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Forecasting impacts of climate change on plantation carbon sink capability

Hung-En Li[1] and Su-Ting Cheng[1,2]
[1]National Taiwan University, School of Forestry and Resource Conservation, Taiwan, Province of China (r09625008@ntu.edu.tw)
[2]Corresponding author (chengsuting@ntu.edu.tw)

In the face of climate change, the government of Taiwan requires new mitigation policies and implementation strategies. As forest plantations are commonly accepted as great carbon sinks, developing reliable carbon systems linking forestry carbon sequestration into green carbon credits in the economic sector requires synergic integration to examine potential carbon sink capability of forest plantations under the ever-changing climate. In this regard, this study developed a process-based stand growth model based on the structure of the Physiological Principles for Predicting Growth (3-PG) for carbon sequestration estimations of Sugi plantations in the National Taiwan University (NTU) Experimental Forest. The model considered monthly solar radiation, temperature, precipitation, vapor pressure deficit (VPD), and the atmospheric carbon dioxide concentration to simulate dynamic biomass production, and then allocated the simulated biomass to root, stem, and foliage by allometric equations fitted to biomass data from the SugiHinoki Database. After that, the mortality of stand was determined by using a zero-inflated Poisson modelling on long-term growth data collected by the NTU Experimental Forest during 1921-2019. In addition, we performed a scenario analysis to forecast future stand growth under 4 climate scenarios of RCP2.6, RCP4.5, RCP6, and RCP8.5. Results revealed higher annual biomass increment (around 4 t $ha^{-1}y^{-1}$) in the end of the century in RCP6.0 and RCP8.5, and lower increment (around 2.5 t $ha^{-1}y^{-1}$) in RCP2.6 and RCP4.5. A step-wise multiple linear regression analysis on the simulated growth data and climatic inputs revealed stronger positive impact of CO_2 concentration than precipitation on unit biomass primary production (NPP/Biomass). Temperature had comparable counter impact against precipitation, and solar radiation showed the least negative influence on unit biomass primary production. Based on this process-based stand growth model, we are able to dig into the relation between climatic variables and carbon sequestration rate, and help sketch prospect of plantations in the carbon market for plantation managers, investors, and policy makers.