## Appendix A: Comparing a Flux-Based BAF to a Stock-Based BAF

### Illustrative Case of BAF for wood biomass from forest thinning

Consider an example where a forest is thinned and the wood biomass is used for energy and its CO2 is emitted by a stationary source at time t=0. This leads to a steep reduction in carbon stocks on the land. Forest re-growth begins to build carbon stock on the land over time as shown by the upward sloping red line in Figure 1. Growth in carbon stock in the policy case is slower than the reference case (shown by the blue line) for 5 years after thinning, then growth is faster than the reference case.

Figure 1 shows the trends in land carbon for the reference and policy cases. The difference between land carbon stocks each year is shown by the vertical difference between the blue line and the red line. This difference is decreasing over time. The area between the blue and the red line is the net cumulative difference in carbon stocks due to the use of biogenic carbon between t=0,….100.

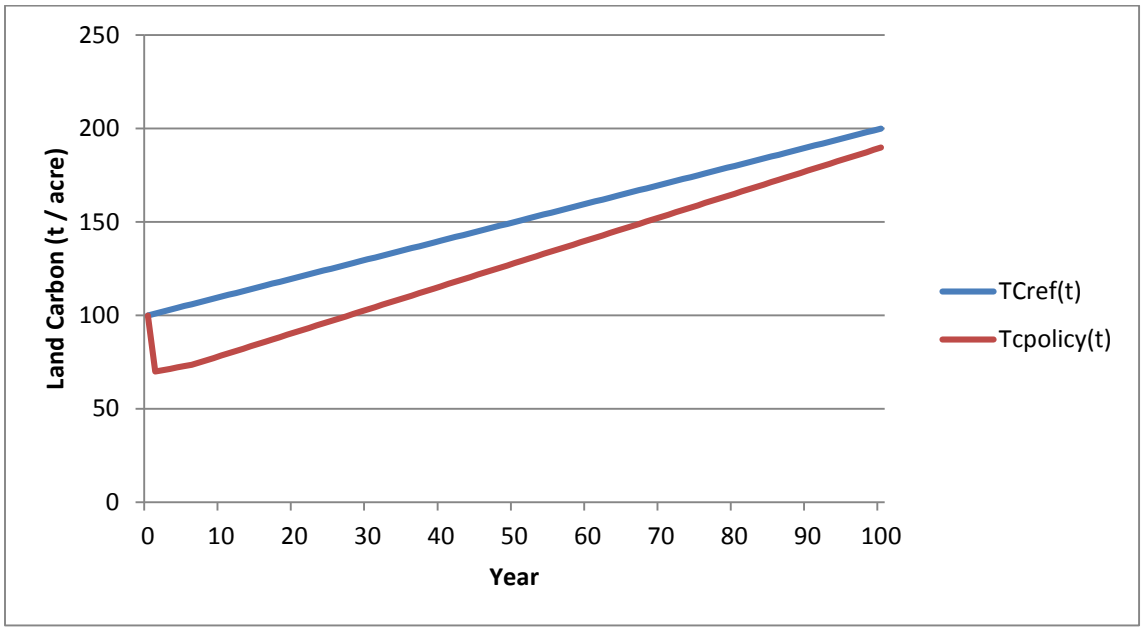


Figure 1 – Land carbon for the reference and policy cases

This vertical difference between the red and blue lines in Figure 1 is plotted in Figure 2 and shown by the yellow line. The yellow line is sloping downwards indicating the decreasing difference in land carbon stocks between the reference case and the policy case. The area under the yellow line is the sum of the difference in land carbon stocks between the reference and the policy case over time t=0,…100.

The black line in Figure 2 represents EPA's PGE, i.e. the change in atmospheric carbon stock due to the emissions from the smokestack of the stationary facility using a biogenic feedstock at time t=0. The horizontal line indicates that the facility has added a fixed amount of carbon to the atmospheric carbon stock for all time t=0,…T by using the forest thinning for bioenergy at time t=0.

The ratio of the yellow line to the black line in Figure 2 is the BAF value suggested in the 2014 Framework. This BAF is shown as the green line in Figure 2 and the blue line in Figure 3.

An alternate BAF value may be computed which would be the area under the yellow line (from year t=0…T) divided by the area under the black line (t=0…T) for each year T. This BAF2 is shown as the green line in Figure 3. The BAF2 value takes into account periods of higher and lower difference in carbon stocks (differences in carbon in the atmosphere) over time.

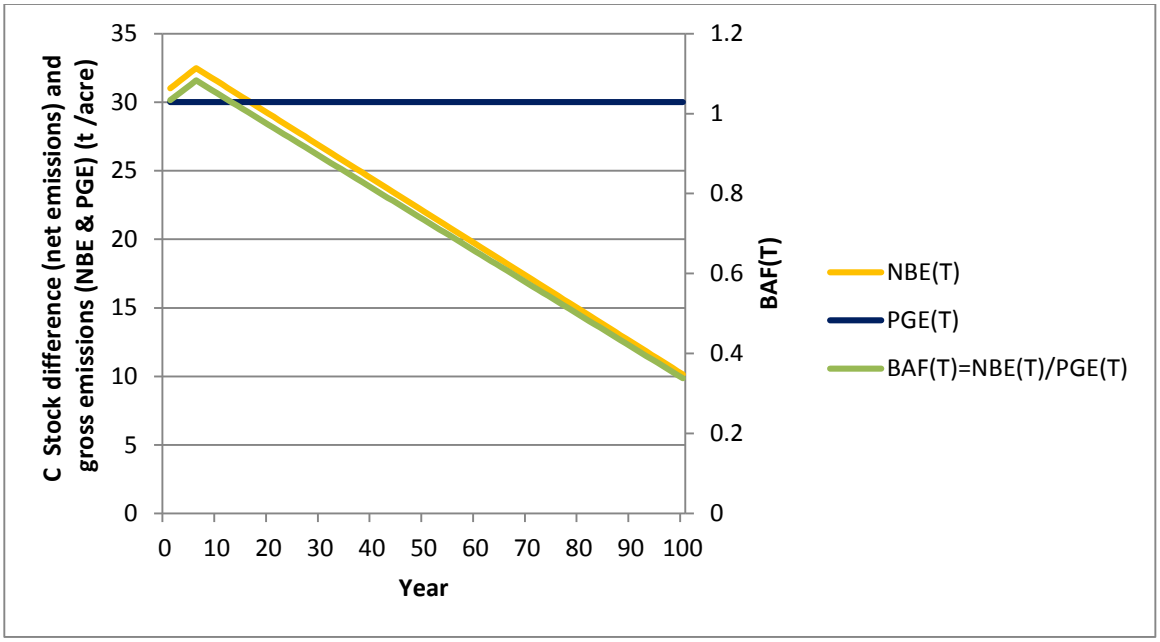


Figure 2 – C stock difference (Cumulative net emissions) and cumulative gross emissions (NEB(T) & PGE(T)) and BAF(T)

The steeper the decline in the yellow line, the smaller the value of the EPA BAF value. Also the longer the time period T, the larger the vertical difference between the black and the yellow lines at T and the smaller the BAF.

Figure 3 shows both EPA's BAF in blue and the alternate BAF2 in green.

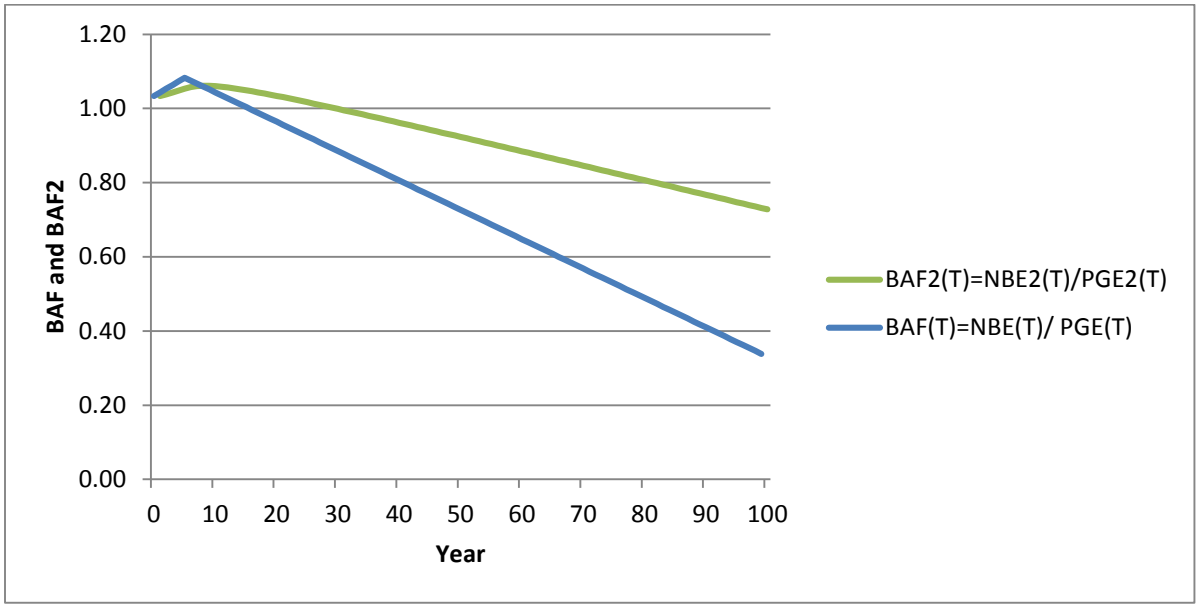


Figure 3 – BAF and BAF2 for the forest thinning example

The 2014 Framework uses a flux-based BAF approach that measures the cumulative difference in carbon emissions between the reference case and the policy case at each point in time and cumulating it over t=0,…T. Specifically it is the ratio of cumulative net emissions over a time period T to cumulative gross emissions over the time period T.

The flux-based BAF calculation in this case is represented by the ratio of the yellow line to the black line in Figure 2 at a point in time. EPA's flux-based approach is based on emissions whereas we are offering a land carbon stock-based approach to account for the fact that use of a long rotation bioenergy feedstock can change the stock of carbon on the land at all points in time and not just at the end-point T. Since the changes in the land carbon stock over t=0,..T imply a corresponding increase in the stock of carbon in the atmosphere with consequent warming effects, it is important to account for these changes in the BAF value. Our stock-based approach is shown by the ratio of the areas under the yellow and black lines in Figure 2.

Figure 3 shows the difference between these two approaches. EPA's BAF value computed using the approach in the 2014 Framework is represented by the blue line. As shown there, this BAF is an underestimate of the BAF2 value calculated using the approach suggested above. The reason for this is that EPA's BAF is only accounting for the difference between carbon stocks under the policy and the reference scenario at a single point in time, whereas our proposed approach is accounting for the cumulative difference in the carbon stocks between the two scenarios over time.

Moreover, the gap between the two measures of BAF is increasing over time, indicating that the error in the EPA's approach will be increasing as the time horizon for the calculation increases.