Application of process-based model of biogeochemical cycling in forest watershed in Hokkaido, northern Japan.

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Biogeochemical processes in forest ecosystem fluctuate largely with time and space. Simulation using process-based ecosystem model is strong research tool to understand those biogeochemical cycling including the tight interaction between biotic and abiotic factors affected by various natural and anthropogenic disturbances. Future prediction of temporal fluctuation in biogeochemical processes due to the environmental change is possible using the process-based model with the validation between observed and predicted values. In particular, it is important to use the model which contains linkage between carbon, nitrogen and water in the ecosystem for understandings of the function of the ecosystem to sequestrate carbon against global climate change and to conserve stream chemistry against increment of air pollution and forest practices, because the carbon, nitrogen and water fluctuated with their strong interactions in the ecosystem.

PnET-CN model, generalized, lumped-parameter model of carbon, water and nitrogen interaction in forest ecosystem (Aber *et al.* 1997) was applied in a forest watershed in Uryu Experimental Forest (UREF) in northern Japan as a core effort to develop the response-prediction model for 5-2 project in Research Institute for Humanity and Nature. UREF is mainly covered natural cool-temperate mixed forest affected by selective cutting partly and rare typhoon disturbances. Climate of UREF is categorized as snow-dominated cool temperate to sub-boreal region (annual precipitation; ca. 1,400 mm, mean temperature 2.5 ^{o}C). The half of the precipitation was supplied as snowfall.

Observed NO_3^- concentration in stream water from 2003 to 2004 in Dorokawa watershed in UREF indicated the higher values in snowmelt season. Monthly mean concentration in stream NO_3^- ranged about 1 to 12 μmol L^{-1}. Prediction of seasonal change in stream nitrate (NO_3^-) concentration in experimental basin in UREF was conducted using PnET-CN with the input variables of monthly climate (maximum and minimum temperature, precipitation and photosynthetic active radiation) and atmospheric deposition (NO_3^- and ammonium). Seasonality in predicted NO_3^- concentration in stream water roughly agreed with the observed values, while slight over-prediction during snowpack period and under-prediction after the peak during the snowmelt period was emerged (Figure 1). The modified PnET model (including the process of accumulation and leaching of atmospheric N deposition from snowpack) well

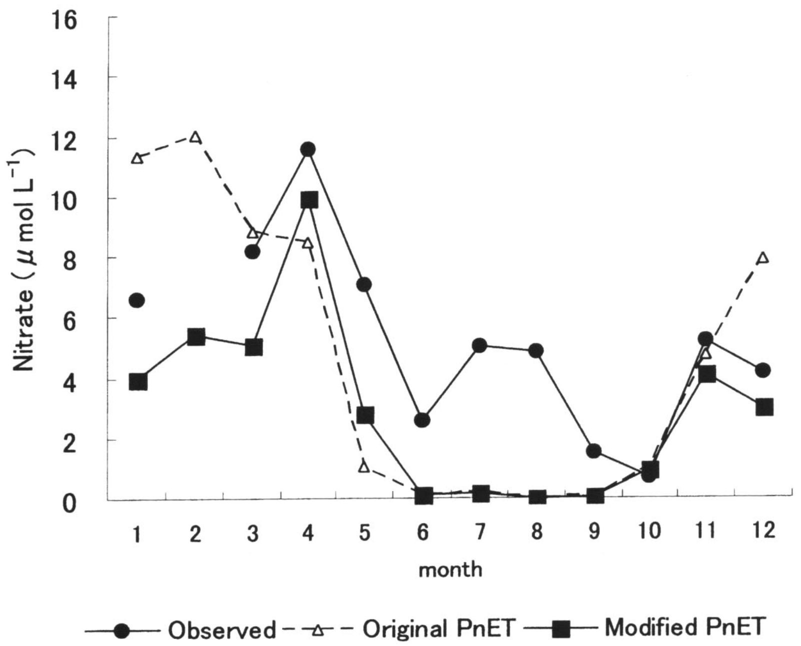

Figure 1. Seasonal pattern of observed and predicted monthly-mean nitrate concentration in stream water at Dorokawa watershed in Uryu Experimental Forest, Hokkaido University, northern Japan.

Observation was conducted from 2003 to 2004. Modified PnET model includes the process of nitrogen accumulation and leaching in snowpack during winter.

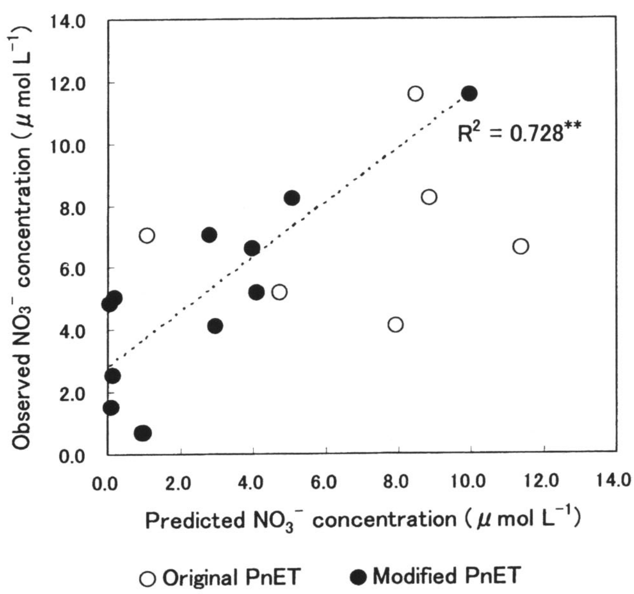

Figure 2. Validation of the simulation in monthly-mean nitrate concentration in stream water using the original and modified PnET model (See the seasonality in Figure 1).

predicted seasonal pattern of NO_3^- concentration in stream water (Figure 1 and 2, $P<0.01$). Simulation of the episodic increase of NO_3^- leaching after tree-cutting indicated that the highest NO_3^- concentration in stream water after the cutting and the recovery time to the background level were strongly influenced by the relative ratio of land area cut in the watershed (Figure 3 and 4). Scenario analysis suggested that the future increase of atmospheric CO2 concentration and N deposition influence the seasonal pattern of stream NO3- concentration with the combined effect (Figure 5). The time lag and slight discrepancies in stream NO_3^- concentration between modeled and observed values (Figure 1) suggested the need to incorporate hydrological processes for N leaching from soil to stream in the PnET-CN model which mainly focuses on one-layer soil compartment.

Reference: Aber, J.D., S.V. Ollinger, and C.T. Driscoll (1997): Modeling nitrogen saturation in forest ecosystems in response to land use and atmospheric deposition. *Ecological Modelling*, 101: 61-78.

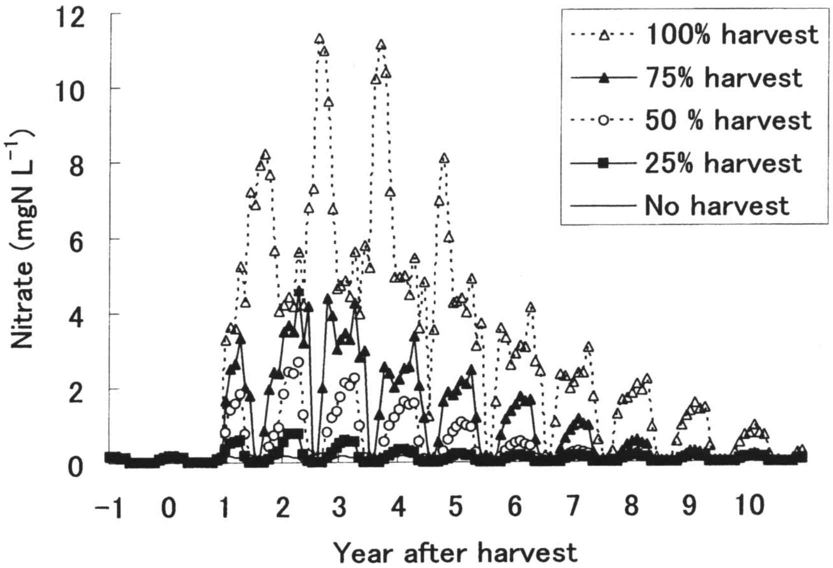

Figure 3. Simulated response of nitrate concentration in stream water to tree-cutting in forest watershed using original PnET-CN model for Uryu Experimental Forest, northern Japan.

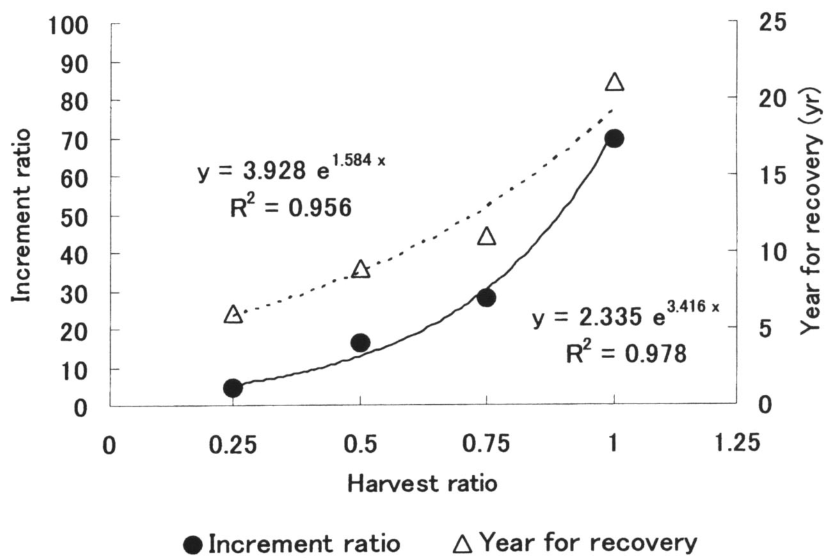

Figure 4. Response of increment ration and recovery period for nitrate concentration in stream water to tree-cutting in the watershed using original PnET-CN model for Uryu Experimental Forest, northern Japan.

The harvest ration represents relative area cut in the watershed. The increment ratio means the ratio of nitrate concentration in stream water after and before the cutting.

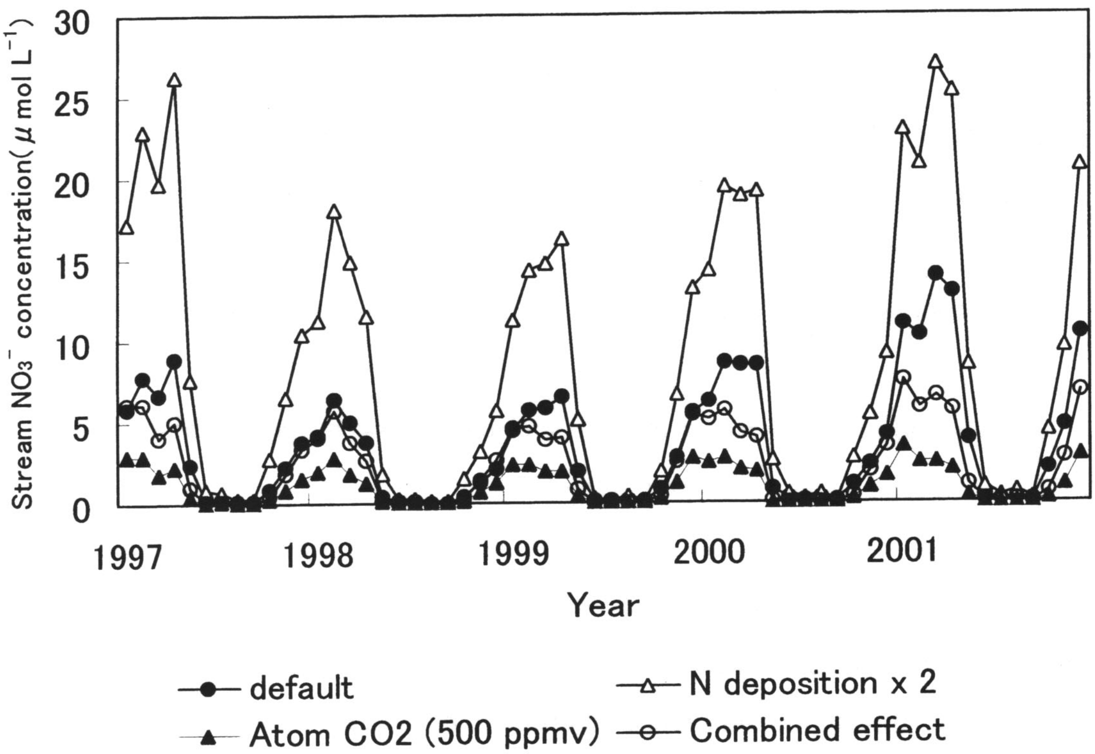

Figure 5. Simulated response of nitrate concentration in stream water to increase of atmospheric nitrogen deposition (double of current values), atmospheric CO_2 concentration (500 ppmv) and their combined effect in forest watershed using original PnET-CN model for Uryu Experimental Forest, northern Japan.