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Evaluating Microclimate Impacts on Post-Fire Vegetation Recovery in BRIS Soils

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ABSTRACT

This study examines vegetation recovery in fire-affected coastal sandy **(BRIS)** soils at **Taman Rimba Ilmu Tanah BRIS, UniSZA Besut Campus**, analyzing **12 plots** with nutrient-poor soils **(pH 6.6–7.0, 0–1.5% moisture)** but high humidity **(72.4%** average), which supports post-fire regeneration. Fire-adapted pioneer species like ***Acacia mangium*** and ***Melaleuca cajuputi*** dominate, while ***Catunaregam tomentosa*** is universally present, demonstrating strong fire resilience. **Plot 4** shows advanced recovery with mature trees **(25cm diameter, 17.4m height)**, suggesting either fire survival or accelerated growth, while ground cover varies **(3–50%)** due to spatial fire impacts. The coastal microclimate plays a key role by maintaining high humidity, counteracting rapid soil drainage & facilitating both pioneer colonization & mature tree persistence. These findings highlight the importance of native, fire-resilient species in coastal restoration & call for further research on long-term succession & climate change effects on recovery dynamics.

INTRODUCTION

Fire events continue to be a significant ecological disturbance in forest ecosystems, reshaping vegetation structure, biodiversity patterns, and underlying soil properties. These effects are particularly pronounced in tropical coastal regions, such as Malaysia, where the interplay between climate change & anthropogenic land use intensifies fire frequency and strength (Chuvieco et al., 2020; Myers-Smith et al., 2019). In recent years, hotter & drier conditions have contributed to longer fire seasons, while human activities such as land clearing & open burning have further forced fire occurrences (de Groot et al., 2022).

Among Malaysia's diverse landscapes, BRIS (Beach Ridges Interspersed with Swales) soils present a unique ecological challenge. Predominantly found along the eastern coastal lowlands of Peninsular Malaysia, BRIS soils are highly permeable, coarse-textured & lack essential nutrients (Wong et al., 2021). These sandy substrates are inherently low in organic matter and exhibit limited water retention capacity, rendering them vulnerable to erosion, desiccation & nutrient leaching. Post-fire recovery in such degraded soils is often hindered by the inability of the soil to retain sufficient moisture for seedling establishment and growth (Noraini et al., 2017).

METHODOLOGY

Study Area

Location & Ecosystem

- Study conducted at **Taman Rimba Ilmu Tanah BRIS**, **UniSZA Besut Campus, Terengganu, Malaysia** (5.8363°N, 102.5176°E).
- Features **BRIS soil ecosystem** with **beach ridges and shallow swales**, typical of northeastern Peninsular Malaysia.

Climate & Native Vegetation

- **Tropical rainforest climate** with **>2,000 mm annual rainfall** & **26–32°C mean temperature**.
- Dominated by **coastal forest species** adapted to **nutrient-poor soils** & **periodic disturbances**.

Fire Event (2023)

- **Moderate to severe fire**, likely **human-induced** during a prolonged dry season.
- Caused **surface vegetation destruction** & **partial canopy loss**, creating a natural post-fire recovery study site.

Research Significance

- Provides insights into **vegetation regeneration** in fire-affected **BRIS soils**.
- Highlights the resilience of coastal species & the role of microclimate in recovery.

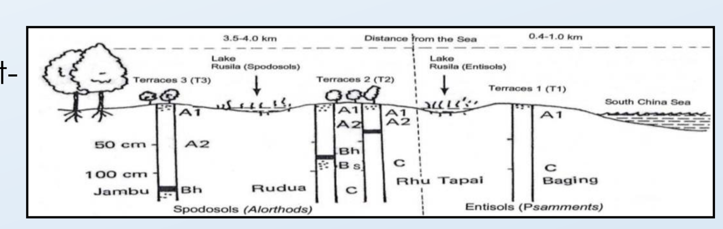

Figure 2: Soil catena of BRIS soils (T1, T2 and T3 represents the young, older and oldest beach ridges, respectively) adopted from Armanto et al (2013).

Sampling Plot

1. Study Plot Design

- Established twelve 10m×10m plots across the burned area
- Plots selected based on burn severity, terrain features & distance to surviving vegetation
- Each plot mapped with GPS coordinates & elevation measurements

2. Data Collection Method

- Divided each plot into four 5m×5m sections for detailed analysis
- Measured plant recovery & soil conditions at plot & subsection levels
- Followed standard ecological protocols to ensure consistent data quality

Microclimate & Vegetation Inventory

1. Microclimate Parameters

- Measurements taken at midday (11:00–13:00) to assess peak environmental stress
- Relative humidity (RH) measured using a sling psychrometer & digital thermo-hygrometer

2. Vegetation Inventory

- Trees measured: DBH ≥1 cm tagged, identified & recorded (tape for DBH, clinometer/pole for height)
- Ground cover: Visually estimated in % classes (<5%, 5–25%, 26–50%, 51–75%, >75%)
- Recovery focus: Pioneer, fire-adapted, & native species, plus regrowth mechanisms (resprouting/seedlings)

Data Analysis

Descriptive statistics were calculated for soil pH, moisture content & RH%. Vegetation data were analysed for species frequency, basal area (BA) & importance value index (IVI) using the formulas:

BA (m²) = π × (DBH/200)² ....eq. 1

IVI = Relative Frequency + Relative Density + Relative Dominance ....eq 2

Pearson correlation analysis was conducted to examine relationships between percentage of relative humidity, soil moisture & vegetation metrics including ground cover, tree height & DBH. Non-metric multidimensional scaling (NMDS) was also applied to visualize species composition differences among plots.

RESULT

1. Soil & Climate

- Sandy, dry soils (pH 6.6-7.0)
- High air humidity (65-78%) helps plants survive dry conditions

2. Plant Recovery

- More plants grew in shady, humid areas (up to 50% cover)
- Tough, fast-growing species like acacia dominated after fire

3. Trees Found

- 97 trees recorded, mostly: *Syzygium spp.* (25), *Acacia mangium* (20) & *Melaleuca cajuputi* (18)
- Big trees (over 17m tall) found in some plots

4. Finding

- Coastal humidity helps forests regrow after fires with certain tough tree species grow well in poor soil & shady areas recover faster than open spaces

CONCLUSION-Coastal humidity helps fire-damaged BRIS soils recover by supporting tough pioneer trees like Acacia & Melaleuca species, showing we should consider microclimate in restoration plans.

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RESULT

Parameter	Range	Mean	Key Observations
Soil pH	6.6 – 7.0	6.93	Near-neutral, suitable for general growth
Soil Moisture	0 – 1.5%	–	10/12 plots had 0% moisture
Relative Humidity (RH)	65.5 – 78.3%	71.9%	High atmospheric moisture despite dry soils