

Vegetation recovery following volcanic disturbance on Mt. Tongariro, New Zealand

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On the 6th of August 2012, a series of volcanic eruptions occurred near the existing Upper Te Maari crater on Mt. Tongariro. The eruptions included pyroclastic density currents (PDCs), a debris flow and volcanic projectiles, each of which significantly affected native vegetation. Between December 2016 and May 2017, I investigated four aspects of vegetation dynamics in relation to the eruptions for my Master of Science (Research) thesis. First, the effect of PDCs on the subalpine conifer, *Phyllocladus alpinus*. Second, differential species sensitivity to the PDCs. Third, the species composition of the impact craters formed by volcanic projectiles, and the fourth aspect, colonisation of a newly formed debris flow.

The aim of this research was to enhance the understanding of vegetation and species responses to volcanic disturbance. The acquisition of this knowledge is an area of ecological importance (del Moral & Grishin 1999) and will provide valuable information to develop accurate models of succession for landscapes effected by volcanic activity.

1: Response of *Phyllocladus alpinus* to the 2012 Te Maari eruptions

Heat from a pyroclastic density current was considered to cause the wide spread die-back (characterised by foliage browning) of many species within the tussock-shrublands to the northwest of Te Maari, including *Phyllocladus alpinus* (Efford et al. 2014). Today some *P. alpinus* appear “Damaged” (1-99% foliar cover) but show signs of resprouting, others appear “Live” (characterised by 100% foliar cover), and others appear “Dead” (characterised by no foliage, Figure 1). To quantify the survival, thirty *P. alpinus* individuals were sampled at each of the twenty-two plots, which were randomly selected, throughout the area affected by the PDCs.

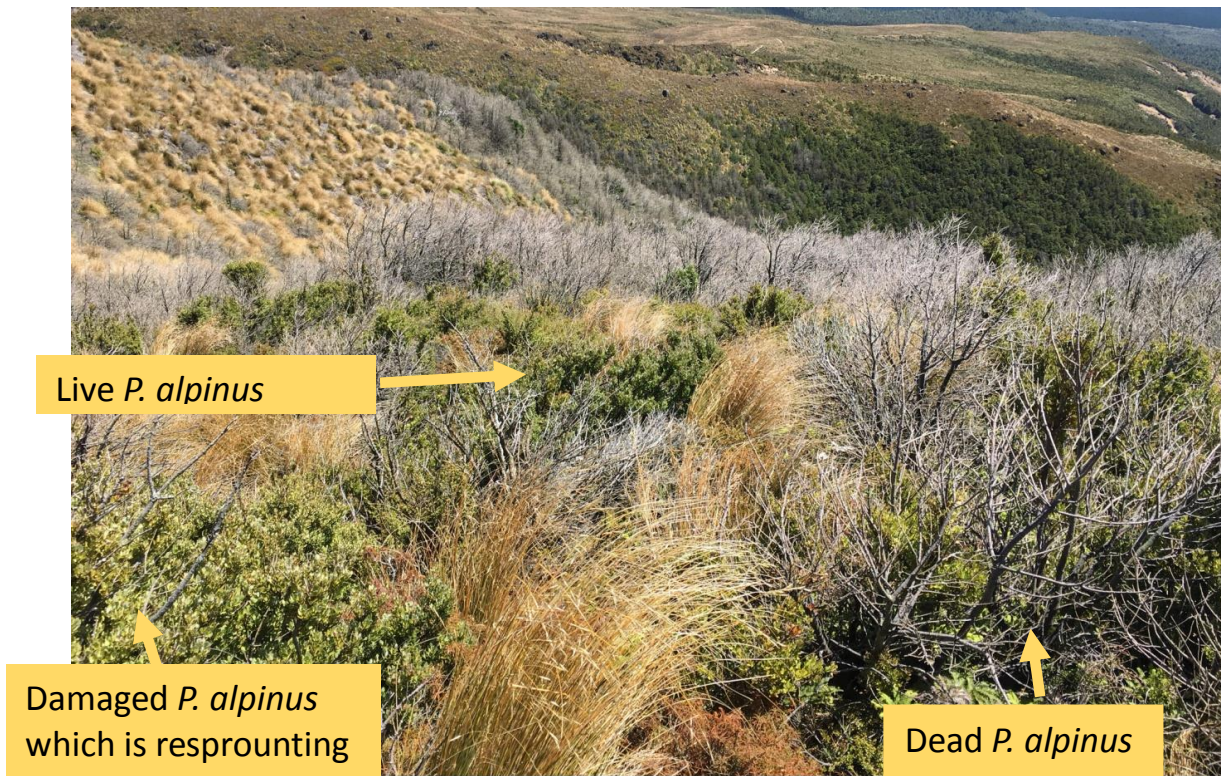


Figure 1: Photograph illustrating the survival of *P. alpinus* in the present day

The survival of *Phyllocladus alpinus* was shown to vary throughout the affected area, with the number of “Live” and “Dead” *P. alpinus* correlated with the distance to the eruption source (Te Maari). Temperature changes associated with the pyroclastic density current (PDC) and/or variations in exposure to the PDC most likely contribute to the varying survival, and is supported by Efford et al. (2014). The age of *P. alpinus* was not shown to affect the rate of foliar recovery after disturbance. The number of “Damaged” individuals increases with altitude and plot size, with altitude the stronger correlation. This may be due to the path of the PDC, a change in growth form (shrub to tree), and/or an increase in light availability with plot size.

2: Species sensitivity to the 2012 Te Maari eruptions

A point intercept method was used to yield proportions representative of the species in the canopy layer, which had maximum exposure to the PDC. The point intercept data was collected from the same 22 circular plots where the *Phyllocladus alpinus* data was measured. I found species sensitivity varied within the research area and of

the 10 most abundant species, *Phyllocladus alpinus* was the most affected and therefore most sensitive species, with 57.73% foliar survival. *Gleichenia alpina* and *Sticherus cunninghamii* (low-growing ferns) were the second and third most affected species with 74.54% and 77.19% live foliage, respectively. *Gaultheria colensoi* and *Coprosma cheesemanii* on the other hand always had live foliage. The overall conclusion was that a combination of height and morphological features most likely determines species sensitivity to PDCs. Small coriaceous or glossy leaves; or narrow flexible leaves appear advantageous morphological features while stiff, curved, hairy, scaly leaves and a dense growth form is a disadvantage for foliar survival from PDCs.

3: Vegetation development of impact craters formed by the 2012 Te Maari eruptions

Of the estimated 13,200 ballistic projectiles produced during the eruptions on 6th of August 2012 (Fitzgerald et al. 2014) more than 2200 impact craters were created in the landscape with a diameter larger than 2.5 m (Breard et al. 2014).

In March of 2013 and 2015 staff and students from the University of Waikato measured the species richness and percent cover, both inside and directly outside (within the debris apron) 15 of these craters. I remeasured 13 of these craters in March 2017 and analysed the change in species composition over time. I found the mean species richness and percent cover was higher in the debris apron than inside the craters; however, types of species were similar in both locations (Figure 2).

Outside the craters there was an increase in species richness with each year of measurement, however, the percent cover decreased from 2013 to 2015 before increasing in 2017. This decrease is most likely attributed to a statistically significant decrease in the cover of *Dracophyllum recurvum*. Between 2013 and 2015 there was a decrease in both species richness and percent cover inside the craters. This trend reversed between 2015 and 2017 with a statistically significant increase in species

richness, and an increase in percent cover. This suggests species survived the initial impact of the projectile but experienced subsequent dieback followed by regeneration.



Figure 2: Crater 4 photographed in 2017, illustrating the species composition inside and outside the craters

4: Vegetation development on a debris flow formed by the 2012 Te Maari eruptions

The fourth aspect of my research was the examination of species colonising a newly formed debris flow (Figure 3).

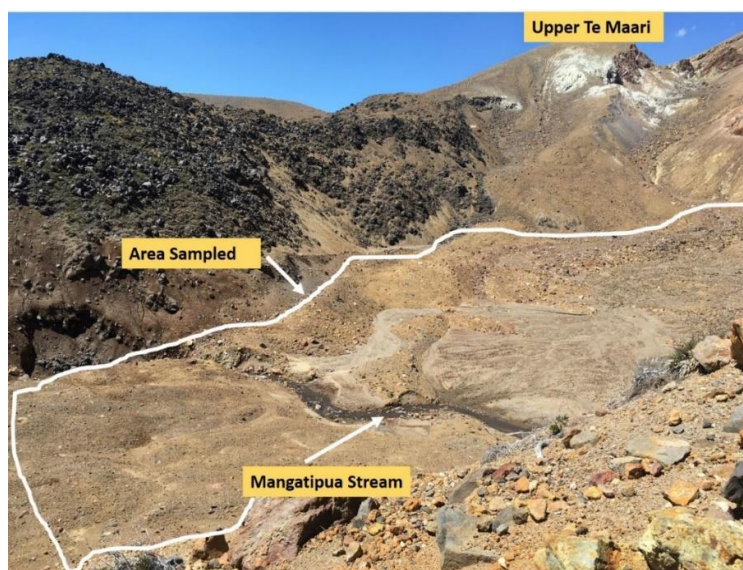


Figure 3: Annotated photograph showing the area sampled within the debris flow

Thirty 2 x 2 m sites were sampled on the debris flow, with nine sites containing vegetation. Due to the terrain and age of individuals, there were seven records identified to species level, and three identified to genus. One record could only be identified to family level (Table 1).

Table 1: Summary of species located on the surface of the debris flow. Mean cover (%) is the average percent cover for that species in quadrats it was located in.

Species	No of quadrats	Mean cover (%)	Life form	Main dispersal mechanism
Lichen		0.1	lichen	wind
<i>Campylopus</i> sp.	2	0.3	moss	wind
<i>Luzula banksii</i>	2	0.2	sedge	wind
<i>Racomitrium lanuginosum</i>	1	0.5	moss	wind
<i>Poa</i> sp.	4	0.6	grass	wind
<i>Poa cita</i>	1	9.0	grass	wind
<i>Coprosma perpusilla</i>	1	0.1	subshrub	bird
<i>Chionochloa rubra</i> subsp. <i>rubra</i> var. <i>rubra</i>	2	0.6	grass	wind
Grass sp.	2	0.4	grass	wind
<i>Epilobium pernitens</i>	1	0.1	dicot herb	wind
<i>Senecio vulgaris</i>	1	0.1	composite herb	wind

The mean species richness over all 30 quadrats sampled was 0.63 species/quadrat, which is an overall colonisation rate of 0.14 species/quadrat per year for the entire debris flow. Although the colonisation rate appears low, the rate is similar to other comparable studies, though these are limited.

The mean percent cover for all thirty quadrats was 0.25%, with *Poa* the most frequent and abundant genus. Colonisations are predominantly near the Mangatipua stream tributary with topography, substrate particle size and proximity to seed sources appearing to constrain seed dispersal and germination, resulting in varying and low rates of colonisation.

Acknowledgement and Future

I thoroughly enjoyed conducting this research and I would like to thank the John Nicholls Memorial Fund, via the Rotorua Botanical Society, for their generous financial contribution which made travelling to the sites possible. I plan to travel overseas for a year, examining similar sites on Mt. St. Helens in the U.S.A. before returning to New Zealand and re-measuring the species richness and percent cover of the impact craters. Ideally, I would like to continue and expand each aspect of this research to establish if allogenic or autogenic processes are driving ecological succession and therefore provide a better understanding of the successional pathways and model/s which are associated with succession.

References

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