The nature and stability of frost flat heathland/ forest ecotones in the Central North Island, New Zealand

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A thesis submitted for the degree of Doctor of Philosophy in the School of Biological Sciences, University of Auckland, 2005

Acknowledgements

For help with permits, historical information, ideas, equipment, climate data and general enthusiasm I would like to thank Mark Smale, NIWA, Anthony Beveridge, Paul Cashmore, Nick Singers, Rod Warne, John Nicholls, Gretel Boswijk and Peter De Lange.

Thanks to Jonathon Boow, Sharon Fisher, Nga Tama, and Nichollette Brown for keeping all my little seedlings alive, and experiments running, in the various greenhouses during my long absences in the field.

The meandering path which this project has followed over the last 7 years has been made considerably more enjoyable by the good students and staff of the School of Biological Sciences. In particular I would like to thank Johnathon Boow, Eamon Ganley, Charlotte Hardy, Dave Clarke, Liam Anderson, Kevin Parker, Sandra Anderson, Dianne Brunton, Joshua Guilbert, Darryl Jefferies, Todd Dennis, Nichollette Brown, Yvette Wharton and Sharon Fisher, who all provided generous helpings of advice, motivation, friendship, and the odd kick in the backside (when I really needed it).

Thanks to my principal supervisor Dr. Shane Wright, who organized funding for this project, enticed me back to my ivory tower, and has spent many hours proof reading on the final run home. Thanks also to my co-superviser Assoc. Prof. John Ogden for freely sharing is knowledge (and data) about the Whirinaki frost flats, advice, great suggestions on thesis re-structuring, and willingness to respond to silly questions.

Financial support was generously provided by the Department of Conservation and Forest and Bird (Waikato Branch).

The realization of this thesis has involved a great deal of data collection over the last five years. Numerous people have given their time in the field under often trying weather conditions. I would like to thank Jenny Lux, Ralph Johnson, Nicole Bishop, Selma Dancy, Ian Fraser, Darryl Jefferies, Martin Evans and Fleur Maseyk. Special thanks to Robyn Kyd, Garry Bishop and Laura Young whose service in the field on numerous occasions, loan of vehicles and love and support over many years went well beyond the call of duty.

Finally I'd like to thank my parents, Doug and Lynn Bishop (who surely must have wondered if I would ever finish) for providing a roof over my head for long periods of time, financial support, and for their love and unwavering belief in me. I couldn't have done it without them.

Abstract

This thesis examines the nature and stability of the ecotone between frost flat heathland (FFH) vegetation, and surrounding forest, in the Central North Island of New Zealand. FFH vegetation is found throughout the Central North Island, in locations where surrounding topography causes cold air to pool on clear, still nights. This increases frost severity and - due to the low frost tolerance of most woody New Zealand plant species - frosts are severe enough to prevent the establishment of most plant species which are common in the surrounding forest vegetation. The majority of work was carried out at four study sites. Rangitaiki is a large (c.2600 ha) remnant of FFH vegetation on a flat, pumice filled, basin. The other three study sites (Tahau, Waione and Pouakani) are much smaller (c.56 ha, c.35 ha, and c.61 ha respectively) basins where cold air is dammed by downstream river gorges. Vegetation change was examined along permanent transects established perpendicular to the FFH/ forest ecotone. Vegetation changed (over 10 - 20m) from a monoculture of *Dracophyllum subulatum* heathland (= FFH) to more diverse forest or scrub vegetation (= forest). A DCA ordination of the transect data showed that vegetation associations on either side of the ecotone diverged over time. That is, there was a more rapid change in the species composition of vegetation across the FFH/ forest ecotone in older sites. While seed rain density is low in FFH vegetation, it is sufficient, particularly around emergent focal trees, to allow forest to invade FFH. Frost severity increased dramatically across the ecotone in all seasons, at all sites, and the extreme ground frost minimums recorded suggest that it is low temperatures which exclude most forest species from FFH vegetation. Microclimate variation was high at all study sites, and locations with favourable microclimates in FFH vegetation were more likely to support (ephemeral) populations of forest tree seedlings. The most important determinants of variation in microclimate were overhead cover of vegetation and microtopography. The survivorship of 2,270 planted *Leptospermum scoparium* seedlings - a frost tolerant pioneer species which is important in forest vegetation at all study sites - was examined on transects perpendicular to the ecotone at three study sites. The most important determinant of seedling survivorship was distance from the ecotone, although the distance at which seedling survivorship dropped to zero was site and transect specific. Changes in seedling weight and height growth rate over the study period showed that many seedlings which survived the study period, would not have survived in the long term. There were no significant changes in soil profiles dug along transects perpendicular to the ecotone

at all study sites. This suggests that edaphic factors are not the cause of the current ecotone position. The size-age structure of *L. scoparium* and *D. subulatum* stems in FFH and forest vegetation was examined using basal disks (n=627) collected on transects perpendicular to the ecotone. These data suggest that the current ecotone position was set soon after the large scale disturbances which initiated vegetation associations at the four study sites. A short section of the site perimeter at the Waione study site has not been disturbed as recently as the other sites, and age structure data suggests that the ecotone at this location has been stable for at least 100 years. Transect position has no influence on the diameter growth rates of *L. scoparium* stems, which suggests that it is frost mortality, rather than a growth rate limitation due to lower temperatures, which is preventing this species colonising FFH vegetation. Stem age data also suggested that the scattered *L. scoparium* shrubs which manage to colonise FFH vegetation are killed by severe irregular climatic events, the most recent of which occurred in the summer of 1972/73. The same events probably also affected the species composition in forests surrounding the FFH study sites. Historical meteorological data suggests the most likely cause of the 1972/73 climatic disturbance was a severe summer drought, combined with a series of moderately severe summer frosts. A severe winter frost in 1978 had no observable effect on indigenous vegetation at the four study sites. The restricted distribution of two key cold tolerant indigenous woody species – due to increased fire frequency - has almost certainly resulted in a longer term dominance of some sites by FFH vegetation. *Phyllocladus alpinus* (not present at any of the study sites) and *Halocarpus bidwilli* (very restricted distribution at one study site only) have cold tolerances and life history characteristics that allow them to invade FFH. The preceeding results suggest that the composition and structure of both FFH, and surrounding forest vegetation, is a direct result of the unique abiotic environment and vegetation history of each site. Protecting vegetation covering the widest possible range of variation in edaphic and environmental conditions should therefore ensure greatest variation in different plant communities, and genotypes of different plant species, is conserved. The ecotone transitions studied in this thesis are clearly identifiable, and appear to represent the true distributional limits of most indigenous woody forest species. FFH/ forest ecotones may therefore be useful as sites for monitoring the future effects of climate change on plant communities. The varied responses of vegetation at the four study sites to the 1972/73 climatic event suggests that monitoring transects should be established at as many different sites as possible, and at different locations within each study site.

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