Explaining the Distributions of Adventive *Trifolium* Species in New Zealand

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Twenty-five species of the genus *Trifolium* have naturalised in New Zealand, a country lacking native *Trifolium*. These species have spread at varying rates to achieve an array of geographic distributions. Differences in the ecological behaviour of closely related species are of tremendous interest to ecologists attempting to predict the fates of plant species introduced beyond their native ranges. In addition, increasing recognition of the agronomic value of adventive *Trifolium* species in both New Zealand and Australia has led to renewed interest in understanding and predicting their dynamics. This work explores the factors responsible for determining the rate and extent of spread of New Zealand's 25 *Trifolium*.

The current distributions of the species were quantified at both coarse (10 regions) and fine (329-cell grid, 1200km^2/cell) spatial scales using the Flora of New Zealand, herbarium specimens, and the New Zealand National Vegetation Survey database. In addition, we calculated a rate of fine-scale spread for each species by plotting the cumulative number of grid cells occupied over time, correcting for variation in total plant specimen collection effort. To explain these patterns, we collected species attributes falling into six broad categories: global transport and use by humans, native range attributes, habitat characteristics, human introduction effort, biological traits, and opportunistic human association in New Zealand. Much of this data came from published references. In addition, an extensive historical record search, focusing on seed catalogues and Department of Agriculture publications, was used to quantify human introduction effort over time, and a global GIS database was used to assess characteristics of species' native ranges.

Using multiple regression modelling, we found that frequent occurrence as a pasture seed contaminant and a long flowering period enabled species to achieve a greater extent of spread at both the coarse and fine scales, as well as faster spread rates. In addition, other factors played a minor role in promoting individual aspects of spread. These included an annual, diploid genetic system, early naturalisation, a native habitat at low elevation, a large native range similar to New Zealand, and a wide distribution in Britain.

Trifolium species' distributions are thus shaped by the interplay of their biological attributes and their relationships with human movement and use. These findings can be used to predict the fate of newly introduced or recently naturalised *Trifolium* or related species in New Zealand.