Ecological modelling of serrated tussock

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Keywords
CLIMEX, DYMEX, Ecological models, serrated tussock

Summary
An international project to study the ecology, ecophysiology and population dynamics of serrated tussock and to develop a series of management-oriented models is described. A draft CLIMEX model of the potential distribution of serrated tussock is nearing completion, and collaborative research sites have been established at eight sites across three countries. Data analysis and model development will parallel further data collection.

Introduction
Ecological modelling can play several roles in weed management. Climate models can provide an estimate of the areas at risk of invasion (Kriticos and Randall 2001), whilst population dynamics models can support an exploration of the likely effects of management techniques applied in isolation, or in combination. Ecological models can also play an important role in managing research by providing a framework within which otherwise disjointed information can be integrated, and through the prioritization of research questions.

The CRC for Weed Management Systems and CSIRO Entomology have been supporting an international research project concerning the ecology and ecophysiology of serrated tussock, *Nassella trichotoma* (Nees) Hack. ex Arechav. This project has a strong ecological modelling component. The research project is still underway. In this paper we describe the project and report on progress.

Methodology
The research project has two lines of investigation, with distinct, but overlapping scales.

Potential distribution
A CLIMEX model (Sutherst *et al.* 1999) is being developed for serrated tussock, based upon its global distribution (Figure 1). Distribution records from Australia and New Zealand are not being used in the model development so they can be used to validate the completed model. This model will provide a more reliable estimate of the potential distribution than a previous model (McLaren *et al.* 1998) which was developed using only the known Australian distribution of serrated tussock. The CLIMEX model will also provide a deeper insight into the climatic factors that limit the plants distribution in different parts of its range. These insights can be used to help tailor control strategies in different climatic regions, and to better understand the importance of climate variability as it affects control techniques and population dynamics. The CLIMEX model will also allow us to explore the sensitivity of the potential distribution of serrated tussock to climate change.

The global distribution of serrated tussock was determined from published sources (Taylor 1987, Torres 1996, Torres 1997, Stace 1997, Henderson 2001), herbarium records (Pretoria Herbarium, Ben Viljoen South Africa and the SAPIA database, Plant Protection Research Institute), and field observations (M. Gardener unpublished data, W. Pettit, unpublished data). The CLIMEX parameters are being fitted to the known distribution in South America, South Africa and Europe. A draft model has been produced, and is currently being fine-tuned.

Ecophysiology and population dynamics
To investigate the ecophysiology and population dynamics of serrated tussock, a collaborative network of research sites has been developed spanning Argentina, Australia and New Zealand. The statistical design framework uses the climate at each site as a multi-dimensional treatment factor. The aim is to develop a climate-driven, process-based, population dynamics model for serrated tussock using DYMEX (Maywald *et al.* 1999). This model will allow researchers to realistically explore the effects of management treatments on serrated tussock populations using weather data for sites of interest. Similarly, the potential impact of biological control agents can be explored prior to their introduction by assessing the effects of different levels of attack on relevant plant life-stages and life processes.

At each research site, a meteorological station is established to record daily minimum temperature, daily maximum temperature, relative humidity at 0900 and 1500, and total rainfall. This information will be used directly in the ecological analyses to understand temperature-related phenomena, and indirectly, to drive a soil moisture model which is related in

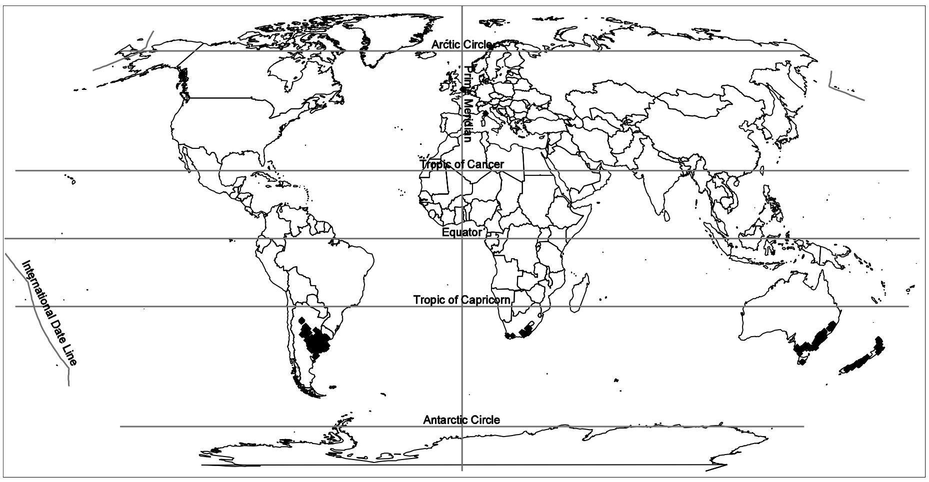

Figure 1. Historical world distribution of *Nassella trichotoma*. Some populations may have been eradicated locally, particularly in New Zealand. Compiled from Taylor 1987, Torres 1996, Stace 1997, Torres 1997, Henderson 2001, Pretoria Herbarium; SAPIA database, Plant Protection Research Institute; M. Gardener unpublished data; W. Pettit, unpublished data.

turn to germination, plant growth and drought mortality.

There is a core sampling protocol at each site that covers seedling demography, plant growth rate and phenology, fecundity, maturity rate and reproductive phenology. Management treatments are included in a factorial design, and vary across sites according to the management strategies that are culturally relevant in each region. In addition to the core ecophysiological studies, seed bank dynamics are also being investigated with experiments on seed germination, dormancy and decay processes.

Spreading the research across a number of sites with contrasting climates, and collecting weather data at each site has a number of benefits over the more traditional approach of building population dynamics models through taking repeated censuses at a single site. Firstly, the data collection time-frame is compressed many times. Effectively, the total data collection effort remains similar, but it is expended in two to three years rather than the more usual five to seven years. By reducing the research time-frame, we can gain more rapidly an understanding of the population dynamics of serrated tussock under each of the promising management techniques. Secondly, the data collection effort can be spread across many of the agencies responsible for developing control technologies for serrated tussock. This reduces duplication of effort, and makes the research more affordable at each location. Thirdly, many of the processes underlying the plants' population dynamics can be inferred from the weather data (Hudes and Shoemaker 1988), and incorporated into the process-based model. This allows the research findings to be generalized so that the effect of climate on the population dynamics and efficacy of control techniques can be assessed across the range of climates that serrated tussock is found.

The data analysis and model-building will proceed in parallel with the collection of a second years worth of data at five of the sites, and the first years data collection at three more sites.

Acknowledgments

The Agricultural and Marketing Research and Development Trust (AGMARDT) have supported the New Zealand component of the research project.

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