

**TO:** The Vermont Climate Council  
**FROM:** The Agriculture & Ecosystem Subcommittee of the Vermont Climate Council  
**DATE:** October 25, 2021  
**SUBJECT:** Carbon Budget Report Review and Recommendations

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The Agriculture & Ecosystems Subcommittee has thoroughly reviewed the paper titled, ‘A Carbon Budget for Vermont: Task 2 in Support of the Development of Vermont’s Climate Action Plan’ (Carbon Budget Report, Report, or Carbon Inventory)<sup>1</sup> submitted by technical consultant ‘the Cadmus Group’ as authored by Dr. Gillian Galford et al.

The Vermont Carbon Budget Report was developed to inform the Vermont Climate Council, its subcommittees, and related task groups on the current balance of greenhouse gas (GHG) emissions and carbon stocks related to agriculture, forestry, and other land uses (AFOLU) in Vermont. This report is a strong foundation for improved understanding of Vermont’s carbon sources and sinks and will help inform more accurate tracking and accounting going forward.

The Report represents the first attempt by Vermont to provide a high-level, comprehensive picture of Vermont’s carbon stocks and fluxes for the AFOLU sector. A carbon stock is how much carbon has been stored both above (plants) and below the ground (soils) and positive fluxes are Vermont’s contributions to atmospheric GHG concentrations while negative fluxes represent a removal of atmospheric GHG concentrations. This Carbon Inventory uses a methodology distinct from the Vermont Greenhouse Gas Emission Inventory conducted by DEC on an annual basis. The DEC GHG Emission Inventory Report estimates emissions from sources exclusive of the Land Use, Land Use, Change and Forestry (LULUCF) sector and agricultural stocks and fluxes from cropland and manure management.

The Carbon Inventory is an important tool to illustrate the importance of Vermont’s natural and working lands (NWLs) for Vermont’s ‘net zero’ GHG emission goals, and it can also help put the sources of GHG emissions and carbon sinks in context as far as scale of impact and extent of coverage in Vermont. The Carbon Budget Report can help the Vermont Climate Council better understand the goal of “Net Zero by 2050” as referenced in the GWSA by providing a cursory framework for accounting and by elevating questions for further research and analysis, including: what land use sectors and standards should be included in the net calculation? Is the current land use list sufficiently comprehensive? What actions count towards a ‘net zero’ calculation? How - and are - we accurately measuring all sectors emissions and sinks? How should changes be tracked over time? What are the current available data sources and what are their respective limitations? Where should the Vermont Climate Council focus on improving estimates of sinks and fluxes? The Carbon Budget Report goes into detail outlining Vermont’s current Carbon Inventory, limitations on the current analysis, and future research needs.

The Carbon Budget Report considers anthropogenic land use – meaning, there is a human component influencing the management of each acre of land represented in the AFOLU sector. The Agricultural and Ecosystems Subcommittee wants to elevate this important consideration regarding the Vermont landowner themselves as a critical consideration for any net zero GHG policies as over 80% of Vermont land is privately held. The report further highlights that landowners may manage multiple natural and working land uses at one time on the same parcel of land (e.g. cropland, forests, and wetlands on the same property). The Report elevates the consideration that a more holistic approach considering a landowner’s full portfolio of land management – while challenging in terms of accounting – is important to consider for net zero carbon goals. This holistic accounting for inventorying carbon stocks and fluxes comports with the Agriculture and Ecosystems subcommittee analysis and development of pathways, strategies, and actions to support and land managers and landowners to manage their natural and working lands in ways that best capacitates adoption of natural climate solutions and other equitable and cost-effective strategies to help meet Vermont’s climate change mitigation, adaptation and resilience goals.

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<sup>1</sup> Whereas a “Carbon Budget” as defined in the IPCC AR5 Report means the projected development over time of the emission of a GHG, aerosols, and GHG precursors at a sub-national, national or international level that meets cumulative emission targets to avoid a certain level of global mean surface temperature rise, the term “Carbon Budget” as used in this report can be used interchangeably with the term “Carbon Inventory” and is intended to mean: “the current balance of greenhouse gas emissions and carbon stocks related to agriculture, forestry, and other land uses (AFOLU) in Vermont. AFOLU is defined on page 1251 of the IPCC AR5 Report.

The Agriculture & Ecosystems Subcommittee would like to acknowledge the significant and novel body of work the contracted technical consultants performed on an expedited timeline and concludes that the contractor has delivered a report which provides a replicable methodology for Vermont's terrestrial and aquatic carbon stock and flux computations which satisfies the Vermont Climate Council's technical request and generally follows national and international standards outlined in the scope of work.

One final important note from the Report is as follows:

*Vermont is unique among states in leading this type of work. There will be opportunities in the future for Vermont to help other states think through and benefit from Vermont's experience developing a carbon budget related to AFOLU. Moving forward, it is recommended that Vermont incorporate some of the approaches used in the Vermont Carbon Budget to augment existing methods and datasets in its GHG Inventory. For example, the EX-ACT model may provide more accurate flux estimates for many land-based sectors than the current GHG Inventory methods because EX-ACT accounts for additional impacts of management actions.*

The Carbon Budget Report is a good first step to support the Vermont Climate Council in accurately quantifying and tracking GHG emissions and sinks from Vermont's natural and working lands to meet GWSA requirements and goals. That landowner and land manager actions and management can influence the rate of emission or sequestration in a given year from the same acre of land is a foundational concept highlighted by this report: emissions or sequestration from the AFOLU sector is not a static emission factor, management matters. The Ex-Ante Carbon Balance Tool (EX-ACT) utilized by the Report, identifies management conditions that result in a range of emissions or sequestration by land use by acre per year – the tool outlines that each land use has the potential for net sequestration, depending on management.

### Findings

The Carbon Budget Report compiled existing datasets that would enable the analysis of gross flux of MMT CO<sub>2</sub>-e yr<sup>-1</sup> between 1990 and 2020 for the AFOLU sector as well as carbon stock available in 2020. The report estimates that the annual net GHG balance for AFOLU is -2.95 MMT CO<sub>2</sub>-e yr<sup>-1</sup> in 2020. The largest AFOLU source of GHG emissions is agriculture (0.49 MMT CO<sub>2</sub>-e yr<sup>-1</sup> in 2020), followed by grasslands and shrublands (0.05 MMT CO<sub>2</sub>-e yr<sup>-1</sup> in 2020). Three AFOLU sectors account for net sequestration, or uptake from the atmosphere, as noted with a negative sign: forests (-3.2 MMT CO<sub>2</sub>-e yr<sup>-1</sup> for net forest sector in 2018), urban and developed [urban trees] (-0.28 MMT CO<sub>2</sub>-e yr<sup>-1</sup> in 2020) and wetlands and water bodies (-0.01 MMT CO<sub>2</sub>-e yr<sup>-1</sup> in 2020).

### Recommendation 1:

The Agriculture & Ecosystems Subcommittee recommends developing and issuing a Request for Proposals (RFP) that will review and analyze methodological gaps of emission inventory tools currently used by the State of Vermont to quantify greenhouse gas emissions for evaluating changes in the Agriculture, Forestry and Other Land Use (AFOLU) sector and the tools' alignment with the Intergovernmental Panel on Climate Change (IPCC), Environmental Protection Agency (EPA), and peer state methodologies and approaches.

As the AFOLU GHG Emissions RFP described above has already been approved by the Vermont Climate Council on 10/12/2021, the Agriculture and Ecosystems Subcommittee would like to note five specific areas of research and analysis that would best help advance research into this important topic of AFOLU emissions and carbon inventory which the subcommittee feels should be included in the scope of the RFP:

- I. Research and recommendation of GHG quantification models that could be adapted and calibrated for Vermont, including a comparison of the three quantification tools already informing the Global Warming Solutions Act (EPA State Inventory Tool [SIT], Low Emissions Analysis Platform [LEAP] and Ex-Ante Carbon Balance Tool [Ex-ACT]), plus at least the DeNitrification-DeComposition (DNDC) and DAYCENT models which are used by other states [e.g. California]; DNDC has been identified in the Carbon Budget Report for the VCC as an important tool to consider;
- II. Background research describing both the IPCC rationale for using net GHG emissions quantification in AFOLU sectors, and peer state's deliberations on accounting GHG in AFOLU as net or gross;

- III. Describe the additional staff or technical support needed to include more accurate and nuanced accounting of GHG from AFOLU;
- IV. Research into data sets that can better track and report land use change in Vermont;
- V. A review of cost and feasibility to support remote sensing technologies for land use identification in Vermont.

Recommendation 2:

Carbon inventory, forecasting, and updates: The Agriculture and Ecosystems subcommittee recommends establishing a periodic and consistent carbon inventory and forecast for Vermont. To develop and update the Vermont Carbon Inventory on an annual basis, the Vermont Climate Council, in coordination with the Secretaries of Administration, of Natural Resources, of Transportation, of Agriculture, Food and Markets, and of Commerce and Community Development, and the Commissioner of Public, should aggregate all existing statewide data on greenhouse gas emissions currently reported to State or federal entities, existing statewide data on greenhouse gas sinks, and otherwise publicly available data.

- I. The next Carbon Inventory should review of the following data and methodological recommendations:
  - a. Incorporating estimates of error for all sectors assessed in the Carbon Inventory.
  - b. Investigate any stocks or fluxes not included in version 1.0. For example, the Urban and Developed sector only includes trees, and not grasses, turf, shrubs and other plants.
    - i. Consider renaming “Urban and Developed” source to “Urban Trees” or expand methodology to include soils and fluxes in a subsequent report.
  - c. Consider movement of carbon from land to water bodies (sedimentation), as this is not included in the Carbon Budget Report
  - d. Land use change from lands other than forests are not included (e.g., wetlands to development) in the report. Consider IPCC categories of landuse transition and attribution of sink or emission.
  - e. Isolated trees or small groups of trees that do not constitute a forest are included if in urban areas, but not if in an agricultural setting. Consider accounting for trees (not forest) on agricultural operations and land, e.g. forest buffers not captured as a Forest source per methodology outlined on page 15 of the Carbon Budget Report.
  - f. Address issues of possible double counting, for example: land use conversion is counted as an immediate source of emissions to the atmosphere, but in forest clearing, there are often harvested wood products that are extracted that end up in products that store carbon for some length of time.
  - g. Consider the separation of agricultural land uses in the current Report and integrate pasture (managed grassland) as an Agriculture source; or split into formal IPCC AFOLU sources, i.e. cropland, grassland, livestock, etc.
  - h. Report gross emissions and gross sequestration in addition to net flux for all sources
  - i. Report rate per sources based on flux of emissions per area of source
  - j. Review management assumptions used for agriculture per source, i.e. crop residue retained, C input, manure, pasture degradation, etc. and update as data sets are reviewed and updated
- II. Future updates to a second Carbon Inventory should consider the following gaps identified by the Agriculture and Ecosystems subcommittee in the Carbon Budget Report 1.0:
  - a. Clarify that the stock of Vermont carbon for 2020 is 2035 MMT CO<sub>2</sub>-e not 1,978 MMT CO<sub>2</sub>-e as published in the Carbon Budget Report in ‘Table ES’ (pg. 7).
  - b. Note that the ‘Fossil Fuel’ row as identified in Table ES includes agricultural emissions included in the Vermont GHG Emission Inventory which are in-fact biogenic and which are counted in the Agriculture and Grasslands & Shrubland rows already considered by the Carbon Inventory as published in Table ES (pg. 7).
  - c. Clarify AFOLU terminology and category as it relates to attributions of sources of carbon emission (pg. 7).
  - d. Clarify that wetlands in the Carbon Budget Report do not use the Ex-ACT tool for its inventory although it is listed as such in the Executive Summary table (pg. 7 & pg. 41).

- e. In the Executive Summary, Table ES, note that the citation should change data source from “Vermont Carbon Budget” to “EX-ACT” (pg. 7).
- f. Update language within the body of the report to clarify that the EPA SIT does not account for agricultural stocks in the VT GHG Emission’s Inventory as found on page 12.
- g. Consider standardizing C Stocks for all land uses and sources (e.g. Agriculture, forest, wetland, etc.) from the same depth. Forest soils use 1 meter depth (100 cm), but ag soils only use 30 cm – deeper depth accounts for more C stored (pg. 35) (wetlands and water also 30 cm depth) multiply by factor of 3.4 to convert between depths (pg. 41).
- h. Page 56 identifies Urban and Developed land as having between 375,000 to 400,000 acres. This figure is in conflict with 118,000 acres of urban and developed land referenced on page 28 of the report.