Effect of watershed-scale practical forest management on nitrogen leaching in a cool-temperate natural forest in northern Japan

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Anthropogenic disturbances in forests, such as cutting of trees, alter ecosystem nitrogen (N) cycling, and increase N leaching from the soil to streams. In forests with dense understory vegetation, mechanical site preparation following tree cutting is commonly used to improve the early establishment of tree seedlings. In cool-temperate forests in northern Hokkaido, Japan, dense understory vegetation (mainly comprising *Sasa* dwarf bamboo) inhibits forest regeneration after tree cutting. Soil scarification is a common site preparation technique for eliminating *Sasa* bamboo and improving forest regeneration. However, the effect of the site preparation on the watershed-scale stream chemistry has not been well understood. For 14 years (2003-2016), we observed the stream water chemistry in naturally forested watersheds where various forest managements were conducted in Uryu Experimental Forest of Hokkaido University (North Hokkaido Experimental Forests Site of JaLTER) in northern Japan. The forest management practice in each watershed includes clear-cutting, soil scarification, and soil replacement. We also established control watersheds which are valuable as a background information to analyze the effect of long-term climate, environment, and vegetation changes on stream water chemistry. Water samples were collected from the outlets of ten watersheds. We measured inorganic N concentrations (nitrate and ammonium) after filtering, and pH, and electrical conductivity (EC) in the stream water. We also monitored stream discharge, water level, and stream water temperature in each watershed. Nitrate concentration ranged 0.01-8.68 mg L-1 in all watersheds during study period. Analysis of covariance that nitrate concentration was assigned as objective variable and time and watershed were assigned as explanatory variable revealed that time and watershed affect to nitrate concentration significantly ($P < 0.001$), indicating that nitrate concentration increased during study period and differed between watersheds. However, interaction effect of time and watershed was not significant ($P = 0.37$), suggesting that clear-cutting does not induce nitrate leaching. On the other hand, soil scarification and soil scarification followed by soil replacement increased nitrate concentration. Nitrate concentration reached maximum in seven years after treatment in soil scarification and five years in soil scarification followed by soil replacement. Nitrate concentration after treatment was higher in in soil scarification followed by soil replacement treatment. These results suggest that clear-cutting only does not induce nitrate leaching from forest ecosystem watershed, whereas soil scarification and soil replacement which eliminate bamboo root system promote nitrate leaching. The response time was shorter and the extent of increase was larger in soil scarification followed by soil replacement treatment. This study revealed the role of understory vegetation in retention of N after clear-cutting.

Keywords: nitrate, clear-cutting, soil scarification, Sasa dwarf bamboo

