Measuring Societal Benefits of Soil Health: Cost Savings for Local Municipalities, Rural Communities, and States

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*This discussion paper was developed by a national interdisciplinary team convened by the Wisconsin-based Michael Fields Agricultural Institute and the National Center for Appropriate Technology. The team, whose broad focus is measuring the societal benefits of soil health, chose to begin with the question, **"How do different conservation/soil health-building practices reduce the amount and contamination of water leaving farm fields from storms of differing severity and timing?"***

***This paper focuses on the potential economic value of watershed-scale soil health** practices that reduce the risk of downstream flooding or pollution. A companion paper, Biophysical Dynamics of Soil Health and Hydrological Ecosystem Services, is available at this link. While these papers are grounded in research and fact, they were written not as academic papers but rather to generate and inform discussion across disciplines, agencies, and kinds of stakeholders about practical solutions to challenging intersectional problems.*

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I. Introduction

The benefits of cover crops, conservation tillage, livestock integration, and crop diversification within the individual farm production system have been, and continue to be, well documented, and are the major focus of current discussions on soil health. This extends to the case made for soil quality practice incentives. Beyond agriculture's relationship with carbon and climate change, *off-farm benefits* to the broader public, including rural municipalities, have rarely been considered. But these off-farm benefits are critical to the cost-benefit analysis of public investment in soil quality practices.

However, recent natural disasters have highlighted the need to better understand the downstream impacts of poor soil health practices and the related benefits that improved farm management can have on downstream communities. Understanding the role of agriculture and farmland management in both extreme and chronic flooding events provides an opportunity to build new analysis that can drive adoption of conservation practices and investment in incentives based on a cost-prevention, taxpayer protection paradigm rather than the cost-benefit to an individual farmer. This analysis has the potential to be a critical tool in bringing unlikely partners - including municipalities, Emergency Management, fiscal conservatives, private investors, and others - into support for broader conservation adoption and incentives.

The primary focus of this paper is to explore: 1) the **non-farm costs** to individuals and local, state, or federal government associated with sediment, nutrient, or chemical contamination of water runoff from farm fields, as well as 2) the **value** to individuals, municipalities, state or federal governments of reducing potential flooding losses or contamination.

In developing this paper, we spoke with experts across several disciplines, who each offered a unique vantage point and direct experience with these complex issues. These include individuals across the academic, non-profit, and municipal sectors with expertise in the areas of cultural anthropology, agricultural economics, agriculture and conservation policy, cost-benefit analysis, impaired watersheds, and stormwater management. Further, our findings were informed by conducting a literature review to identify existing data and research. The intent of this paper is to equally outline what we do know as well as what we don't know, and to foster discussion and inform future research and collaborations.

II. Summary of Non-farm Costs

In this discussion, non-farm costs and benefits associated with agricultural runoff fall into two distinct, but related categories: those associated with *water quantity* and those associated with *water quality*. The impacts of farm runoff are borne by individuals, communities and municipalities, both in terms of the volume (quantity) of the water running off of farm fields, which often results in flooding downstream, as well as the contamination (quality) of sediment, nutrients, and chemicals that are carried with agricultural runoff and floodwaters. When we explore non-farm impacts, it is impossible to talk about flooding without also talking about impaired watersheds and poor water quality. And while the specific impacts (and related benefits) associated with flooding and water quality are disparate and unique, we include them both in our discussion, as the long-term reduction in run-off through improved soil health practices will mitigate both.

It is also important to note that the *decrease*, rather than *increase*, in water that flows off of farms can in other cases *negatively* impact downstream communities, especially those suffering from prolonged or frequent drought. This issue was raised but not discussed in detail in our conversations. Further discussion and research are needed to explore the specific impacts of drought and soil's water holding capacity and the related costs and benefits to surrounding communities.

Table 1 (found in Appendix A) outlines direct and indirect costs associated with both the volume (quantity) of agricultural runoff and any associated downstream water quality impacts. Costs are broken down into the following broad categories: Infrastructure, Public Health and

Safety, Ecology, and Other Costs. Also included is which entity (e.g., individuals, municipalities, states, federal government) principally bears each of these costs. These costs are explored in further detail in the next section.

Several overall themes have emerged from the discussion. First, while we may be able to quantify costs from an event perspective, for the municipality or community experiencing the event, costs are spread out across a spectrum of different entities, and vary widely depending on circumstances (e.g., current water quality), state and local funding, national disaster declaration, and other variables. Damage costs may be borne by local homeowners, business owners, municipalities, states or others. And funding to cover the cost of damages may come from private insurance, or multiple local, state or federal agencies.

For example, while private homeowners bear most of the cost of repairing flood damage and replacing personal property, some assistance is offered through FEMA's National Flood Insurance Program, which is funded by federal taxpayer revenue. Other costs (such as repair of roads and schools) may be borne through a combination of state and local funding, while others are nearly impossible or have yet to be measured (such as loss of entire communities and wildlife). This wide range of cost and funding streams makes overall assessment of costs and benefits difficult to assess.

Second, much of the attention, and resulting appropriations, have focused on major flooding events. With major disaster declarations that hit the national media, there is more likely to be a significant response to address costs associated with the damage. It is also less likely that soil quality practices can have a significant impact on reducing damages associated with major disaster events, as the associated volume of water would overwhelm even the best soil quality water infiltration and holding benefits. But in discussions with several municipalities and research on damages over time, it is the mid-scale disaster events, with less dramatic flooding that does not rise to the level of major disaster declarations that can often have the most devastating impact on local municipalities, businesses, and residents. The impacts of these mid-scale events are also potentially more likely to be mitigated by an increase in the use of soil quality practices. But frequent, mid-scale events have not been the subject of research to date.

Third, while we often focus on reducing the severity of and costs associated with individual events, it is the frequency of events that can determine overall outcomes for a municipality. There is increasing discussion of what is being referred to as "community collapse," as individuals and businesses that have faced repeated flooding in small municipalities decide that it is no longer worth investing in that location, and leave for higher ground. Even with increased funding, this demoralization associated with repeated events can be an existential threat to small municipalities.

III. What Data Exist?

In this section, we examine the data on non-farm costs and benefits of soil health practices that currently exist. We first highlight how researchers measure these data. Then, we discuss why these data are difficult to apply in a policy context. Finally, we catalog what types of data exist.

In general, measuring the non-farm costs and benefits (values) of soil health practices and applying them to a policy (or other) context is difficult because they represent non-market costs and benefits. For goods and services that individuals trade in a market setting, where buyers and sellers come together and agree on the price and quantity of each good or service, the actions of market participants make prices salient. It is easy then, to identify the prices for market goods such as used vehicles, electronics, and produce. However, individuals do not trade water quantity and water quality in a traditional market setting. For example, consider water quality; one cannot go to the store and purchase one "unit" of clean water. As a result, placing values on the costs and benefits of non-market goods and services is less straightforward.

To measure these non-market costs and benefits (i.e. valuation) economists use one of two methods. First is *stated preferences*. Here, the researcher poses hypothetical "conditional valuation" scenarios to survey respondents and uses the collective responses to estimate "willingness to pay" values for the non-market resource; these values represent the price of that good or service. For example, researchers can pose a question to survey respondents asking them how much they would be willing to pay to improve the water quality of a eutrophicated lake to the same water quality level of a different, non-eutrophicated lake.[1] Second, researchers use *revealed preferences*. Here, valuation comes from actual, revealed behavior through markets that are tangentially related to the non-market goods or services. Importantly, researchers know the equilibrium prices and quantities in the related markets, so they can act as a proxy for the value of the non-market goods or services. For example, researchers often use housing prices to value water quality. If all of the attributes of two homes are identical (e.g., square footage, lot size, number of bathrooms), but one is located on a eutrophicated lake and the other is located on a non-eutrophicated lake, then the difference in the price of the two homes is a reasonable proxy for the consumer's willingness to pay for the additional water quality. Collectively, these methods of non-market valuation can identify the value of non-market goods and services and the costs and benefits of changes in their quantity/quality.

Although measuring the costs and benefits of water quantity and water quality is possible, it remains difficult and costly. Perhaps more important, applying these valuations in specific policy contexts can be inappropriate. There are two key reasons why identifying and using the costs and benefits of soil health practices is difficult. First, the data necessary to identify costs and benefits of non-market goods and services are difficult and costly to acquire. Consider stated preference studies. Administering surveys, even for small geographic areas, is costly and time-consuming. The data necessary to perform revealed preference studies are also difficult to

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[1] See, for example, Egan, K.T., J.A. Herriges, C.L. Kling, and J.A. Downing, 2009, "Valuing water quality as a function of water quality measures", *American Journal of Agricultural Economics*, 91(1), 106-123.

acquire on large spatial and temporal scales. As a result, most valuations rely on case studies that cover small spatial and temporal samples. The results of these studies are unlikely to apply to different areas and periods of time.

Second, there exists heterogeneity in the costs and benefits of changes in water quantity and water quality because of different status quo scenarios and ways of measuring costs and benefits; this heterogeneity can make it difficult to compare across situations. For water quality measures, an additional pound of phosphorus runoff into a waterbody has different impacts on the value of that waterbody given its current nutrient levels. The same soil health practice can therefore produce vastly different benefits in two different areas, even if the change in nutrient runoff to each waterbody is similar. Adding to this difficulty, researchers often measure costs and benefits using healthcare costs to account for the health damages associated with flooding or water quality impairments. However, some studies use the costs to infants at birth, others the elderly, and still others fatalities.[2] These "apples to oranges" comparisons make identifying single, policy relevant valuations difficult.

Despite these difficulties, it is important that researchers and state agencies continue to identify the non-farm costs and benefits of soil health practices. This identification, even in a binary sense (i.e., they exist or do not exist), can help to change the narrative of on-farm behavior. Importantly, the identification of costs and benefits can lead to policy changes that properly value on-farm actions that benefit others in the community (even if the land user does not directly experience these costs and benefits), through, for example, farm subsidies and payment assistance programs. To create a more comprehensive list of the non-farm costs and benefits of soil health practices, researchers should continue to catalog the data that exist and perform stated and revealed preference studies, including individual case studies. Additionally, state agencies should continue or enhance long-term monitoring of flooding events and water quality measures, so that researchers can identify costs and benefits longitudinally.

Given this context, we have compiled below a summary of what data exist for various flood and water quality related costs, and at what scale. We supplement these data with case studies (found in Appendix B) that further illustrate what these numbers look like on the ground and shed light on the longer term, and persistent downstream impacts resulting from agricultural runoff.

Overall Flooding Costs

It is well documented that the public losses due to flooding are extensive and expected to increase as climate change increases the severity of extreme weather events. In our scan of existing data, we found that national and state-level data on major flooding events was the most easily accessible and consistently collected data, but there is wide variability in estimates

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[2] EPA generally uses the "value of a statistical life" to value healthcare costs of environmental policy (https://www.epa.gov/environmental-economics/mortality-risk-valuation). However, even this value fluctuates widely depending on the data that each source uses.

of annual flooding costs as well as what specific costs are included in these estimates. While there is no single authority on flood related costs, we found credible data reported by the National Oceanic and Atmospheric Administration (NOAA), the Federal Emergency Management Agency (FEMA), the Congressional Budget Office (CBO), and the U.S. Department of Energy (DOE), summarized in Table 2 below.

Table 2. Annual Flooding Estimates

Source	**Annual Costs**	**Details**	**Dataset**
NOAA	$4 billion	Major floods only	NOAA National Centers for Environmental Information
FEMA	$17 billion	Direct flood costs	Hazus database
CBO	$54 billion	Hurricane wind + storm related flooding	Expected Costs Report (2019)
DOE	$12 billion	All "natural hazard" flood events	DOE Energy Risk Profiles

NOAA estimates total costs from all *major floods* in the U.S. from 1980-2021 to be over $162 billion, or approximately $4 billion per year.[3] The primary limitation with these data is that they only include those flood events that result in over $1 billion in damages, leaving out the much more frequent, but often just as devastating locally, flooding events that are so common in rural communities.

FEMA also includes annual flooding estimates, and reports $17 billion in direct flood losses between 2010-2018, more than quadrupling from $4 billion in the 1980s[4]. Furthermore, FEMA estimates that floods have caused over $155 billion in property damages in the last decade and continue to account for the majority of federally declared disasters. The primary limitation with this dataset is we were unable to determine how FEMA calculates flood damage and to what extent the data reported only reflects flood damages resulting from a national disaster declaration.

CBO estimates that for most types of losses to the U.S. economy caused by hurricane winds and storm-related flooding, expected annual costs total $54 billion, equivalent to 0.3 percent of the nation's 2017 gross domestic product.[5] Unfortunately, CBO does not provide a detailed

[3] National Oceanic and Atmospheric Administration (NOAA). 2021. Billion dollar events summary. Online at www.ncdc.noaa.gov/billions/summary-stats, accessed October 28, 2021.

[4] Federal Emergency Management Agency (FEMA). Facts & Statistics: Flood Insurance. Online at https://www.iii.org/fact-statistic/facts-statistics-flood-insurance, accessed November 29, 2021.

[5] Expected Costs of Damage from Hurricane Winds and Storm-Related Flooding, April, 2019, Congressional Budget Office. https://www.cbo.gov/publication/55019

breakdown of estimates for flood-only related costs, and these costs are likely to be the least relevant to determining agriculture's contribution to flood damages since the data is limited to coastal flooding.

DOE reports that, of natural disasters, flooding events caused the greatest overall property loss nationwide between 2009-2019, with annual losses of $12 billion nationally with an average of 1,917 floods reports each year.[6] It is unclear how DOE defines "natural hazards" but it is plausible that this estimate captures a larger swath of all flooding events than the NOAA major flood database.

DOE also calculates state-level flooding costs[7], utilizing publicly available data reported by the Federal Emergency Management Administration (FEMA) OpenFEMA Dataset[8] and NOAA's Storm Events Database.[9] Flooding data for the top ten agricultural states from 2009-2019 (in terms of total value of production) is as follows:

- California - $123 million
- Iowa - $48 million
- Texas - $4.5 billion
- Nebraska - $81 million
- Kansas - $5 million
- Minnesota - $23 million
- Illinois - $122 million
- North Carolina - $124 million
- Wisconsin - $36 million
- Indiana - $5 million

Residential Infrastructure Costs

Loss of property is one of the most significant direct costs related to flood events, which often goes uncompensated - leaving homeowners on the hook for the bill. CBO estimates flood damage costs at $20 billion in annual losses to the residential sector nationally, with 66% of residential losses due to flooding not being compensated by either insurance or federal disaster assistance programs.[10] As cited in this expose by *The Washington Post*, six million households

[6] U.S. Department of Energy, Office of Cybersecurity, Energy Security and Emergency Response. Online at: https://www.energy.gov/sites/default/files/2021-03/Data%20Sources%20and%20National%20Comparisons%20Energy%20Sector%20Risk%20Profile.pdf
[7] U.S. Department of Energy, Office of Cybersecurity, Energy Security and Emergency Response. Online at: https://www.energy.gov/ceser/state-and-regional-energy-risk-profiles
[8] Federal Emergency Management Agency, Open FEMA Dataset. Online at: https://www.fema.gov/openfema-data-page/disaster-declarations-summaries-v1
[9] National Oceanic and Atmospheric Administration. Online at: https://www.ncdc.noaa.gov/stormevents/
[10] Expected Costs of Damage from Hurricane Winds and Storm-Related Flooding, April, 2019, Congressional Budget Office. https://www.cbo.gov/publication/55019

applied for assistance from FEMA's Individual Assistance Program[11] between 2017 and 2020, and 4 million of them were denied aid.[12] In 2021 so far, FEMA has approved just 13 percent of applicants, its lowest rate yet. The Office of Management and Budget estimates that such claims could double as a result of climate change, costing taxpayers an additional $4 billion to $9 billion annually by 2080.[13]

FEMA's National Flood Insurance Program (NFIP) is the primary funding mechanism to compensate homeowners for flood-related losses. Over its lifetime, the NFIP has provided more than $68 billion to help policyholders rebuild their homes in the aftermath of both inland floods and coastal storms. As a result of the staggering losses from the 2017 hurricane season, Congress canceled $16 billion of debt accrued by the NFIP. Even so, as of July, 2018, the NFIP remained $20.5 billion in debt.[14] There has been increased discussion on how to improve FEMA's Community Ratings System (CRS) Program[15] to more effectively incentivize communities to make improvements and flood prevention measures to mitigate future flooding. For example, CRS could not only help communities increase permeable surfaces, but could also encourage adoption of soil health practices that increase water-holding capacity, such as grass-based systems and cover cropping, in surrounding areas.

Another major issue in addressing housing losses is disparate impacts on low-wealth communities and communities of color. Historically, due to historic discrimination and other longstanding issues, low-wealth and communities of color have often been sited in low-lying or flood-prone areas and incur disproportionate flood-related damages.

Public Infrastructure & Flood Recovery Costs

Damage to public infrastructure is perhaps the single most costly category of damages to state and local governments as a result of extreme and chronic flooding. This damage extends to 1) transportation infrastructure (i.e. roads, bridges, and railroads); 2) other public infrastructure (i.e. schools, churches, hospitals, public landmarks, government buildings, utilities); and 3) flood prevention infrastructure (i.e. construction and maintenance of dams, levees, culverts). Additional public-sector costs are borne by local municipalities to conduct flood recovery, treat waste and drinking water, dredge navigable waterways, and meet emergency needs of affected communities.

[11] FEMA's IRA program helps homeowners without adequate insurance rebuild after federal disasters

[12] Dreier, H. "Assistance Not Approved." Washington Post. April 25, 2021. Online at: https://www.washingtonpost.com/nation/2021/04/25/fema-disaster-assistance-denied/

[13] Office of Management and Budget (OMB). 2016. Climate change: The fiscal risks facing the federal government: A preliminary assessment. Washington, DC. Online at www.eenews.net/assets/2016/11/15/document_pm_01.pdf, accessed October 28, 2021.

[14] Adler, D.; Burger, M.; Moore, R.; Scata, J.; Changing the National Flood Insurance Program for a Changing Climate. Environmental Law Institute. 2019. Online at: https://www.eli.org/sites/default/files/images/49.10320_.pdf, accessed October 28, 2021.

[15] Federal Emergency Management Agency, Community Rating System. Online at: https://www.fema.gov/floodplain-management/community-rating-system

Based on estimated losses due to hurricane wind and storm-based flooding between 2005 and 2016 and modeling of future losses, the Congressional Budget Office estimates national expected annual losses to the public sector total $12 billion annually.[16] This figure includes estimated federal spending to repair damaged government (federal, state, and local) buildings and infrastructure, remove debris, provide emergency shelter, help communities recover, and control future flooding. Of these expected losses, the vast majority (80 percent) are attributable to coastal rather than inland storms. These estimates were restricted to only the largest extreme weather events that triggered a Presidential disaster declaration, and likely do not include estimates of damage due to more chronic flash flooding impacting so many rural communities. Additionally, the CBO estimates do not break down these cost estimates by wind versus flood damage.

There are a number of federal agencies that provide disaster assistance to states and local municipalities to cover the *public-sector* costs of recovery as a result of extreme flooding, though program eligibility requirements vary greatly. For municipalities and local governments navigating infrastructure damage, navigating this complex set of agencies, each with different funding mechanisms, application procedures, etc. forms a significant challenge in obtaining assistance, and in quantifying total damages. Agencies funding public-sector costs include:

- Federal Emergency Management Agency
- Army Corps of Engineers
- Department of Agriculture
- Department of Transportation
- Department of Housing and Urban Development
- Department of Defense
- Department of Health and Human Services
- Other agencies

Most of these programs require cost sharing from states and local municipalities, ranging from 10 to 25 percent of federal assistance. They also vary widely in the time-frame of benefits, from rapid response to funding that is received years after the disaster has ended, and in the application process and specific application evaluation criteria for funding.

It is important to note that these estimates are based on funding following a declared disaster, which is the prerequisite for many of the program benefits listed. It does not include state and local government spending to recover from disaster events that do not meet the threshold to be a declared disaster; similarly, such government spending also does not cover much of the ongoing flood prevention and maintenance costs borne by local municipalities. Costs associated with storms that are not declared disasters can be ineligible for federal and other funding. For example, renovation, demolition and new construction costs for infrastructure that is

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[16] Expected Costs of Damage from Hurricane Winds and Storm-Related Flooding, April, 2019, Congressional Budget Office. https://www.cbo.gov/publication/55019

commonly damaged during flooding events, including city libraries, fire station, animal control, schools, and other public buildings, are often hard fought for and rarely compensated in full to local municipalities.[17]

While forecasting models predict an increase in the severity of major events, they also predict an increase in the frequency of mid-scale events, discussed in further detail below.

Sedimentation Costs

Further, there are many longer-term public sector impacts that persistent flooding events in agricultural areas can have on downstream communities. Sedimentation caused by soil eroded by runoff and stormwaters can have costly impacts on many small towns and communities. Dredging of both recreational lakes as well as navigable waterways is no small undertaking, with local municipalities and states on the hook to bear the brunt of the cost. There is some limited federal funding available to help local communities cope with adverse impacts to natural resources and waterways resulting from natural disasters, such as USDA's Emergency Watershed Protection program (EWP) program.[18] EWP provides up to 75 percent cost share funding for debris removal, protecting eroded streambanks, repairing levees, and correcting damaged drainage facilities.

Dredging lakes and ponds that have become clogged with eroded sediment can be costly for small communities, even with federal support. One recent example comes from the city of Menomonie in Northwest Wisconsin, which doled out $140,000 to dredge Wolske Bay, a part of Lake Menomin.[19] However dredging is a costly, temporary solution to address a longstanding and persistent issue facing many agriculturally based communities.

A study in Wisconsin[20] found that nearly *3 million cubic yards* of sediment were deposited, between 1960 and 2005, into a recreational lake from two upstream rivers. While exact sources of the sedimentation are difficult to account for, streambank and cropland surveys estimated that a significant amount of soil erosion contributed to the siltation downstream. The monetary impacts of downstream issues such as bank stabilization and dredging of navigable waterways is significant. For example, it was estimated to cost $70-$100 per linear foot to stabilize banks from persistent erosion that can cause downstream sedimentation. This cost would be borne by landowners upstream to help protect lake fronts down stream.

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[17] "Cedar Rapids, FEMA Continue to Labor Over Details of Flood Recovery," *The Gazette.* April 21, 2011. Available online: https://www.thegazette.com/government-politics/cedar-rapids-fema-continue-to-labor-over-details-of-flood-recovery/

[18] USDA-NRCS. Emergency Watershed Protection Recovery Assistance. Available online: https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/landscape/ewpp/?cid=nrcseprd1381472

[19] Powers, P. "Wolske Bay Dredging to Begin this Summer." Leader-Telegram. April 19, 2016. Available online: https://www.leadertelegram.com/news/front-page/wolske-bay-dredging-to-begin-this-summer/article_4d48cae0-00ab-5c31-841a-d00b03d0259e.html

[20] Wisconsin Department of Natural Resources. Available online: https://dnr.wi.gov/lakes/grants/Project.aspx?project=10100989

Business & Supply Chain Disruptions

In most flooding events, the most immediate impact felt on the private sector results from a loss of sales or business in the days and weeks immediately following a natural disaster or flash flooding event. However, ripples can extend further as supply chains are disrupted in flood-prone regions, especially due to damage to transportation infrastructure. Further, the impacts of recurring and chronic flooding have an even more devastating impact on businesses and overall communities, as many choose not to return or reopen when floodwaters recede. According to FEMA, 40-60 % of small businesses never reopen following a disaster, and the Small Business Administration estimates that over 90% of businesses fail within two years after being struck by a disaster.[21]

CBO estimates expected annual losses from flooding and hurricanes of $9 billion to the commercial sector, which includes the costs of repairing buildings and retail stores, finding temporary space, as well as revenue losses because of disruption to businesses.[22] However, it's important to note that private insurance coverage, federal flood insurance, and federal disaster assistance only cover on average 40 percent of these costs, leaving business owners on the hook to recoup most of the flood-related costs. For example, after a major 2008 flood devastated the Iowa city of Cedar Rapids, the Chamber of Commerce provided financial assistance to impacted small businesses in the absence of a federal program.[23] In total, the city distributed over $6 million to 330+ small businesses to help them meet payroll, pay for flood clean-up and other disaster expenses. Many businesses cited this early financial assistance program as having saved their business.

In terms of supply chain disruption, there are countless examples of both drought and flooding in rural areas that disrupt the agricultural supply chain and commerce downstream. For example, low water levels associated with the 1988 drought reduced Mississippi River barge traffic by 50 percent. And in 1993, the Mississippi River closed to barge traffic for 4 months due to severe flooding.[24]

Further, many industries rely on access to clean water as part of their business model, and may incur additional costs or disruptions in their supply chain in the event of water contamination as a result of extreme or chronic flooding. The brewing industry is a prime example of a sector that is thriving in many small towns and communities across the country and which could be

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[21] Association of Flood Plain Management Foundation. *Understanding and Managing Flood Risk.* 2020. Online at: https://asfpm-library.s3-us-west-2.amazonaws.com/FSC/Elected_Officials_Guide/ASFPM_Understanding_and_Managing_Flood_Risk_Vol1_2020.pdf

[22] Expected Costs of Damage from Hurricane Winds and Storm-Related Flooding, April, 2019, Congressional Budget Office. https://www.cbo.gov/publication/55019

[23] Cedar Rapids Area Chamber of Commerce. Online at https://www.cedarrapids.org/application/files/6614/7174/5820/Business_Case_Management_Program-BSI-1-12-2012.pdf

[24] Turning Soils into Sponges. Union of Concerned Scientists. August 2017. www.ucsusa.org/SoilsIntoSponges

impacted by water quality issues. The fact that more than 100 craft breweries from around the country have banded together to campaign for regulations that protect water quality highlights the potential disruption to this industry from water quality issues.[25]

Production Losses

While production losses to farmers caused by both drought and flood are often addressed by federal risk management and disaster assistance programs, the financial impacts of lost production also have downstream economic impacts. On-farm production losses occur from a variety of reasons (including extreme heat, flooding, pests, and diseases). Direct losses related to flooding fall into two categories: 1) direct crop losses due to excessive moisture or flooded farm fields and 2) losses from prevented planting losses.

Every year, farmers lose large quantities of crops due to excessive moisture and flooded fields, which can result in disruptions to supply chain and prices, as well as costs to taxpayer funded programs like crop insurance. For example, between 2011 and 2016, flood- and drought-related claims made to the taxpayer-subsidized federal crop insurance program resulted in $38.5 billion in payouts.[26]

The most frequent reason for prevented planting is due to flooding. For example, in 2019, prevented planting claims were filed for 594,204 acres of WI corn, soy and wheat. The value of those crops would have been $269 million,[27] and the prevented planting indemnities for the state totaled over $131 million.[28] This left $138 million in uncompensated financial losses. Further, the multiplier effect of agricultural income, based on University of WI-Madison calculations, is 3.525, which means that those uncompensated losses caused $486 million in losses to the state economy.

The National Agricultural Retailers Association recognized that prevented planting caused significant financial losses to their members and sent a letter in 2019 to then USDA Secretary Perdue asking for a delay in prevented planting deadlines and an extension of acceptable planting dates.[29] For corn and soybeans, the seed and pesticides alone that were not purchased due to prevented planting would cause $77.7 million in losses to the WI economy.[30] While those purchases are not taxable due to agricultural exemption, all downstream uses of that value would be.

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[25] Natural Resources Defense Council. Online at: https://www.nrdc.org/brewers-clean-water

[26] Turning Soils into Sponges. Union of Concerned Scientists. August 2017. www.ucsusa.org/SoilsIntoSponges

[27] 2019 Acreage Data January 20, 2020, USDA Farm Services Agency

[28] Federal Crop Insurance: Record Prevent Plant (PPL) Acres and Payments in 2019, 2020, Congressional Research Service publication R46180.

[29] Agricultural Retailers Association. June 4, 2019. Online at: http://image.email.aradc.org/lib/fe9113727d62067f76/m/1/64c3f59c-cda1-4848-aeff-a809ee9542f5.pdf

[30] University of Wisconsin-Madison. 2020 Crop Budget Analyzer: Online at https://farms.extension.wisc.edu/topics/budgets-and-benchmarks/

Health Impacts

Contamination of water from farm fields also causes significant non-farm costs to downstream communities, including severe and often prolonged health impacts. Agricultural chemicals such as pesticides and fertilizers are carried along with agricultural runoff in the event of extreme and flash flooding events. Two of the most prominent, and costliest, water contamination issues facing rural municipalities are excessive nitrates and pesticides from that make their way into downstream drinking water supplies. These contamination issues are costly for states and municipalities and result in significant negative and costly health impacts.

Chemical fertilizers applied to agricultural fields is a primary source of nitrate contamination in our waterways and drinking water sources. This contamination is only increased with major flooding events. However, soil health practices can reduce the amount of nutrients and chemicals leaving farm fields by increasing soil's water holding capacity.

A recent study of the costs associated with nitrogen contamination in drinking water, using Wisconsin as a case study, estimated direct medical costs for nitrate-attributable negative health outcomes ranged between $23 and $80 million annually.[31] Further, these estimated costs declined by about $406,000 for each 1 percent reduction in statewide nitrate contamination, or $229,000 for each 1 percent reduction in the 15 counties with the highest current drinking water nitrate concentrations. Additional state and regional data on nitrate contamination is available through the Environmental Protection Agency (EPA)'s Source Water Protection Program.[32]

For municipal water systems, the processes that appear to have the most impact on pesticide removal – granular activated carbon (GAC) and powdered activated carbon (PAC) - are commonly found or used in larger water supply systems but, because of high costs, are rarely used by the smallest systems.[33] This leaves many smaller, or under-resourced local municipalities vulnerable to disruptions in access to clean, safe, drinking water as a direct result of upstream agricultural runoff, which is exacerbated due to flooding.

In addition, removal of excessive agricultural nutrients, such as nitrates, from raw drinking water supply in order to meet the EPA's 10 mg/L maximum contaminant level (MCL) is a costly endeavor for most small towns and rural municipalities. In 1991, the City of Des Moines spent $4.1 million to build a nitrate removal facility with the capability of treating 10 million gallons/day.[34] Operating the system can cost the city up to $10,000 per day; in 2015, the system

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[31] Mathewson, P.D; Evans, S; Byrnes, T; Joos, A; Naidenko, O; *Health and Economic Impact of Nitrate Pollution in Drinking Water: a Wisconsin Case Study*. Environmental Monitoring and Assessment. 192, Article 724. 2020.

[32] https://www.epa.gov/sourcewaterprotection/source-water-contacts-epas-regional-offices

[33] Environmental Protection Agency. Finalization of Guidance on Incorporation of Water Treatment Effects of Pesticide Removal and Transformations in Drinking *Water Assessments*. Online at: https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/finalization-guidance-incorporation-water-treatment

[34] Des Moines Water Works. Online at: https://cms9files.revize.com/desmoineswater/Nitrate%20Removal%20Facility.pdf

was used 177 days costing residents $1.7 million in total that year to ensure safe drinking water. The City of Cedar Rapids also has concerns with nitrate levels in its raw water supply. Concentrations of nitrate have never exceeded the MCL and therefore Cedar Rapids does not currently have nitrate removal technologies. However, if nitrate levels continue to rise, the cost of a nitrate removal system is estimated to cost the city between $80 - $160 million.

In addition to flood-related nitrate and pesticide contamination, more and more local municipalities are fighting the impact of harmful algal blooms (i.e. Microcystin), which has become an emerging drinking water issue in recent years. The City of Des Moines was unable to use one of its primary water sources for 110 days in the fall of 2020 due to unsafe levels of the toxin. Unfortunately, there is no effective way for cities to combat this drinking water issue, aside from reducing the runoff of phosphorus from the source (i.e. farm fields).

Recreation & Housing Impacts

In addition to direct non-farm costs to communities due to flooding and agricultural runoff, there are other, more subtle and often longer-term costs, such as decreased tourism and recreation revenue as well as decrease in housing values. These other costs are especially pronounced for lakefront communities that rely on tourism and recreation to support local revenue and tax base.

While there have been some case studies and local analysis conducted to try to determine the overall costs that poor water quality in particular have on downstream communities as it relates to tourism, recreation, and housing, there is no national data set or analysis to measure these costs nationally. However, there has been extensive research conducted on these issues in the Red Cedar Watershed in northwest Wisconsin, led by researchers at the University of Wisconsin-Stout, as explained further in the case study found in Appendix B.

IV. Findings & Recommendations

Thus, there is a wide range of non-farm costs to communities, states and municipalities resulting from agricultural runoff, and a host of benefits associated with reducing flooding and water contamination from farm fields. Direct costs range from damage to private and public infrastructure to longer-term, indirect impacts on recreation, ecology and public health. While it is difficult to precisely and comprehensively quantify these exact costs to policymakers, researchers, and taxpayers alike, the data and case studies provided herein make visible the complicated and intertwined suite of wide reaching impacts that are often borne by communities and individuals least resourced to confront them.

Quantifying the *potential cost savings* associated with increases in soil health (and subsequent reduction in off-farm runoff), is further challenged by the complexity of both natural and political systems. The complexity of mapping the impacts on natural systems (including the wide range of production systems, watersheds, and hydrology, as well as scale, duration and frequency of weather events) is matched by the socio-political complexity of acute vs chronic costs that are spread across municipal, state and federal budgets. While this complexity makes specific quantification difficult, the discussions informing this paper indicate critical trends that merit further research and continued dialogue.

Flooding Threatens Rural Viability - While runoff from farm fields is only one part of the cause, flooding is causing major issues for small and mid-scale municipalities, including threats to the viability of many rural communities. Both acute and chronic issues with both water quality and quantity have significant impacts on both local expenditures (i.e. costs associated with water purification), and the loss of potential revenue to rural communities (i.e. lost tourism dollars associated with increased nutrient and sediment contamination of lakes).

Chronic Runoff Often More Devastating - While much of our discussion has focused on the impacts of large-scale weather events, these events are likely to overwhelm even the greatest increases in soil infiltration associated with improved soil quality, and are most likely to receive more federal assistance for recovery. For the purposes of this discussion, they are therefore less likely to provide clear financial benefits for the incentivization of soil quality benefits.

More important for municipalities and states are costs associated with *chronic* water contamination over time, (i.e. costs associated with purification of agricultural chemicals from municipal drinking water), and costs associated with the increase in the frequency of *low and mid-level* flooding events that have significant impacts and costs, but are not likely to be subject to federal relief. These costs are also more likely to be mitigated by implementation of soil quality practices.

Risk of Community Collapse is Real - There are also several non-monetary impacts that have extremely important outcomes on small and mid-scale municipalities - especially small, rural towns. In recent years, repeated flooding events in small, rural towns have created situations where people no longer have faith in their future within the community, and their ability to continue to invest in the future of the town. In many cases, small business entrepreneurs or residents have invested life savings in recovery from one flooding event (whether business or household), only to see their investment lost in a subsequent event long before they were able to recoup the costs of recovery. This has given rise to the concept of “community collapse,” when recovery dollars are no longer used to rebuild, but to relocate, and losses of money and people threaten the viability of small towns.[35] This issue was raised from direct experiences in at least 3 states represented in our discussions.

Lower Resourced Communities Suffer Disproportionate Impacts - Related to the threat of community collapse, often flooding and agricultural runoff has a disproportionate impact on disadvantaged and lower-resourced communities. This is especially true for flood-prone areas, as well as areas that lose access to clean water. Further, the ability to recover from both acute

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[35] Flavelle, C. “Climate Change is Bankrupting America’s Small Towns” *New York Times.* Sep. 15, 2021. Online at: https://www.nytimes.com/2021/09/02/climate/climate-towns-bankruptcy.html

and chronic flooding events disproportionately impacts lower-resourced individuals and communities.

Funding Needed for Prevention, Not Just Recovery - Our research also indicates the importance of the prevention and reduction of flooding or contamination events, and the role of soil quality practices in that reduction, as opposed to increased disaster recovery funds. While increased funding may assist with the financial impacts of repeated events, it is the impact on the resilience of the people within the municipality that will be determine whether those funds are used to rebuild or to relocate. One avenue to explore further is the extent to which FEMA's Community Rating System could be better employed to incentivize improved soil health practices as a means of flood prevention.

Water Contamination Impacts Rural Wealth Generation - Another important issue raised in these discussions was the impact of chronic farm-originated water contamination, whether by sediment or agricultural chemicals, on local income generation. While there are clear direct impact costs such as the increased costs associated with the water purification technology required to remove agricultural chemicals from drinking water, less clear but no less important is the reduced income associated with lost income opportunities. These include reduced tourism dollars when lakes that once hosted extensive recreational activities and served as a destination to bring tourists to the area became choked with sediment and overgrown with algae and other contaminants, and opportunity for increased economic development by industries that depend on clean water, such as brewing and distilling.

Recommendations

While there has been increased attention to the timely and important topics around soil health and natural disasters, more robust conversations are needed across sectors and across agencies - at both the state and federal level - to develop effective public policies that will address the interconnected, long-standing, and often devastating downstream impacts associated with agricultural runoff. Specific recommendations include:

1. **Increased focus on the impacts of small and mid-scale weather events, and the chronic water quality issues associated with normal water runoff from farm fields.**

   As stated previously, because these events do not rise to the level of federal disaster declarations or funding, they are often underreported and overlooked. State and federal policymakers should take concrete actions to evaluate the chronic water quality and flooding impacts paying specific attention to the impacts on small towns and rural municipalities. Specifically, this would include tracking and disaggregating data on small-scale weather events from those that meet a federal disaster declaration. In addition, more research, analysis and case studies are needed to help quantify the costs associated with these mid-level and chronic flooding events. Finally, those working on the frontlines of disaster assistance, response, and recovery should evaluate the extent to which current programs and policies are adequately responding to chronic and mid-scale flooding in their states and regions, and develop action plans for what investments and specific policy changes are needed at the local, state, and federal level to help prevent future impacts.

2. **Explore new models and frameworks needed to quantify the disparate costs associated with flooding and water contamination across scales.**

   These discussions have indicated the difficulty of obtaining the data and analysis to adequately fulfill our primary research aim - the development of direct and specific cost/benefit analyses of the non-farm impacts of soil quality practices. While there is more work to be done to bring together the results of existing, multidisciplinary research, the development of new frameworks and models drawn from the experience of individual municipalities will be critical to effective research-based stakeholder engagement. Simply, we need different ways of putting the pieces together, and need to come at it from a different angle. For example, federal policymakers could create pilot programs or support modeling studies that more fully integrate flood-related data and resources across agencies such as FEMA, USGS, EPA and USDA.

3. **Increased analysis on the racial equity impacts associated with chronic flooding and water quality impacts.**

   All flooding events tend to have differential impacts by race and wealth. Low-wealth and communities of color are often specifically located in places more prone to flooding. This often skews analysis of the value of lost assets, and under-reports the impact on individuals and families, and can be more likely to cause catastrophic household losses for low-wealth individuals. The impacts of natural disasters and low-level events on persistent poverty and communities of color is an important area of future research.

   And while there is some data and analysis to support these findings, more cross-agency and cross-disciplinary action is needed to fully understand the disparities that lower-resourced communities and communities of color face related to natural disasters and chronic flooding and water quality events. For example, philanthropic and public support could be catalyzed to convene impacted communities and chart an action plan that would begin to reverse these disparities.

4. **Convene a federal task force to coordinate activities across agencies and departments in response to disaster assistance, response, recovery; flood prevention; climate change; soil health; and racial equity.**

   Given the complexity of this issue, the disparate scales of impact, and the disparate entities involved, more coordination and cross-departmental dialogue is needed to ensure concrete actions are taken to minimize costs and downstream impacts on individuals, local municipalities, and rural communities.

5. **Prioritize investments in research, data analysis, and cross-disciplinary dialogue that further explores outstanding questions related to the non-farm impacts of agricultural runoff when exacerbated by flooding. Some suggested areas of research include:**

    - *Increased communication with small rural communities to allow researchers and policymakers at all scales to better understand their unique experiences associated with low and mid level events and ongoing water contamination*. This may include a national survey, coordinating regional stakeholder meetings, or a more in-depth study of affected communities across the country.

    - *Engage agencies and researchers that specialize in historic weather pattern analysis in an effort to identify and quantify low and mid-level events, and associated flooding.* Basically, can we bring policymakers and researchers together to understand the extent to which equivalent rain events are resulting in increased flooding costs and damages?

    - *Integration of costs analysis across funding levels.* To create a more comprehensive list of the non-farm costs and benefits of soil health practices, researchers should continue to catalog the data that exist and perform stated and revealed preference studies, even individual case studies. State agencies should also continue or enhance long-term monitoring of flooding events and water quality measures, so that researchers can identify costs and benefits longitudinally.

The following individuals contributed to the research and drafting of this paper:

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Appendix A

Table 1. Non-farm Costs of Agricultural Runoff

COST	DESCRIPTION	WATER QUANTITY	WATER QUALITY	WHO PAYS
Infrastructure Costs				
Residential property damage	Damage to private homes and property (cars, boats, personal items) and costs to repair homes or replace personal losses. Includes public and private costs of flood insurance.	x		Private homeowners, individuals, landlords taxpayers
Business damage & additional costs	Damage to business store-fronts, warehouses, processing and distribution facilities and related business equipment. Costs to repair or replace buildings or equipment. Additional costs for businesses that require clean water (brewing, etc). Includes public and private costs of flood insurance.	x	x	Business owners, landlords, taxpayers, municipalities
Other buildings damage	Damage to public or private schools, churches, hospitals, cultural landmarks, museums, government buildings.	x		Municipalities, state, academic institutions, non-profits, taxpayers
Transportation damage	Damage and repair to roads, traffic lights, bridges, and railroads. Dredging navigable waterways.	x	x	Municipalities, states, federal
Other infrastructure damage	Damage to culverts, levees, utilities. Costs related to siltation and wastewater treatment caused by soil and debris carried by floodwater.	x	x	Municipalities, states, federal
Infrastructure flood prevention	Construction and maintenance of dams, levees, and culverts.	x	x	Municipalities, federal
Other infrastructure prevention	Construction and maintenance of nutrient and chemical removal systems.		x	Municipalities, states, federal
Flood recovery	Debris collection and removal, environmental remediation, dredging either because sedimentation is hindering the waterway, or because of the excess nutrients carried by the silt (high-phosphorus sedimentation).	x	x	Municipalities, federal

Public Health & Safety Costs				
Drinking water availability	Alternative water sources for municipalities that rely on shallow alluvial aquifers.	x	x	Individuals, municipalities
Evacuation costs	Transportation, temporary housing, and necessary emergency supplies for evacuees (food, water, etc).	x		Individuals, municipalities, states, taxpayers, non-profits
Loss of life / health impacts	Direct deaths resulting from flooding or impaired drinking water. Human health impacts of nitrates.	x	x	Individuals
Ecological Costs				
Hypoxia	Impacts on flora populations; impacts on fauna populations; associated business impacts (ie tourism, commercial fishing).		x	All
Wildlife impacts	Loss of diversity and populations of aquatic organisms and food sources for other wildlife and humans.		x	All
Other Costs				
Supply chain / business disruptions	Lost business revenue and additional costs associated with supply chain delays, disruptions in transportation infrastructure, decreased sales (i.e. commercial fishing).	x	x	Businesses, consumers
Tourism / recreation impacts	Lost revenue to businesses and state due to decreased tourism or recreation activity (esp boating, swimming, fishing, etc).	x	x	Businesses, homeowners, states
Housing values / property taxes	Lower property values and related tax revenue associated with lakefront properties located on impaired waters.		x	Homeowners, municipalities
Lost revenue due to crop losses	Lost revenue for food supply chain businesses (processors, distributors) due to prevented plant or crop losses.	x		Businesses
Crop losses	Private and public costs of crop insurance.	x		Taxpayers, farmers
Risk of community collapse	Depopulation, lost businesses and subsequent revenue and activity in communities chronically impacted by floods. Environmental justice impacts.	x	x	Individuals, businesses, municipalities, states

Opportunity costs	Time spent mitigating impacts of flooding or contamination (e.g., flood washes out road, farmer must take longer route to fertilize/harvest)	x	x	All

Appendix B - Case Studies: Impacts on Local Communities

Local communities and municipalities are often at the nexus of both the costs and important equity issues related to which populations are impacted by flooding and have access to clean drinking water. While honing in on specific costs data at the local, state, and national scale is important, it is helpful to take a closer look at how communities on the ground are impacted. While we are only highlighting two examples in this paper, there are countless more in every state across the country that illustrate just how serious, and in some cases, catastrophic, the downstream effects of agricultural runoff are.

Case Study #1: Wisconsin - Red Cedar Watershed

The Red Cedar Watershed encompasses a 1,893 square mile area in west-central Wisconsin and includes largely agricultural areas of Barron, Dunn, Chippewa, Polk, Rusk, Sawyer, St. Croix, and Washburn Counties. Agriculture is the most common use of land throughout the watershed, and the region has become a focus on conservation efforts in recent years due largely to widespread issues with eutrophication of local waterways. In particular, Lakes Tainter and Menomin are the two biggest impoundments in the watershed and are hypereutrophic, resulting in severe summer algae blooms and very poor water clarity.[36] Lakes Menomin and Tainter were designated as highly eutrophic in 1972, a Phosphorus Total Maximum Daily Load was established in 2012, and an EPA plan for the watershed was approved in 2015.[37]

Current lake conditions are detrimental to fish, plants, and other aquatic species. Algae blooms and cyanobacteria collect each summer leading to a noxious odor and terrible appearance. Cyanobacteria also present a health hazard to both people and pets, with multiple reported cases of dogs dying after drinking the water in recent years.[38] Sources of phosphorus include run-off from agricultural land and urban areas, streambank erosion, animal waste, and other organic matter that enters streams, creeks, and local rivers and then accumulates in the lakes.[39]

Lake Menomin sits in the middle of Menomonie, Wisconsin, a small college town with a historic downtown adjacent to the lake. Historically, the lake had been used extensively for recreation and amenities existed that included a boat house with a dance hall (demolished in the mid 20th century), a boat rental location, a fish hatchery, a small store one could boat to to buy bait and drinks, etc. There are many accounts from older community members of how the lakes were a focal point for the community and how widely they were used for swimming, boating,

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[36]Wisconsin Department of Natural Resources. May 2012. Online at: https://fyi.extension.wisc.edu/redcedar/files/2017/08/Final_Tainter_TMDL_May29_2012.pdf

[37] Red Cedar River Quality Partnership. *A River Runs Through Us.* July 2015. Online at: https://fyi.extension.wisc.edu/redcedar/files/2017/08/RedCedarPlanFinalMedResolution.pdf

[38] Cotton, M. WEAU News. "Menomonie Man Suspects Lake Menomin algae killed dog." June 2021. Online at: https://www.weau.com/2021/06/23/menomonie-man-suspects-lake-menomin-algae-killed-dog/

[39] Wisconsin Department of Natural Resources. May 2012. Online at: https://fyi.extension.wisc.edu/redcedar/files/2017/08/Final_Tainter_TMDL_May29_2012.pdf

picnicking, and community events, including a triathlon which was held for decades but ceased in the early 2000s. However, the lake can no longer be used by local residents for recreation for most of the summer. Signs warn people away from swimming in the lake and many local residents use the municipal pool, built in 1997, instead of the lake the pool sits next to.

Although most of the issues in the Red Cedar Watershed are related to poor water quality, increasingly frequent rain storms, which are often stronger than reported in the past, have also caused localized flooding in the area. For example, parts of northern Wisconsin (just north of the watershed) had several roads washed out after storms in 2016[40] and farmers are reporting increased erosion problems due to severe rain events. Localized flooding has also necessitated local municipalities to repair stormwater retention ponds and other flood prevention infrastructure. For example, a retention pond was damaged during a severe storm in May 2021, costing the city of Menomonie $91,000 to repair. Because the pond was initially built with state grant funds, the City was able to request 50% of total funds from the State to help fund repairs.

Research conducted by the University of Wisconsin-Stout through the Linking Applied Knowledge in Environmental Sustainability Research Experience for Undergraduates Program (LAKES REU), has estimated some of the costs related to poor water quality in the Red Cedar Watershed:

- Estimates of recreational value to boat owners in the Red Cedar Watershed (measured by the amount they report traveling multiplied by the average number of visits to a lake): $10 million annually[41]
- Local residents report they would use the lakes more and spend more money in Menomonie's downtown if the lakes were cleaner. UW Stout Students reported they would be more likely to stay in town for the summer if the lake was cleaner.[42]
- 85% of those surveyed in 2016 reported that they traveled to a lake other than Menomin or Tainter for recreation.[43]
- Current annual economic impact of recreation: $53 million ($4.3 million in tax revenue).
- Annual economic impact of recreation if 10% more tourism occurred (e.g. if there were more days the lake was not exhibiting blooms): $13 million additional ($1.1 million in additional tax revenue).[44]
- Housing values: Researchers calculated the value of a typical house in different areas of the watershed and then calculated the "lake premium," or the additional value that a waterfront house would have as compared to a similar house without lakefront. The lake premium increases on lakes with better water quality. For example, the lake premium for a house in Cumberland (with high water quality) is estimated at $68,000,

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[40] Associated Press. Severe storms wash out northern Wisconsin roads. July 2016. Online at: https://www.wsaz.com/content/news/Severe-storms-wash-out-northern-Wisconsin-roads-386496151.html
[41] University of Wisconsin-Stout. *UW-Stout Red Cedar Basin Research.* May 2019. Online link.
[42] ibid
[43] ibid
[44] Red Cedar Basin Assessment for Water Quality Improvement. January 2021. Pg 16. Online at: http://wcwrpc.org/Documents/RED%20CEDAR%20SUMMARY%20REPORT%20FINAL.pdf

and the premium decreased by $19,000 in Chetek and $32,000 in Menomonie. In all models, increases in water quality led to increasing housing values. For example, one additional foot of water clarity was associated with a $3,976 positive impact on housing values.[45]

In addition to these overall economic impacts, enormous amounts of human capital, tax dollars, and grants from state and federal agencies are spent mitigating the impacts of poor water quality in the area. The costs range from grants used to incentivize better farming practices to increase soil health, to the costs of repairing streambanks to mitigate erosion and dredging lakes, to the time spent monitoring water quality and organizing to educate citizens and landowners about the problem. The overall costs are hard to quantify, but a few examples include:

- $140,000 to dredge one bay on Lake Menomin in 2016 [46]
- $91,000 to repair a stormwater pond in a local park [47]
- $600,000 for 4 year project to assess water quality and its impacts (partnership with UW-Stout, US Army Corps of Engineers, WI DNR, UW-Extension, Tainter Menomin Lake Improvement Association, Dunn County Land and Water Conservation, Barron County Land Conservation, West Central Wisconsin Regional Planning Commission) [48]
- $28,000 DNR Lakes Protection grant to Desair Lake Restoration was used to build 22 catchment basins in dry runs that feed into the lake. The organization had to match 25% of the grant and did this with volunteer labor for members.[49]
- DATCP grants to fund cover crops, soil sampling, building of grass waterways, etc awarded to farmer groups. Red Cedar Conservation Farmers, for example, was awarded $30,000 in 2021. Farmers of Barron County received $17,000.[50]
- Throughout the state, local communities receive multiple small grants from the Department of Natural Resources to address water quality issues. For example, in FY21,

[45] University of Wisconsin-Stout. LAKES REU: Community Capacity Report. 2020. Pg94-98. Online at http://wcwrpc.org/Documents/Addendum%201%20LAKES%20REU%20Community%20Capacity%20Report%20(2019%20UW-Stout).pdf
[46] Powers, P. "Wolske Bay Dredging to Begin this Summer." Leader Telegram. August 19, 2016. Online at: https://www.leadertelegram.com/news/front-page/wolske-bay-dredging-to-begin-this-summer/article_4d48cae0-00ab-5c31-841a-d00b03d0259e.html
[47] Personal communication with city official
[48] Red Cedar Basin Assessment for Water Quality Improvement. January 2021. Pg 16. Online at: http://wcwrpc.org/Documents/RED%20CEDAR%20SUMMARY%20REPORT%20FINAL.pdf
[49] University of Wisconsin-Stout. "Summary of Accomplishments of the Red Cedar River Water Quality Partnership for the End of Year Five (2020) of the Ten-Year Plan." April 2021. Pg3. Online at: https://fyi.extension.wisc.edu/redcedar/files/2021/09/2020-Red-Cedar-Partnership-Annual-Report-and-Accomplishments.pdf
[50] Wisconsin Dept. of Agriculture, Trade, and Consumer Protection. January 12, 2021. ONline at: https://datcp.wi.gov/Pages/News_Media/20210112ProducerLedGrants.aspx

$6.2 million in grant dollars were awarded across the state to municipalities and local organizations for projects related to protecting or restoring water quality.[51]

The efforts made in the Red Cedar Watershed seem to be making a difference, although it is difficult to directly demonstrate the relationship between these efforts and phosphorus reductions. The 2020 report from the Red Cedar Water Quality Partnership (the organization that coordinates and monitors efforts under the EPA-approved plan discussed above) notes that phosphorus loads were reduced by 4,959 lbs in 2020 through a combination of conservation cover, cover crops, critical area planting/field borders, and no till practices. Local lake associations are also seeing decreases in phosphorus levels that they attribute to their efforts to control runoff.[52] A variety of efforts and soil health practices related to these decreases in phosphorus are noted in the report:

- Farmer-led groups that educate farmers on better practices
- Increases across the area in conservation farming practices (i.e. grass waterways, no-till, cover crops, manure management, strip tillage)
- Stream restoration projects
- Educating homeowners on how to control runoff into lakes
- Lake association efforts to stop runoff and sedimentation
- Urban runoff control[53]

Case Study #2: Iowa - Cedar River Watershed

Cedar Rapids is Iowa's second largest city, located in the heavily agricultural region of eastern Iowa. The city is located adjacent to the Cedar River and is subject to chronic flooding. Most of the flooding is driven by precipitation, but land use alterations have shifted the region's hydrology, causing generally higher base flows in the Cedar River.[54] This recent shift has precipitated the loss of wetlands, which has reduced the storage of stormwater and has also disconnected rivers and streams from their floodplains, resulting in a loss of flood flow water storage.[55]

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[51] Wisconsin Dept. of Natural Resources. 2021. Online at: https://dnr.wisconsin.gov/sites/default/files/topic/Aid/surfaceWater/Priority_Funding_List_FY21_Surface_Water_Grants.pdf

[52] University of Wisconsin-Stout. "Summary of Accomplishments of the Red Cedar River Water Quality Partnership for the End of Year Five (2020) of the Ten-Year Plan." April 2021. Online at: https://fyi.extension.wisc.edu/redcedar/files/2021/09/2020-Red-Cedar-Partnership-Annual-Report-and-Accomplishments.pdf

[53] University of Wisconsin-Stout. "Summary of Accomplishments of the Red Cedar River Water Quality Partnership for the End of Year Five (2020) of the Ten-Year Plan." April 2021. Pg3. Online at: https://fyi.extension.wisc.edu/redcedar/files/2021/09/2020-Red-Cedar-Partnership-Annual-Report-and-Accomplishments.pdf

[54] Schilling, K; Libra, R. "Increased baseflow in Iowa over the second half of the 20th Century." *Journal of the American Water Resources Association.* August 2003. Online at: https://www.proquest.com/openview/d28c39eebd5481aec9c3802abd8e33d1/1?pq-origsite=gscholar&cbl=34915

[55] Iowa Flood Center. "Middle Cedar River Watershed Hydrologic Assessment Report". October 2019. Pp 33 - 44. Available online: https://drive.google.com/file/d/1Ej3g0GDYmwMG3q1ZJcCnBIxwaiWz7_5b/view?usp=sharing

While this riverfront community is subject to chronic, low-grade flooding, it has also suffered from devastating widespread flooding events that residents and businesses are still recovering from to this day. In particular, the 2008 Flood, the 5th largest natural disaster when it struck eastern Iowa, flooded 10 square miles (14 percent) of the city of Cedar Rapids, and devastated residents and businesses alike.

With 10 square miles of flooded roads, it was impossible for most residents to get to work or school for at least several weeks after the flood crested. Many small businesses, whose doors were closed for months, chose not to return or reopen. This trend is confirmed by data as well (noted previously), and points to the larger issue of the threat of community collapse in the wake of extreme and chronic flooding events, discussed further below. Additionally, many larger industrial agriculture manufacturing businesses (i.e. Cargill, ADM, Quaker) were impacted by the floods as well and had to shut down their operations for as long as several weeks. This temporary decrease in the processing and distribution of agricultural commodities affected the larger food supply chain as supply narrowed.

A total of 5,390 houses were impacted by the flood, dislocating more than 18,000 residents. While 56 percent of impacted residents were homeowners, a significant number of renters were displaced after the flooding. 1,300 of these flood-damaged properties needed to be demolitioned. The Flood of 2008 disproportionately affected disadvantaged residents - with higher percentage of poverty, female-headed households, elderly, disabled, and renters in flood-impacted areas.[56] Additionally, flooding damaged 310 city facilities such as the City Hall, Fire Station, Public Works, city transportation center, and public libraries, which were estimated to cost $500 million to repair and rebuild. Nearly 42,000 tons of flood debris was removed across the city in the wake of the flood.[57]

Cedar Rapids is still in the recovery process,[58] 13 years later, with many residents and businesses still reeling from the catastrophic impacts of the flood. In particular, many vulnerable populations (including black, brown, and indigenous residents) may not have ever truly recovered from the floods. Eric Tate is a researcher at the University of Iowa, located in Cedar Rapids, who has done extensive research on the disproportionate impacts of natural disasters on socially vulnerable communities.[59] The city is proposing to build a Flood Management System, that includes a permanent system of floodwalls and levees, that will cost

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[56] City of Cedar Rapids. “Flood of 2008 Facts & Statistics” Available online: https://www.cedar-rapids.org/discover_cedar_rapids/flood_of_2008/2008_flood_facts.php
[57] ibid
[58] Cedar Rapids Recovery and Reinvestment Coordinating Team. Progress Report - Flood Recovery: June 13, 2008 - December 13, 2008). Available online: https://abag.ca.gov/sites/default/files/cedar_rapids_recovery_and_reinvestment_coordinating_team_progress_report.pdf
[59] University of Iowa, Department of Geographical and Sustainability Studies. Available online: https://clas.uiowa.edu/geography/people/eric-tate

the city roughly $375 million to protect against future floods.[60] The Iowa Watershed Approach project has already invested over $12 million in the Middle Cedar Watershed to construct distributed storage structures, such as ponds, wetlands, and grade stabilization structures.[61]

As illustrated by both of these case studies, flooding in agriculturally-based communities, such as Cedar Rapids and Menomonie, have devastating and costly impacts on local residents, businesses, as well as state and local budgets, with outsized impacts on vulnerable populations with limited ability to recover or address longer term economic and health issues resulting from poor water quality.

While federal resources have been critical for flood recovery and water quality improvement efforts, additional support is needed to provide more permanent solutions to protect flood prone communities such as Cedar Rapids and Menomonie. A combination of structural solutions (i.e. Flood Management Systems) in combination with a watershed management approach to reduce flood flows in the watershed (such as building soil health to improve the land's ability to retain water; restoring wetlands, building ponds/small structures to retain water, and restoring floodplain areas) will be needed.

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[60] City of Cedar Rapids. "Flood of 2008 - Flood Management System." Available online: https://www.cedar-rapids.org/discover_cedar_rapids/flood_of_2008/flood_management_system.php

[61] Iowa Watershed Approach - Middle Cedar River Watershed. Available online: https://iowawatershedapproach.org/resources/ghost/middle-cedar-river/