

An investigation of the effects of disturbance on the establishment of *Nassella neesiana* (Trin. & Rupr.) Barkworth (Poaceae) in an Australian native grassland

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Summary Chilean needle grass (*Nassella neesiana*) is highly invasive in temperate native grasslands of south-eastern Australia. The mechanisms by which it invades are poorly understood, but well-managed grasslands with relatively intact cover of native grasses appear to be resistant to invasion. Lack of biomass reduction (e.g. by fire) or disturbance resulting in the death of dominant native grasses appear to be required for *N. neesiana* establishment. A field experiment is being undertaken in native *Themeda triandra* grassland to assess the ability of *N. neesiana* to invade. Plots were sown with *N. neesiana* seeds and treated by either killing all or some of the dominant grass, by addition of nutrients (N, P, N+P), or by nutrient immobilisation (sugar). The methodology of this field experiment is detailed.

Keywords *Nassella neesiana*, Chilean needle grass, temperate grassland, biodiversity, nutrient addition, disturbance.

INTRODUCTION

Lowland temperate grasslands are one of the most threatened ecosystems of south-eastern Australia, with <1% of their original area remaining (Groves and Whalley 2002). *Nassella neesiana* (Trin. & Rupr.) Barkworth (Poaceae: Stipeae) is one of the more recent threats to the integrity of these grasslands. *N. neesiana* is a long-lived, C₃ tussock grass, native to South America, which is highly invasive in Australia and is able to out-compete temperate native grassland species (Hocking 1998, Grice 2004, McLaren *et al.* 2004). It is rated as a highly significant threat to grassland biodiversity and is considered to be currently causing rapid degradation of remnants (Morgan 1998, Groves and Whalley 2002, McLaren *et al.* 2004).

There is little quantitative information on the mechanisms of environmental weed invasion in Australia and few studies have incorporated deliberate experimental manipulations to test for effects (Adair and Groves 1998, Grice *et al.* 2004, Coutts-Smith and Downey 2006). In general, areas with higher

susceptibility to weed invasion have strong, temporally-varying change (i.e. high levels of natural or artificial disturbance) that creates periods of abundant under-utilised resources (e.g. high nutrient levels), or are subjected to anthropogenic application of resources (Davis *et al.* 2000, Cox 2004). Propagule pressure is also a significant factor, and production and dispersal of *N. neesiana* seed is relatively well understood because of the significance of the weed in agriculture (Gardener 1998, Grech 2007). However, the other mechanisms that enable *N. neesiana* to actively invade have not been clearly determined.

Nutrient enrichment is a major cause of alien grass invasion worldwide (Milton 2004). In temperate Australian *Themeda triandra* Forssk. grasslands, invasion of native swards appears to require soil disturbance that creates bare ground and releases nutrients normally locked up in the crown and roots of the dominant native grasses (Wijesuriya and Hocking 1999). Intense pulses of N and possibly P appear to be required (Morgan 1998, Wedin 1999, Groves and Whalley 2002, Groves *et al.* 2003). In unmanaged *T. triandra* grasslands, senescence and partial or complete *T. triandra* death, leading to a similar process of nutrient enrichment, may permit or contribute to invasion (e.g. Lunt and Morgan 2000). Observations indicate that a site occupied by a dominant native grass, that suffers no significant disturbance, will remain resistant to invasion (Hocking 1998). This probably occurs because C₄ grasses such as *T. triandra* are able to use available soil N more efficiently than C₃ grasses such as *N. neesiana*. *T. triandra* swards produce litter with a C:N ratio >30:1, which decays slowly because microbial decomposers are N-limited, resulting in little or no release of nitrate and ammonium into soil solution. Thus *T. triandra* appears to perpetuate its competitive advantage (Wedin 1999, Groves and Whalley 2002).

Methods to reduce available soil nutrients to restore degraded grasslands can include biomass reduction such as burning, and application of a labile

C source such as sucrose. Addition of C is believed to feed, or provide substrates for rapid growth of soil microbes that can temporarily 'mop up' available soil N and decrease rates of N mineralisation and nitrification (see review in Corbin *et al.* 2004). Addition of sucrose to soil can rapidly stimulate microbial activity, probably mostly of bacteria. The method has been used effectively in some cases to reduce the competitive ability of invasive plants and above-ground biomass (Corbin *et al.* 2004, Eschen *et al.* 2007).

The aim of the experiment reported here is to examine the level of disturbance required to enable invasion of a *T. triandra* grassland, and determine which of a range of disturbances result in higher rates of seedling establishment and survival.

MATERIALS AND METHODS

The experiment was established in July 2007 at Iramoo grassland reserve, Victoria University, St Albans, Victoria (37°45'S, 144°50'E), 15 km west of Melbourne, in an area with a relatively uniform density of *T. triandra*. Very dense *N. neesiana* infestations are present elsewhere in the reserve. The site was burnt in autumn 2007.

Ninety 1 m × 1 m plots with 1 m buffer zones were laid out. The number of individuals and canopy cover of existing vegetation were quantified in the following categories: *N. neesiana*, *T. triandra*, *Nassella trichotoma* (Nees) Hack. ex Arechav. (serrated tussock), other native grasses, other exotic grasses, *Romulea rosea* (L.) Eckl., native forbs and exotic forbs. The cover of cryptogram crust, bare ground and rocks was similarly assessed.

A range of disturbances involving killing of the existing dominant grasses ('pre-treatments') and the addition of fertiliser or sugar ('treatments') was then applied to a subset of plots. Propagule pressure ('seed treatment') was applied by spreading *N. neesiana* seeds on a subset of plots.

Pre-treatments Three pre-treatments were applied on 10 July: (1) spraying of all existing grass tussocks with glyphosate (label rate for perennial grasses) (= 'full kill'); (2) spraying half the tussocks (= 'half kill'); and (3) no artificial kill of existing vegetation (control).

Treatments Five treatments were applied on 13 July: (1) N fertiliser at 10 kg N ha⁻¹ (2.17 g m⁻² of Incitec Pivot Granular Urea, 46.0% N by weight); (2) P fertiliser at 10 kg P ha⁻¹ (4.83 g m⁻² of Incitec Pivot Triple Super, 20.7% P by weight); (3) N and P fertiliser – at the same rates as in 1 and 2; (4) C (cane sugar) at 0.22 kg C m⁻² (sucrose, 42% C by weight); and (5)

no fertiliser or sugar (control). Additional treatments at the same rates occurred on 19 September and 22 November.

Seed treatment Five hundred *N. neesiana* panicle seeds m⁻² were applied by hand on 13 July to one replicate of each of the disturbance-treated plots. No seed was applied in the other replicates. Seed was collected at Greenvale, Victoria, on 24 December 2003 and stored in a paper bag in the laboratory. Petri dish germination tests (February-March 2007) demonstrated 84% seed viability.

Seed, fertiliser and sugar were applied evenly by hand in still conditions. The three pre-treatments, five nutrient treatments and two seeding treatments gave a total of 30 treatments which were replicated three times (= 90 plots). Two soil cores of 3.5 cm diameter and 5 cm depth were taken from each plot, in the buffer zone close to the plot edge, to assess any pre-existent *N. neesiana* seed bank.

Assessment of treatments Assessment will include the following procedures: (1) an estimation of the density of *N. neesiana* individual plants and their canopy cover at 6, 9, 12 and 24 months; (2) at 24 months (end of trial) determination of the densities of *T. triandra*, and other native and exotic tussock grasses, as well as the percentage canopy cover of *N. neesiana*, *T. triandra*, other native and exotic grasses, native and exotic forbs, cryptogram crust and bare ground; (3) harvest of the standing phytomass in each plot by clipping all plants to 1 cm height, separation of the phytomass into the same six classes, and determination of the dry weight of material in each class.

RESULTS AND DISCUSSION

After one month, a high proportion of the seed had burrowed into the soil. Very little seed had moved out of plots. Winter rainfall in the Melbourne area was extremely low. The first seedlings appeared in early November after good rains.

Clear results may not be apparent until the second year of the experiment because seedlings of *N. neesiana* are difficult to distinguish from those of other grasses. The seed application rate is towards the lower end of what might be expected under natural conditions, since a potential annual seed yield of c. 30,000 m⁻² has been estimated (Slay 2001). The rate of seed application in the experiment was limited by the availability of *N. neesiana* seed.

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