Modelling the spread of wilding conifers

Environment Canterbury

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Problem overview

As a Regional Council, Environment Canterbury is responsible for many aspects of environmental protection and sustainability. A major weed problem has been recognised in the form of wilding conifers spreading from existing plantations and shelterbelts. These threaten native vegetation and important wildlife habitat, as well as impacting on pastoral farmland and the visual and recreational values of Canterbury landscapes. A recent survey by Environment Canterbury mapped over 60 thousand hectares of conifers, including both plantations and wildings. It is estimated that seed dispersal from these threatens a further one million hectares of land. Under the Regional Pest Management Strategy 2002, Environment Canterbury has some funding for wilding conifer control, but this is limited relative to the scale of the problem. Thus, the control budget needs to be strategically allocated to achieve the best possible environmental outcomes for the dollars spent. The problem posed to the MISG centred on modelling wilding conifer spread, with the overall aim of prioritising sites for control operations.

Progress at the MISG

The study group focused efforts on three interrelated aspects. The first was to develop an understanding of the topographic and climatic drivers of short and long distance seed dispersal, in order to identify which existing conifer sites posed the greatest risk to the surrounding land. Fringe spread occurs when seed is released from a tree and is carried some horizontal distance by the wind, until it falls to the ground under the force of gravity. However, Pinus seeds will typically only spread about 100m in this case. To achieve the 810km dispersal distances observed in invasive field situations, the group showed that the effective release height of the seeds had to be much greater than tree height. The literature suggests that thermal uplift may be a major mechanism for this height gain. However, this seemed unlikely at the site for which we had data at MISG the Mount Barker site, near Lake Coleridge in the Canterbury high country. Strong North West winds are the norm when the temperature is high, so thermal uplift is probably rare. The group thought that Mount Barker itself was functioning as a launching ramp for seeds released from mature trees upwind of the hill. They could be carried by the wind up and over to be effectively released at a height 200m above the surrounding land. Even though the great majority of seeds would be dropped in the area of low pressure in the lee of the hill, some would continue on the airflow, and could travel the 8km distance on winds over 100kph. Why then are these long distance spread events so rare for example, only one to three major events at Mount Barker in 100 years if topographic uplift can occur so easily? Some initial calculations showed that wind at slower speeds would tend to go around, rather than over, the hill, so seeds may not obtain the required release height. To assess risk of spread from a site, the group recommends that topographic and climatic factors be analysed to estimate both the maximum possible spread distance and the likely frequency of long distance spread events.

The second area of effort at the MISG was modelling the dispersal of seed once it has been released. There are several distributions suggested in the literature for modelling the density of seed rain and the distances travelled. These models describe the high seed densities that fall out of the airstream close to the source, and the long tail of seed that travels the greater distances. It is the outermost edge of the tail that determines the invasion speed of the conifers. Thus it is important to correctly model the distance and seed rain density for those seeds that travel the farthest, in order to correctly predict invasion speed. The group worked with a set of data from Mount Barker, which gave distance-from-source for each tree in the downwind tail of wilding conifers. Several models were fitted to the data, and the group found that a model first proposed by Okubo and Levin described the tail well. The assumptions and approximations made in this model must now be checked before it can be recommended as appropriate for studying wilding conifer spread.

Finally, the group assessed the effectiveness of a range of management options for controlling conifer spread. This analysis was carried out by first developing a pragmatic model of invasion as a series of discrete steps occurring in a down-wind direction. The group defined a set of possible transitions from young to old and scattered to dense trees, and assigned probabilities to these. This enabled a computer simulation of year-on-year invasion to be developed. Knowing that there was not sufficient budget to remove all trees, the task was to find the management strategy that provided the best control of invaded area. A range of possible management strategies were defined, such as always targeting the largest patches of trees for removal, or always targeting the oldest. These were also simulated, with the chosen management strategy of removing particular patches of trees each year, and the remainder allowed to continue growing and spreading. Some strategies, such as targeting the oldest trees, did not provide good control. Targeting the youngest (which would equate to the outermost edges of the tail of wilding conifers) worked much better. The number of trees cut each year could also be varied in this simulation. The next steps would be to bring in a more detailed model of spread (relatively simple assumptions were used during this initial development) along with dollar-value costs for each of the control strategies. This simulation has the potential to provide a valuable framework for predicting and visualising the effect of various control strategies.

Conclusions

The group at the MISG has increased understanding of topographic and climatic drivers of wilding conifer dispersal distances and event frequency. A more realistic model of seed rain density has been tested, supporting more accurate prediction of invasion speed. These developments are important for site risk assessment. A framework has been developed for modelling conifer invasion in space and time, and for predicting the level of control expected from various management strategies.