



# Conflicts between landscape trees and lawn maintenance equipment – The first look at an urban epidemic



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## ABSTRACT

Urban forests are expected to provide numerous ecosystem benefits in challenging conditions that include environmental and anthropogenic stresses. Cities challenge the growth and survival of trees due to restricted growing space, highly modified soils, extreme soil moisture conditions, and climate that often differs from surrounding undeveloped areas. Compounding these stresses are the human factors, like vandalism – both intentional and accidental. Mechanical wounding of exposed surface roots and the lower stem by lawn maintenance equipment falls into the latter category. Anecdotally, lawn maintenance related mechanical damage is a major stressor to landscape trees, compromising their ability to thrive and thus, to provide ecosystem services. Unfortunately, no previous studies have formally quantified the incidence and extent of the problem. Here, we survey mechanical damage for 1018 trees across 308 randomly stratified plots in parks, nature reserves, cemeteries, educational institutions, and roadside grass verges in Christchurch, New Zealand. At least one wound was found on 62.9% of all surveyed trees. This was mainly driven by trees with exposed surface roots, of which 93.6% had at least one wound. This is in contrast to only 43.9% of trees without surface roots exhibiting wounds. Surveyed trees were subjected to repeat wounding with 17.8% of trees having more than 10 wounds. Maintenance activities (i.e. mulch, physical or chemical removal of grass from around the stem) reduced the incidence of mechanical wounding. In the absence of maintenance activities, 67.1% of trees were wounded, while this was reduced to 46.2%, 43.5%, and 64.2% for each of the three aforementioned maintenance activities respectively. While the reductions in mechanical wounding associated with maintenance practices are promising, alternative solutions are necessary to further reduce mechanical wounding, so that the ecosystem benefits derived from urban forests are not undermined by this blight on tree health and survival.

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## 1. Introduction

This ‘disease’ allegedly affects huge numbers of urban trees. Governments (USDA Forest Service, 1974) and university departments (e.g. Whitehouse, 2006) warn about its consequences. It is not a pest like emerald ash borer, nor a fungal disease like Dutch elm disease – it is ‘lawnmower blight’ (USA), ‘Sheffield blight’ (UK) or mechanical wounding. Mechanical wounding is damage to the roots or stem of trees caused by lawnmowers or line trimmers. Allegedly widespread (Cotrone, 2012; Hartman and Eshenaur, 2004), few studies have formally surveyed the incidence of mechanical wounding on urban trees.

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Mechanical wounding is potentially problematic as it affects the physiology (Arbellay et al., 2012) and growth of urban trees (Smith, 2006). The consequence for cities and citizens is a reduction in ecosystem services provided by urban forests (Nowak et al., 2013). It is unknown whether mechanical wounding really is a problem that affects urban forests as a whole, or just a few individual trees. If mechanical wounding were monitored like any other pest or disease, its prevalence would have been quantified or mapped, as is the case for Emerald Ash Borer (Kovacs et al., 2010). But despite its apparent severity, no steps have been taken to formally survey the number of trees that are affected.

Here we address this gap in knowledge with the first formal urban tree survey designed to quantify mechanical wounding caused by lawn maintenance equipment. The incidence and frequency of wounding were surveyed for trees across a variety of land use types to determine the severity of mechanical wounding in an urban forest. Factors that predisposed trees to wounding and methods to prevent wounding are also discussed. Finally, based on

the study results, recommendations are made for managing trees in lawn environments.

## 2. Methods

### 2.1. Study site

The study was conducted in Christchurch, New Zealand (Lat: 43°31'48"S, Long: 172°37'13"E), a city with a population of 375,000 people. To efficiently survey mechanical wounding for trees in Christchurch, we applied a stratified random sampling design. The city was stratified by land use type and plots (circular, 20 m radius) were randomly distributed (5 plots/hectare) throughout the land uses of interest: parks, nature reserves, cemeteries, education institutions, and roadside grass verges. This initial stratified random sampling design resulted in thousands of potential plots. Surveying all potential plots was unfeasible. Each day, a plot was randomly selected from the potential plots; the randomly selected plot determined which parcel would be surveyed that day. For example, if a plot was randomly selected in "Park X", then all plots in that park were surveyed. The survey was carried out between November 2014 and February 2015 and by its conclusion 1018 trees across 308 plots were measured (Table 1).

### 2.2. Data collection

At each plot, all trees were assessed for mechanical damage, except for those where less than 50% of the surrounding ground area (crown area projected to the ground) was covered in grass. These trees were excluded from the study so that data collection efforts could focus on trees with the potential to be affected by lawn maintenance equipment. For example, a tree surrounded by pavement would not be included because it is unlikely to be affected by lawn maintenance equipment. For each included tree, the following data were collected: species, DBH, # of wounds, wound status (old, new), wound location (roots, base of stem), as well as the presence or absence of surface roots, mulch, herbicide spray ring (chemical removal of grass around the tree), or grass cutout (physical removal of grass around the tree).

A wound was counted if the mechanical damage exposed or injured the cambium. New wounds were identified by their white wood, which had not darkened over time as old wounds had. Up to 10 wounds were counted per tree, after which # of wounds was defined as >10. Wounds were included if they were observed on surface roots or the stem of a tree up to 30 cm high. It was assumed that all mechanical wounds were caused by lawnmowers or line trimmers, though there was no way to be certain of this.

The area of mulch, herbicide ring, and grass cutout surrounding trees was not measured, though anecdotally it varied considerably. A few large specimen trees surveyed in parks had mulch spread beneath their entire crown, a radius exceeding 5 m. In most cases, mulch, herbicide, and grass cutouts did not exceed a 1 m radius around each tree. The physical removal of grass left no trace of

grass surrounding trees, while chemical removal left the dead grass surrounding trees.

### 2.3. Statistical analysis

Chi-square ( $\chi^2$ ) tests (Pearson's  $\chi^2$  test with Yates' continuity correction) were used to determine whether wounding was independent of the presence/absence of land use, surface roots, mulch, herbicide spray rings, or grass cutouts. To account for familywise error rate resulting from multiple comparisons, *p* values were adjusted using the Hochberg procedure (Hochberg, 1988). A generalized linear model with a pairwise TukeyHSD posthoc test using R package multcomp (Hothorn et al., 2008) was undertaken to determine whether the number of wounds differed across land uses and also across different maintenance options (mulch, herbicide spray, grass cutout). A linear regression tested whether the number of wounds on a tree was independent of its DBH. All analyses were conducted in the R statistical software environment (R Core Team, 2014) and significant effects are reported at the  $p < 0.05$  level.

## 3. Results

### 3.1. Overall rates of wounding

The surveyed trees ranged from 3 to 253 cm DBH and represented 116 different species. Of the 1018 trees surveyed, 62.9% had at least one wound. A chi-square test showed that the presence of a wound was independent of land use ( $\chi^2$  [4 d.f.,  $N = 1018$ ] = 3.7,  $p = 0.45$ ), despite the varying percentage of wounded trees (Table 1). While not statistically different, mechanical wounding in parks (65.8%) was highest and mechanical wounding in nature reserves (57.1%) was lowest.

Trees with exposed surface roots were significantly more affected by lawn maintenance related mechanical wounding, with 93.6% of 389 trees affected by at least one wound in contrast to 43.9% for trees with no surface roots ( $\chi^2$  [1 d.f.,  $N = 1018$ ] = 252.14,  $p < 0.0001$ ).

### 3.2. Wounding frequency and repetition

The number of wounds on each tree differed across land use types, ranging from an average of 3.18 on trees in roadside grass verges to 4.59 on park trees (Table 1). The number of wounds per tree was significantly greater in parks than in nature reserves ( $p = 0.012$ ) or on roadside grass verges ( $p < 0.0001$ ). Trees in the latter land use also had a lower number of wounds than trees planted in education institutions ( $p = 0.011$ ).

Of the 371 trees with no wounds, 93.3% had no exposed surface roots. For all trees with at least one wound, the proportion of trees with exposed surface roots increased as the number of wounds increased. For example, trees with exposed surface roots comprised 25.7% of trees with 2 wounds, but 47.9% of trees with 5 wounds, 64% of trees with 8 wounds, and 87.3% of trees with more than

**Table 1**

Summary of surveyed trees including the percentage of wounded trees by land use. Mean and one standard error for the number of wounds on trees across different land uses is also presented. Superscript letters on the mean values identify groups with significantly different means.

Land use	# of Plots	# Trees	% of Wounded Trees	Mean (s.e.) # of Wounds
Park	99	360	65.8	4.59 (0.23) <sup>a</sup>
Nature reserve	33	161	57.1	3.29 (0.33) <sup>bc</sup>
Cemetery	29	96	62.5	3.94 (0.44) <sup>abc</sup>
Education institution	35	118	63.6	4.59 (0.41) <sup>ab</sup>
Roadside grass verge	112	283	62.2	3.18 (0.21) <sup>c</sup>
Total	308	1018	62.9	

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