Mississippi CRP Forest Remote Sensing with Preliminary Global Ecosystem and Dynamics (GEDI) Mission Derived Data Products

Executive Summary

The United States Department of Agriculture's Conservation Reserve Program (CRP) is a federally funded conservation program, whose long-term goal is to re-establish valuable land cover to improve water quality, prevent soil erosion, improve carbon sequestration, and reduce loss of wildlife habitat. This Farm Service Agency-administered program works with farmers and landowners to implement conservation management practices on enrolled lands, with paid contracts ranging from 10 to 15 years in length.

The USDA's CRP has successfully improved the conservation value of private lands; however, the program currently lacks spatially explicit information on land cover and vegetation within CRP-enrolled tracts. Currently, there are over 46,000 CRP contracts in the state of Mississippi alone, making on-the-ground data collection difficult due to the time, resources, and expertise necessary to conduct field vegetation surveys over such extensive holdings. In partnership with the USDA FSA program, the Conservation Biology Institute (CBI) piloted a predictive modeling approach for forested lands in Mississippi participating in the CRP, employing the nuanced relationships between satellite imagery indices, enviro-climatic data, and existing georeferenced vegetation survey data (from USDA's Forest Inventory Assessment) to assess the potential for remote sensing technology to enhance CRP program outcomes.

In this pilot project, CBI initially developed predictive maps of tree height, tree density, biomass, basal area, and forest type using Random Forest machine learning models. Numerous satellite-derived indices from the European Space Agency's (ESA) Sentinel-1 and Sentinel-2 sensors, in addition to soils and topography data, were used as predictor inputs. We then refined these predictive models, focusing primarily on biomass improvements, by implementing new methods for processing Sentinel-1 imagery on the cloud computing platform Google Earth Engine (GEE); significantly updating model code; and incorporating preliminary data products derived from NASA's spaceborne LiDAR mission - the Global Ecosystem Dynamics Investigation (GEDI). We refined the GEDI LiDAR-derived

Credits

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data products and included them in our models, and overall accuracy for the four forest regression models ranged from 57% to 91%. The Biomass model saw the greatest improvement in accuracy with the R2 increasing by 8%, from 49% to 57%. The Basal Area and Tree Height models both had minor 1-2% increases in accuracy, while the Tree Density model had no improvement. The Forest Type classification model had a negligible improvement in overall accuracy, however, the Elm/Ash/Cottonwood class increased in accuracy by ~6%, from 64% to 70%.

The preliminary versions of mapped forest characteristics (without GEDI-enhancements) have been integrated into an easy-to-use online decision support tool, also developed by CBI, that provides USDA's staff and private landowners an opportunity to explore maps and metrics for land enrolled in the CRP. The tool provides access to pertinent spatial information for CRP tracts, as well as the ability to summarize statistics, compare metrics, and download reports for tracts across counties and watersheds.

The new GEDI data products, which are in their early stages of development, combine global GEDI LiDAR measurements with Landsat satellite imagery to provide wall-to-wall estimates of global canopy height. Currently there are large gaps in spatial coverage, but these will get filled as more GEDI-based imagery is processed and updated. Incorporating these products as they become available into our models will increase accuracy in predicted forest metrics.

There are several pathways for future improvement and refinement of forest modeling techniques. Alternative approaches to machine learning, such as gradient boosting algorithms, may offer increased performance over the currently employed Random Forest method, given the large quantity of FIA training data available and the complex nature of forest remote sensing. Migrating additional workflows to GEE presents an opportunity to overcome current data processing limitations by leveraging distributed, cloud computing power, thus offering potential to improve data resolution and gain more information from input variables. Google Earth Engine also offers a rich, multi-petabyte catalog of satellite imagery, which would readily allow us to test additional value added by different sensors and higher resolution imagery. Lastly, criteria for filtering and selecting FIA plots could be revisited to increase the quantity of training data, which may improve model performance.

Our mapped predictions of forest metrics provide a baseline for characterizing forests within CRP tracts in Mississippi and lay a foundation for quantitatively measuring the success of conservation practices over time. Bringing this and other key data together in the multi-faceted online CRP tool allows relevant information to be analyzed, shared, and downloaded by USDA leadership and CRP managers. Future expansion of analytical and online tool functionality will provide additional information to help guide strategic management actions on existing CRP holdings and to prioritize new enrollment in the CRP. The Conservation Biology Institute's suite of powerful products rolled into an accessible online tool allows CRP to leverage these components to implement cost-effective and scientifically sound decision-making.

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