Rainfall partitioning in differently managed montane forest stands in Central Sulawesi, Indonesia

Johannes Dietz[1,2] Dirk Hölscher[1] Christoph Leuschner[2] Hendrayanto[3]

[1)] Department of Tropical Silviculture, University of Göttingen, Germany [2)] Department of Plant Ecology, University of Göttingen, Germany
[3)] Laboratory of Forest Influences, Institut Pertanian Bogor, Indonesia

Introduction

Management activities such as selective logging or conversion to agroforest alter the vegetation structure of many tropical forest landscapes. However, little is known about the hydrological impact of these more gradual changes in vegetation structure.

We studied a gradient from natural forest (A), over forest after small timber extraction (B) and forest after large timber extraction (C) to agroforest (D; Figs. 1 & 2) in order to assess effects of these different management practices on above-ground hydrological processes.





Fig. 1. Pictures of a natural forest (above), and of the diverse land use mosaic in the hills surrounding the Toro Valley (right).

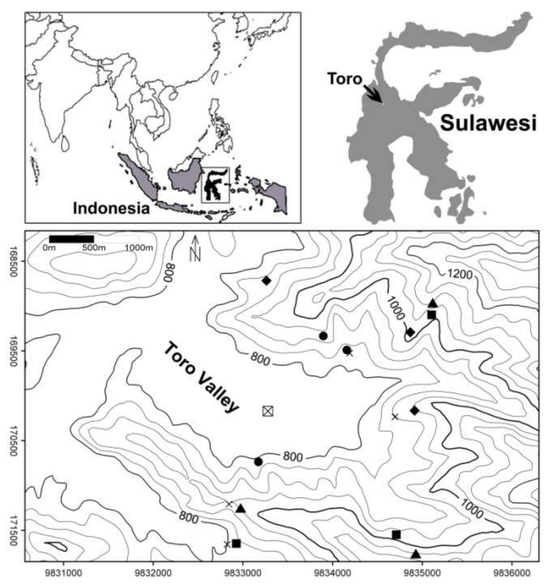


Fig. 2. Location of the study sites in the Toro Valley. Indicated are the different research plots: A (▲), B (■), C (◆), D (●) and the rain stations: permanent (×), automatic (☒)

Objectives

- To analyze stand structural characteristics presumed to be important for rainfall partitioning.
- To determine rainfall partitioning into throughfall, stemflow and interception.
- To identify stand characteristics that may control the partitioning by regression analyses.
- To investigate implications of leaf wetness duration on interception processes.

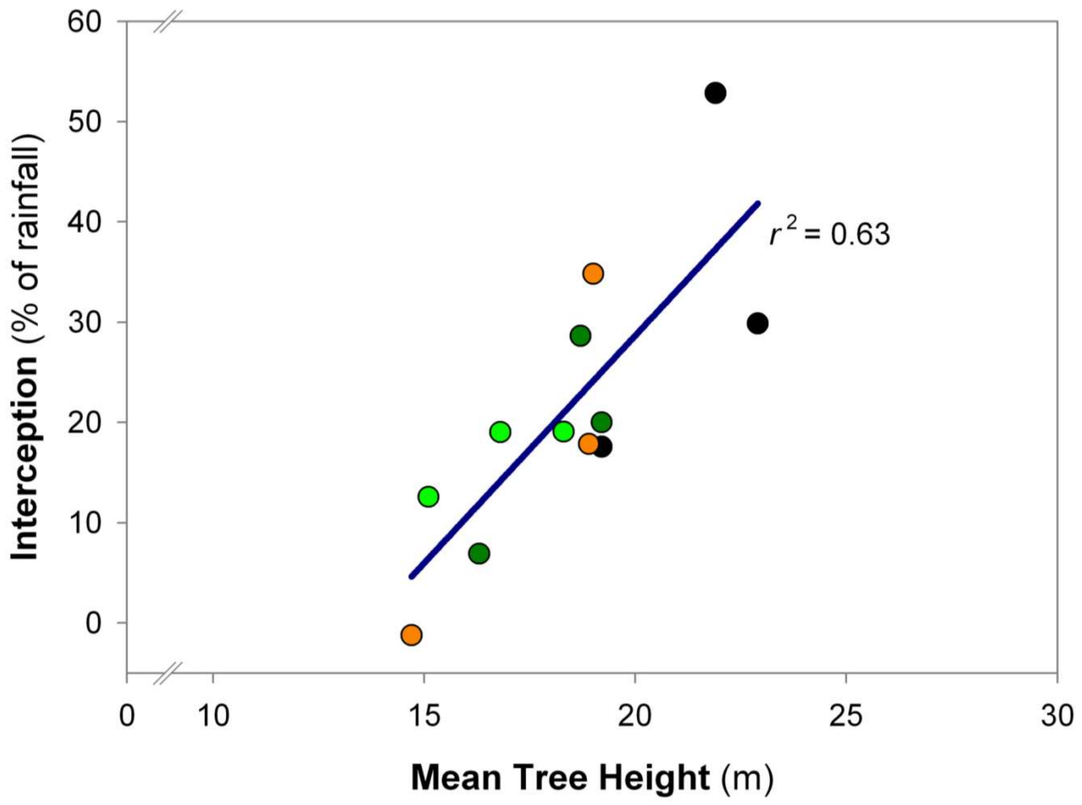


Fig. 3. Rainfall interception (in percent of gross precipitation) as a function of mean tree height (dbh ≥ 10 cm) in the 12 study plots: ● natural forest (A), ● forest after small timber extraction (B), ● forest after large timber extraction (C), and ● agroforest (D).

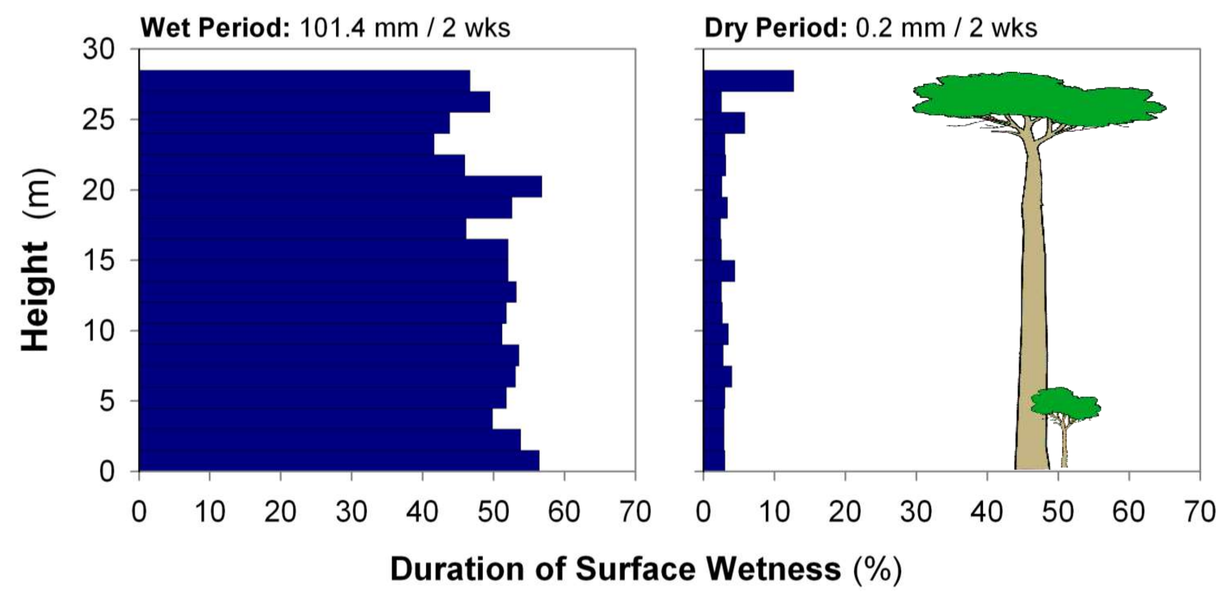


Fig. 4. Average duration of surface wetness (in percent of the time) in a vertical profile inside the Bariri forest in a wet 2-week period (June 1 - June 15, left panel), and a dry period (June 16 - June 40, right panel; with scheme of the principal extension of canopy and understorey).

Methods

Twelve study plots in the surrounding of the Toro valley (four land use types with three replications, Fig. 2) were equipped with 30 throughfall gauges and 10 stemflow collectors each. Gross precipitation was measured nearby each plot.

Thirty leaf wetness sensors were arranged as a profile through the canopy (1.5 - 33 m) along a meteo tower and allowed continuous measurements (> 1 year) of leaf wetness and microclimate at different levels.

Results

Highest interception was recorded in a natural forest plot while the lowest rate was found in an agroforest. Stemflow accounted for less than 1 % of gross precipitation in all plots. Stand height correlated strongly with interception (r^2 = 0.63; Fig. 3). In a multiple regression, tree height combined with leaf area index (LAI), improved the explained variation of interception (r^2 = 0.81).

The leaf wetness study revealed that the foliage of the entire canopy remained wet up to 50 % of the time during periods of frequent rainfall. Even during periods devoid of rainfall the canopy still experienced wetness for up to 5 % of the time (Fig. 4).

Conclusions & Outlook

The forest use intensities strongly affected basal area and tree height. When considered separately, tree height, not LAI, showed the highest positive impact on interception. This suggests that turbulent energy exchange may provide more available canopy storage in higher stands as they may dry off faster after each rainfall event than shorter, more compact stands.

We showed that focusing on LAI as principal estimator and disregarding leaf wetness duration may lead to a substantial bias in applying current interception models to the study area. This shall be explored in greater detail in the near future.

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