Undermining WEEDS

Newsletter 4
January 2013

Dr Graeme Bourdôt with a nassella tussock plant at the site of a plant growth rate experiment in North Canterbury.

Optimising the management of a weed so that it is cost-effective over the long-term requires a thorough understanding of how our control methods (herbicides, biological control agents, mechanical weed control, plant competition, etc.) affect the weed. This understanding is required at various scales of biological organisation depending upon the question being asked by the researcher. Ultimately it is our understanding at the plant population scale that enables us to make the best management decision for a particular species.

Progress update

In our last Newsletter (#3) we reported on three projects from the Undermining Weeds programme in which the impacts of weeds in the pastoral and forestry sectors have been addressed:

1. Giant buttercup is a weed of limited current distribution on dairy farms in New Zealand but, based on a climate suitability model, potentially has a nationwide distribution. This weed typically reduces dairy farm profit by 36%.
2. Yellow bristle grass is an annual weed of increasing concern to dairy farmers in the Waikato region, but has a much wider potential distribution. It has been estimated to reduce milk production by 11% during the summer months.
3. The current chemical herbicide dependency of plantation forestry in New Zealand conflicts with the environmental principles of the Forest Stewardship Council. New research is aimed at cost-effectively integrating cultural, biological and chemical methods of weed control.

In the current Newsletter we present two examples of how researchers in Undermining Weeds are developing and using simulation models: the first a leaf-surface model and the second a population model.

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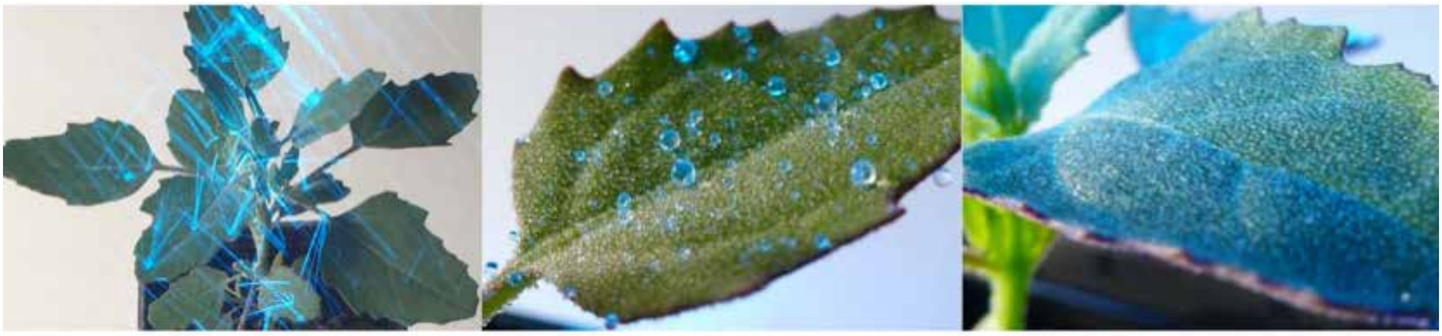
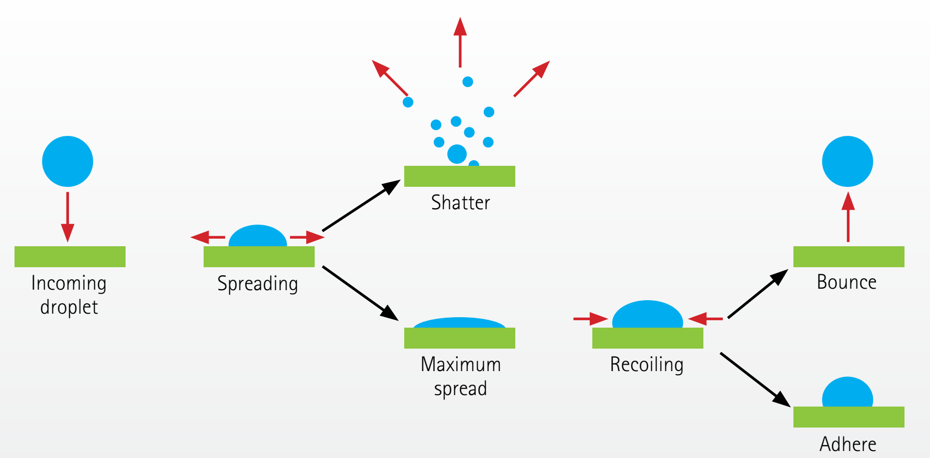


*Droplets impacting and bouncing or shattering off the very difficult-to-wet weed fathen (*Chenopodium album*) (Left) resulting in poor retention and coverage (Middle), while a better formulation provides enhanced retention and coverage (Right).*

Models to predict and enhance spray retention

Spray retention models are being developed to identify formulation and application technologies that optimise spray retention to the target plant, minimise loss to the ground, and reduce the need for expensive operational field trials.



The processes involved in the impact between a spray droplet and a leaf surface showing the three possible outcomes.

The retention and distribution of spray droplets within a plant canopy have a crucial effect on the biological efficacy of pesticides. To maximise spray retention and minimise loss to the ground, droplets that impact a leaf must remain on the plant. When a droplet impacts a leaf surface three outcomes are possible: adhesion, bounce or shatter. Those droplets that bounce or shatter can continue their journey through the canopy, depositing at lower levels within the canopy or on the ground. Whether a droplet shatters, bounces or adheres is dependent on many complex interacting factors such as: the effect of formulants within the spray droplet in flight and on impact, the physical properties of the droplet (size and velocity), and leaf properties of surface morphology, chemistry and leaf orientation. These processes have been studied within Undermining Weeds, and process-based models for bounce/adhesion and shatter have been developed and improved. Prototype interactive software tools have been developed to run the models, allowing the user to determine the effect of changing any of the parameters / factors.

In a collaboration with another Scion programme (MSI LVLX0901), these process-based retention models have recently been implemented within an experimental build of the spray application simulation model AGDISP. This has allowed differences in total spray retention to plants, due to the spray formulation used or species studied, to be predicted. There has been good agreement between the model results and experimentally determined retention, but considerable work is still required to make this approach practical.

These developments should make it possible to tailor spray formulations, as well as application technologies, that maximise retention to plant foliage while minimising loss to the ground and target specific areas in the canopy if required. These models provide a key component of the optimisation of the biological efficacy of sprays used not only in forestry and pastoral weed management, but in any system in which weeds are managed. As they are process based, the models can be used to investigate effects of variations in formulation without the need for large scale, time-consuming and costly experiments. Of course some experiments are necessary to validate and calibrate the models.

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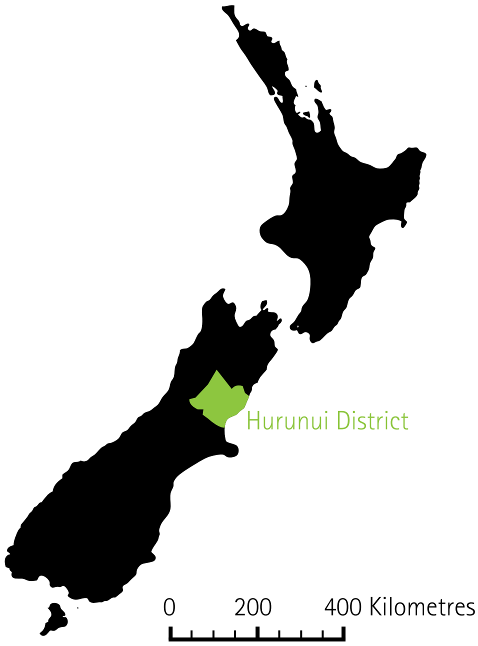
A nassella tussock population comprises plants of various size and developmental stage. Measurements of the fates of the individuals in a population from one census to another (using permanent plots as shown here) form the basis of a model being developed that projects the dynamics of the population over time under alternative forms of management.

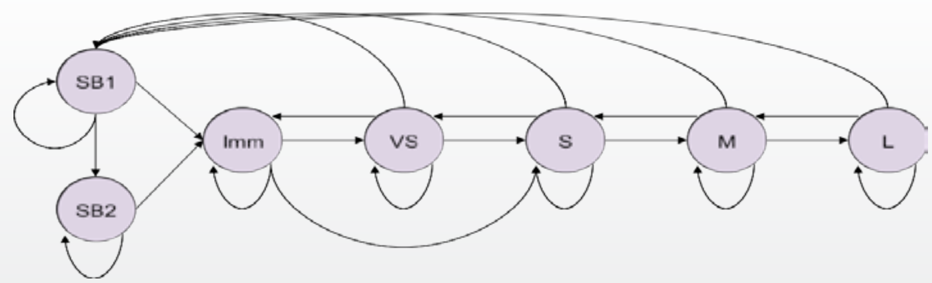
A model to compare management strategies for nassella tussock

Population densities of nassella tussock (*Nassella trichotoma*) in the Hurunui district of North Canterbury have been dramatically reduced over that last 70 years to an equilibrium level of about 14 plants per hectare. Such low densities have no impact on farm productivity and key questions going forward are "how much control effort is needed to maintain this position", "how much extra effort would be required to reduce the density further?" and "what is the long-term economically optimal strategy?"

Nassella tussock (*Nassella trichotoma*) has been considered a serious pastoral weed in North Canterbury for over a century. The plant is of low nutritional value and not palatable to most classes of livestock. This combined with a high tolerance to drought, enables it to invade drought-prone hill pastures. Inadvertently introduced into New Zealand in the early 20th century, by the 1940s population densities as high as 35,000 plants per ha were recorded. Historical control methods included burning, herbicides, over-sowing and the manual removal (by grubbing) of individual plants and these have resulted in much progress being made in reducing the size of the problem. Recently published research has shown that the rate at which this weed can increase in today's hill pastures is much slower than it was historically. This has consequences for the ongoing economics of controlling this weed.

With these questions in mind, the Undermining Weeds team at AgResearch has been developing a computer simulation tool to project nassella tussock population density distributions in the Hurunui district out over time. The model divides the district into 250,000 cells of 400m x 400m. The plants making up the nassella population in each cell are divided into five life stages (immature, very small, small, medium and large plants). Each summer, plants in the model produce seeds that may disperse to neighbouring cells before joining the seed bank. The fate of all plants and seeds are accounted for every 6 months over a simulation period of 10 years. Grubbing may occur at the end of each 6-month period (i.e. April and Oct).





Life stages recognised in the nassella tussock model are the first-year seedbank (SB1), remainder of the seedbank (SB2), immature plants (Imm), very small plants (VS), small plants (S), medium-size plants (M) and large plants (L). The demographic processes (enabling plants to shift from one life stage to another) are shown by the arrows.

A model to compare management strategies for nassella tussock

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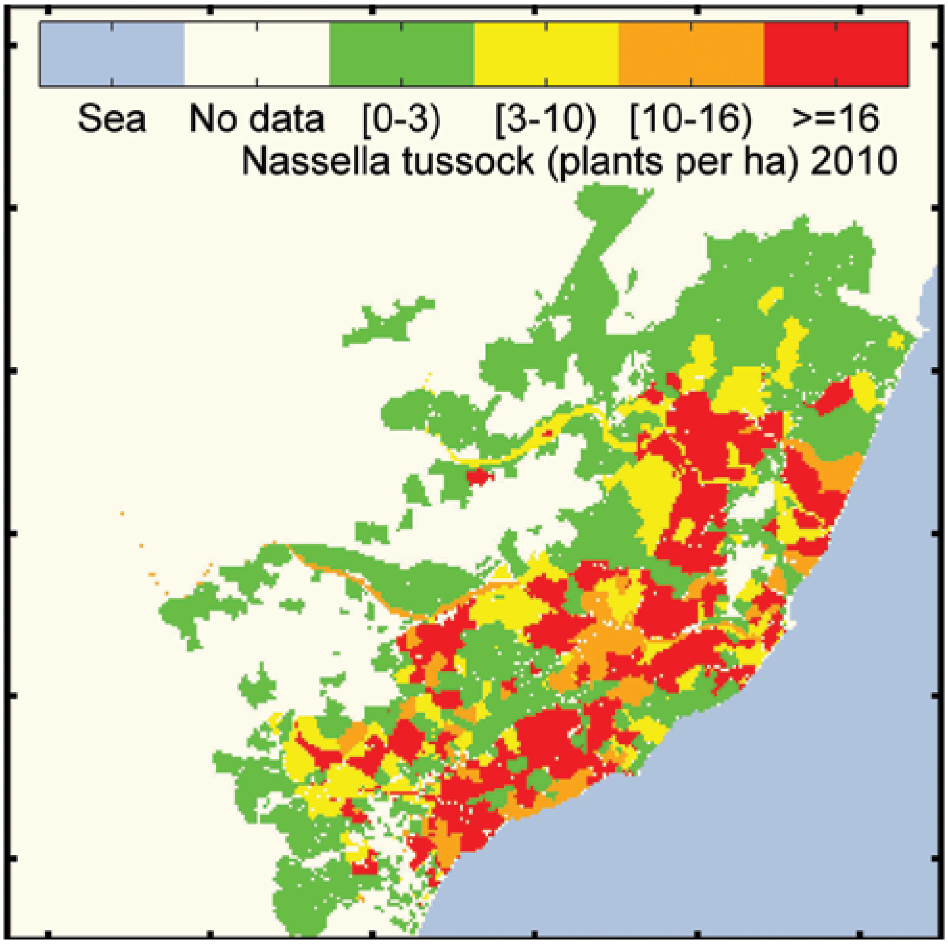
Twelve years of field research data obtained in pastures in the Hurunui district of Canterbury provide the model inputs, such as the initial number of plants (see map below) and seeds (SB1, SB2), and the rates of the demographic processes, such as seed bank survival, seedling recruitment, the grubbing rate in each life stage, life stage transitions for plants and fecundity of plants in each life stage.

Modelling the wind-assisted dispersal of nassella tussock panicles (containing the seeds) remains enigmatic despite a number of experiments. In reality it can never be accurately measured, although we can try a number of alternative dispersal scenarios and see how these affect model outcomes.

Management strategies are incorporated into the model by considering the 6-monthly grubbing rate (percentage of plants removed during each 6-month time period). The current management strategy (the status quo) is annual removal of plants by the compliance date (31st October) imposed under the Canterbury Regional Pest Management Strategy. In this case the model is consistent with field observations, predicting no major change in the densities of the weed over the 10-year simulation period on the infested Hurunui properties.

There are many alternative management strategies that could be compared with the status quo using the model. For example, what happens if grubbing occurs only once every 2 years? What happens if grubbing is concentrated on only the properties with high densities of the weed? What happens if the grubbing rate for large plants (currently easily mistaken for native tussocks and overlooked during grubbing operations) is increased?

The model is simplistic in its assumptions. It does not *predict* the future! It can, however, *compare* alternative grubbing strategies on an equal footing with the status quo, based on our most up-to-date knowledge of the ecology of nassella tussock.



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