Contrasting impacts on the nitrogen cycle of co-occurring exotic species

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AIM

We aimed to assess the nitrogen use strategies of three native and three exotic tree species co-occurring in river banks of inner Spain in order to predict potential impacts on the nitrogen cycle of invaded communities.
We assessed the leaf lifespan, nitrogen resorption in leaves, nitrogen mean residence time, amount and timing of leaf litter production and amount of nitrogen returned to soils.

MATERIALS & METHODS

Exotic species: *Ailanthus altissima*, *Robinia pseudoacacia* and *Ulmus pumila*.
Native species: *Fraxinus angustifolia*, *Ulmus minor* and *Populus alba*.
Study site: floodplains of the Henares River (Province of Madrid, central Spain).
Procedure:
In February 2008, we selected 8 adult trees per species and marked 3 apical, south oriented, mid-crown buds in each (Fig. 1).
In June 2008, we placed 1 littertrap in each tree, 2 meters above the ground (16 x 19 cm) (Fig. 2).

Fig. 1. *Fraxinus angustifolia* apical bud of in April 2009.

Variables:

Leaf life span (LLS)

Feb. ´08-Dec. ´09
We follow the fate of each individual leaf produced in each marked bud until its abscission.

Leaf nitrogen resorption (NRE)

$NRE= (N_{green} - N_{sen}/ N_{green})*100$
N_{green}: Nitrogen content in fresh leaves collected in spring 2008.
N_{sen}: Nitrogen content in senescent leaves collected during the month with the highest peak of leaf litter in 2008.

Amount and timing of leaf litter production

June. ´08-Dec. ´09
Monthly sampling of litter trap content in each tree.
Leaf litter content was oven-dried and weighed.
The quantity of leaf litter produced per year by each tree was expressed as litter dry weight per ha.

Mean residence time (MRT)

$MRT= LLS*(100/100-NRE)$
The MRT assesses how long a unit of a nutrient remains in the plant, and it is defined by both the leaf lifespan (LLS) and the nitrogen resorption (NRE).

Nitrogen returned to soils (Nrs)

$Nrs= (annual\ leaf\ litter * N_{sen})$

Statistics:
We tested the effect of origin (native/exotic) and species (nested within origin) with nested analysis of variance. When origin was not significant, we repeated the analysis removing this factor in order to increase the degrees of freedom for the species factor.
The perimeter at breast height (PBH) was included as a covariate.

Fig. 2. Littertrap placed in a *Robinia pseudoacacia* tree in November 2008.

RESULTS & CONCLUSIONS

We found differences among species in most of the analyzed traits, but these differences did not differentiate between the groups of native and exotic species.
The three natives showed a similar nitrogen use strategy, that can be positioned in the middle of a conservative-opportunistic gradient, on the basis of the studied traits (Table 1).
The three exotics followed completely different strategies in terms of their nitrogen use strategy that would lead to contrasting impacts on the nitrogen cycle upon invasion (Table 1).

Table 1. Average values of perimeter at breast height (PBH), leaf life span (LLS), mean residence time (MRT) and N returned to the soil (Nrs) ± SE per species. Values of nitrogen resorption efficiency (NRE) per species. No SE is shown in this last variable as we pooled the leaf samples previously to the laboratory analysis. The native (N) or exotic (E) origin of each species is indicated. Different letters mean statistical differences among species according to post hoc Tukey tests. N= 8 per species.

Species	Origin	PBH (cm)	LLS (days)	NRE (%)	MRT (days)	Nrs (kg N/ha)
Fraxinus angustifolia	Native	55.7±3.3	203±3a	69	525±11ab	11.85±4.04b
Populus alba	Native	57.1±6.5	187±6a	65	470±33b	12.54±2.45ab
Ulmus minor	Native	77.4±11.0	157±4ab	67	460±21b	36.11±6.03a
Ailanthus altissima	Exotic	50.7±10.2	128±6a	78	467±15b	20.25±7.72ab
Robinia pseudoacacia	Exotic	86.1±11.8	156±7ab	37	311±7c	6.95±1.50c
Ulmus pumila	Exotic	111.6±7.7	190±5a	71	599±23a	13.20±3.88ab

Among the exotic species, *Ulmus pumila* was the most conservative and the N fixer *Robinia pseudoacacia* was the most opportunistic. *Ailanthus altissima* showed properties of both conservative and opportunistic strategies (Table 1).
In the case of a replacement of the studied natives by the exotics, we predict a weak impact on the nitrogen cycle in the case of *Ulmus pumila* dominance, an impoverishment of soils in the case of *Robinia pseudoacacia,* and an increase in nitrogen availability in the case of *Ailanthus altissima*.
This system offers a striking example of the contingencies involved in predicting the ecosystem impacts of exotic plant invasion.

See: González Muñoz, N., Castro-Díez, P., Parker, I.M. (2012) Differences in nitrogen use strategies between native and exotic tree species: predicting impacts on invaded ecosystems. Plant and Soil. In press.