Risk assessment predicts success at the introduction and naturalisation but not the spread stages of invasion for commercial forestry trees (*Pinus* spp.)

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Summary Exotic trees, particularly conifers in the genus *Pinus*, introduced for commercial forestry have become invaders worldwide. New Zealand's government is committed to a 250,000 ha expansion of planted forests by 2025 to mitigate the impacts of climate change. Areas earmarked for afforestation are outside the environmental tolerance of established forestry species, necessitating the introduction of new exotic species. Understanding why some species become invasive while others do not may be enhanced by looking at the different stages of invasion: introduction, naturalisation and spread. Risk assessment schemes are needed to prevent the importation and dissemination of potentially invasive species, and to identify at which stage of the invasion process management should be targeted. Pre-border screening tools, such as the Australian Weed Risk Assessment (WRA) (Pheloung *et al.* 1999), show promise. To test the accuracy of WRA at identifying which species were successful at the introduction and naturalisation stages, we used known outcomes of introduction and naturalisation events for species in the genus *Pinus* in New Zealand and the UK to construct receiver operating characteristics (ROC) curves and calculated area under the ROC curve (AUC) for each stage. To assess WRA's ability to predict spread we calculated the number of regions in which a species was naturalised for both countries and used WRA score and introduction date as explanatory variables. To evaluate the effect of having limited information we identified questions that were driving WRA score and explored WRA performance with these questions excluded. We found that the WRA accurately identified which species were introduced and naturalised (AUC >0.80), but could not predict the number of regions a species was naturalised in for either country (spread). Four questions relating to weediness elsewhere were driving WRA score. When these were excluded, WRA could no longer identify which species were successfully introduced or naturalised (AUC <0.70). Our results show that WRA can differentiate between relatively similar species within one genus. However, it becomes unreliable when no information about weediness elsewhere is available. Our results suggest that selection for weedy species at the introduction stage is strong and drives subsequent naturalisation patterns, but that other factors, such as propagule pressure, may explain spread.

Keywords Australian Weed Risk Assessment, traits, commercial forestry, invasions, *Z* score, *Pinus*.

REFERENCES

Pheloung, P.C., Williams, P.A. and Halloy, S.R. (1999). A weed risk assessment model for use as a biosecurity tool evaluating plant introductions. Journal of Environmental Management 57, 239-51.