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Project Title: Cloud-based small area estimation based on fast, on-demand processing of large-area data sets and mid- to high-resolution geospatial auxiliary remote sensing

Period for report: January 1, 2025 to June 30, 2025

Progress: The goal of this project is to support collaborative development and application of SAE methods by prototyping a cloud-based system that connects users to data, algorithms, and computing resources. System design objectives simultaneously address the needs of research scientists, data analysts, and data end-users. Several of these objectives distinguish this platform from other software systems developed under USFS support or relevant to FIA and PSAE interests in advancing SAE R&D (e.g., Figure 1). Notably, the UMaine cloud-based platform will provide capabilities that specifically support collaborative development of new methods, and testing against either public or private data.

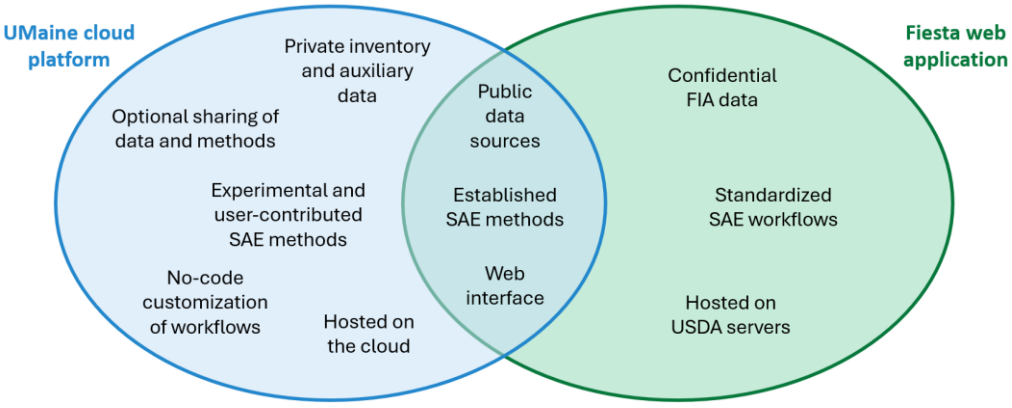

Figure 1: Major features and capabilities of the UMaine SAE cloud platform, as proposed, and the Fiesta web application. Both software systems will ultimately support the use of established SAE algorithms and publicly available datasets to obtain small area estimates via no-code web interfaces. The Fiesta web application will provide a set of standardized workflows that can be executed against FIA CUI on USDA servers. The UMaine cloud platform, in contrast, will support the development, testing, and application of experimental and user-contributed SAE methods and workflows. Additional capabilities provided by the UMaine platform will include no-code customization of SAE workflows, hosting for private inventory and auxiliary data, and opt-in sharing of private data and software resources between verified users. Additional development could include provision of standardized or verified workflows matching those provided by the Fiesta web app, ensuring consistent access to workflows considered important or primary to SAE researchers and practitioners.

Progress during this reporting period has largely focused on 1) the development of an online graphical user interface, and 2) the development of procedures and utility software to support user development of SAE code for execution on the cloud platform. Additional progress has included continued refinement of our modular block and pipeline architecture for SAE workflows, continued development of containerized runtime environments for secure execution of SAE workflows, and continued work on backend implementations of data and job management software subsystems.

Our prototype online user interface now supports graphical editing of SAE workflows, providing functionality similar to that of a flowchart editor (Figure 2). Available data and code blocks are selected by dropdown menus and interconnected to form a processing pipeline. Connections are made between blocks by clicking a source block and dragging a connector to a destination block. Code blocks can be edited to specify input parameters. All file management is automatically performed by the system, meaning the output from one block is automatically sourced to downstream blocks as needed. All pipeline elements can be arranged onscreen as desired, and pipelines can be saved and restored as YAML text files. Future development will provide for the selection of pre-built or saved pipelines.

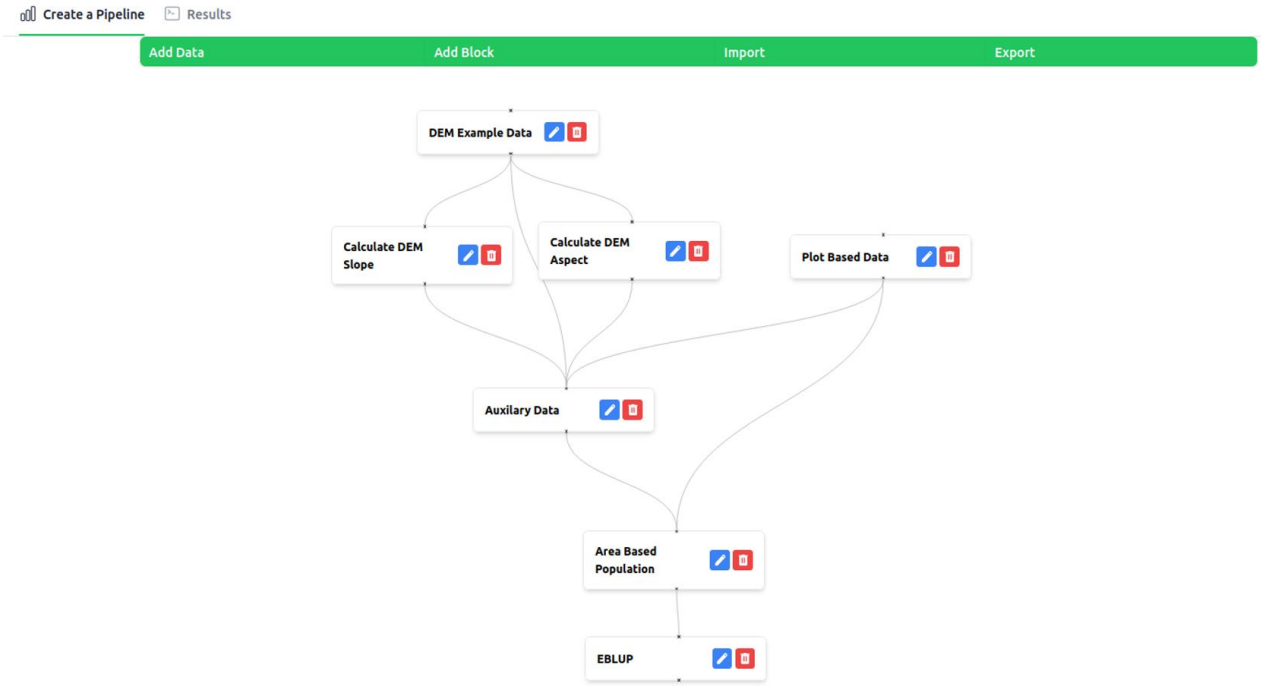

Figure 2: A functional SAE workflow built within a prototype online user interface to the UMaine SAE cloud platform. Data and code blocks are selected via a menu system and then arranged and interconnected as desired.

In addition to pre-built pipelines and code blocks, the UMaine cloud platform will provide support for the integration of user-contributed code blocks written in either R or Python. Progress during this reporting period has included extensive development of utility software to simplify the construction of compatible R and Python blocks. Recent development has also included system software needed to register blocks with the user interface and to load resources into secure runtime environments.

Next period plans: Development during the next reporting period will focus on cloud hosting and integration. This will include integration of a multi-tenant data management subsystem to enable opt-in sharing of data and software resources between verified users. We will also establish connections to external services that host key auxiliary data sources. Our goal for the end of the next period is to deploy a functional prototype for closed testing with PSAE collaborators.