The Forest Edge
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Forest dynamics through the lens of volcanic disturbance: impacts of the 2008-2009 eruption of Chaitén (Chile) on peripheral Valdivian temperate rain forest.

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Introduction

An ecological disturbance is a discrete event that brings about pervasive structural ecological destruction, acting as an agent of change (Pickett et al., 2013). Within the framework of ecological dynamics, ecological disturbances are necessarily temporally short-lived (Turner, 2010).

Ecological disturbances can be characterised in three ways – physical, chemical and biological (Magurran et al., 2011). Physical disturbances pertain to agents of disturbance characterised by forceful processes, such as fire (heat), mass movement or flooding. Chemical disturbances could include anthropogenic sources such as diffuse source pollution, or a natural disturbance such as gasses released during a volcanic eruption. Biological disturbances would include disturbances as a result of pathogens or infestation of non-native species. Disturbances can be a combination of the three types, including all three – for example, a volcanic eruption has both physical (pyroclastic density current, lahars, lava flows etc.) as well as chemical (acid rain, vent degassing) (Magurran et al., 2011).

The 2008-2009 Eruption

Chaitén is a small volcano located in Los Lagos province in Chile's southern austral zone (42.83ºS, 72.65ºW, alt. 1,122 m), nestled in the Andean mountain range. Confirmed by correlative paleoclimatic proxies, the last eruption of Chaitén was 9.4 ka BP (Naranjo and Stern, 2004) with no evidence for a more recent eruptive event (Lara et al., 2006). The volcano's periphery is dominated by Valdivian temperate rain forest, a unique biome with a high degree of endemism among its species (Swanson et al., 2005).

April 30th	Commencement of initiation of eruptive phase. Volcano-tectonic (VT) earthquakes detected 20km away.
May 2nd	Increasing frequency of VT events, up to 20 per hour. First Plinean eruption commences, ash plume with a height of 21km. (0800UTC, dur. ~4hrs).
May 3rd	Continuation of ash expulsion from cone, VT events maintained.
May 6th	A second, slightly smaller Plinean eruptive event takes place, this one at 1232UTC. The height of the column was 20km.
May 8th	A third and final Plinean eruption, 0336UTC.
May 10-12th	The process of extrusion for the newly formed dome atop the cone commences.
May-October	Sustained growth of the dome at a rate of approximately $20m^3 s^{-1}$. Ash columns maintained but height is much reduced, ~3.5km.
June-July	A swarm of VT earthquake events.
July-August	Gradual weakening of the ash columns, at this point sustained height of about 2.0km.

Figure 1: *Approximate timeline highlighting the primary eruptive events for the 2008 eruption of Chaitén. The eruptive period started on April 30th 2008 with the onset of pre-eruptive VT earthquakes. The first Plinean ash column was noted a few days later on May 2nd 2008. The eruption began to subside later that year in August, by which point the ash plume was at an altitude of 2km rather than 20km (Lara et al., 2006).*

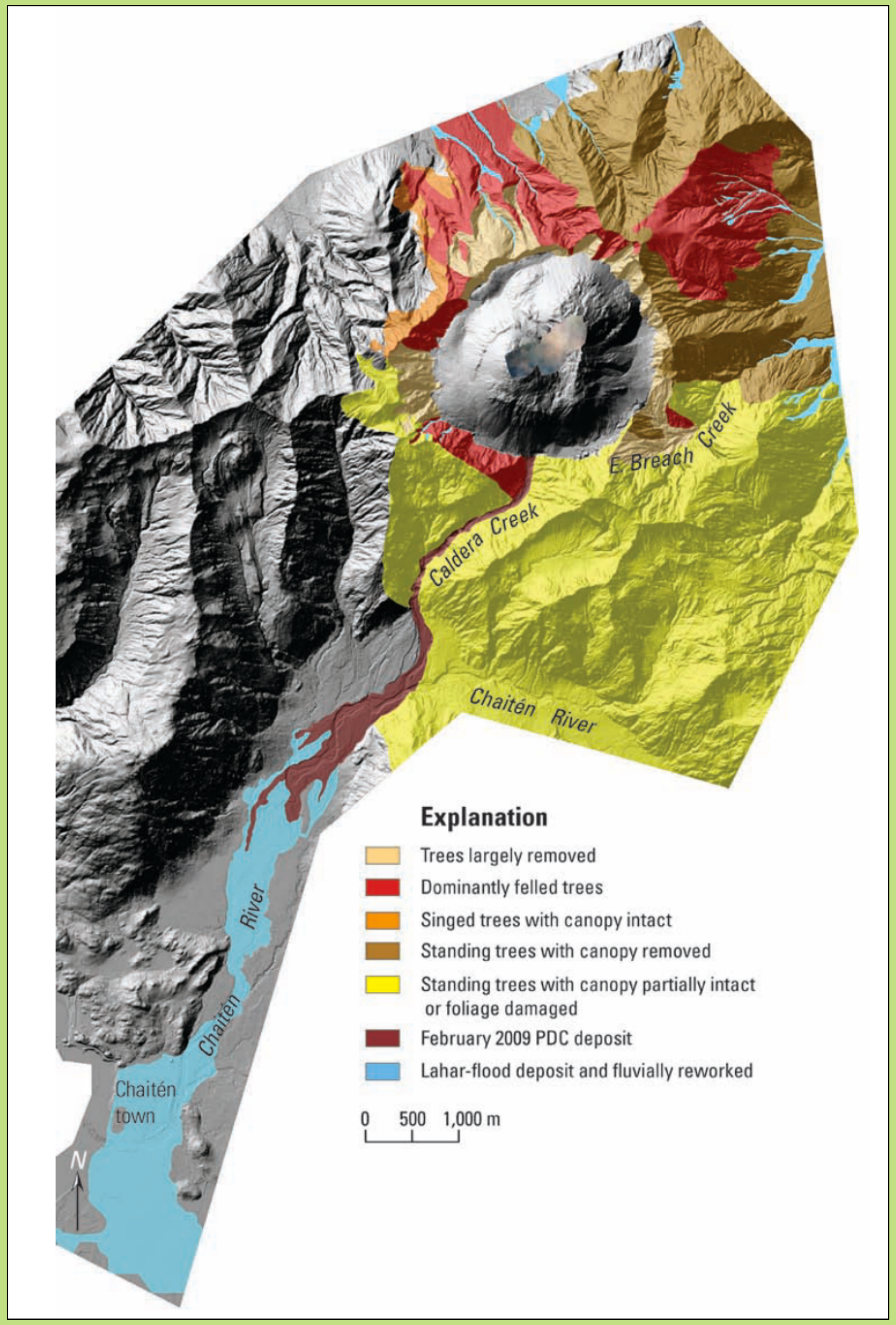

Figure 2: *Impacts of the eruption in space surrounding the volcano. To the north of the caldera was characterised by the most intense disturbance – areas of tree singeing, felling or removal pervade. To the south – closer to the eponymous settlement of Chaitén town – trees are largely still standing, with canopy damage or removal. Fluvial valleys have been inundated with deposits from lahars and pyroclastic density currents (PDCs) (Major and Lara., 2013).*

Volcanoes and Forest Disturbances

In the last century, numerous studies have aimed to analyse the effects of volcanic disturbances on plant communities (Turner, 2010).

Mount Saint Helen's saw a Plinean eruption in 1980, wherein a laterally-directed blast truncated the summit by 400m, inflicted extensive destruction on nearby forests with debris flows, lahars, tephra falls and pyroclastic density flows (Swanson et al., 2005). Debris flows travelled up to 23km, inundating the forested North Fourke Toutle Valley in up to 45m of gravel (Dale et al., 2005).

Mount Pinatubo erupted in 1991 in the Philippines, covering ~30% the eastern flanks of the volcano in pyroclastic deposits. Post-eruptive plant community re-establishment was studied, after which it was concluded that (i) loci of consistent altitude and habitat type tended to have similar metrics of biodiversity, and (ii) topographic stability is also of high-importance, i.e. the characteristics of the newly deposited volcanic substrate determines plant community recovery (Marler and de Moral., 2013).

Chaitén's 2008 eruption was also of a Plinean type, also characterised by pyroclastic density flaws, extensive tephra falls and damage to forests (Dale et al., 2005). Much like in the case of the Mt. Pinatubo study, forest recovery was attributed spatially to geophysical characteristics - e.g. slope, substrate, aspect, et cetera (Gonzalez et al., 2019). Alongside this, it was acknowledged that biological legacies, frugivorous birds and and disturbance intensity also played an impact in determining primary succession characteristics (Gonzalez et al., 2019).

Synthesis

The 2008 eruption of Chaitén sets the stage for a unique ecological study – after instantaneous destruction of a forested area, is the community's recovery dictated by some environmentally deterministic control? Or are patterns of regrowth largely stochastic (spatially random)? What wide-reaching implications would the answer of these questions have in the wider discussion surrounding ecological disturbances on forests?

Aims and Objectives

The aims and objectives of the present study will be to:

- Ascertain the controls on distribution and diversity in the regrowing forest.
- Quantify and account for spatial variation of functional composition and diversity.
- Assess this variation in the context of potential environmental controls, e.g.:
    - Disturbance intensity
    - Topographic controls (aspect, slope, geology/lithology)
    - Microclimatic

In completion of this thesis project, the following questions will be answered:

- How do regrowth patterns in zones of varying disturbance intensity differ from one another?
- To what extent are different environmental controls – e.g. slope, aspect, substrate type - instrumental in controlling regrowth dynamics?
- What implications does this have in regard to wider discourse surrounding primary succession dynamics?
- How do these findings fit in with stochasticity vs. determinism?

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