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Conference Abstract

Centuries of habitat niche expansion reveal pervasive invasion debt in alien plants

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Abstract

Invasion risk assessments capture where alien species occur, not where they will occur. The accumulation of alien species in regional floras is well documented (Essl et al. 2010), but whether individual species progressively colonise new habitat types over time has not been quantified. A species confined to disturbed roadsides today may spread into grasslands, wetlands, and forests over the coming decades, yet current risk frameworks treat habitat associations as static.

We analysed 835,891 vegetation plots from the European Vegetation Archive (Chytrý et al. 2015) spanning ten decades (1930–2023) across 55 European countries. For 1,375 neophyte species introduced after 1492, we compared each species' observed occurrence across 18 habitat types against local habitat availability within equal area hexagonal grid cells (Chytrý et al. 2008). This controls for spatial and temporal sampling bias. A Bayesian hurdle model then separated two processes: the probability of expanding beyond a single habitat, and the number of additional habitats colonised given expansion, with species traits and residence time as predictors.

The probability of occurring in more than one habitat increased 3.4 fold with residence time, from 17% for species present 0–20 years to 57% for those present more than 200 years. Expected habitat counts rose from 1.2 to 2.0. No plateau was reached even after

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two centuries. Man made and ruderal habitats acted as staging areas, with overrepresentation there doubling from 20% to 44%, and species moved outward along non random pathways (Fig. 1, with bidirectional flows between man made habitats and dry grasslands and subsequent colonisation of mesic and wet grasslands.

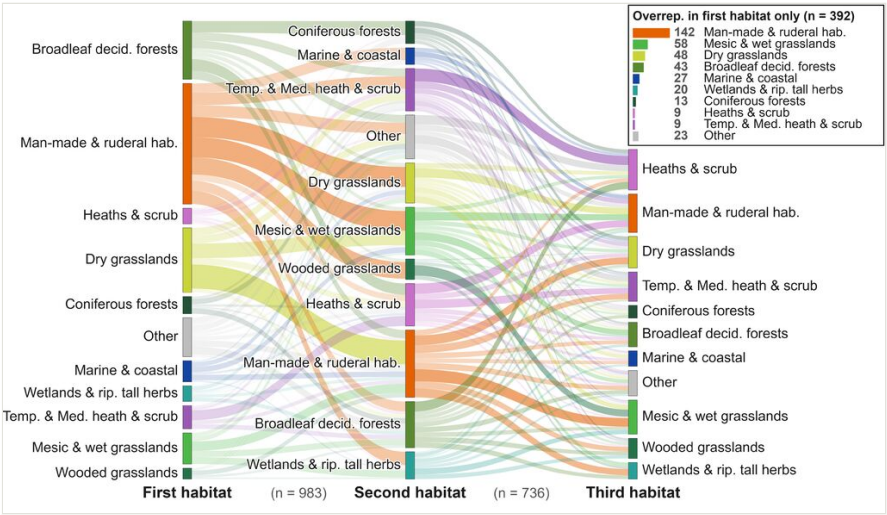

Figure 1.

Habitat transition sequences for neophyte species overrepresented in at least one habitat across Europe. Flows show 983 species that expanded into two or more habitats, ordered chronologically by earliest plot record. The inset shows 392 species confined to a single overrepresented habitat. Man-made and ruderal habitats are the most common entry point (31%), with bidirectional flows to dry grasslands and subsequent diversification into semi-natural vegetation.

Nutrient poor habitats resisted invasion regardless of residence time: alpine grasslands below 1%, bogs below 2%, and arctic alpine scrub below 3%. Long lived perennials, trees, and vines were most likely to spread into multiple habitats. Annuals colonised a first habitat faster but rarely expanded further.

Species introduced in recent decades are still confined to one or two disturbed habitats but, based on the trajectories of their longer established counterparts, will colonise additional vegetation types for centuries. Intervention in the 0–20 year residence window, before habitat expansion begins, and management of gateway habitats as early warning systems offer the most direct routes to reducing this accumulated habitat niche debt.

Keywords

alien plants, biological invasions, European Vegetation Archive, habitat niche debt, invasion debt, residence time

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Conflicts of interest

The authors have declared that no competing interests exist.

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