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Estimating forest carbon dynamics in South Korea from 1954 to 2050 – coupling global forestry model and forest soil carbon model

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There have been demands on reporting national forest carbon (C) inventories to mitigate global climate change. Global forestry models estimate growth of stem volume and C at various spatial and temporal scales but they do not consider dead organic matter (DOM) C. In this study, we simulated national forest C dynamics in South Korea with a calibrated global forestry model (G4M model) and a module of DOM C dynamics in Korean forest C model (FBDC model). 3890 simulation units (1–16 km^2) were established in entire South Korea. Growth functions of stem for major tree species (Pinus densiflora, P. rigida, Larix kaempferi, Quercus variabilis, Q. mongolica, and Q. acutissima) were estimated by internal mechanism of G4M model and Korean yield tables. C dynamics in DOMs were determined by balance between input and output (decomposition) of DOMs in the FBDC model. Annual input of DOM was estimated by multiplying C stock of biomass compartment with turnover rate. Decomposition of DOM was estimated by C stock of DOM, mean air temperature, and decay rate. C stock in each C pool was initialized by spin-up process with consideration of severe deforestation by Japanese exploitation and Korean War. No disturbance was included in the simulation process. Total forest C stock (Tg C) and mean C density (Mg C ha^{-1}) decreased from 657.9 and 112.1 in 1954 to 607.2 and 103.4 in 1973. Especially, C stock in mineral soil decreased at a rate of 0.5 Mg C ha^{-1} yr^{-1} during the period due to suppression of regeneration. However, total forest C stock (Tg C) and mean C density (Mg C ha^{-1}) gradually increased from 607.0 and 103.4 in 1974 to 1240.7 and 211.3 in 2015 due to the national reforestation program since 1973. After the reforestation program, Korean forests became C sinks. Model estimates were also verified by comparison of these estimates and national forest inventory data (2006-2010). High similarity between the model estimates and the inventory data showed a reliability of down-scaled global forestry model and integration of DOM C module. Finally, total C stock gradually increased to 1749.8 Tg C in 2050 at a rate of 2.5 Tg C yr^{-1} and it might be attributed to mature of forest. However, total forest C stock might be overestimated in the future due to the exclusion of disturbance in simulation.

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