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シカによる下層植生の過剰採食が森林生態系の窒素保持及び流出に与える影響
Deer-induced degradation of understory vegetation affects N retention and loss in forested watershed

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Recently, ecosystem degradation by large herbivorous mammals becomes a serious issue worldwide. Loss of plant biodiversity and decreasing in biomass at the forest understory may result in the changes in streamwater chemistry and nutrient loss from forest ecosystem, but the knowledge remains still limited. In central Japan, over-grazing of forest understory vegetation by Japanese sika deer has been pronounced since 2000's. The main goal of this study was to elucidate the relationship between nitrogen (N) retention by understory vegetation and annual N loss, and discuss the effects of deer-overgrazing on N cycling by comparing a 13 ha watershed surrounded by the deer-excluded fence to its adjacent 19 ha control watershed, in cool-temperate forest in Ashiu, Japan.

We have collected streamwater samples monthly at 4 first-order streams (0.3~2.3 ha) and 1 second-order stream (13~19 ha) within each watershed, and analyzed nitrate concentration by ion chromatography since June 2006 when the fence was established. The rate of streamwater discharge was obtained from a Parshall flume by measuring water level. Annual loss of nitrate was calculated by multiplying stream flow by the concentration. As for the understory vegetation, number of species, vegetation cover, and Shannon's *H'* as an indicator of biodiversity were observed in two 800 m^2 plots established in the lower slope and upper slope within each watershed. Nitrogen uptake by understory vegetation was determined by cutting all plant species, including herbaceous species, ferns and tree seedlings, within 145 1 m^2 quadrats randomly established throughout fenced and unfenced watersheds and measuring dry weights and N contents by NC analyzer. Nitrogen uptake by vegetation was calculated by multiplying the dry weights by N contents for annual herbs and current year leaves and branches of woody tree seedling. For perennial and evergreen species, N uptake was estimated by dividing the product of dry weights and N contents by average leaf longevities. Then we made the coverage-biomass and coverage-N uptake regression equation. Also, coverage of each dominant 13 species appeared in our study watersheds was observed by line transect method, and the spatial distribution of their coverage was analyzed by generalized linear model (GLM) based on topographical information (slope, aspect, curvature, wetness index) and a categorical variable representing the spatial extent of the watersheds calculated from 10m-resolution digital elevation model (DEM) data. We then estimated watershed-scale biomass and N uptake of understory vegetation.

In the fenced watershed, number of species, vegetation cover, and Shannon's *H'* of understories remarkably increased at the lower-stream slope and slightly increased at the upper-ridge slope, while in the unfenced watershed, they showed little change or slightly decreased at the both slopes. The nitrate concentration of stream water was lower during plant growing season (May to October) than during dormant season (November to April) in both watersheds, but it decreased year by year in some streams within the fenced watershed since the fence was established. Averages of annual N loss during 2009 to 2011 was 2.36 kgN ha^{-1} in the fenced watershed and 4.87 kgN ha^{-1}, and its difference was 2.51 kgN ha^{-1}. Nitrogen uptake by understory vegetation was estimated to be 5.5 kgN ha^{-1} in the fenced, and 3.3 kgN ha^{-1} in the unfenced, which indicated that loss of N uptake induced by deer over-grazing can directly influence hydrological N loss. In conclusion, despite the small amount of biomass of the forest understory vegetation, the loss of this ecosystem component by deer over-browsing can lead to an increase in nitrate loss to streamwater. Our finding also suggests that understory vegetation recovered from deer grazing can retain nitrate effectively.

キーワード: シカによる過剰採食, 下層植生, 窒素保持, 窒素流出, 硝酸態窒素, 森林生態系
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