## Living in harmony with New Zealands volcanoes: Balancing tourism, social values, land use, and hazards around caldera and cone volcanoes

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Tourism, both domestic and international, is a substantial part of New Zealand's economy, with a strong link to volcanoes. Volcanoes are also widely valued in terms of landscape, access and resources by New Zealanders. Risk management in New Zealand is underpinned by New Zealand's signatory to the post-Sendai 2015 framework for improved community resilience to all natural hazards.

The most challenging hazards around both calderas and cone volcanoes lie at the two ends of the eruption size spectrum. The smallest eruptions, which are often phreatic or phreatomagmatic can occur with little or no warning due to a sudden perturbation in the hydrothermal system. Because these hydrothermal areas are also accessed daily by abundant tourists (Tongariro, Ruapehu, central Taupo Volcanic Zone (cTVZ) calderas, and White Island) even in small eruptions the consequences can be severe. Figure 1 shows the large number of hydrothermal systems across cTVZ and White Island.

At the other end of the spectrum when possible magmatic unrest is detected through monitoring at these volcanoes, the challenge is in interpreting the signals to provide eruption forecasts, and in interpreting and communicating uncertainty. This applies also at less-recently active volcanoes including Auckland, Taranaki and other parts of cTVZ, Cooperation between scientists, emergency managers and communities is complex because response actions such as evacuation can require substantial lead times. This means decisions need to be planned and executed while there is potentially high uncertainty as to whether or how big an eruption may occur.

Research into our most recent large eruption, at Ruapehu 1995-96 shows two paths to tourism impacts. The single largest economic cost was from disruption of flights, however the largest local disruption was the loss 1/3 to 2/3 of eruptive period tourism revenue across those two years.

Living in harmony with New Zealands volcanoes means balancing a desire and need for access to places at risk across this eruption size spectrum. Risk elimination would only be possible through abandonment of large parts of the North Island, and all of New Zealand (like

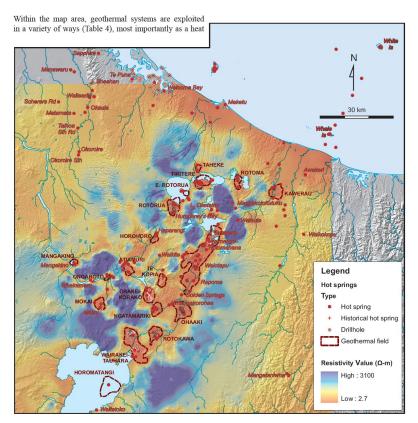


Fig. 1 Distribution of hotsprings across the central Taupo Volcanic Zone (overlain on resistivity data which correlates to geothermal systems). From Leonard et al. 2010.

Japan) has competing risks from earthquakes, tsunami, severe weather, landslides etc. As a result there is a strong focus on risk management – through risk calculation, discussion of what risk is acceptable or tolerable for different land uses or activities, and risk reduction strategies. These include education, physical safety measures, closures and evacuation in response to forecasts or eruptions (Leonard and Potter, 2015). Currently land use planning is an underutilized approach for mitigating volcanic risk, but applications are limited because cone volcanoes are already mostly isolated within national parks, and the potential vent locations in cTVZ and Auckland are widely distributed.

## Main References

Leonard, G.S., Begg, J.G., Wilson, C.J.N. and Leonard, G.S., 2010. Geology of the Rotorua area. GNS Science.

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