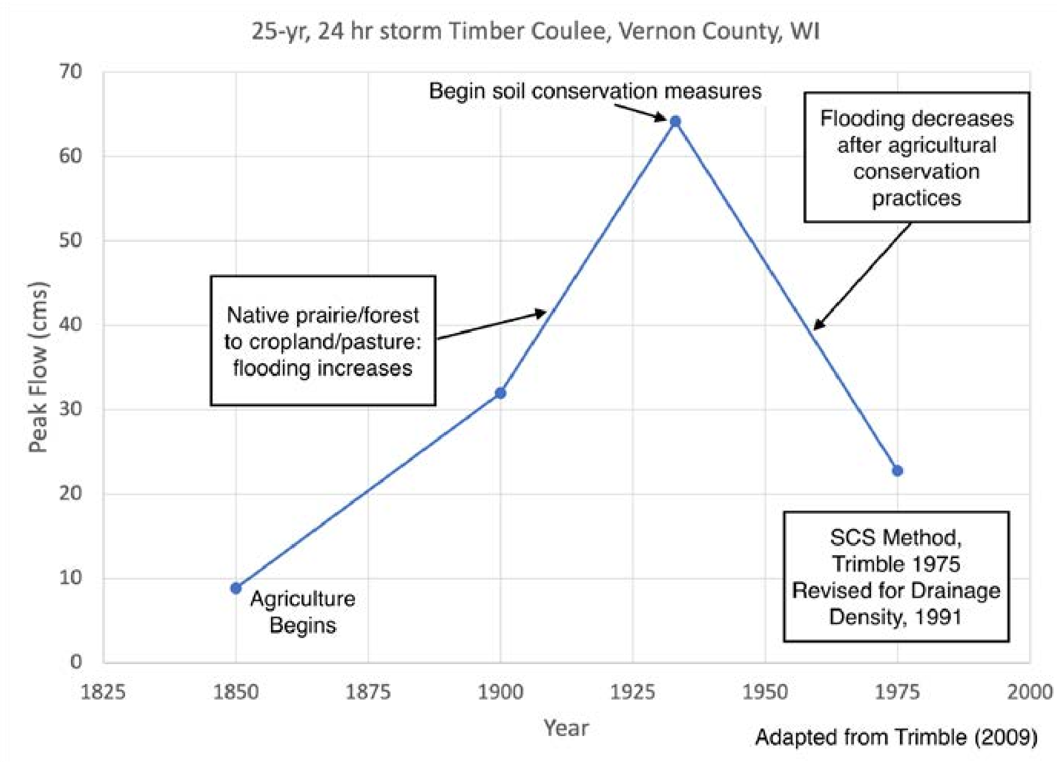
The impact of infiltration has been examined on various land management practices, such as conservation tillage, cover crops, contour strips, buffer strips, alternative grazing practices, terracing, and the use of detention ponds. For example, Basche and DeLonge, (2019) found that perennial cropping systems and cover crops lead to the largest increase in infiltration rates, while no-till also increases infiltration rates when combined with residue retention (leaving crop material on the field). Crop rotation had no significant effect and grazing annual crops reduced infiltration rates. Thus, findings suggest that promoting ground cover and continuous roots, both of which improve soil structure, were most effective at increasing infiltration rates. Cover crops and perennial cropping systems have also been shown to increase spring snowmelt infiltration and help improve soil quality (Haruna et al. 2018, F. C. Kahimba et al. 2008, Franzluebbers and Studemann 2008, Jung et al. 2007). However, conservation tillage by itself increased runoff in some cases (Karlen et al. 2009, Lipiec et al. 2006), but effectively reduced runoff and increased infiltration when combined with other practices (Basche and DeLonge 2019, Karlen et al. 2009, Dao 1993). For example, no-till paired with contour strips reduced runoff by 20 percent and increased crop yield on a watershed scale (Karlen et al. 2009). Buffer strips (areas of perennial vegetation between crops) are another management practice that has helped reduce runoff and increase infiltration in agriculturally dominant watersheds. Contour strip cropping, conservation tillage, buffer strips, and perennial agriculture on pastures are all present in the Coon Creek watershed as a result of the watershed demonstration project but recent changes in their extent have not been investigated. Furthermore, Kent (1999) analyzed the effect of land management practices on baseflow in six southwestern Wisconsin streams, including the neighboring Kickapoo River watershed. Kent found that many land management practices significantly increase baseflow in the streams by increasing infiltration. In particular, conservation tillage with residue management had the greatest contribution to higher baseflow levels. This is because more precipitation is infiltrated and routed to the streams through groundwater than stormflow, which helps to reduce flood peaks.

In the watershed, historic management practices have also been carried out on the hillslope in an attempt to slow runoff and promote infiltration. As previously mentioned, the hillslopes have high infiltration rates and groundwater recharge due to the fractured bedrock and forested land cover despite the steep slopes (Curtis 1966, Olson 1994, Juckem 2003). In order to take advantage of this trend, log terracing and detention ponds were built on the hillslopes as part of the demonstration project in the 1930s, which reduced hillslope runoff and allowed infiltration (Curtis 1966). While these practices were effective, they are costly and difficult to install throughout the watershed at this time. Given the costly nature of hillslope management practices and the multitude of ridge land management practices for slowing runoff and increasing infiltration, we focused our investigation on changes in land management practices on the ridges of the watershed. Juckem (2003) found that infiltration rates on hillslopes were likely larger than infiltration rates in valleys or ridges and that infiltration rates were inversely related to land-use intensity, but no recent measurements have been made to support this claim and land management practices were not included in Juckem's findings. The goal of this section is to quantify recent changes in land management practices and the effect of those changes on runoff and infiltration through infiltration fieldwork and GIS analysis. We will also compare the differences in infiltration between land management practices.

An example of erosion in Coon Creek that prompted the first watershed demonstration project in the nation. Photo courtesy of the USDA Natural Resources Conservation Service.

In order to inform and select adequate GIS methods, a short literature review was conducted on similar studies that attempted to quantify changes in land management practices with GIS in the Driftless Area. First, Roldan (2002) used aerial photography in GIS to measure hillslope reforestation in the Coon Creek Watershed. The study found that the percent of forested land on the hillslopes increased from 36.7 percent in 1939 to 49.7 percent in 1993, which confirms the effort to reduce soil erosion and increase recharge on the steep slopes by the original 1930s conservation project. Similarly, Heasley (2003) used GIS to map land tenure regimes in the neighboring Kickapoo River watershed. The study found that contour strip cropping on Amish land decreased from 1965 to 1995, while contour strip cropping on non-Amish land increased. Morgan (1980) measured cropland erosion management systems in the Pheasant Branch Creek Watershed in southern Wisconsin using aerial photography analysis of contour strip cropping, contour tillage, and grass waterways. The study identified each contour practice by using a visual key where contour strips were distinguishable by a characteristic strip pattern. This research illustrates the usefulness of remote sensing for determining the location and extent of current agricultural management practices and determining areas where these practices are lacking. We used GIS to analyze recent changes in land management practices in the Rullands Coulee sub-watershed of the Coon Creek Watershed.

Figure 12



Graph of a change in flood peaks over time for the 25-year, 24 hour storm for the Timber Coulee Watershed. Modified from Trimble (2009).

Methodology

INFILTRATION METHODS

We measured soil infiltration rates at several ridge locations (Figure 13) in the Rullands Coulee sub-watershed of the Coon Creek Watershed with a double ring infiltrometer to help determine the effect of land use and different land management practices on infiltration. Infiltration sites were selected on ridge locations with various land uses and land management practices and descriptions of each site are included in Appendix I. We used soil data for the watershed from the NRCS soil survey to select sites with similar soil attributes to eliminate soil characteristics as a confounding variable impacting infiltration.

The double ring infiltrometer method uses inner (approximately 10-inch diameter) and outer (approximately 24-inch diameter) metal cylindrical rings driven into the soil, flooded with water, and drained via infiltration. As the water level in the rings decreased, we measured infiltration rates directly from the inner ring by timing successive half-inch drops in water level. In theory, the outer ring buffers lateral flow from altering infiltration in the inner ring, with water from the outer ring spreading beyond the ring's diameter. Therefore, we only measured infiltration rates from the inner ring because it was assumed to represent one-dimensional and vertical infiltration. We continued the repetitive process of refilling and draining until a steady infiltration rate was achieved. The only exception was at sites with very slow infiltration, where we monitored the water level decline for at least three hours and measured the change in water level with a tape if it declined less than a quarter inch. After measurements were conducted and land covers were classified, we performed a T-test to determine statistically significant differences in infiltration rates between perennial and annual land cover.

GIS METHODS

This study used GIS spatial analysis to measure changes in contour strip cropping and land use change to measure the runoff potential of the watershed. This GIS analysis was used to aid a subsequent curve number analysis to evaluate how these land management and land use changes affect runoff response of the Rullands Coulee Watershed over time.

Stream reach in the Rullands Coulee sub-watershed within the Coon Creek Watershed that was impacted by upstream dam breaches in 2018. Photo by Eric Booth

GIS spatial analysis was conducted in the watershed to determine recent changes to contour strip cropping in the watershed. Since contour strip cropping was a prominent practice in the watershed and is easily identifiable from aerial photographs, the analysis focused on mapping the change in the area of contour strip cropping in the Rullands Coulee Watershed in Monroe County near the headwaters of the Coon Creek Watershed. Aerial photography from the USDA-National Agriculture Imagery Program of the watershed was obtained for the years 2000-2018 to contrast the historic and current composition of the watershed. After aerial photography of the coulee was obtained, the United States Geological Survey watershed boundary dataset was used to identify the boundaries of the watershed and identify contour strips within the coulee. Once contour strips were identified, the Rullands Coulee boundary was defined, and contour strips were digitized, with each individual strip being digitized into a polygon with a specific pixel area. The cumulative area of contour strips from 2004, 2008, 2013, and 2018 was then calculated in GIS for each year to determine the change in contour stripping over time.

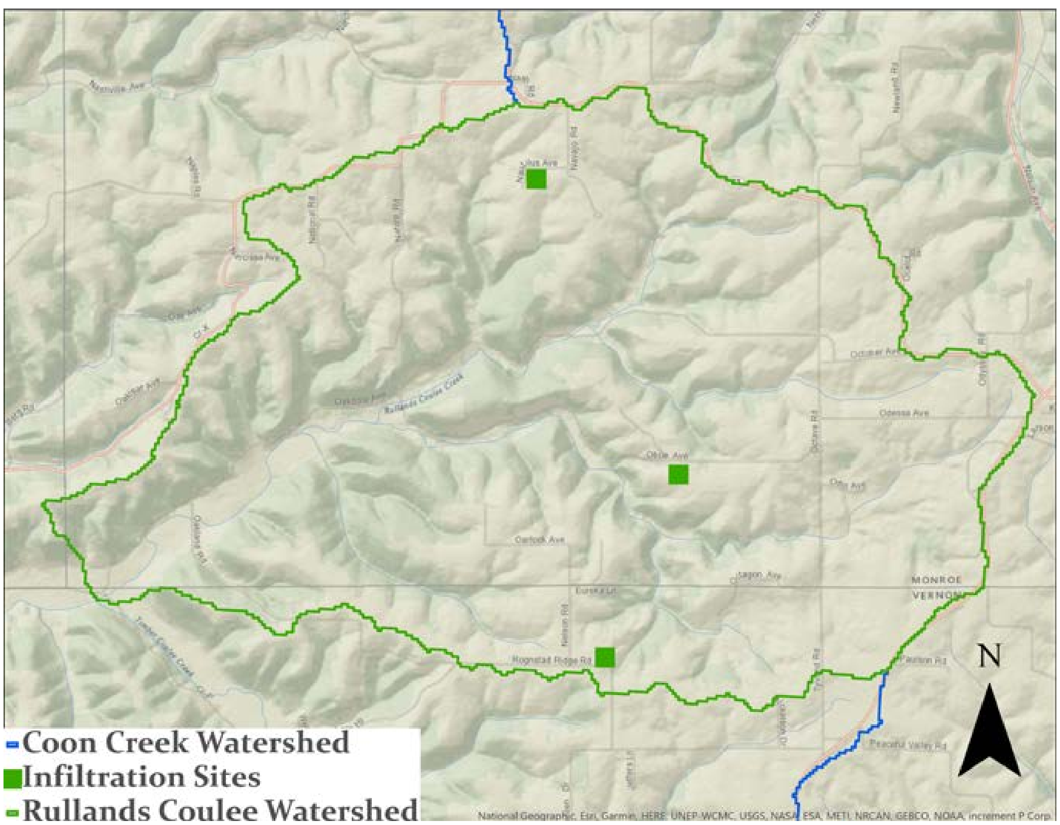
GIS spatial analysis was conducted in the watershed to determine the current composition and track historic changes in land use in the watershed. Land use and land cover layers of the watershed from USGS's Land Change Monitoring, Assessment, Projection (LCMAP) and the National Land Cover Database (NLCD) were obtained for 1985, 1990, 1995, 2000, 2004, 2008, 2013, and 2016 to contrast the historic and current composition of land use in the watershed. The USGS watershed boundary dataset was used to identify the boundaries of the watershed and determine land use within the coulee. Then, using tools in GIS, the pixels were classified from each layer and exported to determine the area and percentage of land use in the watershed and evaluate the change over time. The area of each land use was calculated in the Rullands Coulee Watershed in GIS to determine the change in land use over time in the watershed.

After land use and land management changes in the Rullands Coulee Watershed were identified, the SCS Curve Number method was used to determine the runoff potential of the watershed. The curve number is a dimensionless parameter that determines the runoff response characteristic of a watershed. This parameter is related to land use, land management, hydrological condition, hydrologic soil group, and antecedent soil moisture in the watershed (USDA-NRCS 2010). Land use layers of the coulee were collected from the USDA-NASS Cropland Data Layer (CDL), as the CDL classifies detailed crop types and other land covers that are used in the Curve Number method. Land management practices were represented by using the contour strip layers created earlier in the contour strip analysis and tillage was assumed to be reduced conservation tillage throughout the coulee (personal communication, Bob Micheel, Monroe County conservationist). Hydrologic soil group was determined using the USDA-SSURGO soil survey, while hydrological conditions were assumed to be good and antecedent soil moisture was assumed to be Class II (average conditions). Once these layers were collected, GIS overlay analysis was conducted to identify the change in runoff potential in the Rullands Coulee from 2004-2018 with analysis taking place in 2004, 2008, 2012, and 2018.

In the overlay analysis, the three layers were clipped to match the coulee and the NRCS soils layer and the contour strip layers were rasterized to match the CDL. The three raster layers were then aligned in GIS to have the same pixel size, so when overlaid each pixel has unique land use, land management, and soil group. The pixel data of each layer was then exported to Excel and the data was organized to calculate the curve number for each pixel. Once the curve number was calculated for each pixel, it was averaged across each pixel in the coulee and the average curve number (CN) was compared with 2004, 2008, 2013, and 2018 to determine the change in runoff potential in the coulee. This same analysis was also conducted on the ridge of the Rullands coulee to determine if the CN varied from 2004-2018.

To expand on the CN analysis, the CN values for the coulee from 2004 and 2018 were used to determine peak discharge at the outlet of the coulee using the NRCS dimensionless unit hydrograph method (USDA-NRCS 2010). This method produces a dimensionless unit hydrograph that can be used to estimate the unit t_s-hour hydrograph, where t_s is storm length. In this case, this method was used to project the 6-hr and 24-hr unit hydrographs for 2004 and 2018. Then, the six hour and 24-hour unit hydrographs were applied to the 25-year, 50-year, and 100-year rainfall events from the updated RainyDay model to predict the peak discharge at the outlet for each rain event. These hydrographs and peak flows were used to investigate the effect of changing CN on stream response in the Rullands Coulee Watershed.

Figure 13



Map of infiltration sites in the Rullands Coulee sub-watershed.

Results and discussion

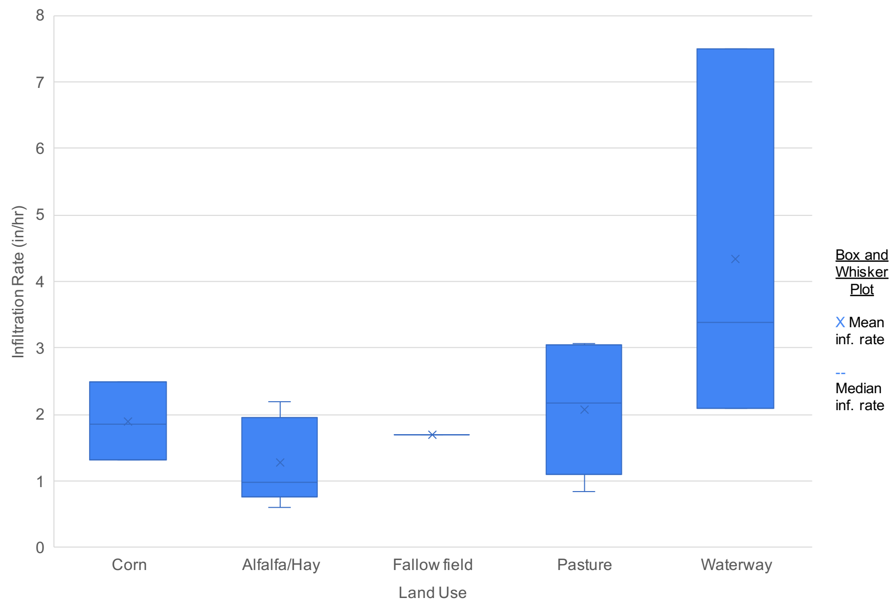
This section analyzes the effect on land use and land management practices on influencing infiltration and the runoff response of the Rullands Coulee Watershed. It evaluates the infiltration rates directly measured on the ridge under various land uses and land management practices. It also highlights recent changes in land use and land management practices in the watershed from GIS and CN analysis.

INFILTRATION RESULTS

Grassed waterways had higher infiltration rates than pasture, corn, alfalfa hay, grassed waterway and fallow field land uses (Figure 14). This finding illustrates the effectiveness of grassed waterways at increasing infiltration rates and potentially reducing runoff, which previous studies support (Carroll et al. 2004, Archer et al. 2013, Anderson et al. 2009). A T-test was used to compare statistically significant differences in infiltration rates between annual land cover and perennial land cover (Figure 15). In this case, annual land cover was categorized as corn and alfalfa as they are seeded annually or semi-annually, and perennial cover included pasture, grassed waterways, and fallow fields. Perennial cover had significantly higher infiltration rates than annual cover (P = 0.04). This finding is supported by Basche and DeLonge (2019), who found that perennial cropping systems increase infiltration rates.

These findings illustrate that infiltration rates decrease with land use intensity, where land use intensity is the sum of materials and labor put into the land per unit area (Dietrich et al. 2012). We see that low intensity land uses (perennial agriculture and grassed waterways) have greater infiltration rates than high intensity land uses (annual crops). Juckem (2003) also found that infiltration rates were inversely related to land use intensity.

Figure 14



A comparison of infiltration rates on different land uses in the Rullands Coulee sub-watershed with a box and whisker plot.

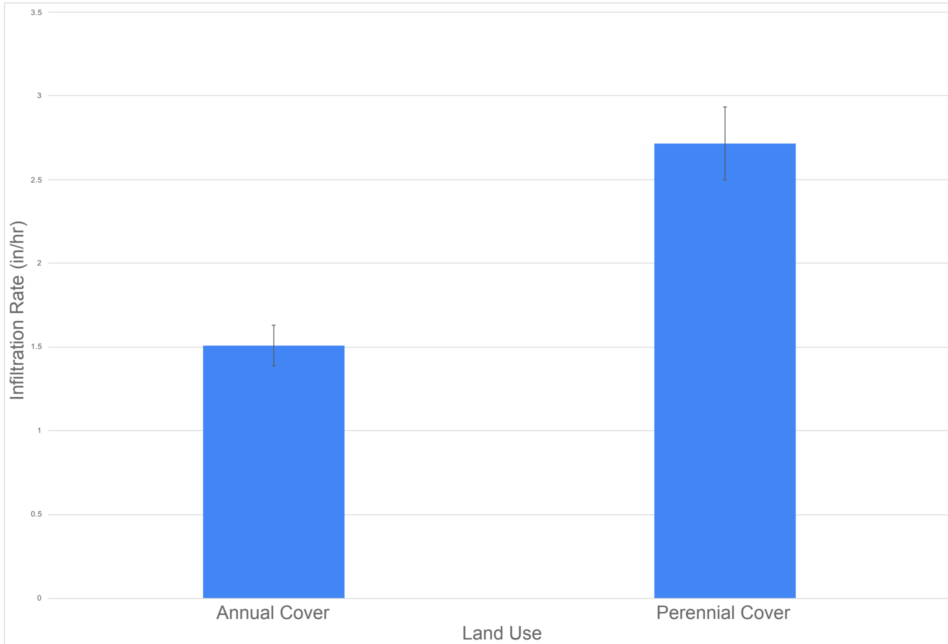
Public fishing access point in the Rullands Coulee watershed where substantial flood damage occurred in 2018 following dam breaches. Photo by Eric Booth

CONTOUR STRIP ANALYSIS RESULTS

After identifying the effect of land use and land management practices in the watershed, we tracked the trends in changing land use and land management practices in the watershed to determine their effect on infiltration, runoff, and stream response. First, we focused on contour strips as they were easily identified in aerial imagery. There was a total loss of 536 acres of contour strip cropping in the Rullands Coulee sub-watershed from 2004 to 2018 (Figure 16). A full summary of the contour strip data can be found in Appendix II.

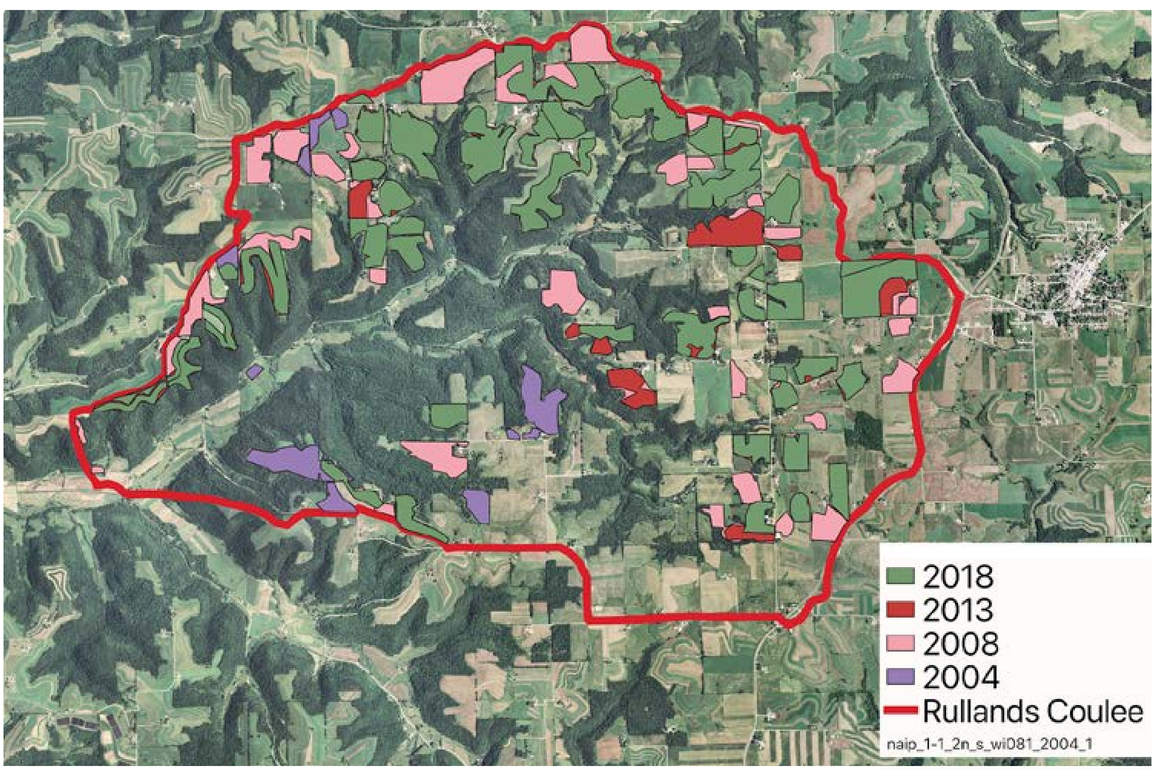
Since contour strip cropping systems help increase infiltration (Karlen et al. 2009), this loss of contour strips may reduce the infiltration capacity of the watershed. However, investigating the change in contour strips alone does not provide a complete picture of the change in infiltration capacity and runoff response of the watershed as other factors (land use change, other land management practices, soil conditions, etc.) also influence infiltration.

Figure 15



A T-test comparison of infiltration rates with standard errors (P=0.04) between annual and perennial cover.

Figure 16



This figure illustrates the areas where contour strips were identified in the Rullands Coulee Watershed. Each color and corresponding year indicate the latest year where contour strips were identified.

CN ANALYSIS RESULTS

To provide a more complete picture of infiltration and runoff in the watershed, the curve number (CN) for the coulee watershed and its ridge and the ridge runoff depth for several design storms were determined for 2004 and 2018 (Table 3). For the ridge only, we see an increase in curve number from 2004 to 2018 and an associated increase in runoff depth from the 100-year flood event. This finding indicates that the Rullands Coulee Watershed's ridge may generate more runoff in 2018 than 2004. However, there is no clear change in CN for the entire coulee watershed from 2004-2018.

To further investigate the change and connect it to stream response, we used the NRCS Curve Number Method to determine the peak discharge at the outlet of the Rullands Coulee Watershed for the 25-year, 50-year, and 100-year floods for six hour and 24-hour events (Figures 17 and 18). There was no notable difference in peak discharge or runoff volume between the two years, but the results illustrate the amount of runoff generated by each storm (Tables 4 and 5). For example, the 2018 rain event in the Coon Creek watershed that caused two dam failures in the Rullands Coulee Watershed was a 100–500-year storm and likely generated more than 5,000 acre-feet of runoff in the Rullands Coulee Watershed resulting in a peak discharge of greater than 4,000 cfs. These values are larger than synthetic runoff and peak discharge of the 100-year storm, which illustrates the magnitude and impact of the 2018 event.

Table 3

	2004	2018
Ridge CN	67.47	70.64
100-yr Ridge Runoff Depth	4.34 in	4.71 in
Rullands Watershed CN	66.24	66.64

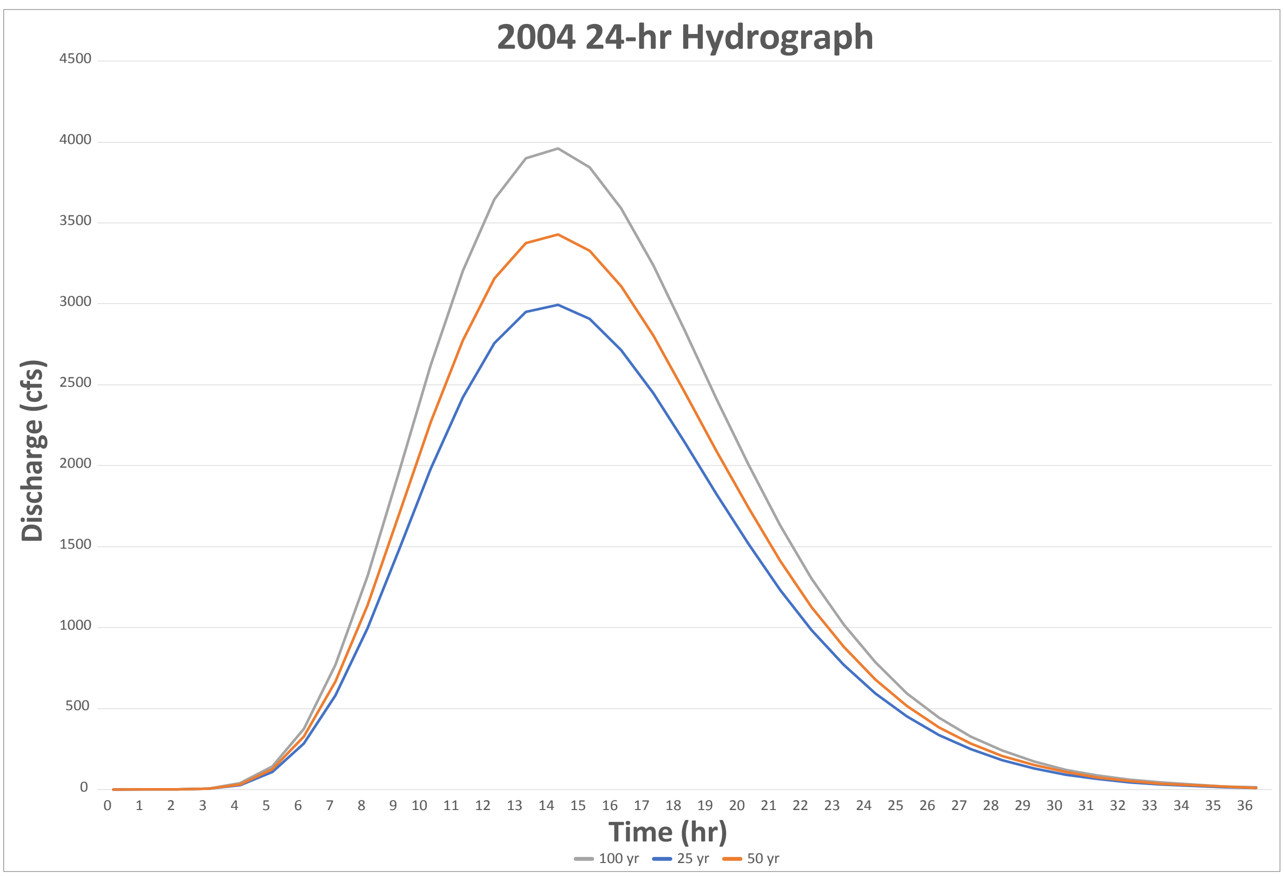
This table reports CNs for the ridge and Rullands Coulee sub-watershed and runoff depths for 2004 and 2018.

Table 4

2004, 24-hr storm		
Frequency	Flood Peaks (cfs)	Runoff Volume (af)
25-yr	2994	3712
50-yr	3429	4250
100-yr	3960	4909

This table reports the results of the NRCS CN Method for 2004, 24 hour storm for 25-year, 50-year and 100-year events.

Figure 17



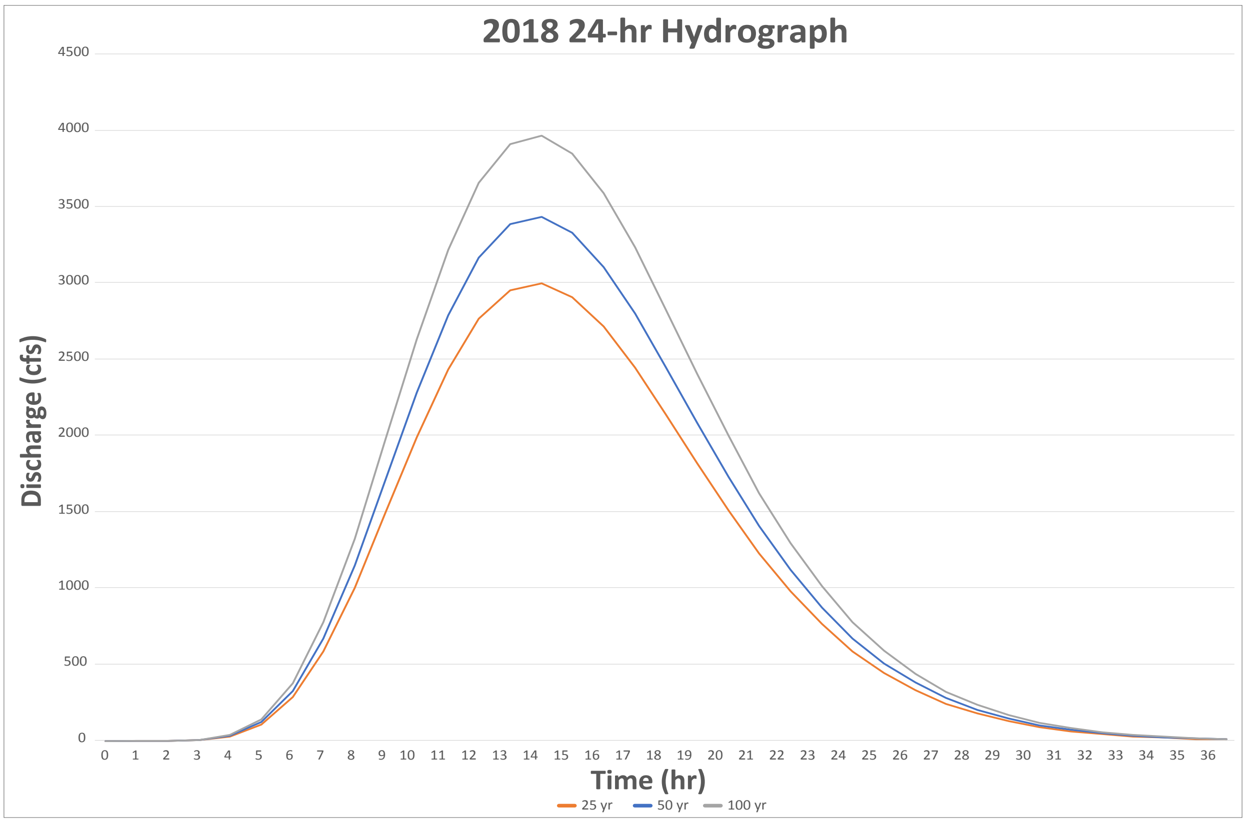
This figure shows the synthetic runoff hydrographs for the 25-year, 50-year and 100-year events for the 2004, 24-hour storm.

Table 5

2018, 24-hr storm		
Frequency	Flood Peaks (cfs)	Runoff Volume (af)
25-yr	2998	3716
50-yr	3433	4256
100-yr	3965	4915

This table reports the results of the NRCS CN Method for 2018, 24-hour storm for 25-year, 50-year and 100-year events.

Figure 18



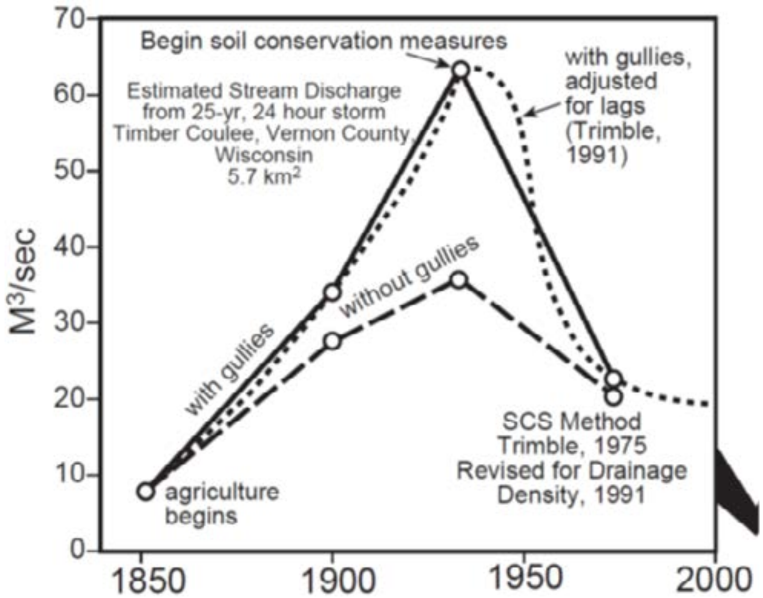
This figure shows the synthetic runoff hydrographs for the 25-year, 50-year and 100-year events for the 2018, 24-hour storm.

TIME OF CONCENTRATION DISCUSSION

Another aspect explored with the NRCS CN method was the effect of time of concentration on stream response in the watershed. Time of concentration is the time for water to flow from the most remote point of the watershed to its outlet, where a shorter time of concentration leads to quicker, greater flood peaks. Trimble (2009) investigated the effect of time of concentration on peak discharge in the neighboring Timber Coulee sub-watershed of the Coon Creek Watershed (Figure 19). Trimble found that conversion to cropland prior to soil conservation projects in the watershed increased flood peaks due to both an increase in the curve number and a reduced time of concentration as cropland generates more rapid runoff. After soil conservation measures, flood peaks decreased as curve number declined and time of concentration increased by slowing the flow of runoff. Trimble also investigated the impact of hillslope gullies on time of concentration and peak discharges. With gullies in place, there's a low time of concentration and a high connectivity to the stream network, so runoff quickly moves into Coon Creek. There is a greater time of concentration without gullies, which also helps block the connectivity of the stream network. The scenario without gullies represents the flow conditions in the watershed prior to European settlement or if gullies were removed. This removal of gullies helps promote infiltration, slow the flow of runoff and reduce the peak discharge.

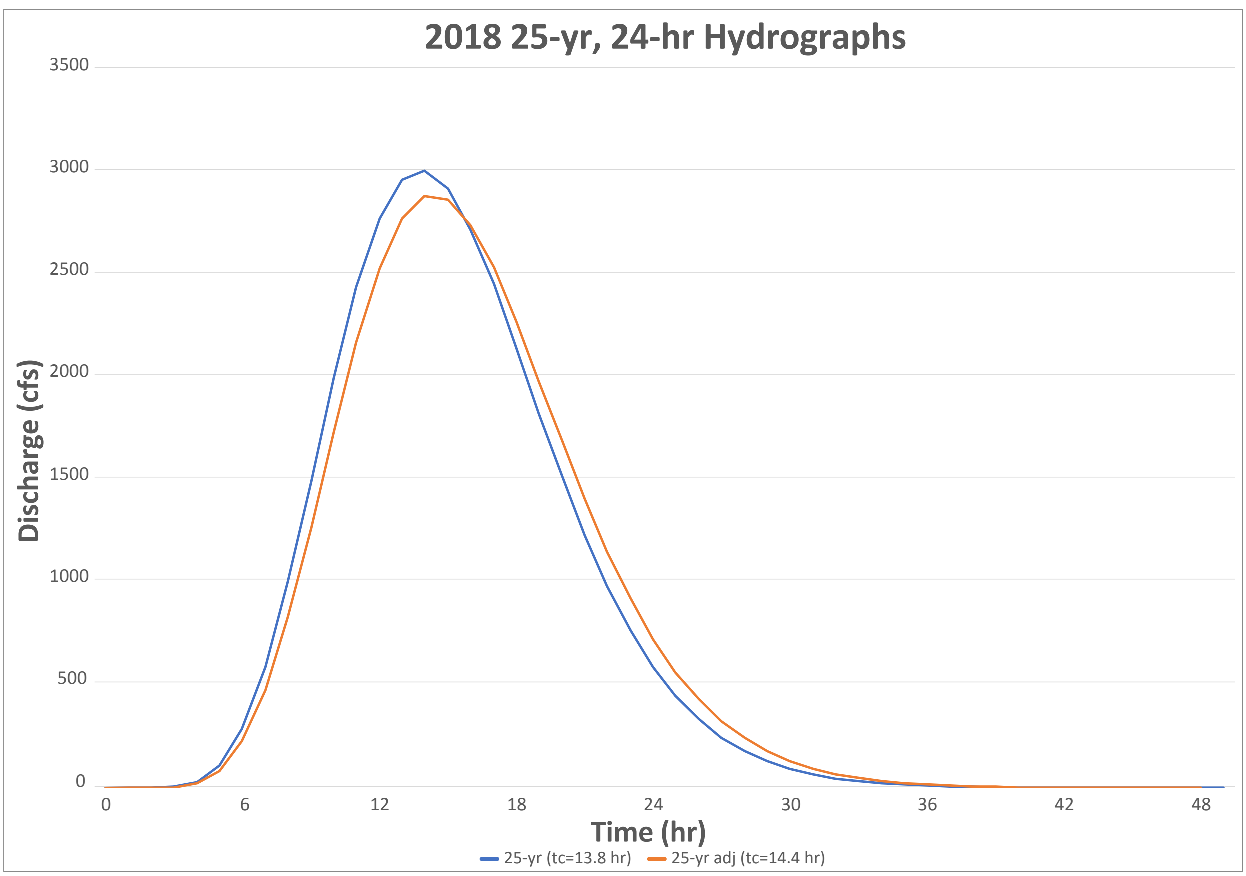
‘Similar to Trimble’s work, the time of concentration was adjusted for the 2018 25-year, 24-hour storm event to illustrate the effect of time of concentration on flood peaks and runoff volume in the Coon Creek watershed. The initial time of concentration from the 25-year, 24- hour flood was 13.8 hour and was arbitrarily increased to 14.4 hour to show the effect of an increased time of concentration (Figure 20). The simulation illustrated that an increased time of concentration decreased the magnitude and increased the timing of the flood peak. This simulated time of concentration increase can be realized in the watershed with effective land management and land use changes, including repairing recently reactivated gullies to promote infiltration, reduce and slow runoff, and reduce flood peaks.

Figure 19



Graph of a change in flood peaks over time for the 25-year, 24-hour storm for the Timber Coulee Watershed with multiple scenarios of with and without gullies. Modified from Trimble (2009).

Figure 20



This figure shows the synthetic runoff hydrographs for the 25-year storm and the adjusted 25-year storm with an increased time of concentration.

Recommendations

Based on our findings in this section, we suggest the following recommendations for helping increase the infiltration capacity and flood resilience of the watershed:

1. **Restore and maintain contour strips and grassed waterways. Our results and literature review illustrate the beneficial impact of grassed waterways and the use of buffer strips in increasing infiltration on the watershed's ridges. However, in recent years, there has been a move away from contour strips in the watershed, as shown by our GIS analysis and anecdotally by Hart (2008). Watershed stakeholders should work to restore and maintain contour strips and grassed waterways in the watershed's agricultural land to increase the watershed's infiltration capacity and decrease its runoff potential. This can be accomplished through a variety of policy initiatives, such as educational outreach, voluntary incentive programs, or a producer-pays approach. Currently, the NRCS uses the EQIP program to help install management practices and its effectiveness and other policy options are discussed further in the Institutions section.**

2. **Promote and implement perennial pasture in the watershed. Our results and literature review also demonstrate that perennial land cover had a higher infiltration rate than annual land cover. In the watershed and across Wisconsin, annual crops are used as feed in the dairy industry and supply for the commodity market, while perennial alfalfa or seeded pasture are also viable options. A move to perennial pasture would help reduce runoff in the watershed. However, enacting this change requires changing a system that dairy farmers have used for generations and dairy farmers have strong influence over state policies. While the barriers are large, a change to more perennial agriculture on a significant amount of the watershed's agricultural land would lead to considerable reductions in runoff and flooding.**

3. **Inform local farmers on impact of conservation practices on runoff generation. An educational campaign for farmers with knowledge and resources to understand the environmental and financial advantages of land management practices would help create a watershed-wide climate that embraces management practices and works to reduce runoff. This campaign could work with current producer-led groups in the region and be run in collaboration with the WDNR and farmers. Given the available resources and present framework, the program would be easy to implement compared to other options. However, education alone does not change farmer behavior and this program relies on farmers to voluntarily install and fund management practices. This program does not guarantee a significant increase in management practices but provides farmers with the knowledge and resources to help reduce runoff and flooding in the watershed.**

4. **Provide more funding for technical staff to help farmers implement management practices and land use changes. This funding would help progress the previous three recommendations as it would aid county and NRCS staff working within the watershed. The watershed has a rich history of conservation and agricultural management practices, so many farmers are aware and looking to adopt best management practices. However, they often lack the resources, funds, or technical assistance needed to install management practices or land use changes. This recommendation would provide the required funding, additional staff, and technical expertise to aid overburdened county conservation departments and NRCS staff in helping promote land use change and best management practices that enhance infiltration in the watershed.**

Students visited the breached dam sites in the Coon Creek Watershed with Monroe County Conservationist Bob Micheel in 2019. Photo by Eric Booth

ECONOMICS OF LAND USE AND MANAGEMENT

Land use plays a critical role in infiltration and flood outcomes throughout the watershed, as demonstrated in the previous section of this report. Changes in land use are driven by many things, including trends at the local, regional, national, and global level. Many drivers of shifts in agriculture and development are not unique to the Coon Creek Watershed. Inducing best management practices and sound land use must operate within these changing patterns. This section will review the microeconomics of an individual agricultural producer adopting best practices to increase flood resilience, as well as the macroeconomic trends that are changing the landscape.

History of land management change

Land use and management practices are intimately tied with agriculture. In the Coon Creek Watershed, the decades-long shift away from dairy is having implications for land use that affect infiltration and flood events.

Agriculture is an important part of the economy in the Coon Creek Watershed and the state as a whole. Wisconsin's agricultural products are traded all over the world, entwining it in macroeconomic shifts that are far beyond the control of a single producer in the region. In the past few decades, there has been a trend of bifurcation in the size of dairy farms (Jackson-Smith & Barham, 2000). Larger farms can increase their economies of scale, resulting in net profits that can sustain operations during times of challenging economic conditions (Macdonald, 2020). Smaller farms have lower overhead costs, leaving medium-sized farms with higher debt-to-asset ratios that force them to close during downturns. The well-known "Get big or get out" approach canonized by President Richard Nixon's Secretary of Agriculture Earl Butz, is largely coming true. In 2019, Wisconsin lost 818 dairy farms, or 10 percent of farms. This was the largest single-year decline in dairies in state history. The recent decline is partly due to sustained low milk prices (Farm Bureau, 2020) but it is also a continuation of a trend over nearly half a century. Between 1980 and 1990, the state lost 11,000 herds, followed by another 12,500 herds in the next ten years. Between 2000 and 2015, there was another decrease of 10,800 herds (Oncken, 2016). In some cases, the loss of dairy farms does not result in fewer cows and less milk. A farm does not sell its cows and raze the barn, but rather is acquired by a larger dairy producer. Bankruptcy or selloffs result in comparatively low prices for larger producers to acquire the newly defunct farm operations. Meanwhile, a single cow has become more productive over the past several decades, due to new technology and better knowledge of medicine, nutrition, and genetics (Runyon, 2016). However, statewide decline in the number of farm operations masks regional shifts that are important to this analysis.

The decline has been equally precipitous in Vernon County, which we use as a proxy for the Coon Creek Watershed given limitations on data scales. The "Get big or get out" approach poses challenges for the Coon Creek Watershed and Driftless Area as a whole, where the steep and rolling topography places natural limits on expansion and consolidation. It is easier to manage 1,000 cows on a big piece of flat land than a contoured parcel with a five percent grade. The loss of dairy farms and cows has subsequent implications for land use. Fields previously designated to pasture are turned into row crops. Hay commonly planted between rows of corn or soybeans in the practice of contour buffer strips is no longer necessary as feed for dairy cows. A watershed manager interviewed for this report summed it up for the Coon Creek Watershed.

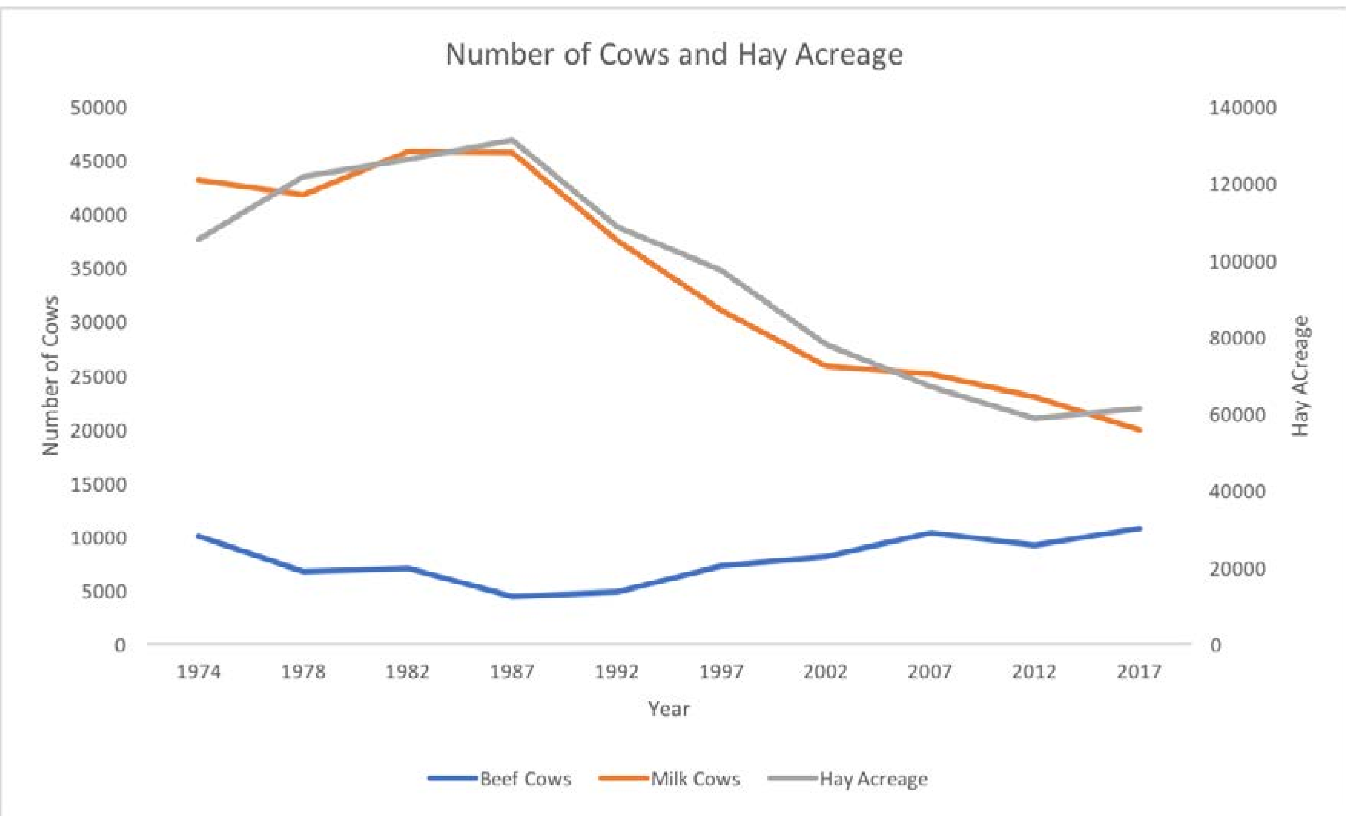
"There are… less animals on the landscape, which means less hay, less contour strips and a lot of conservation practices that our forefathers knew made a really big difference for holding water on the landscape."

Another watershed manager put it this way:

"We're getting a lot of farmers that are getting out of the dairy industry and going into renting or going into cash cropping, corn and soybeans, which are more highly erosive than having hay in your rotation."

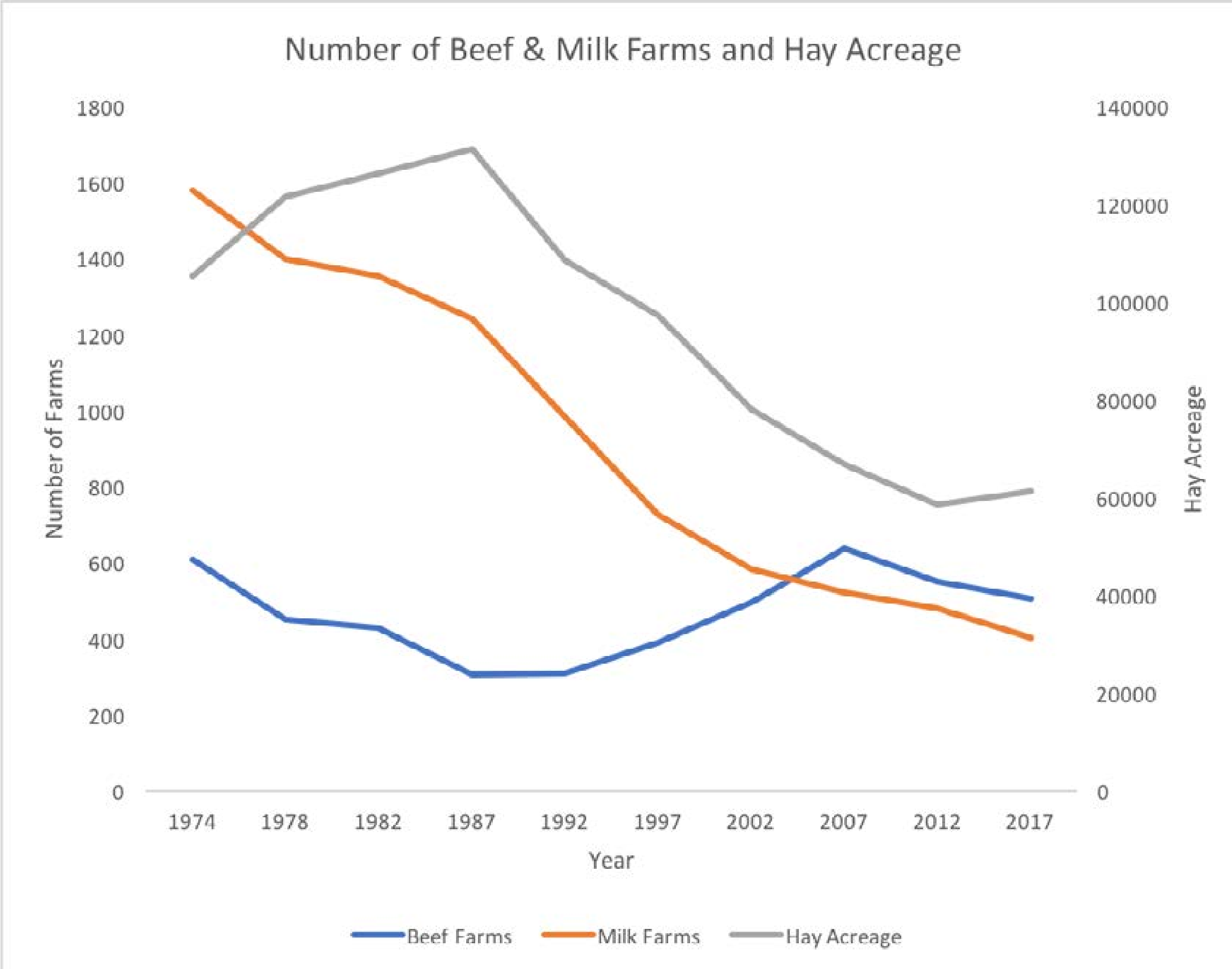
Using data from the Census of Agriculture, conducted approximately every five years, Figure 21 shows the number of milk cows, beef cows, and hay acreage in Vernon County since 1974. Figure 22 shows the number of farms with milk cows, the number of farms with beef cows, and the same values for hay acreage. Taken together, the figures show the decline in milk cows and dairy farms mirrors the decline in hay acreage. Beef operations are steady and possibly increasing, but this trend does little to counter the significant decline in milk cows. In all, the number of farm operations with milk cows has decreased by 75 percent since 1974, with the number of milk cows declining 54 percent. There was a 42 percent decline in hay acreage over the same period.

Figure 21



Data from the Census of Agriculture shows that in the last 50 years the number of milk cows has declined in tandem with the decline in hay acreage in Vernon County.

Figure 22



Data from the Census of Agriculture shows that in the last 50 yars, the number of farms with milk cows has declined in tandem with the decline in hay acreage in Vernon County.

Given the importance of agriculture and the opportunity for agriculture to serve as a leverage point for practices to improve flood resilience, this analysis focused on changing economic conditions as they relate to agriculture. The following section will review the private costs to a producer to implement practices that could improve flood resiliency.

First, we briefly note that there are other economic changes occurring in the region that may also contribute to flood impacts. Although the region is not "urbanizing", according to the Wisconsin Department of Administration the population will grow by approximately 25 percent by 2040 - more than 6,000 people in Vernon County - which can have implications for impervious surfaces as more people build houses and driveways, or communities expand parking lots or commercial districts to accommodate the growing population. Finally, we note that increasing the number of cows on the landscape can result in water quality concerns under certain conditions. Challenges related to water quality are beyond the scope of this report.

COST OF BEST MANAGEMENT

Inducing best management practices as they relate to flood resilience requires the active participation of landowners and producers. However, that participation comes at an initial cost of installation and maintenance, which may be recovered through public or private benefits that are not always included in a producer's decision to install new management practices. The analysis of best management practices earlier in this report identified a variety of practices that can improve infiltration. The costs of three of those practices - contour strip cropping, managed grazing, and cover cropping - are reviewed here.

We performed a Monte Carlo simulation, which repeatedly draws random values from a specified probability distribution to account for the uncertainty in cost and benefits estimates. We wrote a program in Stata that conducted 10,000 random draws to generate 10,000 possible values of costs and benefits for each of the three practices analyzed here. The figures below show the distribution of those costs and, in the case of cover crops, benefits. Table 6 provides a description of the data used in the simulation. All cost parameters were adjusted to November 2020 using the Consumer

Price Index at the U.S. Bureau of Labor Statistics. None of these cost estimates consider the social costs and benefits due to best management practices. For example, the value of reduced flood damage downstream due to the adoption of these practices is not included in these estimates.

Table 6

Variable	Description	Point Estimate	Min/Max	Distribution	Source
Contour Strip Cropping					
Land rent	Opportunity cost of using land for less economically productive use	$129/acre	$101/$142	Triangle	USDA NASS County Cash Rent 2020
Seed cost	The cost of seed for buffer strips (Oats, Grass mix, Alfalfa)	$61.64/acre	$18.53/$84.37	Triangle	Duffy 2015
Surveying	Cost of field survey to develop contour lines	Unknown	$27.25/$54.5	Uniform	Duffy 2015
Drilling	The cost of planting buffer strip seed	$16.73/acre	Unknown	Unknown	Duffy 2015
Managed grazing					
Installation cost	The cost of fence posts, wiring, watering systems, and labor	$100.90/acre	$71.48/$296.92	Triangle	Munsch 2021
Seed cost	Cost of seed for grazing (pasture mix)	$108.34/acre	Unknown	Unknown	Duffy 2015
Equipment cost	The cost of preparing a field for managed grazing (tandem disk, field cultivate, drilling)	$46.29/acre	Unknown	Unknown	Duffy 2015
Land rent	Opportunity cost of using land for less economically productive use	$129/acre	$101/$142	Triangle	USDA NASS County Cash Rent 2020
Harvest savings	The benefit to the producer from reduced harvest costs	$65.90/ton haylage	Unknown	Unknown	Bay et al. 2016
Hay tons	The tons of hay per acre that would otherwise be harvested	2.4 tons	1.6/4	Triangle	Bay et al. 2016
Cover Cropping					
Seed cost	The cost for seed to plant as a cover crop	$15/acre	$10/$50	Triangle	SARE 2020
Planting cost	The cost of planting the cover crop	$18/acre	$5/$20	Triangle	SARE 2020
Termination cost	The cost of terminating the cover crop before the growing season	$0/acre	$0/$10	Triangle	SARE 2020
Increased yield	The benefits of increasing the yield and sale of crops during the growing season	$0/acre	$0/$23.89	Triangle	SARE 2020
Fertilizer savings	The benefit due to reduced costs of purchasing and applying fertilizer	$0/acre	$0/$20	Triangle	SARE 2020
Herbicide savings	The benefit due to reduced costs of purchasing and applying herbicide	$0/acre	$0/$20	Triangle	SARE 2020

Managed rotational grazing can be an effective practice for enhancing infiltration. Photo by Finn Ryan.

There are some important assumptions in this model. First, we assume there are no benefits to the producer. Second, we assume that all acreage requires surveying, which may not be true of parcels that have recently been strip cropped. Finally, we assume the cost of harvesting is unchanged compared to a non-contour strip practice.

Although the mean cost is $236/acre, parcels that do not need a survey or have lower cash rent values would see a lower cost per acre, possibly as low as $164/acre. On the other hand, parcels that are more economically valuable or see higher drilling and harvesting costs due to the complexity of the contours may see higher costs, up to $297/acre.

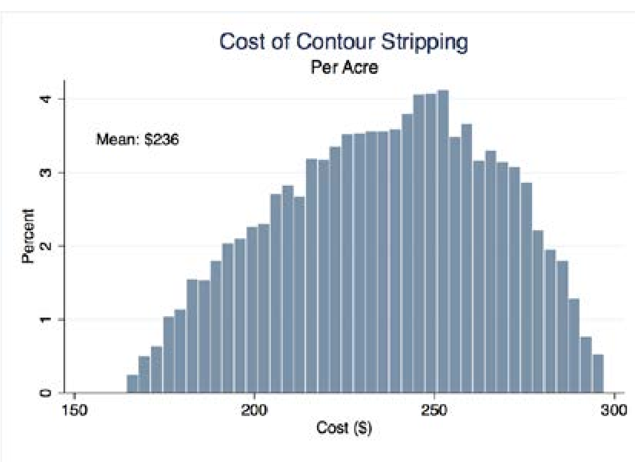
Contour Strip Cropping

As stated, the decline in dairy in the region contributed to a reduction in contour strip cropping. Producers seeking to develop or recover some strip crop acreage will bear some costs to do so, including the cost of seed, surveying the landscape, drilling (or sowing the seed) and the opportunity cost of converting land away from a more economically productive use. Figure 23 shows the distribution of estimated cost per acre to develop contour strips. The mean cost to convert one acre of row crop to a contour strip is $236/acre, with a minimum of $164/acre and a maximum of $297/acre.

Cover cropping

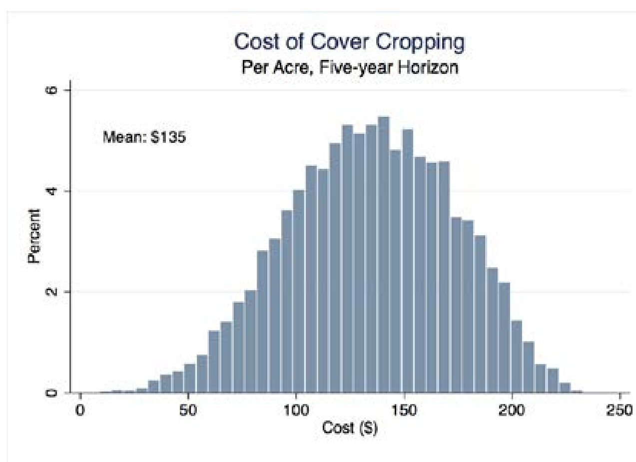
Although cover cropping is not a popular practice in the Coon Creek Watershed, it provides an additional opportunity to increase infiltration on the landscape (Basche & Delonge, 2019). Costs associated with adopting cover crops include the cost of seed, planting and termination. However, there are also potential benefits to the producer through increased yield and reduction of fertilizer and herbicide costs (SARE 2020). Figure 24 shows the distribution of estimated cost per acre for cover cropping over a five-year time horizon with a discount rate of five percent. The mean net cost to begin cover cropping one acre over five years is $134/acre, with a minimum net cost of $9/acre and a maximum net cost of $232/acre.

Figure 23



A Monte Carlo simulation of the costs and benefits of contour strip cropping shows an estimated mean cost of $236/acre.

Figure 24



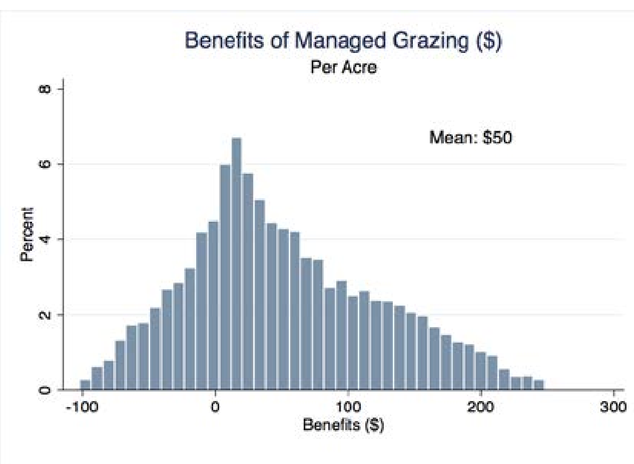
A Monte Carlo simulation of the costs and benefits of cover cropping shows an estimated mean cost of $135/acre discounted over a five-year time horizon.

In this model, we assumed that the application of cover crops occurred annually, with the cost of seed, planting and termination, and benefits of increased yield and reduced input costs in each of the five years, discounted to a present value. We also assumed that substantial benefits of increased yield and fewer fertilizer and herbicide inputs were rare and minimal, which is reflected in the distribution used for those parameters being centered on zero. This assumption suggests these estimates are conservative. Additionally, a discount rate of five percent reflects an assumption that producers will remain on the land long enough to realize long-term benefits. A producer who is more driven by short-term profits may seek a higher discount rate. However, given that all parameters are discounted over the five-year time horizon, a higher discount rate does not result in significantly different cost estimates. For example, a 12 percent discount rate returns a mean cost of $119/acre over five years. Finally, these estimates assume no additional costs or benefits beyond five years. The expected benefit of increased yield grows over time as cover crops continue to enhance soil health and reduce erosion. It is possible that over a longer time horizon, the benefits of cover crops would begin to outweigh the costs to the private producer.

Managed grazing

Managed or rotational grazing represents a potential opportunity for producers with livestock to increase the infiltration rates of their land. Additionally, the practice could generate private benefits for the producer. The bulk of costs associated with managed grazing are related to the initial installation of the practice, which can include fencing and watering systems. There are also seed costs and the cost of preparing and planting a field that was previously under a different use. Benefits accrue to the producer through a reduction in the cost of harvesting and in the offset of costs that would otherwise be required through the purchase of feed. Figure 25 shows the distribution of estimated benefit to institute managed grazing on a single acre. Note that in this figure, contrary to the previous figures on cover cropping and contour strips, the benefits are displayed as positive values.

Figure 25



A Monte Carlo simulation of the costs and benefits of managed grazing shows an estimated mean benefit of $50/acre.

The cost of managed grazing is primarily driven by the installation costs. Additionally, we assume that the land is already owned by the producer and is being used in a more conventional grazing method. We do find benefits to the producer through a reduction in harvest costs and the cost of feed for livestock. These benefits, which we model over a five-year time horizon discounted back to present value, more than offset the costs of installation in most cases. Therefore, the mean benefit of a managed grazing operation is approximately $50 per acre, with potential benefits ranging up to $248 per acre. On the low end, this model shows that a managed grazing program could result in costs to the producer through the five-year time horizon of up to $102 per acre. However, these costs would be mitigated if the managed grazing program continued beyond five years, as the benefits of harvest and feed savings would continue to accrue. There are also potential benefits of higher price premiums for dairy or beef products that are grass-fed. Contrary to the contour strip and cover crop models, the managed grazing model suggests the private producer is likely to see increased income by implementing a managed grazing system. Producers may choose not to adopt a practice - even one that would generate more income - due to lack of knowledge or technical expertise on the topic. Therefore, regional support or endorsement of a managed grazing program should include technical resources and education for producers.

The three cost estimates for best management practices presented here suggest that a producer is likely going to bear a cost to implement these practices. Although good stewardship of the land and a conservation ethic are strong within the region, these cost burdens create a barrier to implementing these practices.

The broader social benefits - benefits accrued to the larger community - such as increased infiltration to reduce flood damages, have incentivized governments to fund programs that help offset some of these costs that would otherwise be borne solely by the producer. In Wisconsin, the most common cost-share program requires counties to supply 70 percent of the funding for a land management practice in order for a landowner to be compelled to adopt the change. Earlier in the report, we reviewed the institutional landscape of another cost-share program housed in the NRCS.

Recommendations

An earlier section of this report demonstrated that there are best management practices that can reduce flood impacts. However, changes in land use on private farms requires consideration of the microeconomic environment in which those changes must operate. In other words, it would be easy to tell all producers to institute managed grazing, contour strips, and cover crops, but the reality is that many producers are unable or unwilling to do so, particularly given the up front costs related to these practices demonstrated here.

Based on our findings in this section, we suggest the following recommendations to help address the economic challenges of land use and management changes. Broadly, we recommend providing funding to producers to aid in the initial installation costs of these practices. This can be accomplished two ways, both of which are related to the existing producer-led watershed protection program, which provides grants to groups of local producers to implement practices that address non-point source pollution. In both cases, funding would be provided by the State of Wisconsin.

1. **Expand the program goal of the producer-led watershed protection program to include improvement of infiltration in addition to improvement of soil and water quality**

Operating within the existing framework of the producer-led watershed protection program would reduce redundancies in program creation and implementation. Additionally, expanding the existing program would allow producer groups focused on infiltration and flood resilience to benefit from the existing strength and public image of the program. The producer-led model is broadly praised for its reliance on local knowledge and leveraging the trust that producers harbor for one another when it comes to adopting new practices, rather than mandates coming down from a state or federal agency that is far from the field. Finally, land management practices that improve infiltration can also have co-benefits of water quality improvement, which would align with the existing program goals. Funding for the program has grown in recent years, including a 33 percent increase up to $1,000,000 in the 2021-23 state budget.

2. **Develop a separate program within the Department of Agriculture, Trade and Consumer Protection (DATCP) specifically targeted at improvement of infiltration and flood resiliency**

Alternatively, the Department of Agriculture, Trade and Consumer Protection (DATCP), the agency that administers the producer-led watershed protection program, could create a separate program targeted at improving infiltration and flood resilience. Separating the programs could mitigate the concern with the water quality-focused programs - that public dollar should not be provided to polluting producers - because a single producer does not cause a flood. Gradual increases in funding for the producer-led watershed protection program suggests there may be funding support for a similar program with a flood resilience focus.

COMMUNITY RESILIENCE

Figure 26

Images of the August 2018 flood in the Coon Creek Watershed. From left to right: flooding in Coon Valley (WKBT/CNN, 2018), residents laying sandbags to protect property in Monona, WI (Mesch, 2018), business owner cleans out damaged building (La Crosse Tribune, 2018), Scott Walker talks to rescue firefighters in Coon Valley (Todd Richmond, 2018).

Introduction

Faced with continual devastation, communities such as the Coon Creek Watershed strive to develop attitudes, customs, and preparedness and response strategies. As defined by John Twigg (2009) in the document *Characteristics of a Disaster-Resilient Community*, community resilience is the capacity of a community to “anticipate, minimize and absorb potential stresses or destructive forces through adaptation or resistance, manage or maintain certain basic functions and structures during disastrous events, and recover or ‘bounce back’ after an event”. A community’s choice to focus on resilience means understanding what the community is doing and can do for themselves. It means strengthening capacity and ability rather than concentrating on their vulnerability to disaster or environmental shock. It is important to note that communities are also affected by their surroundings: environmental, economic, and social. Therefore, the level of community resilience can also be affected by other capacities such as emergency services, policies, and the landscape (Twigg, 2009).

Resilience is critical for any community faced with repeated flooding. In response to this stressor, communities develop characteristics such as the ability to learn and evolve coping mechanisms and being physically and mentally prepared for future hazards. These resilience characteristics are integral to the ability of a community to reduce long time recovery periods after a disaster (Chandra et al., 2011). According to the International Consortium for Organizational Resilience (2021), all communities consist of five primary systems which contribute to the community’s resilience and vulnerability. They include a healthy environment, responsible governance, strong economy, a prepared system, and a high quality of life. Where there are many frameworks and idealistic standards of resilience “there is less clarity on the precise resilience-building process” (Chandra et al., 2011). The general understanding, however, is that community resilience is important in reducing, mitigating, and recovering from disasters.

The Coon Creek Watershed is not a singular community but instead a geographical area that contains individuals who each belong to many overlapping communities defined not only spatially, but also by shared interests and values. While not uniform or singular, as a whole, Coon Creek communities have shared experiences and knowledge of flooding and have developed a community of resilience. Both as individuals and as a collective, resiliency in the sense of adaptation and perseverance has become a way of life. Some common practices that were identified in the interviews among individuals included not finishing basements, increasing infiltration on their property, and always being aware of the weather. As a collective, themes of shared hardship, volunteer emergency rescue teams, and flood awareness have emerged.

Evidenced by interviews conducted for this report, people in the community have many different experiences of resilience. Many participants mentioned the floods of 2007, 2008, and 2018, which provided an understanding of how communities and individuals experience resilience. The resilience of an individual entails overcoming the trauma of experiencing multiple consecutive floods, overcoming the financial burden of damage and loss to property, or implementing mitigation measures on their property and homes to prevent future damage. The experience of resilience as a community was noted to be extremely important. At a smaller scale, those who experienced and were impacted by significant flooding in the valley mentioned that their community did not include ridgetop landowners. Our interviews with residents of the valley revealed that their need for resilience was a constant consideration and at a higher level of urgency. Their awareness of future flooding and mitigation measures manifested at a more significant level of perception and necessity.

Community experience of resilience on a watershed level starts to incorporate multiple levels of community such as neighborhoods, local municipalities, and even government agencies. Within larger groupings a need emerges for different types of communication, organization, and infrastructure. In this sense, community resilience incorporates a multitude of different inward and outward facing strategies. Some of these strategies involve access to financing, pre- and post-disaster community mitigation measures, infrastructure development, coordination and communication between different levels of government, education, and trust in leading organizations. These become foundational to local capacity when dealing with disasters.

The communities in the Coon Creek Watershed have a strong motivation to endure. They have chosen to be resilient. Many generations have lived in this area and have developed their livelihoods based on the land in this region. Even when formal structures, such as governing institutions, do not provide the support that is needed for flood management these communities have seen that they can fill in whatever gaps there are with community action. There is a mismatch in where funding and support are going and where they are most needed. From the results of this analysis of disaster resilient community characteristics, we expect to show that if we can connect community actions with formal governance and identify areas of vulnerability, flood management can be improved.

Methodology

We used two main methods in the research for this analysis starting with a document analysis and literature review. This involved analyzing peer reviewed literature and primary sources such as government documents. Formats we used in this analysis included aggregation of research papers, journal articles, procedure documents, and online books. Sources include international and community-based agreements and frameworks that have been used to inform community resilience and reduce disaster risk.

The second method was to identify vulnerabilities and capacities of resilience within communities of the Coon Creek Watershed. We used the document, *Characteristics of a Disaster-Resilient Community* by Twigg (2009) as the framework for this categorical analysis. Based on a review of multiple disaster resilience frameworks, we chose this document because it was the most comprehensive and detailed and based upon an internationally approved disaster risk reduction plan, the "Sendai Framework". It contains detailed elements of resilience that describe the "ideal" resilient community. Five overarching thematic areas each contain three to seven components of resilience with each component containing five to fifteen characteristics and enabling environments. To limit scope and keep the analysis relevant to the Coon Creek Watershed, we limited analysis to the components that were most applicable to the Coon Creek Watershed. With the understanding that community resilience is a combination of all five of the thematic areas, we chose at least one component from each area to compare to the Coon Creek Watershed. These are highlighted in green in Table 6.

We used the interviews conducted for this report (Public Perspectives (pg. 6)) as well as information gleaned from informal conversations and compared them to the characteristics used to determine how they fit into the framework. This process provided us with a clearer understanding of the scale of resilience that exists within communities in the Coon Creek Watershed. Using this framework enabled us to identify gaps and vulnerabilities. We subsequently developed recommendations on community flood management strategies for Monroe, Vernon, and La Crosse Counties based on strategies uncovered in the literature review and interviews. The recommendations are concrete actionable items that these communities can take to enhance resiliency.

COMMUNITY RESILIENCE FRAMEWORKS

Most community resilience work is based around reducing disaster risk. This involves reducing the immediate effects of a disaster on a community. There are many documents outlining recommendations to increase resilience but not many that outline and identify indicators of a resilient community. As part of the literature review, we compared many different resilience frameworks, documents, and scorecards. A few international documents and research projects based around reducing disaster risks exist such as one endorsed by the European Union, "The Sendai Framework for Disaster Risk Reduction 2015-2030" and the Community Resilience Framework (2016) developed by the International Consortium for Organizational Resilience. There are also a number of national documents, two of which include the "Homeland Security Advisory Council's Community Resilience Task Force Recommendations" and "Building Community Resilience to Disasters: A Way Forward to Enhance National

Health Security". Locally, Wisconsin Sea Grant and the Wisconsin Department of Health Services have created a community self-assessment called the Flood Resilience Scorecard.

The Sendai Framework for Disaster Risk Reduction 2015-2030 (UNDRR, 2015)

The Sendai Framework was developed by the United Nations Office for Disaster Risk Reduction as the successor to the Hyogo Framework for Action (2005 - 2015) with engagement from stakeholders and intergovernmental negotiations. It is one of the only internationally agreed upon frameworks for disaster risk reduction and was endorsed by the European Union. It was designed to "work hand in hand with other 2030 Agenda agreements, including The Paris Agreement on Climate Change, The Addis Ababa Action Agenda on Financing for Development, the New Urban Agenda, and ultimately the Sustainable Development Goals" (UNDRR, 2019).

The goal of this framework is to "Prevent new, and reduce existing, disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience." In order for this to be accomplished the framework outlines four priorities of action, seven global targets, and 38 indicators.

The priorities for action provide guidance to communities for where to invest in disaster risk reduction. These areas include: (1) Understanding disaster risk, (2) Strengthening disaster risk governance to manage disaster risk, (3) Investing in disaster risk reduction for resilience, (4) Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction.

The seven targets are global goals to reach by 2030. They include: (1) Reduce global disaster mortality, (2) Reduce the number of affected people globally, (3) Reduce direct economic loss in relation to GDP, (4) Reduce disaster damage to critical infrastructure and disruption of basic services, (5) Increase the number of countries with national and local risk reduction strategies, (6) Substantially enhance international cooperation to developing countries, (7) Increase the availability and access to multi-hazard early warning systems. Focusing on these areas aim to increase resilience, reduce impact of current risk, and prevent creation of future risk. In order for communities to assess their progress towards these targets, the Sendai Framework has also developed 38 indicators to "measure progress and determine global trends in the reduction of risk and losses".

Community Resilience Framework by the International Consortium for Organizational Resilience (ICOR, 2021)

The Community Resilience Framework outlines the theory and concepts of community resilience. As noted previously this framework consists of five fundamental legs upon which a system of resilience is sustained. Understanding community resilience as a system encourages focusing on the function of the system as a whole. Where, if each part of the system functions effectively it prompts adaptive capacity, and if not, it becomes "more vulnerable and less able to manage change and endure stress. A community relies on its systems to be strong and flexible, to be able to evolve and adapt when necessary, and to be sufficiently agile to take advantage of opportunity"

Figure 27

Chart of the Community Resilience Framework organized by the International Consortium for Organizational Resilience. Portrays the 4 components of societal resilience for a disaster.

The Community Resilience framework includes five systems: 1) A Healthy Environment which seeks to protect and restore natural resources while reducing the impacts of climate change through adaptation and mitigation; 2) Responsible Governance protects its community members and provides them with needed services, effectively manages and adapts to budgetary changes, is self-sustaining, and enforces its laws humanely; 3) Strong Economy is one where community members have access to good jobs and wages based on education, is diversified, maintains its currency and produces necessary resources; 4) Having a Prepared System involves networks and partnerships with community members and organizations where preparedness and resilience practices are widespread; 5) A high quality of life involves access to more than just basic human rights; it involves access to education and information, social freedoms, employment and prosperity, and the feeling of safety and security.

This framework is an idealized vision of community resilience. It contains elements of resilience, goals, and explanations of how each piece of the puzzle fits together. There is no road map or any type of guidance for communities on how to get to this place of resilience. Rather, this framework aims to be an international standard that professionals can be trained in order to bring this type of organization back to their communities.

Homeland Security Advisory Council: Community Resilience Task Force Recommendations (US Department of Homeland Security 2011)

After the terrorist attack on the United States on September 11, 2001, and with the urgent threat of climate change, national resiliency became one of the most pertinent questions the Department of Homeland Security (DHS) was tasked with understanding. Some of the questions that had to be confronted included: How can we increase individual and community engagement and participation in resilience capacity building and sustainment? How should we build, design, and incorporate security and resilience into urban planning? How can we better plan and acquire resources across the federal government in support of national, regional, state, tribal, local, and individual resilience efforts?

DHS created the Community Resilience Task Force (CRTF) to develop recommendations that aimed to answer these questions taking into account the understanding that community resilience ensures resilience to disasters and therefore is imperative to homeland security. This resilience "is about enabling and mobilizing American communities". One of the CRTFs findings was that many communities are already encouraging preparedness capabilities, however, they are rarely linked explicitly to resilience in the form of risk reduction and preparedness. DHS promotes community resilience and prioritizes risk reduction through preparedness and outcomes of resilience.

The CRTF identified three separate facets related to building national resilience. They include "community resilience stemming from people, their individual and collective actions, and resilience of the built environment that delivers essential services to the communities and regions in which people live". Recommendations were found for each of these categories. However, ones specifically related to community resilience are listed here: (1) Build a Shared Understanding of the Shared Responsibility, (2) Build a Coherent and Synergistic Campaign to Strengthen and Sustain National Resilience, (3) Organize for Effective Execution, (4) Build the Knowledge and Talent Base for Resilience.

Building Community Resilience to Disasters: A Way Forward to Enhance National Health Security (Chandra et al., 2011)

"Building Community Resilience to Disasters" was sponsored by the U.S. Department of Health and Human Services Assistant Secretary for Preparedness and Response to understand how national health security plays a role in community resilience, disaster response and recovery. This document aims to fill the need for "a roadmap or initial list of activities that communities could implement to bolster community resilience specific to national health security". It is meant as an instrument local governments and planners can use to plan for and enhance resiliency. Many of the components are akin to a how-to guidebook. The framework includes overarching components of resiliency, levers that act to fulfill the components, elements which are outcomes affecting the levers, and actions which are ways to achieve each element.

Using national health as a lens for community resilience, Chandra et al. (2011) developed a working definition of community resilience to guide the framework: "Community resilience entails the ongoing and developing capacity of the community to account for its vulnerabilities and develop capabilities that aid that community in (1) preventing, withstanding, and mitigating the stress of a health incident; (2) recovering in a way that restores the community to a state of self-sufficiency and at least the same level of health and social functioning after a health incident; and (3) using knowledge from a past response to strengthen the community's ability to withstand the next health incident."

By using the three key components of community resilience in the definition, the levers, which act to strengthen and fulfill the components could be identified: wellness, access, education, engagement, self-sufficiency, partnership, quality, and efficiency. Associated with each lever are activities and processes that communities are encouraged to use to build resiliency. They involve actions on multiple organizational levels, functional partnership and networks, policy frameworks and suggestions, communication strategies, engagement capacity, among others. While many of the components in this guide are laid out in a step-by-step comprehensive nature, they are not intended as a one-size-fits-all solution. Each community is different and has different levels of capacity and vulnerability; so, these guidelines need to be adapted accordingly.

The Flood Resilience Scorecard - The Wisconsin Sea Grant Institute (Wisconsin Sea Grant, 2020)

The Flood Resilience Scorecard is a comprehensive, whole community approach focused tool to assist communities in assessing their vulnerability to flooding. The scorecard, developed in a partnership between the Wisconsin Department of Health Services and Wisconsin Sea Grant, assesses resilience through three different lenses: environmental, institutional, and social. Communities score themselves on a variety of metrics related to the three categories and then receive recommendations on ways to improve flood resilience based on their scores.

The Environmental Module examines flood vulnerabilities related to the natural and physical landscape. This includes exogenous characteristics of the region such as precipitation patterns, slope and elevation, and soil types. It also includes more human-driven characteristics such as land use and implementation of best practices in agriculture.

The Institutional Module reviews the governance and infrastructural capacity of a community to address flooding, including policy content. This includes the adequate resource inventory, floodplain mapping, land use planning, and enforcement of standards. It also includes a human capital component, or the presence of adequate staff and technological capacity to fully participate in flood resilience.

The Social Module explores the broader community capacity and social capital needed to adequately respond to and mitigate flood events. This includes an analysis of the demographics, transportation, and housing characteristics of a community to determine potentially vulnerable populations. It also includes a review of the short- and long-term health impacts of flood events, the cohesion of businesses and community organizations, and the capacity for a community to engage in education and outreach related to flooding.

To complete the scorecard, communities will need proficiency in GIS, engineering, planning, community development, and public health officials. Many small communities, such as those in the Coon Creek Watershed, lack the internal staff to complete the scorecard. Therefore, communities should look to partner with their county, regional planning commission, and other organizations to assist in completing the scorecard. Absent the resources to fully participate in the scorecard, communities can still use the framework provided in the scorecard to engage in conversations about flood resilience in their communities.

Characteristics of a Disaster-Resilient Community, Version 2 - (Twigg, 2009)

"Characteristics of a Disaster-Resilient Community is a guidance note for government and civil society organizations working on disaster risk reduction (DRR) and climate change adaptation (CCA) initiatives at community level in partnership with vulnerable communities" (Twigg, 2009). This schema has been used with communities since 2007 at the local level to encourage self-sufficiency and resiliency in times of disaster. Twigg's framework of community resilience can help to illustrate how communities in the Coon Creek region have developed behaviors to adapt to persistent flooding and how these communities compare to the resilient indicators within the framework.

Figure 28

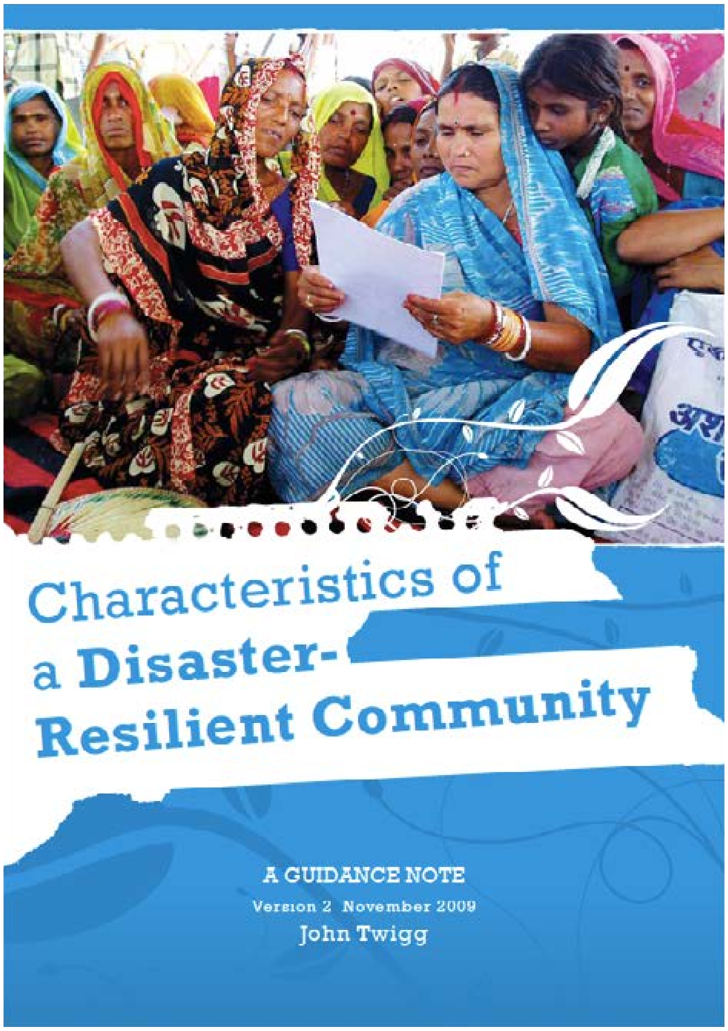


Image of the *Characteristics of a Disaster-Resilient Community* report by John Twigg (2009). This report, version 2, had been ground tested and adapted by numerous communities internationally.

FRAMEWORK FOR RESILIENCE

We chose *Characteristics of a Disaster-Resilient Community* by John Twigg (2009) as the framework to identify the capacities and vulnerabilities of communities to disasters. This framework was chosen over others, such as those mentioned above, because it is an empirically based framework with easy-to-use assessment indicators. It is comprehensive, objective and easily adaptable to the Coon Creek Watershed. It not only contains characteristics of community resilience but also investigates the types of environments that enable the characteristics to succeed such as political climate, community organization, and local government resources.

Known as *The Characteristics*, this document is a framework that describes different elements of the "ideal" resilient community. It provides examples of how a community might achieve these resilient practices. These characteristics are based on the Hyogo Framework for Action 2005-2015, developed by the UN International Strategy for Disaster Reduction, the most widely accepted scheme for disaster risk reduction (DRR). The current DRR strategy is the Sendai Framework for Disaster Risk Reduction 2015-2030. The contribution of *The Characteristics* to these frameworks is that it helps fill the gaps in qualifying and quantifying a disaster resilient community.

The Characteristics is divided up into five different thematic areas, each containing three to seven components of resilience. Within each component is a detailed list of characteristics that describe the ideal resilient community. Additionally, each component lists characteristics of an enabling environment which describe environments in the community that allow the resilient characteristics to flourish. The list of thematic areas and characteristics are listed in Table 7.

Table 7

Thematic Areas	Components of Resilience
Governance	• Policy, planning, priorities and political commitment • Legal and regulatory systems • Integration with development policies and planning • Integration with emergency response and recovery • Institutional mechanisms, capacities and structures; allocation of responsibilities • Partnerships • Accountability and community participation
Risk Assessment	• Hazards/risk data and assessment • Vulnerability/capacity and impact data and assessment • Scientific and technical capacities and innovation
Knowledge and Education	• Public awareness, knowledge and skills • Information management and sharing • Education and training • Cultures, attitudes, motivation • Learning and research
Risk Management and Vulnerability Reduction	• Environmental and natural resource management • Health and wellbeing • Sustainable livelihoods • Social protection • Financial instruments • Physical protection; structural and technical measures • Planning régimes
Disaster Preparedness and Response	• Organizational capacities and coordination • Early warning systems • Preparedness and contingency planning • Emergency resources and infrastructure • Emergency response and recovery • Participation, voluntarism, accountability

Thematic Areas and Components of Resilience from the document *Characteristics of Disaster Resilient Communities*, Twigg, 2009.

Results

Comparative analysis was conducted using the *Characteristics of a Disaster Resilient Community* framework to identify areas where communities in the Coon Creek Watershed are resilient and where there is room to improve. These will be denoted as capacities and vulnerabilities. The capacities and vulnerabilities identified were gathered from interviews, information gleaned from informal conversations and interactions, and our research and analysis.

GOVERNANCE

Table 8

Resilient component	Capacities	Vulnerabilities
Institutional mechanisms, capacities and structures; allocation of responsibilities	•Collaboration and communication between county conservationists is prevalent.	•Community disaster plans are hard to find and/or understand and the process of writing them might not include all stakeholders. •There is a lack of clear roles and responsibilities between government organizations. •There are barriers to obtaining necessary disaster recovery funds. •Non-local governments respond slowly to problems requiring immediate action. •There are insufficient community-managed funds for DRR and disaster recovery.
Accountability and community participation	•Interviewees repeatedly reported trust amongst community members. •Interviewees reported trust between community, facilitating organizations, and local government agencies. •Public meetings are held to plan for and implement flood resilience. •Interviewees repeatedly reported high levels of volunteerism.	•Changes in land use exacerbate flooding. •Interviews revealed widespread public volunteerism post disaster but less long-term entire community flood mitigation work.

RISK ASSESSMENT

Table 9

Resilient component	Capacities	Vulnerabilities
Hazards/risk data and assessment	•Vernon County has an updated "Multi-Hazards Mitigation Plan" for 2018-2022. This plan describes demographics and a comprehensive risk assessment of the area. (Mississippi River Regional Planning Commission, 2018) •La Crosse County has an updated "Multi-Hazards Mitigation Plan" for 2020-2024 with a comprehensive risk assessment. (Mississippi River Regional Planning Commission, 2020) •Monroe County has an "All Hazard Mitigation Plan" that was updated in 2021 (Monroe County).	•The hazard mitigation plans do not address climate change or incorporate new information. •Lack of input and review from all stakeholders in the hazard mitigation plans.

KNOWLEDGE AND EDUCATION

Table 10

Resilient component	Capacities	Vulnerabilities
Public awareness, knowledge and skills	•Interviews revealed an understanding that everyone is responsible for flood-related efforts. •Another project "Stories from the Flood" gathered stories from community members in this region who experienced flooding in order to share how people have survived and responded to flood events in the past.	•There could be greater awareness on precipitation change trends data due to global warming; and the ensuing ability to assess risk.
Cultures, attitudes, motivation	•Interviews expressed the presence of strong community ties. •Interviews revealed an understanding that flooding will continue and may get worse. •Community members developed "flood aware" attitudes and habits. •Those who were previously flooded demonstrate a proactive understanding of personal responsibility for preparing for disaster and reducing risk. •County government representatives understand the need to act despite uncertainties in the exact increased risk due to climate change.	•Interviews revealed differing attitudes within the community itself (ridge vs. valley; the flooded and those who haven't been) in feelings of personal responsibility for preparedness and reduction of flood risk. •Potential to increase "possession of/access to the information, resources and support desired/needed to ensure safety."

RISK MANAGEMENT AND VULNERABILITY REDUCTION

Table 11

Resilient component	Capacities	Vulnerabilities
Environmental and natural resource management	•A strong conceptual knowledge and understanding of best management practices for farming due to conservation history of the region exists. •Strip cropping, no till, buffer strips, check dams, and terracing are strategies that have been in use for almost a century. (Leopold, 1935) •The watershed has the attention from many organizations such as the NRCS, the University of Wisconsin- Madison, DNR, etc. that are willing to work with communities to do research, develop resilient strategies, resource management, and advocacy. •The watershed is a desired location for trout fisheries and other recreational pursuits and therefore there is a desire from residents and the public to conserve the natural resources. •Organizations such as Trout Unlimited have a vested interest in maintaining and sustainably managing the environment, restoring stream conditions, protecting wetlands.	•BMPs for farming are reverting back to those not responsive to infiltration such as increased row cropping and diminishing contour strips. •Species diversity is diminishing due to buffer strip removal, invasive species, and increased mono-cropping •Watershed communities do not have the money or staffing capacity to do all that is necessary to mitigate flooding. •Generational knowledge is becoming lost with new landowners and larger scale farming practices.
Physical protection; structural and technical measures	•Recent zoning laws have made it more difficult to build in the floodplain due to the high standard of compliance necessary. (Monroe County) •Lower Chaseburg has moved or bought out all of its buildings within the floodplain and moved to higher elevation. Due to the relocation, this part of the town no longer floods. •NRCS is doing an analysis on the reconstruction of dams within the Coon Creek watershed that was reviewed on page 5 of this report. (Pomplun, 2020) •Physical alterations to some public park gates involve a latch allowing water to pass through unencumbered. •Many of the public parks are located in the floodplain.	•Many farms, businesses, homes and communities lay within the floodplain and consistently flood. •Not all homes in the floodplain have flood insurance. •Many homes and properties that flooded were not covered by insurance- cost is unmanageable. •Most of the dams in the Coon Creek Watershed are over 60 years old and are reaching the end of their life expectancy. (Pomplun, 2020) •Many of the homes located in the floodplain are over 100 years old and are most likely not built up to current building standards. •There is a lack of a standard approach for floodplain buyouts due to institutional barriers

DISASTER PREPAREDNESS AND RESPONSE

Table 12

Resilient component	Capacities	Vulnerabilities
Organizational capacities and coordination	•Hosting space is available on short term notice for evacuations, available equipment for emergency rescues. •The NRCS in partnership with La Crosse, Vernon, and Monroe Counties is developing a Watershed Project Plan-Environmental Impact Statement for each watershed. ("WFK and CC Watershed Planning", 2019) •There is strong local response responsibility for emergency situations, e.g.: emergency rescue responders are local volunteers. •Vernon County has a Multi-Hazards Mitigation Plan updated for 2018 – 2022 (Mississippi River Regional Planning Commission 2018), La Crosse's Plan is for 2020-2024 (Mississippi River Regional Planning Commission 2020), Monroe County has an All Hazard Mitigation Plan (Monroe County)	•Lack of communication between ridgetop and valley landowners, more specifically, those who have been flooded versus not, prevents understanding and awareness. Flood preparedness/ awareness organizations have not been founded. •There is not enough funding or staffing to support flood preparedness activities or infrastructure. •Little coordination or communication between communities within the Coon Creek Watershed exposes flood response vulnerabilities. •Coordination and communication between La Crosse, Vernon and Monroe Counties at a watershed level has yet to fully be established.
Early warning systems	•Monroe county has an emergency management department which does include emergency alerts for community members who sign up. (Monroe County) •There is development of an early warning system in the area. DamWatch is available for "watershed managers"	•Lack of overall early warning system/ not all counties have an emergency alert system •Cell service is not stable and reliable in the valley.
Preparedness and contingency planning	•Vernon County has a Multi-Hazards Mitigation Plan updated for 2018 – 2022 (Mississippi River Regional Planning Commission 2018), La Crosse's Plan is for 2020-2024 (Mississippi River Regional Planning Commission 2020), Monroe County has an All Hazard Mitigation Plan that was updated in 2021. (Monroe County), which include disaster plans for most major risks. •All counties have local emergency planning committees. •Hazard assessments have been conducted for dams located in the watershed.	•All counties lack specific flood emergency plans with material easily disseminated. •Emergency management website for Monroe County has scarce documentation available for emergency preparedness/mitigation. •La Crosse County Emergency management website lacks usability. •Community staffing for flood planning, management, mitigation, etc., is limited.
Emergency resources and infrastructure	•All counties have an emergency management website. •Emergency staff includes WI Emergency Management, FEMA, volunteer firefighters, local law enforcement and others.	•Websites vary and lack links to specific flood and emergency resources.
Emergency response and recovery	•Multiple state and government agencies including WEM, FEMA, provide emergency response and recovery for the area. •Community emergency response mainly includes local firefighters and volunteers. •Strong community response to floods and disasters. •Local response during flooding prevented deaths.	•There is confusion over how to obtain and who qualifies for FEMA and other government funding. •Even if applied for, it takes some time for the funding to be dispersed. Other areas include technicalities of NFIP, buyout programs etc.
Participation, voluntarism, accountability	•Volunteers across all three intersecting counties respond and assist in flood preparedness, response, recovery. •Volunteerism is heavily relied upon after disasters and therefore local government and agencies have facilitated the ad hoc coordination of these groups.	•There are few ways for people to express views, learn from each other, and share lessons from flood events. •A lack of stakeholder participation in creation of disaster management plans leaves out important perspectives. •Audit/assessment of emergency plans or dissemination of this information to the public has not occurred. •A lack of accessible emergency plans and materials leaves the population unprepared.

Discussion

Community resilience brings a holistic perspective to disaster risk reduction where it accounts for not just one preparedness strategy, but the whole system. By understanding what factors are included in community resilience it is possible to assess a community's resiliency through qualitative and quantitative indicators. This allows communities to effectively reduce their vulnerabilities and risk for future disasters. Communities in the Coon Creek Watershed portray many characteristics of community resilience. Within the assessment of vulnerabilities and capacities, six major themes tended to appear frequently. They include flood awareness, local ties and volunteerism, distribution of information, disconnect between those flooded and not flooded, confusion of institutional roles, and lack of support.

The first important theme derived from the analysis is that residents and municipalities know flooding will persist. The Coon Creek Watershed and surrounding communities have a long history of flooding. Because of this and studies done in the area showing land use changes, changes in land conservation practices, and rain trends, residents and municipalities are aware that flooding will persist and will most likely worsen. This has led to flood awareness, where residents constantly pay attention to weather forecasts and integrate flood-friendly practices into their daily life. Some of these practices include elevating belongings and utilities such as water heaters in basements, rerouting gutters, and changing cattle rotation based on weather forecasts.

Another prominent theme seen throughout the analysis of the Coon Creek Watershed was that strong local ties and connections help increase resilience. There are themes of shared hardship throughout the watershed's communities and the surrounding areas. In response to flood events and disasters, emergency response includes the local communities, firefighters and emergency response departments but it also includes volunteers. Volunteers from many of the surrounding communities came to help shovel out buildings and homes and provide other aid.

There were a number of challenges that became prominent during the analysis of community resilience. First, dissemination of information before, during, and after a flood is not always easy. During a flood event, there is no widespread system to alert the community, especially those in the path of the flood. This vulnerability, however, is starting to be addressed through increased

Students visited the breached dam sites in the Coon Creek Watershed with Monroe County Conservationist Bob Micheel in 2019. Photo by Eric Booth monitoring systems, but interviews revealed hesitancy in these systems due to their inconsistent reliability. It is unclear how well it will function once in place. In addition, emergency action or evacuation plans are not easily found or distributed to the public. We learned that technology exists (NRCS DamWatch) that can predict how much water a storm is carrying and whether a dam may be breached by such a storm, but residents and those most affected do not have access to that information. This lack of information makes it difficult for communities to act in the most efficient and effective manner when time is of the essence.

Another challenge identified through interviews was that there are misaligned connections, communication, and understanding between those who have been flooded and those who have not. Those who have experienced flooding have an elevated state of trauma and do not have outlets to deal with the emotional and physical toll it has taken. Residents who have not been flooded do not understand the impact. For example, one person who did not get flooded, but lives in the valley, expressed not even knowing there was a flood until the next day and disbelief for the damage it caused. We also heard that those on the ridge or in higher elevations do not feel responsible for or see the need to implement flood prevention or mitigation practices. In practice, the land use of residents across the whole watershed affects the magnitude of flood events, but those who have been flooded suffer a disproportionate toll of the flood impacts.

Other challenges to community resilience are driven by barriers in mechanisms of government institutions. While similar components are addressed in the Institutions chapter page 17, this challenge warrants incorporation into community resilience as well. As Twig notes, "governance is really a cross-cutting theme underlying the other thematic areas" of the characteristics of a disaster-resilient community (Twigg, p. 11). Twigg also "acknowledges the importance of wider institutional, policy and socio-economic factors in supporting community-level resilience." In the Coon Creek Watershed these challenges include the relative lack of staffing and funds at the county level in proportion to the magnitude of need. Additionally, an unclear definition of the various government organizations' roles and responsibilities as seen from the public viewpoint are foundational barriers to local community resiliency.

Recommendations

Based on the identification of capacities and vulnerabilities found within communities in the Coon Creek Watershed three main recommendations were identified as strategies that these communities can use to enhance resilience to flooding disasters.

1. **Develop a comprehensive website or alternative central database for disaster preparedness-related information.**

In the Coon Creek Watershed communication with the public and across involved parties needs improvement to reduce confusion, make flood mitigation/recovery easier, and help spread needed information and increase involvement. We recommend developing a comprehensive website or an alternative central database that would serve as a medium for public access to resources and information. Considering that not everyone may be comfortable with or has access to an online format, this information hub could be organized in another way, possibly in a paper format or accessible by phone.

Transparency of knowledge is an important component of disaster risk management and accountability. Both of these concepts are mentioned in the Sendai Framework. Transparency of knowledge fosters trust in local and higher-level government organizations. It would also provide a space for government, organizational, and institutional accountability (UNDRR, 2015). All and any risk assessment findings should be consolidated, comprehensible, easily digestible, and public. Policies, plans, and any flood-related material should be accessible and easy to understand. This would make it easier for the public/community to participate and gain knowledge of the area. It would also allow the community to understand and prepare for risks.

Having a central database such as a website will help with deciphering institutional roles and responsibilities. Similar to transparency, having a central database that lays out the roles and responsibilities of the varying institutions involved in flooding disasters would reduce confusion and increase confidence in the organizations whose job it is to respond and regulate in these situations. It would increase awareness of which agency is responsible for what and the limitations that exist. Clarifying institutional roles during flooding disasters opens up accessibility for the community by streamlining the routes to take for accessing aid, information, or resources.

Additionally, this database could effectively create a community wide effort for mitigation. It would close the gap in communication and coordination between community members seeking to implement flood resilient practices or help others in need. During flood events, this tool could be used by individuals and help coordinate mitigation efforts. A central database would foster connections and allow community members to seek help, resources, or support from others. It may provide those with resources to connect to others who need their services. Such a website may benefit from connecting to existing social media and networking sites such as Facebook or Twitter which may help reach an even larger community network. For example, Facebook was critical in coordinating some informal response activities during the 2018 flood. These sources would allow individuals to easily determine where they can go, what their options are, who they can talk to, and how they can prepare. This coordination would enhance resiliency and reduce risk for everyone. Instead of mitigation measures occurring on an individual level, they could now happen on a community scale. Disaster preparedness would become a community responsibility instead of an individual responsibility.

Figure 28

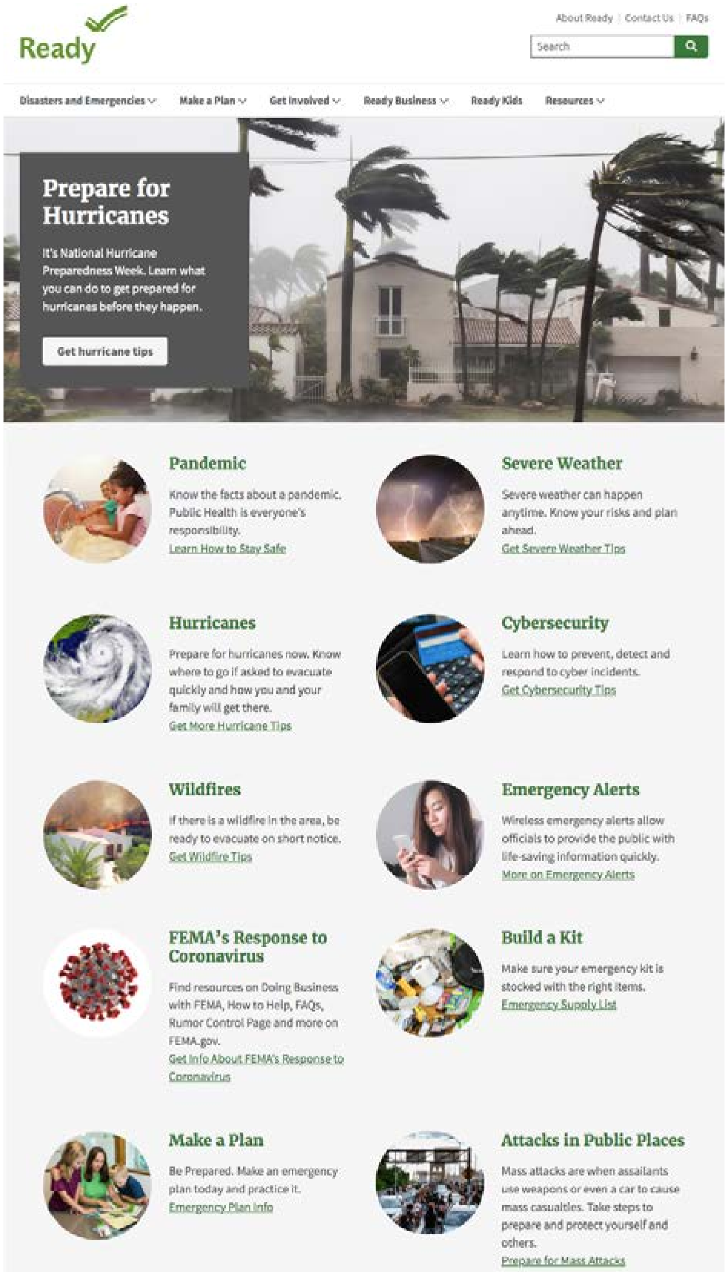


Image from Ready.gov (2021) showing multiple different areas of preparedness with a brief description. Clicking on each title leads the user to a new page with resources specifically for that disaster. This simple website is easy to navigate and find resources.

Components to include in the database

Contact information that should be included could range from emergency numbers for who to reach in the case of an emergency, to who can help with disaster preparedness or recovery, to public officials, etc. They should include local, state, and nationwide contacts for the DNR and FEMA. This information should also incorporate emails as well as physical addresses and be updated on a regular basis.

Emergency hazard plans, emergency action plans, as well as any type of evacuation plan, needs to be easily searchable, accessible, and available to the public. The content of these plans should be easy to understand and easily communicable to a widespread audience. Additionally, information within these plans should be relevant and up to date. Local emergency plans, especially for communities in the Coon Creek Watershed, may be beneficial in case of flash floods or dam breaches.

Resources should be compiled for community members that would allow them easy access and the ability to implement the four cyclical phases of emergency management: mitigation, preparedness, response, recovery. Resources for emergency management before, during, and after flood events should be available on the website or central database. Some of these resources may be in the form of grants or other financial assistance. They might be lists of companies to contact who provide restoration and recovery assistance, or those who provide services to flood prevention strategies. Or there could be information on property buyouts and eligibility for money from FEMA during disasters.

An education component in the website would provide a central hub for residents, community members, as well as visitors to get up-to-date information about current climate data, flood impacts, or organizational activities. It would allow those interested to be fully informed on how climate change will affect future flood patterns and what the population's risk may be. It could provide a space that would serve as a home base for organizations to form around emergency action. This would allow safety networks to form while connecting and involving residents in the community. Discussion boards would provide a format to request information, provide information, and prompt healthy correspondence or a space to express emotion about flooding. Educating community members on why increased flooding is occurring would enable them to become more prepared for future flood events as well as adopt practices that would increase infiltration in order to mitigate flooding.

There may be a few pathways to implement this website. Currently, the existing websites in Monroe, La Crosse, and Vernon counties have been created and are hosted by commercial website builders. Ideally this control should be internal in order for the counties to have more immediate control over the content. This would require at least one dedicated staff member who could be funded by an external grant. Another possibility would be an internship position or something similar in connection with the University of Wisconsin for continued support in the resiliency effort. Other funding could potentially come from, with the establishment of the Joint Powers board, a dedicated budget item to which all counties contribute.

2. **Create a comprehensive disaster preparedness and response plan which involves stakeholder participation.**

Communities should develop a specific comprehensive disaster preparedness and response plan for the public and local municipalities. The August 2018 flood event and others proved that the community already has a strong response system to evacuate people and respond immediately to flooding when it occurs, through volunteers, firefighters and others. However, there seems to be a need for a more streamlined plan which would ideally involve input from all stakeholders to lessen confusion in times of crises on preparedness strategies such as emergency evacuations, infrastructure, and communication. However, we recognize that this level of involvement may be pragmatically difficult to implement.

Some practices that the community could develop are early warning systems, emergency/evacuation routes, emergency infrastructure and two-way communication systems all of which need to involve input from as many stakeholders as possible. Any plan needs to be easily accessible to the public in addition to having input from all stakeholders. This plan can be put onto community websites, bulletin boards or other easily dispersible avenues preferred by the communities. Additionally, the plan itself needs to be straightforward and easily digestible for the public.

An early warning system is currently in development in the watershed. Monroe County has a Climate Change Task Force whose goals include implementing monitoring devices (weather stations) and warning systems in real time by working with emergency management and the National Weather Service (Monroe County, 2019). They also partner with the Kickapoo Valley Association for fundraising efforts to buy these weather stations and flood warning systems. As stated on their brochure, monitoring stations will improve regional flood resilience by supplying precipitation and stream level data that could warn of potential flooding events (Monroe County, Kickapoo Watershed). Establishing monitoring systems upstream, as the current systems are planned in the upper Kickapoo watershed, will help warn downstream communities of potential flood events. Broadening this system into the rest of the Kickapoo Watershed and the upper Coon Creek Watershed will provide more information to predict heavy rain and storm events that could lead to potential flooding.

Two-way communications systems could be beneficial to those that are further from the towns and in the valley where there may not be reliable cell service. Additionally, clearly laid out emergency evacuation routes and locations could help decrease confusion at the time of flooding. As flooding can cause road washouts, communities could elevate and fortify a central road to allow clear paths for evacuations. The plan could also include a layout or list of communities/homes that are in the valley and particularly at risk so responders can make sure these residents are safe. This can also lead to more swift response and evacuation. In the August 2018 flood event, evacuated residents in Coon Valley were moved to higher elevations from the village hall to the fire station, and then to the elementary school as waters advanced (Lu, 2019). The plan can include different evacuation places based on the predicted rainfall, flood potential and the location of residents.

3. **Coordinate a systematic approach for managed retreat.**

Managed retreat is the "purposeful, coordinated movement of people and assets out of harm's way" (Siders 2019). As a method of flood preparedness, it ensures human health by removing people from risk altogether. This represents a long-term vision of flooding preparedness. The premise behind floodplain "buyouts" or land acquisition is that a county, or other governing body, buys the floodplain land from private owners, demolishes the structures on the land, and maintains the land as open space in perpetuity.

While the most thorough means of flood preparedness is arguably the absence of people and structures from the floodplain, there are many complexities in enacting a policy of managed retreat. It requires providing tools for the public to assess their long-term risks and determine if there is economic benefit in leaving or staying. Subsequently, it requires a willing public for whom land acquisition programs are perceived to be and are a beneficial practice. The county or municipality must acquire funding to purchase private property in the floodplain. There must also be an equitable system of land acquisition and an economically viable alternative site for those who relocate. In the best-case scenario, the acquired land is managed as riparian habitat that can mitigate flood impacts downstream. A land acquisition program, or "buyouts," can benefit the Coon Creek Watershed as they reduce potential for health hazards, reduce the future economic burden of flooding, and present a new opportunity for flood mitigation through a creekside riparian zone.

One fundamentally important factor of managed retreat is property owners' decision to permanently leave their current homes. Interviews informed us of the strength of heritage, community, and importance of place for residents of Coon Creek. Many said they have no interest in leaving their homes despite being aware of future flood risk. However, the buyout programs are being used by some residents and businesses of the area. There are also examples of residents that would like to participate in a buyout program but did not qualify.

The most common route to access buyout programs is through the Hazard Mitigation Grant Program (HMGP) which occurs only after a presidentially declared national disaster and for properties meeting given criteria (see insert for details). Working before a disaster occurs to identify best suited properties can be beneficial. Kenosha County in Wisconsin provides an example in which planning and analysis of properties most in need of buyouts tangentially created a high level of community awareness and receptivity to participate in buyout programs (Institute for the Environment, Kenosha County, 2016). The counties within the Coon Creek Watershed could collect and disseminate imperative information that allows for the public to understand and evaluate their interest in the buyout process. Counties could conduct an analysis of the properties at most risk to determine those sites likely to benefit from relocation in the long-term. This analysis might also articulate specific benefits for local governments and citizens to break a cycle of repeated reconstruction and repeated damage. The Mississippi River Regional Planning Commission, to which the Coon Creek Watershed counties belong, has helped to conduct this type of work in the past such as in Pierce County (Institute for the Environment, Pierce County, 2016).

Additionally, preemptive planning in managed retreat could reduce the time for recovery after a disaster. The HMGP program is associated with many interim procedures. The time between applying for grants and receiving the buyout funding can take multiple years. This is problematic when your house or business has been flooded and is potentially, upon receipt of the grant, slated for demolition.

Given funds not dependent on a recent disaster, the counties could pursue a coordinated managed retreat that maintains the strength of community ties while relocating individuals from locations with highest risk. These community ties are an important component of resiliency in Coon Creek. Coordinated managed retreat may allow for relocation from flood prone regions without losing important community support. Soldiers Grove, a town 30 miles southeast of the Coon Creek Watershed in the Driftless Region, provides an example of community-wide managed retreat as an opportunity to invest in new infrastructure and new technologies while working in coordination to relocate an entire downtown (David & Mayer 1984).

Managed retreat strategies must be actionable and economically feasible for the county and its residents. Zoning often stipulates that no structure on the floodplain can be improved upon more than some percentage of its total assessed value (Mississippi River Regional Planning Commission 2018). The restraint from further development in the floodplain is well reasoned as it is the most effective flood damage prevention method. However, this leaves residents of the floodplain only able to invest to a limited degree in their home as an asset. This is especially troublesome as property values may depreciate in value as flooding continues to occur more frequently.

Managed retreat must empathetically work with those whose property and health are put at risk of repetitive flooding. At risk households should have access to complete information on the programs available as well as access to known trends of future flooding risks. While coordinated managed retreat may help to maintain the strength of community ties, the decision to relocate remains an individual household.

Implementation of managed retreat

Despite personal and practical barriers, managed retreat is becoming a more common practice in the US (Siders 2019). Most managed retreat in the United States is funded through federal acquisition programs such as the Federal Emergency Management Agency's Hazard Mitigation Grant Program. The prevalence of buyout programs began after devastating flooding in the Midwest in 1993. At this time, Congress amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 increasing federal funding for long-term hazard mitigation measures including for the acquisition of flood-prone properties (Environmental Law Institute, 2017). Subsequently, the Federal Emergency Management Agency (FEMA) created the Hazard Mitigation Grant Program (HMGP). Since this event, the HMGP has been involved in funding much of the managed retreat taking place in the US through floodplain "buyouts".

The HMGP works in the following way. The president declares a disaster. The local governments that choose to do so inform the public of the potential for buyouts. Sub-applicants and homeowners apply to their local government. They must live in counties that are in accordance with pre-approved mitigation plans. Their cases must be found to be cost-effective through FEMA's Benefit-Cost Analysis (BCA) methodology. If accepted, FEMA funds must be matched at 25 percent from a non-federal source. FEMA funds are given to the applicant's state. The local government makes an offer on the property to a willing owner at its assessed pre-flood value. This requires coordination from federal, state, and county governments. The process of acquiring FEMA grants is far from transparent as experienced by both local governing bodies (sub-applicants) and citizens (applicants). Furthermore, with many interim procedures, the time between applying for grants and receiving the buyout funding can be anywhere from six months to five years. This is problematic when your house or business has been flooded and is potentially, upon receipt of the grant, slated for demolition.

It is important to note that other programs also fund managed retreat through land acquisition including FEMA's Pre-Disaster Mitigation (PDM) Program, FEMA's Flood Mitigation Assistance Grant Program (FMA), Wisconsin Department of Natural Resources' (DNR) Municipal Flood Control Grant Program, Wisconsin Department of Natural Resources' Urban Rivers Grant Program, and Wisconsin Department of Commerce's Community Development Block Grant, and potentially others relevant to the Coon Creek watershed.

CONCLUSION

This study recognizes flooding as a physical phenomenon which is influenced by a social context. Riverine flooding is a natural phenomenon driven primarily by precipitation, but human behavior such as community action, land use, and much more affect flood impacts and flood recovery. Research on flooding in the Coon Creek Watershed therefore requires the perspectives of many disciplines. Studying each flood related issue in its interwoven context allows for better understanding than researching any singular component individually.

Resilience to flooding in the Coon Creek Watershed is a story of perseverance. By looking through the lens of Marchese et al.'s (2018) definition, "the ability of a system to prepare for threats, absorb impacts, recover, and adapt following persistent stress or a disruptive event" we divided our efforts into five components to increase resilience. We used the public's perspectives to understand flooding impacts and current concerns within the community. This allowed us to incorporate a diversity of opinion and local perception into the project. An investigation into the institutional landscape of flooding policies and organizations revealed a dissonance between community needs in relation to policies and provisions. Understanding this information can help determine how to provide assistance within those limitations.

Research into the land use and management practices around the Coon Creek Watershed was instrumental in confirming a need to increase infiltration in order to reduce flooding, a similar conclusion to the 1930s CCC project (Johansen, 1969). Doing an economic analysis of these changing land use practices enabled us to see the challenges and benefits of yet again altering management strategies in the area. Lastly, a holistic community-specific approach helped us identify gaps and capacities of flood management actions that surround current infrastructure, community initiatives, and long-term preventative actions.

Residents in the Coon Creek Watershed have lived with flooding for decades. They understand the issue and the need for resilient strategies. However, one of the most important issues standing in the way of implementing any resilient practice or strategy isn't a community's lack of desire, knowledge, or need, but funding and people power. Small communities often have little staff, funding, and time. They need to make their resources stretch as far as possible and make efficient, long-ranging decisions. This can be done by increasing coordination and communication on the watershed level instead of the county level so communities will be better prepared for flooding. For example, forming a joint powers board and/or developing a central database hub will allow for more coordinated efforts to implement best practices and flood management strategies. Additionally, local and county institutions could create programs to support flooding solutions, namely increasing infiltration, soil, and water quality which involve promoting farming and land-use practices that manage water where it falls.

There is already an extensive amount of existing work done in and by the Coon Creek community to increase flood resilience both formally and informally. This research highlights the strength of the existing knowledge, networks, and community present in Coon Creek. Examples of existing flood resilience include efforts to enhance infiltration through land management and high levels of volunteerism during flooding crises. While these communities have proved over and over again their tenacity to persist, expanded funding, technical assistance, and staffing is still needed for enduring flood resilience.

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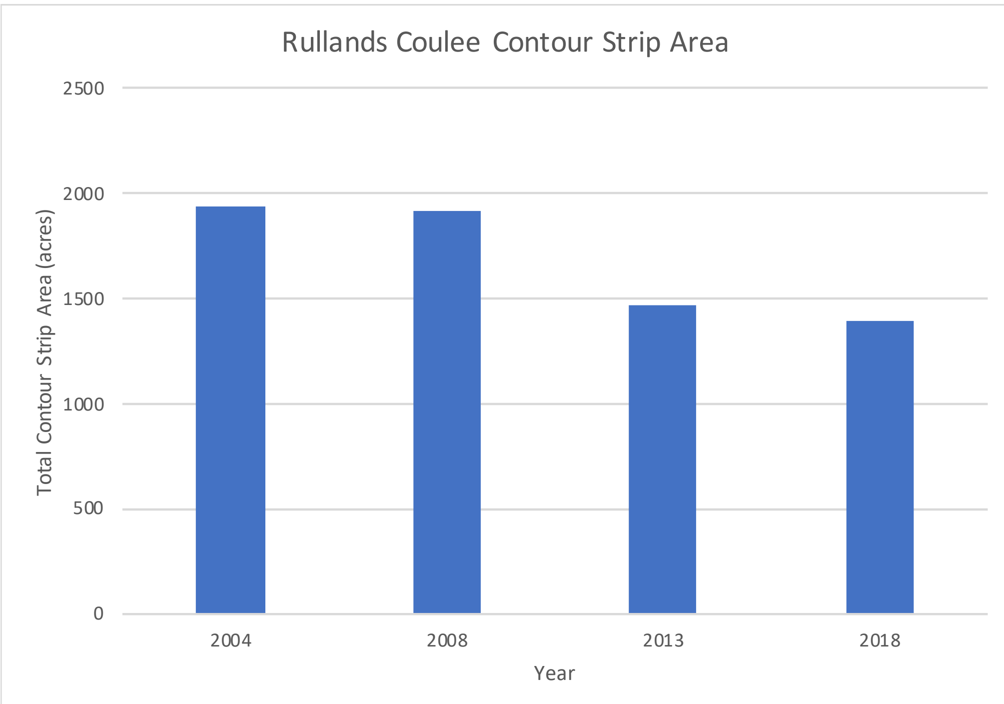
APPENDIX I

Site Location	Description	Latitude Longitude	NRCS Hydrologic Soil Group	Avg. Infiltration Rate (in/hr)
Seeded cow pasture	Cow pasture south of Oboe Ave and just north of breached Luckasson Dam site	43.7320509, -90.8392488	B	3.1
Native grass cow pasture	Cow pasture south of Oboe Ave and just north of breached Luckasson Dam site	43.7338672, -90.8378507	B	2.5
Contour stripped alfalfa field	Contour stripped farm field southwest of Navajo Rd	43.7562974, -90.8555523	C	2.4
Contour stripped alfalfa field	Contour stripped farm field southwest of Navajo Rd	43.7562954, -90.8555502	C	0.6
Contour stripped corn field	Contour stripped farm field southwest of Navajo Rd	43.7587187, -90.8545525	C	1.86
Grassed waterway	Contour stripped farm field southwest of Navajo Rd	43.7587180, -90.8545520	C	7.5
Seeded cow pasture	Cow pasture south of Oboe Ave and just north of breached Luckasson Dam site	43.7336889, -90.8365609	C	1.19
Native grass cow pasture	Cow pasture south of Oboe Ave and just north of breached Luckasson Dam site	43.7346370, -90.8372552	C	0.84
Contour stripped alfalfa field	Contour stripped farm field southwest of Navajo Rd	43.7582896, -90.85442811	C	0.99
Contour stripped alfalfa field	Contour stripped farm field southwest of Navajo Rd	43.758029, -90.8543681	C	0.93
Contour stripped corn field	Contour stripped farm field southwest of Navajo Rd	43.7570357, -90.8561219	C	1.32
Grassed waterway	Contour stripped farm field southwest of Navajo Rd	43.7570357, -90.8561219	C	2.1
Seeded cow pasture	Cow pasture south of Oboe Ave and just north of breached Luckasson Dam site	43.7323203, -90.8387170	B	3.05
Native grass cow pasture	Cow pasture south of Oboe Ave and just north of breached Luckasson Dam site	43.7335815, -90.8382500	B	1.84
Contour stripped alfalfa field	Contour stripped farm field southwest of Navajo Rd	43.7582347, -90.8543030	C	1.69
Contour stripped corn field	Contour stripped farm field southwest of Navajo Rd	43.7587187, -90.854520	C	2.5
Grassed waterway	Contour stripped farm field southwest of Navajo Rd	43.7587184, -90.8545520	C	3.39
Fallow field	Fallow field north of Rognstad Ridge Rd	43.7191335, -90.8460475	C	1.7

APPENDIX II

Year	Contour Strip Area (acres)
2004	1931.68
2008	1916.83
2013	1468.03
2018	1395.50



APPENDIX III

COON CREEK WATERSHED PUBLIC PERSPECTIVES INTERVIEW QUESTIONS:

1. What is your relationship to the Coon Creek Watershed? Flooding? The area?

2. How have you personally been affected by flood events in Coon Creek?

   a) How have flood events shaped the community/affected your life?

3. Why do you think flooding is occurring and accelerating in Coon Creek?

4. Who should be responsible for managing the impacts of flooding?

5. Who should be responsible for preventing flooding in Coon Creek?

6. What should be done to prevent future flood impacts in Coon Creek?

7. Should reconstruction of dams be a part of flood prevention? Why or why not?

8. Is the lowest cost option the best for you? Frame this outside of economics

9. Federal involvement in the planning process requires a calculation of the costs and benefits of a project. What do you believe should be included as costs and benefits? For example, the actual construction of a dam would be a cost and reduction in flood damage to existing properties would be a benefit.

10. Should government agencies purchase flood-prone homes and vacate them?

11. How would you evaluate the local government's response to the August 2018 flood event?

12. How would you evaluate the state government's response to the August 2018 flood event?

13. How would you evaluate the federal government's response to the August 2018 flood event?

14. Would you categorize the local government response as not effective, somewhat effective, or very effective?

15. Would you categorize the state government response as not effective, somewhat effective, or very effective?

16. Would you categorize the federal government response as not effective, somewhat effective, or very effective?

ADDITIONAL QUESTIONS FOR MANAGERS:

17. What does the general public misunderstand when it comes to flood management?

18. What can landowners do to prevent flooding in Coon Creek?

19. What can the general public do to prevent flooding in Coon Creek?

20. What group of people do you usually talk to about this topic?

ADDITIONAL QUESTIONS FOR GENERAL PUBLIC:

21. What do government agencies such as the county, state, or federal government misunderstand when it comes to flooding in Coon Creek?

22. Describe your experience working with local government officials (municipal/county) after flood events.

23. Describe your experience working with state officials after flood events.

24. Describe your experience working with federal officials after flood events.

25. Have you considered moving to avoid future flood events?

26. Describe the reasons why you continue to live in the Coon Creek Watershed.

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