Mongolian oak encroachment aggravates nitrogen limitation to Dahurian larch in southern Asian boreal forest

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Results

1 Interspecific difference in foliar nitrogen concentration, δ^{15}N and Δ^{15}N

Foliar N concentration of Dahurian larch (17.0 ± 2.0 mg g^{-1}) was lower than that of Mongolian oak (25.8 ± 4.0 mg g^{-1}) (paired t test, t = −11.12, P < 0.001; Fig. 2a). Foliar δ^{15}N showed significantly lower values in Mongolian oak (−1.3 ‰ ± 0.9 ‰) than in Dahurian larch (1.2 ‰ ± 2.9 ‰) (t = 4.70, P < 0.001; Fig. 2b). Similarly, Δ^{15}N of Mongolian oak (−4.8 ‰ ± 1.1 ‰) was significantly lower than that of Dahurian larch (2.3 ‰ ± 3.0 ‰) (t = 4.46, P <0.001; Fig. 2c). Besides, there existed weak correlation between Mongolian oak and Dahurian larch in foliar N (P = 0.127; Fig. 2b), δ^{15}N (P = 0.689; Fig. 2d) and Δ^{15}N (P = 0.598; Fig. 2f).

2 Effect of Mongolian oak encroachment on nitrogen nutrition of Dahurian larch

Variation of foliar N were mainly explained by basal area percent (BAP), MAT, MAP and stand aspect (total variance explained 64.2%; Fig. 2a). Conditional regression model showed that foliar N of Dahurian larch was positively correlated with basal area proportion of Mongolian oak (variance explained 16.3%, P < 0.01; Fig. 2b), but decreased with MAP (variance explained 18.3%, P < 0.01; Fig. 2a), MAT (variance explained 14.6%, P < 0.01; Fig. 2d) and stand aspect (variance explained 15.0%, P < 0.01; Fig. 2e).

Foliar δ^{15}N and Δ^{15}N of Dahurian larch both increased significantly with basal area proportion of Mongolian oak (variance explained 33.4% for δ^{15}N, P < 0.01; variance explained 42.3% for Δ^{15}N, P < 0.01; Fig. 5), while the roles of other potential factors were not statistically important (P > 0.05; Fig. 4a & 4f). Specifically, foliar δ^{15}N decreased with herb coverage, stand aspect, and slope (total variance explained 36.7%, P < 0.01; Fig.4c−4e). The variation of foliar Δ^{15}N of Mongolian oak decreased with stand aspect (variance explained 11.7%, P < 0.01)

Bivariate linear regression model indicated that the basal area increment (BAI) of Darhurian larch increased significantly with soil δ^{15}N (R^2 = 0.15, P < 0.05; Fig. 5).

3 Effects of Mongolian oak encroachment on soil nitrogen availability

Soil δ^{15}N ranged from 1.62‰ to 5.65‰ across the forest ecotone. The spatial variation of soil ^{15}N values was mainly explained by stand slope and aspect (total variance explained 41.9%) (Fig. 5b). Specifically, conditional regression model showed that soil δ^{15}N decreased significantly with stand slope (P < 0.01, Fig 5c). Furthermore, soil δ^{15}N varied significantly with stand aspect (P < 0.01, Fig. 4b). However, basal area proportion of Mongolian oak was not a statistically important predictor of soil $\delta^{15}N$ ($P = 0.19$; Fig. 4d).

Figure 1. Study area across the temperate-boreal forest ecotone. Panel (a) vegetation distribution and sampling transect in the study area; Panel (b) the sampling plots across the ecotone. Size of blue circle in panel (b) indicates the relative dominance (e.g., basal area percent, ranging from 0 to 0.5, see Method) of Mongolian oak in each sampling plot.

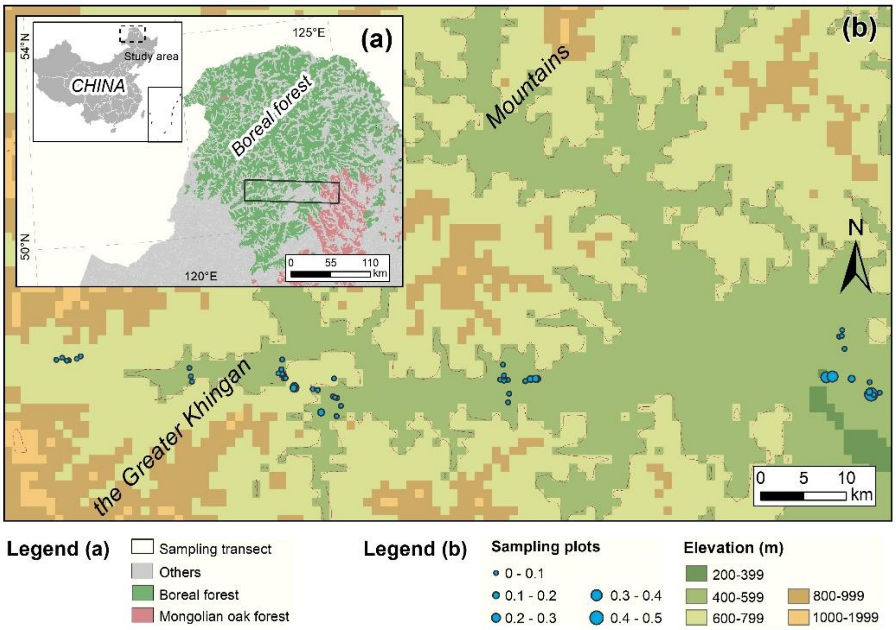

Figure 2. Interspecific difference and correlations of foliar N concentration (a, b), δ ^{15}N (c, d) and Δ^{15}N (e, f) between Mongolian oak and Dahurian larch. Paired *t*-test was used to test the interspecific difference.

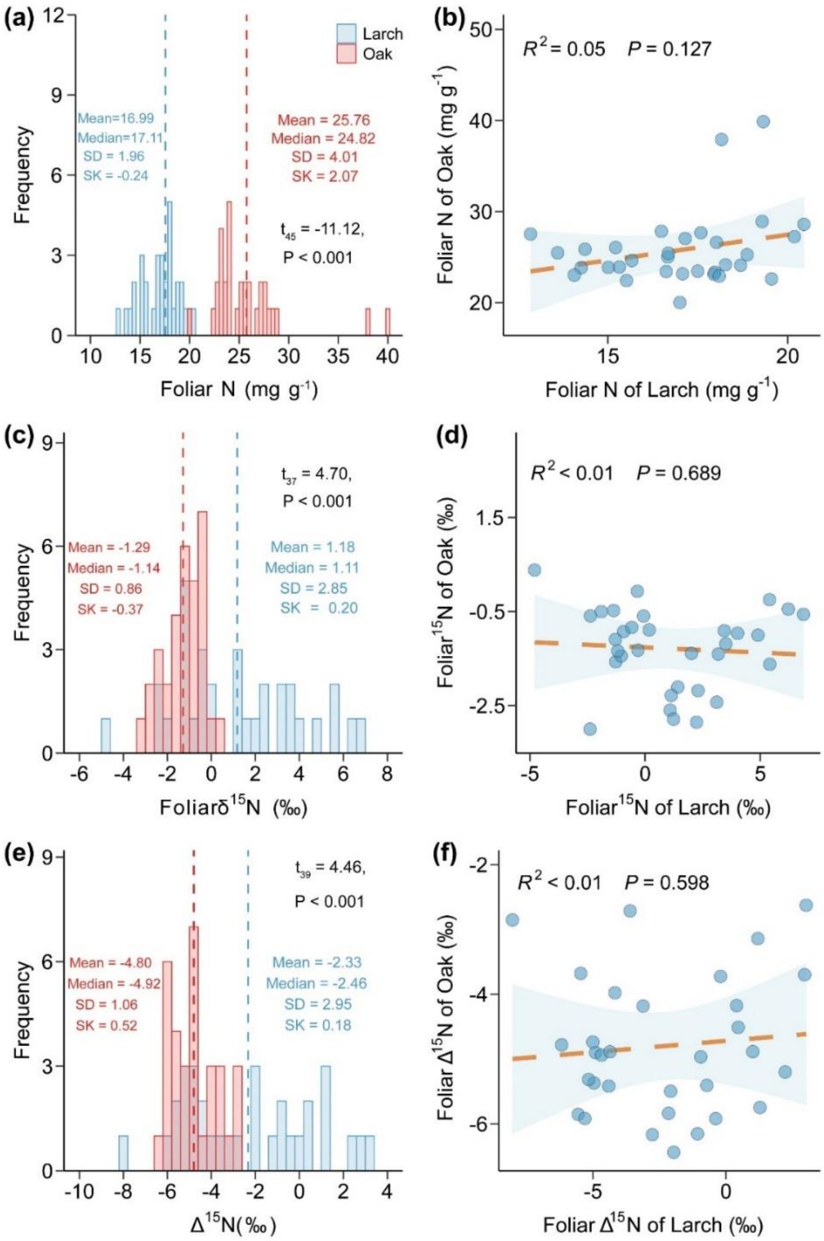

Figure 3. Relative importance of predictors for foliar N concentration of Dahurian larch (a) and changes in foliar N concentration with basal area proportion (BAP) of Mongolian oak (c). The shaded areas represent the 95% confidence intervals of the linear model fit.

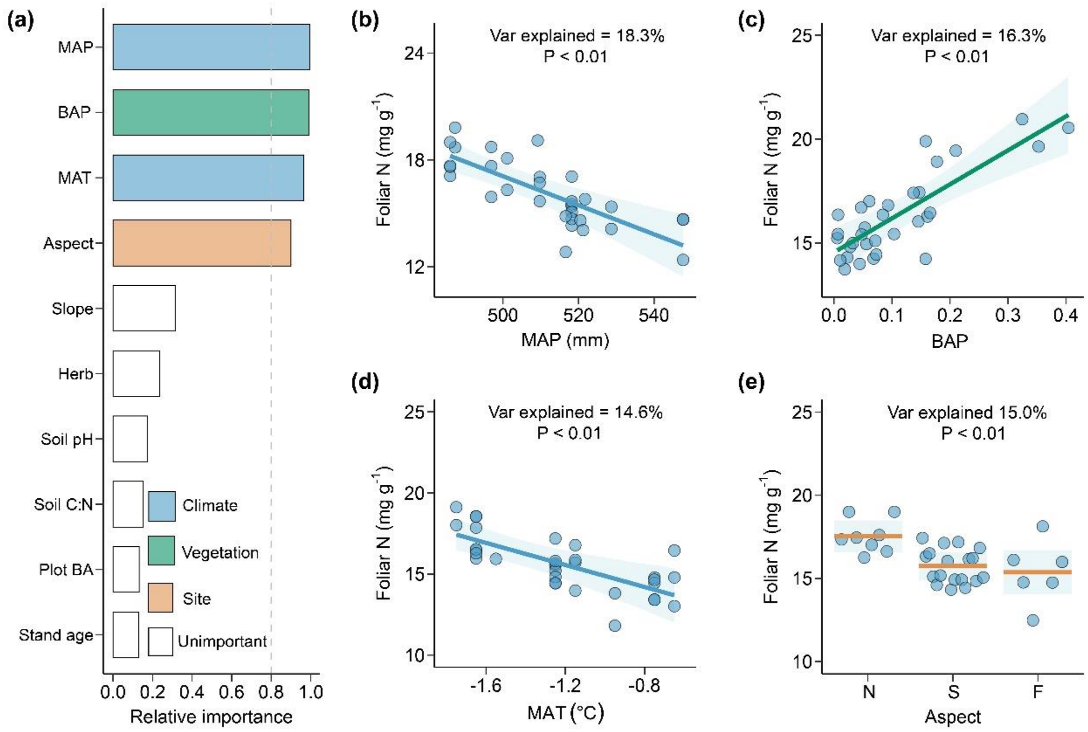

Figure 4. Relative importance of predictors for foliar δ^{15}N and Δ^{15}N of Duhurian larch (a, f) and changes in foliar δ^{15}N and Δ^{15}N with basal area proportion (BAP) of Mongolian oak (b, g). The shaded areas represent the 95% confidence intervals of the linear model fit.

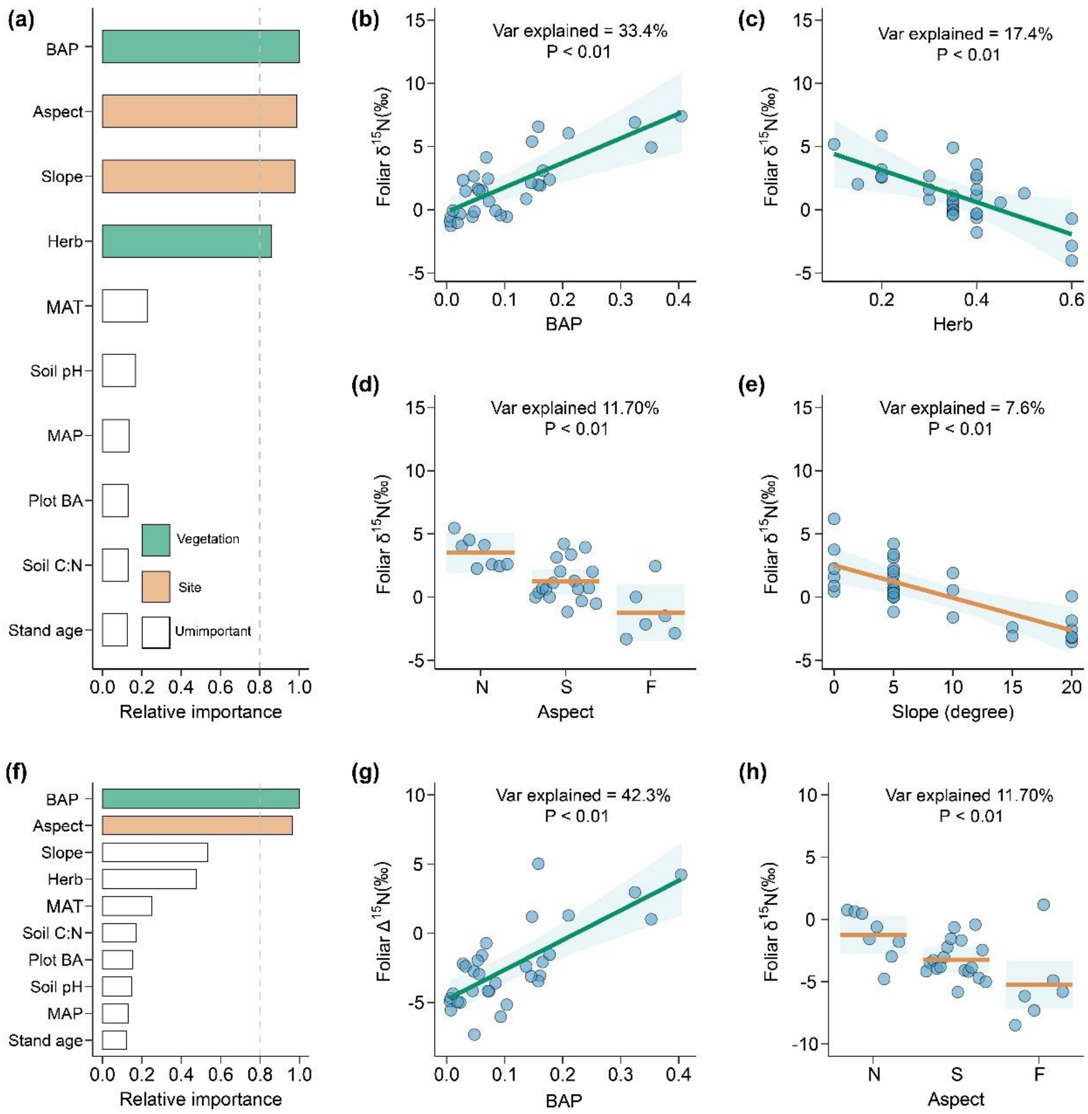

Figure 5. Relative importance of predictors of surface soil δ^{15}N (a) and conditional regression plots for the important drivers. Slope (b), Soil C: N (c).