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Effect of invasive black locust (*Robinia pseudoacacia* L.) on nitrogen cycle in floodplain ecosystem

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ABSTRACT

Black locust colonization of floodplains can exacerbate the problems associated with increasing nitrogen inputs into the riparian area and river ecosystem. In this study we compare the nitrogen budgets of two sites of floodplain ecosystem, one is colonized by invasive black locust and the other is forested by the indigenous willow species. Our data report the considerably higher N-flow rates, nitrogen storage and the faster total N-related ecosystem processes in the *Robinia* site in comparison to the indigenous *Salix* site of the study floodplain. Black locust affects the nitrogen cycle in the study riparian ecosystem through the N-fixation, high N-content litterfall and rapid litter decomposition that results in the increase of the nitrogen flow into the river and contaminates the water. Black locust appeared to reduce the conservation values of colonized areas and adjacent river. Restoration strategies that remove the black locust from invaded sites and prevent the further invasion will slow down the contamination. However, high availability of nitrogen in soil and soil degradation might have a long-term effect on floodplain ecosystem after the restoration.

1. Introduction

Black locust (*Robinia pseudoacacia* L.) is one of the most abundant tree in the world after the Eucalyptus and Poplar (Boring and Swank, 1984). It is cultivated worldwide because of the high-quality wood properties, high tolerance against drought and erosion (Böhm et al., 2011). In Ukraine black locust is planted as a roadside tree, an erosion-control species, as well as the tree species for the vegetation buffer zone around the industrial facilities. It is highly competitive to native species as it grows efficiently on poor-nutrient soils and adapts easily to early successional conditions and rapidly invades indigenous communities (Rice et al., 2004). *Robinia* is planted to prevent erosion on the highland floodplains of the rivers in Ukraine, where it moves fast to the riparian area.

Black locust colonization of riparian ecosystems can exacerbate the problems associated with increasing nitrogen inputs into the floodplain area and river ecosystem. Many studies have reported a high capacity of *Robinia pseudoacacia* for the dinitrogen fixation (Boring and Swank, 1984; Danso et al., 1995). High amount of fixed nitrogen may exceed the demand for plant nutrition causing the excessed nitrogen to accumulate in soil and to lose through leaching, runoff and denitrification (Berthold, 2005). These processes may be followed by soil degradation and loss of base cations causing a significant decrease in the pH and increase in the soil exchangeable Al (Van Miegroet and Cole, 1984; Berthold, 2005). Furthermore, frequent inundation of floodplain can cause the nitrate contamination of river water. Leaching of nitrate can lead also to the nitrate pollution of ground water (Berthold, 2005).

Several studies have reported that rates of litter decomposition and N mineralization under *Robinia* stands are higher than under nitrogen non-fixing trees (Tateno et al., 2007; Malcolm et al., 2008) causing strong N-enrichment of soil and subsequent invasion by non-native species and loss of biodiversity (Levine et al., 2003).

More than a decade the black locust has colonized the riparian areas of Prut River in Ukraine. Such invaded sites of the floodplain represent a potential source of nitrogen flow into the Prut River.

The aim of the current study was to investigate the effect of the black locust on nitrogen budget in the riparian area (lowland floodplain) of the Prut River in Chernivtsi Region in Ukraine. To understand the impact of the *Robinia* on the study ecosystem we

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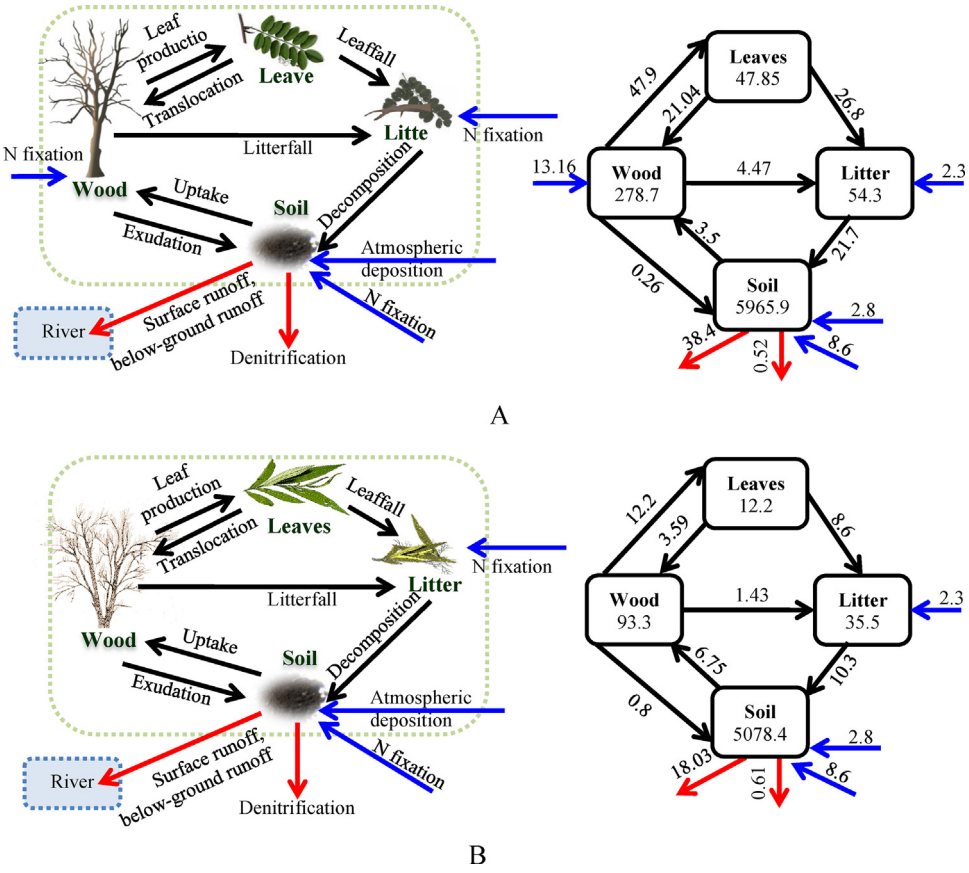

Fig. 1. Conceptual diagrams (left) and the parametrized models (right) of the nitrogen budgets of the black locust (A) and willow (B) study sites of Prut river floodplain in Ukraine.

compared two sites of the study floodplain, one colonized by the invasive black locust and the other forested by the indigenous willow species.

The specific objectives of this study were as follows:

(i) To measure and analyze the nitrogen related ecosystem processes within the each of the study site.
(ii) To build the nitrogen budget models for each of the study systems and to compare the N-flow rates, N-storage, cycling and system N turnover time among the *Robinia* colonized site and the *Salix* spp. planted area.
(iii) To investigate the soil properties in each of the study sites in order to elucidate the *Robinia*-mediated changes in the soil.

The conceptual model diagrams for each of the study systems are presented in Fig. 1.

2. Materials and methods

2.1. Study area

The data for this study were collected from two study sites of the floodplain of river Prut within the village boundaries of Boyany, in Chernivtsi Region in Ukraine (with average sea level 158 m) (Fig. 2). Prut River (approximately 850 km long) originates on the eastern slope of Mountain Hoverla in the Carpathian Mountains and flows through Romania and Moldova, joining the Danube River. The study floodplain is inundated annually for 2–3 months during late March – April.

The study site I (48°16′59.5″ N 26°08′12.7″ E) is near 50 m wide and it is colonized along the stream with the black locust stands (*Robinia pseudoacacia* L.) near 12 years old. The study site II (48°16′18.7″ N 26°07′21.2″ E) is forested with the different age indigenous willow species (*Salix* spp.), namely *Salix caprea* L. and *Salix alba* L.

2.2. Sampling and analysis

At each of the two sites the sampling was conducted along three 100 m^2 plots (transects), placed parallel to one another along the river. Most of the field work was conducted during the lowest river water level within the summer period during June–July, 2013. The peak of the plant vegetation period was June 21.

2.2.1. Plant biomass and N content

Each tree within the study area was examined for the shoot basal diameter (SBD) using the forestry caliper about 10 cm and 15 cm above soil for the *Robinia* and *Salix* spp. respectively. Wood (trunk and branches) and leaves dry weight for each *Robinia* tree were calculated using the biomas-SBD allometric equations by Boring and Swank (1984), as follows:

$$y_{\text{leaves}} = 0.0293764965196153 \times x^{1.708}$$

$$y_{\text{branches}} = 0.0246036760414763 \times x^{2.321}$$

$$y_{\text{trunk}} = 0.0246036760414763 \times x^{2.901}$$

where y is an oven-dried weight (kg), x is diameter (cm) at 10 cm above-ground level.