学 位 論 文 要 旨

論文題名 Influence of Forest Management on Hydrological Processes and Susceptibility to Soil Erosion in a Steep Japanese Watershed

（日本の急峻な流域における森林管理が水文過程と土壌浸食性に及ぼす影響）

（ふりがな）　チャールズ　ジョン　コンシグナド　グナイ

学位申請者CHARLES JOHN CONSIGNADO GUNAY ㊞

（ 学位論文要旨 ）

Forest management practices can alter the overall canopy structure which influences the water permeability and erosion susceptibility of the soil. Although there were already attempts that quantitatively investigated the impacts of forest management on discharge and erosion-related processes, most of these studies have relied on either conventional field measurement methods or hydrological models alone. One of the world-renowned models for investigating water balance and soil loss is the physically-based Soil and Water Assessment Tool (SWAT). Originally developed for mildly-sloped agricultural watersheds, SWAT has also been proven to be a reliable tool for studying the hydrological processes in steep forested catchments. However, the default input parameters in SWAT inadequately represent the effect of management on the forest floor properties. Therefore, it is essential to incorporate field surveys and empirical modeling in the analysis to improve the accuracy and reliability of the sediment yield predictions.

The Ogouchi Dam watershed has 98.6% of its 262.9-km^2 catchment area covered by forests, with 65.3% being natural forests, 20.4% well-maintained Government-managed forests, and 12.8% poorly-maintained private forests. The large spatial variability in ownership and governance in the small Government-divided forest units, i.e., forest lands with areas of less than 5 ha, render such a watershed qualified for addressing certain knowledge gaps about hydrological processes and erosion susceptibility in small and steep mixed-management catchments.

It is hypothesized that Government intervention in such an environment causes significant improvements in the soil permeability and erosion susceptibility in the watershed, and consequently, stabilization in the accumulated sediment in the reservoir. To verify such a hypothesis, this Ph.D. research intends to illustrate the long-term changes in climate trends and soil water storage characteristics, develop a robust erosion susceptibility model for quantifying raindrop erosion risk, and estimate the probable sediment yield and cumulative sediment volume for multiple forest management scenarios. This dissertation is specifically composed of seven chapters.

Chapter 1 is the introduction that provides the background, review of literature, general and specific objectives, and outline of the dissertation.

Chapter 2 outlines the methodology, which includes the procedures for analyzing hydroclimatic data, estimating the discharge components using the conceptual-type tank model and the distributed-type SWAT model, field investigation of geophysical properties of different forest types, empirical modeling of raindrop erosion risk, and physically-based modeling of sediment yield.

Chapter 3 presents the analysis of climate and discharge trends for the past half-century (1965–2015) in the watershed. Using the Mann-Kendall trend test, it was found that rainfall and discharge exhibited non-significant increasing and decreasing trends. In contrast, significantly increasing trends were found in the air temperature analysis, with the rise during winter being the most drastic. Analyzing the rate of change for each month using the Theil-Sen's slope method, it was inferred that the increase in air temperature during the hotter months (Apr–Sep) is less compared to the air temperature rise in its adjacent urban stations.

Chapter 4 discusses two independent approaches in illustrating the decadal trends in soil water storage characteristics based on the temporal variation in discharge. The first method applied a linear correlation analysis between Thiessen-averaged rainfall and tank-modeled runoff, while the second method utilized the calibration of sensitive discharge parameters in SWAT. Results from the correlation analysis affirmed a gradual increase in the soil water storage capacity at continuous rainy days that accumulate less than 70 mm of rain. On the other hand, the decadal trends from the parameter calibration showed a constant coefficient in the runoff potential and a high possibility of a steady improvement in the soil available water capacity.

Chapter 5 highlights the empirical modeling of raindrop erosion susceptibility. Field surveys were first carried out in a total of 59 points to evaluate the differences in geophysical properties among natural forests, private forests, unfenced Government-managed forests, and fenced Government-managed forests in the upstream basins, Taba, Ushiroyama, and Minetani, as well as in the downstream basins, Kosuge and Okutama. The analysis commenced with the estimation of probable open and throughfall raindrop impact energies based on the measured crown openness and canopy top and bottom heights in each survey point. Then, surface protection was redefined as the average of the percentages of understory vegetation and leaf litter. The total erodibility coefficient (*TEr*), defined as the standardized coefficient that quantifies the susceptibility to raindrop erosion based on properties affected by forest management, was modeled as a function of these three components. It was concluded that both open and throughfall raindrop impacts can be expressed using stand density, while surface protection is additionally influenced by ground slope and management system. The spatial distribution of *TEr* showed that 25.8% of Government-managed forests and 45.1% of the private forests have exceeded the average *TEr* in natural forests.

Chapter 6 focuses on calculating the annual sediment yield and the sediment accumulation volume for various management scenarios by corresponding the *TEr* value in each forest unit to the MUSLE management practice factor (MUSLE *P*) input in each hydrologic response unit (HRU) in SWAT. About 20.9% of the Government-managed forests and 61.6% of the private forests have higher probable sediment yield relative to the value calculated in the natural forest. A maximum reduction of 14.4% in cumulative sediment is likely attainable upon full Government control.

Finally, Chapter 7 summarizes the findings and the recommendations for future work.

注意　　・和文：２０００字程度　英文：８００語、１２ポイントで記載
　　　　・題名が英文の場合は英題（和題）とすること