Carbon Life Cycle Assessment of Electricity Produced from Forest-Derived Biomass in Virginia

Prepared for the Virginia Department of Forestry

Lisa Colosi Peterson, Nafisa Ahmed, Abigail Van Eerden

0. Abstract/Executive Summary

A carbon life cycle assessment (LCA) was conducted to assess the climate impacts of using harvest residuals as feedstock to produce electricity at three biomass power plants operated by Dominion Energy in Virginia. The **BASE** case corresponded to current operations (status quo). Results reveal that Dominion consumes approximately 15% of the harvest residuals produced per year within the region of interest. Accordingly, it was assumed that Dominion's operations correspond to this "fraction" (f_D) of relevant carbon fluxes, including forest carbon uptake (**FOREST ECOSYSTEM** flux) and decay of wood products (**HARVEST PRODUCTS** flux). Emissions arising from **PROCESSING & TRANSPORT** and combustion of harvest residuals to produce **POWER** were also computed. When all carbon fluxes were added together, the **NET** sum for the **DEFAULT BASE** case was negative (less than zero), corresponding to net carbon uptake.

Data from Virginia's Timber Product Output (TPO) survey documents the use of roundwood as fuelwood, though it is unknown to what extent such materials are consumed by Dominion. Therefore, sensitivity analyses were conducted in which it was assumed that Dominion consumes 50% or 100% of the diverted roundwood. Values of f_D computed for these analyses were smaller than in the **DEFAULT BASE** case, 13% and 12% for the "S50" and "S100" cases, respectively. As the value of f_D decreased, net emissions became less negative compared to the **DEFAULT BASE** case but were still less than zero.

The LCA also evaluated three hypothetical **ALTERNATIV**E cases in which harvest residuals cannot be consumed as feedstock to produce electricity. The magnitudes of **FOREST ECOSYSTEM** and **HARVEST PRODUCTS** fluxes were the same as in the **DEFAULT BASE** case; however, **POWER** emissions were changed because it was assumed that some other electricity source must replace what was previously produced from harvest residuals. It was also necessary to account for emissions arising from alternative management of harvest residuals, which was assumed to occur via **DECOMPOSITION** or **SITE PREP BURN**. Annual and cumulative **NET** fluxes for all **ALTERNATIVE** cases were negative, corresponding to net carbon uptake. Based on pairwise comparisons, it was observed that emissions for the **DEFAULT BASE** case were slightly higher (less negative) than in the **DECOMPOSITION** case and about the same as in the **SITE PREP BURN** case**.** The **DEFAULT BASE** case also initially exhibited similar emissions to the **FOREST CONVERSION** case, but by the end of the modeled 100-year interval**,** its cumulative **NET** emissions were markedly lower (more negative). In contrast, results from the **S50** and **S100** sensitivity analyses showed appreciably higher (less negative) **NET** emissions than in the **DEFAULT BASE** case, such that the **S50** and **S100 BASE** cases were not preferred relative to most of the modeled **ALTERNATIVE** cases.

In addition to **NET** flux calculations, this study also evaluated **FOREGONE SEQUESTRATION**, which was defined as emissions that could have been avoided if certain trees had not been consumed to produce bioelectricity. This quantity cannot be explicitly added into the formula for computing **NET** flux. Therefore, an additional, simplified analysis was conducted so that **FOREGONE SEQUESTRATION** could be accounted for in the comparison between **BASE** and **ALTERNATIVE** cases. Under the simplified framing, all three **BASE** cases (default, S50, and S100) exhibited lower emissions than the **SITE PREP BURN** and **FOREST CONVERSION** cases. In contrast, all three **BASE** cases started out with higher emissions than the **DECOMPOSITION** case, but this trend was reversed over time such that the **BASE** case was ultimately preferred by the end of the modeled 100-year interval. The apparent divergence in conclusions, whereby the **DECOMPOSITION** case is most preferred under the full life-cycle framing but the **BASE** case is generally preferred for all or at least some of the study duration under the simplified framing, likely reflects the significant contribution of biogenic **POWER** emissions in the **BASE** case when full life-cycle accounting is applied. Harvest residuals deliver relatively low heat output per mass, such that large quantities of carbon emissions are created when they are used as fuel. These emissions are assumed to "cancel out" in the simplified analysis, such that the **BASE** case compares more favorably to the modeled **ALTERNATIVES** than in the full life-cycle comparison.

In conclusion, results from this study do not offer clear indication that use of harvest residuals to produce bioelectricity is definitively better or worse than the modeled **ALTERNATIVES**. Results from the sensitivity analyses highlight the strong influence of roundwood diversion, whereby the **BASE** case becomes less preferred to the modeled **ALTERNATIVES** if it assumed that existence of a biomass market contributes to use of roundwood as fuelwood. However, it is unknown to what extent Dominion consumes the roundwood in question. Using only the **DEFAULT BASE** case to compare with modeled **ALTERNATIVES**, **BASE** case emissions were slightly less negative than the **DECOMPOSITION** case, about the same as the **SITE PREP BURN** case**,** and slightly more negative than the **FOREST CONVERSION** case. If it is anticipated that all three modeled **ALTERNATIVES** would be pursued to varying extents if harvest residuals could no longer be used as feedstock to produce electricity, then a reasonable representation for an ensemble **ALTERNATIVE** case would be somewhere in the range bounded by results from each individual case. This value would likely be close in magnitude to the estimated magnitude of the **DEFAULT BASE** case emissions.

1. Introduction

1.1 Motivation

In the 2023 session of the Virginia General Assembly, HB 2026 and SB 1231 amended the Virginia Clean Economy Act (VCEA) to allow continued use of woody biomass as feedstock for electric power generation in Virginia (VA HB 2026, 2023; VA SB1231, 2023). The legislation made electricity produced by several existing biomass energy facilities eligible to qualify under the Renewable Portfolio Standard for sale of Renewable Energy Credits (RECs) (Viginia Clean Economy Act, 2020). The legislation also directed the Virginia Department of Forestry (VDOF) to convene an advisory panel to examine a range of topics related to the use of forest-derived biomass for electricity generation, including a life-cycle carbon analysis (LCA), and to submit a report of their findings and recommendations to the General Assembly by December 1, 2024 (VDOF, 2023). This report summarizes framing, methodology, results, and conclusions from the carbon LCA undertaken by the advisory panel.

1.2 LCA Framing

This carbon LCA study was consistent with principles of ISO 14040 and 14044 (ISO, 2006a and 2006b). The **goal** of the study was based directly on the language of HB 2026; namely, to estimate net carbon emissions resulting from continued operation of three biomass energy facilities operated by Dominion Energy at Altavista, Hopewell, and Southampton, relative to the alternative scenario in which the facilities are shut down. The analysis accounted for all carbon emissions, including supply chain emissions, forgone sequestration, and emissions from burning biomass for electricity generation. The analysis was based on current science, publicly accessible data, and prevailing conventions of forest ecosystem carbon modeling. It quantified changes in carbon stock and greenhouse gas (GHG) fluxes resulting from various management practices and biomass-based product pathways. Results will be disseminated to various stakeholders, including the Virginia General Assembly.

The **scope** of the carbon LCA encompassed four cases. The **BASE** case corresponded to current operation of the three Dominion facilities, in which they consume forest harvest residuals (biomass) to produce electricity. Three **ALTERNATIVE** cases were also evaluated; one in which forest harvest residuals are managed via **DECOMPOSITION**, another in which harvest residuals are managed via **SITE PREP BURN**, and a third in which it was assumed that loss of biomass market contributes to accelerated **FOREST CONVERSION** over time, such that some forest acreage is harvested one last time before being cleared via burning and then converted to some other land use. It is anticipated that all three of the **ALTERNATIVE** cases could occur to varying extents, based on the circumstances of individual private forest owners. In other words, it is unlikely that all forest owners would use the same residuals management approach if harvest residuals were no longer permitted to be used as feedstock for electricity production. However, it was more straightforward to model each **ALTERNATIVE** case separately, without assigning specific likelihoods (weights) to each option. In all modeled cases, the three facilities were modeled collectively, rather than each being assessed independently on its own.

The **functional unit** (FU) for this analysis was the quantity of electricity currently produced by the three Dominion plants of interest, with adjustment for the portion that comes from harvest residuals. Under the **BASE** case, this electricity is produced from biomass feedstocks. In all three **ALTERNATIVE** cases, it was assumed that non-biomass power would replace the electricity currently being produced by the plants

of interest. All cases were evaluated over a 100-year time horizon (2028-2127). The start date for this interval was selected as the year in which the VCEA initially stipulated that all biomass powered facilities in Virginia would be shut down (Viginia Clean Economy Act, 2020). **Figure 1** illustrates the **systems boundaries** for the carbon LCA undertaken in this study

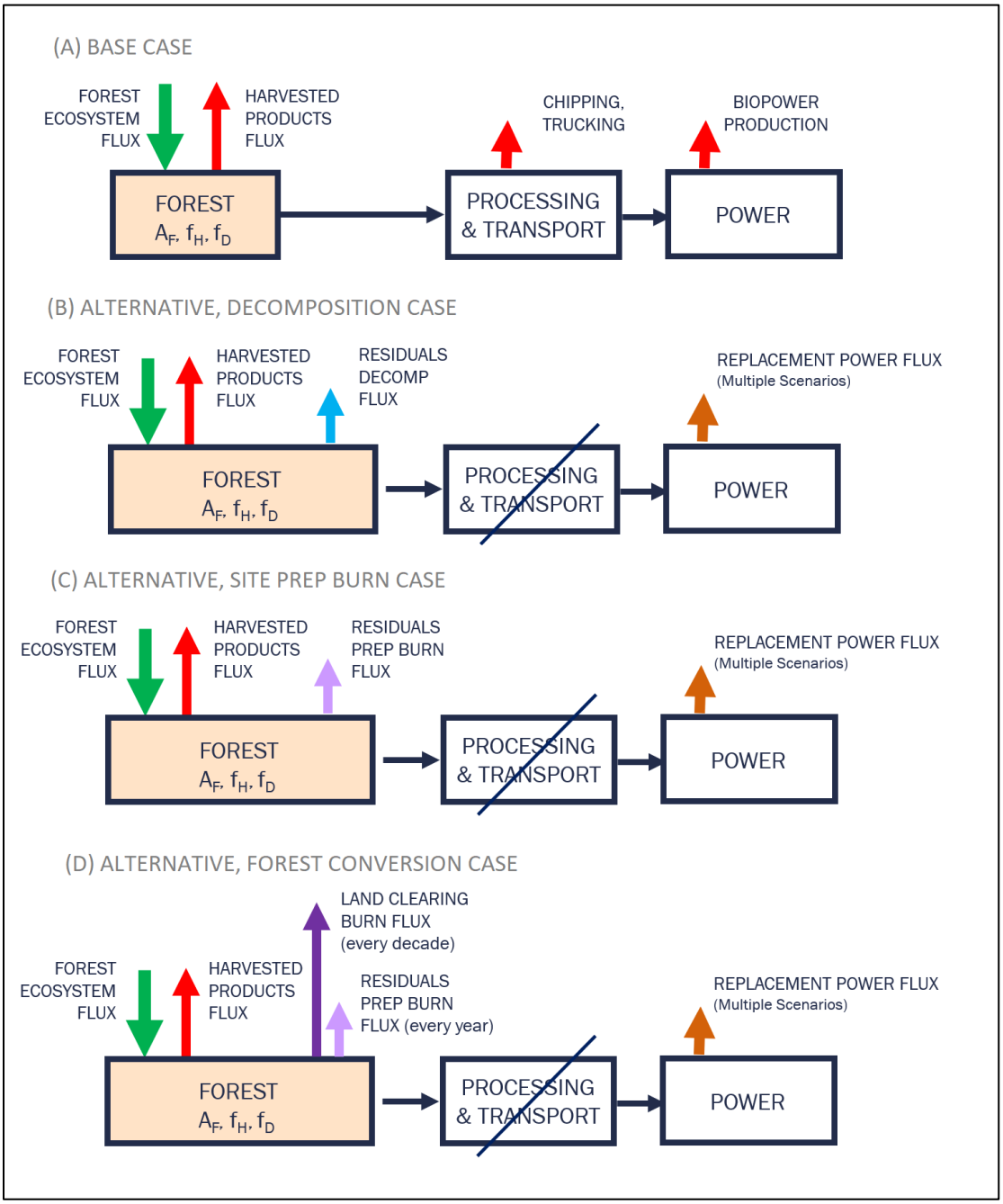

Figure 1*. Systems boundaries for cases evaluated in this LCA study. Panel A depicts the* ***BASE*** *case, which corresponds to current operations ("status quo"). Panels B, C, and D depict three hypothetical* ***ALTERNATIVE*** *cases in which harvest residuals cannot be consumed to produce biopower in Virginia.*

1.3 Overview of Relevant Fluxes and Related Quantities

Figure 1 depicts the carbon fluxes that are evaluated for each modeled case. The first is **FOREST ECOSYSTEM** flux, which accounts for carbon uptake by forestland as trees grow. Notably, current forest carbon modeling frameworks from the US Forest Service (USFS), the Intergovernmental Panel on Climate Change (IPCC), and others account for carbon uptake into live trees plus five other pools; namely, standing dead trees, understory, down dead wood, forest floor (litter), and soil organic material (Smith et al., 2006; Westfall et al., 2022). These pools can be quantified individually or summed to produce a total estimate of carbon uptake per acre per year.

HARVEST PRODUCTS flux corresponds to decay of products created from harvested forest materials. A widely used modeling framework from USFS defines four stocks of harvested materials (products, landfill, energy, and emissions), and provides empirical estimates of how quickly each stock is converted back into CO_2 over a 100-year time horizon, based on harvest volume, geographic region, and wood type (Smith et al., 2006; Hoover et al., 2014). “Products” stocks constitute end-use products that are not yet discarded or destroyed, such as construction materials, containers, and paper products. “Landfill” stocks constitute wood and paper products discarded to landfills. The sum of these two stocks are considered “stored” carbon (i.e., not returning to the atmosphere). In contrast, “energy” and “emissions” stocks constitute emissions from combustion of wood products with and without energy capture, respectively. "Energy” and “emissions” stocks were added together, and their rate of change over time was used to estimate the magnitude of **HARVEST PRODUCTS** fluxes.

PROCESSING & TRANSPORT fluxes were computed for the **BASE** case modeling, to account for carbon emissions arising from creation and transportation of chipped biomass.

POWER flux was computed to account for emissions created during electricity creation. Under the **BASE** case, the **POWER** flux magnitude was based on measured CO_2 emissions at the Dominion facilities of interest. In all **ALTERNATIVE** cases, it was assumed that one or more sources of non-biomass power replaces biomass power. Two replacement scenarios were evaluated; one accounting for the current “background” grid mix (without biomass) in Virginia and on the PJM; and one anticipating implementation of the VCEA and other relevant regulatory frameworks seeking to deliver marked reductions in electricity carbon intensity over time.

It was also necessary to account for fluxes arising from management of harvest residuals in each **ALTERNATIVE** case, since it was assumed that such materials can no longer be consumed to produce bioelectricity. Two alternative approaches were assessed. In the **DECOMPOSITION** case, it was assumed that harvest residuals are left in place in the forest after harvest. Empirical data were used to estimate conversion of residual stocks to emissions over time. In the **SITE PREP BURN** case, it was assumed that harvest residuals are burned in the field, producing emissions of both CO_2 and methane (CH_4). Emission magnitudes for this case were computed based on a methodology from the UN FCCC (UNFCCC, 2009). Finally, in the **FOREST CONVERSION** case it was assumed that loss of a market for harvest residuals (biomass) could contribute to accelerated conversion of forestland to other land uses. To model this case, it was assumed that harvests occur at the same rate per year as in the **BASE** case and that residuals are managed via **SITE PREP BURN**, but that a subset of the harvested stands are cleared via burning after their last harvest. During clearing, underground biomass is significantly consumed producing additional emissions of CO_2 and CH_4. Calculations of fluxes arising from the clearing burns were based on the same

protocol as was used to model **SITE PREP BURN** (UNFCCC, 2009). Again, it is emphasized that it would be unlikely for all forest owners to choose the same residuals management practice such that all residuals would be decomposed or burned via site prep burn. However, without data to know what fraction of residuals would be subject to each alternative management strategy, it simplified the analysis to separately model each approach being used for all of the residuals.

The final quantity computed in this analysis was **FOREGONE SEQUESTRATION**, which is an estimate of what carbon emissions could have been avoided if a particular activity had not occurred. For this analysis, **FOREGONE SEQUESTRATION** was defined as the amount of carbon emissions that could have been avoided if specific trees were not removed and consumed to produce biopower in the **BASE** case. Logger surveys and other data had previously revealed that most of the biomass (88%) consumed by Dominion is created during clear-cut harvests (VDOF, 2023). It was therefore of interest to estimate what amount of carbon was embodied in non-industrial wood stocks removed during such harvests. In theory, these stocks might remain in place if the market for harvest residuals did not exist.

To conclude, the quantities named above were used to compute **NET** fluxes for the **BASE** case and each **ALTERNATIVE** case. Positive magnitudes (values > 0) were assigned to fluxes that *release* carbon emissions into the atmosphere; namely, **HARVEST PRODUCTS**, **PROCESSING & TRANSPORT (P&T)**, **POWER**, **DECOMPOSITION**, **SITE PREP BURN**, and/or **FOREST CONVERSION** burns. Negative magnitudes (values < 0) were assigned to fluxes that *take up* (sequester) carbon from the atmosphere; namely, **FOREST ECOSYSTEM** flux. **FOREGONE SEQUESTRATION** was not added into the calculation of **NET** fluxes for any modeled case, because it does not constitute a physical flux. Therefore, an additional simplified comparison was included in this study to explicitly account for **FOREGONE SEQUESTRATION** in the comparisons between **BASE** and **ALTERNATIVE** cases.

2. Methodology

2.0 Data Source & Forest Types

Data for this analysis was primarily collected from the Forest Inventory and Analysis Database (FIADB). Preliminary analyses were conducted with data queried via the online portal, EVALIDator (USDA, 2024a) Relevant quantities were initially queried for each power plant's individual draw area, using circles centered on each facility and a 64-mile radius, which was selected based on input from the advisory panel (VDOF, 2023). Resulting datasets were initially examined for 2020, 2021, and 2022; however, it was observed that relevant magnitudes did not vary markedly by year. Accordingly, the final analysis was based on the most recent "EVALID" (year) of FIA data for Virginia (512022) and North Carolina (372022). The same set of parameters were queried again for the integrated (combined) draw area encompassing the summed draw area of each individual facility including overlapping regions (**Figure 2**). The FIA query for the integrated area was conducted by USFS personnel since it is not possible to query overlapping draw circles when using the publicly accessible EVALIDator tool.

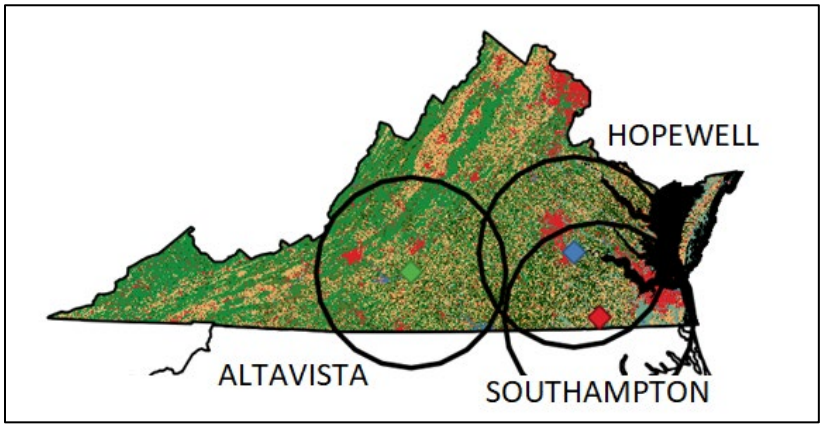

***Figure 2**. Locations of the three Dominion biomass power plants evaluated in this study. Circles correspond to radii of 64 miles surrounding each individual plant. The "integrated draw area" (A_F) corresponds to the sum of forested area in each individual circle, without double-counting for overlapping regions.*

Analysis of forest area (FIA parameter #2) revealed that most (95%) of the integrated draw region comprises four main forest types: Loblolly-shortleaf pine, oak-gum-cypress, oak-hickory, and oak-pine. Calculations requiring specific information by forest type were performed for these four classes, and results were assembled into area-weighted averages. Weighted averages were then divided by the fraction of the total forest area comprising the sum of these four types to compute an adjusted estimate corresponding to the full draw area.

2.1 Estimating Dominion's "Fraction" of Regional Forest Fluxes (f_D)

The mass of harvest residuals available per year was estimated based on three FIA datasets for "annual harvest removals dry weight" per year: aboveground biomass of trees (≥1 inch DBH) (FIA #403), merchantable bole bark and wood biomass of trees (≥ 5 inch DBH) (FIA #574067), and stump bark and biomass of trees (≥ 5 inch DBH) (FIA #574077). The merchantable bole and stump masses were subtracted from aboveground biomass to estimate what amount of harvest residuals is available. It was assumed that

this quantity corresponds to tops, limbs, and other portions of harvested trees that are not suitable as industrial roundwood. It was also assumed that stumps are left in place after harvests.

The mass of harvest residuals consumed per year by the three Dominion facilities of interest was based on estimation of how much biomass must be combusted to produce as much heat as is required to generate their known electricity output per year. Electricity generation across all three plants was 0.93 million MWh for 2020, 0.92 million MWh for 2021, and 1.02 million MWh for 2022 (VDOF, 2023). Information from Dominion indicated that 75-85% of this output is created from harvest residuals (VDOF, 2023). The assumed average value for energy content of wood residues was 3995 BTU/lb (green basis) (VDOF, 2023; Wood Forest Industries, n.d.). The assumed value for heat-only electricity production efficiency was 27% (Oregon LPRO, 2019). Combining these parameters, the range of harvest residuals consumed by all three plants was 1.10-1.39 million short tons (green basis) per year.

The mass of harvest residuals consumed by Dominion per year was divided by the mass of harvest residuals produced per year, to estimate what fraction of the total available pool is consumed by the power plants of interest. The resulting value of this quantity (f_D) was 15.3%. Mathematically "assigning" this portion of the forested draw area to Dominion reflects assumption that the harvest operations have some "virtual correspondence" to power plant operation, which is an LCA-based assumption.

2. 2 BASE Case ("Default) – Fluxes and Other Relevant Quantities

2.2.1 FOREST ECOSYSTEM Flux

FOREST ECOSYSTEM flux for the **BASE** case was computed based on "annual net growth dry weight" of live trees (DBH ≥ 1 inch) (FIA parameter #311) as normalized per forest area (FIA #2). Values were exported by forest type (Loblolly-shortleaf pine, oak-gum-cypress, oak-hickory, and oak-pine) in units of dry short tons per acre per year. These quantities were multiplied by 50%, the average carbon content in wood (Smith et al., 2006), to estimate uptake in units of dry short tons of carbon per acre per year. Results were then multiplied by empirical "multipliers" to account for carbon uptake into other pools. Multiplier values were the ratio of "total non-soil" carbon relative to "live tree" carbon from tables in Appendix A of Smith et al. (2006). Once total carbon uptake values per acre had been computed for each forest type, they were assembled into a weighted average across the integrated draw region, which was then adjusted to correct for the small fraction of the draw area comprising other forest types. Finally, the adjusted weighted average was converted to units of tonne C per acre per year and then multiplied by total forest area in the integrated draw area (A_F) and Dominion's fraction of the harvest residuals (f_D). The resulting value was reported in units of tonne C per year. The same value was used for all 100 years of the **BASE** case modeling.

2.2.2 HARVEST PRODUCTS Flux

HARVEST PRODUCTS flux for the **BASE** case was computed using two "annual harvest removals volume" parameters from FIA: "merchantable bole wood volume of trees" (DBH ≥ 5 inches) (FIA #238), and "sawlog wood volume of sawtimber trees "(FIA #240). Both quantities were exported in units of cubic feet and grouped as hardwood vs. softwood. Pulpwood volumes were estimated as the difference between merchantable bole volume minus sawlog volume, also grouped as hardwood vs. softwood. Sawlog and pulpwood values were used as inputs to the *iTree Harvest Carbon Calculator* (iTree, n.d.). The iTree tool also required the corresponding harvest area as input, which was computed by multiplying total forest area (A_F) times the fraction harvested per year (f_H = 7%) (USDA, 2024b).

iTree's output was a 100-year time series for four carbon stocks: "products", "landfill", "energy" (including mill residues combusted at mill locations), and "emissions". Units were tonnes C/ha/year. The values of "energy" and "emissions" were added together in each year and the sum was fit to a logarithmic function in Microsoft Excel. The resulting equation was useful to compute what mass of carbon initially embodied in harvested products had been returned to the atmosphere at any point in time over the following 100 years. The first derivative of this function was then used to estimate the change in stock per year; i.e., the amount of harvest products carbon returned to the atmosphere in any single year. The resulting quantities were then used to estimate **HARVEST PRODUCTS** flux per year. The magnitude of this flux increased each year, whereby in Year 1, it accounted only for decay of that year's harvested products. In later years, the flux magnitude accounted for that year's harvested products *plus* continuing decay of products created in all preceding years. Flux values for each year of the 100-year analysis were multiplied by the harvested area per year ($f_H \times A_F$) and Dominion's portion of the harvest residuals (f_D).

2.2.3 POWER and PROCESSING & TRANSPORT Fluxes

Magnitudes for the **POWER** and **PROCESSING & TRANSPORT (P&T)** fluxes were not computed using FIA data. Instead, **POWER** emissions were based on measured CO_2 releases for the three facilities of interest, with adjustment to account for the fact that harvest residuals constitute 75-85% of Dominion's bio-feedstocks at the facilities of interest (VDOF, 2023). Using average emissions measurements for 2021, 2022, and 2023, average emissions from harvest residuals was 0.36 million short tons of CO_2 per year. This value was converted to tonnes C per year, for compatibility with other fluxes. The same value was used for all 100 years of the **BASE** case modeling.

Emissions arising from **P&T** of the harvest residuals ("fuel chips") were estimated based on published empirical data and conventional LCA practice. For processing emissions, the mass of harvest residuals produced per year was multiplied by the assumed density of wood (300 kg/m^3) (Smith et al., 2006) to compute what volume of wood is chipped per year. This quantity was then multiplied by an estimate of fuel (diesel) consumption per volume of chips produced (0.5 L diesel per m^3 chips) (Spinelli and Magagnotti, 2014) to estimate how much diesel is consumed per year via chipping. This quantity was then multiplied by an emissions factor for diesel (10 kg CO2-equivalent [CO2e] per gallon) (US EPA, 2023). The resulting quantity was converted to tonnes C per year, for compatibility with other fluxes.

For transportation emissions, the mass of harvest residuals produced per year was divided by the assumed volumetric capacity of a tractor trailer (26 short green tons) (VDOF, 2023) to compute the number of truck trips required per year. Assumed roundtrip distance per trip was 100 miles (VDOF, 2023). Emission quantities for heavy-duty truck transport were 1.387 kg CO2 per vehicle-mile, 0.013 g CH_4 per vehicle-mile, and 0.038 g nitrous oxide (N_2O) per vehicle-mile (EPA, 2014. These individual greenhouse gas emissions were aggregated into an equivalent global warming potential (GWP), 1.399 kg CO2e per vehicle mile (US EPA, 2023). The GWP value was multiplied by the total number of truck-miles driven per year. The resulting quantity was converted to tonnes C per year, for compatibility with other fluxes. Processing and transportation emissions were added together, and the same value was used for all 100 years of the **BASE** case modeling.

2.2.4 Foregone Sequestration

Reiterating from Section 1.3, **FOREGONE SEQUESTRATION** was defined in this study as the amount of carbon emissions that could have been avoided if specific trees were not removed and consumed

to produce biopower. For the **BASE** case, this quantity was defined as the mass of carbon embodied in unmerchantable "small" trees (DBH < 5 inches) removed during clear-cut harvests. It was estimated using "annual harvest removals dry weight" data from FIA, specifically "aboveground biomass of trees" (DBH ≥ 1 inch) (FIA # 403). These data were exported with classification by diameter. The resulting value was used as an estimate of foregone sequestration for the **BASE** case model. The same value was used for all 100 years of the **BASE** case modeling.

2.2.5 NET Flux

Annual **NET** fluxes were computed for each year of the 100-year analysis. The magnitude of the **NET** flux was given by Equation 1. Units were tonne C per year.

Eq. 1 NET = HARVEST PRODUCTS + POWER + P&T – FOREST ECOSYSTEM

Positive values of **NET** flux (> 0) indicate that more carbon is emitted than taken up in a particular year. Negative values of **NET** flux (< 0) indicate that more carbon is taken up (sequestered) than emitted in a particular year. Annual values were summed to produce cumulative estimates over the 100-year time horizon of this study.

FOREGONE SEQUESTRATION was not explicitly included in the calculation of **NET** flux because it is not a flux. Moreover, adding it into the calculation of **NET** emissions for the **BASE** case would essentially double count the **POWER** emissions, since it was assumed that the harvested materials with DBH < 5 were consumed to make electricity.

2. 3 BASE Case ("Sensitivity Analysis") – Fluxes and Other Relevant Quantities

The **BASE** case modeling described in Section 2.2 corresponds to a "default" case in which it was assumed that only harvest residuals are consumed to produce electricity at the Dominion facilities. However, data from Virginia's Timber Product Output (TPO) survey indicate that 13% (≈ 72,000 MCF) of industrial roundwood produced during 2021 was consumed as fuelwood (USDA, 2021). The data did not specify which entity had consumed this material; therefore, it is unknown how much, if any, was consumed by the Dominion facilities of interest. Still, it was anticipated that use of roundwood to produce biopower would influence the LCA of electricity produced from forest-derived biomass. It was therefore of interest to conduct sensitivity analyses in which it was assumed that at least some of the diverted roundwood is consumed by Dominion. Two framings were applied. "S50" assumed that 50% of the diverted roundwood (≈ 36,000 MCF) is consumed by Dominion facilities. "S100" assumed that 100% of the diverted roundwood (≈ 72,000 MCF) is consumed by Dominion facilities. In each framing, magnitudes of the **FOREST EOCSYSTEM** and **HARVEST PRODUCTS** fluxes were different than in the default **BASE** case. **FOREGONE SEQUESTRATION** was also adjusted. In contrast, **POWER** and **P&T** flux magnitudes remained the same as they were in the default **BASE** case. The 50% and 100% values were selected without any particular significance.

The magnitudes of the **FOREST ECOSYSTEM** fluxes in the sensitivity analysis cases were smaller (less negative) than in the **BASE** case, because use of roundwood as fuelwood increases the quantity of forest-derived biomass that is produced per year, thereby reducing the estimated fraction consumed by Dominion (i.e., f_D decreases). Because Dominion's biomass consumption stayed the *same* while the quantity of available biomass *increased*, the fraction consumed by Dominion (f_D) was reduced. Values of f_D for the S50 and S100 sensitivity analysis framings were 0.132 and 0.116, respectively. These quantities

were multiplied by carbon uptake per area (Section 2.2.1) and the fraction of the total forest area harvested per year ($f_H \times A_F$). The resulting values were used to parameterize **FOREST ECOSYSTEM** flux magnitudes for the S50 and S100 cases. Different magnitudes were computed for each case, but the same value was used for all 100 years of modeling within each case.

The magnitudes of the **HARVEST PRODUCT** fluxes in the sensitivity analysis cases were smaller (less positive) than in the **BASE** case for two reasons. First, the mass of harvest products created is reduced when roundwood is diverted for use as fuelwood. Second, as noted above, Dominion's fraction of the harvest residuals (f_D) decreases. The first change was modeled by using different inputs for the *iTree* tool. It was assumed that the diverted roundwood comes from the pulpwood fractions of both hardwoods and softwoods. Therefore, *iTree* inputs for pulpwood volumes under the S50 and S100 cases were smaller than in the default **BASE** case. Sawlog volumes were assumed to be the same as in the **BASE** case. *iTree* outputs were processed as described in Section 2.2.2 to estimate carbon emissions per acre arising from decay of harvested products in a particular year. As in the **BASE** case, these values were multiplied by the harvested area per year ($f_H \times A_F$) and Dominion's portion of the harvest residuals (f_D); however, f_D values were lower for the S50 and S100 cases than in the **BASE** case.

It was also necessary to adjust the estimate of **FOREGONE SEQUESTRATION** in the S50 and S100 cases. These adjustments were made by adding the masses of carbon embodied in the diverted roundwood to the **FOREGONE SEQUESTRATION** value computed for the default **BASE** case. Reiterating from Section 2.2.4, "aboveground biomass of trees" (DBH ≥ 1 inch) (FIA # 403) was exported with classification by diameter, such that it was possible to compute what mass of harvested trees had exhibited diameters greater than 5 inches. This sum was multiplied by 6.5% or 13% for the S50 and S100 cases, respectively. Resulting quantities were then converted to units of tonne C per year and added to the previously computed value of **FOREGONE SEQUESTRATION** for the default **BASE** case. The same value was used for all 100 years of the **BASE** case modeling.

NET fluxes for each framing of the sensitivity analysis (S50 and S100) were computed using Equation 1. As in the default **BASE** case, **FOREGONE SEQUESTRATION** was not explicitly accounted for in the calculation of annual or cumulative **NET** fluxes.

2. 4 ALTERNATIVE Cases

2.4.1 Overview of Flux Magnitude Changes (relative to BASE case)

Three **ALTERNATIVE** cases were modeled to assess carbon emissions under the hypothetical situation in which harvest residuals cannot not be consumed to produce electricity. All three **ALTERNATIVE** cases had the same magnitudes of **FOREST ECOSYSTEM** flux and **HARVEST PRODUCTS** flux as in the default **BASE** case. In contrast, **P&T** fluxes were zero, because there is no need to chip or transport harvest residuals if they are not consumed to produce electricity. The **ALTERNATIVE** cases assumed that the same amount of harvest residuals are produced in the **BASE** case, but that they are managed via **DECOMPOSITION** or **SITE PREP BURN**, each creating a new source of biogenic emissions that must be parameterized. It is unknown what fraction of forest owners would choose either decomposition or site prep burn to manage their harvest residuals if they were not permitted to be burned as feedstock for electricity production. It is likely that some forest owners would choose each of the modeled options or other alternatives (e.g., use of herbicide for hardwood control).

Finally, the magnitude of the **POWER** flux was changed to reflect assumptions about the carbon intensity of the electricity that replaces what had been previously produced at the three Dominion facilities of interest. Two **POWER** scenarios were created for use in all three **ALTERNATIVE** cases. Under the first scenario, it was assumed that replacement energy has the same carbon intensity as the current PJM and Virginia grid mixes, since they have approximately the same value once biomass is removed from the Virginia mix (US EIA, 2024). This value (332 kg CO2e/MWh) was converted to tonne Carbon-equivalent (Ce)/MWh and multiplied by the average amount of energy produced by the Dominion facilities per year. The resulting value was used for all 100 years of the analysis. Under the second scenario, it was assumed that the Virginia grid mix becomes increasingly decarbonized over time. Accordingly, different values of carbon intensity were assigned in different years. The "PJM and Virginia" value was assigned for Years 1 and 2 (i.e., 2028 and 2029). This value was reduced by 30% to reflect compliance with the Regional Greenhouse Gas Initiative (RGGI). The resulting value, 232 kg CO2e/MWh, was assigned for Years 3-17 (2030-2044). The value for Years 18-100 (2045 onwards) was computed assuming that combustion sources will no longer be permitted in Virginia, such that replacement electricity will come from a mix of dispatchable, non-combustion sources. The assigned value of 39 kg CO2e/MWh corresponds to an unweighted average of solar (with battery), wind (with battery) nuclear, and hydropower (NREL, 2021). As in the other **POWER** flux scenario, the assigned carbon intensities were converted to tonne Ce/MWh and multiplied by the average amount of energy produced by the Dominion facilities per year (approximately 1 million MWh per year), as adjusted to reflect that 75-85% of the output is produced using harvest residuals as feedstock (VDOF, 2023).

2.4.2 DECOMPOSITION Flux

For the **DECOMPOSITION** case, it was assumed that harvest residuals are left in place to decompose over time. A first order (exponential) model was used to predict decomposition, $C = C_0 \times \exp(-k \times t)$. Here, C is residuals stock over time, C_0 is the initial mass of harvest residuals, *k* is a first-order rate constant, and t is time in years. Rate constants for hardwood and softwood residuals were collected from relevant literature (**Figure 3**) (Russell et al., 2014; USDA 2022; US EPA, 2014). Average values were $k_{SOFTWOOD}$ = -0.014 1/year and $k_{HARDWOOD}$ = -0.021 1/year. The first derivative of the exponential decay model was used to estimate the change in mass of harvest residuals per year; i.e., the amount of harvest residuals decomposing and returning carbon to the atmosphere in any single year. The resulting quantities were then used to estimate **DECOMPOSITION** flux per year. The magnitude of this flux increased each year, whereby in Year 1, it accounted only for decomposition of that year's harvest residuals. In later years, it accounted for decomposition of that year's harvest residuals plus continuing decomposition of harvest residuals created in all preceding years. Flux values for each year of the 100-year analysis were multiplied by Dominion's portion of the harvest residuals ($f_{D)}$.

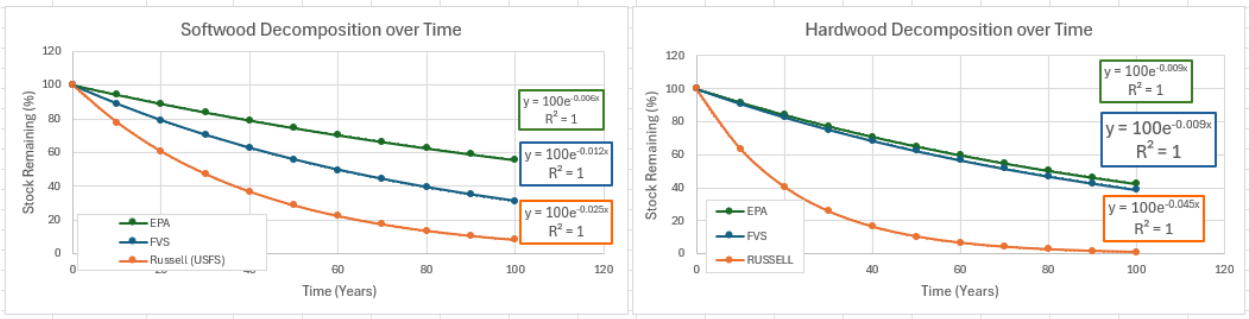

***Figure 3**. Decomposition rate models for softwood (left) and hardwood (right), based on data collected from relevant literature. Best-fit models are exponential equations from Microsoft Excel.*

2.4.3 SITE PREP BURN Flux

For the **SITE PREP BURN** case, it was assumed that harvest residuals are managed via controlled burn. According to relevant literature, approximately 60-85% (likeliest = 75%) of available biomass is consumed during such burns (Hardy, 1996; Ter-Mikaelian et al., 2015; UN FCCC, 2009). A framework from the UN FCCC was used to estimate relevant emissions; however, it was assumed that underground biomass remains in place (is not consumed) during site prep burns to manage harvest residuals (UN FCCC, 2009). Emissions factors were 1 tonne CO_2 as C and 0.012 kg CH_4 as C per tonne of harvest residuals consumed. The methane value was adjusted to Ce basis using the GWP value for "land/agricultural sources" (27 kg CO_2e per kg CH_4) from IPCC (IPCC, 2023). The resulting GWP (in tonnes Ce) was multiplied by Dominion's portion of the harvest residuals produced per year (f_D). The same magnitude was assigned to all 100 years of the analysis.

2.4.4 FOREST CONVERSION Case

A third **ALTERNATIVE** case was used to assess how the carbon balance would be affected if loss of biomass market contributed to accelerated forest conversion over time. In this case, it was assumed that the harvest residuals produced each year are managed via **SITE PREP BURN** (see Section 2.4.3) and that some forest acreage harvested each year is subsequently cleared via additional burning. Assumed rate of forestland conversion was 5% per decade. This value was selected arbitrarily without meaningful justification. Emissions arising from management of the harvest residuals were computed for each year. Additional emissions were added at the end of each decade, to account for burning to clear the fraction of forestland converted in the preceding ten years. The UNFCCC (2009) framework was used to estimate GWP arising from CO_2 and CH_4 emissions created during combustion of underground biomass ("tree dry weight, belowground biomass of live trees [DBH $\geq$ 1 inch]", FIA #59) during clearing burns. GWP emissions were converted to units of tonne Ce per year. Emissions from burning of harvest residuals (occurring every year) and land-conversion burning (occurring every tenth year) were added together to compute total **FOREST CONVERSION** flux per year. The magnitude of this flux decreased each decade because the quantity of harvest residuals produced and the acreage of land converted via burning decreased over time. Flux values for each year of the 100-year analysis were multiplied by Dominion's portion of the harvest residuals (f_D).

2.5 "Simplified" Carbon Balance Analysis

LCA judgement is required to apportion forest carbon uptake, insofar as the fraction (f_D) of the forest corresponding to Dominion's operations is not actually owned or controlled by them. Also, the **ECOSYSTEM** and **HARVEST PRODUCTS** fluxes account for all tree components, even though the majority of the mass is accounted for in the bole not the harvest residuals. Finally, **NET** carbon fluxes computed using the "full life cycle" calculations (Sections 2.3 and Section 2.4) cannot meaningfully make use of **FOREGONE SEQUESTRATION** because it is not a flux.

To address these challenges, a "simplified" carbon balance was computed. It purposefully excluded **FOREST ECOSYSTEM** or **HARVEST PRODUCT** fluxes. In doing so, it was assumed that carbon taken up into the portions of live trees that become harvest residuals "cancels out" when the residuals are later combusted to produce electricity. In other words, the simplified analysis assumes that the difference between carbon uptake into harvest residuals and carbon emissions produced when the residuals are burned is essentially zero. Making this simplification, it was then possible to "zoom in" and compare the **BASE** cases (with biomass market) and **ALTERNATIVE** cases (without biomass market) more directly. Specifically, the sum of **FOREGONE SEQUESTRATION** plus **P&T** emissions under the **BASE** case, was compared with the sum of replacement **POWER** plus **DECOMPOSITION** or **SITE PREP BURN** emissions under each **ALTERNATIVE** case. These comparisons were computed over the same 100-year timeframe as in the full life-cycle calculations.

3. Results and Discussion

3.1 BASE Cases – "Default" and Sensitivity Analysis ("S50", "S100")

Table 1 summarizes estimated magnitudes of *annual* fluxes and other quantities for the default **BASE** case and sensitivity analyses in which it is assumed that the Dominion facilities consume half ("S50") or all ("S100") of the diverted roundwood. The flux magnitudes are per year for selected years, to illustrate how some fluxes exhibit different magnitudes in different years. The values in **Table 1** do not correspond to cumulative values.

Figure 4 summarizes annual and cumulative emissions for the **BASE** case. These plots highlight how the very large magnitudes of **FOREST ECOSYSTEM** flux strongly influence **NET** fluxes, resulting in negative values (i.e., net carbon uptake). The magnitude of this flux reflects the assumption that a fraction (f_D) of the forested draw area can be "assigned" to Dominion based on the fraction of the local pool of harvest residuals that it consumes to produce electricity. In reality, Dominion does not own those lands or directly influence how they are managed. Therefore, assigning a portion of the **FOREST ECOSYSTEM** flux to operations of the power plants reflects assumption that the harvest operations have some "virtual correspondence" to power plant operation. This is an LCA-based assumption. Without assignment of a portion of forest-based carbon uptake to the power plants, there would be no negative terms in the **BASE** case modeling, such that the overall **NET** fluxes could not be less than zero.

Figure 4 also shows that cumulative **NET** fluxes for the **BASE** cases become less negative over time. This change occurs because **HARVEST PRODUCTS** flux increases over time, as it accounts for decay of harvested wood products from more and more previous years' harvests.

Finally, **Figure 4** also illustrates how the **NET** carbon balance becomes less negative with increasing diversion of roundwood for use as fuelwood, even though **NET** values for both sensitivity analysis cases (**S50** and **S100**) are still negative. Numerical quantities corresponding to **Figure 4** are summarized in **Appendix Tables A1-A3**. Results from the **DEFAULT, S50, and S100 BASE** cases highlight the strong influence of roundwood diversion on the overall **NET** carbon balance for the **BASE** case (status quo).

Table 1. *Flux magnitudes and other relevant quantities for the* ***BASE*** *cases (default, "S50", and "S100"). Units are tonne C/year. Values are annual (i.e., not cumulative).*

Flux or Other Relevant Quantity	Case		
	BASE, "default"	BASE, "50% sensitivity" (S50)	BASE, "100% sensitivity" (S100)
Dominion's fraction harvest residuals, f_D	0.153	0.132	0.116
FOREST ECOSYSTEM flux (C uptake per acre × IPCC multiplier × A_F × f_D)	Same value for all years, -2.8E6	Same value for all years, -2.4E6	Same value for all years, -2.1E6
HARVEST PRODUCTS flux (C uptake per acre × IPCC multiplier × A_F × f_D)	Value changes per year, Year 1 = 2.5E5 Year 100 = 4.9E5	Value changes per year, Year 1 = 2.0E5 Year 100 = 3.9E5	Value changes per year, Year 1 = 1.6E5 Year 100 = 3.2E5
POWER flux (measured value for Dominion facilities)	Same value for all years, 3.2E5	Same value for all years, 3.2E5	Same value for all years, 3.2E5
PROCESSING & TRANSPORT flux (chipping and truck transport diesel use)	Same value for all years, 3.3E3	Same value for all years, 3.3E3	Same value for all years, 3.3E3
ANNUAL NET FLUX (Equation 1)	Value changes per year, Year 1 = -2.2E6 Year 100 = -2.0E6	Value changes per year, Year 1 = -1.9E6 Year 100 = -1.7E6	Value changes per year, Year 1 = -1.7E6 Year 100 = -1.5E6
FORGONE SEQUESTRATION (mass DBH < 5 for BASE) (mass DBH < 5 + diverted roundwood mass for S50 and S100)	Same value for all years, 1.0E5	Same value for all years, 1.5E5	Same value for all years, 1.8E5

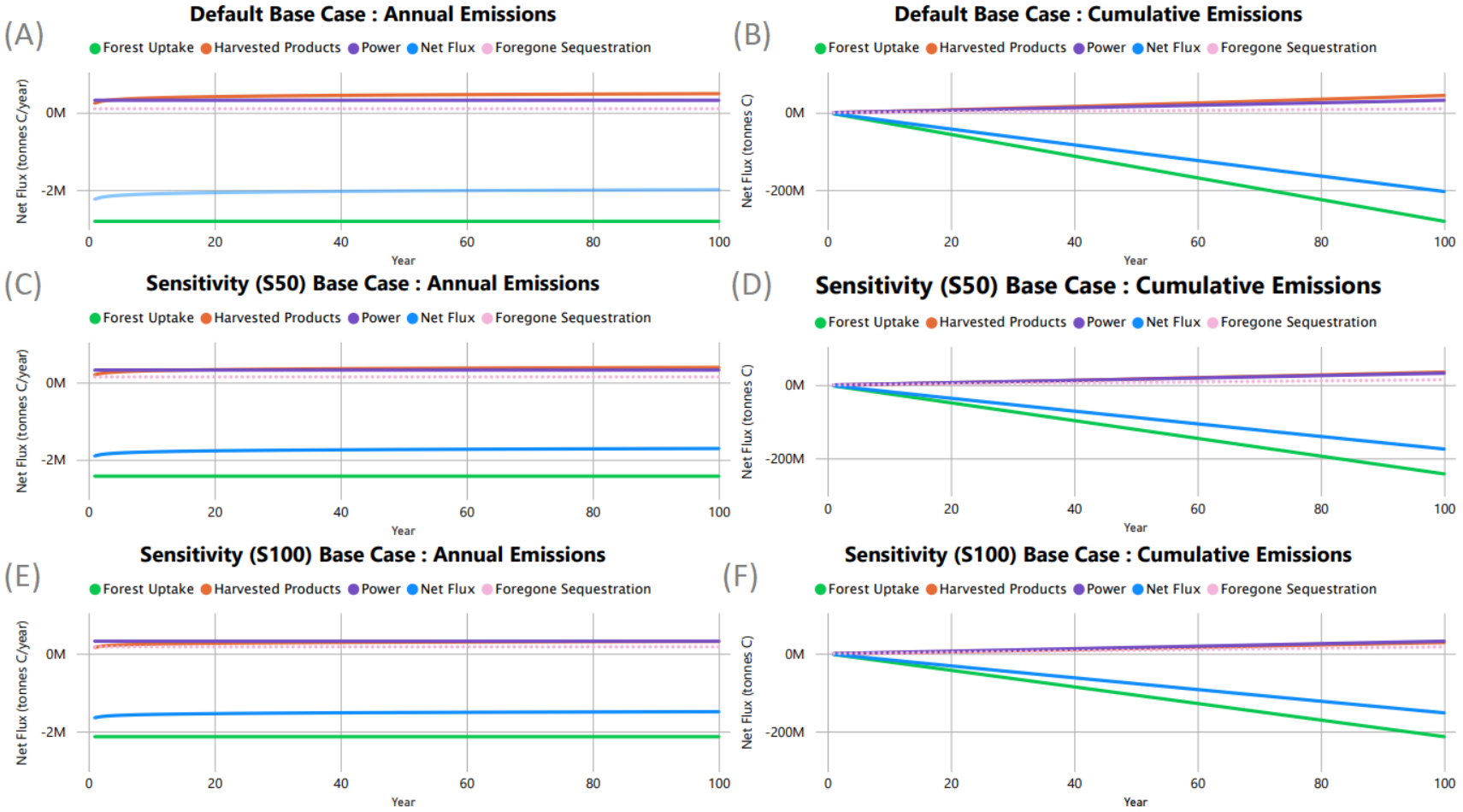

Figure 4. *Fluxes and* ***FOREGONE SEQUESTRATION*** *for the default* ***BASE*** *case (upper), S50 sensitivity analysis (middle), and S100 sensitivity analysis (lower). All annual fluxes (left panels) are plotted on the same axes. All cumulative fluxes (right panels) are plotted on the same axes. For magnitude values, see* ***Appendix Tables A1-A3.***

3.2 ALTERNATIVE Cases

Table 2 summarizes estimated magnitudes of *annual* fluxes for three **ALTERNATIVE** cases in which it was assumed that harvest residuals cannot be consumed to produce bioelectricity. The flux magnitudes are per year for given years, to illustrate how some fluxes exhibit different magnitudes in different years. The values in **Table 2** do not correspond to cumulative values.

Figure 5 summarizes annual and cumulative emissions for the **ALTERNATIVE** cases over the 100-year period corresponding to 2028-2127. As in the **BASE** case results, **Figure 5** illustrates how **FOREST ECOSYSTEM** flux magnitude strongly influences overall **NET** flux magnitudes. **SITE PREP BURN** emissions from combustion of harvest residuals exhibit the same flux magnitude each year. In contrast, the **DECOMPOSITION** flux starts out quite small and increases over time, reflecting accumulating decay of more and more previous years' harvests in later years. Numerical quantities corresponding to **Figure 5** are summarized in **Appendix Table A4-A6.**

Table 2. *Flux magnitudes for the* ***ALTERNATIVE*** *cases. Units are tonne C/year. Values are annual (i.e., not cumulative).*

Flux or Other Relevant Quantity	Case		
	DECOMPOSITION	SITE PREP BURN	FOREST CONVERSION
FOREST ECOSYSTEM flux (C uptake per acre × IPCC multiplier × A_F × f_D)	Same value for all years, -2.8E6	Same value for all years, -2.8E6	Value changes per year, Year 1 = -2.8E6 Year 100 = -1.8E6
HARVEST PRODUCTS flux (C uptake per acre × IPCC multiplier × A_F × f_D)	Value changes per year, Year 1 = 2.5E5 Year 100 = 4.9E5	Value changes per year, Year 1 = 2.5E5 Year 100 = 4.9E5	Value changes per year, Year 1 = 2.5E5 Year 100 = 3.1E5
HARVEST RESIDUALS MANAGEMENT flux (decomposition or site prep burn)	Value changes per year, Year 1 = 5.5E3 Year 100 = 2.5E5	Same value for all years, 2.6E5	Value changes per year, Year 1 = 2.6E5, Year 10 = 7.3E5 Year 99 = 1.6E5, Year 100 = 4.6E5
POWER flux – "PJM & Virginia" Scenario (GWP × MWh per year), GWP = 332 kg CO2e/MWh	Same value for all years, 6.9E4	Same value for all years, 6.9E4	Same value for all years, 6.9E4
POWER flux – "VCEA" Scenario (GWP × MWh per year), GWP = 332 kg CO2e/MWh for 2028, 2029 GWP = 232 kg CO2e/MWh for 2030-2044 GWP = 39 kg CO2e/MWh for 2045-2127	Value changes per year, Year 1 = 6.9E4, Year 3-17 = 4.8E4 Year 18-100 = 8.1E3	Value changes per year, Year 1 = 6.9E4, Year 3-17 = 4.8E4 Year 18-100 = 8.1E3	Value changes per year, Year 1 = 6.9E4, Year 3-17 = 4.8E4 Year 18-100 = 8.1E3
ANNUAL NET FLUX – "PJM & Virginia" Scenario (Equation 1)	Value changes per year, Year 1 = -2.5E6 Year 100 = -2.0E6	Value changes per year, Year 1 = -2.2E6 Year 100 = -2.0E6	Value changes per year, Year 1 = -2.2E6 Year 100 = -9.3E5
ANNUAL NET FLUX – "VCEA" Scenario (Equation 1)	Value changes per year, Year 1 = -2.5E6 Year 100 = -2.1E6	Value changes per year, Year 1 = -2.2E6 Year 100 = -2.1E6	Value changes per year, Year 1 = -2.2E6 Year 100 = -9.9E5

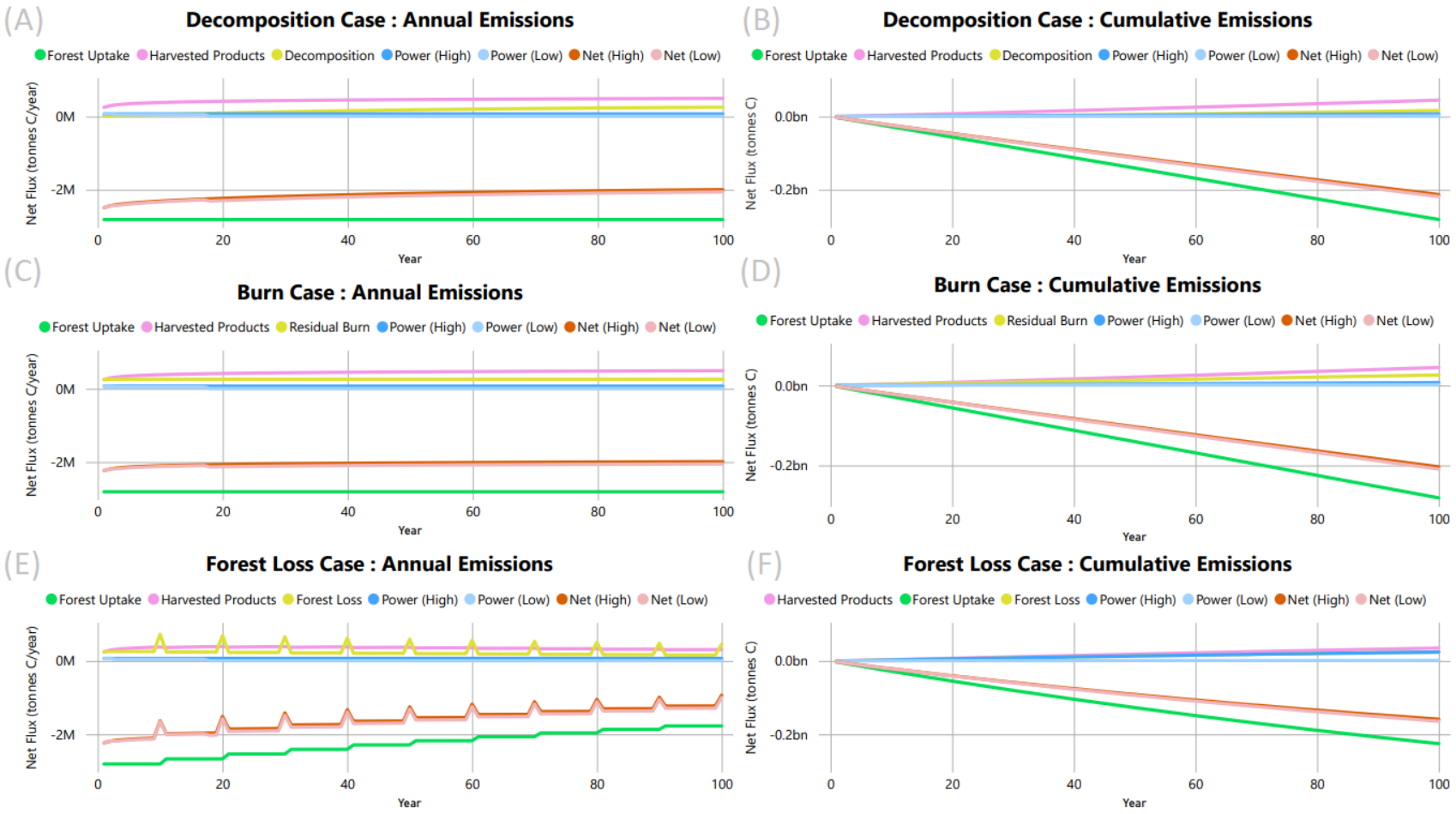

Figure 5. *Fluxes for the* ***DECOMPOSITION ALTERNATIVE*** *case (Panels A & B),* ***SITE PREP BURN ALTERNATIVE*** *case (Panels C & D), and* ***FOREST CONVERSION*** *case (Panels E &F). All annual fluxes (left panels) are plotted on the same axes. All cumulative fluxes (right panels) are plotted on the same axes. For flux magnitude values, see* ***Appendix Tables A4-A6.***

Comparison of results in **Figures 4 and 5** (and **Tables A1-A6**) yields conclusions about the carbon impacts of each **BASE** case relative to each **ALTERNATIVE** case. **Table 3** summarizes pairwise comparisons among cases at three selected years: 2028 (modeled Year 1), 2050 (modeled Year 23), and 2127 (modeled Year 100). These timepoints are highlighted to help illustrate which option (**BASE** or **ALTERNATIVE**) is preferred at the start and end of the analysis and as of 2050, which corresponds to the target for achievement of a zero-carbon electricity sector in Virginia under the *Virginia Clean Economy Act*. **Table 3** includes color-coded shading to help facilitate interpretation for each pairwise comparison. *Green* shading indicates a comparison in which cumulative **NET** flux for the **BASE** case is less than (more negative) than the **ALTERNATIVE** case. *Red* shading indicates the opposite outcome, whereby a **BASE** case exhibits higher (less negative) cumulative **NET** flux than the **ALTERNATIVE**. Shading is used to highlight *nominal* differences between cases that are greater than or equal to 10%. A full quantitative uncertainty analysis was not conducted in this study (see Section 4.2), which means it is not possible to formally assess the statistical significance in apparent differences between cases. Nevertheless, the 10% threshold was selected to facilitate convenient *informal* interpretation of results.

Summarizing the outcomes of relevant pairwise comparisons, the **DEFAULT BASE** case exhibits cumulative **NET** emissions that are considerably higher (less negative) than in the **DECOMPOSITION** case at the start of the modeled 100-year interval, but the difference in emissions between both cases decreases over time. In contrast, the **DEFAULT BASE** and **SITE PREP BURN** cases have approximately the same **NET** emissions for all modeled years. Finally, the **DEFAULT BASE** case exhibits markedly lower emissions than the **FOREST CONVERSION** case. In contrast, the **S50 and S100 BASE** cases exhibit higher (less negative) emissions than all three **ALTERNATIVE** cases. The only exception to this trend is the comparison between the **S50 BASE** and **FOREST CONVERSION** cases, in which **S50 BASE** starts out with higher (less negative) emissions but than transitions to lower (more negative) emissions breaking even in 2090 or 2099 under the **VA/PJM** and **VCEA POWER** scenarios, respectively.

Table 3. *Summary of comparisons between* ***BASE*** *case and* ***ALTERNATIVE*** *cases. Shading highlights pairwise comparisons in which the nominal difference between cases is ≥10%. Green indicates that the* ***BASE*** *case is preferred. Red indicates that the* ***ALTERNATIVE*** *case is preferred. Shading is meant to facilitate convenient informal comparison – determinations are not based on formal statistical comparison.*

BASE Case	ALTERNATIVE	Year 1 (2028) Cumulative **NET** Flux Comparison	Year 23 (2050) Cumulative **NET** Flux Comparison	Year 100 (2127) Cumulative **NET** Flux Comparison	Summary of Comparison [including **breakeven year**]
DEFAULT	DECOMPOSITION, VA/PJM POWER	BASE is 10% larger (less negative)	BASE is 9% larger (less negative)	BASE is 4% larger (less negative)	No breakeven. BASE case has less negative NET emissions than the DECOMPOSITION ALTERNATIVE for all modeled years, though difference decreases over time.
	DECOMPOSITION, VCEA POWER	BASE is 10% larger (less negative)	BASE is 10% larger (less negative)	BASE is 7% larger (less negative)	
DEFAULT	SITE PREP BURN, VA/PJM POWER	BASE and ALTERNATIVE are essentially the same.	BASE and ALTERNATIVE are essentially the same.	BASE and ALTERNATIVE are essentially the same.	No breakeven. BASE case has approximately the same NET emissions as the SITE PREP BURN ALTERNATIVE for all modeled years.
	SITE PREP BURN, VCEA POWER	BASE and ALTERNATIVE are essentially the same.	BASE is 1% larger (less negative)	BASE is 2% larger (less negative)	
DEFAULT	FOREST CONVERSION, VA/PJM POWER	BASE and ALTERNATIVE are essentially the same.	BASE is 6% smaller (more negative)	BASE is 28% smaller (more negative)	BASE and FOREST CONVERSION ALT cases start off with approximately same emissions, but BASE becomes more negative than the ALTERNATIVE over time.
	FOREST CONVERSION, VCEA POWER	BASE and ALTERNATIVE are essentially the same.	BASE is 4% smaller (more negative)	BASE is 24% smaller (more negative)	
S50	DECOMPOSITION, VA/PJM POWER	BASE is 24% larger (less negative)	BASE is 22% larger (less negative)	BASE is 18% larger (less negative)	No breakeven. BASE case has appreciably less negative NET emissions than DECOMPOSITION ALT for all modeled years.
	DECOMPOSITION, VCEA POWER	BASE is 24% larger (less negative)	BASE is 23% larger (less negative)	BASE is 20% larger (less negative)	
S50	SITE PREP BURN, VA/PJM POWER	BASE is 15% larger (less negative)	BASE is 15% larger (less negative)	BASE is 14% larger (less negative)	No breakeven. BASE case has appreciably less negative NET emissions than SITE PREP BURN ALTERNATIVE for all modeled years.
	SITE PREP BURN, VCEA POWER	BASE is 15% larger (less negative)	BASE is 16% larger (less negative)	BASE is 16% larger (less negative)	

Table 3. *Continued from previous page.*

BASE Case	ALTERNATIVE	Year 1 (2028) Cumulative **NET** Flux Comparison	Year 23 (2050) Cumulative **NET** Flux Comparison	Year 100 (2127) Cumulative **NET** Flux Comparison	Summary of Comparison [including **breakeven year**]
S50	FOREST CONVERSION, VA/PJM POWER	BASE is 15% larger (less negative)	BASE is 10% larger (less negative)	BASE is 10% smaller (more negative)	BASE case starts out with less negative NET emissions than FOREST CONV ALT but ends with more NET negative emissions. Breakeven year is 2090 for PJM/VA power and 2099 for VCEA power.
	FOREST CONVERSION, VCEA POWER	BASE is 15% larger (less negative)	BASE is 11% larger (less negative)	BASE is 6% smaller (more negative)	
S100	DECOMPOSITION, VA/PJM POWER	BASE is 34% larger (less negative)	BASE is 32% larger (less negative)	BASE is 29% larger (less negative)	No breakeven. BASE case has appreciably less negative NET emissions than DECOMPOSITION ALT for all modeled years.
	DECOMPOSITION, VCEA POWER	BASE is 34% larger (less negative)	BASE is 33% larger (less negative)	BASE is 30% larger (less negative)	
S100	SITE PREP BURN, VA/PJM POWER	BASE is 26% larger (less negative)	BASE is 26% larger (less negative)	BASE is 25% larger (less negative)	No breakeven. BASE case has appreciably less negative NET emissions than SITE PREP BURN ALT for all modeled years
	SITE PREP BURN, VCEA POWER	BASE is 26% larger (less negative)	BASE is 27% larger (less negative)	BASE is 27% larger (less negative)	
S100	FOREST CONVERSION, VA/PJM POWER	BASE is 26% larger (less negative)	BASE is 21% larger (less negative)	BASE is 4% larger (less negative)	No breakeven. BASE case has appreciably less negative NET emissions than FOREST CONVERSION ALT for all modeled years, though difference decreases over time.
	FOREST CONVERSION, VCEA POWER	BASE is 26% larger (less negative)	BASE is 23% larger (less negative)	BASE is 7% larger (less negative)	

The three hypothetical **ALTERNATIVE** cases assume that the magnitudes of the **FOREST ECOSYSTEM** and **HARVEST PRODUCT** fluxes remain the same as in the **DEFAULT BASE** case. This mathematical framing reflects the assumption that harvest practice would remain the *same* (in frequency and volume) regardless of whether there is a biomass energy market. This assumption is based on input from stakeholders who argue that higher value wood products are what drive harvest decision-making and logging business models, and that biomass energy markets merely influence behavior *after* harvest, by providing incentive for forest landowners to invest in re-establishing and managing their future forest. They argue that removal of tops, limbs, and smaller trees creates less competition such that new trees can grow back and sequester carbon more quickly. However, other stakeholders assert that the biomass market *increases* harvesting beyond what would otherwise occur, including harvest of roundwood for use as fuelwood. They argue that loss of the biomass market would likely decrease the acreage harvested per year, citing work by Garrin et al., (2022). Such a change would increase the magnitude of the **FOREST ECOSYSTEM** flux and simultaneously decrease the magnitude of the **HARVEST PRODUCT** flux compared to the **BASE** cases. Both changes would contribute to lower (more negative) **NET** emissions than were computed in this study. Relatedly, some stakeholders contend that the existing market for low value wood significantly contributes to the maintenance of a viable forest economy by making it cost-effective for forest owners to have their timber harvested (TNCV, 2024). The anticipation that loss of the biomass market would make it not cost-effective for forest owners to harvest their timber as frequently as in the past was part of the motivation for including the **FOREST CONVERSION** case. It addresses the possibility that economic hardship could lead forest owners to seek out alternative land uses, which would also result in reduced carbon uptake over time as forest acreage is cleared for other uses.

It is unknown to what extent each individual **ALTERNATIVE** case would occur if harvest residuals could no longer be consumed to produce electricity. Individual landowners could choose different management strategies, such that the aggregate result could reflect combination of one or all **ALTERANTIVE** cases. Results in **Table 3** illustrate that the **DECOMPOSITION** case exhibits lower (more negative) emissions than the **SITE PREP BURN**, which in turn exhibits lower emissions than the **FOREST CONVERSION** case. It is also currently unknown what the future composition of the PJM and Virginia grid mixes will be. Therefore, the two replacement **POWER** scenarios were intended to bound the range of future electricity GWP. The "PJM & VA" scenario likely corresponds to the maximum emissions for replacement power. The "VCEA" scenario likely corresponds to the minimum emissions for replacement power. The results in **Table 3** illustrate that the assignment of replacement **POWER** GWP has relatively little influence on the comparison between each pairing of **BASE** and **ALTERNATIVE** cases.

Finally, an additional consideration when comparing cumulative **NET** fluxes between the **BASE** and **ALTERNATIVE** cases pertains to the origin of the carbon emitted – specifically, whether it is derived from *biogenic* or *fossil* sources. For the **BASE** cases, all fluxes constituted biogenic carbon except **P&T**. For the **ALTERNATIVE** cases, all fluxes constituted biogenic carbon except for the portion of the **POWER** flux that comes from fossil sources. For the VA/PJM scenario, approximately 52-65% of current electricity emissions are derived from fossil sources (i.e., coal and natural gas). For the VCEA scenario, it was assumed that the fossil content starts at the same value as the VA/PJM scenario but then decreases over time. By 2045, it is assumed that all replacement electricity comes from renewable (non-fossil) sources; however, some amount of fossil carbon inputs will likely be embedded in the infrastructure to produce and store the renewable sources. For example, storage accounts for approximately 40% of the GWP for solar with battery and 70% of the GWP for wind with battery (NREL, 2021). Using these estimates, it was possible to estimate how much fossil carbon is emitted per MWh of electricity in each modeled case. Resulting values were 4.3 kg fossil Ce per MWh in the **BASE** cases, 52.5 kg fossil Ce per MWh in the

ALTERNATIVE cases with **VA/PJM POWER**, and 18.3 kg fossil Ce per MWh per for the **ALTERNATIVE** cases with **VCEA POWER** (starting in 2045). All **BASE** cases (default, S50, and S100) have the same fossil emissions value. Similarly, all **ALTERNATIVE** cases have the same fossil emissions value within a particular **POWER** scenario (PJM/VA vs. VCEA).

3.3 Foregone Sequestration

The very large magnitudes of **FOREST ECOSYSTEM** flux computed for all **BASE** and **ALTERNATIVE** cases make it challenging to meaningfully compare differences in other fluxes. This difficulty is compounded by the subtly of accurately apportioning forest carbon uptake, whereby the fluxes in **Tables 1 and 2** account for all portions of harvested trees, even though the majority of the mass is accounted for in the bole not the harvest residuals. Relatedly, determining what fraction of forest should be "assigned to Dominion" (f_D) requires LCA judgement, insofar as there is no way to say with certainty that activities occurring in particular subsections of the forest truly "correspond" to operation of the three facilities of interest. Finally, results in **Figures 4 and 5** do not meaningfully make use of **FOREGONE SEQUESTRATION** estimates.

To address these challenges, this study also included a simplified carbon balance that does not explicitly account for **FOREST ECOSYSTEM** or **HARVEST PRODUCT** fluxes. In the simplified analysis, it was assumed that carbon taken up into the portions of trees that become harvest residuals "cancels out" when the materials are combusted, such that the difference between forest uptake and **BASE**-case **POWER** emissions is essentially zero. Making this simplification, it was then possible to compare the sum of **FOREGONE SEQUESTRATION** plus **P&T** emissions under the **BASE** case with the sum of replacement **POWER** plus **DECOMPOSITION** or **SITE PREP BURN** emissions under each **ALTERNATIVE** case. These comparisons were computed over the same 100-year timeframe as was used in the full life-cycle calculations.

Table 4 summarizes results from the simplified carbon balance analysis. **BASE** case results are shown at far left to facilitate comparison with various **ALTERNATIVE** cases in columns to the right. The annotations in the table indicate to what extent a **BASE** case is preferred to each **ALTERNATIVE** case over the course of the 100-year analysis. For example, in the first table, the default **BASE** case is compared to four **ALTERNATIVE** cases. Red shading in the columns for **SITE PREP BURN** with **VCEA POWER** and **SITE PREP BURN** with **VA/PJM POWER** indicates that the default **BASE** case is preferred to each of the latter case for all years of the modeled 100-year period. For comparisons where a **BASE** case starts out less preferred (higher cumulative **NET** flux) than a given **ALTERNATIVE** case, two outlined cells are shown in the same row to highlight the year in which the **BASE** case becomes preferred. For example, the default **BASE** case becomes preferred over the **DECOMPOSITION** with **VA/PJM POWER** cases and the **DECOMPOSITION** with **VCEA POWER** cases in 2041 and 2059, respectively. Notably, there are no comparisons in which the **BASE** case is never preferred over the 100-year interval. Finally, the **FOREST CONVERSION** cases had even higher cumulative net fluxes than the **SITE PREP BURN** cases in every year, such that it was also never preferred over the **BASE** case.

Table 4. *Results from a simplified carbon balance that excludess* ***FOREST ECOSYSTEM*** *and* ***HARVESTED PRODUCTS*** *fluxes, to better articulate comparisons among other fluxes and* ***FOREGONE SEQUESTRATION*** *.*
Gray shading highlights "decadal" years (e.g., 2030, 2040, etc.). Unshaded years are include to show change in preference between BASE and ALTERNATIVE cases (i.e., breakeven year)

		BASE CASE (DEFAULT)				DECOMP ALTERNATIVE, VCEA POWER				BURN ALTERNATIVE, VCEA POWER				DECOMP ALTERNATIVE, VA/PJM POWER				BURN ALTERNATIVE, VA/PJM POWER			
YEAR	#	FOREGONE SEQ.	CHIP & TRANS	ANNUAL SUM	CUMULATIVE SUM	REPLACEMENT POWER (LOW/VCEA)	RESIDUALS DECOMP	ANNUAL SUM	CUMULATIVE SUM	REPLACEMENT POWER (LOW/VCEA)	BURN	ANNUAL SUM	CUMULATIVE SUM	REPLACEMENT POWER (VA/PJM)	RESIDUALS DECOMP	ANNUAL SUM	CUMULATIVE SUM	REPLACEMENT POWER (VA/PJM)	RESIDUALS BURN	ANNUAL SUM	CUMULATIVE SUM
2028	1	1.03E+05	3.30E+03	1.06E+05	1.06E+05	6.93E+04	5.53E+03	7.48E+04	7.48E+04	6.93E+04	2.59E+05	3.28E+05	3.28E+05	6.93E+04	5.53E+03	7.48E+04	7.48E+04	6.93E+04	2.59E+05	3.28E+05	3.28E+05
2030	3	1.03E+05	3.30E+03	1.06E+05	3.18E+05	4.84E+04	1.63E+04	6.47E+04	2.20E+05	4.84E+04	2.59E+05	3.07E+05	9.63E+05	6.93E+04	1.63E+04	8.56E+04	2.41E+05	6.93E+04	2.59E+05	3.28E+05	9.84E+05
2040	13	1.03E+05	3.30E+03	1.06E+05	1.38E+06	4.84E+04	6.43E+04	1.13E+05	1.14E+06	4.84E+04	2.59E+05	3.07E+05	4.03E+06	6.93E+04	6.43E+04	1.34E+05	1.37E+06	6.93E+04	2.59E+05	3.28E+05	4.26E+06
2041	14	1.03E+05	3.30E+03	1.06E+05	1.49E+06	4.84E+04	6.87E+04	1.17E+05	1.26E+06	4.84E+04	2.59E+05	3.07E+05	4.34E+06	6.93E+04	6.87E+04	1.38E+05	1.51E+06	6.93E+04	2.59E+05	3.28E+05	4.59E+06
2050	23	1.03E+05	3.30E+03	1.06E+05	2.44E+06	8.14E+03	1.04E+05	1.12E+05	2.25E+06	8.14E+03	2.59E+05	2.67E+05	6.86E+06	6.93E+04	1.04E+05	1.73E+05	2.93E+06	6.93E+04	2.59E+05	3.28E+05	7.54E+06
2059	32	1.03E+05	3.30E+03	1.06E+05	3.40E+06	8.14E+03	1.34E+05	1.42E+05	3.41E+06	8.14E+03	2.59E+05	2.67E+05	9.27E+06	6.93E+04	1.34E+05	2.03E+05	4.64E+06	6.93E+04	2.59E+05	3.28E+05	1.05E+07
2060	33	1.03E+05	3.30E+03	1.06E+05	3.50E+06	8.14E+03	1.37E+05	1.45E+05	3.56E+06	8.14E+03	2.59E+05	2.67E+05	9.53E+06	6.93E+04	1.37E+05	2.06E+05	4.85E+06	6.93E+04	2.59E+05	3.28E+05	1.08E+07
2070	43	1.03E+05	3.30E+03	1.06E+05	4.56E+06	8.14E+03	1.65E+05	1.73E+05	5.17E+06	8.14E+03	2.59E+05	2.67E+05	1.22E+07	6.93E+04	1.65E+05	2.34E+05	7.07E+06	6.93E+04	2.59E+05	3.28E+05	1.41E+07
2080	53	1.03E+05	3.30E+03	1.06E+05	5.62E+06	8.14E+03	1.87E+05	1.95E+05	7.02E+06	8.14E+03	2.59E+05	2.67E+05	1.49E+07	6.93E+04	1.87E+05	2.57E+05	9.54E+06	6.93E+04	2.59E+05	3.28E+05	1.74E+07
2090	63	1.03E+05	3.30E+03	1.06E+05	6.69E+06	8.14E+03	2.06E+05	2.14E+05	9.08E+06	8.14E+03	2.59E+05	2.67E+05	1.75E+07	6.93E+04	2.06E+05	2.75E+05	1.22E+07	6.93E+04	2.59E+05	3.28E+05	2.07E+07
2100	73	1.03E+05	3.30E+03	1.06E+05	7.75E+06	8.14E+03	2.22E+05	2.30E+05	1.13E+07	8.14E+03	2.59E+05	2.67E+05	2.02E+07	6.93E+04	2.22E+05	2.91E+05	1.51E+07	6.93E+04	2.59E+05	3.28E+05	2.39E+07
2110	83	1.03E+05	3.30E+03	1.06E+05	8.81E+06	8.14E+03	2.35E+05	2.43E+05	1.37E+07	8.14E+03	2.59E+05	2.67E+05	2.29E+07	6.93E+04	2.35E+05	3.04E+05	1.80E+07	6.93E+04	2.59E+05	3.28E+05	2.72E+07
2120	93	1.03E+05	3.30E+03	1.06E+05	9.87E+06	8.14E+03	2.46E+05	2.54E+05	1.62E+07	8.14E+03	2.59E+05	2.67E+05	2.55E+07	6.93E+04	2.46E+05	3.15E+05	2.11E+07	6.93E+04	2.59E+05	3.28E+05	3.05E+07
2127	100	1.03E+05	3.30E+03	1.06E+05	1.06E+07	8.14E+03	2.53E+05	2.61E+05	1.80E+07	8.14E+03	2.59E+05	2.67E+05	2.74E+07	6.93E+04	2.53E+05	3.22E+05	2.34E+07	6.93E+04	2.59E+05	3.28E+05	3.28E+07

		BASE CASE ($100)				DECOMP ALTERNATIVE, VCEA POWER				BURN ALTERNATIVE, VCEA POWER				DECOMP ALTERNATIVE, VA/PJM POWER				BURN ALTERNATIVE, VA/PJM POWER			
YEAR	#	FOREGONE SEQ.	CHIP & TRANS	ANNUAL SUM	CUMULATIVE SUM	REPLACEMENT POWER (LOW/VCEA)	RESIDUALS DECOMP	ANNUAL SUM	CUMULATIVE SUM	REPLACEMENT POWER (LOW/VCEA)	BURN	ANNUAL SUM	CUMULATIVE SUM	REPLACEMENT POWER (VA/PJM)	RESIDUALS DECOMP	ANNUAL SUM	CUMULATIVE SUM	REPLACEMENT POWER (VA/PJM)	RESIDUALS BURN	ANNUAL SUM	CUMULATIVE SUM
2028	1	1.76E+05	3.30E+03	1.79E+05	1.79E+05	6.93E+04	5.53E+03	7.48E+04	7.48E+04	6.93E+04	2.59E+05	3.28E+05	3.28E+05	6.93E+04	5.53E+03	7.48E+04	7.48E+04	6.93E+04	2.59E+05	3.28E+05	3.28E+05
2030	3	1.76E+05	3.30E+03	1.79E+05	5.38E+05	4.84E+04	1.63E+04	6.47E+04	2.20E+05	4.84E+04	2.59E+05	3.07E+05	9.63E+05	6.93E+04	1.63E+04	8.56E+04	2.41E+05	6.93E+04	2.59E+05	3.28E+05	9.84E+05
2040	13	1.76E+05	3.30E+03	1.79E+05	2.33E+06	4.84E+04	6.43E+04	1.13E+05	1.14E+06	4.84E+04	2.59E+05	3.07E+05	4.03E+06	6.93E+04	6.43E+04	1.34E+05	1.37E+06	6.93E+04	2.59E+05	3.28E+05	4.26E+06
2050	23	1.76E+05	3.30E+03	1.79E+05	4.12E+06	8.14E+03	1.04E+05	1.12E+05	2.25E+06	8.14E+03	2.59E+05	2.67E+05	6.86E+06	6.93E+04	1.04E+05	1.73E+05	2.93E+06	6.93E+04	2.59E+05	3.28E+05	7.54E+06
2060	33	1.76E+05	3.30E+03	1.79E+05	5.92E+06	8.14E+03	1.37E+05	1.45E+05	3.56E+06	8.14E+03	2.59E+05	2.67E+05	9.53E+06	6.93E+04	1.37E+05	2.06E+05	4.85E+06	6.93E+04	2.59E+05	3.28E+05	1.08E+07
2070	43	1.76E+05	3.30E+03	1.79E+05	7.71E+06	8.14E+03	1.65E+05	1.73E+05	5.17E+06	8.14E+03	2.59E+05	2.67E+05	1.22E+07	6.93E+04	1.65E+05	2.34E+05	7.07E+06	6.93E+04	2.59E+05	3.28E+05	1.41E+07
2080	53	1.76E+05	3.30E+03	1.79E+05	9.50E+06	8.14E+03	1.87E+05	1.95E+05	7.02E+06	8.14E+03	2.59E+05	2.67E+05	1.49E+07	6.93E+04	1.87E+05	2.57E+05	9.54E+06	6.93E+04	2.59E+05	3.28E+05	1.74E+07
2090	63	1.76E+05	3.30E+03	1.79E+05	1.13E+07	8.14E+03	2.06E+05	2.14E+05	9.08E+06	8.14E+03	2.59E+05	2.67E+05	1.75E+07	6.93E+04	2.06E+05	2.75E+05	1.22E+07	6.93E+04	2.59E+05	3.28E+05	2.07E+07
2100	73	1.76E+05	3.30E+03	1.79E+05	1.31E+07	8.14E+03	2.22E+05	2.30E+05	1.13E+07	8.14E+03	2.59E+05	2.67E+05	2.02E+07	6.93E+04	2.22E+05	2.91E+05	1.51E+07	6.93E+04	2.59E+05	3.28E+05	2.39E+07
2118	91	1.76E+05	3.30E+03	1.79E+05	1.63E+07	8.14E+03	2.44E+05	2.52E+05	1.57E+07	8.14E+03	2.59E+05	2.67E+05	2.50E+07	6.93E+04	2.44E+05	3.13E+05	2.05E+07	6.93E+04	2.59E+05	3.28E+05	2.98E+07
2120	93	1.76E+05	3.30E+03	1.79E+05	1.67E+07	8.14E+03	2.46E+05	2.54E+05	1.62E+07	8.14E+03	2.59E+05	2.67E+05	2.55E+07	6.93E+04	2.46E+05	3.15E+05	2.11E+07	6.93E+04	2.59E+05	3.28E+05	3.05E+07
2127	100	1.76E+05	3.30E+03	1.79E+05	1.79E+07	8.14E+03	2.53E+05	2.61E+05	1.80E+07	8.14E+03	2.59E+05	2.67E+05	2.74E+07	6.93E+04	2.53E+05	3.22E+05	2.34E+07	6.93E+04	2.59E+05	3.28E+05	3.28E+07

		w BIOMASS POWER (S50)				DECOMP ALTERNATIVE, VCEA POWER				BURN ALTERNATIVE, VCEA POWER				DECOMP ALTERNATIVE, VA/PJM POWER				BURN ALTERNATIVE, VA/PJM POWER			
YEAR	#	FOREGONE SEQ.	CHIP & TRANS	ANNUAL SUM	CUMULATIVE SUM	REPLACEMENT POWER (LOW/VCEA)	RESIDUALS DECOMP	ANNUAL SUM	CUMULATIVE SUM	REPLACEMENT POWER (LOW/VCEA)	BURN	ANNUAL SUM	CUMULATIVE SUM	REPLACEMENT POWER (VA/PJM)	RESIDUALS DECOMP	ANNUAL SUM	CUMULATIVE SUM	REPLACEMENT POWER (VA/PJM)	RESIDUALS BURN	ANNUAL SUM	CUMULATIVE SUM
2028	1	1.45E+05	3.30E+03	1.48E+05	1.48E+05	6.93E+04	5.53E+03	7.48E+04	7.48E+04	6.93E+04	2.59E+05	3.28E+05	3.28E+05	6.93E+04	5.53E+03	7.48E+04	7.48E+04	6.93E+04	2.59E+05	3.28E+05	3.28E+05
2030	3	1.45E+05	3.30E+03	1.48E+05	4.44E+05	4.84E+04	1.63E+04	6.47E+04	2.20E+05	4.84E+04	2.59E+05	3.07E+05	9.63E+05	6.93E+04	1.63E+04	8.56E+04	2.41E+05	6.93E+04	2.59E+05	3.28E+05	9.84E+05
2040	13	1.45E+05	3.30E+03	1.48E+05	1.92E+06	4.84E+04	6.43E+04	1.13E+05	1.14E+06	4.84E+04	2.59E+05	3.07E+05	4.03E+06	6.93E+04	6.43E+04	1.34E+05	1.37E+06	6.93E+04	2.59E+05	3.28E+05	4.26E+06
2050	23	1.45E+05	3.30E+03	1.48E+05	3.40E+06	8.14E+03	1.04E+05	1.12E+05	2.25E+06	8.14E+03	2.59E+05	2.67E+05	6.86E+06	6.93E+04	1.04E+05	1.73E+05	2.93E+06	6.93E+04	2.59E+05	3.28E+05	7.54E+06
2060	33	1.45E+05	3.30E+03	1.48E+05	4.88E+06	8.14E+03	1.37E+05	1.45E+05	3.56E+06	8.14E+03	2.59E+05	2.67E+05	9.53E+06	6.93E+04	1.37E+05	2.06E+05	4.85E+06	6.93E+04	2.59E+05	3.28E+05	1.08E+07
2070	43	1.45E+05	3.30E+03	1.48E+05	6.36E+06	8.14E+03	1.65E+05	1.73E+05	5.17E+06	8.14E+03	2.59E+05	2.67E+05	1.22E+07	6.93E+04	1.65E+05	2.34E+05	7.07E+06	6.93E+04	2.59E+05	3.28E+05	1.41E+07
2080	53	1.45E+05	3.30E+03	1.48E+05	7.84E+06	8.14E+03	1.87E+05	1.95E+05	7.02E+06	8.14E+03	2.59E+05	2.67E+05	1.49E+07	6.93E+04	1.87E+05	2.57E+05	9.54E+06	6.93E+04	2.59E+05	3.28E+05	1.74E+07
2090	63	1.45E+05	3.30E+03	1.48E+05	9.33E+06	8.14E+03	2.06E+05	2.14E+05	9.08E+06	8.14E+03	2.59E+05	2.67E+05	1.75E+07	6.93E+04	2.06E+05	2.75E+05	1.22E+07	6.93E+04	2.59E+05	3.28E+05	2.07E+07
2094	67	1.45E+05	3.30E+03	1.48E+05	9.92E+06	8.14E+03	2.13E+05	2.21E+05	9.96E+06	8.14E+03	2.59E+05	2.67E+05	1.86E+07	6.93E+04	2.13E+05	2.82E+05	1.33E+07	6.93E+04	2.59E+05	3.28E+05	2.20E+07
2100	73	1.45E+05	3.30E+03	1.48E+05	1.08E+07	8.14E+03	2.22E+05	2.30E+05	1.13E+07	8.14E+03	2.59E+05	2.67E+05	2.02E+07	6.93E+04	2.22E+05	2.91E+05	1.51E+07	6.93E+04	2.59E+05	3.28E+05	2.39E+07
2110	83	1.45E+05	3.30E+03	1.48E+05	1.23E+07	8.14E+03	2.35E+05	2.43E+05	1.37E+07	8.14E+03	2.59E+05	2.67E+05	2.29E+07	6.93E+04	2.35E+05	3.04E+05	1.80E+07	6.93E+04	2.59E+05	3.28E+05	2.72E+07
2120	93	1.45E+05	3.30E+03	1.48E+05	1.38E+07	8.14E+03	2.46E+05	2.54E+05	1.62E+07	8.14E+03	2.59E+05	2.67E+05	2.55E+07	6.93E+04	2.46E+05	3.15E+05	2.11E+07	6.93E+04	2.59E+05	3.28E+05	3.05E+07
2127	100	1.45E+05	3.30E+03	1.48E+05	1.48E+07	8.14E+03	2.53E+05	2.61E+05	1.80E+07	8.14E+03	2.59E+05	2.67E+05	2.74E+07	6.93E+04	2.53E+05	3.22E+05	2.34E+07	6.93E+04	2.59E+05	3.28E+05	3.28E+07

LEGEND:
BASE case is always preferred over ALTERNATIVE (i.e., this ALTERNATIVE is never preferred)
BASE case becomes preferred over ALTERNATIVE case in a particular year (two outlined cells are shown in same row) - i.e., breakeven year

4. Conclusions and Limitations

4.1 Conclusions

When full life-cycle accounting was applied, it was observed that the **DEFAULT BASE** case exhibited cumulative **NET** emissions that were slightly higher (less negative) than the **DECOMPOSITION** case and about the same as the **SITE PREP BURN** case. **DEFAULT BASE** case emissions also started out higher (less negative) than the **FOREST CONVERSION** case, but this trend was reversed before the end of the modeled 100-year interval. In contrast, for the S50 and S100 sensitivity analyses, the **BASE** case exhibited higher (less negative) emissions than all three **ALTERNATIVE** cases.

When the simplified analysis incorporating **FOREGONE SEQUESTRATION** was applied, all three **BASE** cases (default, S50, and S100) exhibited lower emissions than the **SITE PREP BURN** and the **FOREST CONVERSION** cases for every year of the 100-year analysis. All three **BASE** cases started out with higher emissions than the **DECOMPOSITION** case, but this trend was reversed over time such that the **BASE** case was also ultimately preferred by the end of the 100-year analysis.

The apparent divergence in conclusions, whereby the **BASE** case seems less preferred than **ALTERNATIVES** in the full life-cycle accounting but more preferred in the simplified accounting, reflects the significant contribution of biogenic **POWER** emissions in the **BASE** case when full life-cycle accounting is applied. Harvest residuals produce relatively low heat output per mass, such that large quantities of carbon emissions are created when they are used as fuel. These emissions are assumed to "cancel" out in the simplified analysis, such that the **BASE** case compares more favorably to the modeled **ALTERNATIVES** than in the full life-cycle comparison.

In conclusion, results from this study do not suggest that use of harvest residuals to produce bioelectricity is definitively better or worse than the modeled **ALTERNATIVES**. It is likely that all three **ALTERNATIVE** approaches would be used to some extent by forest owners in the absence of a biomass energy market, such that the ensemble cumulative **NET** emissions would be somewhere in the range bounded by the three separate cases. Such value would likely be close to the cumulative **NET** value exhibited by the **DEFAULT BASE** case. Results from the sensitivity analyses (S50 and S100) highlight the strong influence of roundwood diversion, whereby the **BASE** case become less preferred to the modeled **ALTERNATIVES** if it assumed that existence of a biomass market contributes to use of roundwood as fuelwood. However, it is unknown to what extent Dominion consumes the roundwood in question.

4.2 Limitations

Various members of the stakeholder advisory panel had markedly different views on some parts of the methodology used in this study. Key topics of disagreement included: parameterization of **FOREGONE SEQUESTRATION**, framing of the **FOREST CONVERSION** case, assignment of replacement **POWER** GWP, the relevance of **SITE PREP BURN** in Virginia, selection of appropriate thresholds for the sensitivity analysis related to roundwood diversion, and possible inclusion of a fourth **ALTERNATIVE** case. The paragraphs below summarize points of view related to each topic.

There was significant discourse regarding parameterization of **FOREGONE SEQUESTRATION**, whereby some panel members argued strongly that this quantity should include not only the carbon mass embodied by certain trees felled during clear-cut harvest (i.e., DBH < 5 and industrial

roundwood used as fuelwood) but also the *additional* carbon those trees would have continued to sequester over time had they been left in place. The relevant panel members referred to several related studies in which such an approach was used (e.g., Schlamadinger and Marland, 1996; Jandl et al., 2007; Bucholz et al., 2021). However, other panel members argued that it is not local practice to leave selected trees standing during commercial harvests, such that small trees are often felled when a stand is harvested, regardless of whether a biomass market exists. Panel members taking the latter view also referenced published studies in which it was observed that younger forests take up carbon more quickly than mature forests (e.g., Pugh et al., 2019), arguing that rapid carbon uptake by new trees growing back after a clear-cut harvest offsets the component of **FOREGONE SEQUESTRATION** corresponding to continued uptake by older trees that could have been left in place. These different points of view, coupled with time limitations, made it such that simulation was not pursued in this study, as would be required to estimate continued carbon uptake over time by the trees that could have hypothetically been left in place. The same stakeholders who objected to the model's parameterization of **FOREGONE SEQUESTRATION** also argued that the analysis failed to account for "leakage" in the framing of the sensitivity analyses related to use of roundwood as fuelwood. These stakeholders argued that use of roundwood as biomass would trigger additional harvests outside of the woodshed (indirect "leakage" effects), as has been accounted for in some relevant studies (e.g., Daigneault et al., 2023).

The panel also had significant discourse related to the framing of the **FOREST CONVERSION** case. The majority view was that loss of a biomass market could contribute to greater economic difficulties for private forest owners, such that they may be more likely to convert their forest into another land use. It was therefore of interest to assess the carbon balance impacts of possible forest loss over time. However, a minority view was that it has not been well documented (based on research, etc.) that loss of a market for forest biomass will contribute to accelerated forest land use change. All panel members acknowledged the difficulty of quantifying forest loss rate, which is how 5% per decade was selected as an arbitrary placeholder. Future work could seek to better parameterize the **FOREST CONVERSION** case and/or assess how sensitive the overall results are to assumptions made in the framing of this case.

Regarding replacement **POWER**, panel members had differing views about whether the ambitious goals for electricity decarbonization under the VCEA will be realistically achievable, given the dramatic rate at which electricity demand is increasing in Virginia and the continued need for dispatchable (non-intermittent) power. As a compromise, the model framing included representations of both the current VA/PJM grid mix and an anticipated grid mix under the VCEA.

The panel had differing views on the extent to which **SITE PREP BURNs** are used for residuals management in Virginia. Some panel members argued that there is not good documentation for such practice in the region of interest and that it is more commonplace for local forest owners to use herbicide for hardwood control. Panel members questioning the relevance of **SITE PREP BURN** argued that the emissions estimates computed for this case were unrealistically high. Other panel members argued that SITE PREP BURNS are widely used in the study region.

There were different perspectives on what threshold levels should be included in the sensitivity analysis related to roundwood diversion. The 50% (S50) and 100% (S100) levels were selected early in the study without any particular significance. Towards the end of the study, some panel members suggested that it might have been more appropriate to assume that Dominion consumes 5% and 25% of the roundwood diverted for use as fuelwood. Unfortunately, there was not enough time to conduct the additional analyses.

It was also suggested at the end of the study that a fourth **ALTERNATIVE** case should have been included, in which it is assumed that existence of a biomass market triggers additional harvests, further increasing **FOREGONE SEQUESTRATION**. There was not enough time for the panel to fully discuss this suggestion or for it to be included in the modeling.

Finally, due to data access challenges and time limitations, this study did not include a fully quantitative uncertainty analysis. This omission makes it challenging to assess to what extent various modeling choices related to the topics referenced above influence the overall results. Lack of formal quantitative uncertainty analysis also makes it impossible to formally evaluate the apparent differences in flux quantities computed for the various cases (i.e., it is not possible to assess whether the apparent differences in **Table 3** constitute statistically significant difference). The relevant ISO standards recommend inclusion of quantitative uncertainty and sensitivity analysis as a best practice for LCA. Accordingly, such analyses could be possible topics for future related study.

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Appendix

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Appendix Table A3 **S100 BASE** case fluxes and other magnitudes
Data corresponds to Figure 4, Panels E and F.

Appendix Table A4 **DECOMPOSITION ALTERNATIVE** cases flux magnitudes
Data corresponds to Figure 5, Panels A and B.

Appendix Table A5 **SITE PREP BURN ALTERNATIVE** cases flux magnitudes
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Appendix Table A6 **FOREST CONVERSION ALTERNATIVE** cases flux magnitudes
Data corresponds to Figure 5, Panels E and F.

Appendix Table A0. *List of acronyms and abbreviations*

A_F	Total forest area in the integrated draw region
Ce	Carbon equivalents (akin to CO2 equivalents)
DBH	Diameter at breast height
f_D	Fraction assigned to Dominion
f_H	Fraction of forest area harvested per year
FIA(DB)	Forest Inventory Analysis (Database)
FU	Functional unit
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
LCA	Life cycle assessment
MWh	Megawatt-hour
PJM	Pennsylvania-New Jersey-Maryland Interconnection
P&T	Processing and transport
S50	Sensitivity analysis for 50% consumption of diverted roundwood
S100	Sensitivity analysis for 100% consumption of diverted roundwood
TPO	Timber Product Outputs
UN FCCC	United Nations Framework Convention on Climate Change
USFS	United States Forest Service
VA	Virginia
VCEA	Virginia Clean Economy Act
(V)DOF	(Virginia) Department of Forestry

Appendix Table A1. Fluxes and other magnitudes for default BASE case. Annual data correspond to Figure 4, Panel A. Cumulative data corresponds to Figure 4, Panel B.

DEFAULT BASE CASE								
YEAR	Time (years)	ANNUAL FOREST UPTAKE	ANNUAL HARVESTED PRODUCT EMISSIONS	ANNUAL POWER EMISSIONS	ANNUAL TRANSPORT & PROCESSING	ANNUAL NET	ANNUAL FOREGONE SEQ	CUMULATIVE NET
2028	1	-2.81E+06	2.48E+05	3.22E+05	3.30E+03	-2.24E+06	1.03E+05	-2.24E+06
2029	2	-2.81E+06	2.95E+05	3.22E+05	3.30E+03	-2.19E+06	1.03E+05	-4.43E+06
2030	3	-2.81E+06	3.19E+05	3.22E+05	3.30E+03	-2.17E+06	1.03E+05	-6.59E+06
2031	4	-2.81E+06	3.35E+05	3.22E+05	3.30E+03	-2.15E+06	1.03E+05	-8.74E+06
2032	5	-2.81E+06	3.47E+05	3.22E+05	3.30E+03	-2.14E+06	1.03E+05	-1.09E+07
2033	6	-2.81E+06	3.56E+05	3.22E+05	3.30E+03	-2.13E+06	1.03E+05	-1.30E+07
2034	7	-2.81E+06	3.64E+05	3.22E+05	3.30E+03	-2.12E+06	1.03E+05	-1.51E+07
2035	8	-2.81E+06	3.71E+05	3.22E+05	3.30E+03	-2.11E+06	1.03E+05	-1.72E+07
2036	9	-2.81E+06	3.77E+05	3.22E+05	3.30E+03	-2.11E+06	1.03E+05	-1.94E+07
2037	10	-2.81E+06	3.82E+05	3.22E+05	3.30E+03	-2.10E+06	1.03E+05	-2.15E+07
2038	11	-2.81E+06	3.87E+05	3.22E+05	3.30E+03	-2.10E+06	1.03E+05	-2.36E+07
2039	12	-2.81E+06	3.91E+05	3.22E+05	3.30E+03	-2.09E+06	1.03E+05	-2.57E+07
2040	13	-2.81E+06	3.95E+05	3.22E+05	3.30E+03	-2.09E+06	1.03E+05	-2.77E+07
2041	14	-2.81E+06	3.98E+05	3.22E+05	3.30E+03	-2.09E+06	1.03E+05	-2.98E+07
2042	15	-2.81E+06	4.02E+05	3.22E+05	3.30E+03	-2.08E+06	1.03E+05	-3.19E+07
2043	16	-2.81E+06	4.05E+05	3.22E+05	3.30E+03	-2.08E+06	1.03E+05	-3.40E+07
2044	17	-2.81E+06	4.08E+05	3.22E+05	3.30E+03	-2.08E+06	1.03E+05	-3.61E+07
2045	18	-2.81E+06	4.11E+05	3.22E+05	3.30E+03	-2.07E+06	1.03E+05	-3.81E+07
2046	19	-2.81E+06	4.13E+05	3.22E+05	3.30E+03	-2.07E+06	1.03E+05	-4.02E+07
2047	20	-2.81E+06	4.16E+05	3.22E+05	3.30E+03	-2.07E+06	1.03E+05	-4.23E+07
2048	21	-2.81E+06	4.18E+05	3.22E+05	3.30E+03	-2.07E+06	1.03E+05	-4.44E+07
2049	22	-2.81E+06	4.20E+05	3.22E+05	3.30E+03	-2.06E+06	1.03E+05	-4.64E+07
2050	23	-2.81E+06	4.23E+05	3.22E+05	3.30E+03	-2.06E+06	1.03E+05	-4.85E+07
2051	24	-2.81E+06	4.25E+05	3.22E+05	3.30E+03	-2.06E+06	1.03E+05	-5.05E+07
2052	25	-2.81E+06	4.27E+05	3.22E+05	3.30E+03	-2.06E+06	1.03E+05	-5.26E+07
2053	26	-2.81E+06	4.29E+05	3.22E+05	3.30E+03	-2.06E+06	1.03E+05	-5.47E+07
2054	27	-2.81E+06	4.30E+05	3.22E+05	3.30E+03	-2.05E+06	1.03E+05	-5.67E+07
2055	28	-2.81E+06	4.32E+05	3.22E+05	3.30E+03	-2.05E+06	1.03E+05	-5.88E+07
2056	29	-2.81E+06	4.34E+05	3.22E+05	3.30E+03	-2.05E+06	1.03E+05	-6.08E+07
2057	30	-2.81E+06	4.35E+05	3.22E+05	3.30E+03	-2.05E+06	1.03E+05	-6.29E+07
2058	31	-2.81E+06	4.37E+05	3.22E+05	3.30E+03	-2.05E+06	1.03E+05	-6.49E+07
2059	32	-2.81E+06	4.39E+05	3.22E+05	3.30E+03	-2.05E+06	1.03E+05	-6.70E+07
2060	33	-2.81E+06	4.40E+05	3.22E+05	3.30E+03	-2.05E+06	1.03E+05	-6.90E+07
2061	34	-2.81E+06	4.41E+05	3.22E+05	3.30E+03	-2.04E+06	1.03E+05	-7.10E+07
2062	35	-2.81E+06	4.43E+05	3.22E+05	3.30E+03	-2.04E+06	1.03E+05	-7.31E+07
2063	36	-2.81E+06	4.44E+05	3.22E+05	3.30E+03	-2.04E+06	1.03E+05	-7.51E+07
2064	37	-2.81E+06	4.45E+05	3.22E+05	3.30E+03	-2.04E+06	1.03E+05	-7.72E+07
2065	38	-2.81E+06	4.47E+05	3.22E+05	3.30E+03	-2.04E+06	1.03E+05	-7.92E+07
2066	39	-2.81E+06	4.48E+05	3.22E+05	3.30E+03	-2.04E+06	1.03E+05	-8.12E+07
2067	40	-2.81E+06	4.49E+05	3.22E+05	3.30E+03	-2.04E+06	1.03E+05	-8.33E+07
2068	41	-2.81E+06	4.50E+05	3.22E+05	3.30E+03	-2.03E+06	1.03E+05	-8.53E+07
2069	42	-2.81E+06	4.52E+05	3.22E+05	3.30E+03	-2.03E+06	1.03E+05	-8.74E+07
2070	43	-2.81E+06	4.53E+05	3.22E+05	3.30E+03	-2.03E+06	1.03E+05	-8.94E+07
2071	44	-2.81E+06	4.54E+05	3.22E+05	3.30E+03	-2.03E+06	1.03E+05	-9.14E+07
2072	45	-2.81E+06	4.55E+05	3.22E+05	3.30E+03	-2.03E+06	1.03E+05	-9.34E+07
2073	46	-2.81E+06	4.56E+05	3.22E+05	3.30E+03	-2.03E+06	1.03E+05	-9.55E+07

2074	47	-2.81E+06	4.57E+05	3.22E+05	3.30E+03	-2.03E+06	1.03E+05	-9.75E+07
2075	48	-2.81E+06	4.58E+05	3.22E+05	3.30E+03	-2.03E+06	1.03E+05	-9.95E+07
2076	49	-2.81E+06	4.59E+05	3.22E+05	3.30E+03	-2.03E+06	1.03E+05	-1.02E+08
2077	50	-2.81E+06	4.60E+05	3.22E+05	3.30E+03	-2.03E+06	1.03E+05	-1.04E+08
2078	51	-2.81E+06	4.61E+05	3.22E+05	3.30E+03	-2.02E+06	1.03E+05	-1.06E+08
2079	52	-2.81E+06	4.62E+05	3.22E+05	3.30E+03	-2.02E+06	1.03E+05	-1.08E+08
2080	53	-2.81E+06	4.63E+05	3.22E+05	3.30E+03	-2.02E+06	1.03E+05	-1.10E+08
2081	54	-2.81E+06	4.64E+05	3.22E+05	3.30E+03	-2.02E+06	1.03E+05	-1.12E+08
2082	55	-2.81E+06	4.64E+05	3.22E+05	3.30E+03	-2.02E+06	1.03E+05	-1.14E+08
2083	56	-2.81E+06	4.65E+05	3.22E+05	3.30E+03	-2.02E+06	1.03E+05	-1.16E+08
2084	57	-2.81E+06	4.66E+05	3.22E+05	3.30E+03	-2.02E+06	1.03E+05	-1.18E+08
2085	58	-2.81E+06	4.67E+05	3.22E+05	3.30E+03	-2.02E+06	1.03E+05	-1.20E+08
2086	59	-2.81E+06	4.68E+05	3.22E+05	3.30E+03	-2.02E+06	1.03E+05	-1.22E+08
2087	60	-2.81E+06	4.69E+05	3.22E+05	3.30E+03	-2.02E+06	1.03E+05	-1.24E+08
2088	61	-2.81E+06	4.69E+05	3.22E+05	3.30E+03	-2.02E+06	1.03E+05	-1.26E+08
2089	62	-2.81E+06	4.70E+05	3.22E+05	3.30E+03	-2.01E+06	1.03E+05	-1.28E+08
2090	63	-2.81E+06	4.71E+05	3.22E+05	3.30E+03	-2.01E+06	1.03E+05	-1.30E+08
2091	64	-2.81E+06	4.72E+05	3.22E+05	3.30E+03	-2.01E+06	1.03E+05	-1.32E+08
2092	65	-2.81E+06	4.72E+05	3.22E+05	3.30E+03	-2.01E+06	1.03E+05	-1.34E+08
2093	66	-2.81E+06	4.73E+05	3.22E+05	3.30E+03	-2.01E+06	1.03E+05	-1.36E+08
2094	67	-2.81E+06	4.74E+05	3.22E+05	3.30E+03	-2.01E+06	1.03E+05	-1.38E+08
2095	68	-2.81E+06	4.75E+05	3.22E+05	3.30E+03	-2.01E+06	1.03E+05	-1.40E+08
2096	69	-2.81E+06	4.75E+05	3.22E+05	3.30E+03	-2.01E+06	1.03E+05	-1.42E+08
2097	70	-2.81E+06	4.76E+05	3.22E+05	3.30E+03	-2.01E+06	1.03E+05	-1.44E+08
2098	71	-2.81E+06	4.77E+05	3.22E+05	3.30E+03	-2.01E+06	1.03E+05	-1.46E+08
2099	72	-2.81E+06	4.77E+05	3.22E+05	3.30E+03	-2.01E+06	1.03E+05	-1.48E+08
2100	73	-2.81E+06	4.78E+05	3.22E+05	3.30E+03	-2.01E+06	1.03E+05	-1.50E+08
2101	74	-2.81E+06	4.79E+05	3.22E+05	3.30E+03	-2.01E+06	1.03E+05	-1.52E+08
2102	75	-2.81E+06	4.79E+05	3.22E+05	3.30E+03	-2.01E+06	1.03E+05	-1.54E+08
2103	76	-2.81E+06	4.80E+05	3.22E+05	3.30E+03	-2.01E+06	1.03E+05	-1.56E+08
2104	77	-2.81E+06	4.81E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.58E+08
2105	78	-2.81E+06	4.81E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.60E+08
2106	79	-2.81E+06	4.82E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.62E+08
2107	80	-2.81E+06	4.82E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.64E+08
2108	81	-2.81E+06	4.83E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.66E+08
2109	82	-2.81E+06	4.84E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.68E+08
2110	83	-2.81E+06	4.84E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.70E+08
2111	84	-2.81E+06	4.85E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.72E+08
2112	85	-2.81E+06	4.85E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.74E+08
2113	86	-2.81E+06	4.86E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.76E+08
2114	87	-2.81E+06	4.86E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.78E+08
2115	88	-2.81E+06	4.87E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.80E+08
2116	89	-2.81E+06	4.87E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.82E+08
2117	90	-2.81E+06	4.88E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.84E+08
2118	91	-2.81E+06	4.88E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.86E+08
2119	92	-2.81E+06	4.89E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.88E+08
2120	93	-2.81E+06	4.89E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.90E+08
2121	94	-2.81E+06	4.90E+05	3.22E+05	3.30E+03	-2.00E+06	1.03E+05	-1.92E+08
2122	95	-2.81E+06	4.91E+05	3.22E+05	3.30E+03	-1.99E+06	1.03E+05	-1.94E+08
2123	96	-2.81E+06	4.91E+05	3.22E+05	3.30E+03	-1.99E+06	1.03E+05	-1.96E+08
2124	97	-2.81E+06	4.91E+05	3.22E+05	3.30E+03	-1.99E+06	1.03E+05	-1.98E+08
2125	98	-2.81E+06	4.92E+05	3.22E+05	3.30E+03	-1.99E+06	1.03E+05	-2.00E+08
2126	99	-2.81E+06	4.92E+05	3.22E+05	3.30E+03	-1.99E+06	1.03E+05	-2.02E+08
2127	100	-2.81E+06	4.93E+05	3.22E+05	3.30E+03	-1.99E+06	1.03E+05	-2.04E+08

Appendix Table A2. Fluxes and other magnitudes for S50 (sensitivity analysis) BASE case. Annual data correspond to Figure 4, Panel C. Cumulative data corresponds to Figure 4, Panel D.

S50 BASE CASE								
YEAR	Time (years)	ANNUAL FOREST UPTAKE	ANNUAL HARVESTED PRODUCT EMISSIONS	ANNUAL POWER EMISSIONS	ANNUAL TRANSPORT & PROCESSING	ANNUAL NET	ANNUAL FOREGONE SEQ	CUMULATIVE NET
2028	1	-2.43E+06	1.99E+05	3.22E+05	3.30E+03	-1.90E+06	1.45E+05	-1.90E+06
2029	2	-2.43E+06	2.36E+05	3.22E+05	3.30E+03	-1.86E+06	1.45E+05	-3.77E+06
2030	3	-2.43E+06	2.55E+05	3.22E+05	3.30E+03	-1.85E+06	1.45E+05	-5.61E+06
2031	4	-2.43E+06	2.67E+05	3.22E+05	3.30E+03	-1.83E+06	1.45E+05	-7.44E+06
2032	5	-2.43E+06	2.76E+05	3.22E+05	3.30E+03	-1.82E+06	1.45E+05	-9.27E+06
2033	6	-2.43E+06	2.84E+05	3.22E+05	3.30E+03	-1.82E+06	1.45E+05	-1.11E+07
2034	7	-2.43E+06	2.90E+05	3.22E+05	3.30E+03	-1.81E+06	1.45E+05	-1.29E+07
2035	8	-2.43E+06	2.95E+05	3.22E+05	3.30E+03	-1.80E+06	1.45E+05	-1.47E+07
2036	9	-2.43E+06	3.00E+05	3.22E+05	3.30E+03	-1.80E+06	1.45E+05	-1.65E+07
2037	10	-2.43E+06	3.04E+05	3.22E+05	3.30E+03	-1.80E+06	1.45E+05	-1.83E+07
2038	11	-2.43E+06	3.08E+05	3.22E+05	3.30E+03	-1.79E+06	1.45E+05	-2.01E+07
2039	12	-2.43E+06	3.11E+05	3.22E+05	3.30E+03	-1.79E+06	1.45E+05	-2.19E+07
2040	13	-2.43E+06	3.14E+05	3.22E+05	3.30E+03	-1.79E+06	1.45E+05	-2.37E+07
2041	14	-2.43E+06	3.17E+05	3.22E+05	3.30E+03	-1.78E+06	1.45E+05	-2.54E+07
2042	15	-2.43E+06	3.20E+05	3.22E+05	3.30E+03	-1.78E+06	1.45E+05	-2.72E+07
2043	16	-2.43E+06	3.22E+05	3.22E+05	3.30E+03	-1.78E+06	1.45E+05	-2.90E+07
2044	17	-2.43E+06	3.24E+05	3.22E+05	3.30E+03	-1.78E+06	1.45E+05	-3.08E+07
2045	18	-2.43E+06	3.27E+05	3.22E+05	3.30E+03	-1.77E+06	1.45E+05	-3.26E+07
2046	19	-2.43E+06	3.29E+05	3.22E+05	3.30E+03	-1.77E+06	1.45E+05	-3.43E+07
2047	20	-2.43E+06	3.31E+05	3.22E+05	3.30E+03	-1.77E+06	1.45E+05	-3.61E+07
2048	21	-2.43E+06	3.33E+05	3.22E+05	3.30E+03	-1.77E+06	1.45E+05	-3.79E+07
2049	22	-2.43E+06	3.34E+05	3.22E+05	3.30E+03	-1.77E+06	1.45E+05	-3.96E+07
2050	23	-2.43E+06	3.36E+05	3.22E+05	3.30E+03	-1.76E+06	1.45E+05	-4.14E+07
2051	24	-2.43E+06	3.38E+05	3.22E+05	3.30E+03	-1.76E+06	1.45E+05	-4.32E+07
2052	25	-2.43E+06	3.39E+05	3.22E+05	3.30E+03	-1.76E+06	1.45E+05	-4.49E+07
2053	26	-2.43E+06	3.41E+05	3.22E+05	3.30E+03	-1.76E+06	1.45E+05	-4.67E+07
2054	27	-2.43E+06	3.42E+05	3.22E+05	3.30E+03	-1.76E+06	1.45E+05	-4.84E+07
2055	28	-2.43E+06	3.43E+05	3.22E+05	3.30E+03	-1.76E+06	1.45E+05	-5.02E+07
2056	29	-2.43E+06	3.45E+05	3.22E+05	3.30E+03	-1.76E+06	1.45E+05	-5.19E+07
2057	30	-2.43E+06	3.46E+05	3.22E+05	3.30E+03	-1.75E+06	1.45E+05	-5.37E+07
2058	31	-2.43E+06	3.47E+05	3.22E+05	3.30E+03	-1.75E+06	1.45E+05	-5.54E+07
2059	32	-2.43E+06	3.49E+05	3.22E+05	3.30E+03	-1.75E+06	1.45E+05	-5.72E+07
2060	33	-2.43E+06	3.50E+05	3.22E+05	3.30E+03	-1.75E+06	1.45E+05	-5.89E+07
2061	34	-2.43E+06	3.51E+05	3.22E+05	3.30E+03	-1.75E+06	1.45E+05	-6.07E+07
2062	35	-2.43E+06	3.52E+05	3.22E+05	3.30E+03	-1.75E+06	1.45E+05	-6.24E+07
2063	36	-2.43E+06	3.53E+05	3.22E+05	3.30E+03	-1.75E+06	1.45E+05	-6.42E+07
2064	37	-2.43E+06	3.54E+05	3.22E+05	3.30E+03	-1.75E+06	1.45E+05	-6.59E+07
2065	38	-2.43E+06	3.55E+05	3.22E+05	3.30E+03	-1.74E+06	1.45E+05	-6.77E+07
2066	39	-2.43E+06	3.56E+05	3.22E+05	3.30E+03	-1.74E+06	1.45E+05	-6.94E+07
2067	40	-2.43E+06	3.57E+05	3.22E+05	3.30E+03	-1.74E+06	1.45E+05	-7.12E+07
2068	41	-2.43E+06	3.58E+05	3.22E+05	3.30E+03	-1.74E+06	1.45E+05	-7.29E+07
2069	42	-2.43E+06	3.59E+05	3.22E+05	3.30E+03	-1.74E+06	1.45E+05	-7.47E+07
2070	43	-2.43E+06	3.60E+05	3.22E+05	3.30E+03	-1.74E+06	1.45E+05	-7.64E+07
2071	44	-2.43E+06	3.61E+05	3.22E+05	3.30E+03	-1.74E+06	1.45E+05	-7.81E+07
2072	45	-2.43E+06	3.61E+05	3.22E+05	3.30E+03	-1.74E+06	1.45E+05	-7.99E+07
2073	46	-2.43E+06	3.62E+05	3.22E+05	3.30E+03	-1.74E+06	1.45E+05	-8.16E+07
2074	47	-2.43E+06	3.63E+05	3.22E+05	3.30E+03	-1.74E+06	1.45E+05	-8.33E+07
2075	48	-2.43E+06	3.64E+05	3.22E+05	3.30E+03	-1.74E+06	1.45E+05	-8.51E+07
2076	49	-2.43E+06	3.65E+05	3.22E+05	3.30E+03	-1.74E+06	1.45E+05	-8.68E+07
2077	50	-2.43E+06	3.65E+05	3.22E+05	3.30E+03	-1.73E+06	1.45E+05	-8.86E+07
2078	51	-2.43E+06	3.66E+05	3.22E+05	3.30E+03	-1.73E+06	1.45E+05	-9.03E+07
2079	52	-2.43E+06	3.67E+05	3.22E+05	3.30E+03	-1.73E+06	1.45E+05	-9.20E+07
2080	53	-2.43E+06	3.68E+05	3.22E+05	3.30E+03	-1.73E+06	1.45E+05	-9.38E+07

2081	54	-2.43E+06	3.68E+05	3.22E+05	3.30E+03	-1.73E+06	1.45E+05	-9.55E+07
2082	55	-2.43E+06	3.69E+05	3.22E+05	3.30E+03	-1.73E+06	1.45E+05	-9.72E+07
2083	56	-2.43E+06	3.70E+05	3.22E+05	3.30E+03	-1.73E+06	1.45E+05	-9.89E+07
2084	57	-2.43E+06	3.70E+05	3.22E+05	3.30E+03	-1.73E+06	1.45E+05	-1.01E+08
2085	58	-2.43E+06	3.71E+05	3.22E+05	3.30E+03	-1.73E+06	1.45E+05	-1.02E+08
2086	59	-2.43E+06	3.72E+05	3.22E+05	3.30E+03	-1.73E+06	1.45E+05	-1.04E+08
2087	60	-2.43E+06	3.72E+05	3.22E+05	3.30E+03	-1.73E+06	1.45E+05	-1.06E+08
2088	61	-2.43E+06	3.73E+05	3.22E+05	3.30E+03	-1.73E+06	1.45E+05	-1.08E+08
2089	62	-2.43E+06	3.73E+05	3.22E+05	3.30E+03	-1.73E+06	1.45E+05	-1.09E+08
2090	63	-2.43E+06	3.74E+05	3.22E+05	3.30E+03	-1.73E+06	1.45E+05	-1.11E+08
2091	64	-2.43E+06	3.75E+05	3.22E+05	3.30E+03	-1.73E+06	1.45E+05	-1.13E+08
2092	65	-2.43E+06	3.75E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.14E+08
2093	66	-2.43E+06	3.76E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.16E+08
2094	67	-2.43E+06	3.76E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.18E+08
2095	68	-2.43E+06	3.77E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.20E+08
2096	69	-2.43E+06	3.77E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.21E+08
2097	70	-2.43E+06	3.78E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.23E+08
2098	71	-2.43E+06	3.79E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.25E+08
2099	72	-2.43E+06	3.79E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.27E+08
2100	73	-2.43E+06	3.80E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.28E+08
2101	74	-2.43E+06	3.80E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.30E+08
2102	75	-2.43E+06	3.81E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.32E+08
2103	76	-2.43E+06	3.81E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.33E+08
2104	77	-2.43E+06	3.82E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.35E+08
2105	78	-2.43E+06	3.82E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.37E+08
2106	79	-2.43E+06	3.83E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.39E+08
2107	80	-2.43E+06	3.83E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.40E+08
2108	81	-2.43E+06	3.83E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.42E+08
2109	82	-2.43E+06	3.84E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.44E+08
2110	83	-2.43E+06	3.84E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.45E+08
2111	84	-2.43E+06	3.85E+05	3.22E+05	3.30E+03	-1.72E+06	1.45E+05	-1.47E+08
2112	85	-2.43E+06	3.85E+05	3.22E+05	3.30E+03	-1.71E+06	1.45E+05	-1.49E+08
2113	86	-2.43E+06	3.86E+05	3.22E+05	3.30E+03	-1.71E+06	1.45E+05	-1.51E+08
2114	87	-2.43E+06	3.86E+05	3.22E+05	3.30E+03	-1.71E+06	1.45E+05	-1.52E+08
2115	88	-2.43E+06	3.87E+05	3.22E+05	3.30E+03	-1.71E+06	1.45E+05	-1.54E+08
2116	89	-2.43E+06	3.87E+05	3.22E+05	3.30E+03	-1.71E+06	1.45E+05	-1.56E+08
2117	90	-2.43E+06	3.87E+05	3.22E+05	3.30E+03	-1.71E+06	1.45E+05	-1.57E+08
2118	91	-2.43E+06	3.88E+05	3.22E+05	3.30E+03	-1.71E+06	1.45E+05	-1.59E+08
2119	92	-2.43E+06	3.88E+05	3.22E+05	3.30E+03	-1.71E+06	1.45E+05	-1.61E+08
2120	93	-2.43E+06	3.89E+05	3.22E+05	3.30E+03	-1.71E+06	1.45E+05	-1.63E+08
2121	94	-2.43E+06	3.89E+05	3.22E+05	3.30E+03	-1.71E+06	1.45E+05	-1.64E+08
2122	95	-2.43E+06	3.89E+05	3.22E+05	3.30E+03	-1.71E+06	1.45E+05	-1.66E+08
2123	96	-2.43E+06	3.90E+05	3.22E+05	3.30E+03	-1.71E+06	1.45E+05	-1.68E+08
2124	97	-2.43E+06	3.90E+05	3.22E+05	3.30E+03	-1.71E+06	1.45E+05	-1.69E+08
2125	98	-2.43E+06	3.91E+05	3.22E+05	3.30E+03	-1.71E+06	1.45E+05	-1.71E+08
2126	99	-2.43E+06	3.91E+05	3.22E+05	3.30E+03	-1.71E+06	1.45E+05	-1.73E+08
2127	100	-2.43E+06	3.91E+05	3.22E+05	3.30E+03	-1.71E+06	1.45E+05	-1.75E+08

Appendix Table A3. Fluxes and other magnitudes for S100 (sensitivity analysis) BASE case. Annual data correspond to Figure 4, Panel E. Cumulative data corresponds to Figure 4, Panel F.

S100 BASE CASE								
YEAR	Time (years)	ANNUAL FOREST UPTAKE	ANNUAL HARVESTED PRODUCT EMISSIONS	ANNUAL POWER EMISSIONS	ANNUAL TRANSPORT & PROCESSING	ANNUAL NET	ANNUAL FOREGONE SEQ	CUMULATIVE NET
2028	1	-2.13E+06	1.61E+05	3.22E+05	3.30E+03	-1.65E+06	1.76E+05	-1.65E+06
2029	2	-2.13E+06	1.91E+05	3.22E+05	3.30E+03	-1.62E+06	1.76E+05	-3.26E+06
2030	3	-2.13E+06	2.06E+05	3.22E+05	3.30E+03	-1.60E+06	1.76E+05	-4.86E+06
2031	4	-2.13E+06	2.16E+05	3.22E+05	3.30E+03	-1.59E+06	1.76E+05	-6.46E+06
2032	5	-2.13E+06	2.24E+05	3.22E+05	3.30E+03	-1.58E+06	1.76E+05	-8.04E+06
2033	6	-2.13E+06	2.30E+05	3.22E+05	3.30E+03	-1.58E+06	1.76E+05	-9.62E+06
2034	7	-2.13E+06	2.35E+05	3.22E+05	3.30E+03	-1.57E+06	1.76E+05	-1.12E+07
2035	8	-2.13E+06	2.39E+05	3.22E+05	3.30E+03	-1.57E+06	1.76E+05	-1.28E+07
2036	9	-2.13E+06	2.43E+05	3.22E+05	3.30E+03	-1.56E+06	1.76E+05	-1.43E+07
2037	10	-2.13E+06	2.46E+05	3.22E+05	3.30E+03	-1.56E+06	1.76E+05	-1.59E+07
2038	11	-2.13E+06	2.49E+05	3.22E+05	3.30E+03	-1.56E+06	1.76E+05	-1.74E+07
2039	12	-2.13E+06	2.52E+05	3.22E+05	3.30E+03	-1.56E+06	1.76E+05	-1.90E+07
2040	13	-2.13E+06	2.54E+05	3.22E+05	3.30E+03	-1.55E+06	1.76E+05	-2.06E+07
2041	14	-2.13E+06	2.57E+05	3.22E+05	3.30E+03	-1.55E+06	1.76E+05	-2.21E+07
2042	15	-2.13E+06	2.59E+05	3.22E+05	3.30E+03	-1.55E+06	1.76E+05	-2.37E+07
2043	16	-2.13E+06	2.61E+05	3.22E+05	3.30E+03	-1.55E+06	1.76E+05	-2.52E+07
2044	17	-2.13E+06	2.63E+05	3.22E+05	3.30E+03	-1.55E+06	1.76E+05	-2.67E+07
2045	18	-2.13E+06	2.64E+05	3.22E+05	3.30E+03	-1.54E+06	1.76E+05	-2.83E+07
2046	19	-2.13E+06	2.66E+05	3.22E+05	3.30E+03	-1.54E+06	1.76E+05	-2.98E+07
2047	20	-2.13E+06	2.68E+05	3.22E+05	3.30E+03	-1.54E+06	1.76E+05	-3.14E+07
2048	21	-2.13E+06	2.69E+05	3.22E+05	3.30E+03	-1.54E+06	1.76E+05	-3.29E+07
2049	22	-2.13E+06	2.70E+05	3.22E+05	3.30E+03	-1.54E+06	1.76E+05	-3.44E+07
2050	23	-2.13E+06	2.72E+05	3.22E+05	3.30E+03	-1.54E+06	1.76E+05	-3.60E+07
2051	24	-2.13E+06	2.73E+05	3.22E+05	3.30E+03	-1.53E+06	1.76E+05	-3.75E+07
2052	25	-2.13E+06	2.74E+05	3.22E+05	3.30E+03	-1.53E+06	1.76E+05	-3.90E+07
2053	26	-2.13E+06	2.76E+05	3.22E+05	3.30E+03	-1.53E+06	1.76E+05	-4.06E+07
2054	27	-2.13E+06	2.77E+05	3.22E+05	3.30E+03	-1.53E+06	1.76E+05	-4.21E+07
2055	28	-2.13E+06	2.78E+05	3.22E+05	3.30E+03	-1.53E+06	1.76E+05	-4.36E+07
2056	29	-2.13E+06	2.79E+05	3.22E+05	3.30E+03	-1.53E+06	1.76E+05	-4.52E+07
2057	30	-2.13E+06	2.80E+05	3.22E+05	3.30E+03	-1.53E+06	1.76E+05	-4.67E+07
2058	31	-2.13E+06	2.81E+05	3.22E+05	3.30E+03	-1.53E+06	1.76E+05	-4.82E+07
2059	32	-2.13E+06	2.82E+05	3.22E+05	3.30E+03	-1.53E+06	1.76E+05	-4.98E+07
2060	33	-2.13E+06	2.83E+05	3.22E+05	3.30E+03	-1.52E+06	1.76E+05	-5.13E+07
2061	34	-2.13E+06	2.84E+05	3.22E+05	3.30E+03	-1.52E+06	1.76E+05	-5.28E+07
2062	35	-2.13E+06	2.85E+05	3.22E+05	3.30E+03	-1.52E+06	1.76E+05	-5.43E+07
2063	36	-2.13E+06	2.85E+05	3.22E+05	3.30E+03	-1.52E+06	1.76E+05	-5.58E+07
2064	37	-2.13E+06	2.86E+05	3.22E+05	3.30E+03	-1.52E+06	1.76E+05	-5.74E+07
2065	38	-2.13E+06	2.87E+05	3.22E+05	3.30E+03	-1.52E+06	1.76E+05	-5.89E+07
2066	39	-2.13E+06	2.88E+05	3.22E+05	3.30E+03	-1.52E+06	1.76E+05	-6.04E+07
2067	40	-2.13E+06	2.89E+05	3.22E+05	3.30E+03	-1.52E+06	1.76E+05	-6.19E+07
2068	41	-2.13E+06	2.89E+05	3.22E+05	3.30E+03	-1.52E+06	1.76E+05	-6.34E+07
2069	42	-2.13E+06	2.90E+05	3.22E+05	3.30E+03	-1.52E+06	1.76E+05	-6.50E+07
2070	43	-2.13E+06	2.91E+05	3.22E+05	3.30E+03	-1.52E+06	1.76E+05	-6.65E+07
2071	44	-2.13E+06	2.92E+05	3.22E+05	3.30E+03	-1.52E+06	1.76E+05	-6.80E+07
2072	45	-2.13E+06	2.92E+05	3.22E+05	3.30E+03	-1.52E+06	1.76E+05	-6.95E+07
2073	46	-2.13E+06	2.93E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-7.10E+07
2074	47	-2.13E+06	2.94E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-7.25E+07
2075	48	-2.13E+06	2.94E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-7.41E+07
2076	49	-2.13E+06	2.95E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-7.56E+07
2077	50	-2.13E+06	2.95E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-7.71E+07
2078	51	-2.13E+06	2.96E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-7.86E+07

2079	52	-2.13E+06	2.97E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-8.01E+07
2080	53	-2.13E+06	2.97E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-8.16E+07
2081	54	-2.13E+06	2.98E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-8.31E+07
2082	55	-2.13E+06	2.98E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-8.46E+07
2083	56	-2.13E+06	2.99E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-8.61E+07
2084	57	-2.13E+06	2.99E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-8.76E+07
2085	58	-2.13E+06	3.00E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-8.92E+07
2086	59	-2.13E+06	3.00E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-9.07E+07
2087	60	-2.13E+06	3.01E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-9.22E+07
2088	61	-2.13E+06	3.01E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-9.37E+07
2089	62	-2.13E+06	3.02E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-9.52E+07
2090	63	-2.13E+06	3.02E+05	3.22E+05	3.30E+03	-1.51E+06	1.76E+05	-9.67E+07
2091	64	-2.13E+06	3.03E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-9.82E+07
2092	65	-2.13E+06	3.03E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-9.97E+07
2093	66	-2.13E+06	3.04E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.01E+08
2094	67	-2.13E+06	3.04E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.03E+08
2095	68	-2.13E+06	3.05E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.04E+08
2096	69	-2.13E+06	3.05E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.06E+08
2097	70	-2.13E+06	3.06E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.07E+08
2098	71	-2.13E+06	3.06E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.09E+08
2099	72	-2.13E+06	3.06E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.10E+08
2100	73	-2.13E+06	3.07E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.12E+08
2101	74	-2.13E+06	3.07E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.13E+08
2102	75	-2.13E+06	3.08E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.15E+08
2103	76	-2.13E+06	3.08E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.16E+08
2104	77	-2.13E+06	3.08E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.18E+08
2105	78	-2.13E+06	3.09E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.19E+08
2106	79	-2.13E+06	3.09E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.21E+08
2107	80	-2.13E+06	3.10E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.22E+08
2108	81	-2.13E+06	3.10E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.24E+08
2109	82	-2.13E+06	3.10E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.25E+08
2110	83	-2.13E+06	3.11E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.27E+08
2111	84	-2.13E+06	3.11E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.28E+08
2112	85	-2.13E+06	3.11E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.30E+08
2113	86	-2.13E+06	3.12E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.31E+08
2114	87	-2.13E+06	3.12E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.33E+08
2115	88	-2.13E+06	3.12E+05	3.22E+05	3.30E+03	-1.50E+06	1.76E+05	-1.34E+08
2116	89	-2.13E+06	3.13E+05	3.22E+05	3.30E+03	-1.49E+06	1.76E+05	-1.36E+08
2117	90	-2.13E+06	3.13E+05	3.22E+05	3.30E+03	-1.49E+06	1.76E+05	-1.37E+08
2118	91	-2.13E+06	3.13E+05	3.22E+05	3.30E+03	-1.49E+06	1.76E+05	-1.39E+08
2119	92	-2.13E+06	3.14E+05	3.22E+05	3.30E+03	-1.49E+06	1.76E+05	-1.40E+08
2120	93	-2.13E+06	3.14E+05	3.22E+05	3.30E+03	-1.49E+06	1.76E+05	-1.42E+08
2121	94	-2.13E+06	3.14E+05	3.22E+05	3.30E+03	-1.49E+06	1.76E+05	-1.43E+08
2122	95	-2.13E+06	3.15E+05	3.22E+05	3.30E+03	-1.49E+06	1.76E+05	-1.45E+08
2123	96	-2.13E+06	3.15E+05	3.22E+05	3.30E+03	-1.49E+06	1.76E+05	-1.46E+08
2124	97	-2.13E+06	3.15E+05	3.22E+05	3.30E+03	-1.49E+06	1.76E+05	-1.48E+08
2125	98	-2.13E+06	3.16E+05	3.22E+05	3.30E+03	-1.49E+06	1.76E+05	-1.49E+08
2126	99	-2.13E+06	3.16E+05	3.22E+05	3.30E+03	-1.49E+06	1.76E+05	-1.51E+08
2127	100	-2.13E+06	3.16E+05	3.22E+05	3.30E+03	-1.49E+06	1.76E+05	-1.52E+08

Appendix Table A4. Fluxes and other magnitudes for the DECOMPOSITION ALTERNATIVE case. Annual data correspond to Figure 5, Panel A. Cumulative data correspond to Figure 5, Panel B.

DECOMPOSITION ALTERNATIVE CASE										
YEAR	Time (years)	ANNUAL FOREST UPTAKE	ANNUAL HARVESTED PRODUCT EMISSIONS	ANNUAL REPLACEMENT POWER EMISSIONS [VA/PJM]	ANNUAL REPLACEMENT POWER EMISSIONS [VCEA]	ANNUAL RESIDUALS MANAGEMENT EMISSIONS	ANNUAL NET [VA/PJM]	ANNUAL NET [VCEA]	CUMULATIVE NET [VA/PJM]	CUMULATIVE NET [VCEA]
2028	1	-2.81E+06	2.48E+05	6.93E+04	6.93E+04	5.53E+03	-2.49E+06	-2.49E+06	-2.49E+06	-2.49E+06
2029	2	-2.81E+06	2.95E+05	6.93E+04	6.93E+04	1.10E+04	-2.43E+06	-2.43E+06	-4.92E+06	-4.92E+06
2030	3	-2.81E+06	3.19E+05	6.93E+04	4.84E+04	1.63E+04	-2.41E+06	-2.43E+06	-7.33E+06	-7.35E+06
2031	4	-2.81E+06	3.35E+05	6.93E+04	4.84E+04	2.15E+04	-2.38E+06	-2.41E+06	-9.71E+06	-9.76E+06
2032	5	-2.81E+06	3.47E+05	6.93E+04	4.84E+04	2.66E+04	-2.37E+06	-2.39E+06	-1.21E+07	-1.21E+07
2033	6	-2.81E+06	3.56E+05	6.93E+04	4.84E+04	3.17E+04	-2.35E+06	-2.37E+06	-1.44E+07	-1.45E+07
2034	7	-2.81E+06	3.64E+05	6.93E+04	4.84E+04	3.66E+04	-2.34E+06	-2.36E+06	-1.68E+07	-1.69E+07
2035	8	-2.81E+06	3.71E+05	6.93E+04	4.84E+04	4.14E+04	-2.33E+06	-2.35E+06	-1.91E+07	-1.92E+07
2036	9	-2.81E+06	3.77E+05	6.93E+04	4.84E+04	4.62E+04	-2.32E+06	-2.34E+06	-2.14E+07	-2.16E+07
2037	10	-2.81E+06	3.82E+05	6.93E+04	4.84E+04	5.09E+04	-2.31E+06	-2.33E+06	-2.37E+07	-2.39E+07
2038	11	-2.81E+06	3.87E+05	6.93E+04	4.84E+04	5.54E+04	-2.30E+06	-2.32E+06	-2.60E+07	-2.62E+07
2039	12	-2.81E+06	3.91E+05	6.93E+04	4.84E+04	5.99E+04	-2.29E+06	-2.31E+06	-2.83E+07	-2.85E+07
2040	13	-2.81E+06	3.95E+05	6.93E+04	4.84E+04	6.43E+04	-2.28E+06	-2.30E+06	-3.06E+07	-3.08E+07
2041	14	-2.81E+06	3.98E+05	6.93E+04	4.84E+04	6.87E+04	-2.27E+06	-2.29E+06	-3.29E+07	-3.31E+07
2042	15	-2.81E+06	4.02E+05	6.93E+04	4.84E+04	7.29E+04	-2.27E+06	-2.29E+06	-3.51E+07	-3.54E+07
2043	16	-2.81E+06	4.05E+05	6.93E+04	4.84E+04	7.71E+04	-2.26E+06	-2.28E+06	-3.74E+07	-3.77E+07
2044	17	-2.81E+06	4.08E+05	6.93E+04	4.84E+04	8.12E+04	-2.25E+06	-2.27E+06	-3.97E+07	-4.00E+07
2045	18	-2.81E+06	4.11E+05	6.93E+04	8.14E+03	8.52E+04	-2.25E+06	-2.31E+06	-4.19E+07	-4.23E+07
2046	19	-2.81E+06	4.13E+05	6.93E+04	8.14E+03	8.91E+04	-2.24E+06	-2.30E+06	-4.41E+07	-4.46E+07
2047	20	-2.81E+06	4.16E+05	6.93E+04	8.14E+03	9.30E+04	-2.23E+06	-2.29E+06	-4.64E+07	-4.69E+07
2048	21	-2.81E+06	4.18E+05	6.93E+04	8.14E+03	9.68E+04	-2.23E+06	-2.29E+06	-4.86E+07	-4.92E+07
2049	22	-2.81E+06	4.20E+05	6.93E+04	8.14E+03	1.00E+05	-2.22E+06	-2.28E+06	-5.08E+07	-5.14E+07
2050	23	-2.81E+06	4.23E+05	6.93E+04	8.14E+03	1.04E+05	-2.21E+06	-2.28E+06	-5.30E+07	-5.37E+07
2051	24	-2.81E+06	4.25E+05	6.93E+04	8.14E+03	1.08E+05	-2.21E+06	-2.27E+06	-5.52E+07	-5.60E+07
2052	25	-2.81E+06	4.27E+05	6.93E+04	8.14E+03	1.11E+05	-2.20E+06	-2.26E+06	-5.74E+07	-5.82E+07
2053	26	-2.81E+06	4.29E+05	6.93E+04	8.14E+03	1.15E+05	-2.20E+06	-2.26E+06	-5.96E+07	-6.05E+07
2054	27	-2.81E+06	4.30E+05	6.93E+04	8.14E+03	1.18E+05	-2.19E+06	-2.25E+06	-6.18E+07	-6.28E+07
2055	28	-2.81E+06	4.32E+05	6.93E+04	8.14E+03	1.21E+05	-2.19E+06	-2.25E+06	-6.40E+07	-6.50E+07
2056	29	-2.81E+06	4.34E+05	6.93E+04	8.14E+03	1.25E+05	-2.18E+06	-2.24E+06	-6.62E+07	-6.73E+07
2057	30	-2.81E+06	4.35E+05	6.93E+04	8.14E+03	1.28E+05	-2.18E+06	-2.24E+06	-6.84E+07	-6.95E+07
2058	31	-2.81E+06	4.37E+05	6.93E+04	8.14E+03	1.31E+05	-2.17E+06	-2.23E+06	-7.06E+07	-7.17E+07
2059	32	-2.81E+06	4.39E+05	6.93E+04	8.14E+03	1.34E+05	-2.17E+06	-2.23E+06	-7.27E+07	-7.40E+07
2060	33	-2.81E+06	4.40E+05	6.93E+04	8.14E+03	1.37E+05	-2.16E+06	-2.23E+06	-7.49E+07	-7.62E+07
2061	34	-2.81E+06	4.41E+05	6.93E+04	8.14E+03	1.40E+05	-2.16E+06	-2.22E+06	-7.70E+07	-7.84E+07
2062	35	-2.81E+06	4.43E+05	6.93E+04	8.14E+03	1.43E+05	-2.16E+06	-2.22E+06	-7.92E+07	-8.06E+07
2063	36	-2.81E+06	4.44E+05	6.93E+04	8.14E+03	1.46E+05	-2.15E+06	-2.21E+06	-8.14E+07	-8.28E+07
2064	37	-2.81E+06	4.45E+05	6.93E+04	8.14E+03	1.49E+05	-2.15E+06	-2.21E+06	-8.35E+07	-8.50E+07
2065	38	-2.81E+06	4.47E+05	6.93E+04	8.14E+03	1.51E+05	-2.14E+06	-2.20E+06	-8.56E+07	-8.72E+07
2066	39	-2.81E+06	4.48E+05	6.93E+04	8.14E+03	1.54E+05	-2.14E+06	-2.20E+06	-8.78E+07	-8.94E+07
2067	40	-2.81E+06	4.49E+05	6.93E+04	8.14E+03	1.57E+05	-2.14E+06	-2.20E+06	-8.99E+07	-9.16E+07
2068	41	-2.81E+06	4.50E+05	6.93E+04	8.14E+03	1.59E+05	-2.13E+06	-2.19E+06	-9.21E+07	-9.38E+07
2069	42	-2.81E+06	4.52E+05	6.93E+04	8.14E+03	1.62E+05	-2.13E+06	-2.19E+06	-9.42E+07	-9.60E+07
2070	43	-2.81E+06	4.53E+05	6.93E+04	8.14E+03	1.65E+05	-2.12E+06	-2.19E+06	-9.63E+07	-9.82E+07
2071	44	-2.81E+06	4.54E+05	6.93E+04	8.14E+03	1.67E+05	-2.12E+06	-2.18E+06	-9.84E+07	-1.00E+08
2072	45	-2.81E+06	4.55E+05	6.93E+04	8.14E+03	1.69E+05	-2.12E+06	-2.18E+06	-1.01E+08	-1.03E+08
2073	46	-2.81E+06	4.56E+05	6.93E+04	8.14E+03	1.72E+05	-2.11E+06	-2.17E+06	-1.03E+08	-1.05E+08
2074	47	-2.81E+06	4.57E+05	6.93E+04	8.14E+03	1.74E+05	-2.11E+06	-2.17E+06	-1.05E+08	-1.07E+08
2075	48	-2.81E+06	4.58E+05	6.93E+04	8.14E+03	1.76E+05	-2.11E+06	-2.17E+06	-1.07E+08	-1.09E+08
2076	49	-2.81E+06	4.59E+05	6.93E+04	8.14E+03	1.79E+05	-2.10E+06	-2.16E+06	-1.09E+08	-1.11E+08
2077	50	-2.81E+06	4.60E+05	6.93E+04	8.14E+03	1.81E+05	-2.10E+06	-2.16E+06	-1.11E+08	-1.13E+08
2078	51	-2.81E+06	4.61E+05	6.93E+04	8.14E+03	1.83E+05	-2.10E+06	-2.16E+06	-1.13E+08	-1.16E+08
2079	52	-2.81E+06	4.62E+05	6.93E+04	8.14E+03	1.85E+05	-2.09E+06	-2.16E+06	-1.15E+08	-1.18E+08
2080	53	-2.81E+06	4.63E+05	6.93E+04	8.14E+03	1.87E+05	-2.09E+06	-2.15E+06	-1.17E+08	-1.20E+08
2081	54	-2.81E+06	4.64E+05	6.93E+04	8.14E+03	1.89E+05	-2.09E+06	-2.15E+06	-1.19E+08	-1.22E+08
2082	55	-2.81E+06	4.64E+05	6.93E+04	8.14E+03	1.91E+05	-2.09E+06	-2.15E+06	-1.22E+08	-1.24E+08
2083	56	-2.81E+06	4.65E+05	6.93E+04	8.14E+03	1.93E+05	-2.08E+06	-2.14E+06	-1.24E+08	-1.26E+08
2084	57	-2.81E+06	4.66E+05	6.93E+04	8.14E+03	1.95E+05	-2.08E+06	-2.14E+06	-1.26E+08	-1.28E+08
2085	58	-2.81E+06	4.67E+05	6.93E+04	8.14E+03	1.97E+05	-2.08E+06	-2.14E+06	-1.28E+08	-1.31E+08
2086	59	-2.81E+06	4.68E+05	6.93E+04	8.14E+03	1.99E+05	-2.07E+06	-2.14E+06	-1.30E+08	-1.33E+08
2087	60	-2.81E+06	4.69E+05	6.93E+04	8.14E+03	2.01E+05	-2.07E+06	-2.13E+06	-1.32E+08	-1.35E+08
2088	61	-2.81E+06	4.69E+05	6.93E+04	8.14E+03	2.03E+05	-2.07E+06	-2.13E+06	-1.34E+08	-1.37E+08
2089	62	-2.81E+06	4.70E+05	6.93E+04	8.14E+03	2.04E+05	-2.07E+06	-2.13E+06	-1.36E+08	-1.39E+08
2090	63	-2.81E+06	4.71E+05	6.93E+04	8.14E+03	2.06E+05	-2.06E+06	-2.13E+06	-1.38E+08	-1.41E+08
2091	64	-2.81E+06	4.72E+05	6.93E+04	8.14E+03	2.08E+05	-2.06E+06	-2.12E+06	-1.40E+08	-1.43E+08
2092	65	-2.81E+06	4.72E+05	6.93E+04	8.14E+03	2.10E+05	-2.06E+06	-2.12E+06	-1.42E+08	-1.45E+08
2093	66	-2.81E+06	4.73E+05	6.93E+04	8.14E+03	2.11E+05	-2.06E+06	-2.12E+06	-1.44E+08	-1.48E+08
2094	67	-2.81E+06	4.74E+05	6.93E+04	8.14E+03	2.13E+05	-2.05E+06	-2.12E+06	-1.46E+08	-1.50E+08
2095	68	-2.81E+06	4.75E+05	6.93E+04	8.14E+03	2.14E+05	-2.05E+06	-2.11E+06	-1.48E+08	-1.52E+08
2096	69	-2.81E+06	4.75E+05	6.93E+04	8.14E+03	2.16E+05	-2.05E+06	-2.11E+06	-1.50E+08	-1.54E+08
2097	70	-2.81E+06	4.76E+05	6.93E+04	8.14E+03	2.17E+05	-2.05E+06	-2.11E+06	-1.52E+08	-1.56E+08

2098	71	-2.81E+06	4.77E+05	6.93E+04	8.14E+03	2.19E+05	-2.05E+06	-2.11E+06	-1.55E+08	-1.58E+08
2099	72	-2.81E+06	4.77E+05	6.93E+04	8.14E+03	2.20E+05	-2.04E+06	-2.10E+06	-1.57E+08	-1.60E+08
2100	73	-2.81E+06	4.78E+05	6.93E+04	8.14E+03	2.22E+05	-2.04E+06	-2.10E+06	-1.59E+08	-1.62E+08
2101	74	-2.81E+06	4.79E+05	6.93E+04	8.14E+03	2.23E+05	-2.04E+06	-2.10E+06	-1.61E+08	-1.64E+08
2102	75	-2.81E+06	4.79E+05	6.93E+04	8.14E+03	2.25E+05	-2.04E+06	-2.10E+06	-1.63E+08	-1.67E+08
2103	76	-2.81E+06	4.80E+05	6.93E+04	8.14E+03	2.26E+05	-2.04E+06	-2.10E+06	-1.65E+08	-1.69E+08
2104	77	-2.81E+06	4.81E+05	6.93E+04	8.14E+03	2.27E+05	-2.03E+06	-2.09E+06	-1.67E+08	-1.71E+08
2105	78	-2.81E+06	4.81E+05	6.93E+04	8.14E+03	2.29E+05	-2.03E+06	-2.09E+06	-1.69E+08	-1.73E+08
2106	79	-2.81E+06	4.82E+05	6.93E+04	8.14E+03	2.30E+05	-2.03E+06	-2.09E+06	-1.71E+08	-1.75E+08
2107	80	-2.81E+06	4.82E+05	6.93E+04	8.14E+03	2.31E+05	-2.03E+06	-2.09E+06	-1.73E+08	-1.77E+08
2108	81	-2.81E+06	4.83E+05	6.93E+04	8.14E+03	2.33E+05	-2.03E+06	-2.09E+06	-1.75E+08	-1.79E+08
2109	82	-2.81E+06	4.84E+05	6.93E+04	8.14E+03	2.34E+05	-2.02E+06	-2.08E+06	-1.77E+08	-1.81E+08
2110	83	-2.81E+06	4.84E+05	6.93E+04	8.14E+03	2.35E+05	-2.02E+06	-2.08E+06	-1.79E+08	-1.83E+08
2111	84	-2.81E+06	4.85E+05	6.93E+04	8.14E+03	2.36E+05	-2.02E+06	-2.08E+06	-1.81E+08	-1.85E+08
2112	85	-2.81E+06	4.85E+05	6.93E+04	8.14E+03	2.37E+05	-2.02E+06	-2.08E+06	-1.83E+08	-1.87E+08
2113	86	-2.81E+06	4.86E+05	6.93E+04	8.14E+03	2.39E+05	-2.02E+06	-2.08E+06	-1.85E+08	-1.90E+08
2114	87	-2.81E+06	4.86E+05	6.93E+04	8.14E+03	2.40E+05	-2.02E+06	-2.08E+06	-1.87E+08	-1.92E+08
2115	88	-2.81E+06	4.87E+05	6.93E+04	8.14E+03	2.41E+05	-2.01E+06	-2.07E+06	-1.89E+08	-1.94E+08
2116	89	-2.81E+06	4.87E+05	6.93E+04	8.14E+03	2.42E+05	-2.01E+06	-2.07E+06	-1.91E+08	-1.96E+08
2117	90	-2.81E+06	4.88E+05	6.93E+04	8.14E+03	2.43E+05	-2.01E+06	-2.07E+06	-1.93E+08	-1.98E+08
2118	91	-2.81E+06	4.88E+05	6.93E+04	8.14E+03	2.44E+05	-2.01E+06	-2.07E+06	-1.95E+08	-2.00E+08
2119	92	-2.81E+06	4.89E+05	6.93E+04	8.14E+03	2.45E+05	-2.01E+06	-2.07E+06	-1.97E+08	-2.02E+08
2120	93	-2.81E+06	4.89E+05	6.93E+04	8.14E+03	2.46E+05	-2.01E+06	-2.07E+06	-1.99E+08	-2.04E+08
2121	94	-2.81E+06	4.90E+05	6.93E+04	8.14E+03	2.47E+05	-2.00E+06	-2.07E+06	-2.01E+08	-2.06E+08
2122	95	-2.81E+06	4.91E+05	6.93E+04	8.14E+03	2.48E+05	-2.00E+06	-2.06E+06	-2.03E+08	-2.08E+08
2123	96	-2.81E+06	4.91E+05	6.93E+04	8.14E+03	2.49E+05	-2.00E+06	-2.06E+06	-2.05E+08	-2.10E+08
2124	97	-2.81E+06	4.91E+05	6.93E+04	8.14E+03	2.50E+05	-2.00E+06	-2.06E+06	-2.07E+08	-2.12E+08
2125	98	-2.81E+06	4.92E+05	6.93E+04	8.14E+03	2.51E+05	-2.00E+06	-2.06E+06	-2.09E+08	-2.14E+08
2126	99	-2.81E+06	4.92E+05	6.93E+04	8.14E+03	2.52E+05	-2.00E+06	-2.06E+06	-2.11E+08	-2.16E+08
2127	100	-2.81E+06	4.93E+05	6.93E+04	8.14E+03	2.53E+05	-2.00E+06	-2.06E+06	-2.13E+08	-2.18E+08

Appendix Table A5. Fluxes and other magnitudes for the SITE PREP BURN ALTERNATIVE case. Annual data correspond to Figure 5, Panel C. Cumulative data correspond to Figure 5, Panel D.

SITE PREP BURN ALTERNATIVE CASE										
Year	Time (years)	ANNUAL FOREST UPTAKE	ANNUAL HARVESTED PRODUCT EMISSIONS	ANNUAL REPLACEMENT POWER EMISSIONS [VA/PJM]	ANNUAL REPLACEMENT POWER EMISSIONS [VCEA]	ANNUAL RESIDUALS MANAGEMENT EMISSIONS	ANNUAL NET [VA/PJM]	ANNUAL NET [VCEA]	CUMULATIVE NET [VA/PJM]	CUMULATIVE NET [VCEA]
2028	1	-2.81E+06	2.48E+05	6.93E+04	6.93E+04	2.59E+05	-2.23E+06	-2.23E+06	-2.23E+06	-2.23E+06
2029	2	-2.81E+06	2.95E+05	6.93E+04	6.93E+04	2.59E+05	-2.19E+06	-2.19E+06	-4.42E+06	-4.42E+06
2030	3	-2.81E+06	3.19E+05	6.93E+04	4.84E+04	2.59E+05	-2.16E+06	-2.18E+06	-6.59E+06	-6.61E+06
2031	4	-2.81E+06	3.35E+05	6.93E+04	4.84E+04	2.59E+05	-2.15E+06	-2.17E+06	-8.73E+06	-8.77E+06
2032	5	-2.81E+06	3.47E+05	6.93E+04	4.84E+04	2.59E+05	-2.14E+06	-2.16E+06	-1.09E+07	-1.09E+07
2033	6	-2.81E+06	3.56E+05	6.93E+04	4.84E+04	2.59E+05	-2.13E+06	-2.15E+06	-1.30E+07	-1.31E+07
2034	7	-2.81E+06	3.64E+05	6.93E+04	4.84E+04	2.59E+05	-2.12E+06	-2.14E+06	-1.51E+07	-1.52E+07
2035	8	-2.81E+06	3.71E+05	6.93E+04	4.84E+04	2.59E+05	-2.11E+06	-2.13E+06	-1.72E+07	-1.74E+07
2036	9	-2.81E+06	3.77E+05	6.93E+04	4.84E+04	2.59E+05	-2.11E+06	-2.13E+06	-1.93E+07	-1.95E+07
2037	10	-2.81E+06	3.82E+05	6.93E+04	4.84E+04	2.59E+05	-2.10E+06	-2.12E+06	-2.14E+07	-2.16E+07
2038	11	-2.81E+06	3.87E+05	6.93E+04	4.84E+04	2.59E+05	-2.10E+06	-2.12E+06	-2.35E+07	-2.37E+07
2039	12	-2.81E+06	3.91E+05	6.93E+04	4.84E+04	2.59E+05	-2.09E+06	-2.11E+06	-2.56E+07	-2.58E+07
2040	13	-2.81E+06	3.95E+05	6.93E+04	4.84E+04	2.59E+05	-2.09E+06	-2.11E+06	-2.77E+07	-2.79E+07
2041	14	-2.81E+06	3.98E+05	6.93E+04	4.84E+04	2.59E+05	-2.08E+06	-2.10E+06	-2.98E+07	-3.00E+07
2042	15	-2.81E+06	4.02E+05	6.93E+04	4.84E+04	2.59E+05	-2.08E+06	-2.10E+06	-3.19E+07	-3.21E+07
2043	16	-2.81E+06	4.05E+05	6.93E+04	4.84E+04	2.59E+05	-2.08E+06	-2.10E+06	-3.39E+07	-3.42E+07
2044	17	-2.81E+06	4.08E+05	6.93E+04	4.84E+04	2.59E+05	-2.07E+06	-2.10E+06	-3.60E+07	-3.63E+07
2045	18	-2.81E+06	4.11E+05	6.93E+04	8.14E+03	2.59E+05	-2.07E+06	-2.13E+06	-3.81E+07	-3.85E+07
2046	19	-2.81E+06	4.13E+05	6.93E+04	8.14E+03	2.59E+05	-2.07E+06	-2.13E+06	-4.02E+07	-4.06E+07
2047	20	-2.81E+06	4.16E+05	6.93E+04	8.14E+03	2.59E+05	-2.07E+06	-2.13E+06	-4.22E+07	-4.27E+07
2048	21	-2.81E+06	4.18E+05	6.93E+04	8.14E+03	2.59E+05	-2.06E+06	-2.13E+06	-4.43E+07	-4.49E+07
2049	22	-2.81E+06	4.20E+05	6.93E+04	8.14E+03	2.59E+05	-2.06E+06	-2.12E+06	-4.64E+07	-4.70E+07
2050	23	-2.81E+06	4.23E+05	6.93E+04	8.14E+03	2.59E+05	-2.06E+06	-2.12E+06	-4.84E+07	-4.91E+07
2051	24	-2.81E+06	4.25E+05	6.93E+04	8.14E+03	2.59E+05	-2.06E+06	-2.12E+06	-5.05E+07	-5.12E+07
2052	25	-2.81E+06	4.27E+05	6.93E+04	8.14E+03	2.59E+05	-2.06E+06	-2.12E+06	-5.25E+07	-5.33E+07
2053	26	-2.81E+06	4.29E+05	6.93E+04	8.14E+03	2.59E+05	-2.05E+06	-2.12E+06	-5.46E+07	-5.54E+07
2054	27	-2.81E+06	4.30E+05	6.93E+04	8.14E+03	2.59E+05	-2.05E+06	-2.11E+06	-5.66E+07	-5.76E+07
2055	28	-2.81E+06	4.32E+05	6.93E+04	8.14E+03	2.59E+05	-2.05E+06	-2.11E+06	-5.87E+07	-5.97E+07
2056	29	-2.81E+06	4.34E+05	6.93E+04	8.14E+03	2.59E+05	-2.05E+06	-2.11E+06	-6.07E+07	-6.18E+07
2057	30	-2.81E+06	4.35E+05	6.93E+04	8.14E+03	2.59E+05	-2.05E+06	-2.11E+06	-6.28E+07	-6.39E+07
2058	31	-2.81E+06	4.37E+05	6.93E+04	8.14E+03	2.59E+05	-2.05E+06	-2.11E+06	-6.48E+07	-6.60E+07
2059	32	-2.81E+06	4.39E+05	6.93E+04	8.14E+03	2.59E+05	-2.04E+06	-2.11E+06	-6.69E+07	-6.81E+07
2060	33	-2.81E+06	4.40E+05	6.93E+04	8.14E+03	2.59E+05	-2.04E+06	-2.10E+06	-6.89E+07	-7.02E+07
2061	34	-2.81E+06	4.41E+05	6.93E+04	8.14E+03	2.59E+05	-2.04E+06	-2.10E+06	-7.10E+07	-7.23E+07
2062	35	-2.81E+06	4.43E+05	6.93E+04	8.14E+03	2.59E+05	-2.04E+06	-2.10E+06	-7.30E+07	-7.44E+07
2063	36	-2.81E+06	4.44E+05	6.93E+04	8.14E+03	2.59E+05	-2.04E+06	-2.10E+06	-7.50E+07	-7.65E+07
2064	37	-2.81E+06	4.45E+05	6.93E+04	8.14E+03	2.59E+05	-2.04E+06	-2.10E+06	-7.71E+07	-7.86E+07
2065	38	-2.81E+06	4.47E+05	6.93E+04	8.14E+03	2.59E+05	-2.04E+06	-2.10E+06	-7.91E+07	-8.07E+07
2066	39	-2.81E+06	4.48E+05	6.93E+04	8.14E+03	2.59E+05	-2.03E+06	-2.10E+06	-8.11E+07	-8.28E+07
2067	40	-2.81E+06	4.49E+05	6.93E+04	8.14E+03	2.59E+05	-2.03E+06	-2.09E+06	-8.32E+07	-8.49E+07
2068	41	-2.81E+06	4.50E+05	6.93E+04	8.14E+03	2.59E+05	-2.03E+06	-2.09E+06	-8.52E+07	-8.70E+07
2069	42	-2.81E+06	4.52E+05	6.93E+04	8.14E+03	2.59E+05	-2.03E+06	-2.09E+06	-8.72E+07	-8.91E+07
2070	43	-2.81E+06	4.53E+05	6.93E+04	8.14E+03	2.59E+05	-2.03E+06	-2.09E+06	-8.93E+07	-9.12E+07
2071	44	-2.81E+06	4.54E+05	6.93E+04	8.14E+03	2.59E+05	-2.03E+06	-2.09E+06	-9.13E+07	-9.33E+07
2072	45	-2.81E+06	4.55E+05	6.93E+04	8.14E+03	2.59E+05	-2.03E+06	-2.09E+06	-9.33E+07	-9.53E+07
2073	46	-2.81E+06	4.56E+05	6.93E+04	8.14E+03	2.59E+05	-2.03E+06	-2.09E+06	-9.54E+07	-9.74E+07
2074	47	-2.81E+06	4.57E+05	6.93E+04	8.14E+03	2.59E+05	-2.03E+06	-2.09E+06	-9.74E+07	-9.95E+07
2075	48	-2.81E+06	4.58E+05	6.93E+04	8.14E+03	2.59E+05	-2.02E+06	-2.09E+06	-9.94E+07	-1.02E+08
2076	49	-2.81E+06	4.59E+05	6.93E+04	8.14E+03	2.59E+05	-2.02E+06	-2.08E+06	-1.01E+08	-1.04E+08
2077	50	-2.81E+06	4.60E+05	6.93E+04	8.14E+03	2.59E+05	-2.02E+06	-2.08E+06	-1.03E+08	-1.06E+08
2078	51	-2.81E+06	4.61E+05	6.93E+04	8.14E+03	2.59E+05	-2.02E+06	-2.08E+06	-1.05E+08	-1.08E+08
2079	52	-2.81E+06	4.62E+05	6.93E+04	8.14E+03	2.59E+05	-2.02E+06	-2.08E+06	-1.07E+08	-1.10E+08
2080	53	-2.81E+06	4.63E+05	6.93E+04	8.14E+03	2.59E+05	-2.02E+06	-2.08E+06	-1.10E+08	-1.12E+08
2081	54	-2.81E+06	4.64E+05	6.93E+04	8.14E+03	2.59E+05	-2.02E+06	-2.08E+06	-1.12E+08	-1.14E+08
2082	55	-2.81E+06	4.64E+05	6.93E+04	8.14E+03	2.59E+05	-2.02E+06	-2.08E+06	-1.14E+08	-1.16E+08
2083	56	-2.81E+06	4.65E+05	6.93E+04	8.14E+03	2.59E+05	-2.02E+06	-2.08E+06	-1.16E+08	-1.18E+08
2084	57	-2.81E+06	4.66E+05	6.93E+04	8.14E+03	2.59E+05	-2.02E+06	-2.08E+06	-1.18E+08	-1.20E+08
2085	58	-2.81E+06	4.67E+05	6.93E+04	8.14E+03	2.59E+05	-2.02E+06	-2.08E+06	-1.20E+08	-1.22E+08
2086	59	-2.81E+06	4.68E+05	6.93E+04	8.14E+03	2.59E+05	-2.01E+06	-2.08E+06	-1.22E+08	-1.24E+08
2087	60	-2.81E+06	4.69E+05	6.93E+04	8.14E+03	2.59E+05	-2.01E+06	-2.08E+06	-1.24E+08	-1.27E+08
2088	61	-2.81E+06	4.69E+05	6.93E+04	8.14E+03	2.59E+05	-2.01E+06	-2.07E+06	-1.26E+08	-1.29E+08
2089	62	-2.81E+06	4.70E+05	6.93E+04	8.14E+03	2.59E+05	-2.01E+06	-2.07E+06	-1.28E+08	-1.31E+08
2090	63	-2.81E+06	4.71E+05	6.93E+04	8.14E+03	2.59E+05	-2.01E+06	-2.07E+06	-1.30E+08	-1.33E+08
2091	64	-2.81E+06	4.72E+05	6.93E+04	8.14E+03	2.59E+05	-2.01E+06	-2.07E+06	-1.32E+08	-1.35E+08
2092	65	-2.81E+06	4.72E+05	6.93E+04	8.14E+03	2.59E+05	-2.01E+06	-2.07E+06	-1.34E+08	-1.37E+08
2093	66	-2.81E+06	4.73E+05	6.93E+04	8.14E+03	2.59E+05	-2.01E+06	-2.07E+06	-1.36E+08	-1.39E+08
2094	67	-2.81E+06	4.74E+05	6.93E+04	8.14E+03	2.59E+05	-2.01E+06	-2.07E+06	-1.38E+08	-1.41E+08

2095	68	-2.81E+06	4.75E+05	6.93E+04	8.14E+03	2.59E+05	-2.01E+06	-2.07E+06	-1.40E+08	-1.43E+08
2096	69	-2.81E+06	4.75E+05	6.93E+04	8.14E+03	2.59E+05	-2.01E+06	-2.07E+06	-1.42E+08	-1.45E+08
2097	70	-2.81E+06	4.76E+05	6.93E+04	8.14E+03	2.59E+05	-2.01E+06	-2.07E+06	-1.44E+08	-1.47E+08
2098	71	-2.81E+06	4.77E+05	6.93E+04	8.14E+03	2.59E+05	-2.01E+06	-2.07E+06	-1.46E+08	-1.49E+08
2099	72	-2.81E+06	4.77E+05	6.93E+04	8.14E+03	2.59E+05	-2.01E+06	-2.07E+06	-1.48E+08	-1.51E+08
2100	73	-2.81E+06	4.78E+05	6.93E+04	8.14E+03	2.59E+05	-2.00E+06	-2.07E+06	-1.50E+08	-1.53E+08
2101	74	-2.81E+06	4.79E+05	6.93E+04	8.14E+03	2.59E+05	-2.00E+06	-2.07E+06	-1.52E+08	-1.56E+08
2102	75	-2.81E+06	4.79E+05	6.93E+04	8.14E+03	2.59E+05	-2.00E+06	-2.06E+06	-1.54E+08	-1.58E+08
2103	76	-2.81E+06	4.80E+05	6.93E+04	8.14E+03	2.59E+05	-2.00E+06	-2.06E+06	-1.56E+08	-1.60E+08
2104	77	-2.81E+06	4.81E+05	6.93E+04	8.14E+03	2.59E+05	-2.00E+06	-2.06E+06	-1.58E+08	-1.62E+08
2105	78	-2.81E+06	4.81E+05	6.93E+04	8.14E+03	2.59E+05	-2.00E+06	-2.06E+06	-1.60E+08	-1.64E+08
2106	79	-2.81E+06	4.82E+05	6.93E+04	8.14E+03	2.59E+05	-2.00E+06	-2.06E+06	-1.62E+08	-1.66E+08
2107	80	-2.81E+06	4.82E+05	6.93E+04	8.14E+03	2.59E+05	-2.00E+06	-2.06E+06	-1.64E+08	-1.68E+08
2108	81	-2.81E+06	4.83E+05	6.93E+04	8.14E+03	2.59E+05	-2.00E+06	-2.06E+06	-1.66E+08	-1.70E+08
2109	82	-2.81E+06	4.84E+05	6.93E+04	8.14E+03	2.59E+05	-2.00E+06	-2.06E+06	-1.68E+08	-1.72E+08
2110	83	-2.81E+06	4.84E+05	6.93E+04	8.14E+03	2.59E+05	-2.00E+06	-2.06E+06	-1.70E+08	-1.74E+08
2111	84	-2.81E+06	4.85E+05	6.93E+04	8.14E+03	2.59E+05	-2.00E+06	-2.06E+06	-1.72E+08	-1.76E+08
2112	85	-2.81E+06	4.85E+05	6.93E+04	8.14E+03	2.59E+05	-2.00E+06	-2.06E+06	-1.74E+08	-1.78E+08
2113	86	-2.81E+06	4.86E+05	6.93E+04	8.14E+03	2.59E+05	-2.00E+06	-2.06E+06	-1.76E+08	-1.80E+08
2114	87	-2.81E+06	4.86E+05	6.93E+04	8.14E+03	2.59E+05	-2.00E+06	-2.06E+06	-1.78E+08	-1.82E+08
2115	88	-2.81E+06	4.87E+05	6.93E+04	8.14E+03	2.59E+05	-2.00E+06	-2.06E+06	-1.80E+08	-1.84E+08
2116	89	-2.81E+06	4.87E+05	6.93E+04	8.14E+03	2.59E+05	-2.00E+06	-2.06E+06	-1.82E+08	-1.86E+08
2117	90	-2.81E+06	4.88E+05	6.93E+04	8.14E+03	2.59E+05	-1.99E+06	-2.06E+06	-1.84E+08	-1.88E+08
2118	91	-2.81E+06	4.88E+05	6.93E+04	8.14E+03	2.59E+05	-1.99E+06	-2.06E+06	-1.86E+08	-1.91E+08
2119	92	-2.81E+06	4.89E+05	6.93E+04	8.14E+03	2.59E+05	-1.99E+06	-2.05E+06	-1.88E+08	-1.93E+08
2120	93	-2.81E+06	4.89E+05	6.93E+04	8.14E+03	2.59E+05	-1.99E+06	-2.05E+06	-1.90E+08	-1.95E+08
2121	94	-2.81E+06	4.90E+05	6.93E+04	8.14E+03	2.59E+05	-1.99E+06	-2.05E+06	-1.92E+08	-1.97E+08
2122	95	-2.81E+06	4.91E+05	6.93E+04	8.14E+03	2.59E+05	-1.99E+06	-2.05E+06	-1.94E+08	-1.99E+08
2123	96	-2.81E+06	4.91E+05	6.93E+04	8.14E+03	2.59E+05	-1.99E+06	-2.05E+06	-1.96E+08	-2.01E+08
2124	97	-2.81E+06	4.91E+05	6.93E+04	8.14E+03	2.59E+05	-1.99E+06	-2.05E+06	-1.98E+08	-2.03E+08
2125	98	-2.81E+06	4.92E+05	6.93E+04	8.14E+03	2.59E+05	-1.99E+06	-2.05E+06	-2.00E+08	-2.05E+08
2126	99	-2.81E+06	4.92E+05	6.93E+04	8.14E+03	2.59E+05	-1.99E+06	-2.05E+06	-2.02E+08	-2.07E+08
2127	100	-2.81E+06	4.93E+05	6.93E+04	8.14E+03	2.59E+05	-1.99E+06	-2.05E+06	-2.04E+08	-2.09E+08

Appendix Table A6. Fluxes and other magnitudes for the FOREST CONVERSION ALTERNATIVE case. Annual data correspond to Figure 5, Panel E. Cumulative data correspond to Figure 5, Panel F.

FOREST CONVERSION CASE

Year	Time (years)	ANNUAL FOREST UPTAKE	ANNUAL HARVESTED PRODUCT EMISSIONS	ANNUAL REPLACEMENT POWER EMISSIONS [VA/PJM]	ANNUAL REPLACEMENT POWER EMISSIONS [VCEA]	ANNUAL RESIDUALS MANAGEMENT EMISSIONS	ANNUAL NET [VA/PJM]	ANNUAL NET [VCEA]	CUMULATIVE NET [VA/PJM]	CUMULATIVE NET [VCEA]
2028	1	-2.81E+06	2.48E+05	6.93E+04	6.93E+04	2.59E+05	-2.23E+06	-2.235E+06	-2.23E+06	-2.23E+06
2029	2	-2.81E+06	2.95E+05	6.93E+04	6.93E+04	2.59E+05	-2.19E+06	-2.187E+06	-4.42E+06	-4.42E+06
2030	3	-2.81E+06	3.19E+05	6.93E+04	4.84E+04	2.59E+05	-2.16E+06	-2.184E+06	-6.59E+06	-6.61E+06
2031	4	-2.81E+06	3.35E+05	6.93E+04	4.84E+04	2.59E+05	-2.15E+06	-2.169E+06	-8.73E+06	-8.77E+06
2032	5	-2.81E+06	3.47E+05	6.93E+04	4.84E+04	2.59E+05	-2.14E+06	-2.157E+06	-1.09E+07	-1.09E+07
2033	6	-2.81E+06	3.56E+05	6.93E+04	4.84E+04	2.59E+05	-2.13E+06	-2.147E+06	-1.30E+07	-1.31E+07
2034	7	-2.81E+06	3.64E+05	6.93E+04	4.84E+04	2.59E+05	-2.12E+06	-2.139E+06	-1.51E+07	-1.52E+07
2035	8	-2.81E+06	3.71E+05	6.93E+04	4.84E+04	2.59E+05	-2.11E+06	-2.133E+06	-1.72E+07	-1.74E+07
2036	9	-2.81E+06	3.77E+05	6.93E+04	4.84E+04	2.59E+05	-2.11E+06	-2.127E+06	-1.93E+07	-1.95E+07
2037	10	-2.81E+06	3.82E+05	6.93E+04	4.84E+04	7.29E+05	-1.63E+06	-1.651E+06	-2.10E+07	-2.11E+07
2038	11	-2.67E+06	3.67E+05	6.93E+04	4.84E+04	2.46E+05	-1.99E+06	-2.009E+06	-2.29E+07	-2.31E+07
2039	12	-2.67E+06	3.71E+05	6.93E+04	4.84E+04	2.46E+05	-1.98E+06	-2.004E+06	-2.49E+07	-2.51E+07
2040	13	-2.67E+06	3.75E+05	6.93E+04	4.84E+04	2.46E+05	-1.98E+06	-2.001E+06	-2.69E+07	-2.71E+07
2041	14	-2.67E+06	3.79E+05	6.93E+04	4.84E+04	2.46E+05	-1.98E+06	-1.997E+06	-2.89E+07	-2.91E+07
2042	15	-2.67E+06	3.82E+05	6.93E+04	4.84E+04	2.46E+05	-1.97E+06	-1.994E+06	-3.09E+07	-3.11E+07
2043	16	-2.67E+06	3.85E+05	6.93E+04	4.84E+04	2.46E+05	-1.97E+06	-1.991E+06	-3.28E+07	-3.31E+07
2044	17	-2.67E+06	3.88E+05	6.93E+04	4.84E+04	2.46E+05	-1.97E+06	-1.988E+06	-3.48E+07	-3.51E+07
2045	18	-2.67E+06	3.90E+05	6.93E+04	8.14E+03	2.46E+05	-1.96E+06	-2.026E+06	-3.68E+07	-3.71E+07
2046	19	-2.67E+06	3.93E+05	6.93E+04	8.14E+03	2.46E+05	-1.96E+06	-2.023E+06	-3.87E+07	-3.92E+07
2047	20	-2.67E+06	3.95E+05	6.93E+04	8.14E+03	6.92E+05	-1.51E+06	-1.574E+06	-4.02E+07	-4.07E+07
2048	21	-2.54E+06	3.77E+05	6.93E+04	8.14E+03	2.33E+05	-1.86E+06	-1.917E+06	-4.21E+07	-4.27E+07
2049	22	-2.54E+06	3.79E+05	6.93E+04	8.14E+03	2.33E+05	-1.85E+06	-1.915E+06	-4.40E+07	-4.46E+07
2050	23	-2.54E+06	3.81E+05	6.93E+04	8.14E+03	2.33E+05	-1.85E+06	-1.913E+06	-4.58E+07	-4.65E+07
2051	24	-2.54E+06	3.83E+05	6.93E+04	8.14E+03	2.33E+05	-1.85E+06	-1.912E+06	-4.77E+07	-4.84E+07
2052	25	-2.54E+06	3.85E+05	6.93E+04	8.14E+03	2.33E+05	-1.85E+06	-1.910E+06	-4.95E+07	-5.03E+07
2053	26	-2.54E+06	3.87E+05	6.93E+04	8.14E+03	2.33E+05	-1.85E+06	-1.908E+06	-5.13E+07	-5.22E+07
2054	27	-2.54E+06	3.88E+05	6.93E+04	8.14E+03	2.33E+05	-1.85E+06	-1.906E+06	-5.32E+07	-5.41E+07
2055	28	-2.54E+06	3.90E+05	6.93E+04	8.14E+03	2.33E+05	-1.84E+06	-1.905E+06	-5.50E+07	-5.60E+07
2056	29	-2.54E+06	3.91E+05	6.93E+04	8.14E+03	2.33E+05	-1.84E+06	-1.903E+06	-5.69E+07	-5.79E+07
2057	30	-2.54E+06	3.93E+05	6.93E+04	8.14E+03	6.58E+05	-1.42E+06	-1.478E+06	-5.83E+07	-5.94E+07
2058	31	-2.41E+06	3.75E+05	6.93E+04	8.14E+03	2.22E+05	-1.74E+06	-1.805E+06	-6.00E+07	-6.12E+07
2059	32	-2.41E+06	3.76E+05	6.93E+04	8.14E+03	2.22E+05	-1.74E+06	-1.804E+06	-6.18E+07	-6.30E+07
2060	33	-2.41E+06	3.77E+05	6.93E+04	8.14E+03	2.22E+05	-1.74E+06	-1.802E+06	-6.35E+07	-6.48E+07
2061	34	-2.41E+06	3.78E+05	6.93E+04	8.14E+03	2.22E+05	-1.74E+06	-1.801E+06	-6.53E+07	-6.66E+07
2062	35	-2.41E+06	3.80E+05	6.93E+04	8.14E+03	2.22E+05	-1.74E+06	-1.800E+06	-6.70E+07	-6.84E+07
2063	36	-2.41E+06	3.81E+05	6.93E+04	8.14E+03	2.22E+05	-1.74E+06	-1.799E+06	-6.87E+07	-7.02E+07
2064	37	-2.41E+06	3.82E+05	6.93E+04	8.14E+03	2.22E+05	-1.74E+06	-1.798E+06	-7.05E+07	-7.20E+07
2065	38	-2.41E+06	3.83E+05	6.93E+04	8.14E+03	2.22E+05	-1.74E+06	-1.797E+06	-7.22E+07	-7.38E+07
2066	39	-2.41E+06	3.84E+05	6.93E+04	8.14E+03	2.22E+05	-1.73E+06	-1.796E+06	-7.39E+07	-7.56E+07
2067	40	-2.41E+06	3.85E+05	6.93E+04	8.14E+03	6.25E+05	-1.33E+06	-1.391E+06	-7.53E+07	-7.70E+07
2068	41	-2.29E+06	3.67E+05	6.93E+04	8.14E+03	2.11E+05	-1.64E+06	-1.703E+06	-7.69E+07	-7.87E+07
2069	42	-2.29E+06	3.68E+05	6.93E+04	8.14E+03	2.11E+05	-1.64E+06	-1.702E+06	-7.86E+07	-8.04E+07
2070	43	-2.29E+06	3.69E+05	6.93E+04	8.14E+03	2.11E+05	-1.64E+06	-1.702E+06	-8.02E+07	-8.21E+07
2071	44	-2.29E+06	3.70E+05	6.93E+04	8.14E+03	2.11E+05	-1.64E+06	-1.701E+06	-8.18E+07	-8.38E+07
2072	45	-2.29E+06	3.70E+05	6.93E+04	8.14E+03	2.11E+05	-1.64E+06	-1.700E+06	-8.35E+07	-8.55E+07
2073	46	-2.29E+06	3.71E+05	6.93E+04	8.14E+03	2.11E+05	-1.64E+06	-1.699E+06	-8.51E+07	-8.72E+07
2074	47	-2.29E+06	3.72E+05	6.93E+04	8.14E+03	2.11E+05	-1.64E+06	-1.698E+06	-8.68E+07	-8.89E+07
2075	48	-2.29E+06	3.73E+05	6.93E+04	8.14E+03	2.11E+05	-1.64E+06	-1.697E+06	-8.84E+07	-9.06E+07
2076	49	-2.29E+06	3.74E+05	6.93E+04	8.14E+03	2.11E+05	-1.64E+06	-1.696E+06	-9.00E+07	-9.23E+07
2077	50	-2.29E+06	3.75E+05	6.93E+04	8.14E+03	5.94E+05	-1.25E+06	-1.313E+06	-9.13E+07	-9.36E+07
2078	51	-2.17E+06	3.57E+05	6.93E+04	8.14E+03	2.00E+05	-1.55E+06	-1.610E+06	-9.28E+07	-9.52E+07
2079	52	-2.17E+06	3.57E+05	6.93E+04	8.14E+03	2.00E+05	-1.55E+06	-1.609E+06	-9.44E+07	-9.68E+07
2080	53	-2.17E+06	3.58E+05	6.93E+04	8.14E+03	2.00E+05	-1.55E+06	-1.608E+06	-9.59E+07	-9.84E+07
2081	54	-2.17E+06	3.59E+05	6.93E+04	8.14E+03	2.00E+05	-1.55E+06	-1.608E+06	-9.75E+07	-1.00E+08
2082	55	-2.17E+06	3.59E+05	6.93E+04	8.14E+03	2.00E+05	-1.55E+06	-1.607E+06	-9.90E+07	-1.02E+08
2083	56	-2.17E+06	3.60E+05	6.93E+04	8.14E+03	2.00E+05	-1.55E+06	-1.606E+06	-1.01E+08	-1.03E+08
2084	57	-2.17E+06	3.61E+05	6.93E+04	8.14E+03	2.00E+05	-1.54E+06	-1.61E+06	-1.02E+08	-1.05E+08
2085	58	-2.17E+06	3.61E+05	6.93E+04	8.14E+03	2.00E+05	-1.54E+06	-1.61E+06	-1.04E+08	-1.06E+08
2086	59	-2.17E+06	3.62E+05	6.93E+04	8.14E+03	2.00E+05	-1.54E+06	-1.60E+06	-1.05E+08	-1.08E+08

2087	60	-2.17E+06	3.63E+05	6.93E+04	8.14E+03	5.64E+05	-1.18E+06	-1.24E+06	-1.06E+08	-1.09E+08
2088	61	-2.07E+06	3.45E+05	6.93E+04	8.14E+03	1.90E+05	-1.46E+06	-1.52E+06	-1.08E+08	-1.11E+08
2089	62	-2.07E+06	3.46E+05	6.93E+04	8.14E+03	1.90E+05	-1.46E+06	-1.52E+06	-1.09E+08	-1.12E+08
2090	63	-2.07E+06	3.46E+05	6.93E+04	8.14E+03	1.90E+05	-1.46E+06	-1.52E+06	-1.11E+08	-1.14E+08
2091	64	-2.07E+06	3.47E+05	6.93E+04	8.14E+03	1.90E+05	-1.46E+06	-1.52E+06	-1.12E+08	-1.15E+08
2092	65	-2.07E+06	3.47E+05	6.93E+04	8.14E+03	1.90E+05	-1.46E+06	-1.52E+06	-1.14E+08	-1.17E+08
2093	66	-2.07E+06	3.48E+05	6.93E+04	8.14E+03	1.90E+05	-1.46E+06	-1.52E+06	-1.15E+08	-1.18E+08
2094	67	-2.07E+06	3.48E+05	6.93E+04	8.14E+03	1.90E+05	-1.46E+06	-1.52E+06	-1.17E+08	-1.20E+08
2095	68	-2.07E+06	3.49E+05	6.93E+04	8.14E+03	1.90E+05	-1.46E+06	-1.52E+06	-1.18E+08	-1.21E+08
2096	69	-2.07E+06	3.49E+05	6.93E+04	8.14E+03	1.90E+05	-1.46E+06	-1.52E+06	-1.20E+08	-1.23E+08
2097	70	-2.07E+06	3.50E+05	6.93E+04	8.14E+03	5.36E+05	-1.11E+06	-1.17E+06	-1.21E+08	-1.24E+08
2098	71	-1.96E+06	3.33E+05	6.93E+04	8.14E+03	1.81E+05	-1.38E+06	-1.44E+06	-1.22E+08	-1.26E+08
2099	72	-1.96E+06	3.33E+05	6.93E+04	8.14E+03	1.81E+05	-1.38E+06	-1.44E+06	-1.23E+08	-1.27E+08
2100	73	-1.96E+06	3.34E+05	6.93E+04	8.14E+03	1.81E+05	-1.38E+06	-1.44E+06	-1.25E+08	-1.28E+08
2101	74	-1.96E+06	3.34E+05	6.93E+04	8.14E+03	1.81E+05	-1.38E+06	-1.44E+06	-1.26E+08	-1.30E+08
2102	75	-1.96E+06	3.35E+05	6.93E+04	8.14E+03	1.81E+05	-1.38E+06	-1.44E+06	-1.28E+08	-1.31E+08
2103	76	-1.96E+06	3.35E+05	6.93E+04	8.14E+03	1.81E+05	-1.38E+06	-1.44E+06	-1.29E+08	-1.33E+08
2104	77	-1.96E+06	3.36E+05	6.93E+04	8.14E+03	1.81E+05	-1.38E+06	-1.44E+06	-1.30E+08	-1.34E+08
2105	78	-1.96E+06	3.36E+05	6.93E+04	8.14E+03	1.81E+05	-1.38E+06	-1.44E+06	-1.32E+08	-1.36E+08
2106	79	-1.96E+06	3.36E+05	6.93E+04	8.14E+03	1.81E+05	-1.38E+06	-1.44E+06	-1.33E+08	-1.37E+08
2107	80	-1.96E+06	3.37E+05	6.93E+04	8.14E+03	5.09E+05	-1.05E+06	-1.11E+06	-1.34E+08	-1.38E+08
2108	81	-1.86E+06	3.20E+05	6.93E+04	8.14E+03	1.72E+05	-1.30E+06	-1.36E+06	-1.35E+08	-1.40E+08
2109	82	-1.86E+06	3.21E+05	6.93E+04	8.14E+03	1.72E+05	-1.30E+06	-1.36E+06	-1.37E+08	-1.41E+08
2110	83	-1.86E+06	3.21E+05	6.93E+04	8.14E+03	1.72E+05	-1.30E+06	-1.36E+06	-1.38E+08	-1.42E+08
2111	84	-1.86E+06	3.22E+05	6.93E+04	8.14E+03	1.72E+05	-1.30E+06	-1.36E+06	-1.39E+08	-1.44E+08
2112	85	-1.86E+06	3.22E+05	6.93E+04	8.14E+03	1.72E+05	-1.30E+06	-1.36E+06	-1.41E+08	-1.45E+08
2113	86	-1.86E+06	3.22E+05	6.93E+04	8.14E+03	1.72E+05	-1.30E+06	-1.36E+06	-1.42E+08	-1.46E+08
2114	87	-1.86E+06	3.23E+05	6.93E+04	8.14E+03	1.72E+05	-1.30E+06	-1.36E+06	-1.43E+08	-1.48E+08
2115	88	-1.86E+06	3.23E+05	6.93E+04	8.14E+03	1.72E+05	-1.30E+06	-1.36E+06	-1.44E+08	-1.49E+08
2116	89	-1.86E+06	3.23E+05	6.93E+04	8.14E+03	1.72E+05	-1.30E+06	-1.36E+06	-1.46E+08	-1.50E+08
2117	90	-1.86E+06	3.24E+05	6.93E+04	8.14E+03	4.84E+05	-9.88E+05	-1.05E+06	-1.47E+08	-1.52E+08
2118	91	-1.77E+06	3.08E+05	6.93E+04	8.14E+03	1.63E+05	-1.23E+06	-1.29E+06	-1.48E+08	-1.53E+08
2119	92	-1.77E+06	3.08E+05	6.93E+04	8.14E+03	1.63E+05	-1.23E+06	-1.29E+06	-1.49E+08	-1.54E+08
2120	93	-1.77E+06	3.09E+05	6.93E+04	8.14E+03	1.63E+05	-1.23E+06	-1.29E+06	-1.50E+08	-1.55E+08
2121	94	-1.77E+06	3.09E+05	6.93E+04	8.14E+03	1.63E+05	-1.23E+06	-1.29E+06	-1.52E+08	-1.57E+08
2122	95	-1.77E+06	3.09E+05	6.93E+04	8.14E+03	1.63E+05	-1.23E+06	-1.29E+06	-1.53E+08	-1.58E+08
2123	96	-1.77E+06	3.09E+05	6.93E+04	8.14E+03	1.63E+05	-1.23E+06	-1.29E+06	-1.54E+08	-1.59E+08
2124	97	-1.77E+06	3.10E+05	6.93E+04	8.14E+03	1.63E+05	-1.23E+06	-1.29E+06	-1.55E+08	-1.61E+08
2125	98	-1.77E+06	3.10E+05	6.93E+04	8.14E+03	1.63E+05	-1.23E+06	-1.29E+06	-1.57E+08	-1.62E+08
2126	99	-1.77E+06	3.10E+05	6.93E+04	8.14E+03	1.63E+05	-1.23E+06	-1.29E+06	-1.58E+08	-1.63E+08
2127	100	-1.77E+06	3.11E+05	6.93E+04	8.14E+03	4.59E+05	-9.32E+05	-9.93E+05	-1.59E+08	-1.64E+08