2020-2021 NDWRRI Annual Report – General Information

Products

Peer-reviewed Journal Papers

1) Acharya, U., Daigh, A.L.M., and Oduor, P.G. 2021. Factors affecting in the use of weather stations data in predicting surface soil moisture for agricultural applications. *Canadian Journal of Soil Science*. https://doi.org/10.1139/CJSS-2021-0034.
2) Acharya, U., Daigh, A.L.M., and Oduor, P.G. 2021. Machine learning for predicting field soil moisture using soil, crop, and nearby weather station data in the Red River Valley of the North. *Soil Syst.* 5(4), 57, https://doi.org/10.3390/soilsystems5040057
3)

4) Das, T. K., Quentin, S, and Bezbaruah, A. N. 2021. Montmorillonite clay-iron crosslinked alginate beads for aqueous phosphate removal. *Chemosphere*. 281, 130837, https://doi.org/10.1016/j.chemosphere.2021.130837.
5) Das, T. K. and Bezbaruah, A. N. 2021. Comparative study of arsenic removal by iron-based nanomaterials: Potential candidates for field applications. *Science of the Total Environment*. 142914. https://doi.org/10.1016/j.scitotenv.2020.142914.
6) Das, T. K., Sakthivel, T. S., Jeyaranjan, A., Seal, S., and Bezbaruah, A. N. 2020. Ultra-high arsenic adsorption by graphene oxide iron nanohybrid: Removal mechanisms and potential applications. *Chemosphere*. 126702. https://doi.org/10.1016/j.chemosphere.2020.126702.
7) Lin, Z., Lim, S. H., Lin, T., and Borders, M. 2020. Using agent-based modeling for water resources management in the Bakken region. *Journal of Water Resources Planning and Management*, *146*(1), 05019020, https://doi.org/10.1061/(ASCE)WR.1943-5452.0001147.
8) Rashid, U. S., Das, T. K., Sakthivel, T. S., Seal, S., and Bezbaruah, A. N. 2021. Mechanisms of rapid fluoride removal by GO-CeO_2 nanohybrid. *Science of the Total Environment.* 148547. https://doi.org/10.1016/j.scitotenv.2021.148547.
9) Vaddevolu, U.B.P., Lester, J., Jia, X., Scherer, T.F., and Lee, C.W. 2021. Tomato and watermelon production with mulches and automatic drip irrigation in North Dakota. *Water*, 13(14): 1991. https://doi.org/10.3390/w13141991.
10) Zeng, L. and Chu, X. 2021. A new probability-embodied model for simulating variable contributing areas and hydrologic processes dominated by surface depressions. *Journal of Hydrology*, 602, 126762, 1-15. https://doi.org/10.1016/j.jhydrol.2021.126762.
11) Zeng, L., and Chu, X. 2021. Integrating depression storages and their spatial distribution in watershed-scale hydrologic modeling. *Advances in Water Resources*, 151, 103911, 1-14, https://doi.org/10.1016/j.advwatres.2021.103911.

Conference Proceeding Papers

1) Atashi, V. and Lim, Y. H. 2021. Investigation of Muskingum Routing parameters in natural channel in North Dakotan River under snowmelt-induced flooding conditions. In: *Proceeding*

of 2021 Western South Dakota Hydrology Conference, APR 21-22, 2021, Rushmore Plaza Civic Center, Rapid City, SD.

2) Vaddevolu, U. B. P., Jia, X., Scherer, T. F., and Lee, C. 2020. Automatic sensor controlled drip irrigation under mulches for tomato and watermelon productions. In: *Proceedings of the 2020 ASABE International Meeting*, Omaha, NE, USA, 12–15 July 2020; p. 2001035.

Dissertations and Theses

1) Acharya, Umesh. 2021. Soil Moisture Prediction using Meteorological Data, Satellite Imagery, and Machine Learning in the Red River Valley of the North. Ph.D. Dissertation. Soil Science, College of Graduate and Interdisciplinary Studies, North Dakota State University, Fargo, ND (available at: https://www.proquest.com/docview/2572634490/54D8B495D0C44CD0PQ/1?accountid=6766)
2) Almen, Kristen Karen. 2020. Impacts of Controlled Drainage and Subirrigation in the Red River Valley. M.S. Thesis. Environmental and Conservation Sciences, College of Graduate and Interdisciplinary Studies, North Dakota State University, Fargo, ND (available at: https://www.proquest.com/docview/2477876026/13710E66E47447F6PQ/1?accountid=6766)
3) Das, Tonoy Kumar. 2021. Graphene Oxide Supported Metal Oxide Nanohybrids for Aqueous Arsenic Removal. Ph.D. Dissertation. Environmental and Conservation Sciences, College of Graduate and Interdisciplinary Studies, North Dakota State University, Fargo, ND (available at: https://www.proquest.com/docview/2572633759/6B7B4C4065224892PQ/1?accountid=6766)
4) Jones, Rebecca. 2021. Influence of Habitat Characteristics on Amphibian Stress and Reproductive Success in North Dakota. M.S. Thesis. Biological Sciences, College of Graduate and Interdisciplinary Studies, North Dakota State University, Fargo, ND (available at: https://www.proquest.com/docview/2543807471/947C1F2995FC4F5DPQ/1?accountid=6766)
5) Lin, Tong. 2021. An Agent-based Model for Water Allocation and Management at the Bakken Shale in Western North Dakota. Ph.D. Dissertation. Environmental and Conservation Sciences Program, College of Graduate and Interdisciplinary Studies, North Dakota State University, Fargo, ND
6) Schlarb, Alicia Michelle. 2021. The Effects of Salinity on Canadian Toad (*Anaxyrus hemiophrys*) Larvae and Post-Metamorphic Juveniles. M.S. Thesis. Environmental and Conservation Sciences, College of Graduate and Interdisciplinary Studies, North Dakota State University, Fargo, ND (available at: https://www.proquest.com/docview/2544279966/A2DA49EFA47F43DAPQ/1?accountid=6766)
7) Zeng, Lan. 2020. Improved Hydrologic Modeling for Characterizing Variable Contributing Areas and Threshold-Controlled Overland Flow in Depression-Dominated Areas. Ph.D. Dissertation. Civil Engineering, College of Graduate and Interdisciplinary Studies, North Dakota State University, Fargo, ND (available at: https://www.proquest.com/docview/2478600088/E3C31B319BC74B5FPQ/1?accountid=6766)

Information Transfer Program

Information dissemination was mainly done through the Institute's website, the annual newsletter, as well as a variety of publications and conference presentations. The major information transfer activities supported with the 104b annual base grants and required matching funds include:

1) Maintaining the Institute's website as an effective way to disseminate all Institute-related information and communicate to the public. Particularly, the NDWRRI homepage has been redesigned and more improvements are under way.
2) Publishing the Institute newsletter to highlight the graduate research fellowship program and the impacts of the funded projects, profile the Institute researchers and their accomplishments, and provide information on water issues in the State.
3) Publishing the research findings by the Institute's Fellows and their advisors (PIs of the funded projects) in peer-reviewed journals, proceedings, book chapters, as well as theses and dissertations.
4) Presenting research results by the Institute's Fellows and their advisors at various conferences.
5) Sponsoring or co-sponsoring local or regional conferences (note that due to the COVID-19 pandemic, all conferences have been postponed, cancelled, or changed to an online conferences). The NDWRRI is a partner of the North Dakota Water Quality Monitoring Conference to be held in Bismarck, ND on March 21-23, 2022.

USGS Collaboration

Dr. David Mushet, a Research Wildlife Biologist and Chief of the Climate and Land-use Branch at the USGS Northern Prairie Wildlife Research Center in Jamestown, North Dakota, has played a co-advisor role for a Ph.D. student and has been involved in the project titled "Assessment of Agricultural Impact on Biotic Components of North Dakota Wetland Resources Using Habitat Suitability Landscape Genomics of Amphibians" (2020ND077B).

Student Support

The NDWRRI continued its Graduate Research Fellowship (GRF) program supported with the annual base (104b) and required matching funds (including the funds from the North Dakota State Water Commission). It provided competitive funds for graduate students and their advisors (PIs) at North Dakota State University and the University of North Dakota to conduct water resources research and particularly, to address the water issues in the State. In FY2020, the fellowships were awarded to 19 graduate students, including 14 Ph.D. students and 5 M.S. students from the two universities. The funding period ranged from 3 months (summer only) to 12 months.

Notable Achievements and Awards

In FY2020, nineteen projects were funded through the Institute's GRF program to address various water resources issues in North Dakota. 19 graduate students and 19 faculty members (PIs) have been involved in these projects. They have published 11 peer-reviewed journal papers and 2 conference proceeding papers, and given numerous conference presentations at various conferences. 4 Ph.D. students and 3 M.S. students supported by the 104b federal funds and required matching funds have successfully received their degrees and published their dissertations/theses. The awards the Institute's Fellows received in this funding period are listed as follows:

1) Umesh Acharya received a Graduate Student Travel Award for oral presentation at the Soils and Crop Conference, University of Saskatchewan, Canada.

2) Pavankumar Challa Sasi received the 2nd prize at 3MT (3-minute Thesis) competition held at the University of North Dakota for a presentation on Destruction of "Forever Chemicals."
3) Tonoy K Das received 2021 Doctoral Dissertation Fellowship from the College of Graduate and Interdisciplinary Studies, North Dakota State University.
4) Justin Waraniak won a runner-up in the Northern Plains Biological Symposium Best Poster Competition.
5) Kui Hu received 2021 Harvey K. Nelson Scholarship.
6) Jarrett Lardy won the 3rd Place Poster at the 65th Annual Manitoba Soil Science Society Conference and Annual General Meeting, February 3-4, 2021.
7) Berkay Koyuncu received a travel award from American Physical Society (APS) to present his research at 2021 APS Division of Fluid Dynamics (DFD) Meeting, November 21-23, 2021, Phoenix, AZ.

Assessment Of Agricultural Impact On Biotic Components Of North Dakota Wetland Resources Using Habitat Suitability Landscape Genomics Of Amphibians

Project Type: Annual Base Grant
ProjectID: 2020ND077B

Project Impact:

Connectivity analyses using landscape genetic data from northern leopard frog (Rana pipiens) populations were completed, which provided insights into land use and other landscape feature impacts on the fragmentation of populations. The best landscape resistance models explaining genetic distance among R. pipiens populations sampled in the James River and Lake Oahe basins identified land use and topography as the most important variables influencing connectivity. Open water (primarily large lakes and the Missouri River), high intensity urban areas (Jamestown and Bismarck), and wetlands impeded gene flow, whereas cropland had moderately high resistance but was still somewhat permeable. Pasture and grassland consistently had the lowest resistances and were the most important land uses maintaining connectivity. Topographic roughness was also an important landscape variable; gene flow occurred primarily over flat land while areas with steep slope impeded movements. There were no apparent effects of habitat fragmentation on genetic diversity or population structure of R. pipiens in the study area. No inbreeding-coefficient estimates were significantly greater than 0 and measures of genetic diversity were not related to amount of nearby agriculture. There was weak spatial structure among the sample sites, suggesting high gene-flow levels historically throughout the study area. This research shows how land use is influencing functional biotic connectivity of wetlands in the Prairie Pothole Region. Conversion of grassland and pasture to cropland increases the risk of habitat fragmentation for amphibians. Additionally, output from the landscape resistance models can be used to help managers identify areas important for maintaining or restoring connectivity.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water availability

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

ecosystem management; freshwater ecosystems

Automatic Sensor-controlled Drip Irrigation Under Mulches For Tomato And Watermelon Productions

Project Type: Annual Base Grant
ProjectID: 2020ND088B

Project Impact:

Irrigation is one of the most important factors in agriculture. Irrigation scheduling determines the time and the amount of water supply, which is based on crop water use or soil moisture status. Therefore, the irrigation water can be applied using an irrigation controller, which is a device to operate irrigation automatically. In this study, a soil water potential sensor based controller was used to manage the drip irrigation system automatically in a two-year field experiment. Watermelon and tomato productions using the automatic drip irrigation system under black plastic, clear plastic, and landscape fabric mulch along with no mulch were tested in Fargo, ND. During the field experiments, the irrigation system was tested at threshold 4 (approximately -25 centibars) under different mulches. The results showed that the tomato yield from irrigation under black plastic mulch had the highest yield compared to the other regimes, whereas the drip irrigation under clear plastic mulch for watermelons had the best yield and quality.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water availability

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

water budget, water supply and demand, water use

Development Of A New Depression-oriented Watershed Hydrologic Model And Its Application In North Dakota

Project Type: Annual Base Grant
ProjectID: 2020ND081B

Project Impact:

In this project, a new depression-oriented watershed-scale hydrologic model was developed to simulate the influence of depressions on surface runoff generation and propagation processes. In the model, a subbasin is divided into many depressional time-area zones to quantify the spatially distributed depression storages. For each depressional time-area zone, the intrinsic changing patterns of depression storage and connected areas during the depression filling processes were identified, based on which the formation of connected areas and generation of surface runoff during real rainfall events were simulated. Then, based on the depressional time-area zone scheme, the outlet contributing area was determined and the surface runoff generated from each depressional time-area zone was routed to the subbasin outlet. The likelihood of occurrence of outlet CA and runoff contributions was also quantified by using a joint probability distribution associated with depression storages and their spatial distribution. The developed model was applied to the upper portion of the Sheyenne River Watershed in the Prairie Pothole Region of North Dakota. Results demonstrated the model capabilities in tracking the formation of outlet contributing area and simulating the depression-influenced surface runoff processes, which highlighted the important roles of depressions. Without considering depression storages, a model would overestimate outlet contributing area and runoff contribution to the subbasin outlet. Without considering the spatial distribution of depression storages, a model would fail to track the outlet contributing area and characterize the timing and quantity of runoff contributions. The new model developed in this project can also be used to estimate the probability of occurrence of outlet discharges under rainfall events with different return periods.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water prediction

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

water budget

Does Wetland Restoration Affect The Accumulation Of Glyphosate?

Project Type: Annual Base Grant
ProjectID: 2020ND076B

Project Impact:

In the Prairie Pothole Region, wetland restoration is an important remediation tool. However, more information is needed on how its efforts impact agrochemicals and microbial succession, which play crucial roles in ecosystem functioning. This project is investigating relationships between wetland restoration, common use herbicides, and microorganisms. Having a better understanding on wetland succession post-restoration could broaden future conservation mechanisms. In July 2020, surface sediment (~1-2 cm) was sampled from 20 wetlands in North Dakota (5 replicates each wetland, n = 100), where 15 wetlands were restored and 5 were natural. Replicates were composited to yield one sediment sample per wetland (n = 20) for analyses. Microbial DNA was extracted and the extracts were stored in -20 ºC until 16S rRNA sequencing. Additionally, sediments were submitted to the University of Guelph Agriculture and Food Laboratory (Ontario, Canada) for herbicide residue analyses. They were analyzed for the top five most commonly used herbicides in North Dakota, including glyphosate, atrazine, 2,4-D, metolachlor, and acetochlor. Results showed no detections in any sample for all five herbicides tested with the maximum limit of quantifications as follows: glyphosate, AMPA (glyphosate metabolite), acetochlor, and desethyl-atrazine (atrazine metabolite) = 0.02 ppm, atrazine = 0.008 ppm, 2,4-D = 0.03 ppm, and metolachlor = 0.005 ppm. The results suggested that herbicide residues did not persist in benthic sediments of these wetlands. However, additional testing is needed to confirm these results and findings.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water availability

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

freshwater ecosystems, water quality

Effectively And Practically Remove Per- And Polyfluoroalkyl Substances From Landfill Leachate And Groundwater

Project Type: Annual Base Grant
ProjectID: 2020ND082B

Project Impact:

Poly- and perfluoroalkyl substances (PFAS) are a large group of organic contaminants that have been detected nationally in the aquatic environment. Two PFAS compounds, perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), have been observed in >95% of the blood samples collected during multiple U.S. national surveys at health-relevant concentrations. Contaminated drinking water is a major source exposure to PFAS for the general public. The U.S. EPA has recently set a drinking water advisory on the combined level of PFOA and PFOS at 0.070 µg/L, making removal of PFAS from drinking-water sources a priority issue. The goal of this project is to develop an innovative treatment system that can effectively and practically remove PFAS from landfill leachate and groundwater. The leachate samples were pretreated to simulate a typical wastewater treatment setup using flocculation/coagulation and ozonation. The fate of PFAS throughout the entire process was identified. We also performed experiments on the adsorption of PFAS using various commercially available granular activated carbon (GAC) samples using DI water, surface water, and leachate. We tested the decomposition of PFAS using thermal treatment techniques discussed in our previous publications on leachate samples. The results of this project have important implications for technological improvements in water purification. Water treatment plants, the water industry, water resources personnel, and the broader education and research communities who are concerned about PFAS contamination would benefit from the results of this project.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water availability

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

water supply and demand, water use, water quality

Fabrication Of Point Of Use Treatment Systems For Aqueous Arsenic And Their Evaluation

Project Type: Annual Base Grant
ProjectID: 2020ND087B

Project Impact:

Drinking water arsenic contamination affects more than 250 million global population and turns into a significant public health concern due to arsenic carcinogenicity and genotoxicity. Low iron use efficiency and slow reaction kinetics of iron-based adsorbents make it ineffective for field application despite its low cost and easy availability. In this work, we developed a novel graphene-oxide iron-nanohybrid (GFeN) with high adsorption capacity (306/431 mg/g for As(III)/As(V)) and quick reaction kinetics for aqueous arsenic removal. The nanohybrids showed significantly better arsenic removal performances than the conventional iron nanoparticles in a wide range of pH, temperature, and presence of co-existing ions. The graphene oxide sheet in GFeN played an essential role in enhancing iron use efficiency and stabilizing the adsorbed arsenic through active electron transfer between the graphene oxide layer and iron nano interface. Our two-year batch desorption data indicates that adsorbed arsenic remains stable with a ~ 5.73% desorption of adsorbed phase arsenic. Powdered GFeN has some operational challenges in point-of-use treatment systems like the movement of nanomaterial through the filter bed and potential clogging. GFeN is entrapped into a polyether sulfone matrix for ease of field application. Cellulose nanofiber was also used in polymer bead formation to enhance the beads' internal porosity, which improved arsenic removal by 15-40%. Further, economic feasibility, application viability, and stakeholder acceptability of the technology should be evaluated. This research provides fundamental understanding of reliable and safe nano-based safe materials for aqueous arsenic removal and elucidates the mechanisms in the arsenic removal process.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water availability

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

water supply and demand, water use, water quality

Flood And Bathymetry Alteration Simulations Under Ice-Coverage In Red River

Project Type: Annual Base Grant
ProjectID: 2020ND073B

Project Impact:

This study investigates the impacts of ice on hydrodynamics of meandering rivers. The existence of ice cover complicates the entire flow structure, including secondary flow patterns and shear velocity distribution. Many measurements are conducted throughout this study to examine the flow structures of the Red River in North Dakota. The digital terrain map is reconstructed by LiDAR and Acoustic Doppler Current Profiler data acquired using moving-vessel and stationary deployment technique. Stationary deployment technique is used to collect vertical velocity profiles at more than 120 fixed stations under open surface and ice-covered conditions. Datasets are processed to identify the logarithmic layers and shear velocity distribution by employing the best-fitting method. Extension of the logarithmic layer near the riverbed under ice-covered condition is found to be limited in comparison to the open surface case. Afterwards, secondary flow patterns are visualized and circulations are located accordingly. Results show that the secondary flow patterns under ice-covered condition are drastically different from those under the open surface condition. More significantly, it is observed that the position of the main circulations is shifted towards the outer bank, which weakens the circulation strength. This phenomenon is crucial in addressing sediment transport and erosion risks. The same vertical profiles are processed by using quartic solution to evaluate the shear velocity distributions in ice-covered case. Results suggest that the shear velocity is significantly low under ice coverage near the outer bank. The ice coverage contributes significantly to the transition of flow dynamics, which occur during fall-winter and winter-spring periods.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water observing

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

water budget

Hydraulic And Hydrologic Routing Parameters In Natural Channels In North Dakota Under Spring Snowmelt Conditions

Project Type: Annual Base Grant
ProjectID: 2020ND090B

Project Impact:

Hydrological processes related to snow occur in large regions on earth including North Dakota where runoff triggered by snowmelt is an important annual event. The Muskingum model is one of the most popular models for hydrologic channel flood routing. Despite the simplicity of the Muskingum equation, the parameters of this equation have not been calibrated for streams in North Dakota using actual flow hydrographs due to the lack of pair-wise gauging sites along streams. In this research, the parameters of the Muskingum model were identified by using the basin characteristics representing the inlet and outlet of the channel reach for two stations in the Pembina River, North Dakota (Walhalla and Neche) and two stations in the Red River (Grand Forks and Emerson). The Muskingum flood routing method was applied to three flood events in 2009, 2011, and 2017 for the Pembina River. Further work will be conducted to investigate other reaches in the region. To achieve the goal, the coefficients of x and K as outcomes from HEC-RAS were determined. The result showed that the coefficient of x of the Muskingum method had values close to zero for the Red River Basin during spring melting season, which was consistent with the results for streams with wide flood plains. The coefficient of K of the Muskingum method was found to be 24.26, 20.8, and 34.126 for the events in 2009, 2011, and 2017, respectively.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water prediction

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

water budget

Hydrological Changes Due To Recent Wetting In A Cold Region Riverine Headwaters Environment

Project Type: Annual Base Grant
ProjectID: 2020ND084B

Project Impact:

Gradual increases in precipitation in the headwaters of the Sheyenne River above Harvey, ND have led to changes in previously observed patterns of snow accumulation, timing of peak snow-water equivalent and melt, duration of snow cover period, snowmelt runoff, streamflow generation mechanism, frozen vs. unfrozen soil conditions, and infiltration capacity. The use of a physically-based model in the Cold Regions Hydrologic Model (CRHM) platform helps to understand the impacts of this climatic shift on hydrologic processes in space and time. Intensive data collection was conducted for the CRHM model, including weather and climate data, elevation, soil type, land use and land cover maps, and division of the entire watershed into over 1,000 hydrologic response units (HRUs). The model setup has also incorporated more robust sources of data, such as IMERG precipitation data and USGS streamflow data at hourly resolution. Verification of the model's initial conditions is ongoing, in particular to confirm the depressional storage within the basin so that fill-and-spill hydrology processes are accurately reflected in the model results. Periods of regional wet and dry cycles on the order of 3-4 years are generally well defined for the Red River of the North contributing area, and further refinement of the individual contributing watersheds appears possible with more vigorous analysis of higher-quality data sources. Preliminary results indicate a strong influence of fill-spill hydrology and variable contributing area on snowmelt streamflow generation during the deluge years.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water prediction

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

water budget

Impact Of Subsurface Drainage And Subirrigation On Water Quality In Richland County, North Dakota

Project Type: Annual Base Grant
ProjectID: 2020ND079B

Project Impact:

Drainage water management via controlled drainage (CD) and subirrigation (SI) has shown positive effects on water quality. To determine the impact of CD and SI in the Red River Valley (RRV), water samples from two fields, each with CD and SI, were analyzed. A decreasing trend in overall nutrient load loss was observed due to reduced drainage flow via drainage water management. However, few chemical concentrations (e.g. sulfate) were above the recommended surface water quality standards during spring free drainage (FD) period, which was caused by the soil chemistry in this region. The water quality during the SI periods was significantly different from that during the CD and FD periods, likely due to the SI water source of marginal quality, which also impacted soil quality near the drain tile. Overall, the CD and SI reduced the nutrient loss and benefited the agricultural fields.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water observing

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

water budget, water supply and demand, water use

Imprinting And Hydromulch For Soil Erosion Reduction And Plant Establishment In Semi-arid Soils Disturbed From Oil And Gas Development

Project Type: Annual Base Grant
ProjectID: 2020ND091B

Project Impact:

Energy development and construction, specifically construction of natural gas pipelines, has expanded across western North Dakota within the Williston Basin (Bakken and Three Forks formations). This expansion challenges reclamation when vegetative plant establishment is limited post-installation. Limited vegetation establishment increases soil erosion and water runoff, and provides an environment with the potential to allow invasive plant species to encroach, resulting in numerous, expensive attempts of reseeding right-of-ways. This study examines five seed-preparation methods near Williston, ND, and their effects on water runoff, sediment loss, and vegetation establishment under rainfall simulation during a severe drought in a semi-arid climate. The treatments used in this study were wood-fiber hydromulch, land imprinting, wheat-straw crimping, the combination of hydromulch and imprinting, and bare ground (control), all on 2% and 5% slopes within the same catena. Rainfall simulations were completed in September 2020, and again in June 2021 to examine the treatments over time. Crimping straw, one of the most economical options, was the only treatment that reduced runoff long-term with an equivalent depth of 0.7 cm of water, compared to 1.8 cm of water for the control. However, hydromulch and imprinting with hydromulch were the only treatments that reduced sediment load over both simulations, reducing erosion by over 58% when compared to the control. Plant establishment was not significant for any treatment, likely due to the severe drought conditions. Cover is necessary in times of drought when plants fail to establish, with straw crimping being the best option during an extended drought.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water availability

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

water budget, water use, water quality

Influence Of Habitat Characteristics On Amphibian Stress And Reproductive Success In North Dakota

Project Type: Annual Base Grant
ProjectID: 2020ND083B

Project Impact:

Assessments of habitat suitability provide a necessary framework to guide conservation decisions. This is particularly true for amphibians, as they are experiencing unprecedented population declines and extinction events. Northern Leopard frogs (Lithobates pipiens) are no exception, as they have been observed declining in the central and eastern regions of North America. Large portions of diverse wetlands across the State of North Dakota are being lost to agriculture at unprecedented rates and as a result, habitat for anurans is declining. Larval and visual encounter surveys were conducted to distinguish the essential habitat characteristics that are crucial during each stage of amphibian reproduction. In addition to collection of amphibian data, macro- and micro-habitat data were recorded at each site. Captured individuals had their blood drawn and water-borne corticosterone samples collected to assess this environmental stress. This study found that surrounding developed area impacts larval suitability of a habitat and stress levels. Additionally, there was a near significant positive relationship with variance in phosphate and corticosterone levels. It would be interesting to see if this relationship were to increase with a larger sample size. This research provides an updated suitability model, baseline levels of corticosterone and white cell profiles for a native anuran species, and reference wetland habitat/water characteristic data for Wildlife Management Areas (WMAs) in North Dakota.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water availability

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

ecosystem management, freshwater ecosystems

Red Lake River And Red River Raw Water Quality Investigation

Project Type: Annual Base Grant
ProjectID: 2020ND092B

Project Impact:

The City of Grand Forks, ND has built a new drinking-water treatment plant that treats surface water from the Red River and the Red Lake River by two systems. In one of the systems, conventional processes are used. Another system consists of membrane filtration technologies, including ultrafiltration and reverse osmosis. The pretreatment of membrane filtration is a coagulation/flocculation process. However, our preliminary data show that total organic carbon (TOC) after conventional/enhanced coagulation is still greater than 3.5 mg/L, which appears to be too high for membrane filtration. In addition, removal of TOC from water prior to chlorine disinfection is able to reduce the formation of cariogenic disinfection byproducts. In this project, we identified the major sources of TOC in the Red River and the Red Lake River in order to reduce the input of TOC to the drinking-water treatment plant, mitigate the organic fouling of membranes, and reduce the formation of disinfection byproducts. The results can potentially lead to the reduction of TOC and disinfection byproducts in drinking water of this city.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water availability

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

water supply and demand, water use, water quality

Rejuvenation Of Urban Streams In Cold Climate Regions Using Hydroponic Systems: A Case Study On English Coulee In Grand Forks, North Dakota

Project Type: Annual Base Grant
ProjectID: 2020ND078B

Project Impact:

The primary objective of this project was to determine the effectiveness of a Floating Treatment Wetland (FTW) system, specifically in the case of the English Coulee in Grand Forks, ND. Over the course of this experiment, two pilot scale FTW systems were set up in the coulee and monitored over the period from May to September in 2021. This study primarily examined nitrate and phosphate levels as a measure of performance by the FTWs. Data was also collected on how the plants responded to environmental conditions in the cold weather region of North Dakota. The data collected helped determine the optimal plant species for a theoretical full-scale system as well as the removal efficiency of that system. The study identified Juncus effusus and Leersia oryzoides as optimal candidates for full scale design showing the highest survival and growth rates. At this stage, little to no difference in upstream nutrient concentrations was observed, which is due to the small size and unestablished root systems. With each successive growing season, the roots become more established, and the plants can grow to larger sizes, improving the FTW efficiency. As these plants continue to grow in next season, growth rate and nutrient removal will continue to be monitored to help better understand the impact of this system and the potential for a full-scale design. Thus, more effort and data collection are needed.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water observing

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

contaminant transport, water quality

Soil Amendment For Reducing The Runoff Of Nutrients From Agricultural Lands

Project Type: Annual Base Grant
ProjectID: 2020ND085B

Project Impact:

The runoff of nitrogen (N) and phosphorus (P) from agricultural lands is responsible for 40% of the impaired lake/river area in the U.S. Loss of N and P from agricultural lands applied with conventional fertilizers not only wastes the State billions of dollars every year, but also results in negative agronomic and environmental consequences including decreased crop profitability, water impairment, and potential impacts on climate change. In this project, we developed a novel carbonaceous bio-soil amendment (CSA) from biomass (renewable) resources to retain nutrients and act as a controlled-release form of N and P. The substrate is bio-char made by pyrolysis of biomass materials, such as crop residue and agricultural waste materials, at moderate temperature and under limited oxygen supply. The CSA was produced optimally binding phosphate, ammonium and metal cations (i.e., magnesium (Mg) or calcium (Ca)) on the surface of bio-char. Consistent with our hypotheses, we found that nano-crystallites of struvite ($MgNH_4PO_4$) and calcium ammonium phosphate ($CaNH_4PO_4$) precipitates are deposited on surfaces and in pores of char; and such precipitates were sparingly soluble and acted as controlled-release supplies of N and P. The results of this project may promote innovation and result in the development of the next-generation soil conditioner–fertilizer compost by sustainably utilizing the biomass materials that are abundant in the Midwest.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water availability

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

contaminant transport, water quality

Soil Moisture Mapping Using Landsat Data In A Frigid Glaciolacustrine Landscape With Agricultural Production

Project Type: Annual Base Grant
ProjectID: 2020ND089B

Project Impact:

Weather stations provide key information related to soil moisture and have been used by farmers to decide various field operations. We first evaluated the discrepancies in soil moisture between a weather station and nearby field due to soil texture, crop residue cover, crop type, growth stage and duration of temporal dependency to recent rainfall and evaporation rates using regression analysis. The analysis showed a strong relationship between soil moisture at the weather station and the nearby field at the late vegetative and early reproductive stages. The correlation thereafter declined at later growth stages for corn and wheat. The regression coefficient of soil moisture with four-day cumulative rainfall slightly increased with an increase in the crop residue resulting in a low root mean square error (RMSE). We compared different machine learning models and found Random Forest Regression and Boosted Regression Trees performed best over others (RMSE = 0.045 and 0.048 m3 m-3, respectively). We then evaluated the integration of weather station data, (RFR) machine learning, and remotely sensed satellite imagery to predict soil moisture in nearby fields. Soil moisture predicted with an RFR algorithm using OPtical TRApezoidal Model (OPTRAM) moisture values, rainfall, standardized precipitation index, and percent clay showed high goodness of fit (r2 = 0.69) and low RMSE (0.053 m3 m-3). This research shows that the integration of weather station data, machine learning, and remote sensing tools can be used to effectively predict soil moisture in the Red River Valley of the North among a large diversity of cropping systems.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water prediction

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

water budget, water use

The Ecotoxicological Effects Of Saline Water Characteristics On Amphibian Survival And Development

Project Type: Annual Base Grant
ProjectID: 2020ND062B

Project Impact:

Sodium Chloride production in the United States is at an all-time high. As weather patterns become harsher through climate change and demands on energy and agriculture increase, evidence of long-term NaCl exposure is emerging throughout environments. Salt loading practices affect sensitive inhabitants, such as amphibians that are dependent on freshwater resources. With a focus on Canadian toads (CT) exposed at multiple developmental time periods, this research fills existent gaps of NaCl effects on tadpole weight, survival, time to metamorphosis, and hatch success (eggs), while also highlighting urban wetland conductivity and chloride (Cl) fluctuations. Conductivity and Cl levels were monitored throughout the spring and summer of 2020 from 20 wetlands around the Fargo area. Concurrently, CT eggs were collected and exposed to the same environmentally observed salinity concentrations within a lab-controlled environment. It was found that conductivity spiked in May and June, with the lowest level recorded in August. Chloride levels were the highest at the beginning of the warm season, peaking in June, with the lowest levels recorded in August. Although weight, survival, and hatch success were not affected by NaCl, the time taken to complete metamorphosis was extended in tadpoles exposed to NaCl at an older age. These levels coincide with CT breeding as they tend to lay in early May. Eggs continue to hatch throughout May and larval development continues into June. Metamorphosis typically occurs at the end of June into July when the levels are at their highest, potentially impacting the time to complete metamorphosis.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water availability

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

water quality, freshwater ecosystems

Understanding Intra-lake Seasonal And Spatial Variability In Shallow Prairie Lake Diatom Communities: Implications For Paleolimnological Studies

Project Type: Annual Base Grant
ProjectID: 2020ND080B

Project Impact:

Prairie-pothole wetlands are an important freshwater resource in the Northern Great Plains and play a significant role in providing vital ecosystem services. However, the high variability of regional climate and complex hydrology can make it difficult to effectively manage these systems. To better understand the hydrologic influences on water chemistry of prairie-pothole wetlands, we examined the water chemistry of two adjacent, but hydrologically contrasting prairie-pothole wetlands in the Cottonwood Lake Study Area, North Dakota. Wetland P1, a closed-basin wetland, appeared to be more susceptible to precipitation-driven variability in water levels compared to Wetland P8, which had a natural outlet that limited the maximum water depths during periods of high precipitation. Our results showed that water isotopic signals (δ18O, δ2H) were depleted in both study wetlands during the wetter year, which likely resulted from increased snow melt or direct precipitation inputs. Nutrient concentrations in both wetlands responded mostly to precipitation amounts, while major ions concentrations were more closely related to topographic influences on hydrology; the closed-basin wetland possessed higher concentrations of major ions than the open-basin wetland. These differences were likely due to an increased pond periphery in the closed-basin wetland that provided more ionic movement from shallow groundwater into the wetland and losses of ions through the outlet of the open-basin wetland during the wet period. Our results highlight the importance of considering spatial variability, such as basin topographic features when managing prairie-pothole wetlands.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water observing

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

freshwater ecosystems. water budget

Using Coupled Human And Natural Systems For Water Resources Management In The Bakken Region Of Western North Dakota

Project Type: Annual Base Grant
ProjectID: 2020ND086B

Project Impact:

Previously, we developed a SWAT model for the Little Muddy River and coupled it with our agent-based model under different climate, population growth, water demand, and policy scenarios. To further investigate the impact of hydraulic fracturing (HF) water use on regional groundwater, we loosely coupled an agent-based model with a developed MODFLOW groundwater model. The coupled models were designed to simulate the groundwater level changes of the Fox Hill-Hell Creek aquifer under fourteen scenarios, including HF water demand increase, precipitation decrease, population increase, and policy change scenarios. The results showed that the hydraulic fracturing water demand scenarios, the population increase scenarios, the precipitation scenarios, and two policy change scenarios did not cause any changes in the groundwater drawdown because of the industrial water use restriction policy on the aquifer. However, had this restriction policy been removed, the average groundwater level in the Fox Hill-Hell Creek aquifer would have decreased by 65%. The number of agents withdrawing water from this aquifer would have increased from 5 to 27, and the amount of water use would have increased from 962 acre-feet to 14,358 acre-feet between 2007 and 2014. The largest water-level drawdown would have occurred in the western and southeastern regions, the outskirts of the core four-county area. The coupled agent-based SWAT and groundwater models are able to identify the HF water impact on regional water resources, and help understand the impact of the increasing hydraulic fracturing water use on regional sources under different conditions.

Does this project relate to research, outreach and engagement, or education and training? (enter one of these options in the space below)

research

Which of these USGS science priorities best aligns with this project: water observing; water availability; water prediction; water related emergencies and conflicts; or water-data infrastructure? (enter one of these options in the space below)

water prediction

Please list up to three keywords that are most relevant to this project (see keyword list provided in the instruction document):

water budget, water use, socioeconomics