Project Summary

Including Campus Forest Carbon Estimates Into Climate Mitigation Planning

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Current Monitoring and Planning of Forest Carbon for Universities

Across universities, greenhouse gas (GHG) targets are set based on historical and current fossil fuel emissions. Targets vary and are dependent on the university's climate action goals and ambition for reduction. For example, the University of Maryland's (UMD) 40-year Climate Action Plan (CAP) sets targets to reach carbon neutrality by 2050. Their most recent targets aim to reduce carbon emissions by 60% from 2005 levels by 2025. Targets across universities are outlined within each university CAP. Similar to GHG reduction targets, CAPs differ based on the university's specific goals and in their inclusion of land use. Including land use into plans is advantageous for universities to reach climate reduction goals more quickly. However, the inclusion of land use, and of forest carbon in particular, into climate action plans and GHG inventories is variable among universities. In fact, most universities do not include land-use, and thus do not account for carbon sequestered or emitted from land-use change. University GHG inventories primarily track ongoing emissions associated with campus operations. While some effort has been made to recognize the potential of forests, universities lack the resources and science necessary to fully include land use into their calculations (Figure 1). Universities such as Duke and UMD voluntarily report annual net forest carbon sequestration estimates within their own inventory. However, they are currently unable to formally include forest sinks against their carbon emissions reduction goals relative to their Second Nature Carbon Commitment.

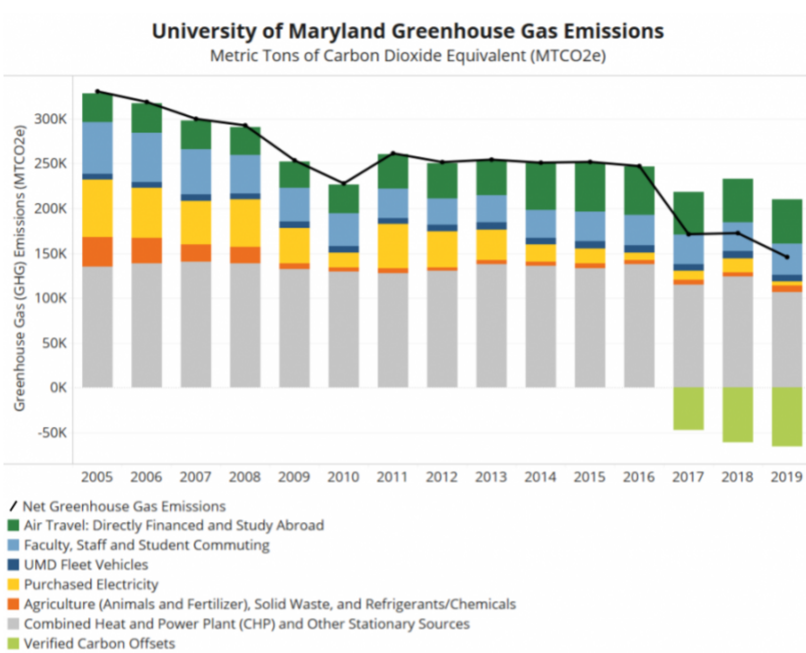


Figure 1: University of Maryland's current GHG inventory and percentage of emission sources by category. Forest carbon is excluded from this inventory.

Most universities with CAPs are Second Nature signatories. Second Nature assists higher education institutions in meeting their climate action goals through their signature program, the Climate Leadership Network (CLN). University presidents and chancellors that have formally committed to one of three Presidents' Climate Leadership commitments become a part of the CLN of signatories. This network enables sustainability professionals from these schools to collaborate and include the most innovative climate reduction strategies into their CAP. UMD and Duke university are examples of signatory universities. Through this network, university signatories are provided the resources and tools needed to implement their climate action goals. One of these resources is the Sustainability Indicator Management and Analysis Platform (SIMAP). The platform primarily uses the Campus Carbon Calculator, a tool to track institutional greenhouse gas emissions and allow universities to measure, calculate, and report their campus' carbon footprint. Although it did at one time, SIMAP no longer requires forest carbon sequestration or emissions in its calculations. Instead it offers campuses an opportunity to voluntarily record and track annual forest carbon gains, pending that campus has its own science resources. Second Nature is hesitant to include forest carbon into planning because it may impede GHG reduction targets in other sectors. This means that current monitoring and planning of forest carbon for universities is limited and ultimately, excluded from holistic GHG accounting (Figure 2). This also suggests an opportunity to include land use and forest carbon into SIMAP and enable institutions to advance their climate action goals with improved forest carbon science.

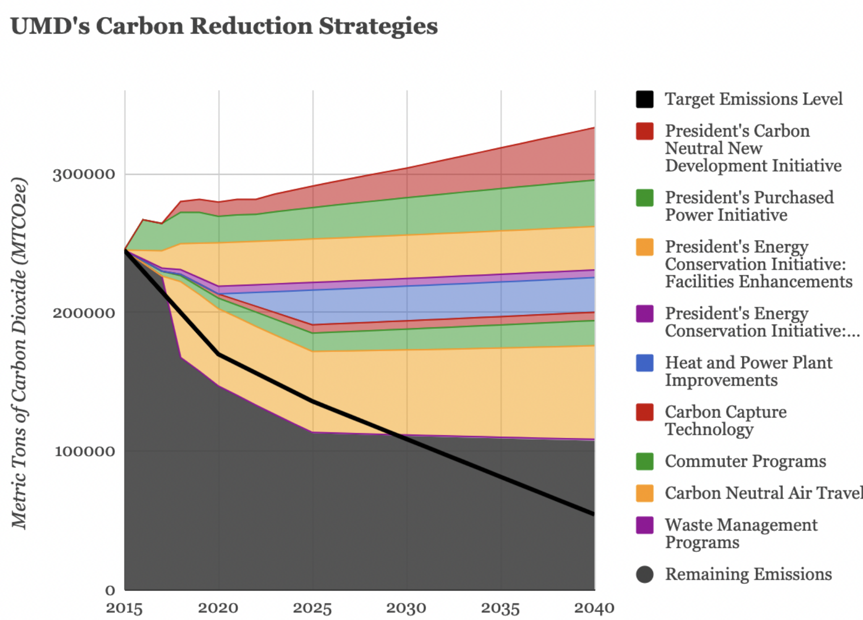


Figure 2: University of Maryland's current carbon reduction strategies to achieve carbon neutrality by 2050. Forest carbon is not accounted for in their reduction strategies.

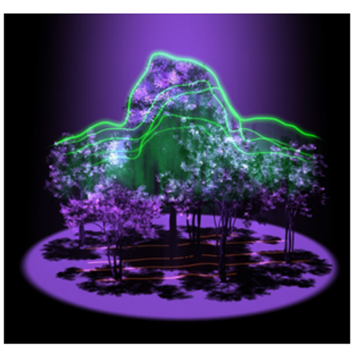
Challenges and Opportunities of Forest Carbon Inclusion

It is apparent that including forest carbon within the SIMAP tool would be beneficial to signatory universities, but certain challenges are inhibiting this step. Forest carbon was included in SIMAP calculations in 2018 as "offsets with additionality", but has since been changed to “non-additional sequestration”, meaning that the carbon sink from forest carbon sequestration no longer counts towards the university’s greenhouse gas reduction goals. The exact reasoning behind this shift in language is unknown, though certain challenges connected to measuring this carbon could point to why it has been removed.

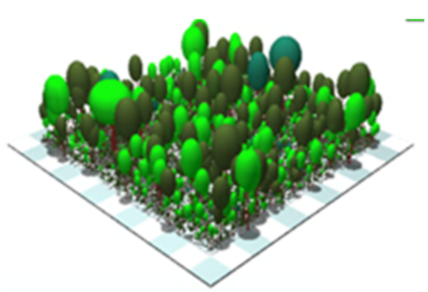
Currently it is difficult to measure all land use sources of carbon, including all forest carbon pools. Traditionally, forest carbon measurements are collected through field data sampling, which results in high energy and labor costs as well as irregularly updated datasets. Today we are able to use remotely sensed data to estimate above ground biomass and the annual carbon sequestration of forests. However, data collection can also be expensive and irregular, with tree canopy height data from LiDAR often reported in 5-10 year intervals. Additionally, measuring below ground biomass and soil carbon still presents additional challenges for remote sensing data calibration and validation. An innovative approach to forest carbon monitoring and planning using a combination of remote sensing and ecosystem modeling could provide universities with the opportunity to seriously consider land stewardship in the context of their climate commitments.

Information Needed for Forest Carbon Inclusion

To include forest carbon within university plans and inventories, the data and analysis need to meet three core needs: establish carbon baselines, assist annual monitoring, and support future planning (Figure 3). First, the data should be able to establish a baseline for contemporary forest carbon estimates over all university-owned and managed lands. In addition to having a contemporary baseline, it may also be helpful to have a baseline estimate at the time of the policy start year. Second, the data should be updated to monitor changes in forest carbon over time, including the forest carbon flux. The forest carbon flux is a result of the forest carbon gains minus the forest carbon losses, and indicates if the total land area is an annual source or a sink of emissions. The total forest carbon flux (total ecosystem flux) is a sum of the individual flux components that are being reported (e.g., above ground biomass, below ground biomass, soil carbon). Finally, the data used should be able to project future carbon sequestration potentials to inform planning. This would provide information on how much carbon can be sequestered and by when. Ideally, this carbon sequestration potential can provide an estimate of how much more carbon can be sequestered by both existing forests and from reforestation. This can be useful for universities to track their progress towards their goal of reaching carbon neutrality by a certain year.



***Mapping** to Establish Baseline*



***Modeling** to Facilitate Planning*

***Monitoring** to Provide Assessment*

Figure 3: The three objectives to include forest carbon within a university's carbon budget.

To meet the three objectives of mapping for baseline, modeling for planning, and monitoring for assessment, the data used should have several key attributes. First, the data should ideally be of high resolution with wall-to-wall coverage to capture trees even if they are outside of forests. Using high resolution, wall-to-wall data, as opposed to sample based data, provides more complete coverage when mapping to establish a baseline and becomes useful when modeling for planning purposes. Second, the data source used should have the ability to adjust to the policy base year when mapping to establish a baseline. Third, to achieve the monitoring objective, the data should be updated every year so that the process can be annualized along with the other sections of the GHG inventory. Fourth, the sources of data should be the same across uses to maintain consistency among estimates. This means the same data source should be used for all three objectives. Fifth, the final results reported in the inventory should be in units of CO2e to allow for easy comparison to other reported sections of the inventory. Finally, the forest carbon data reported should be for all property owned and managed by the university. This ensures that the estimates included as part of the monitoring and planning objectives and in the inventory are reflective of the geographic scope for which the university has control and responsibility.

NASA CMS Science & Approach

The NASA Carbon Monitoring System (CMS) provides carbon stock and flux estimates to characterize the state of and potential changes to carbon to improve overall monitoring of the global carbon cycle (Hurtt et al. 2014). NASA satellite observations and remote sensing technology are used to develop carbon Monitoring Reporting and Verification systems (MRV), quantifying and predicting global carbon sources and sinks. NASA CMS products use mapped 3D vegetation structures and aboveground biomass (AGB) from airborne LiDAR as reference data to monitor forest carbon stocks (Figure 4). At high spatial resolutions, carbon monitoring can range from MD counties to the entire regional greenhouse gas initiative (RGGI) region (Huang et al. 2015; Huang et al. 2019; Tang et al. 2021). Further, the potential for a high-resolution forest carbon baseline map at a national scale can improve forest carbon accounting nationally. High-resolution baseline mapping of forest aboveground biomass across the RGGI region and beyond provides critical science necessary for carbon monitoring and climate change mitigation policy regarding forests. Specifically, forest aboveground biomass and carbon sequestration potential estimates for Maryland are used to update afforestation and reforestation estimates in MD state policy, such as the Maryland's Greenhouse Gas Reduction Act (GGRA) (Hurtt et al. 2019).

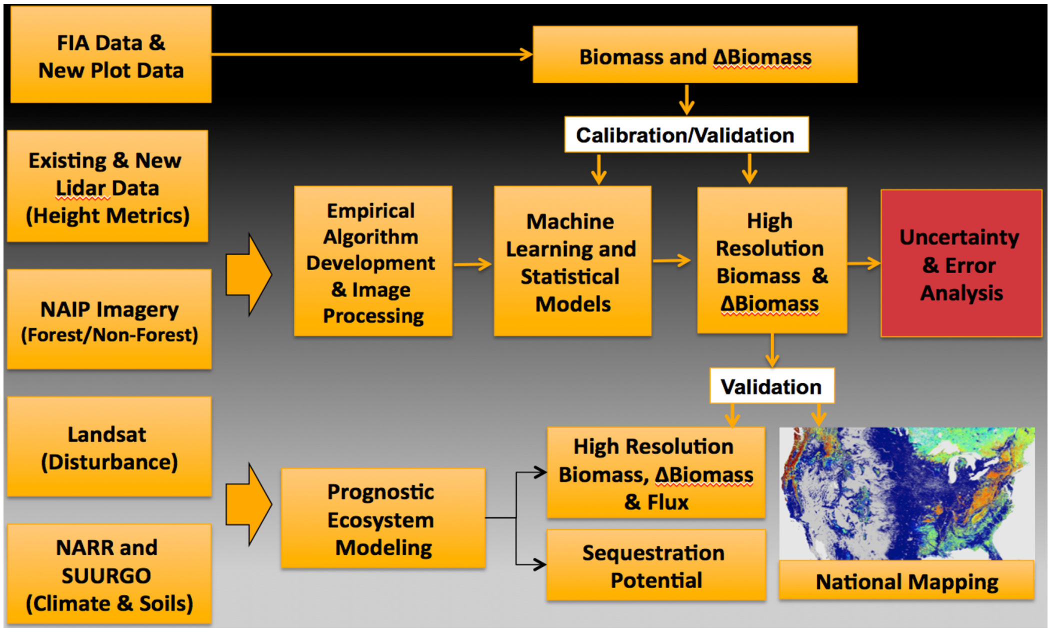


Figure 4: NASA CMS science flowchart including inputs and outputs

NASA CMS science has several characteristics that make it ideal for university forest carbon planning and accounting. Recently developed CMS science is geospatially explicit, annually updated, high resolution (90-meter), heavily calibrated and validated, and is already used by several state entities within their own climate mitigation planning (Hurtt et al. 2019, Ma et al. 2021). In more detail, geospatially explicit data allows for wall-to-wall carbon estimates across the entire desired domain. Additionally, annually updated monitoring data allows us to track changes from year-to-year. Thousands of U.S. Forest Service's Forest Inventory Analysis field plot data has been used to validate carbon monitoring estimates across broad spatial domains. Finally, because this science and data is already being used by other state entities, monitoring approaches and results will be consistent across scales.

UMD Campus Forest Carbon Project

The UMD Campus Forest Carbon Project proposal details four main goals to accomplish in a three-year timeframe from 2020-2022. These goals include:

1. Complete historical analysis of annual forest carbon change from 2011-2018
2. Update annual forest carbon wedge of campus budget for future years as optical imagery becomes available (2019-2021)
3. Quantify and make transparent the carbon impact of planned campus development activity
4. Showcase UMD leadership and work to replicate analysis across members of the Climate Commitment

At the University of Maryland (UMD), NASA CMS science and data has been primarily used for the annual forest monitoring approach (goals 1 & 2). This approach aims to track forest carbon changes that have occurred over a specified domain and time range. In doing so, universities, state entities, and other users can understand the contribution and/or debit forests make for their carbon reduction goals. In short, this approach would involve the following big picture steps: 1) obtain annual forest area change data from Global Forest Watch (Hansen et al. 2013), 2) estimate annual carbon stocks, gains, losses, and fluxes for the specified years using outputs from the lidar-initialized Ecosystem Demography model, and 3) incorporate results into campus reporting, GHG budget, and climate action plan. See Figure 5 below for sample results from using this annual forest monitoring approach for the UMD campus.

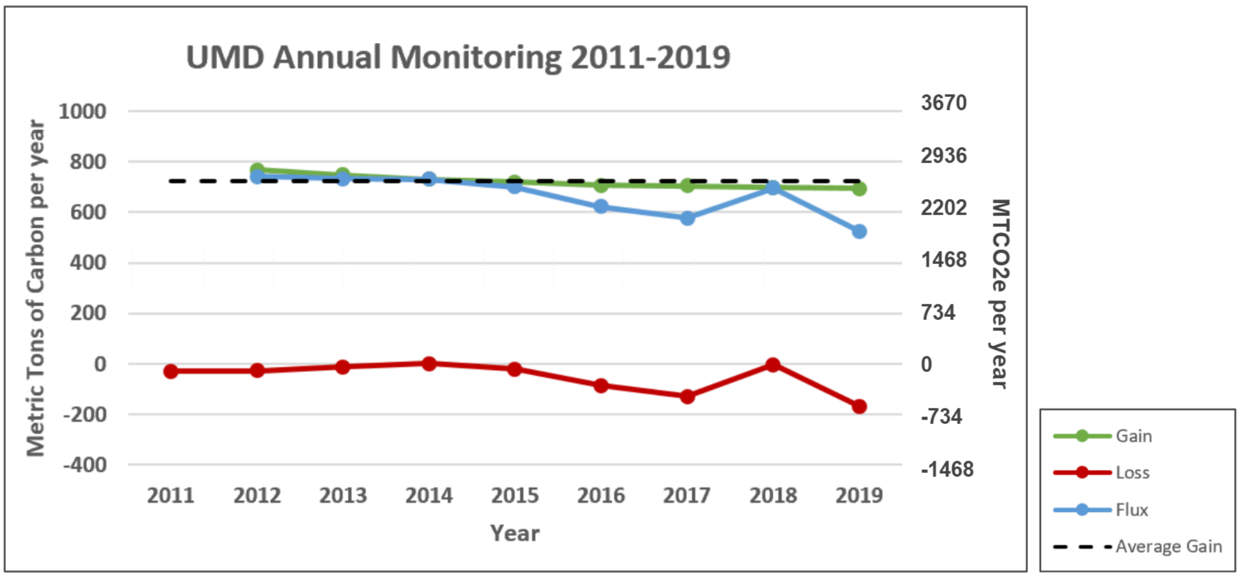


Figure 5: Forest carbon gain, loss, flux, and average gain over UMD owned/managed properties from 2011-2019. It is important for campus to track loss of forests in addition to forest carbon gain to understand the impact of construction and land use change.

In addition to annual forest monitoring, the same underlying science can be used to estimate future forest carbon under a reforestation planning approach (goal 3). This approach aims to estimate projected forest carbon sequestration on specific areas where reforestation occurs (Figure 6). The first step of this approach is to identify areas that could be reforested based on specific criteria. Reforested area criteria includes, but is not limited to, percentage of impervious surface, land use, and other co-benefits of forests, such as stormwater management. Subsequent steps include: 2) estimating projected forest carbon growth on the selected reforested areas, 3) estimating projected forest carbon growth on all other existing forests within the domain, and 4) incorporating results into campus planning reports and planning. Next steps include visualizing these reforestation planning approaches within already existing graphs and figures produced by UMD's Sustainability Office for the Campus Climate Action Plan. Examples can be found here: https://sustainability.umd.edu/progress/climate-action-plan

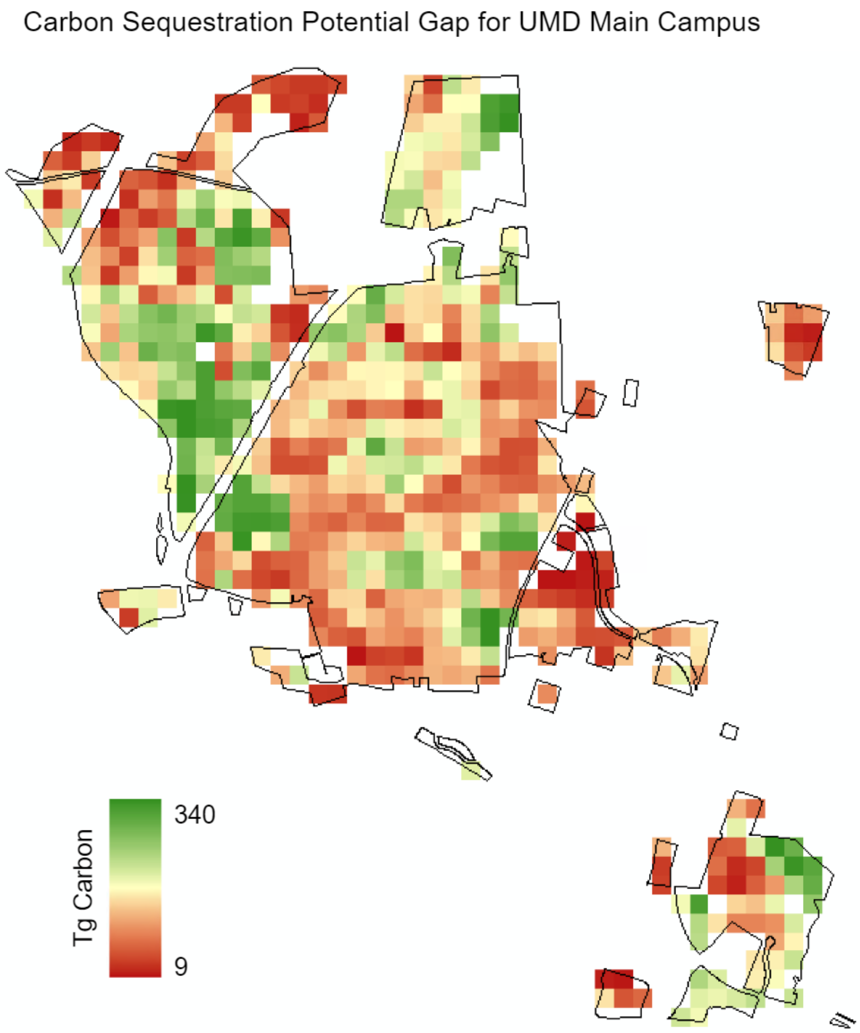


Figure 6: The carbon sequestration potential gap visualizes the maximum amount of remaining carbon that could be sequestered by forests from the 2011 values. This is an important metric for selecting priority areas for reforestation.

Expanding to Other Universities (Goal 4)

To widen the scope of this science and project, future goals include expanding to other universities so that this science is a model for other campus greenhouse gas initiatives. Stakeholders crucial to this step include the University of New Hampshire, who works closely with the SIMAP carbon calculator tool, and the Second Nature Working Group, who connects climate-committed universities in the Northeastern US. First, the methodology would be most effective in the RGGI states because they currently have the necessary data to thoroughly apply this planning and accounting method (Figure 7). These universities first need to process the data to create a baseline including the average forest biomass for the state they are in as well as the area of forest that the particular campus has. They would then calculate losses through either remote sensing methods or a supplemental method, such as working with Campus Arboretum datasets. A potential peer-to-peer training program could be beneficial to ensure the proper method of tracking forest carbon changes. Hopefully with continued communication with these universities a multi-tiered platform could be created.

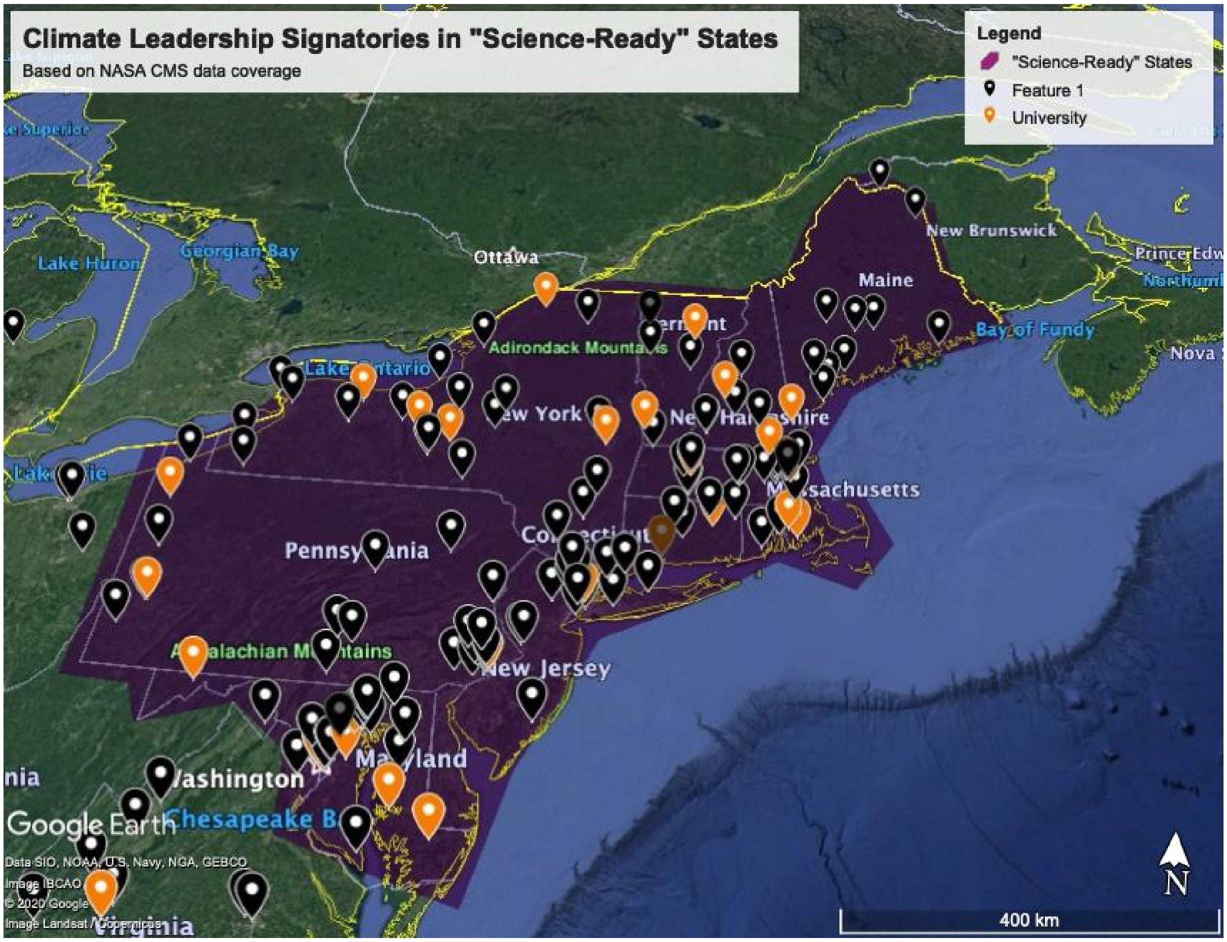


Figure 7: The purple highlighted states are all included in the RGGI and are signatories to the President's Climate Commitment. These states are "science-ready", meaning that they have the necessary datasets for this methodology.

Conclusion

Across university signatories to the Second Nature climate commitments, forest carbon estimates are not generally included in campus climate planning and GHG reporting. Further the SIMAP tool for tracking forest carbon estimates does not allow for forest carbon to count towards GHG reductions, leaving a gap for forest carbon inclusion in universities' climate action goals. Historically, it has been difficult to collect forest carbon data because field sampling in urban areas as well as wall-to-wall high resolution LiDAR data were not readily available or cost-effective. Now, new NASA CMS technology and science can be used to meet core needs for forest carbon baseline mapping, planning, and annual monitoring. NASA CMS data has unique characteristics that make it an accurate and accessible choice for campuses interested in holistic forest carbon accounting. The science and approach has already been put to use for the state of Maryland and the University of Maryland campus. NASA CMS science will be expanded under future grants to cover a larger domain, thus this approach can soon be adapted to other university signatories.

Ongoing project updates can be found here:
https://geog.umd.edu/project/campus-forest-carbon-project

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