# Impacts of deer on Kaimanawa beech forests

A thesis presented in partial fulfilment of the
requirements for the degree of

Doctor of Philosophy
in
Ecology

at Massey University, Palmerston North
New Zealand

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2003

Ecology Stream, southern Kaimanawa Forest Park

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**Acknowledgements**

Where to start? There are so many good people to thank. Looking back it's really hard to appreciate how much work it's taken to plan, collect data, organise trips and put it all together. There's no way that the huge project that this thesis represents would have been completed without so many wonderful people, who were far more generous with their time than anyone could rightfully ask. First, thanks to my hard-working, dependable and upfront supervisors, Alastair Robertson, David Coomes, Ian Henderson and Rob Allen. I could not ask for better.

The many volunteer field workers really stand out. There were some pretty long days put into some pretty rough country to collect data for this study. Some have become good friends, and I hope that I can return some of the time that you've so selflessly given to help me learn more about Kaimanawa beech forests. Adam, Aleisha, Alexis, Amy, Andre, Anna, Annalise, Åsa, Bill, Birgit, Carolyn, Clare, Christian, Daisy, Damon, Dan, David, Deirdre, Gunilla, Hanna, Hella, Heneleen, Iciar, Jana, Jasper, Jenny, Lena, Liz, Lotta, Malcolm, Michelle, Oscar, Patrick, Per, Pete, Rachel, Rannveig, Robyn, Sibylle, Sofia, Stephen, Thorild, Tia, Tilly and Troy will always live in my good Kaimanawa memories. I hope I can spend many more evenings around camp fires, sipping on Kaimanawa Milos with you.

Others helped with organisation, transport, data entry and checking, advice, graphics and deer culling. Thanks to you all. Steve Deverell of the Department of Conservation's Tongariro/Taupo Conservancy and Colin Taylor from the East Coast/Hawkes Bay Conservancy deserve special thanks for being the steadfast forces behind fieldwork and data entry. Steve Deverell was always willing to help ensure work went smoothly in Kaimanawa Forest Park, and Colin Taylor always pushed forward no matter the difficulty in Kaweka Forest Park. If the field ecologists I work with in the future are half as good I'll be happy.

Reviews, comments and discussion from Chris Frampton, Clare Veltman, Chris Ward, Paddy Gordon, Cathy Allan, Ian Westbrooke, Greg Sherley, Jaap Jasperse, Julie Slee, Siva Ganesh and Rod Hay helped me to develop as a scientist, and made this thesis much better than it otherwise would have been. Harley Betts of Landcare Research provided advice on analysis of aerial photographs.

The New Zealand Department of Conservation has financially supported this PhD. Thanks DOC. I'm grateful for the foresight of staff of the former New Zealand Forest Service who established the Kaimanawa Region permanent plots. Study area maps were prepared by the drafting division, DOC Wanganui.

My parents sent me on this path, and I hope that it's all been worthwhile. Thanks to mum for always being supportive and willing just to listen. And thanks to Bill for all the adventures. I'm sure that this is just a start on a long journey of many more...

## Contribution of others to study

While this PhD thesis is substantially my own work there has been considerable input from others, particularly assistance with fieldwork and reviewing of manuscripts. Several hundred permanent plots have been repeatedly measured for this study. Typically, each plot took a team of four people a full day to establish or re-measure. After data collection took place there was an equally large amount of effort required to enter data into databases, and then to check and correct errors. The sampling design for fenced and unfenced plots used in chapter five was devised by Chris Ward (East Coast/Hawkes Bay Conservancy), and sites were selected and plots established by Department of Conservation staff from Tongariro/Taupo and the East Coast/Hawkes Bay Conservancies.

All chapters were reviewed at least once by my chief supervisor, Alastair Robertson (Ecology Group, Institute of Natural Resources, Massey University), who suggested numerous changes to analysis, presentation and text. Chapters one, two and seven were reviewed by an associate supervisor Ian Henderson (also from the Ecology Group, Institute of Natural Resources, Massey University). Chapter two is based on a paper submitted to a Department of Conservation journal, Science for Conservation, that I am a senior author for, and for which Ian Henderson is a co-author. Chapter three has been critically reviewed several times by Rob Allen (from Landcare Research Lincoln), who is also an associate supervisor. That chapter is intended for eventual submission to the Journal of Applied ecology with Rob Allen and Alastair Robertson as co-authors, and myself as the senior author. Chapter four is based upon a manuscript that has been published in Forest Ecology and Management. An associate supervisor, David Coomes (Department of Plant Sciences, University of Cambridge), is a co-author of that paper, along with Alastair Robertson, and myself as senior author. That chapter has been reviewed several times by David Coomes and Alastair Robertson and once by two anonymous referees, and co-authorship is in recognition of the advice and manuscript reviewing that both provided. Chapter five is intended for submission to Wildlife Research with myself as senior author and Alastair Robertson as co-author. That manuscript has been intensively reviewed by Rob Allen and a number of Department of Conservation staff, particularly Clare Veltman and Chris Ward. Chapter six is also eventually destined for publication with myself as senior author and David Coomes, Alastair Robertson and Chris Frampton (Christchurch School of Medicine and Health Sciences) as co-authors, each of whom have reviewed that chapter. Chris Frampton has also provided advice on statistical analysis for chapters three, four and five.

**Abstract**

Extensive mountain beech (*Nothofagus solandri* var. *cliffortioides*) canopy collapse has been apparent for decades in the Kaimanawa Region, central North Island of New Zealand. In most other unlogged mountain beech forests prolific seedling regeneration follows canopy collapse, but in the central North Island regeneration has been impeded by red (*Cervus elaphus*) and sika deer (*Cervus nippon*) browsing. The primary objective of this study was to determine relative impacts on mountain beech regeneration of red and sika deer, and the impacts of deer in general on Kaimanawa Region beech forest composition. Previous international research has shown that herbivores can drastically modify seedling species composition, but the ongoing consequences of herbivory for canopy composition and competitive interactions between plants on a landscape-scale are still poorly understood. This PhD uses short and long-term monitoring of vegetation to examine the effects of herbivory on forest regeneration and successional processes. In an attempt to restore mountain beech regeneration, high intensity deer culling was initiated in October 1998 to reduce deer densities. A further objective of this study was to determine the effect of deer culling on deer densities and mountain beech seedling growth.

Data from 20 m x 20 m permanent plots are used to relate the impacts of sika and red deer to changes in mountain, red (Nothofagus fusca) and silver (Nothofagus *menziesii*) beech forest composition and regeneration. Plots were established on randomly located transects over two decades ago and were re-measured periodically since. Mountain beech seedling abundance is compared among areas with different sika deer colonisation histories to determine impacts of sika deer over time. Comparisons are also made with areas outside the region, where no sika deer were present.

At ten subjectively located sites, paired fenced and unfenced plots were established in a high-intensity deer culling area between 1997 and 1999, to monitor benefits of deer culling for mountain beech seedling growth. To provide comparisons, paired plots were also established at eleven sites in areas with low- and medium-intensity deer culling.

Results show that sika deer have widespread impacts on Kaimanawa beech (*Nothogagus* spp.) forest regeneration and composition. Where sika deer have been dominant over red deer for more than a decade, mountain beech seedling regeneration has been suppressed in comparison to areas without sika deer. This is particularly evident at stands which had low

occupancy by trees, and where prolific seedling regeneration is expected due to increased nutrient and light availability.

Mountain beech forest composition in the Kaimanawa Region has undergone shifts towards browse-tolerant and browse-resistant species over the last two decades. In red and silver beech forests there was an increase in the stem densities of species of small trees that are unpalatable to deer. Analysis of seedling densities indicates that deer-palatable *Weinmannia racemosa* and *Griselinia littoralis* trees were failing to recruit into the >75 cm height class. In the southern part of the Kaimanawa study area understorey composition shifted over two decades towards browse-tolerant turf forming herb, fern, grass and bryophyte communities, which may have been due to the presence of deer.

Analysis of seedling growth rates from paired fenced and unfenced plots provides strong evidence that mountain beech seedling growth increased once deer browsing was removed through fencing, and to a lesser extent following reductions in deer abundance through high-intensity deer culling.

I established two experiments to examine the relationships between herbivory and competition between mountain beech seedlings and other turf-forming plant species. These experiments showed that the composition of turf communities had little effect on mountain beech seedling establishment, but their complete removal increased mountain beech seedling growth and survivorship. There was no immediate compositional response of turf communities to the removal of deer browsing, so the reversibility of deer-induced impacts are unclear.