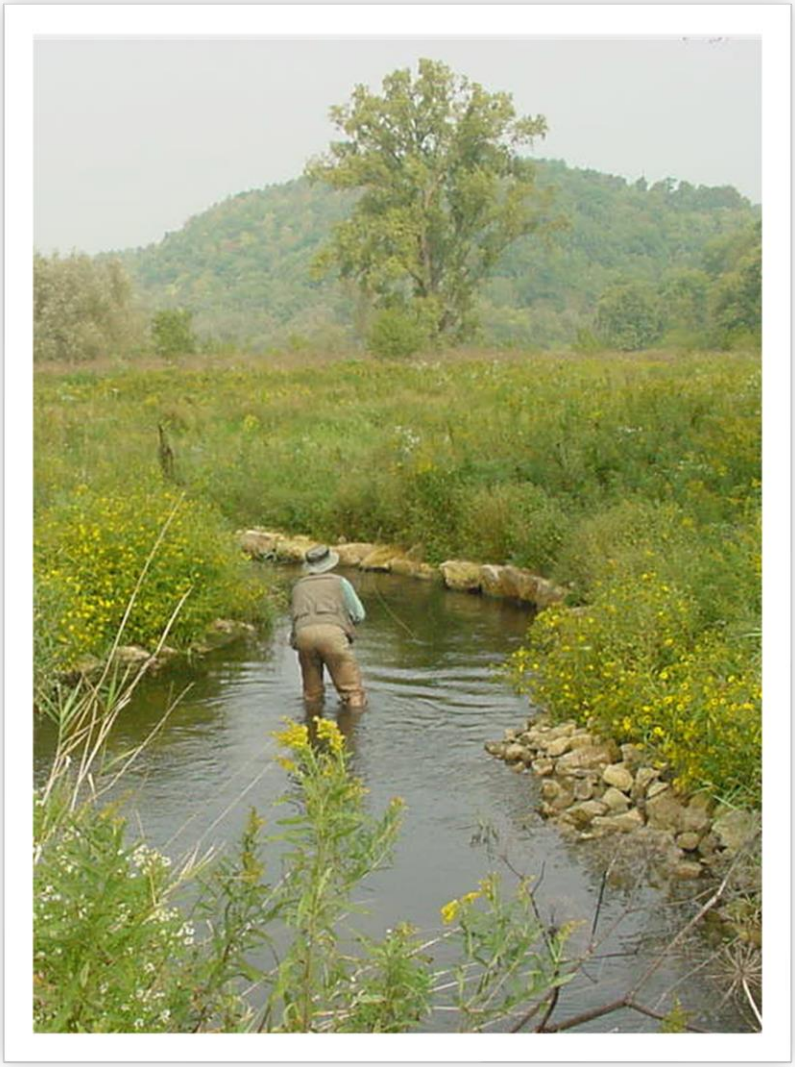

Driftless Area Angler Science: 2020 Annual Report

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July 2021

2020 Program Overview

Ambitious intentions for expansion of the Trout Unlimited (TU) Angler Science Driftless Area Program in 2020 were greatly hampered by the COVID-19 pandemic. In 2020, the Program was intended to expand from Pierce County (WI), monitored by the TU Kiap-TU-Wish Chapter in 2019, to the other 14 TU Chapters, US Fish and Wildlife (US FWS) staff, and Minnesota and Wisconsin Departments of Natural Resources (DNR) staff with regions active in the Driftless Area. Prior to the COVID-19 outbreak, the Project Team (Carter Borden, Dan Dauwalter, and Kent Johnson) highlighted the WiseH2OTM mobile app (mApp) at the 2020 Driftless Area Symposium (February 4-5), making a presentation, staffing an information booth, and hosting a workshop, with 40 participants between the booth and workshop. Additionally, the Project Team met with MDNR and WDNR staff in Lake City, Minnesota on February 3. As governments attempted to limit COVID-19 spread through "stay-at-home" orders, closing of business and government agencies, and restricting meetings and gatherings, promotion and rollout of the Angler Science Program was greatly hindered. Thus, attending TU meetings to provide an overview of the Program and get chapters and individuals involved was not a viable option. Webinar presentations were made on May 26 and September 10 to promote the use of the mApp but reached only 20 TU chapter leaders and agency staff. In the end, only 144 observations were made in the northern third of the Driftless Area in 2020 (Figure 1). While this total number of observations fell far short of the 1,000+ observations originally desired for 2020, the information helpfully characterizes water quality and habitat conditions in the northern third of the Driftless Area and has set the stage for increased activity in 2021.

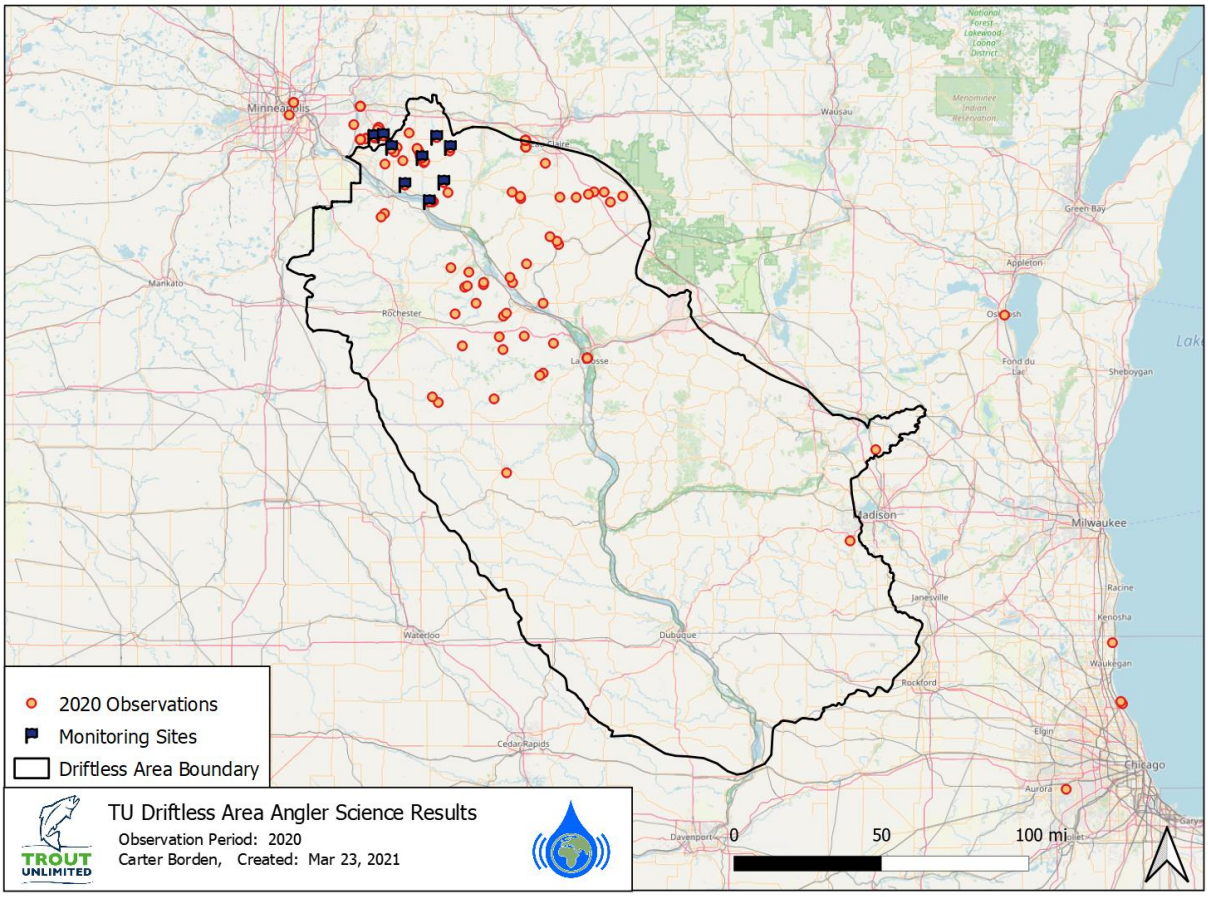


Figure 1. Angler observation locations for 2020 in the Driftless Area.

Although fewer-than-desired WiseH2O mApp observations were made in 2020, the TU and MobileH2O, LLC (MH2O) Project Team used the pandemic-induced shutdown to improve the implementation infrastructure supporting the expansion of the Angler Science Program. The implementation infrastructure improvements include:

1. Making the WiseH2O mApp available in the Google Play Store and Apple Store for free downloading and updates,
2. Introducing educational messaging into the mApp,
3. Creating written and video training materials, available on the mApp and the MobileH2O website (https://www.mobileh2o.com/mh2oapp),
4. Developing a dedicated webpage for the Angler Science Driftless Area Program (https://www.mobileh2o.com/driftlessprogram),
5. Preparing a "*Get Started Guide for Participants*", for organizations and individuals joining the Angler Science Program (https://www.mobileh2o.com/driftlessprogram), and
6. Establishing an online store for the purchase of test kits.

This 2020 annual report summarizes the efforts to expand the Angler Science Driftless Area Program, describes improvements to the supporting infrastructure and WiseH2O mobile application (mApp), and presents summary 2020 monitoring results.

We would like to thank the Angler Science Driftless Area Program sponsors and participating TU Chapters, organizations, agencies, and individuals. Financial contributors include Trout Unlimited's Coldwater Conservation Fund, TU Driftless Area Restoration Effort (TUDARE), US Fish and Wildlife Service, National Fish and Wildlife Foundation, and National Fish Habitat Partnership. Finally, we would like to thank all the TU Chapters and their members for contributing their time towards helping to characterize the trout stream conditions in the Driftless Area.

2020 Program Activities

As stated, while 2020 did not see extensive water quality monitoring, progress was made on laying the foundation for an efficient expansion of the Program in 2021. Activities focused on three areas:

1. Expanding the Program by informing TU Chapters, non-profit organizations, and agencies of the Program, establishing a set of Program goals to support the resource management objectives for TU, state agencies, and the US FWS, and getting all organizations introduced to the Program,
2. Upgrading the WiseH2O mApp with educational information and the ability to easily download and install the mApp on Android and iPhones, and
3. Developing the supporting implementation infrastructure and services allowing for efficient expansion of the Program.

Program Expansion

In 2019, the Program was piloted by a single TU Chapter (Kiap-TU-Wish) monitoring within one Wisconsin county. While feasible on a small scale, the pilot project highlighted several challenges for efficiently scaling the Program to involve more participating organizations and enlarge the geographical extent of the Program throughout the Driftless Area. These challenges included the widescale distribution of the mApp, conducting training and disseminating training materials, generating awareness of the Angler Science Driftless Area Program and getting organizations and individuals involved, educating users on why water quality is important and how the results will be used, and distributing test kits. Therefore, the 2020 objectives were to develop a campaign that got groups and individuals involved and minimized barriers to making water quality observations with the WiseH2O mApp.

Specifically, the 2020 objectives were:

- Continued monitoring by the Kiap-TU-Wish Chapter, with a focus on fully implementing their monitoring plan,
- Expand the Program domain to the Driftless Area,
- Involve all 15 Driftless Area TU Chapters, as well as other government agencies and organizations active in the management of the coldwater streams in the Driftless Area,
- Emphasize native brook trout streams for monitoring and data collection, and
- Make 1,000+ observations via all participants, driven in part by TU's Community Science (formerly referred to as Angler Science) emphasis in its strategic plan.

The campaign focused on contacting key personnel, promoting the Program through media and presentations, providing "seed" test kits, improving technology, and developing supporting infrastructure for the Angler Science Program. The narratives below describe these activities in greater detail. Note that these objectives were also adopted for the 2021 Program, including a target of 1,000+ observations.

Promotional Activities: Key personnel in TU chapters, the Wisconsin and Minnesota Departments of Natural Resources (DNRs), and interested organizations were directly informed of the project and how to get involved. The Program was more generally promoted by presentations and workshops (e.g. the 2020 Driftless Area Symposium), online presentations, announcements and articles on social media, the Program website, and email notifications (Table 1). Note that before the pandemic, Kent Johnson (TUDARE Program Coordinator) and Dan Dauwalter (TU Staff Scientist) had intended to promote the Program by attending several regional TU and water quality conferences and presenting at several TU

Chapter meetings. With the lockdown, these in-person efforts were halted. In addition, Kent Johnson, Carter Borden, and Dan Dauwalter fielded questions from emails and phone calls about the program and technology throughout the year.

Table 1. Promotional activities for the 2020 Angler Science Program.

Event	Media	Date
Monitoring Water Quality with the WiseH2O Mobile App: Trout Unlimited (Kiap-TU-Wish) Pilot Project	Webinar	Jan 16
Meeting with Minnesota and Wisconsin DNR Staff	Meeting	Feb 3
2020 Driftless Area Symposium	Presentation/Information Booth/Workshop	Feb 4-5
WiseH2O Training/Angler Science Program Overview	Webinar	May 26
WiseH2O Training/Angler Science Program Overview	Webinar	Sept 10
American Fisheries Society Virtual Annual Meeting	Poster (Virtual)	Sept 14-25

Test Kit Distribution: To encourage Program participation by TU Chapters and individual anglers, the TU Coldwater Conservation Fund provided funding to cover the cost of free test kits (Basic and Premium), which were offered to TU Chapters, the Minnesota and Wisconsin DNRs, and the US FWS in 2020 and 2021(Table 2). In addition, an online store was established to allow users to purchase additional test kits and support wider distribution (https://www.mobileh2o.com/shop).

Table 2. TU Chapters and Agencies receiving free test kits via the TU Coldwater Conservation Fund

	Available		Distributed 2020	
Organization	**Basic Kits[a]**	**Premium Kits[b]**	**Basic Kits[a]**	**Premium Kits[b]**
TU Chapters				
Kiap-TU-Wish	5	3	5	3
Clear Waters	5	3	2	1
Coulee	5	3		
Nohr	5	3		
Southern Wisconsin	5	3		
Blackhawk	5	3		
Leopold	5	3		
Win-Cres	5	3	5	3
Hiawatha	5	3	5	3
Twin Cities	5	3		
Spring Creeks	5	3	5	3
Iowa Driftless	5	3	5	3
North Bear	5	3	5	3
Oak Brook	5	3	5	3
Lee Wulff	5	3		
Agencies				
Iowa DNR				1
Minnesota DNR		2		1
Wisconsin DNR		2		1
USFWS		2		2

[a]Basic Kits: 5 x 5n1 strip (alkalinity, hardness, pH), 5 x 2n1 strip (nitrate, nitrite)

[b]Premium Kits: 25 x 5n1 strip (alkalinity, hardness, pH), 25 x 2n1 strip (nitrate, nitrite), 25 orthophosphate

WiseH2O Mobile Application (mApp) Updates: During Spring 2020, major improvements to the mApp increased access, performance, and educational experience for the users. These improvements included:

1. Upon first login by new users, welcome screens now introduce the mApp's purpose and call to action (Figure 2).

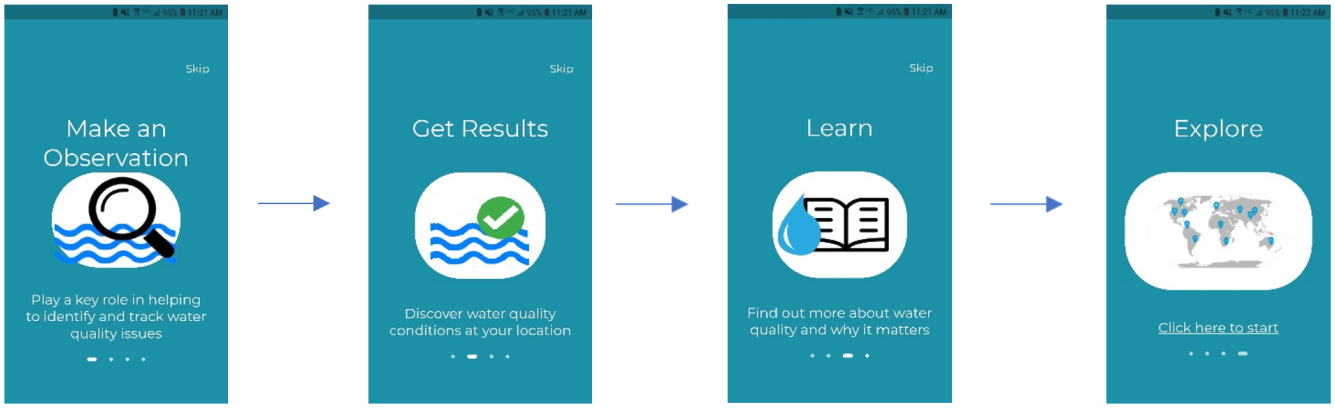


Figure 2. Welcome screens for the WiseH2O mApp.

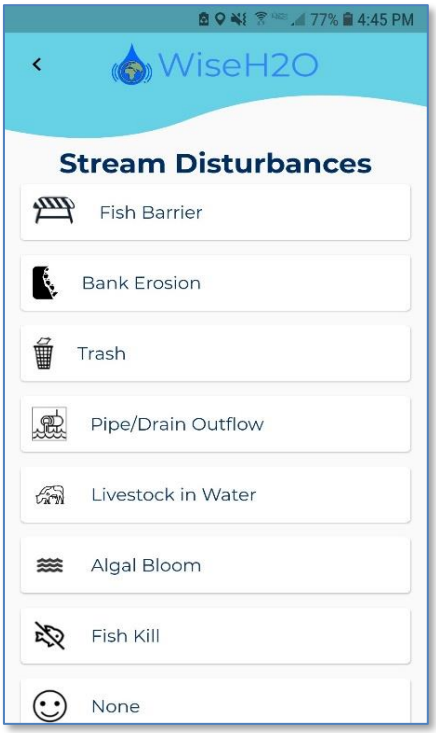


Figure 3. Stream disturbances page in the 2020 mApp

2. iPhone: image capture issues with the 5n1 and 2n1 test strips were fixed. Lingering difficulties in consistently capturing the test strip/calibration card image were fixed, making the system reliable.
3. Stream disturbances have been expanded to include "Algal Bloom", "Fish Kill", and "Livestock in Water" (Figure 3).
4. Results bars and educational information were added for alkalinity, hardness, nitrate, nitrite, pH, orthophosphate, and water temperature. Presenting the results on color bars relating to values educates users on how the result impacts fish health. Furthermore, for users who want to learn more, tapping on the results bar for an analyte leads to information pages on fish and habitat health over a range of analyte values, as well as an educational page providing greater insight on the information (Figure 4).
5. Links to training materials. When in range of cell phone or internet connection, users can view the training materials posted on the MobileH2O website (https://www.mobileh2o.com/mh2oapp).
6. Choice of monitoring networks. In 2020, only the Kiap-TU-Wish Chapter had an established monitoring network. In 2021, the Twin Cities TU Chapter also developed a monitoring network. As more TU chapters and organizations develop monitoring networks, the mApp allows for the introduction of new monitoring sites, thereby enabling users to choose which network to display and select monitoring sites.

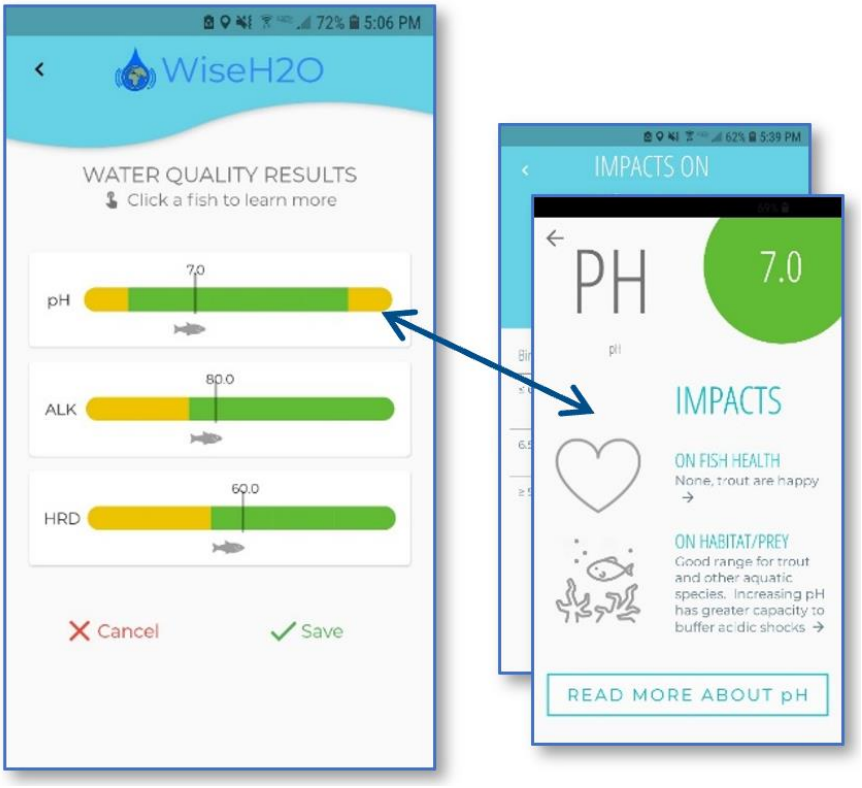


Figure 4. Results page and accompanying analyte educational pages

Supporting Implementation Infrastructure and Services: In 2019 and the beginning of 2020, a TU member, agency staff, or other interested people would have to contact TU or MobileH2O to get involved with or become informed about the Angler Science Program. To support the expansion of the Program, the following efforts were implemented:

1. The mApp is available for free on the Apple Store (iPhone) and the Play Store (Android). Placing the mApp in these stores allows anyone with an iPhone (OS 6 or newer) or Android (OS 6 or newer) to install and use the mApp, avoiding the need for installation files for the Android and use of the Testflight app on the iPhone, which requires permission from an Apple account. It also allows for updates to be downloaded directly by users when made available.
2. Training materials were updated and expanded to support the use of the updated WiseH2O mApp. Training materials include a written user manual and an instructional video, allowing users to learn how to use the app via self-training. These documents can be found at https://www.mobileh2o.com/mh2oapp, and the written document is also available through a link on the WiseH2O mApp (Preferences=> Tutorials).
3. An introductory webpage was created as a base landing for information about the Angler Science Driftless Area Program (https://www.mobileh2o.com/driftlessprogram) (Figure 5). In 2021 this webpage will be periodically updated to include overall monitoring progress for the season.
4. To get interested parties started, the document "*Monitoring Driftless Area Trout Streams with the WiseH2O Mobile Application - Get Started: A Guide for Participants*" provides a brief background on the Program, a road map for organizations and individuals to get started, and guidance on

developing a monitoring plan. A link to the document is on the Angler Science Driftless Area Program webpage.

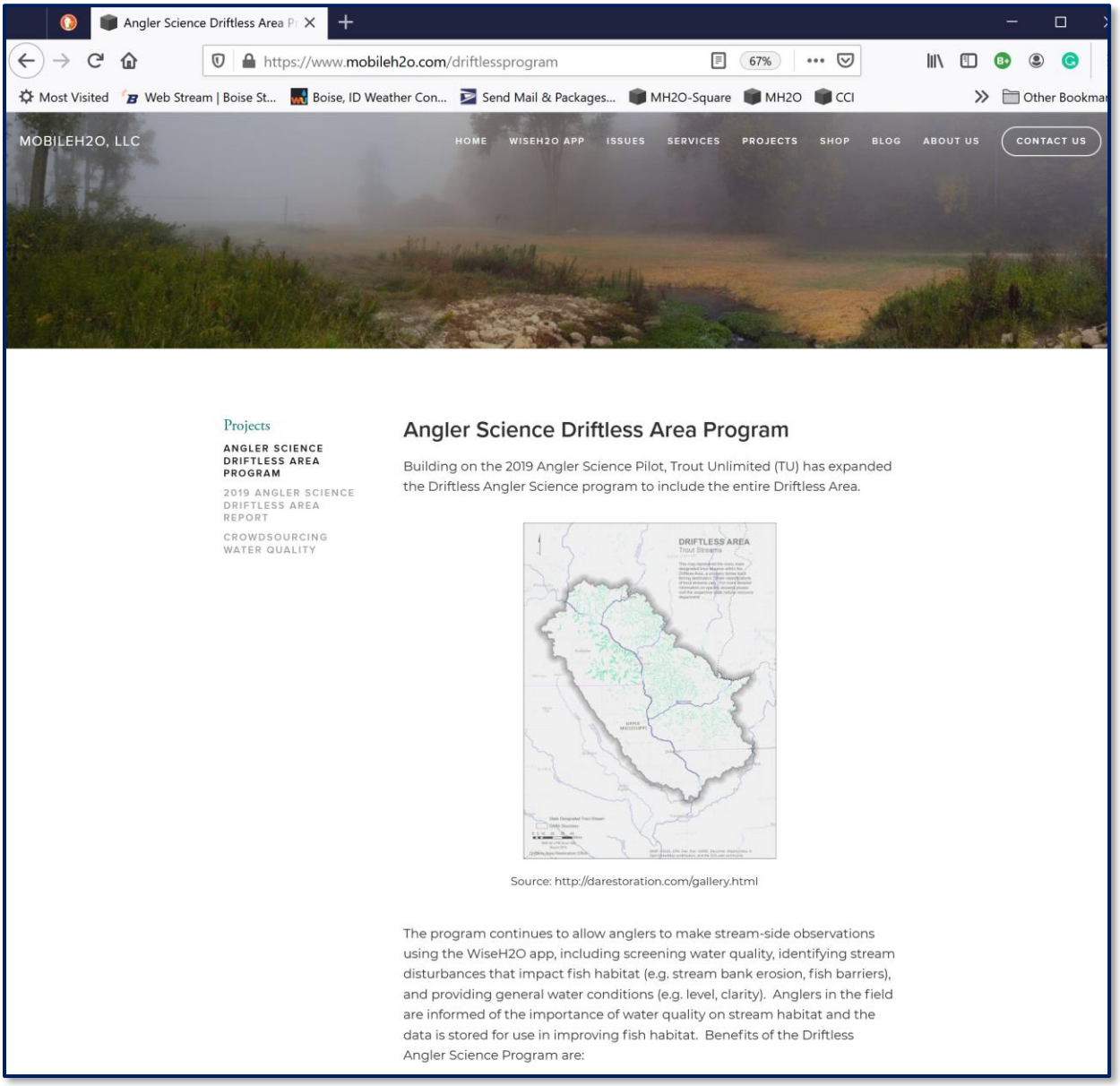


Figure 5. Webpage for the 2020-21 Angler Science Driftless Area Program.

5. The 2019 and 2020 Angler Science Driftless Area Program monitoring results and reports are presented on a separate webpage: https://www.mobileh2o.com/anglerscience (Figure 6).
6. To assist with monitoring plan development, the Kiap-TU-Wish Chapter's monitoring plan is posted on the 2019 Angler Science webpage. The Kiap-TU-Wish plan provides a template that can be used by other TU Chapters and organizations to develop their own monitoring plans. These documents, along with a description of the project, are available for download on the Program website: https://www.mobileh2o.com/anglerscience (Figure 6).

7. To distribute test kits to interested organizations and individuals, an online store was established, allowing for the direct purchase of test kits: https://www.mobileh2o.com/shop. See description above (Page 5).

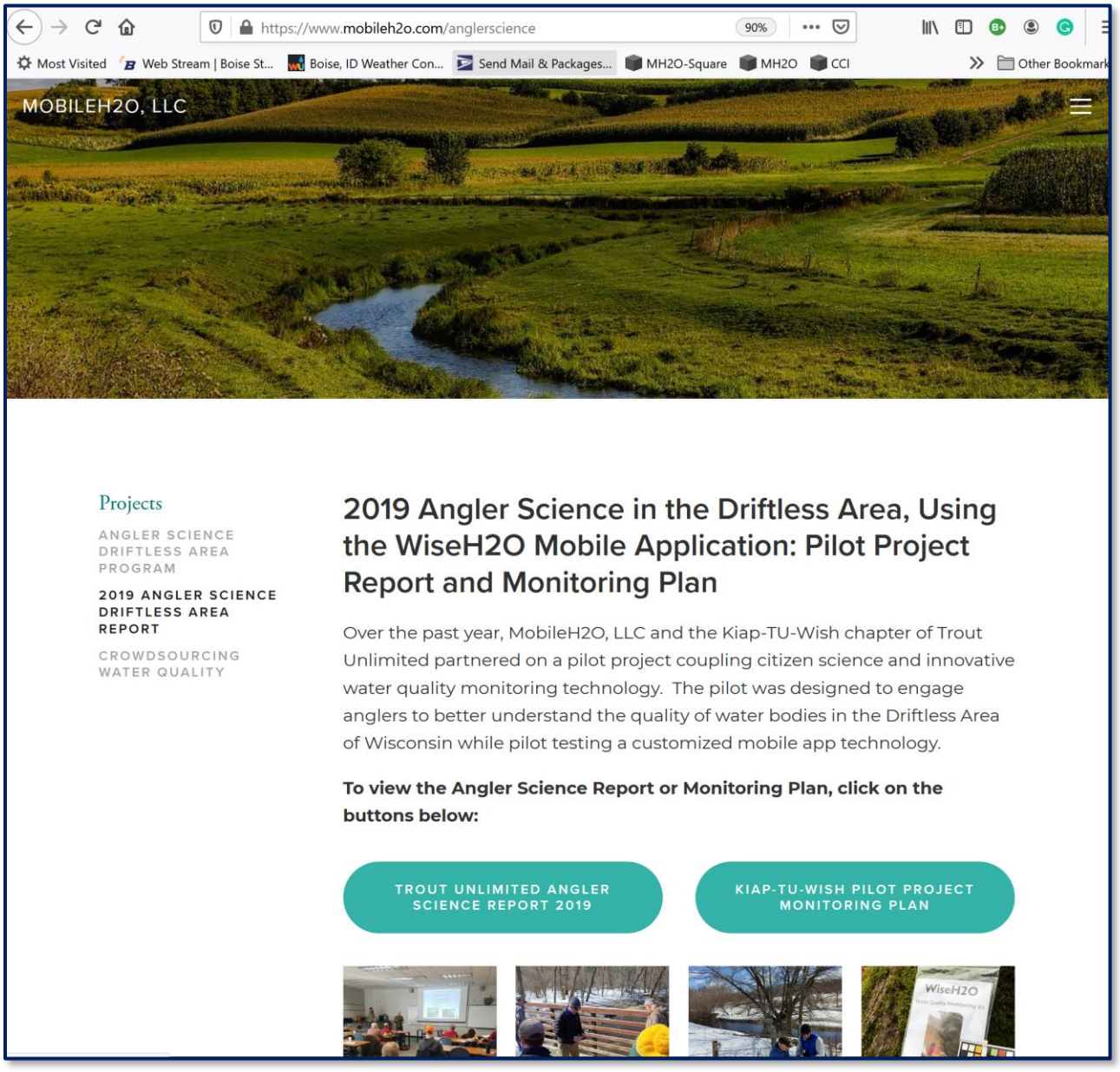


Figure 6. 2019 Pilot Angler Science Program webpage (with Kiap-TU-Wish chapter).

2020 Observations

Although Covid-19 curtailed monitoring, 144 observations were made in 2020. Including the 2019 pilot study, anglers and agency staff have made 227 observations in the Driftless Area (Table 3, Figure 1). These data have largely been collected in the northern half of the Driftless Area. Of the data collected, observers report Water Source, Stream Disturbances and Current Conditions 89%, 80%, and 94% of the time, respectively, during their observations. Amongst the water quality measurements made, use of the 5n1 test strips averaged 79%, while water temperature and orthophosphate measurements averaged 67% and 60%, respectively (Table 3). In 2019, the colorimetric algorithm for the 2n1 test strips was not yet finalized, and thus no measurements were made. Greater than 86% of the observations were collected from streams and rivers, so the results largely represent stream conditions (Table 4). For the 2021 monitoring season, we are targeting 1000+ mApp observations that are distributed throughout the Driftless Area.

Table 3. Number of mApp observations made and the information submitted for 2019-2020.

Year	Observations	Water Source	5n1 Strip	2n1 Strip	Orthophos-phate	Water Temperature	Stream Disturbance	Current Conditions	Monitoring Locations
2019	83	83	72	0	53	57	79	70	51
2020	144	115	108	92	84	95	103	115	54
Total	227	198	180	92	137	152	182	185	105
% of Total	100%	87%	79%	41%	60%	67%	80%	81%	46%

Table 4. Water Sources for mApp observations made in 2019-2020.

Water Source	River/Stream	Lake/Pond	Canal/Ditch	Springs	Groundwater Well	Tap Water
2019	46	0	1	3	0	4
2020	100	3	0	9	1	2
Total	146	3	1	12	1	6
% of Total	86%	2%	1%	7%	1%	4%

Water Quality Screening Data

As depicted in Table 3, 227 mApp observations have been made in the Driftless Area from 2019 - 2020. These observations included information on water quality (with the exception of nitrite- and nitrate-nitrogen in 2019), stream disturbances, and current conditions (Table 5). Appendix A presents data in summary tables, graphs, and maps for the water quality analytes (Alkalinity, Hardness, Orthophosphate, pH, Water Temperature) and stream disturbances. While this report does not provide interpretation of the data, tables outlining the impacts of each analyte on trout and coldwater ecosystems are included in Appendix A for context.

Table 5. Observation information collected by the WiseH2O mApp

Parameter	Method	Range/Options
Alkalinity	Colorimetric Algorithm (5n1)	0, 40, 80, 120, 180, 240 mg/L
Hardness	Colorimetric Algorithm (5n1)	0, 30, 60, 120, 180 mg/L
pH	Colorimetric Algorithm (5n1)	6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0
Nitrite (NO_2)	Colorimetric Algorithm (2n1)	0, 0.15, 0.3, 1.0, 1.5, 3.0 mg/L
Nitrate (NO_3)	Colorimetric Algorithm (2n1)	0, 1, 2, 5, 10, 20, 50 mg/L
Orthophosphate	Test Strip	0, 100, 200, 300, 500, 1000, 2500 ug/L
Water Temperature	External Thermometer	0-100 degrees Fahrenheit
Site Photograph	Mobile Phone Camera	Photograph
Site Comments	Key in Comment	Text Comments
Stream Disturbances	User Observation	Fish Barrier, Bank Erosion, Trash, Drain Outflow, Livestock in Water, Algal Bloom, Fish Kill, None
Water Level	User Observation	Baseflow, Mid-Stage, Bankfull Stage, Overbank Flooding
Water Clarity	User Observation	Clear, Murky, Muddy
Recent Weather	User Observation	Regional Rainfall, Local Thunderstorm, Warmth Causing Snowmelt, None

Next Steps: 2021 and Beyond

After a challenging 2020, we are excited to extend the TU Angler Science Program to the entire Driftless Area, with much greater participation. More specifically, our 2021 objectives include:

- Make 1000+ mApp observations, distributed throughout the Driftless Area,
- Report findings and progress throughout 2021, via the project webpage,
- Include metrics that summarize the contributions of individual anglers and TU Chapters,
- Conduct training sessions for individuals who would like to get involved but have not yet "jumped in",
- Provide more education and outreach, to promote mApp usage and target areas where information is lacking,
- Provide ongoing support for monitoring plan development, including targeted monitoring of brook trout streams,
- Generate a 2021 report that links monitoring results to water resource management decisions.
- Continue to highlight program successes through TU chapter, TU council, and TU DARE newsletters and social media.

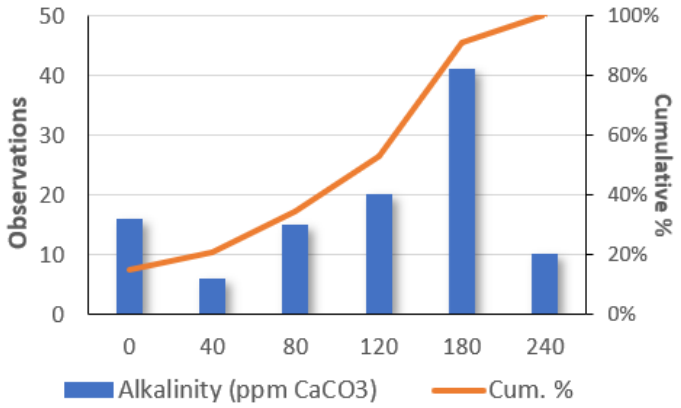
The Project Team looks forward to your involvement, for a promising and successful 2021.

Appendix A: 2020 WiseH2O mApp Monitoring Results

Alkalinity: Alkalinity, measured as the concentration of carbonate and bicarbonate ions, is the capacity of water to resist changes in pH that would make the water more acidic. High alkalinity concentrations provide buffering to prevent increasing acid levels (decreasing pH) in streams, which can affect cellular function and, thus, the physiology of aquatic organisms, including fish.

Table 6. Distribution of alkalinity concentrations (ppm $CaCO_3$) in Driftless Area waters, 2020.

Alkalinity (ppm CaCO3)	Observations	% Total Obs.	Cum. %
0	16	15%	15%
40	6	6%	20%
80	15	14%	34%
120	20	19%	53%
180	41	38%	91%
240	10	9%	100%
Total	108		



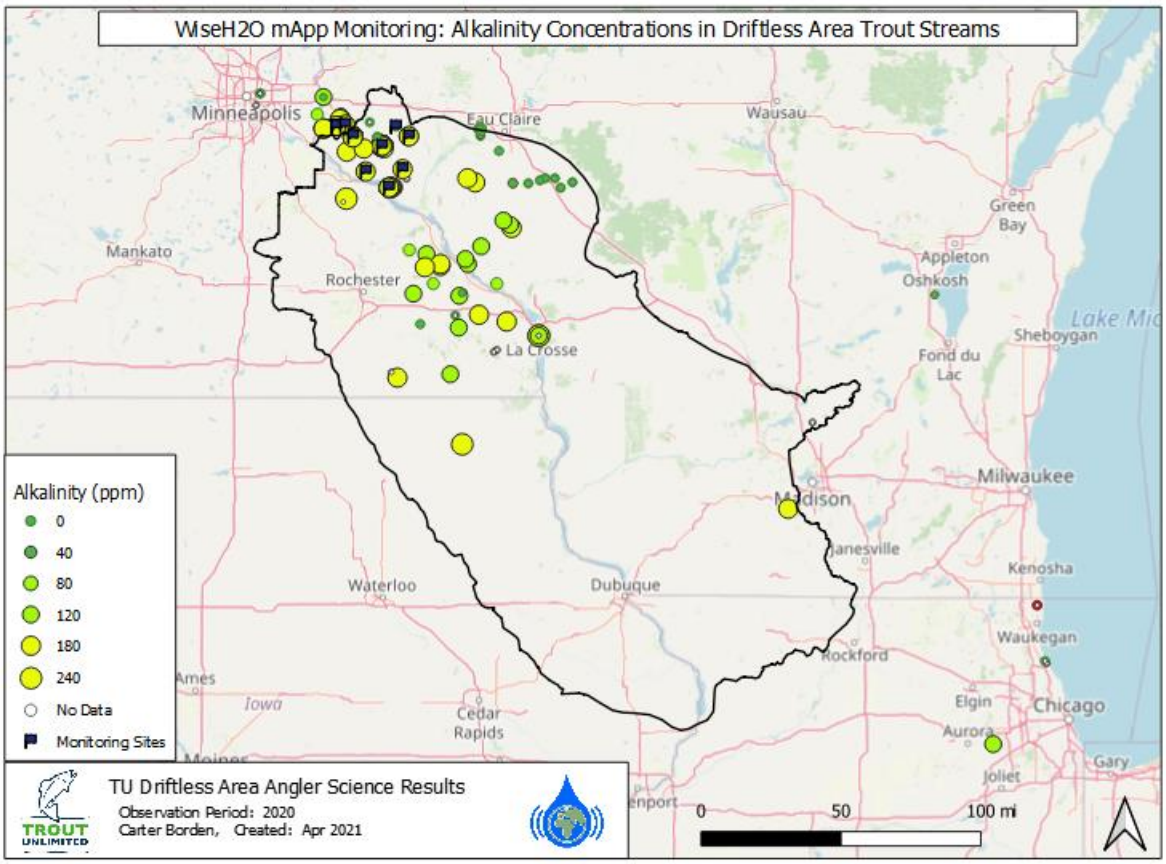


Figure 7. Alkalinity concentrations (ppm $CaCO_3$) in Driftless Area waters, 2020.

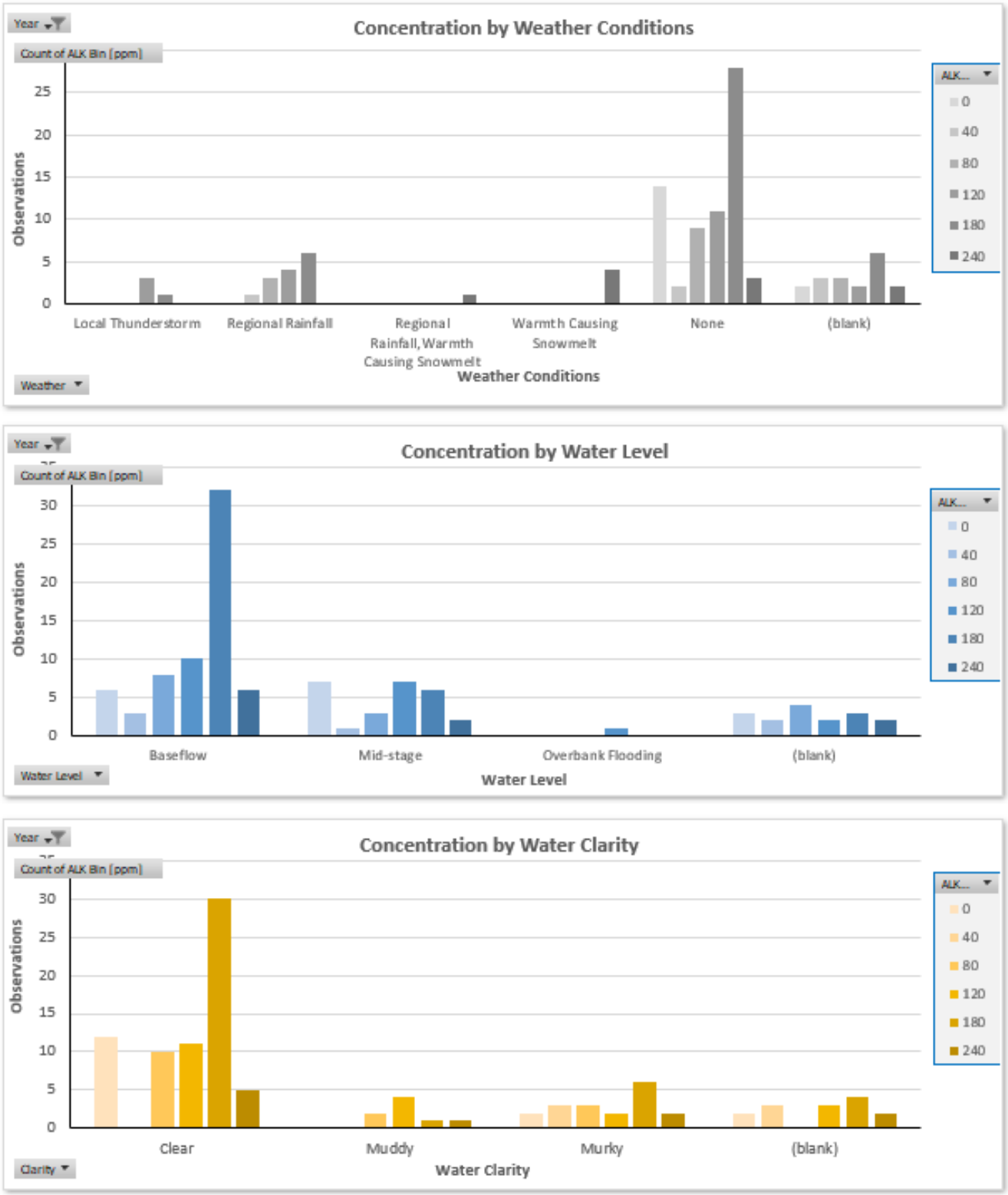


Figure 8. Alkalinity concentrations (ppm CaCO3) by weather conditions, water level, and water clarity for the Driftless Area, 2020. The "blank" category represents observations without reported condition

Table 7. Alkalinity impacts on trout and coldwater ecosystems.

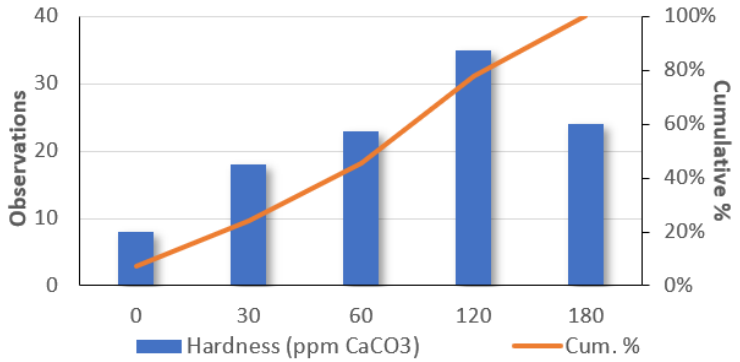
Bin Value (ppm)	Fishery Condition[a]	Trout and Coldwater Ecosystem Impacts
0		Direct: Low alkalinity concentrations may increase the uptake of trace metals (e.g. cadmium) in fish. Habitat/Prey: Streams with lower alkalinity concentrations are more susceptible to acidic shocks from wastewater discharges, agricultural runoff, and acid rainfall.
40		
80		Direct: No direct impact from alkalinity. Habitat/Prey: Higher alkalinity concentrations in streams create a greater buffering capacity against acidic stressors, such as wastewater discharges, agricultural runoff, and acid rainfall.
120		
180		
240		

a Fisheries condition:  Good Fair Poor Lethal

Hardness: Hardness is a measurement of the concentration of dissolved calcium and magnesium in water, usually acquired as rainwater percolates through soil and rock. In most natural waters, calcium and magnesium salts contribute most of the hardness, with only trace contributions from other metals such as iron and zinc. These salts are important to aquatic organisms because they are used to make shells (mollusks) and are important in cellular function, general physiology, and skeletal structure (bones) of fish. General guidelines for classification of water hardness are: 0-60 ppm (as $CaCO_3$) is classified as soft; 61-120 ppm as moderately hard; 121-180 ppm as hard; and more than 180 as very hard.

Table 8. Distribution of hardness concentrations (ppm $CaCO_3$) in Driftless Area waters, 2020.

Hardness (ppm CaCO3)	Observations	% Total Obs.	Cum. %
0	8	7%	7%
30	18	17%	24%
60	23	21%	45%
120	35	32%	78%
180	24	22%	100%
Total	108		



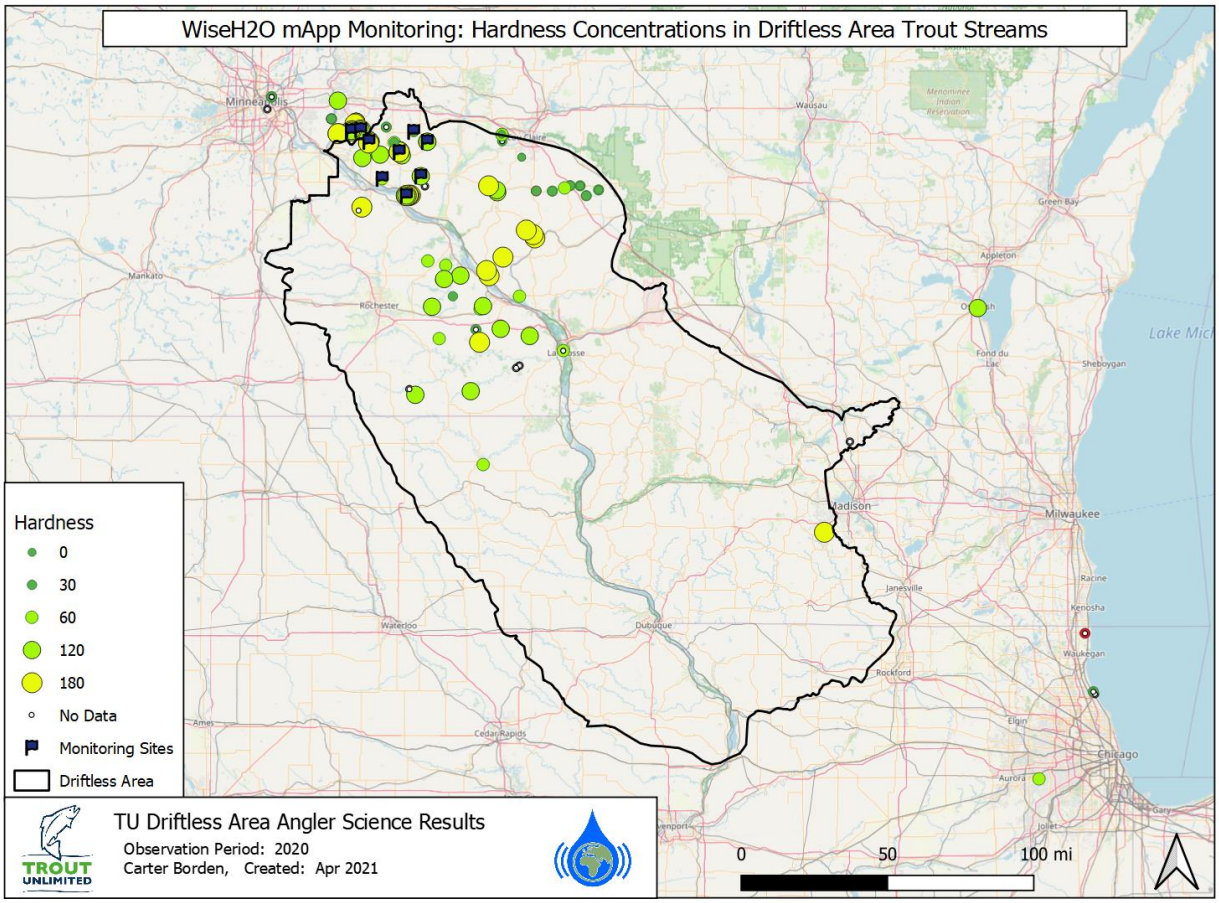


Figure 9. Hardness concentrations (ppm $CaCO_3$) in Driftless Area waters, 2020.

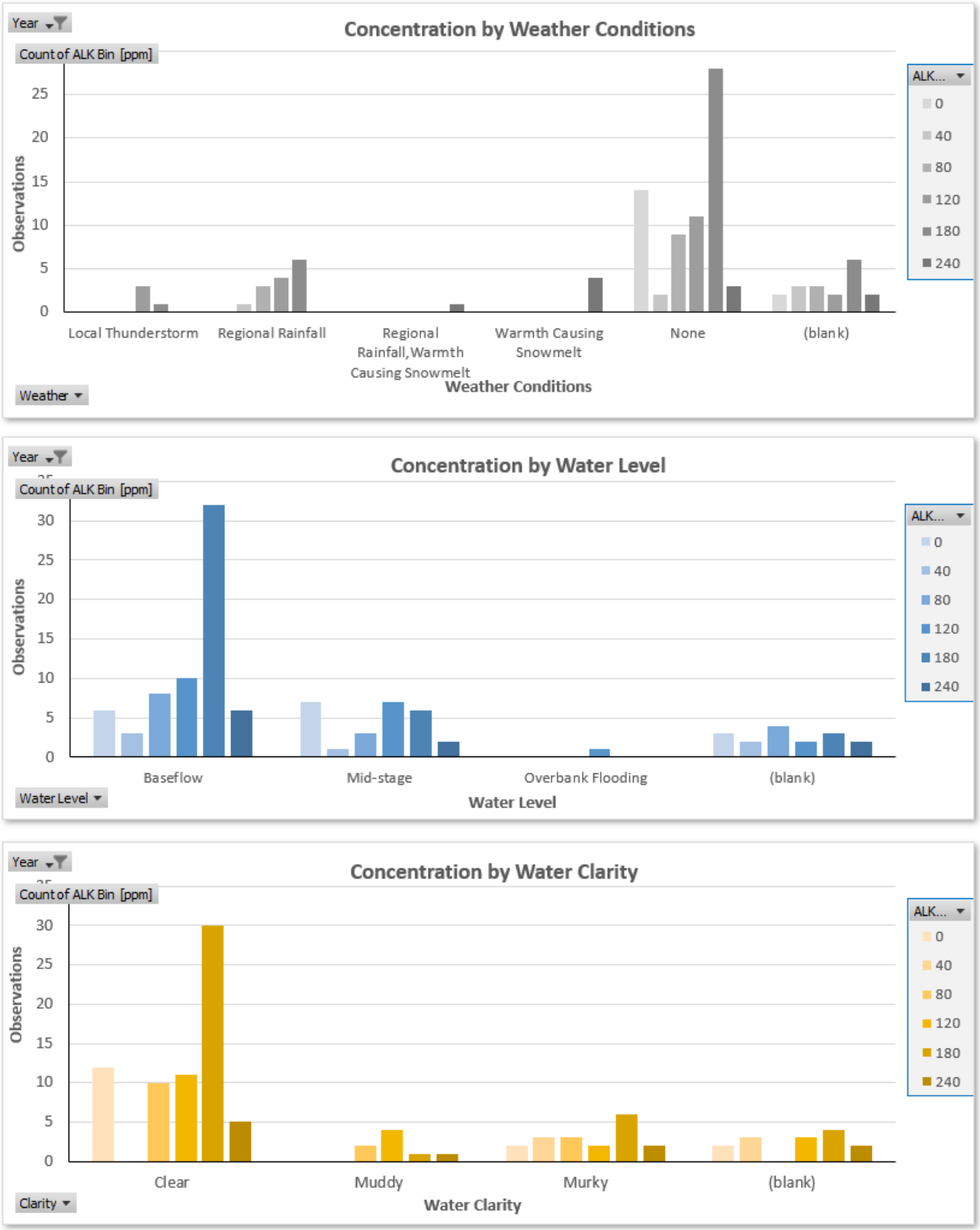


Figure 10. Hardness concentrations (ppm $CaCO_3$) by weather conditions, water level, and water clarity for the Driftless Area, 2020. The "blank" category represents observations without reported conditions.

Table 9. Hardness impacts on trout and coldwater ecosystems.

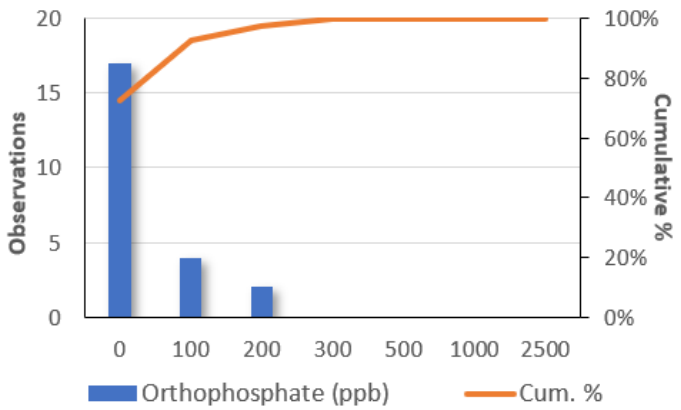
Bin Value (ppm)	Fishery Condition[a]	Trout and Coldwater Ecosystem Impacts
0		Direct: Low hardness concentrations may increase the uptake of metals (e.g. cadmium) in fish Habitat/Prey: Streams with lower hardness concentrations are more susceptible to acidic shocks from wastewater discharges, agricultural runoff, and acid rainfall
30		
60		Direct: No direct impact from hardness Habitat/Prey: Good range for trout and other coldwater species. Higher hardness concentrations generally indicate the presence of strong groundwater sources to the stream.
120		
180		

a Fishery condition: Good Fair Poor Lethal

Orthophosphate: Nutrients, such as phosphorus and nitrogen, are essential for plant and animal nourishment and growth, but the overabundance of certain nutrients in surface waters and groundwater can cause several undesirable health and ecological effects. Phosphorus in water exists in two main forms: dissolved (soluble) and particulate (attached to soil particles or organic matter). Orthophosphate is the primary dissolved form of phosphorus, and it is readily available to algae and aquatic plants. Under natural conditions, phosphorus (P) is typically scarce in water. However, human activities can result in excessive "loading" of phosphorus into many freshwater ecosystems. These excessive amounts of phosphorus can lead to eutrophication, a water quality condition that can include algae blooms, decreased oxygen levels (hypoxia), and fish kills. Lakes that appear relatively clear in spring can resemble "green soup" in late summer, due to algae blooms fueled by phosphorus. Similarly, excessive phosphorus in streams and rivers may lead to the development of algae (periphyton) attached to in-stream habitat (e.g., rocks), thereby diminishing benefits for invertebrates and fish. Orthophosphate is rapidly used by algae and other plants, and thus very rarely reaches levels directly toxic to fish. Impacts typically manifest through eutrophication.

Table 10. Distribution of orthophosphate concentrations (ppb) in Driftless Area waters, 2020.

Orthophosphate (ppb)	Observations	% Total Obs.	Cum. %
0	61	73%	73%
100	17	20%	93%
200	4	5%	98%
300	2	2%	100%
500	0	0%	100%
1000	0	0%	100%
2500	0	0%	100%
Total	84		



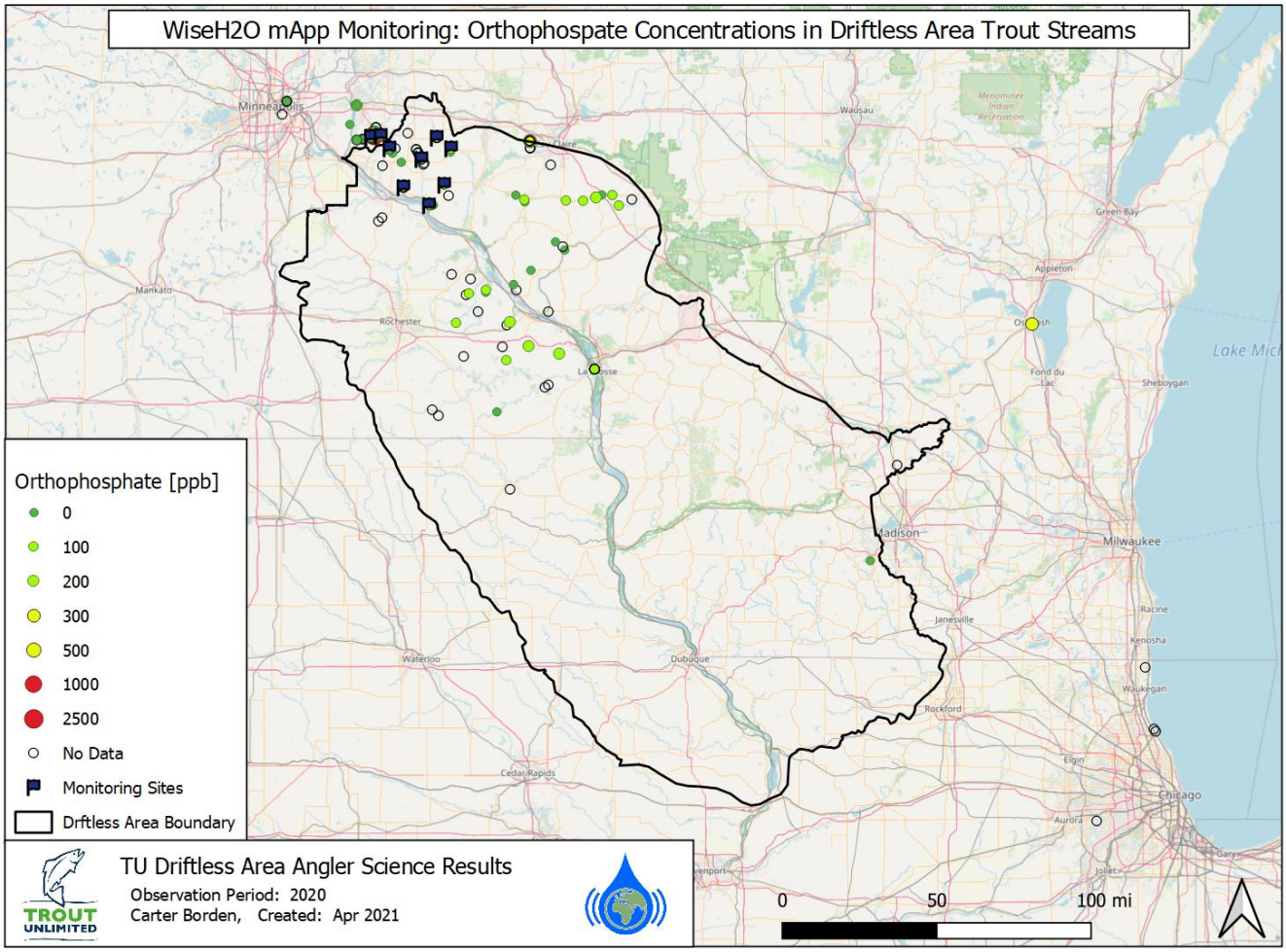


Figure 11. Orthophosphate concentrations (ppb) in Driftless Area waters, 2020.

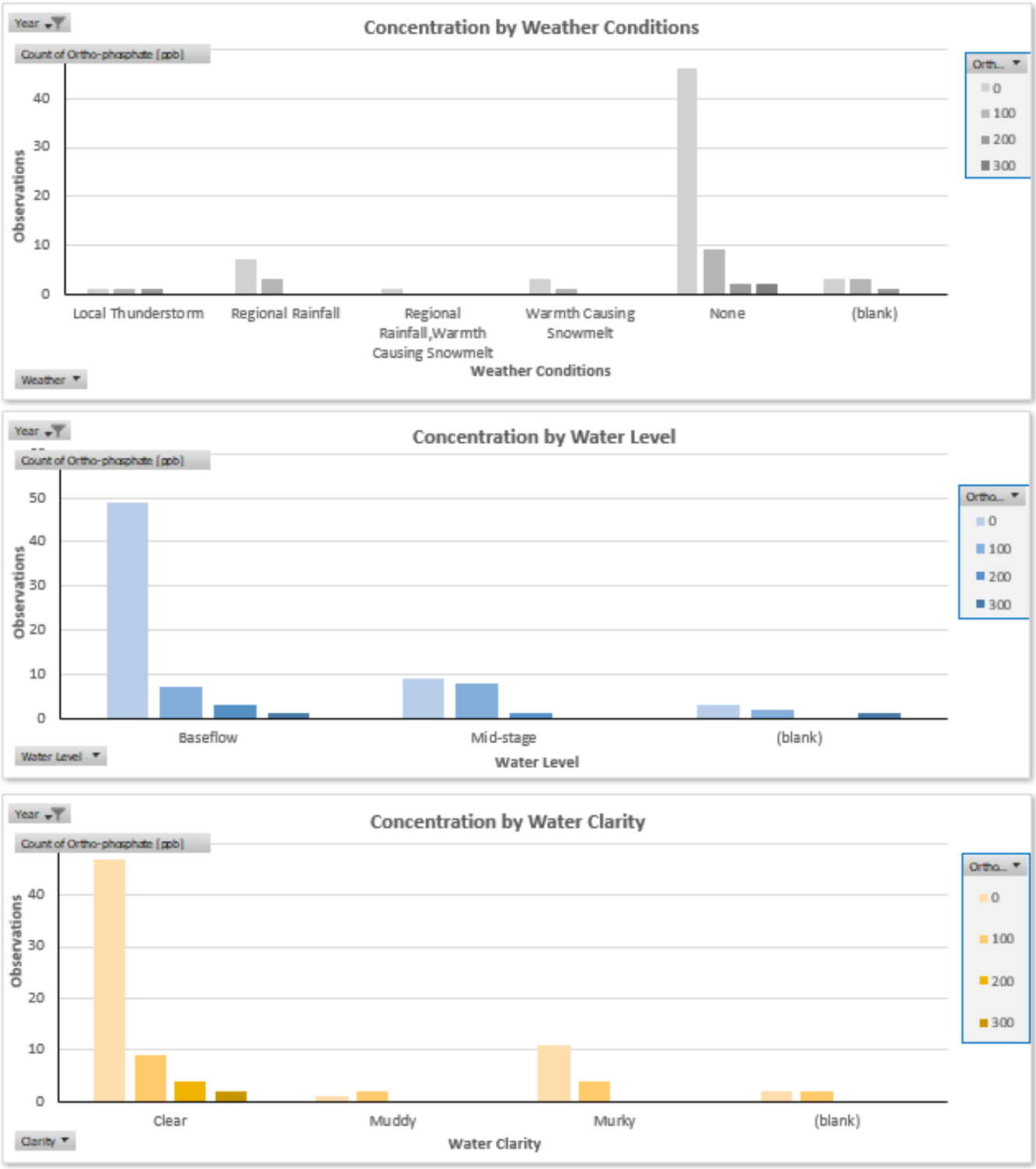


Figure 12. Orthophosphate concentrations (ppb) by weather conditions, water level, and water clarity for the Driftless Area 2020. The "blank" category represents observations without reported conditions.

Table 11. Orthophosphate impacts on trout and coldwater ecosystems.

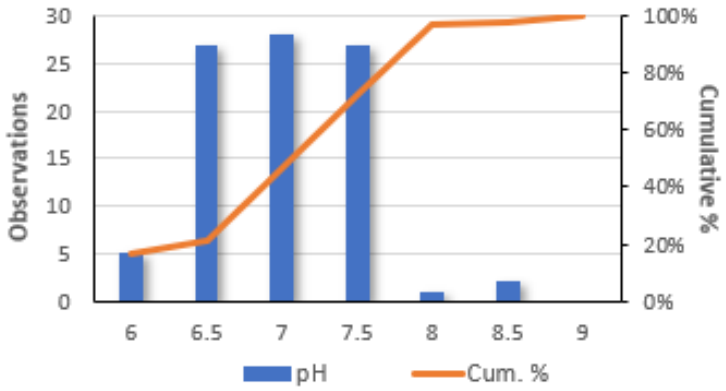
Bin Value (ppb)	Fishery Condition[a]	Trout and Coldwater Ecosystem Impacts
0		Direct: None Habitat/Prey: Good range for trout and other coldwater species.
100, 200, 300, 500, 1000, 2500		Direct: None Habitat/Prey: With higher orthophosphate concentrations, coldwater ecosystems are more likely to become eutrophic.

a Fishery condition: Good Fair Poor Lethal

pH: pH is a measure of the acidity or basicity of water. The range for pH in water extends from 0 to 14, with 7 being neutral. pH values less than 7 indicate acidity, whereas pH values greater than 7 indicate basicity. Water that has more free hydrogen ions (H+) is acidic, whereas water that has more free hydroxyl ions (OH-) is basic. pH is reported in logarithmic units, with each pH value representing a 10-fold change in the acidity/basicity of the water. For example, water with a pH value of five is ten times more acidic than water having a pH value of six.

Table 12. Distribution of pH values in Driftless Area waters, 2020.

pH	Observations	% Total Obs.	Cum. %
6	18	17%	17%
6.5	5	5%	21%
7	27	25%	46%
7.5	28	26%	72%
8	27	25%	97%
8.5	1	1%	98%
9	2	2%	100%
Total	108		



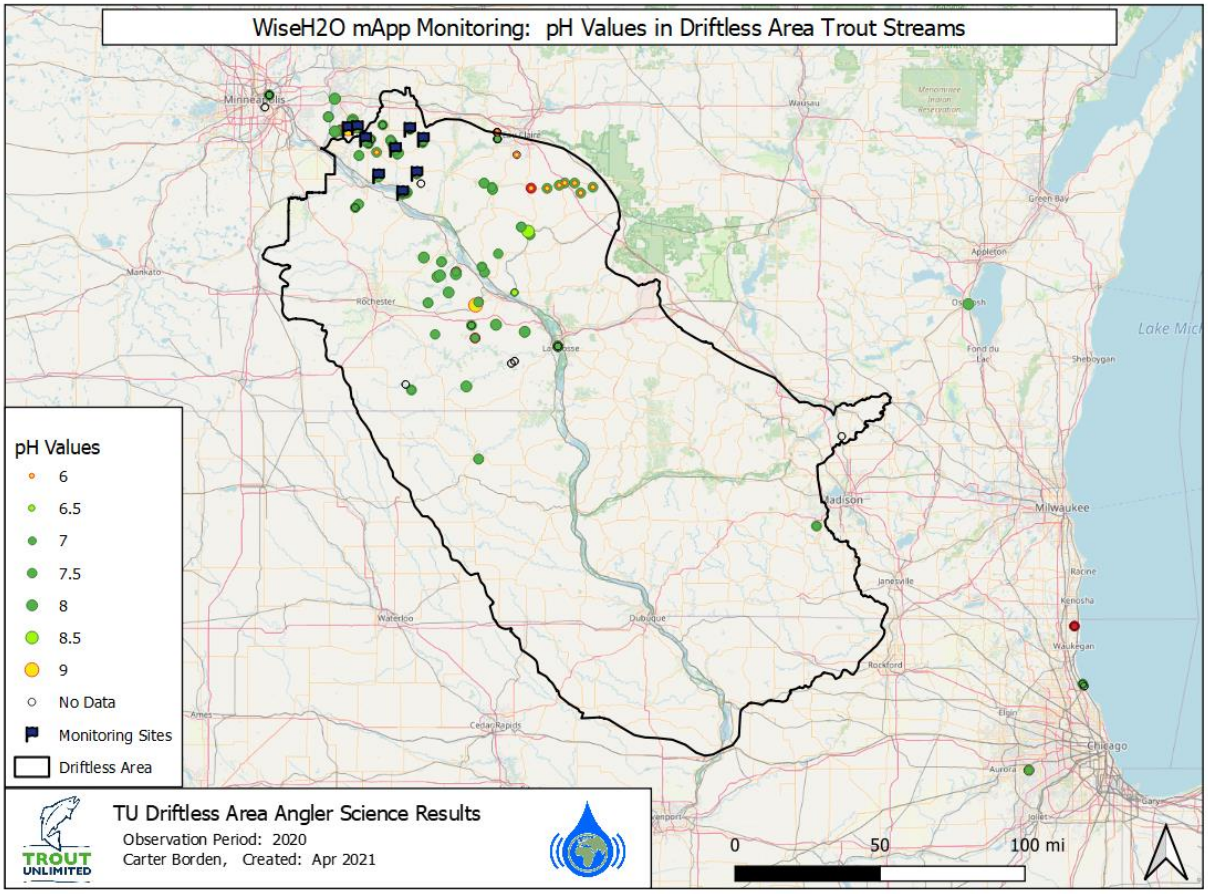


Figure13. pH values in Driftless Area waters, 2020

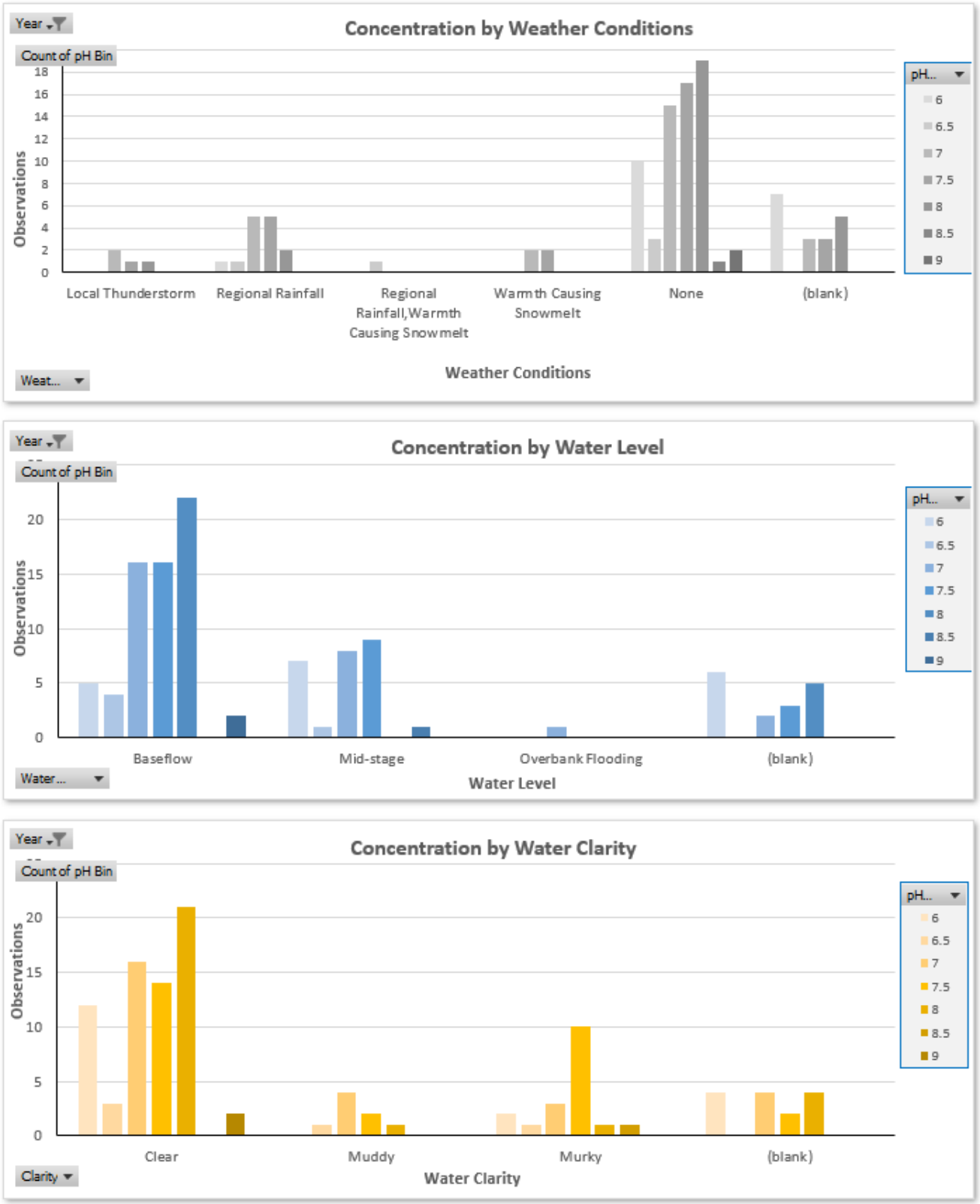


Figure 14. pH values by monitoring site, weather conditions, water level, and water clarity for the Driftless Area, 2020. The "blank" category represents observations without reported conditions.

Table 13. pH impacts on trout and coldwater ecosystems.

pH	Fishery Condition[a]	Trout and Coldwater Ecosystem Impacts
≤ 6.0		Direct: Trout become vulnerable to fungal infections and toxicity from heavy metals and ammonia Habitat/Prey: Ecosystems are susceptible to acidic shocks
6.5 – 8.5		Direct: None Habitat/Prey: Good range for trout and other coldwater species
≥9.0		Direct: pH levels above 9.6 are lethal to trout Habitat/Prey: Ecosystems have more capacity to buffer acidic shocks

a Fishery condition: Good Fair Poor Lethal

Water Temperature: Water temperature is a critical factor for determining the presence of trout, invertebrates, and other aquatic life in coldwater ecosystems. All aquatic species have a preferred temperature range, outside of which their ability to survive, grow, and reproduce is diminished. Even within preferred temperature ranges, rapid changes in water temperature (thermal shock) can be detrimental to aquatic life.

The thermal environment in which trout live can be defined by lower and upper lethal limits, and within these bounds are suitable and preferred temperatures for survival, growth, and reproduction. The suitable and preferred temperature ranges and upper incipient lethal temperature for brook, brown, and rainbow trout are presented in Table 14. A temperature range of 39-72 °F is suitable for trout survival, although 72 °F is only tolerable as an average temperature for as long as 3 weeks. Further, temperatures less than 39 °F can be stressful to trout, particularly if winter habitat is lacking. Although trout can feed and grow at temperatures within the 39-72 °F range, feeding and growth are compromised as temperatures move farther away from the preferred temperature range (50-61 °F).

Table 14. Suitable and preferred temperature ranges and upper incipient lethal temperature for trout.

Species	Suitable Temperature Range for Survival (°F)	Preferred Temperature Range for Feeding/Growth (°F)	Upper Incipient Lethal Temperature (°F)
Brook, Brown, and Rainbow Trout	39-72	50-61	77[1]

Table 15. Minimum, average, and maximum monthly water temperatures in Driftless Area trout streams, 2019-2020.

	Monthly Stream Water Temperatures							
	Minimum [oF]		Average [oF]		Maximum [oF]		Observations	
Month	2019	2020	2019	2020	2019	2020	2019	2020
Jan								1
Feb		41		55		70		14
Mar	34	34	45	41	68	50	15	11
Apr	42	42	48	47	54	55	15	13
May	46	46	54	56	65	66	16	16
Jun	55	52	60	58	65	64	10	13
Jul		46		55		66		7
Aug		58		63		71		12
Sep		0		49		63		37
Oct	40	45	45	49	47	54	4	9
Nov		45		47		48		7
Dec		0		0		0		4

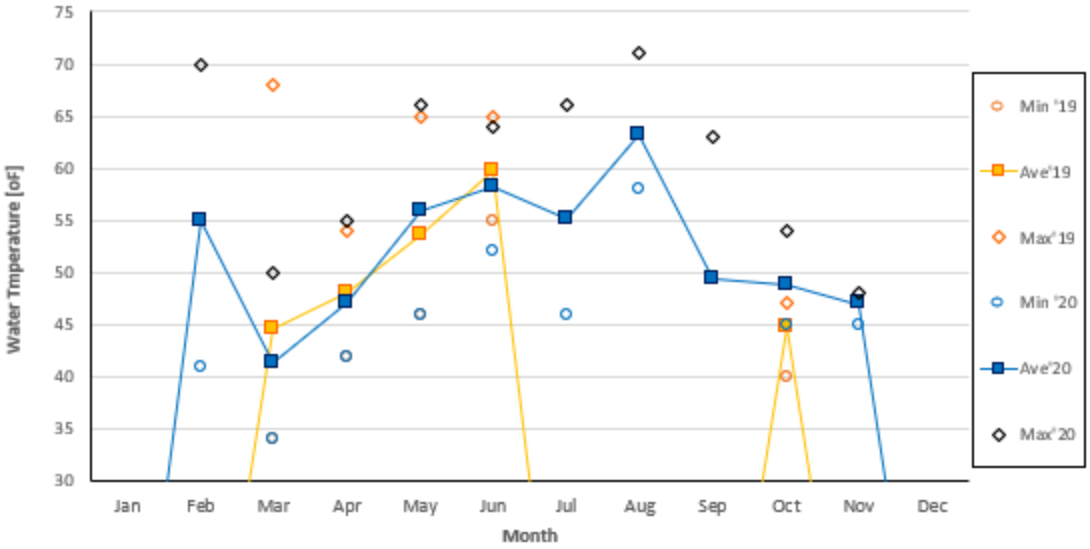


Figure 75. Minimum, average, and maximum monthly water temperatures in Driftless Area trout streams, 2019 – 2020. Lines represent average monthly water temperature values.

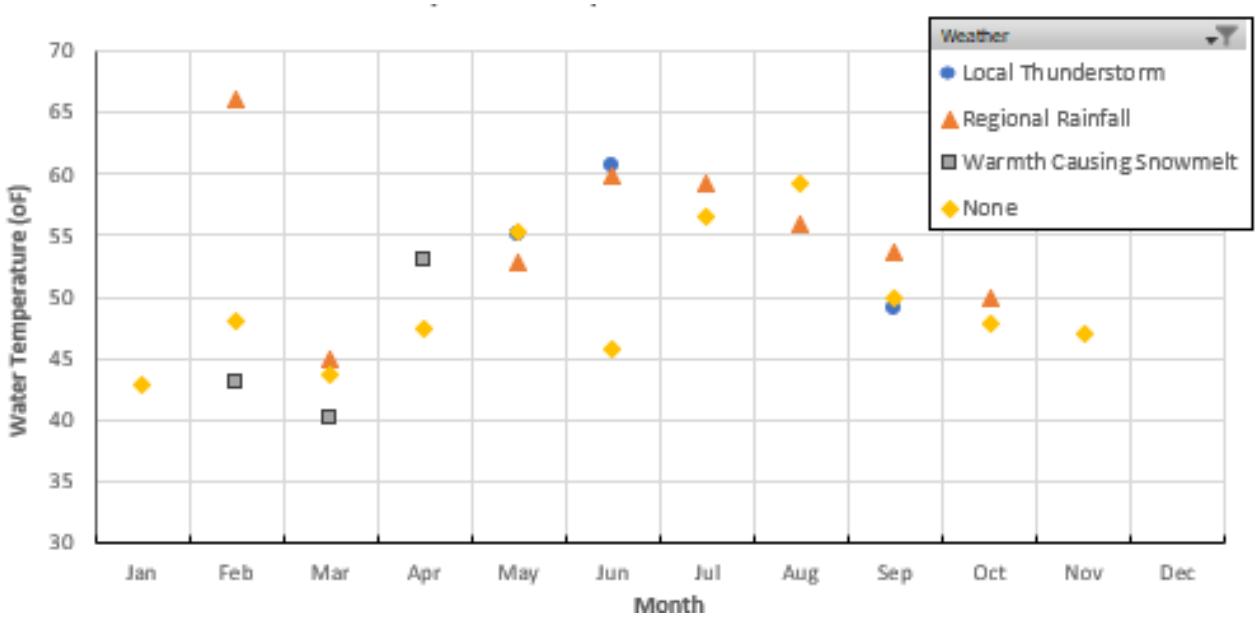


Figure 16. Average monthly temperatures, by weather event, in Driftless Area trout streams, 2020

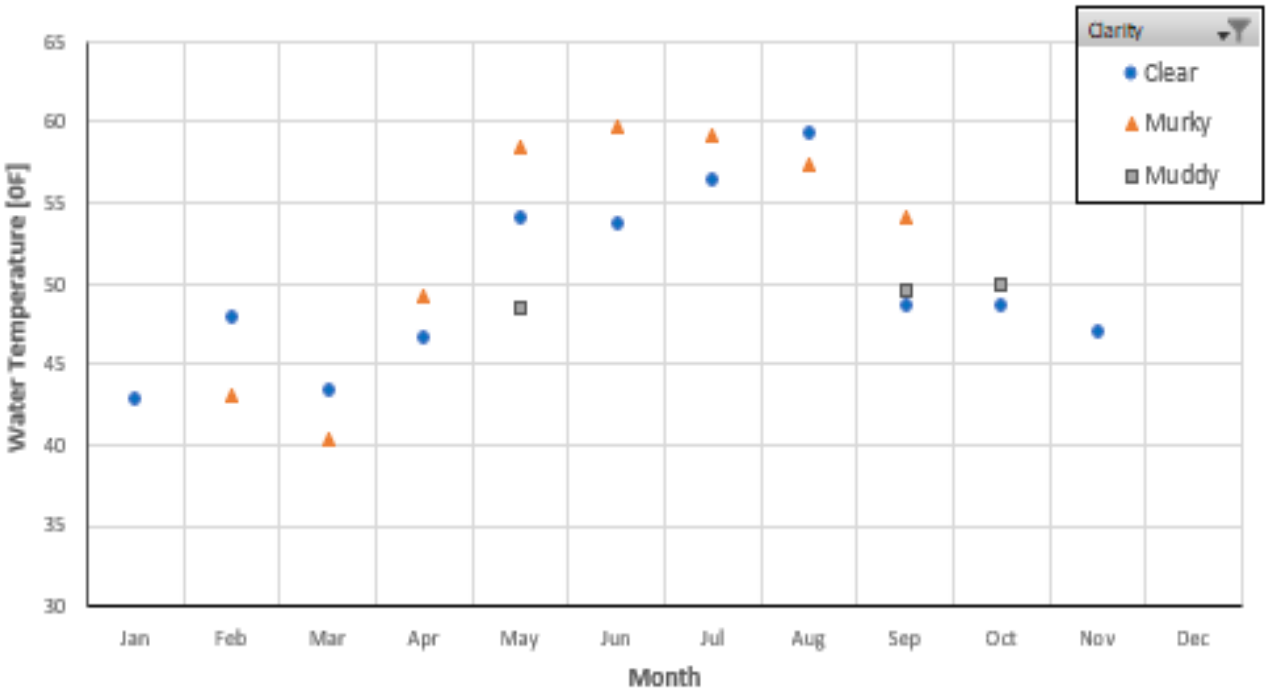


Figure 17. Average monthly temperatures, by water clarity, in Driftless Area trout streams, 2020

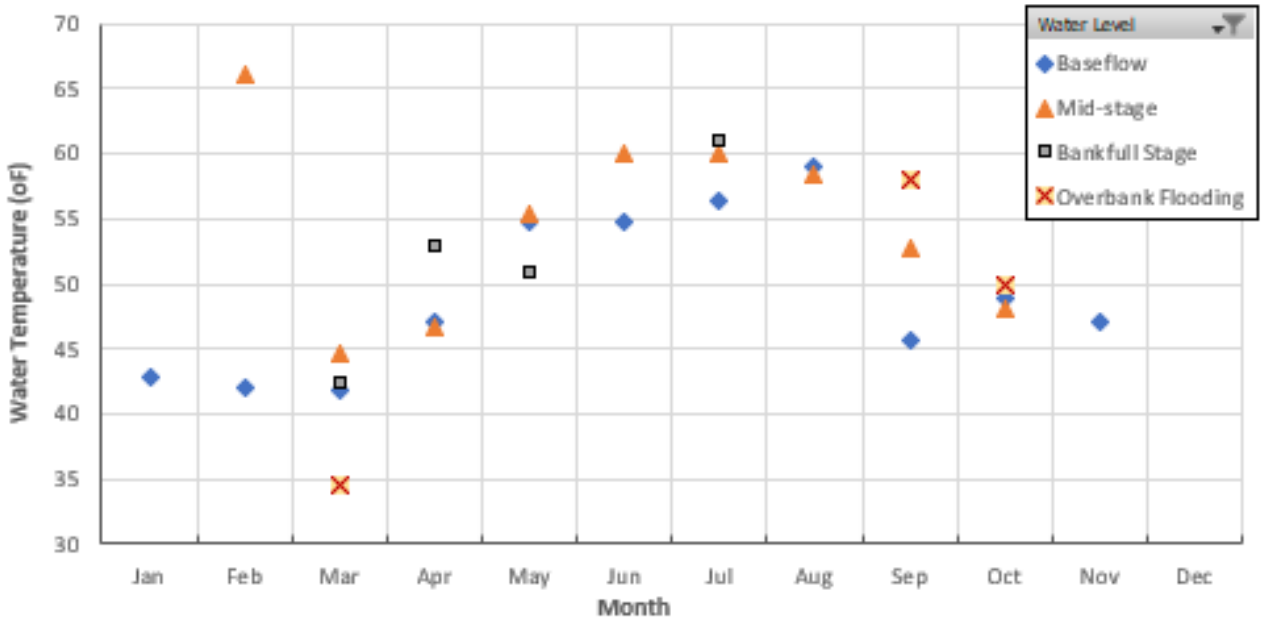


Figure 18. Average monthly temperatures, by water level, in Driftless Area trout streams, 2020

Table 16. Water temperature impacts on trout and coldwater ecosystems.

Temperature (ºF)	Fishery Condition[a]	Trout and Coldwater Ecosystem Impacts
39 - 66		Direct: None Habitat/Prey: Good range for trout and other coldwater species
67 - 76		Direct: Increasing stress on trout and other coldwater species, as temperatures extend beyond suitable ranges and less dissolved oxygen is available for respiration Habitat/Prey: Increasing competition from warm water species
≥77		Direct: Lethal to trout and other coldwater species (depending on acclimation and duration of exposure)

a Fisheries condition: Good Fair Poor Lethal

Table 17. Water quality criteria for water temperatures (°F), to protect coldwater ecosystems.

	Coldwater Ecosystems[1]		
Month	**Ta**[2]	**SL**[3]	**A**[4]
JAN	35	47	68
FEB	36	47	68
MAR	39	51	69
APR	47	57	70
MAY	56	63	72
JUN	62	67	72
JUL	64	67	73
AUG	63	65	73
SEP	57	60	72
OCT	49	53	70
NOV	41	48	69
DEC	37	47	69

1 Cold = Waters with a fish and aquatic life use designation of "cold water community"
2 Ta = Ambient water temperature
3 SL = Sub−lethal criterion (maximum weekly average temperature)
4 A = Acute criterion (daily maximum temperature)

Stream Disturbances: When making a WiseH2O mApp observation, anglers can note the presence of stream disturbances that could impair trout fisheries. These disturbances include *Fish Barriers, Bank Erosion, Trash, Drains/Pipes Outflow, Livestock in Water, Algal Bloom, and Fish Kill* in streams. If no disturbances are present, anglers note *None*. Of the 144 total mApp observations made in the Driftless Area during 2020, 103 observations of stream disturbances were reported by anglers (Table 7, Figure 1919, *Figure 200*).

Table 18. Stream disturbances reported in Driftless Area trout streams, 2020.

Disturbance	Present	Absent	Not Reported
Fish Barrier	1	102	41
Bank Erosion	24	79	41
Trash	3	100	41
Pipe/Drain Outflow	2	101	41
Livestock in Water	2	101	41
Algal Bloom	1	102	41
Fish Kill	0	103	41
None	74	29	41

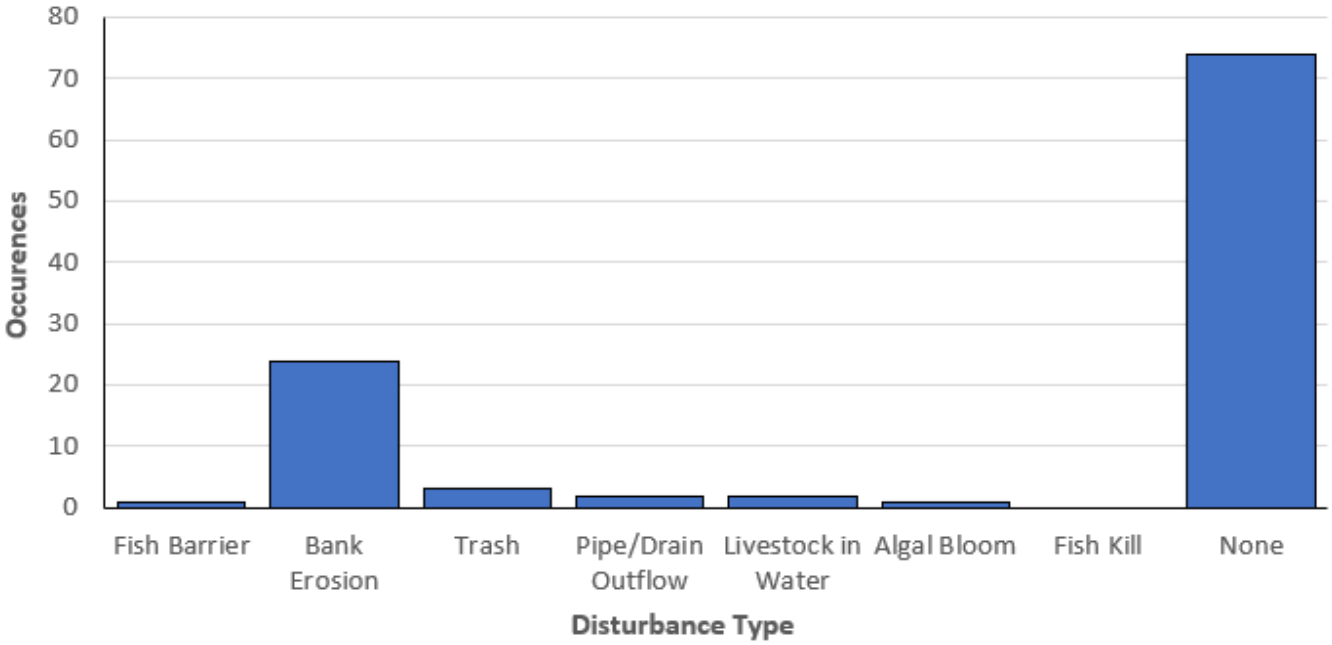


Figure 19. Angler observations of stream disturbances in Driftless Area trout streams, 2020.

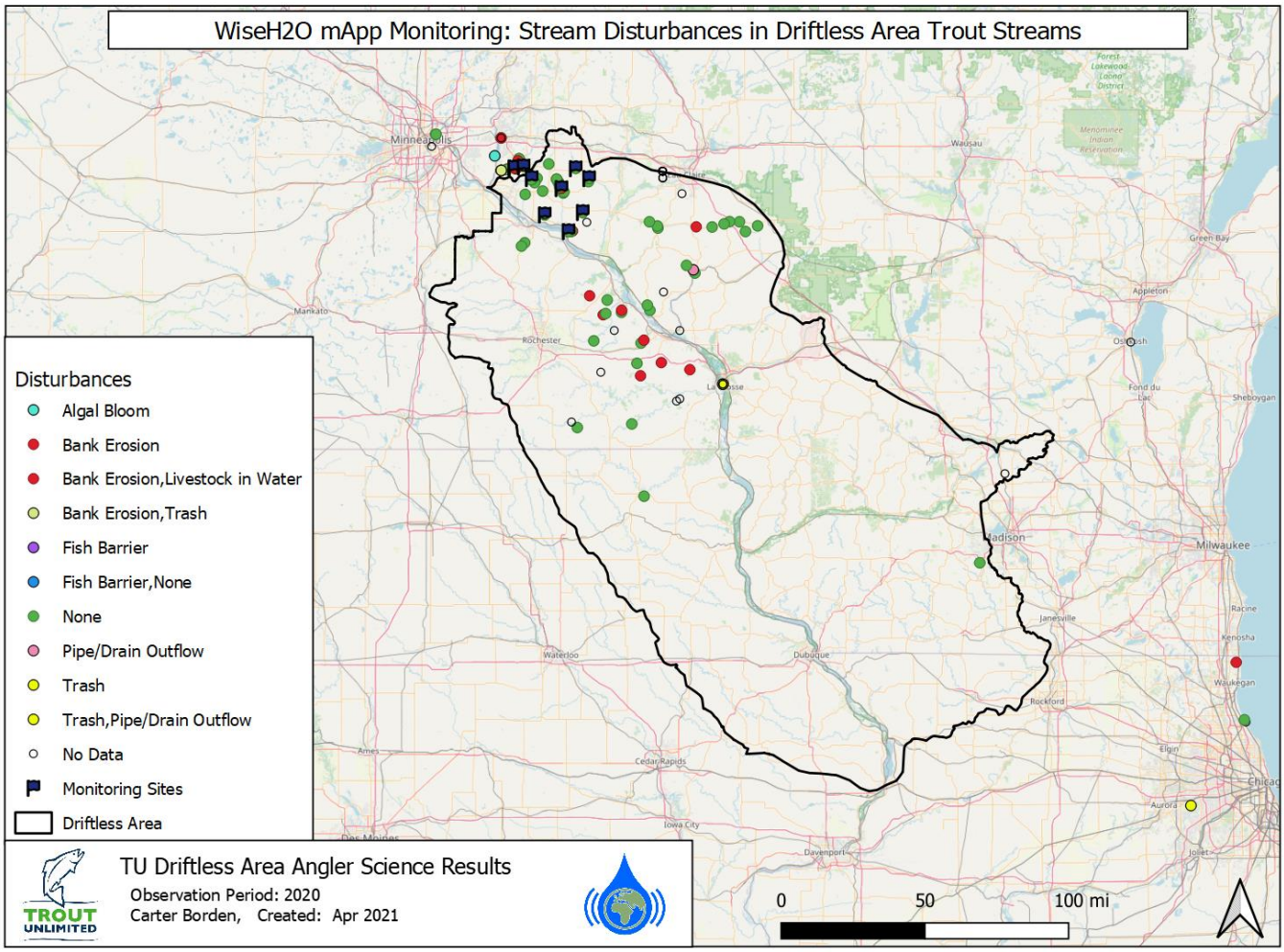


Figure 20. Angler observations of stream disturbances in Driftless Area trout streams, 2020.