



Research Proposal: The Relationship Between Canopy Cover and Carbon Sequestration Potential in Phakmaiwittayanukul School

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Abstract

The objective of this research was to compare the physical structure and carbon sequestration capacity between the Open Forest and Dense Forest at Phakmaiwittayanukul School, Sisaket. Conducted from December 2025 to January 2026 following GLOBE Protocols, the study utilized a Densiometer for canopy cover, the GLOBE Observer app for tree height, and Diameter at Breast Height (DBH) measurements. Data analysis followed the standards of the Thailand Greenhouse Gas Management Organization (TGO).

Results showed the Dense Forest had a higher canopy cover (51.56%) than the Open Forest (45.31%). Ground cover in the Dense Forest (40.63%) was exclusively green vegetation, while the Open Forest (48.44%) displayed higher diversity with both green vegetation and brown leaf litter. Crucially, the Open Forest demonstrated a higher carbon sequestration capacity (18,175.14 kgCO₂eq) compared to the Dense Forest (13,960.31 kgCO₂eq).

The discussion concludes that carbon sequestration is primarily determined by individual tree biomass rather than canopy density. Large *Sindora siamensis* (Makha Tae) trees in the Open Forest provided higher biomass than the smaller, high-density trees in the Dense Forest. Thus, preserving existing mature trees alongside supplemental planting is recommended for effective, sustainable greenhouse gas reduction.

Keywords: Canopy Cover Percentage, Carbon Sequestration, GLOBE Protocol, Phakmaiwittayanukul School

Introduction

Background and Significance

Phakmaiwittayanukul School has continuously implemented tree-planting initiatives to improve the local environment, expand green spaces, and create an atmosphere conducive to student learning. Trees play a vital role in mitigating greenhouse gas emissions by absorbing and sequestering carbon dioxide (CO₂) from the atmosphere. This carbon is stored within various components of the tree, including the trunk, branches, leaves, and root systems a fundamental process in addressing global warming and climate change.

Research Problem

One of the key factors that may influence a tree's carbon sequestration capacity is the Canopy Cover Percentage, which represents the proportion of the ground area covered by the tree's foliage. A denser and more extensive canopy typically indicates a higher rate of photosynthesis and a larger light-interception area, which may be directly correlated with the accumulation of biomass carbon within the tree.

Objectives and Benefits

Studying the relationship between canopy cover percentage and carbon sequestration within the school grounds will provide a deeper understanding of how canopy structures contribute to carbon storage. The findings can be utilized to plan and manage the school's green spaces with maximum efficiency to enhance environmental quality and reduce the impacts of climate change. Furthermore, this study serves as a model for neighboring schools and communities to adapt and implement in their own local contexts.







Research Questions

1. How do different structural characteristics of the study areas (Open Forest vs. Dense Forest) affect the Canopy Cover Percentage and Percentage of Ground Cover?
2. Is there a relationship between the amount of carbon sequestration in trees and canopy density, and if so, to what extent?

Research Hypotheses

1. Dense forest areas will exhibit a higher percentage of both canopy cover and ground cover compared to open forest areas.
2. Areas with a higher Canopy Cover Percentage (dense forest) will demonstrate a greater total carbon sequestration capacity than areas with a lower Canopy Cover Percentage (open forest).

Materials and Equipment

<p>1. Densiometer</p>  <p>Used for measuring and calculating the Canopy Cover Percentage.</p>	<p>2. Compass</p>  <p>Used to determine and maintain direction during the field survey.</p>
<p>3. Measuring Tape (Short)</p>  <p>Used for measuring pace length and short distances.</p>	<p>4. Diameter Tape / Tape Measure</p>  <p>Used for measuring the circumference of trees at breast height (CBH).</p>
<p>5. GLOBE Observer app</p>  <p>Used for measuring tree height and submitting data to the GLOBE Data Entry system</p>	<p>6. LESS-FOR-01 Calculation Tool</p>  <p>To calculate Carbon Sequestration Potential using tree species, height, and circumference data.</p>

Scope of the Study

1. Research Parameters

1.1 Study of Canopy Cover Percentage: Measuring the density and extent of the foliage covering the study area.

1.2 Study of Ground Cover Percentage: Assessing the proportion of vegetation and materials covering the soil surface.

1.3 Tree Biometrics: Measuring tree height and circumference at breast height (GBH/CBH) for biomass calculation.

1.4 Carbon Sequestration Potential: Estimating the amount of greenhouse gases sequestered, expressed in kilograms of carbon dioxide equivalent (kgCO₂eq).

2. Study Area Scope

The study was conducted within the forested areas of Phakmaiwittayanukul School, categorized into two distinct site types based on their structural characteristics.

2.1 Open Forest Site: Located at coordinates 14.943871° N, 104.027387° E

2.2 Dense Forest Site: Located at coordinates 14.944081° N, 104.027504° E



【Figure 1. Geographic location and GPS coordinates of the 30x30 meter.】

3. Time Scope

The study was conducted from December 2025 to January 2026.

Research Methodology

1. Site Selection and Plot Establishment

1.1 Site Identification: Two study sites with similar geographical characteristics but differing forest densities (Open Forest and Dense Forest) were selected. Within each site, a 30 x 30 meters square plot was established. The central coordinate of each plot was identified and recorded using Google Maps.

1.2 Pace Calibration and Plot Layout: * To ensure accurate field measurements, a 50-meter distance was measured using a tape measure. Each researcher walked this distance three times to calculate their average pace length.

Starting from the center of the square plot, the researchers measured and marked the diagonal lines toward the four cardinal/intercardinal directions: Northeast (NE), Southeast (SE), Northwest (NW), and Southwest (SW). Flags were placed at the boundary points of each direction to define the study area.



(a)



(b)

【Figure 2. (a) Mapping the designated study sites with GPS coordinates and (b) Placing boundary flags to define the sampling plots for data collection.】

2. Measuring Canopy Cover Percentage and Ground Cover

2.1 Plot Navigation: Begin at the center of the square plot and walk toward the flags positioned in the four cardinal/intercardinal directions: NE, SE, NW, and SW.

2.2 Canopy Observation: At every single pace along each direction, look upward to observe the canopy through the densiometer to determine the presence or absence of foliage.



【Figure 3. (a) Measuring canopy cover and (b) Recording the collected data on the field data sheet】

2.3 Ground Cover Observation: Look down at the ground area between your feet to observe and identify the type of ground cover.



【Figure 4. Method for assessing ground cover percentage by observing the ground area at each designated pace.】

2.4 Data Recording: Record the observations for both canopy and ground cover at each sampling point on the data sheet.

2.5 Calculation: Calculate the Canopy Cover Percentage and ground cover based on the collected data.

1) Canopy Cover Percentage Calculate the total Canopy Cover Percentage by summing all positive (+) observations, dividing by the total number of observations (both + and -), and multiplying by 100.

$$\text{Canopy Cover \%} = \left(\frac{\text{Total (+)}}{\text{Total (+)} + \text{Total (-)}} \right) \times 100$$

2) Green Ground Cover Percentage Calculate the percentage of green ground cover by summing all (G) observations, dividing by the total number of ground observations (G, B, and -), and multiplying by 100.

$$\text{Green Ground Cover \%} = \left(\frac{\text{Total (G)}}{\text{Total (G)} + \text{Total (B)} + \text{Total (-)}} \right) \times 100$$

3) Brown Ground Cover Percentage Calculate the percentage of brown ground cover by summing all (B) observations, dividing by the total number of ground observations (G, B, and -), and multiplying by 100.

$$\text{Brown Ground Cover \%} = \left(\frac{\text{Total (B)}}{\text{Total (G)} + \text{Total (B)} + \text{Total (-)}} \right) \times 100$$

4) Total Ground Cover Percentage The total ground cover percentage is the sum of the green ground cover percentage and the brown ground cover percentage.

$$\text{Total Ground Cover \%} = \text{Green Ground Cover \%} + \text{Brown Ground Cover \%}$$

3. Measuring Tree Height and Circumference

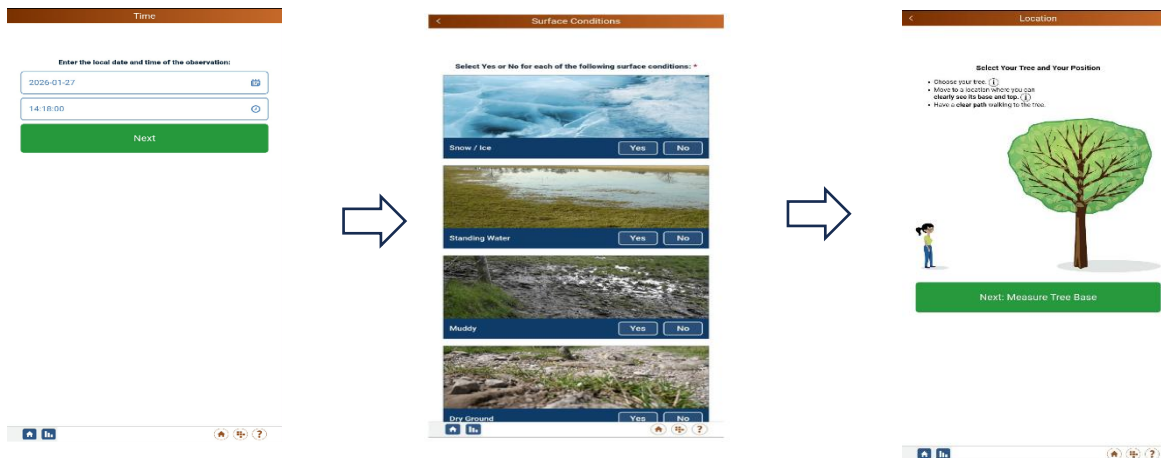
3.1 Tree Height Measurement using the GLOBE Observer Application

The operational steps for measuring tree height are as follows:

1) Launch and Setup: Open the GLOBE Observer application, select the Trees protocol, and choose "New Tree Observation."



2) Site Calibration: Set the current Date and Time, then select the type of Surface (ground conditions) you are standing on and stand in a location where both the base and the top of the tree are clearly visible.



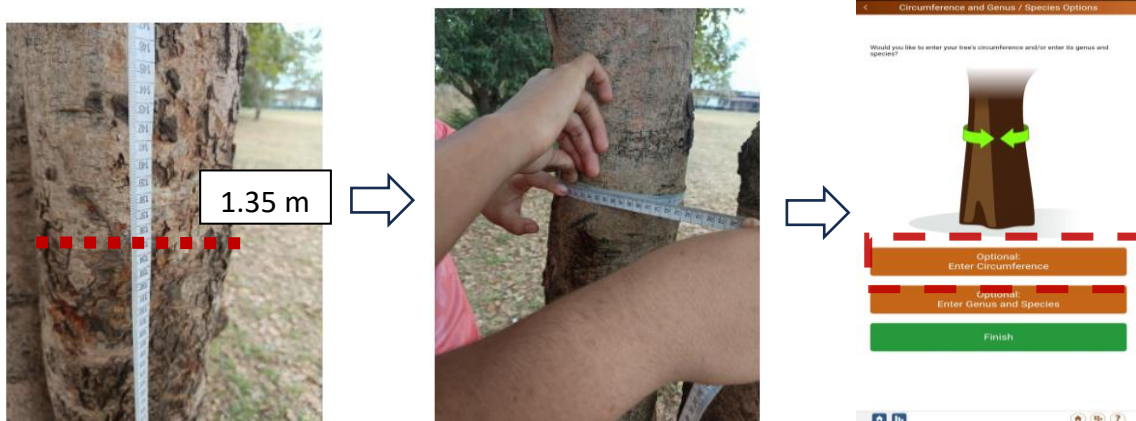
3) Image Capture: Capture photos of both the tree base and the tree top.

4) Distance Measurement: Walk toward the tree and count the number of steps (paces) from your observation point to the base of the tree to calculate the distance.



3.2 Tree Circumference Measurement

- 1) Measure a height of 1.35 meters from the ground up the tree trunk.
- 2) Measure the tree circumference at that specific height (1.35 meters).
- 3) Record the data in centimeters (cm) for further analysis.



3.3 Data Submission

- 1) Data Verification: Carefully review and verify all collected measurements and tree information for accuracy.
- 2) Upload to Data Entry: Submit the finalized data to the GLOBE Data Entry system (via the "Send All Trees Data Now" function).

The image shows the GLOBE Observer app interface. On the left is the 'Review' screen with fields for 'Your Measurements' (Camera Height: 169 cm, Stride Length: 73.9 cm, Number of Steps: 15, Distance to Tree: 11.09 m) and a 'Calculated Tree Height' of 11.08 m (36 ft. 4 in.). Below are 'Optional Input' fields for Circumference (15cm), Genus, Species, and Common Name, along with a 'Comments' section. A 'Finish' button is at the bottom. In the center is the 'Complete' screen with a confirmation message and buttons for 'Send All Trees Data Now', 'Review/Edit Observations', 'Share', 'New Trees Observation', 'My Observations', and 'My Trees Map'. On the right is a 'Biometry - Tree Heights' table with the following data:

Biometry - Tree Heights	
Measured Date:	2026-01-24
Organization Name:	Phakmaiwitayanusukul school
Site ID:	359994
Site Name:	48PUB853524
Country Name:	Thailand
Country Code:	THA
Latitude:	14.944347
Longitude:	104.026406
Elevation:	141.8m
Measured At:	2026-01-24T06:54:00
Leaves On Trees:	true
Tree Height Average:	15.31 m
Circumference:	68.5 cm
Dry Ground:	true
Data Source:	GLOBE Observer App
GLOBE Teams:	GlobeSULBU GLOBE Thailand, THDataEntryCampaign2025

4. Calculation of Carbon Sequestration Potential

4.1 Utilizing the LESS-FOR-01 Program: The estimation of carbon storage is performed through the following steps:

- 1) Tree Species Group Identification: Identify and select the specific tree species group as classified within the program.
- 2) Data Entry: Input the measured tree height and circumference (at breast height) for each individual tree.
- 3) Recording Results: Document the calculated Carbon Sequestration Potential, which represents the amount of greenhouse gases sequestered in kilograms of carbon dioxide equivalent

The image shows the LESS-FOR-01 program interface. On the left is a table with columns for 'ลำดับ' (Order), 'ชื่อพรรณไม้' (Tree Name), 'กลุ่มชนิดพรรณไม้' (Tree Group), 'ความสูง (เมตร)' (Height), 'เส้นรอบวงของต้นไม้ (เซนติเมตร)' (Circumference), and 'ปริมาณก๊าซเรือนกระจกที่กักเก็บได้ (kgCO₂e)' (Carbon Sequestration Potential). The first row is highlighted with a red dashed border. On the right is a callout box with the following data:

กลุ่มชนิดพรรณไม้	ความสูง (เมตร)	เส้นรอบวงของต้นไม้ (เซนติเมตร)	ปริมาณก๊าซเรือนกระจกที่กักเก็บได้ (kgCO ₂ e)
พรรณไม้ทั่วไป	20	100	1,138.62

Below the callout box are four labels with arrows pointing to the corresponding data points: 'Tree Species Group Identification', 'Tree Height (meters)', 'Tree Circumference (cm)', and 'Carbon Sequestration Potential'.

Results

1. Results of Canopy Cover Percentage Study

Table 1 Data Recording Table for Canopy Cover Percentage: Open Forest

Pace \ Direction	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
NE	+	-	+	+	+	+	+	+	-	+	+	+	+	+	+	+
SE	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+
NW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SW	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+
Total (+)	29															

Table 2 Data Recording Table for Canopy Cover Percentage: Dense Forest

Pace \ Direction	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
NE	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-
SE	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+
NW	-	-	-	-	-	+	-	-	+	-	-	+	-	-	-	-
SW	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+
Total (+)	33															

The canopy cover was assessed using a densiometer, where a positive symbol (+) indicates the presence of foliage and a negative symbol (-) represents open sky. The total percentage was calculated by dividing the sum of positive observations by the total number of sampling points, multiplied by 100. The results demonstrate that the **Dense Forest**, with a total of 33 positive points, has a higher foliage density compared to the **Open Forest**, which recorded 29 positive points.

2. Results of Ground Cover Percentage Study

Table 3 Data Recording Table for Ground Cover Percentage: Open Forest

Pace \ Direction	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
NE	-	-	G	G	G	G	G	G	G	G	G	G	G	G	G	G
SE	-	-	-	-	-	-	-	-	-	-	G	G	G	G	G	G
NW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SW	-	-	-	-	-	B	B	B	B	B	B	B	B	B	B	B
Total (G),(B)	G = 20								B = 11							

Table 4 Data Recording Table for Ground Cover Percentage: Dense Forest

Pace Direction	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
NE	G	G	G	G	G	G	-	-	-	-	-	-	-	-	-	-
SE	G	G	-	G	G	G	-	-	-	G	G	G	G	G	-	-
NW	-	-	-	-	-	G	-	-	G	-	-	G	-	-	G	G
SW	-	-	-	-	-	-	-	-	-	-	-	G	G	G	G	G
Total (G),(B)	G = 26								B = 0							

Ground cover was assessed by observing the area between the feet at each sampling point, using symbols for green vegetation (G), brown ground cover (B: brown plants or leaf litter), and bare soil (-). The results show that the Dense Forest consists entirely of green ground cover (G = 26). In contrast, the Open Forest exhibits a mix of both green and brown cover, with 26 points of green vegetation (G) and 11 points of brown ground cover (B).

3. Results of Carbon Sequestration Potential Analysis

Table 5 Data Recording Table for Carbon Sequestration Potential: Open Forest

No.	Tree Species	Height (m)	Circumference (cm)	Carbon Sequestration Potential (kgCO ₂ eq)
1	<i>Sindora siamensis</i>	12	149	1,492.52
2		21	153	2,660.94
3		21	190	4,006.30
4		21	102	1,237.71
5		21	160	2,895.51
6		20	143	2,236.70
7		21	145	2,404.35
8		12	78	439.41
9		12	58	250.86
10	Rain Tree	12.31	34	93.50
11		12.3	43	145.74
12		12.3	31	78.44
13	Golden Shower Tree	11.5	57	233.16
Total				18,175.14

Table 6 Data Recording Table for Carbon Sequestration Potential: Dense Forest

No.	Tree Species	Height (m)	Circumference (cm)	Carbon Sequestration Potential (kgCO ₂ eq)
1	<i>Sindora siamensis</i>	21	129	1,928.15
2		21	105	1,307.33
3		21	127	1,872.11
4		22	145	2,512.29
5		21	142	2,311.30
6		11	42	125.40
7		16	46	1,928.15
6		14	24	1,307.33
7	<i>Syzygium cumini</i>	20	23	70.63
8		15	32	100.52
9		14	60	309.49
10		20	13	23.99
11		9	19	23.11
12		10	20	28.14
13		12	22	40.04
14	A bamboo clump with 14 culms	10	25	42.727
15	A bamboo clump with 10 culms	7	15	29.598
Total				13,960.31

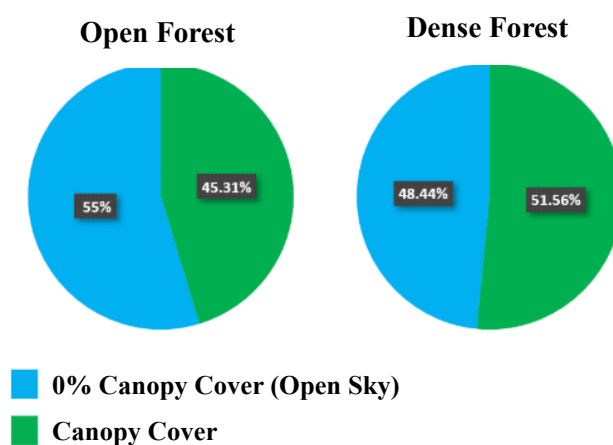
The carbon sequestration potential was evaluated based on tree species, height (m), and circumference (cm). The species identified in the study areas included *Sindora siamensis*, Rain Tree, Golden Shower Tree, *Syzygium cumini*, and bamboo clumps. The analysis revealed that the **Open Forest** plot sequestered a total of **18,175.14** (kgCO₂eq), while the **Dense Forest** plot recorded a total of **13,960.31** (kgCO₂eq)

Table 7: Summary of Research Results

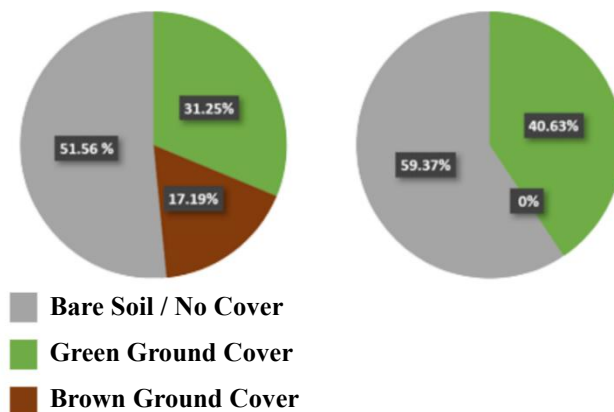
Study Area	Canopy Cover (%)	Green Ground Cover (G) %	Brown Ground Cover (B) %	Total Ground Cover %	Carbon Sequestration Potential (kgCO ₂ eq)
Open Forest	45.31	31.25	17.19	48.44	18,175.14
Dense Forest	51.56	40.63	0	40.63	13,960.31

Table 8: Comparison of Dominant Species and Tree Biometrics

Study Area	Dominant Species	Max Height	Max Circumference	Carbon Sequestration Potential (Range per Tree)
Open Forest	<i>Sindora siamensis</i>	21 m.	190 cm	250.86 - 4,006.30 (kgCO ₂ eq)
Dense Forest	<i>Sindora siamensis</i> & Bamboo	22 m.	145 cm	23.11 - 2,512.29 (kgCO ₂ eq)



【Figure 3. Comparison of Canopy Cover Percentage between Open Forest (45.31%) and Dense Forest (51.56%)】



【Figure 4. Comparison of Ground Cover Composition, highlighting the presence of brown litter only in the Open Forest plot】

Research Conclusion

The comparative study between the Open Forest and Dense Forest at Phakmaiwittayanukul School reveals three key findings:

1) **Physical Structure:** The Dense Forest exhibits higher density in both canopy cover (51.56%) and total ground cover compared to the Open Forest.

2) **Ground Cover Composition:** The Open Forest shows greater diversity in ground cover, consisting of green vegetation (31.25%) and brown litter (17.19%). In contrast, the Dense Forest contains only green vegetation (40.63%) with no brown cover observed.

3) **Carbon Sequestration:** Despite its lower density, the Open Forest has a higher total carbon sequestration potential of 18,175.14 (kgCO₂eq), exceeding the 13,960.31 (kgCO₂eq) recorded in the Dense Forest.

Discussion

1) **Biomass Significance over Density** Individual tree analysis indicates that carbon sequestration is primarily driven by biomass-determined by tree circumference and height-rather than tree quantity or canopy density.

1.1) **Open Forest:** Large *Sindora siamensis* trees (circumferences of 143–190 cm) possess substantial biomass, leading to significantly higher total carbon storage.

1.2) **Dense Forest:** Despite higher canopy cover, this area is dominated by smaller trees and bamboo (circumferences of 13–60 cm), resulting in lower overall carbon accumulation compared to the larger trees in the Open Forest.

2) **Relationship Between Light and Ground Cover** The lower canopy cover in the Open Forest (45.31%) allows more sunlight to reach the forest floor. This facilitates greater ground cover diversity, consisting of both growing green vegetation and brown litter from leaf shedding, which eventually decomposes into essential soil nutrients.

Recommendations

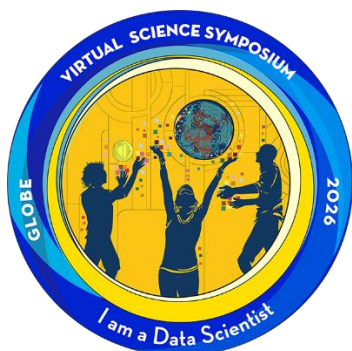
1) **Green Space Management:** The school should prioritize the preservation of existing mature trees, such as *Sindora siamensis*, alongside new planting initiatives. These large trees serve as "primary carbon sinks," which are significantly more efficient at sequestering carbon than a high density of smaller trees.

2) **Future Research Expansion:** For future Virtual Science Symposium (VSS) projects, it is recommended to conduct a comparative study on "soil moisture" or "soil nutrients" between these two forest types. This would provide deeper insights into how soil conditions influence the different growth rates of trees in each area.

References

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《Optional Badges》



I AM A DATA SCIENTIST

Our project demonstrates data science by integrating field measurements with the GLOBE database and TGO standards. We analyzed multiple variables across two forest plots to identify a critical correlation between biomass and carbon sequestration. These data-driven inferences allowed us to address local environmental issues and provide actionable recommendations for school green space management.



I AM AN EARTH SYSTEM SCIENTIST

Our research applies an Earth system science approach by investigating the interconnectedness between the Biosphere (tree biomass and ground cover) and the Atmosphere (carbon sequestration). We utilized multiple GLOBE protocols, including Trees and Land Cover, to collect high-fidelity data across two distinct forest plots. By analyzing how physical structures influence greenhouse gas storage, we demonstrate a deep understanding of the dynamic processes that define our local Earth system.



I MAKE AN IMPACT

Our research addresses a local environmental issue by evaluating the carbon sequestration capacity of **Phakmaiwittayanukul School's** green spaces. By identifying that mature trees like *Sindora siamensis* are primary carbon sinks, we provide actionable recommendations for the school to prioritize biomass preservation. This study empowers our community to make informed decisions in managing local forests to mitigate global climate change effectively.