The role of *Empodisma minus* as the ecosystem engineer of the fen-bog transition (FBT) in New Zealand mires.

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Abstract

Mire ecosystem engineers create an acidic, nutrient poor and slowly permeable peat due to specific morphological, physiological and organo-chemical properties, changing the ecology of fens (high-nutrient, wet mires) so that they become bogs (low nutrient mires with drier surfaces), the so-called fen-bog transition. Observations on the development of raised restiad bogs in New Zealand support the concept of ecosystem engineering in forming raised mires, but involving the species *Empodisma minus* and *Empodisma robustum*, of the family Restionaceae.

The aim of this thesis is to examine the facility with which *Empodisma minus* fits the model of the ecosystem engineer of the fen-bog transition in New Zealand, and the techniques used to achieve that transition. A model for identifying mire engineers is proposed, based on the collated literature. Species best able to compete in the low nutrient raised mire environment possess morphological adaptations to increase nutrient capture, or traits which minimise nutrient losses (low tissue nutrient levels, high leaf longevity, high nutrient resorption prior to abscission). Whilst both *Empodisma minus* and *Chionochloa rubra* appear to possess nutrient retention and capture traits, Empodisma minus appears to out-compete *Chionochloa rubra* in low nutrient mires, implying superior nutrient capture or retention strategies.

In a survey of 70 mire communities in New Zealand – taking canopy biomass, soil physico-chemistry and the existence of capillaroid root growth and hummock-hollow topography into account - it is clearly shown that *Empodidma minus* is tolerant of a wide range of environmental conditions, thus enabling it to establish in minerotrophic fens, and persist after the fen-bog transition. In contrast to its widespread occurrence in wetland vegetation communities, extensive capillaroid root growth and the associated hummock-hollow topography occur less frequently. Despite P-limited growth being indicated, capillaroid root growth is infrequent or absent in coal pavement and pakihi communities, or where *Empodisma minus* is not the dominant canopy species. *Empodisma minus* appears to form capillaroid roots to maximise nutrient capture in the surface litter layer under a dense *Empodisma* canopy, and a complex relationship between capillaroid root formation, climate, canopy biomass and nutrients is indicated.

Lower tissue nutrient levels where the species co-exist in mires suggest *Empodisma minus* is a more frugal user of limiting nutrients than *Chionochloa rubra*, of importance as the growing surface of the mire becomes increasingly dependent on ombrotrophic (rainfall) nutrient

sources as a result of peat accumulation. I studied the competitive relations between *Empodisma minus* and *Chionochloa rubra* in a 26 month long, de Wit replacement competition experiment. *Empodisma minus* is the superior competitor long-term in the oligotrophic conditions of the fen-bog transition and raised mire environments, providing a high water table is maintained; otherwise species co-existence will likely occur. These results suggest a dense *Empodisma* canopy is required to maintain the wet environment needed for apogeotropic root weft growth, which displayed plasticity in proliferation and placement.

To further examine nutrient retention and loss traits in *Empodisma minus* and *Chionochloa rubra*, I evaluated their production and decomposition characteristics in a 12 month Litter Decomposition Experiment in a montane transitional mire. *Empodisma minus* culms comprise much of the canopy biomass in wet, oligotrophic conditions of the mire environment, while *Chionochloa rubra* tussocks are reduced in density and biomass. Mass losses after 12 months were lowest from *Empodisma minus* capillaroid roots, which contain high fibre, and less P, K, and celluose than *Chionochloa rubra* below-ground biomass. Both *Empodisma minus* and *Chionochloa rubra* produce low nutrient, slowly decomposing foliar litters, with *Empodisma minus* withdrawing much of the nutrient content from its senescing culms. While a large component of total litter inputs in transitional restiad fens may be comprised of senesced *Empodisma minus* culms, the slower decay of *Empodisma minus* capillaroid roots suggest these contribute an increasing proportion of the accumulating organic matter after 12 months.

There is a significant relationship between short-term decay rates and location within the mire, however, this appears to be unrelated to the nutrient content or geochemistry of the substrate, and may reflect the influence of hummock-hollow topography and/or hydrology on decomposition.

Empodisma minus possesses both mechanisms employed in engineering the fen-bog transition - superior nutrient capture and nutrient retention - which results in increased production of slowly decaying capillaroid roots and foliage in oligotrophic mires, and hence increased peat accumulation. The mechanisms enable *Empodisma minus* to engineer the fen-bog transition in New Zealand mires.

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BD	Bulk density
C:N	Carbon:Nitrogen ratio
CEC	Cation exchange capacity
Cond	Conductivity
EE	Ecosystem Engineer
FBT	Fen-Bog Transition
ICP-MS	Inductively coupled plasma mass spectrometer
k	Decay rate constant
LOI	Loss on Ignition
M_0	Initial mass
Moist	Moisture content
M_t	Final mass
N:P	Nitrogen:Phosphorus ratio
PCA	Principal components analysis
PVC	Polyvinyl chloride
REI	Relative Efficiency Index
RYT	Relative Yield Total
TC	Total carbon
TN	Total nitrogen
TK	Total potassium
TP	Total phosphorus
TY	Total Yield
VP	Von Post decomposition index
WCI	Wetland condition index
X_0	Initial nutrient content
X_1	Final nutrient content
Y	Yield