**PROJECT TITLE: Optimizing Land Cover Data for Water Resource Analysis**

1. **PROJECT STATEMENT:**

Tracking the adoption of cover crops that protect nearby waterways from sediment, nitrogen and phosphorus pollution is critical for sustainable agriculture planning and management. Satellite remote sensing during clear days in the months of November and December can be used to track cover crop adoption based on the fact that cover crops are typically still green in color during that time. However, other crops also have a green color at that time, including alfalfa, hay or pasture. In the US, the Cropland Data Layer (CDL) is the only publicly accessible and nationally used dataset of crop type information. It is a geospatial land cover map that is updated every year by United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS). CDL parcels classified as alfalfa, hay, or pasture can in principle be subtracted (masked out) from late fall satellite images in order to identify locations where cover crops are planted. However, this approach has limitations, because while the CDL reasonably assesses the major crops of corn and soybeans, it does not accurately classify alfalfa, hay, or pasture. The CDL also is relatively inaccurate in classifying minor crops that appear green during the period from May to October, including small grains, canning crops, sugar beets, potatoes, wetland complexes, filter and buffer strips, and pollinator habitats. If we want to track the adoption of planting cover crops into these minor crops (after their harvest), it is imperative to have a CDL that accurately classifies minor crops. Due to errors in classifying minor crops with the CDL, it is imperative to develop an alternative land use classification method for minor crops. The focus of this project is to leverage new data and deep learning techniques to improve the accuracy and usability of the CDL for water resource analysis in Minnesota.

Multiple opportunities exist for improving the CDL. The current workflow USDA uses to develop the CDL is first collecting ground truth information through field surveys and censuses, and then combining these data with 30-meter (m) resolution Landsat satellite imagery to train a land cover classifier, and finally using that classifier to determine the land cover type of each 30x30m pixel at a regional scale. Two serious problems in this workflow include: (i) ground truth labels are biased towards corn and soybean; and (ii) the USDA classification algorithm approach dates back to more than a decade ago. In this project, we will employ new sampling approaches and the most sophisticated deep learning algorithms to improve the overall accuracy of predicting agricultural land cover for minor crops and land uses in Minnesota. By using near real-time satellite data, we anticipate publishing an improved CDL months earlier than the USDA CDL.

**II. PROJECT ACTIVITIES AND OUTCOMES (Duration is July 1, 2020 to June 30, 2023)**

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| **Activity 1 Title: Collect ground truth and remote sensing data for major and minor crops**  **Description:** The University of Minnesota (U of M) will collect ground truth data for major and minor crop classification during July and October of 2020 in collaboration with staff from two Soil and Water Conservation (SWCDS) districts across Minnesota regions differing in soil characteristics, slope, and rainfall patterns. At least 200 field locations in each of these counties will be visited to collect ground truth data, locations will include corn and soybeans, as well as a number of minor crops and land uses. Remote sensing data will be collected at a 10 m spatial resolution using both the Landsat-8 and Sentinel 2 satellites for the surveyed sites on as many dates as possible between May and November 2020. The results from this analysis will be summarized in a technical report.  **ENRTF BUDGET: $40,000** |

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| **Outcome** | **Completion Date** |
| 1. Summarize ground truth data for minor crops in two counties collected by SWCD staff | Jan 30, 2021 |
| 2. Compare USDA CDL classification with ground truth data to assess extent of errors in CDL | Mar 30, 2021 |
| 3. Summarize preliminary accuracy in predicting minor crops using remote sensing data | May 31, 2021 |

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| **Activity 2 Title: Expand geographic scope of ground truth and remote sensing data collection and refine tools for classifying remote sensing images into locations with minor crops**  **Description:** The University of Minnesota (U of M) will expand ground truth and remote sensing data collection during spring, summer and fall of 2021 in collaboration with staff from six SWCDs. Remote sensing data for these counties will be analyzed and calibrated against ground truth data using refined deep learning algorithms based on results of Activity 1.  **ENRTF BUDGET: $300,000** |

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| **Outcome** | **Completion Date** |
| 1. Summarize results of ground truth data collection for minor crops/land uses and compare these results with USDA CDL classifications | December 31, 2021 |
| 2. Develop new deep learning techniques for analyzing remote sensing data to better identify minor crops/land uses | July 30, 2022 |
| 3. Assess accuracy of deep learning techniques to classify minor crops/land uses in six Minnesota counties relative to ground truth data | December 31, 2022 |

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| **Activity 3 Title: Refine Classification Tools to Develop and Improve CDL Map for Minor Crops/Land uses**  **Description:**The fine-tuned classification algorithm that achieved the best performance in Activity 2 will be applied across the whole state to generate a state-wide map of crop types/land uses. Post-processing will be applied to remove pixel-level noise so as to make sure all pixels within a sub-field are classified as the same crop type. The project team will develop a technical report that summarizes project findings, state-wide statistics and recommendations. The refined crop type map, along with detailed documentation of map accuracy and recommended use, will be published as a geospatial data layer on MnGEO commons for public use and benefit.  **ENRTF BUDGET: $30,000** |

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| **Outcome** | **Completion Date** |
| 1. Develop map with improved accuracy at identifying locations with minor crops/land uses | March 31, 2023 |
| 2. Develop technical report summarizing project findings and recommendations | May 31, 2023 |
| 3. Publish geospatial data on the MnGEO commons | June 15, 2023 |

**III. PROJECT PARTNERS AND COLLABORATORS:** Collaborators include the University of Minnesota Departments of Soil Water and Climate, Bioproducts and Biosystems Engineering, and Computer Science and Engineering, and the Minnesota Office for Soil Health. Project partners advising on this project will include the Minnesota Department of Agriculture, Minnesota Pollution Control Agency, the Minnesota Geospatial Agency (MnGEO), and the Minnesota Association of Soil and Water Conservation Districts.

**IV. LONG-TERM IMPLEMENTATION AND FUNDING:** Data from this project will be shared on the MnGEO commons and the public will have access to readily use this data. This data will be updated on an annual basis. The outputs of this data will be used to inform the on-going Tillage and Erosion Survey Project sponsored by BWSR and the U of M Soil, Water, and Climate Department. Also, this foundational data layer will be utilized in water quality decision support models such as the Agricultural Conservation Planning Framework (ACPF) and Prioritize Target and Measure Application (PTMApp).

**V. SEE ADDITIONAL PROPOSAL COMPONENTS:**

**A. Proposal Budget Spreadsheet:** (included)

**B. Visual Component or Map:** (included)

**C. Parcel List Spreadsheet:** Does not apply

**D. Acquisition, Easements, and Restoration Requirements:** Does not apply

**E. Research Addendum**

**F. Project Manager Qualifications and Organization Description**

**G. Letter or Resolution:** Does not apply

**H. Financial Capacity:** Does not apply