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Fifteen years of carbon flux measurements and the effects of nitrogen fertilization in a Pacific Northwest Douglas-fir stand

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Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) dominated forest stands on the west coast of North America constitute an ecosystem that plays an important role in regional timber supplies and also in carbon (C) sequestration. However, due to soils generally poor in nutrients, and little nitrogen (N) deposition this region being away from industrial activity, N fertilization is practiced to enhance forest growth. The objectives of this study were to synthesize 15 years (2002 to 2016) of eddy-covariance (EC) measurements of C and water fluxes in a Pacific Northwest Douglas-fir stand planted in 1988, and to determine the long-term effects of N-fertilization of the stand at 200 kg N ha^{-1} in January 2007. The stand was a moderate C source in 2002 and turned into a C sink in 2005 at the age of 17 years. Low precipitation had a major impact on C sequestration and caused the most negative net ecosystem productivity (NEP), which occurred in 2004 (-155 g C m^{-2} $year^{-1}$). It also caused the NEP to decrease from 196 g C m^{-2} $year^{-1}$ in 2012 to 117 g C m^{-2} $year^{-1}$ in 2015. We used the process-based forest growth model: Physiological Principles Predicting Growth (3-PG) to explore interactions among environmental variables and their combined influences on C fluxes. Furthermore, 3-PG was validated using pre-fertilization EC data and then used to simulate C and water fluxes for the post-fertilization period assuming the stand was not fertilized. The effects of N-fertilization were obtained as the differences between post-fertilization-simulated and EC-measured fluxes. N-fertilization in 2007 enhanced tree growth increasing net C sequestration, which lasted until at least 2016 with increases of up to 170 g C m^{-2} $year^{-1}$ depending upon annual climate.