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Modeling the variability in water and carbon fluxes over the 1990-2010 period in the Leyre water catchment in Les Landes de Gascogne forest: attribution to climate and management drivers.

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In order to understand the temporal changes in the 1990-2010 greenhouse gas balance of a forested subregion of Les Landes de Gascogne forest, we implement the biogeochemical process based model GO+ over high resolution datasets describing soil, climate, land use, forests and including remote sensing data. Including the available knowledge on the climatic sensitivity of biophysical and biogeochemical processes involved in atmospheric exchanges and carbon cycle of forest ecosystems as well as management operations effects, GO+ can produce long-term backward simulations of forest carbon and water cycles. The study area corresponds to the Leyre river catchment and covers 2200 km^2. The Pine forest represents more than 90% of this area. For 1990-2010, it experienced large-scale damages caused by the Martin hurricane in December 1999 and several drought episodes during the latter decade.

The sensitivity analysis underlines the role of precipitation regime and atmospheric evaporative demand and differentiated the sensitivity of the forest atmospheric exchanges according to stand age. Frequency of soil preparation operations and ground vegetation management played a major role in controlling the net carbon flux into the atmosphere in juvenile stands (0 to 15 y-old) whereas climate and rotation duration controlled the functioning of adult stands.
It was revealed that the 1999 windstorm provoked a dramatic and long lasting change in the age class distribution of the forest management together with a mean net loss of biomass carbon of 15t C-CO_2.ha-1 across the area. The net balance of the soil carbon remained close to neutral because the carbon losses provoked by tree uprooting and soil preparation practices (tillage, weed removal) were offset by the input of harvest residues into the soil and burial of organic layers. The Bowen ratio of the clearcut stand was strongly enhanced and evapotranspiration decreased leading to a dramatic increase in water runoff and in the peak flows from the watersheds damaged by the windstorm. The management operations linked to the reforestation of damaged stands led subsequently to a net increase in the rate of fixation of CO_2 by the forest cover associated with canopy rejuvenation.
Drought affected dramatically the net carbon and water balances of fallow, young stands regrowing after clearcutting as well as mature stands leading the 2002 annual carbon balance of the entire area close from zero. The model predicts that a drier and warmer climate will reduce the forest productivity and deplete soil and carbon stocks in managed forest from Southwestern Europe within decades, such effects being amplified for most intensive management alternatives.

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