Sensitivity_Soil_Nutrient_Pools Data Analysis Summary

Executive Summary

The analysis investigates how **Soil Microbial Diversity** (measured via `faith_pd` or Phylogenetic Diversity) is influenced by various environmental and management factors. The dataset includes 1,006 samples collected between 2018 and 2022 across two sites (**FK** and **TB**). The primary variables analyzed include grazing treatments, microbial types (Bacteria vs. Fungi), rainfall reduction, and temporal (yearly) trends.

2. Detailed Explanation of Analysis & Findings

A. Data Preparation (Cleaning)

- **The Problem:** Initially, the `faith_pd` column was stored as a text "Object" because the numbers contained multiple dots (e.g., `3.912.908.739`).
- **The Action:** The analysis successfully cleaned this data by removing the extra dots and converting the values into a numeric (integer/float) format, enabling mathematical calculations.

B. Impact of Grazing Management

The study compared three treatments: **Stable**, **Heavy**, and **Destock**.

- **Stable Treatment:** Showed the **highest average diversity** (~3.47e+09). This suggests that consistent, moderate land use preserves microbial richness.
- **Heavy Grazing:** Resulted in a decrease in diversity (~3.41e+09), indicating that over-grazing places stress on the soil ecosystem.
- **Destocking:** Interestingly, the areas where grazing was completely stopped (Destock) showed the **lowest diversity** (~3.31e+09). This often implies that some level of moderate biological interaction (like stable grazing) is actually beneficial for soil health.

C. Microbial Type: Bacteria vs. Fungi

- **Bacteria** showed a significantly higher phylogenetic diversity (~3.44e+09) compared to **Fungi** (~3.35e+09).
- **Explanation:** Bacteria are typically more diverse and adaptable to various soil micro-climates, playing a dominant role in nutrient cycling within this specific study area.

D. Rainfall Reduction Correlation

- **Finding:** The correlation between rainfall reduction and diversity was extremely low (**0.056**).

- **Explanation:** This indicates that the microbial diversity is remarkably resilient to water scarcity in the short term, or that other factors (like land management) are far more influential than rainfall alone.

E. Temporal (Yearly) Trends

- The data shows a **concerning downward trend** over time. Diversity was highest in 2018 (~3.77e+09) but experienced a **sharp drop in 2020** (~3.16e+09), remaining low through 2022 (~3.13e+09).
- **Explanation:** This suggests a long-term decline in soil health or a specific environmental shock that occurred in 2020 from which the soil has not yet recovered.

3. Strategic Recommendations

1. **Prioritize "Stable" Grazing:** To maintain maximum soil health and microbial richness, land managers should avoid both "Heavy" grazing and complete "Destocking." A "Stable," moderate grazing schedule is the most effective management strategy.
2. **Investigate the 2020 Threshold:** Since a drastic drop occurred in 2020, it is recommended to cross-reference this data with external factors like extreme temperature events or specific land-use changes that year to identify the cause of the decline.
3. **Monitor Soil Recovery:** Because diversity levels have remained low from 2020 to 2022, long-term monitoring is required. If the trend continues downward, soil restoration efforts (like organic amendments) may be necessary to prevent permanent loss of microbial complexity.
4. **Focus on Fungal Health:** Since fungal diversity is lower than bacterial, specific practices to support fungal growth (like reducing soil tillage or increasing organic matter) should be explored to balance the ecosystem.