**PROJECT TITLE:**

**Where and When? Improving the cost effectiveness of Minnesota’s water quality conservation programs.**

**I. PROJECT STATEMENT**

**Our overarching goal is to improve Minnesota’s water quality by determining how to best implement conservation practices across both space and time. We will accomplish this by combining landscape analysis with predictive seasonal weather forecasting.**

Soil erosion and loss of nutrients from farm fields represent significant threats to water quality and agricultural productivity. Agencies work to improve environmental quality through efforts to enroll farmers in conservation programs, with some efforts focused on establishment of long-term practices like buffer strips or grassed waterways. **Environmental benefits, however, may be achievable through more effective application of year-to-year management decisions made by the farmer.** For example, a cold and wet spring season could result in excessive losses of nitrogen fertilizer; resulting in financial loss to the farmer and degraded water quality. Reliable seasonal forecasting produces information that allows farmers to modify their fertilizer application and reduce runoff losses. Current approaches to conservation guidance do not account for changes in the effectiveness of conservation practices caused by inter-annual weather variability.

Policy makers, natural resource managers, and farmers must balance their decision making between long-term planning and short-term contingencies. While there are numerous climate model projections available to provide insight on how average climate conditions may be changing in Minnesota’s future, there is currently a gap in information available for resource managers and farmers to make decisions on the seasonal or sub-seasonal scale. Because of the limited conservation funds available to policy makers and conservation programs, **we will develop guidance to increase the cost-effectiveness of conservation programs in Minnesota.** This guidance goes beyond current targeting approaches because it will also rely on seasonal weather forecasts to produce recommendations that are tailored for the upcoming year. Potential examples are provided below:

**Seasonal Forecast**

Warm & Wet Spring

Cold & Wet Spring

Dry Spring

**Example of Proposed Management Guidance**

*Runoff is likely.*

 → Recommend cover crops to increase available soil moisture storage and delayed spring fertilizer application to minimize runoff losses

*Runoff is likely but cold weather will limit cover crops.*

 → Recommend reduced tillage and delayed spring fertilizer application.

*Excess water runoff is unlikely to be a problem in most areas.*

 → Recommend targeted conservation tillage in sensitive areas, and typical fertilizer application during planting.

By developing management guidance sensitive to the landscape (soils & topography) as well as upcoming seasonal weather conditions (temperature & precipitation), it will be possible to increase the efficiency by which conservation resources are applied to Minnesota’s agricultural landscape. We have preliminary results that show our ability to: *(1) evaluate how conservation practices can be spatially arranged to optimize environmental outcomes* and (2) *develop seasonal predictions of precipitation and temperature that will be key to determining the effectiveness of selected conservation practices.*

**II. PROJECT ACTIVITIES AND OUTCOMES**

**Activity 1: Develop and validate seasonal forecast models and generate plausible weather scenarios.**

*The primary objective of this activity is to improve the lead time for seasonal forecast models in order to maximize effective planning and decision making to help develop optimal conservation management guidelines*. We will develop a series of predictive models that rely on global climate variables to estimate Minnesota’s weather. Our preliminary models accurately predict Minnesota’s springtime weather based on winds, temperature, and pressure conditions over North America and the Pacific Ocean. Results show very good agreement between observed and predicted weather, with a current model lead time of 2 months.

While aggregate conditions are predicted with good skill in our preliminary models, the day-to-day variability of weather systems is predominantly what drives insecurity in environmental systems. We will account for this by developing a stochastic weather generator to generate plausible future weather scenarios that are conditioned on the seasonal forecasts. Candidate weather simulations will exhibit the characteristics of the seasonal forecast and be used to predict landscape response to varying management practices.

**ENTRF Budget:** $ 71,876

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| **Outcome** | **Completion Date** |
| 1. Identify two study watersheds in the Minnesota River Basin and perform exploratory data analysis | 12/31/2020 |
| 2. Develop and test seasonal forecasting models with optimal lead time | 06/30/2021 |
| 3. Develop and test stochastic weather generator at the seasonal scale | 03/31/2022 |

**Activity 2: Develop prescriptive guidelines to meet Minnesota’s water quality goals.**

Current approaches to applying conservation practices to agricultural landscapes do not commonly consider weather data. Even if only long-term average weather data were considered, environmental benchmarks will be missed roughly half of the time (and met or exceeded the other half of the time) because of the great variability in Minnesota’s weather. With the help of accurate seasonal forecasts, however, conservation efforts can be tailored to account for temporal variability of weather in addition to spatial variability of where to best place practices on the landscape. *We will quantify the benefits of conservation practices under different seasonal conditions by using a watershed-scale model combined with future weather scenarios (Activity 1).* Modeled outcomes of conservation practices will be analyzed with the goal of prescribing practices that are well-positioned to protect against predicted environmental challenges of the coming year.

**ENTRF Budget:** $ 205,700

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| **Outcome** | **Completion Date** |
| 1. Perform initial model calibration and validation of two study watersheds | 12/31/2020 |
| 2. Develop a method to link weather scenarios with the watershed model | 06/30/2021 |
| 3. Evaluate 10-12 conservation practices under varying weather scenarios | 12/31/2021 |
| 4. Develop guidance for conservation practice implementation  | 06/30/2022 |

**III. PROJECT PARTNERS AND COLLABORATORS:**

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| --- | --- | --- | --- |
| **Name** | **Title** | **Affiliation** | **Role** |
| Brent Dalzell, Ph.D. | Research Associate | Univ. Minnesota (WRC) | Principle Investigator |
| Lucia Levers, Ph.D.  | Research Associate | Univ. Minnesota (WRC) | Co-Investigator |
| Andrew Verdin, Ph.D. | Research Scientist | Univ. Minnesota (ISRDI) | Co-Investigator |

**IV. LONG-TERM IMPLEMENTATION AND FUNDING**

This project will provide critical insight into the inter-annual variability of the effectiveness of natural resources conservation policy. In addition to reporting to LCCMR, scientific advances in spatial and seasonal forecasting analyses will be submitted for publication in peer-reviewed scientific journals. This project will lay the groundwork for future efforts (to be funded by state and/or national agencies) in which we aim to include stakeholders to provide the most salient information possible when developing management guidelines.