Appendix: Estimation of GHG emission reduction

Methodology of estimating GHG reductions from selected projects is described in this Appendix. The selected projects with quantified GHG emission reductions are: (1) Project 2.2 Portable Biochar Production for Forest Restoration and Carbon Management, (2) Project 2.3 Forest Infrastructure to Measure and Monitor Forest and Agricultural GHG Emissions, (3) Project 2.4 Carbon Fiber Recycling Demonstration Using Waste Heat, and (4) Project 2.5 GHG Sequestration in Farming Methods: No Till and Cover Crops.

Portable Biochar Production for Forest Restoration and Carbon Management

Quantification of carbon benefits from biochar production was conducted based on the carbon removal from forest and the subsequent storage of carbon as biochar. An annual rate of 3.1 MT CO_2e per acre of forest was estimated in Mississippi PCAP (MDEQ 2024) for the carbon removal rate in Mississippi forestland. By deploying biochar production, this same amount of annual carbon removed from the project forestland is therefore assumed to be stored in biochar. Consequently, the annual carbon sequestration and storage rate for the biochar production is assumed to be 3.1 MT CO_2e per acre of forest.

The project has a timeline of 5 years for deploying biochar production with an annual conversion rate of 500 acres per year at five forest sites; a total of 2,500 acres of forestland will continuously be implemented with biochar production beginning Year 6. For Year 1 to Year 5, the conversion of 500 acres each year is assumed to carried out over the course of the entire year, and the emission reduction from this additional conversion was thus estimated as 775 MT CO_2e (an annual average size of 250 acres multiplying 3.1 MT CO_2e per acre). The project implementation forestland area and annual emission reductions are subsequently calculated (Table 1).

Table 1. Annual conversion of forestland to biochar production and corresponding carbon sequestration

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6 and afterwards
Annual Conversion (acre)	500	500	500	500	500	0
Cumulative Conversion (acre)	500	1000	1500	2000	2500	2500
Annual sequestration (MT CO_2e)	775	2325	3875	5425	6975	7750

Based on this implementation timeline and annual emission reductions, the estimation of GHG reduction over the two time periods (2025-2030 and 2025-2050) was obtained (Table 2).

Table 2. Estimated carbon sequestration from this project.

	Results
Planned total acreage (acre)	2,500
2025 Reduction (MT CO_2e)	775
2026 Reduction (MT CO_2e)	2,325
2027 Reduction (MT CO_2e)	3,875

	Results
2028 Reduction (MT CO_2e)	5,425
2029 Reduction (MT CO_2e)	6,975
2030 Reduction (MT CO_2e)	7,750
Annual Average Reduction 2025-2030 (MT CO_2e)	4,521
Annual Reduction after 2030 (MT CO_2e)	7,750
2025-2030 Total Reduction (MT CO_2e)	**27,125**
2025-2050 Total Reduction (MT CO_2e)	**182,125**

Forest Infrastructure to Measure and Monitor Forest and Agricultural GHG Emissions

The GHG reduction for this project focuses on monitoring of forest, and was estimated based on (a) the annual carbon removal from managed forest and (b) the expected improvement on the forest carbon removal from the monitoring infrastructure.

Mississippi PCAP (MDEQ 2024) provides the carbon storage with forest management at different forest types in the Southcentral States (Table 3), which was used to calculate the annual average carbon sequestration with forest management.

Table 3. Carbon storage and sequestration from forest management.

Number of years after the implementation	1 year	5 years	10 years	30 years	50 years	90 years
Carbon storage - Loblolly-Shortleaf Pine (MT carbon per acre)	5.7	8.8	23.5	35.8	42.6	46.4
Carbon storage - Oak-Pine (MT carbon per acre)	5.7	7.8	16.5	34.9	40.8	57.3
Carbon storage - Oak-Hickory (MT carbon per acre)	5.8	4.3	15.4	36.5	48.2	61.6
Carbon storage - Oak-Gum-Cypress (MT carbon per acre)	4.6	4.3	7.9	30.4	42.0	51.5
Carbon storage - Elm-Ash-Cottonwood (MT carbon per acre)	3.8	3.2	8.4	24.5	32.2	44.2
Average carbon storage among forest types (MT carbon per acre)	5.1	5.7	14.4	32.4	41.2	52.2
Average carbon storage among forest types (MT CO_2e per acre)	18.8	20.8	52.6	118.9	150.9	191.4
Annual carbon removal (MT CO2e per acre)	-	0.4	3.4	3.3	2.6	1.9

The deployment and operation of measuring and monitoring infrastructure – providing feedback and key information related to the sequestration and performance of forest management and facilitating the optimization of management practices – are assumed to improve 20% of the carbon removal rate at the managed forestland. Consequently, assuming the managed forest can sequester 3.3 MT CO_2e per acre annually based on Table 3, a 20% of which is attributed to the operation of monitoring infrastructure (i.e., in comparison, 2.67 MT CO_2e per acre can be removed without monitoring). This 20% assumption generally aligns with the improvement to forest carbon removal from using forest management practices (Mäkipää et al. 2023). The carbon removal quantification for this project is therefore based on a 0.66 MT CO_2e per acre of carbon removal rate.

The total carbon removal for the project is subsequently calculated (Table 4).

Table 4. Carbon storage and sequestration from forest management.

	Results
Annual sequestration from forest (MT CO_2e per acre forest)	3.3
Benefits from forest measuring and monitoring infrastructure	20%
Planned total acreage (acre)	3750
Annual Reduction (MT CO_2e)	2475
2025-2030 Total Reduction (MT CO_2e)	**14850**
2025-2050 Total Reduction (MT CO_2e)	**64350**

Carbon Fiber Recycling Demonstration Using Waste Heat

Quantification of emission reductions for this project is based on the emission reductions from carbon fiber recycling (i.e., 80% reduction from the 24.83kg-CO_2e-emission per kg-carbon-fiber produced). Additionally, the projected future carbon fiber market size was used to quantify the annual recycled carbon fiber production for this project (Table 5). As shown in Table 5, the global market of carbon fiber is assumed to increase with an annual ~9% growth rate, from 140,000 MT in 2023 to 800,000 MT in 2043 (and staying at the same level from 2043 to 2050); the North American production capacity is assumed to be 25% of the global market size (Cook and Booth 2024; Das et al. 2016; Koumoulos et al. 2019). The carbon fiber recycling research and production deployed by this project has a fixed annual production capacity of 100 MT from 2026 to 2030, and beginning 2031, the outcome of this research is expected to lead to an annual recycled capacity of 1% of the North American carbon fiber production.

Table 5. Annual carbon fiber production.

Year	Global Market Size (MT)	North America Production (MT)	Recycled Carbon Fiber Production form this project (MT)
2023	140,000	35,000	0
2024	152,748	38,187	0
2025	166,657	41,664	0
2026	181,833	45,458	100
2027	198,390	49,598	100
2028	216,455	54,114	100
2029	236,166	59,041	100
2030	257,671	64,418	100
2031	281,134	70,283	703
2032	306,733	76,683	767
2033	334,664	83,666	837
2034	365,138	91,285	913
2035	398,387	99,597	996
2036	434,664	108,666	1,087
2037	474,244	118,561	1,186
2038	517,427	129,357	1,294
2039	564,544	141,136	1,411
2040	615,950	153,988	1,540
2041	672,038	168,009	1,680

Year	Global Market Size (MT)	North America Production (MT)	Recycled Carbon Fiber Production form this project (MT)
2042	733,233	183,308	1,833
2043	800,000	200,000	2,000
2044	800,000	200,000	2,000
2045	800,000	200,000	2,000
2046	800,000	200,000	2,000
2047	800,000	200,000	2,000
2048	800,000	200,000	2,000
2049	800,000	200,000	2,000
2050	800,000	200,000	2,000

Based on the annual production of recycled carbon fiber in Table 5, the emission reductions were quantified (Table 6), including the two project periods of 2025-2030 and 2025-2050.

Table 6. Estimated GHG emission reduction from recycled carbon fiber production.

Project period	2025-2030	2025-2050
Annual average recycled carbon fiber production (MT)	83	1,183
Total recycled carbon fiber production during this period (MT)	500	1,230
Emissions from carbon fiber production (kg CO2e per kg carbon fiber)	24.83	24.83
Emission reduction from recycled carbon fiber	80%	80%
Annual average emission reduction (MT CO_2e)	1,655	23,489
Total emission reduction from recycled carbon fiber (MT CO_2e)	**9,932**	**610,726**

GHG Sequestration in Farming Methods: No Till and Cover Crops

The GHG sequestration rate for framing practices of no tillage and cover crops provided in Mississippi PCAP (MDEQ 2024) was used to quantify the carbon benefits of this project (Table 7).

Table 7. Carbon benefits from agriculture management practices.

Best management practice	Carbon Sequestration (MT CO_2e per 10,000 acres)
Cover Crops	6,870
Multiple Conservation Practices	12,880
Nutrient Management	2,800
Residue and Tillage Management – No-Till	3,960
Residue and Tillage Management – Reduced Till	2,010
Strip-cropping	2,390

Based on the annual sequestration rates presented in Table 7 for the no tillage and cover crops practices, the total carbon benefits of this project were estimated (Table 8), with the two types of practices implemented to 10,000 acres of cropland each (and assuming the management practices are implemented starting from 2026).

Table 8. Estimated GHG sequestration from this project.

	No Till	Cover Crops	**Total**
Reduction per cropland (MT CO_2e per 1,000 acre)	396	687	
Planned cropland (thousand acre)	10	10	
Annual Reduction (MT CO_2e)	3,960	6,870	
2025-2030 Total Reduction (MT CO_2e)	19,800	34,350	**54,150**
2025-2050 Total Reduction (MT CO_2e)	99,000	171,750	**270,750**

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