Comparison of Carbon Sequestration Potential in Restored Forests of Different Ages at Limestone Mining Sites

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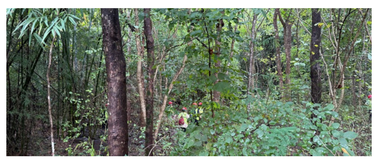
Abstract

Forest areas are continuously decreasing due to population growth and human activities, such as mining, which cause severe land degradation and require forest restoration. This study aimed to investigate the carbon sequestration potential in limestone mine restoration areas (planted in 2012, 2016, 2020, and 2024) of Siam Cement Group (SCG) in Lampang Province. In each plantation age, three 200 m² sample plots were established. Diameter at breast height and tree height were measured for trees taller than 1.3 m. The aboveground biomass were estimated using the allometric equations of Chave (2014) and Ogawa (1965) and belowground biomass and carbon stock were calculated using IPCC (2006) equation. The results showed that carbon sequestration was directly related to the age of the restored forest. Comparison of the allometric equations indicated that Chave (2014) and Ogawa (1965) produced similar results. The comparison of carbon sequestration potential among, *Gmelina arborea* Roxb., *Bauhinia purpurea* L., and *Oroxylum indicum* (L.) Kurz, *Gmelina arborea* showed the highest carbon accumulation. Therefore, plantation age and tree species are key factors influencing carbon accumulation, and *Gmelina arborea* is a suitable species for accelerating carbon sequestration in limestone mining restoration.

Introduction



turn into



- **Background**: Anthropogenic CO_2 emissions drive global warming, making forest carbon sinks crucial.
- **Problem**: Semi-open cut limestone mining causes severe land degradation, impeding natural ecosystem recovery.
- **Implication**: Restoration of mined sites is essential to recover biodiversity and enhance carbon sequestration capacity.

Objectives

- To determine carbon accumulation in restoration areas of different plantation ages (planted in 2012, 2016, 2020, and 2024).
- To compare aboveground biomass estimated using the allometric equations of Chave (2014) and Ogawa (1965).
- To compare carbon accumulation among three specific tree species: *Gmelina arborea* Roxb., *Bauhinia purpurea* L., and *Oroxylum indicum* (L.) Kurz.

Methodology

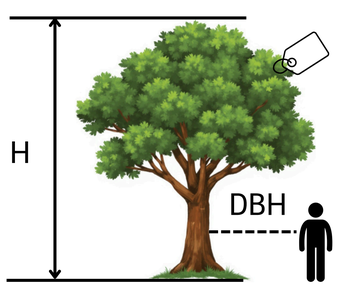
- **Study area**: Limestone mine of the Siam Cement Group (SCG) in Lampang, Thailand, across four plantation ages (2012, 2016, 2020, and 2024).





- **Sampling**: Three 200 m² plots established for each age class.

- **Data collection**: Species name, Diameter at Breast Height (DBH), and Height (H) for trees 1.3 m or more of height
- **Classification**: Trees; DBH ≥ 4.5 cm and Saplings; DBH < 4.5 cm



- **Data analysis**:

Above-Ground Biomass (AGB) Calculation

$AGB = 0.0673 \times (WD \times D^2 \times H)^{0.976}$: Chave (2014)

$AGB = 0.0430 \times (DH)^{1.093}$: Ogawa (1965)

- Use for plantation ages and specific species; *Gmelina arborea* Roxb., *Bauhinia purpurea* L., and *Oroxylum indicum* (L.) Kurz.

Below-Ground Biomass (BGB) Calculation

BGB = AGB x 0.20 or 0.24 : IPCC (2006)

Total Carbon Stock Calculation

Total Carbon Stock = (AGB + BGB) × 0.47 : IPCC (2006)

Conclusion

- A positive relationship exists between stand age and carbon storage; older new forests accumulate significantly more carbon.
- *Gmelina arborea* demonstrated the highest carbon sequestration potential among the studied species.
- The two allometric equations used for biomass estimation yielded no significant difference.

Results

- **Plant Species Richness and Diversity**

Table 1 Species Richness Increased in older plots (2012, 2016) but decreased in younger sites (2020, 2024). Shannon Index and Evenness are higher in younger plots.

Year	Initial Species	Current Species	Shannon index	Evenness
2012	12	18	2.029	0.373
2016	18	24	2.763	0.546
2020	30	24	2.858	0.537
2024	28	23	2.894	0.923

- **Biomass and Carbon Stock**

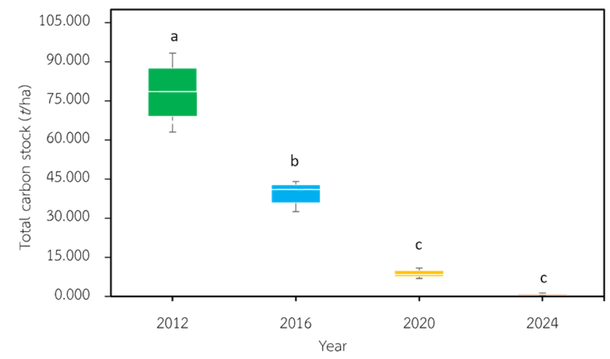


Fig. 1 Carbon accumulation in restoration areas of different ages.

- **Carbon Stock of Specific Species**

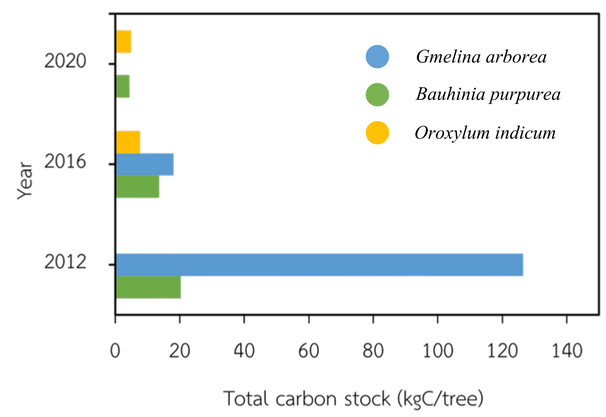


Fig. 2 Total carbon accumulation of the three specific species.

- **Allometric equations**

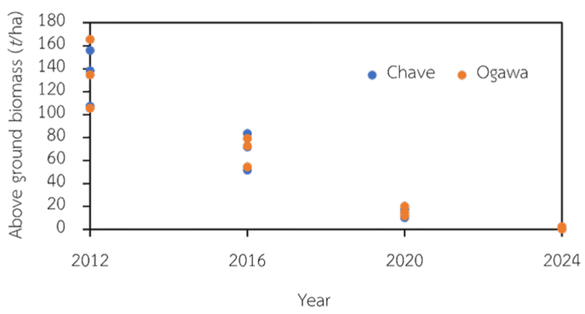


Fig. 3 Comparison of aboveground biomass estimated using the allometric equations of Chave and Ogawa across different plantation years.

Discussion

- Tree species richness and species diversity (Shannon Index) depended on number of species planted and age of plantation
- Carbon accumulation increases continuously with stand age. Biomass increases as the new forest matures.
- This difference of carbon accumulation among three species is driven by biomass allocation. *G. arborea* allocates 84% of its biomass to the main stem. In contrast, *O. indicum* and *B. purpurea* allocates more biomass to branches and leaves.

Acknowledgements

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