Property Risk Inspection LIMITED

The 2018–2019 UK residential dwelling clay shrinkage subsidence event

- Claims analysis -

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Introduction

Subsidence as a term has a variety of definitions based on the context of its use, but for the purposes of differential movement of land or property it encompasses subsidence, settlement, landslip and heave. Whilst the mechanisms of the ground or building movement vary considerably in the above definitions; (excepting settlement, with its implied poor design of foundations or bad ground), the courts have taken the view that if the impacts in structural integrity are obvious and the causation can be verified that an insurer will be expected to not repudiate any claim made.

Differential subsidence of low-rise buildings on cohesive plastic soils is a geotechnical and engineering reality. The cracking and displacement of structures and failed structural integrity has always occurred but it was not until the early 1970s that subsidence was added as a class of insured peril to residential general insurance policies (P.G., 1998). With the addition of insurance cover for subsidence and as a result of the extended dry summer and winter periods in 1975-77, 1984, and 1989-1991, (Marsh, Monkhouse, Arnell, Lees, & Reynard, 1994). The aggregation of claims experience within General Insurers created a claims management sector comprising insurers, chartered adjusters, engineers, soil scientists, plant specialists and repair management contractors.

The dynamic relationships between low-rise buildings, cohesive soils, vegetation and climate have been well documented. It is established that the loss of water from the soil matrix leads to changes in the overall volume of the soil, which in the presence of a loaded low-rise structure can lead to a differential downward/rotational “subsidence”, exacerbated by the brittleness of modern buildings. This water loss is driven by plant requirements, which are principally a function of seasonal transpiration demand and of a higher magnitude during warmer, drier summers.

MORECS

The Meteorological Office Rainfall and Evapotranspiration Calculation System (MORECS) is an operational system providing estimates of evaporation, soil moisture deficits (SMD) and precipitation under British climatic conditions (Hough & Jones, 1997). Daily synoptic weather provides these estimates averaged over a grid comprising 40km x 40km squares covering Great Britain. Introduced in 1978 as a replacement for the Estimated Soil Moisture Deficit (ESMD), the initial use of MORECS as a “crop” cover and soil water tool for land use and management at the agricultural level, evolved to include “tree cover” in the 1995 revision by modelling differing tree cover type impacts including oil-seed rape, set-aside, forestry area and revision for urban areas on evapotranspiration and soil water modelling.

MORECS is a particularly valuable baseline measure of large scale and population level impacts on vegetation communities and likely impacts on the housing stock from differing climatic states. What would be lost in consideration of the site-specific soils’ analysis from detailed trial hole logs is obvious in the broad agricultural movement of water in and out of the soil as precipitation falls and rises and transpiration demand increases in hot and dry weather. Trans-calendar and temporal changes in water increase and loss from soils at the $40km^2$ level clearly indicate the variable seasonal, annual and decadal impacts of climate movements and seasonality on UK clay soils.

The development of the MORECS system from an agricultural management tool to a multi-purpose land management and subsidence claims handling system has taken place against the context of rapidly rising subsidence claims since the 1970s. Throughout the 1990s, the Meteorological Office and certain system users have researched and developed the MORECS model to more effectively interface with the real time problems of building failure. While the overall flow of MORECS data now spans many decades, there is currently no single theory that describes the data in its full sense. This paper cannot hope to complete this task; however, it is hoped that it will continue to build on the basic first model to be developed, from which a comprehensive theory of “how claims occur” can be established.

What cannot be argued is that the UK climate has a complex and alternating set of states or phases that constantly move from warm and wet, through cold and dry. Whilst tree related subsidence of low rise buildings can occur in any year (fast growing tree and susceptible foundation), it is in those years in which hot and dry weather dominates for a period of 8-12 summer weeks that an initiating event subsidence surge year will commence.

Alpha years

Event years are a soil – climate – vegetation – insurance reality. Within the model, event or *Alpha* years are characterised by a hot and/or extended dry summer/autumn period of between 10- and 20-weeks duration. This period is the initiating event, which leads to high evapotranspirational levels and a rapid rise in MORECS figures between May and September of that year. To be an event year, the MORECS figures will achieve “model” exhaustion of the first 1m of model soil and a period of time will elapse (October – December) when the peak value is maintained against the gravitational force of precipitation by evapotranspirational activity of plants. The peak is reached and sustained against autumn rains.

The model postulated suggests that fundamental changes occur as a result of this initiating event in the root architecture of clay specialist vegetation and clay opportunist vegetation. Root architecture for many tree species is flexible, with high levels of plasticity in root form and function when subjected to drought conditions.

As a result of the initiating event, it is proposed that for many common plant species growing within the United Kingdom this plasticity, whilst designed to invest the engineering soil "Resource Depletion Zones" (RDZs), has a second important outcome. (Lawson, M. (2000). Tree Related Subsidence of Low Rise Buildings and the Management Options.)

Beta & Gamma years

There is no doubt that the *Alpha* year exists as a phenomena and that one can postulate factors that would lead to a higher claims total in the second year after the initiating event that are not technically related to geotechnical/arboricultural factors (i.e. greater public awareness, lower repudiations by sub contracted specialists less familiar with the issues as a resource requirement of insurers); however, to ignore the plant response is felt to be potentially damaging to our understanding of this issue.

One reality of an initiating event is that roots of plants are now "in-situ" within the engineering soil RDZ at depth. The very high MORECS account being at the maximum modelled and only slowly declining into the winter and following spring inevitably means that a positive MORECS figure elevates plant soil water requirements and the building deficit against the ordinary fully saturated soil model of a wet phase spring. The plants will require water many weeks earlier from available root architecture already fully invested and ready to work at transpirational requirements.

The model therefore proposes a "trajectory" for the *Beta* year as a result of the *Alpha* that is inevitable. This is regardless of the weather associated with the *Beta* year, although it is possible for hot dry weather in the *Beta* year to further extend the event duration. The current proposition is that this trajectory can in certain circumstances extend so far as a *Gamma* year regardless of the current climatological position and simply as a function of the energy applied in the *Alpha* year and the long-term cybernetic response from many clay specialist tree species and opportunist trees.

An assessment of key-initiating *Alpha* years, 1976, 1990, 1995 and 2003 indicates all of the factors and trends earlier referenced. What is clear against these trends is that the elevated MORECS figures in the following spring months produced meteorological and geotechnical *Beta* years. For the first 3 events, the “flip” to the new state was sudden and achieved in a matter of weeks, whilst the return to the wet phase was slow and achieved over many months. The model suggests that an initiating event will guarantee a minimum of 12 months of elevated claims numbers with lower repudiation rates with the possibility of a 20 month+ dry phase affected and directed by the *Alpha* year impact on soil/vegetation continuum, almost regardless of the precipitation rates in the *Beta* year.

Hypotheses and aims

The aim of this paper is to assess baseline information on how an event year initiates, the framework for land, trees and property types involved and the management responses in a modern environment. The paper seeks to address to what extent a correlation exists between claims numbers and MORECS data, between insurer repudiation rates falling (the rate at which they decline claims on evidential grounds), the site collected data from specific trial hole bore logs and the total spend in an annual year by insurers.

Property Risk Inspection Limited (PRI) is a specialist claims investigator of subsidence cases with a stable market share over a double decadal horizon. This was the case at the start of 2018, and by July 2018 it was clear that a major dry weather event was in progress. In line with the agreed insurers surge plan of operations, PRI authorised its own response both financially and operationally as of 1st September 2018. This surge plan assumed a sudden and sustained rise in claim numbers with few repudiations and high numbers of tree related claims moving across the UK but focussed on the south and east.

A unique opportunity has therefore arisen to cross reference the data stored by PRI as a result of the surge in claim numbers precipitated by the hot, dry summer of 2018. This has allowed PRI to again collect all claim data by a range of unique identifying markers into a central database for consideration and assessment. Furthermore, the raw data has now been exported in a geospatially referenced manner.

MORECS and claims analysis

The MORECS data used in this analysis is from grid square 161, Figure 1, which represents the 40km^2 area centred north of the river Thames and north London. The data is extrapolated from the deciduous trees profile and plots weekly MORECS measurements of SMD. Square 161 is underlain by a highly cohesive London Clay, which shows classical geotechnical properties of very high plasticity, high shrinking and swelling properties in the presence of vegetation and a poor rehydration profile following precipitation. It therefore drives a relatively “clean” picture of vegetation resource depletion of soil water and of root architecture across all plant species.

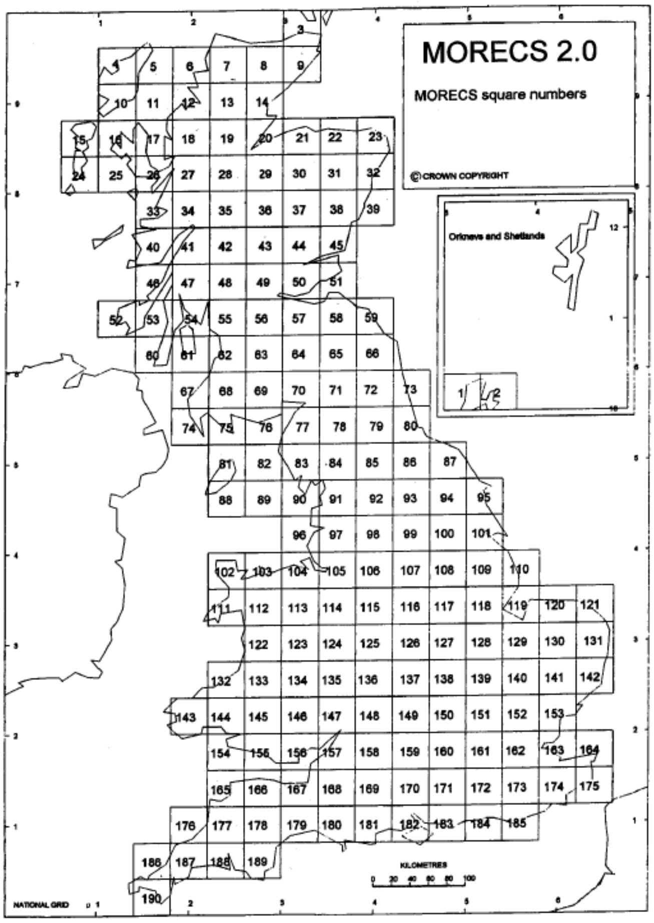

Figure 1: Grid square numbering system used in MORECS, (Hough & Jones, 1997)

PRI continues to receive the full MORECS dataset of this square covering a period from the beginning of policy inception of cover for subsidence of low-rise buildings during the 1970s to the present day and is therefore a very accurate and well-established model; however, for the purposes of this analysis, a detailed assessment has been carried out which sets the ordinary meteorological "phase" for the UK against the less typical hot/dry phase of event years.

The wet phase

Note: "wet" is a descriptive term designed to simply assert that it was not a noticeably dry year.

Within the recent wet phase (2012 – 2016), total precipitation and available soil water in the agricultural soil was sufficient annually to satisfy most plant growth. Figure 2 represents a graphical form of the MORECS data of this period. Note how not once in these years did the SMD reach the maximum figure of 308 for a significant period of 10-12 weeks, thus claim numbers in this period were relatively low. Figure 3 shows the relatively low count of claims per month processed by PRI during this period.

The repudiations against those claims (being that insurers' representatives do not believe the cause is soil differential movement) are relatively high. Therefore, the vegetation-related claims not being repudiated are associated with trees which are very close to properties, large and growing rapidly, large and with a very high moisture requirement adjacent to highly susceptible buildings, contributory to some other cause (e.g. drainage problems) or associated with a policyholder's or prospective policyholder's intolerance of any building movements (i.e. new homebuyers).

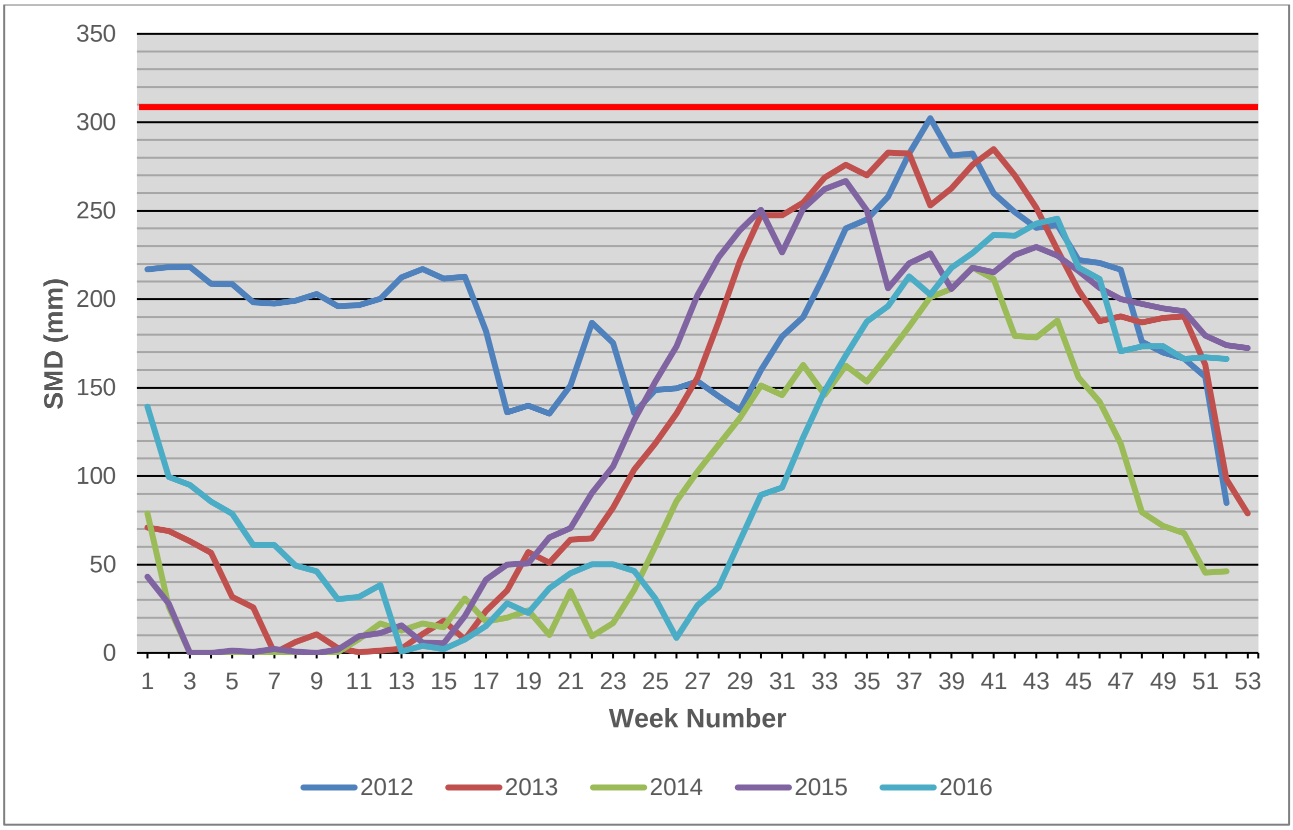

Figure 2: 2012 – 2016 MORECS data grid square 161

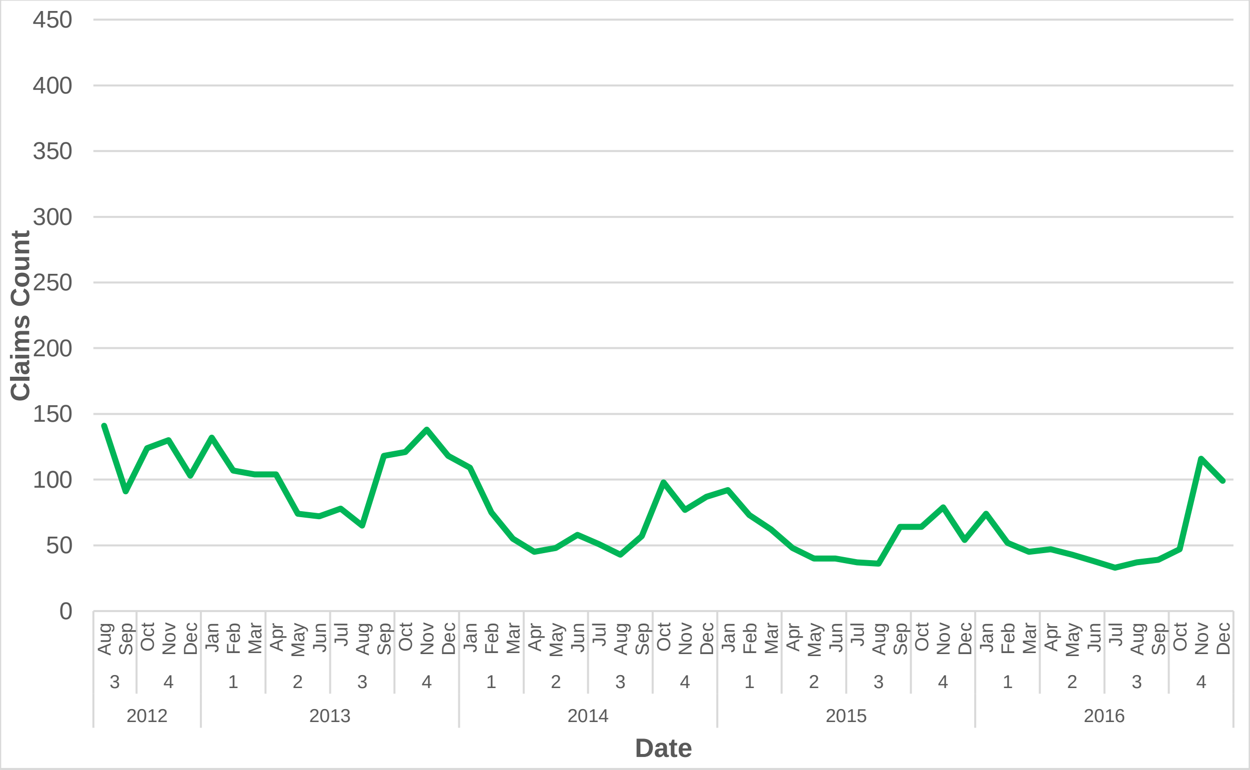

Figure 3: 2012 – 2016 claim numbers, source: PRI

The dry phase

Note: “dry” simply indicates a movement towards higher soil moisture deficits

In the dry phase (2017 – 2018), a subtle shift occurs from the typical wet pattern of 2016 to an initiating drier (although not event) year in 2017. Figure 4 shows the MORECS figures for 2017, in red, where evidently, total precipitation was below average (high MORECS figures) for a critical period or for an extended period (low winter rainfall) and is characterised by the full claim initiating event year of hot and dry summer temperatures putting plant communities under real and prolonged water stress.

The 2018 *Alpha* year

The 2018 event year follows this classical and as predicted pattern, with MORECS figures (green in Figure 4) increasing in an exponential manner towards the maximum 300mm SMD for a period of 10-12 weeks in the summer against a highly variable weather pattern with wild swings in anomaly against the long-term average. This trend for upward MORECS growth of such inherent unpredictability and anomaly alongside a beta phase of the 2017-2018 dry winter correlates to the upward growth in claim numbers shown in Figure 5 towards the tail end of 2018, confirming the author’s hypothesis that there is a very strong correlation between claims events, costs and impacts and MORECS data recording changes in SMD and initiating dry years.

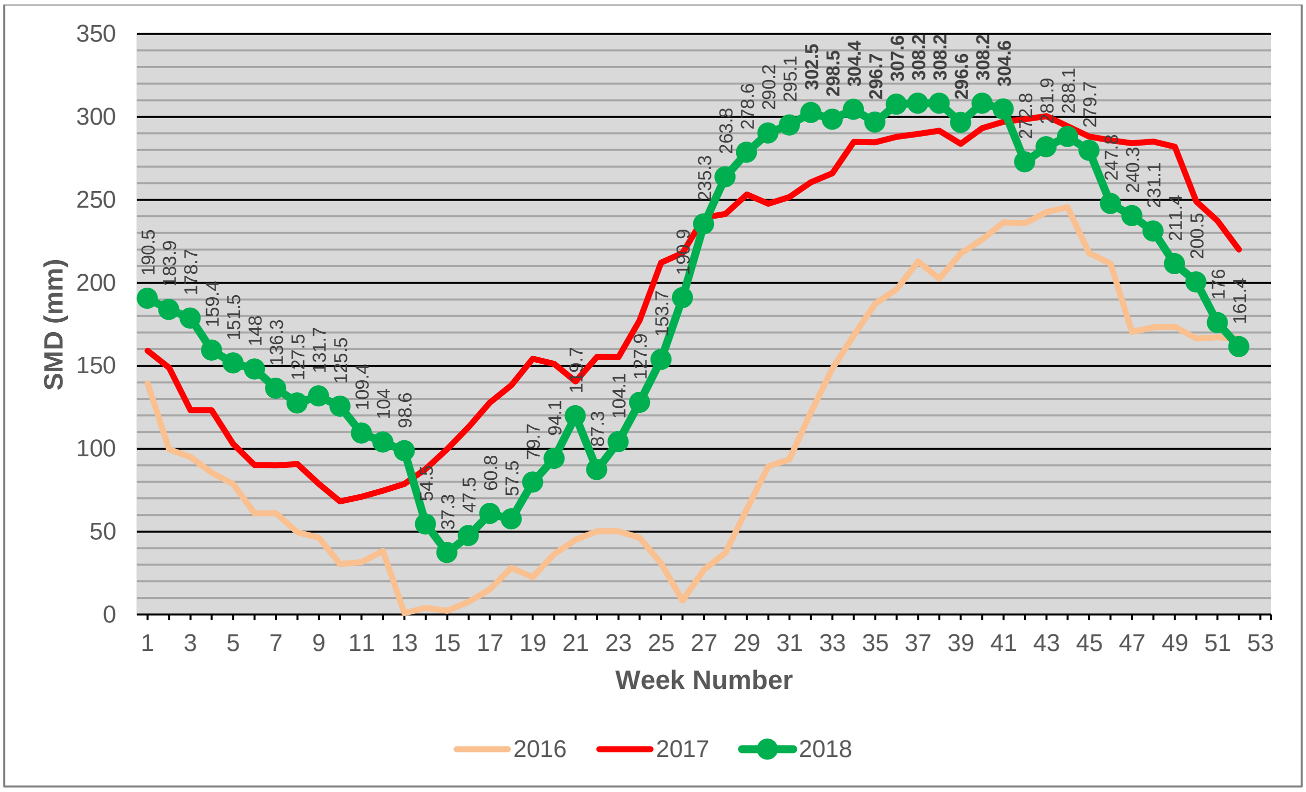

Figure 4: 2016 – 2018 MORECS data grid square 161

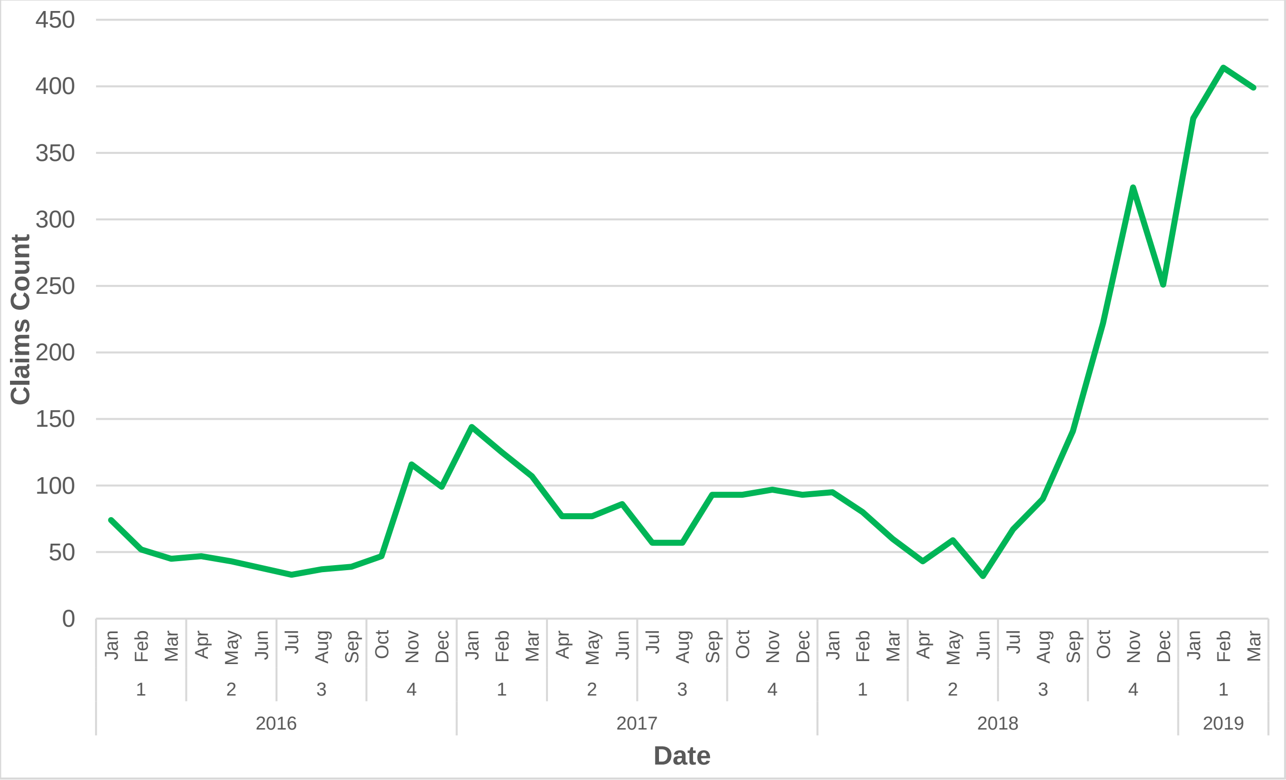

Figure 5: 2016 – 2019 claim numbers, source: PRI

The claims experience

The next section will analyse subsidence case data collected from PRI during the claim harvest period July 2018 – April 2019, covering a sample ~2,000 cases, 14,000 vegetation units surveyed with 6,000 vegetation units implicated. For clarity, the term “vegetation units” refers to items of vegetation surveyed (including trees, tree groups, hedges, climbers and shrubs). PRI has developed a bespoke field app software which enables data on vegetation units to be captured, geocoded and assessed.

It must be stressed that “implicated” is on the basis of trained arboriculturists using a combination of the engineer’s engineering appraisal, the geotechnical or other site investigation data and experience to make choices as to the most likely contributing vegetation.

Figure 6 shows the distribution of claims for this period, indicating that the increase in claim numbers was a primarily English lowlands phenomenon.

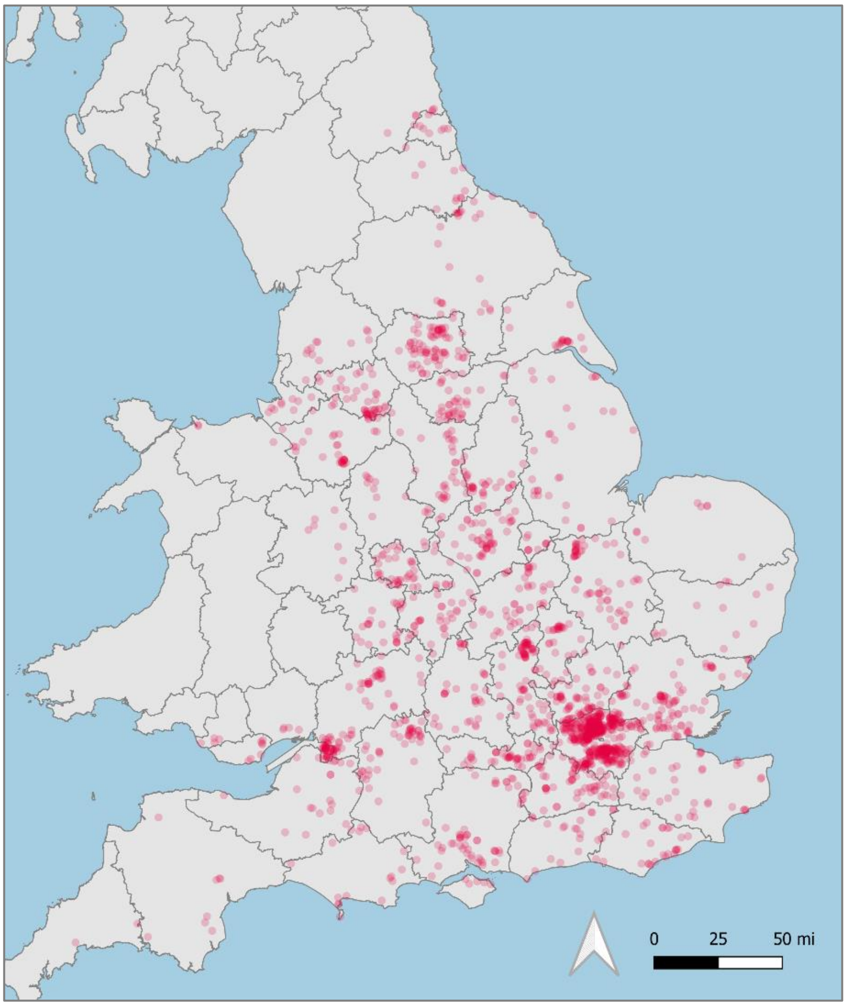

Figure 6 – Subsidence claims distribution July 2018 - April 2019, source: PRI

It should be obvious that the geographically dispersed claim experience confirms an initiating role of the *Alpha* year in plant response to a dry weather event.

Given the statistical validity of the data sample, what will be of equal interest to land managers is the relative frequency of occurrence of claim type against the total, and the following results diagrammatically illustrate some clear trends visible from the vegetation-related claim experience which may assist those involved in this topic in formulating policy and/or for the purposes of further investigation.

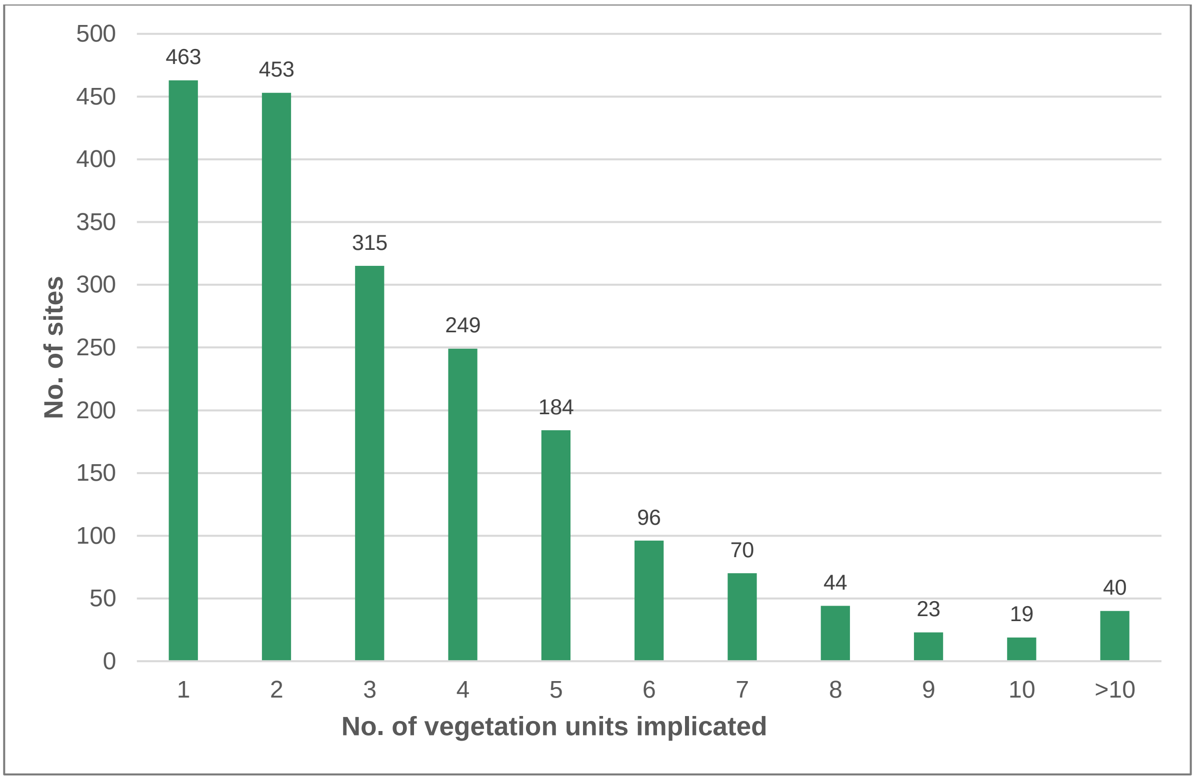

Figure 7 – Number of implicated vegetation units per site, source: PRI

The data in Figure 7 indicates a significant bias towards 5 or fewer implicated vegetation units per site. This is consistent with the overall nature of clay shrinkage subsidence cases, the presence of a construction feature with shallow foundations and distance to damage with a spatial arrangement allowing vegetation to cause or contribute to the subsidence event. Overall, 5 or fewer vegetation units implicated per site makes up 85% of all claims in the study, and this is consistent with earlier claims experience.

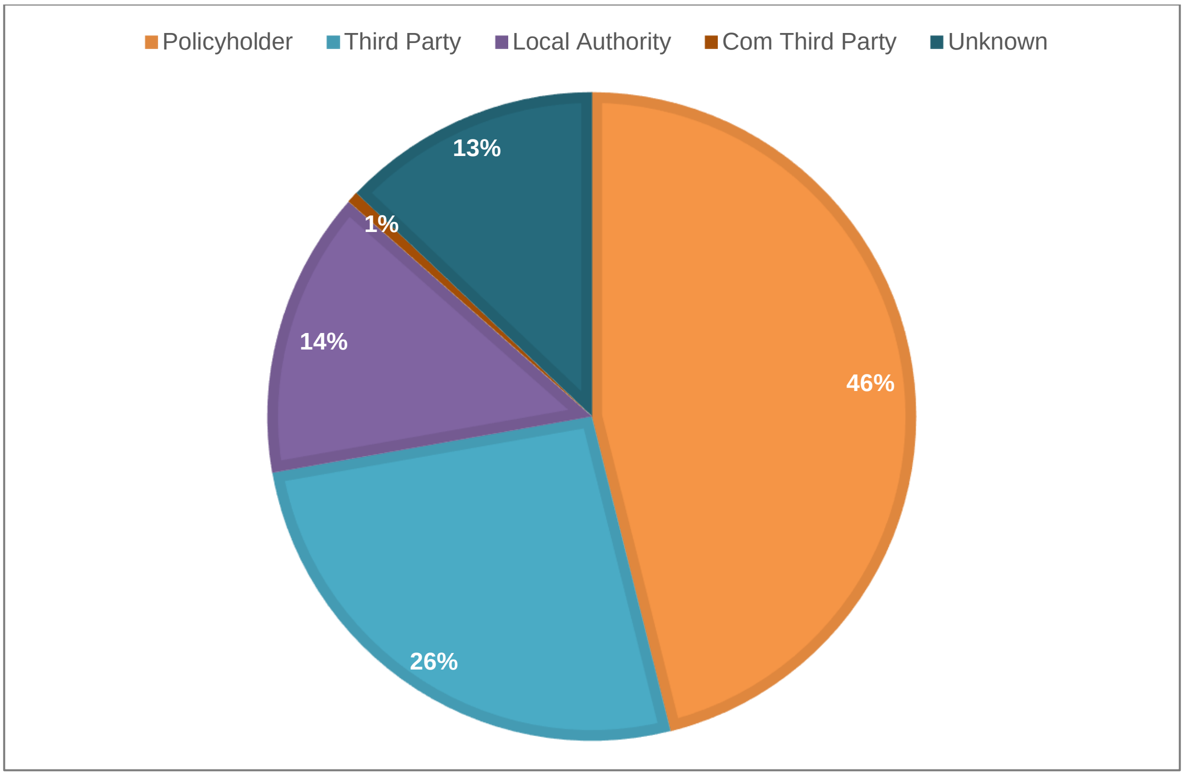

Figure 8 – Land ownership of implicated vegetation units, source: PRI

From Figure 8, approaching half of all vegetation units were under the policy holder's control with a further 26% located in residential neighbouring gardens. Both figures would be expected to increase as the 13% of vegetation units with unknown ownership were verified by land registry checks, and therefore a minimum of 75% of vegetation units causing subsidence were not statutorily managed (highways, parks, social housing).

Around 14% of vegetation units causing subsidence were in some way controlled by a Council Department, and only 1% were on commercial land (as with the above, both of these figures would be expected to increase as the 13% of vegetation units with unknown ownership were verified by land registry checks).

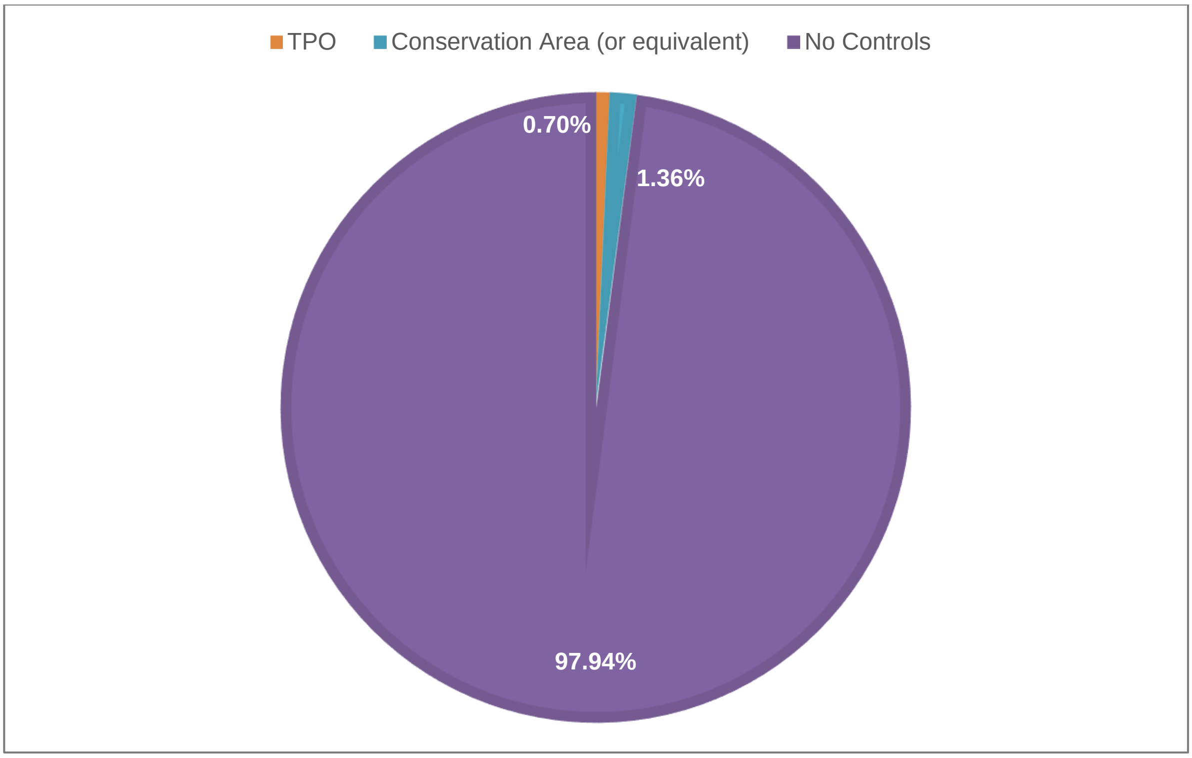

Figure 9 – Statutory control of implicated vegetation units, source: PRI

Figure 9 demonstrates that 97.94% of cases contained no implicated trees that were the subject of statutory controls (Tree Preservation Orders or Conservation Areas). As it is sometimes the case that only some of the implicated vegetation within a survey is subject to a Tree Preservation Order or Conservation Area (or equivalent Trust area), the overall proportion of implicated trees that were the subject of such controls is likely to be under 2%.

When considered in relation to the data shown in Figure 8, the implication of the above is that around 75% of vegetation units were in private residential control and were neither in any Conservation Area (or equivalent Trust area) or had ever been considered of amenity significance by a Planning Department under the Tree Preservation Order legislation.

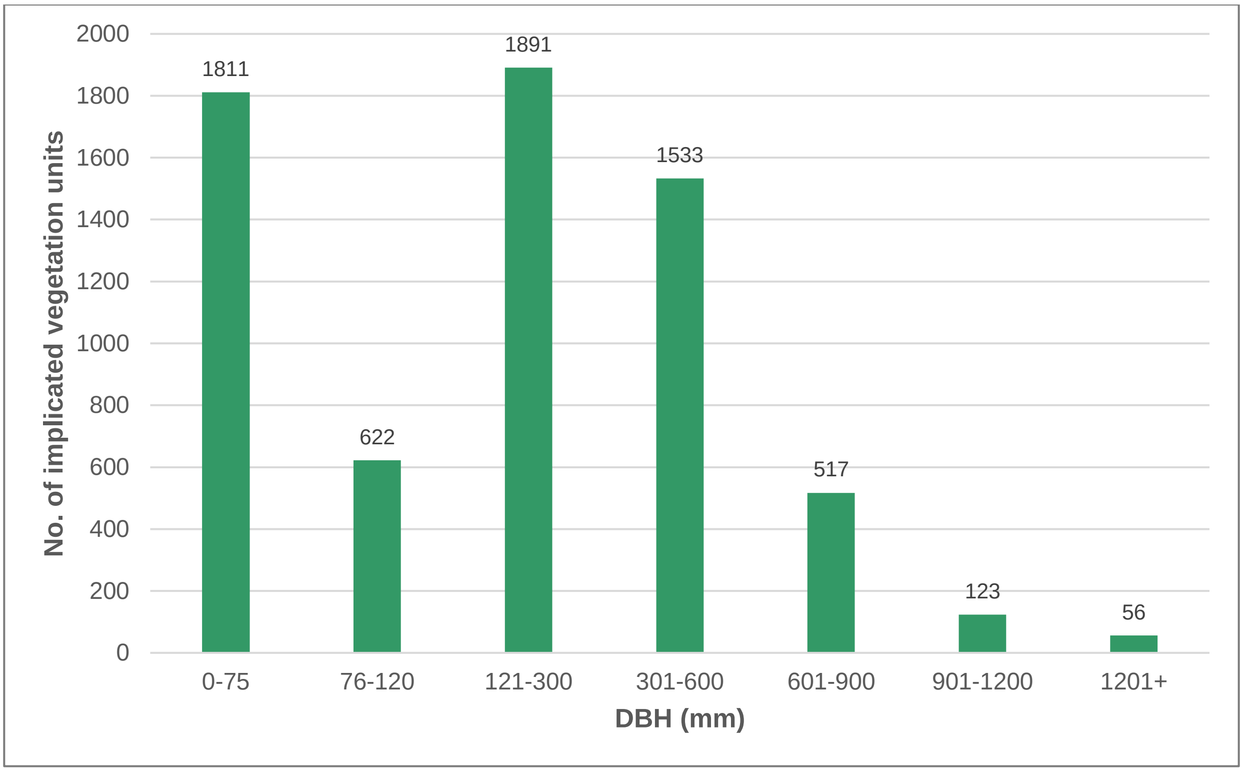

Figure 10 - DBH of implicated vegetation units, source: PRI

Figure 10 indicates that some 66% of vegetation units were at or below 300mm in diameter at breast height (DBH), and 89% were below 600mm. Only 11% were above 600mm, an interesting find in that in the public (and certainly in the local authority) imagination, subsidence cases are seen as involving primarily very large, fully mature and major landscape feature trees. There is no evidence to support this hypothesis, and the bulk of vegetation units causing subsidence are of modest diameter, especially during an *Alpha* year of subsidence claims. It is possible that during dry years where claims are relatively low, implicated trees are larger and closer to properties.

This data is supported by returned tree work prices for claims under remediation, which indicates that some 73% of cases had a total site contract value of £1,000 or under, and 85% of cases had a value of £1,500 or under.

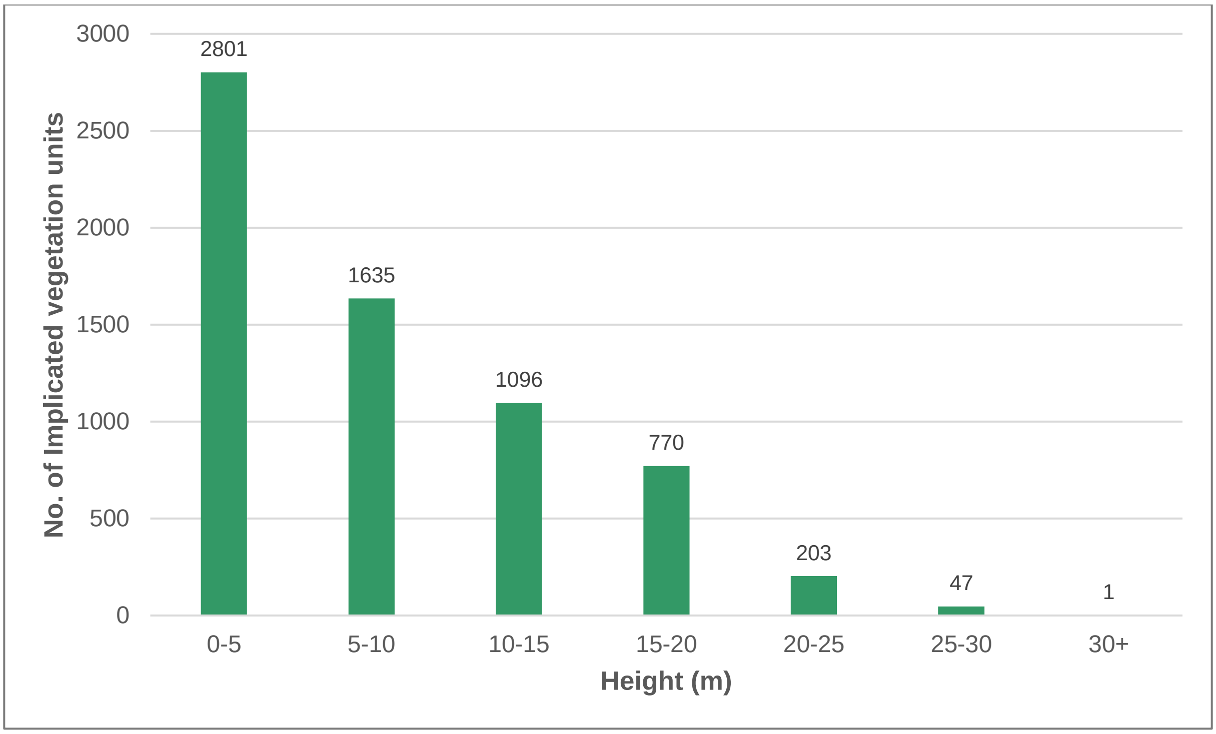

Figure 11 - Height (m) implicated vegetation units, source: PRI

From Figure 11, some 68% of vegetation units were at or below 10m in height and 84% were below 15m in height. Only 4% were above 20m, again interesting in that in the public (and certainly in the local authority) imagination, subsidence cases are seen as involving primarily very large, fully mature and major landscape feature trees. As with the above, there is no evidence to support this hypothesis, and the bulk of vegetation units causing subsidence are of modest size.

This perhaps suggests why so few of the implicated trees were subject to statutory controls, as few of the trees would be considered prominent in a visual amenity sense from a local authority perspective.

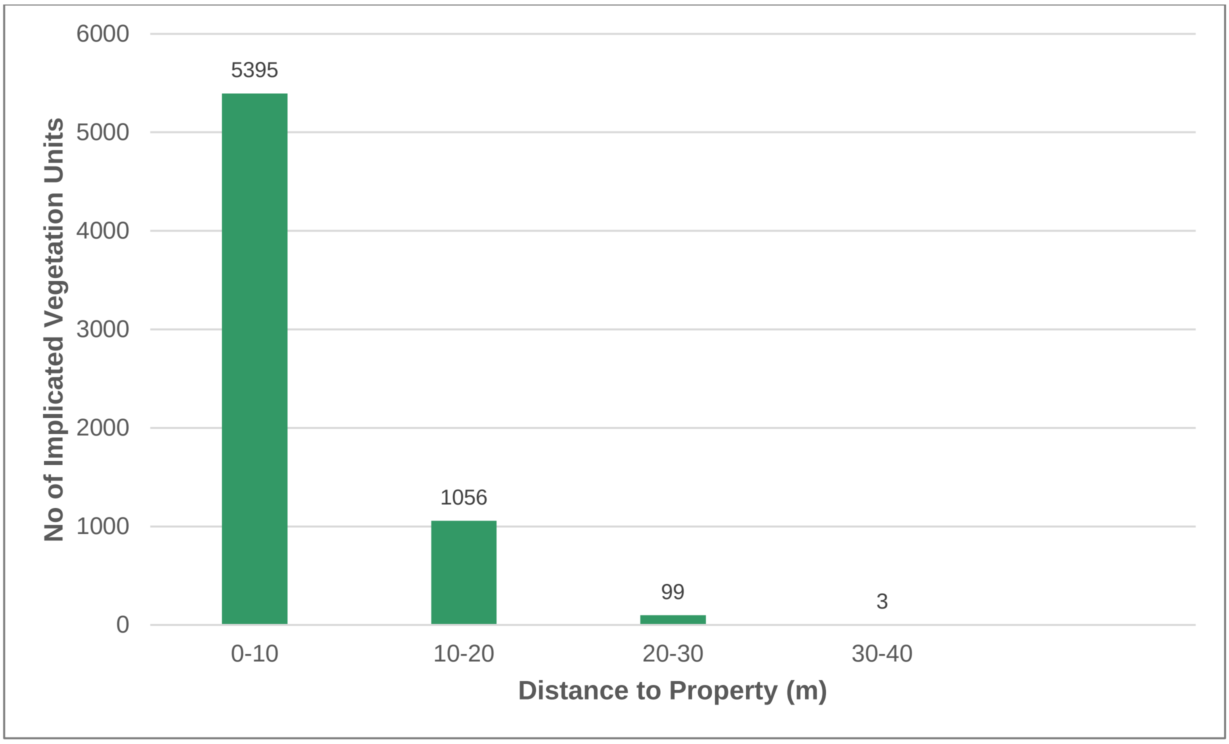

Figure 12 - Distance (m) of implicated vegetation units, source: PRI

From Figure 12, the vast majority of vegetation units implicated (82%) were within 10m of the property, and 98% of implicated vegetation units were within 20m. This finding perhaps again explains why so few statutorily controlled trees appear in the data, being as they are primarily confined within private residential gardens. This again indicates that local government concerns that subsidence is a major threat to the public amenity are misplaced.

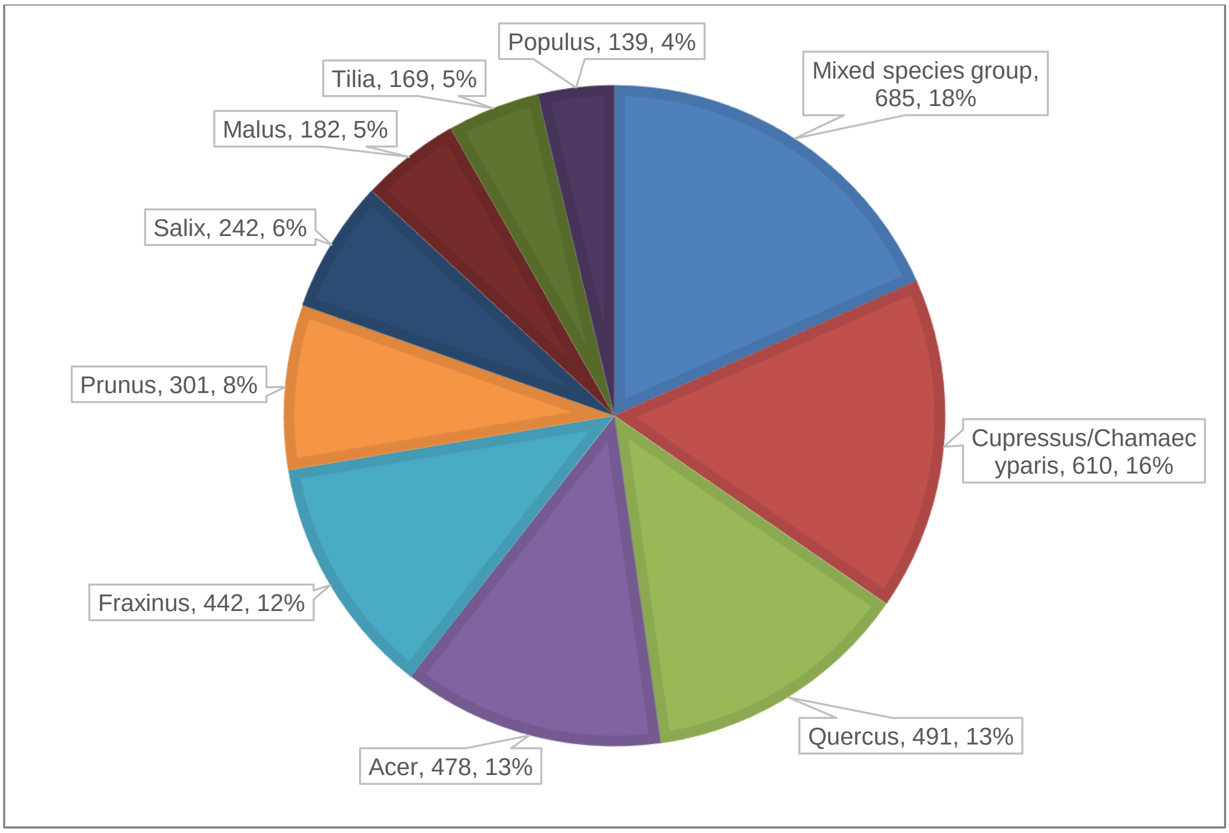

Figure 131 - Most common genera of implicated vegetation units, source: PRI

A key finding of significance from Figure 13 is that Cypress species was the most frequently implicated type of vegetation unit in the data (precluding generic categories such as “mixed species group”), representing almost 16% of all implicated vegetation units. This reflects the continued use of this very fast-growing species in “quick fit” boundary hedging alignment.

Oak (genus Quercus) and Ash (genus Fraxinus) also being prominently represented (combined making up 25% of all vegetation units implicated) reflects the significance of these important species, very often in remnant plantations as part of housing schemes over the last 50 years. Cypress, Oak and Ash together represent almost half of all implicated vegetation units.

It will be interesting to see if Ash maintains its status as a major contributor to subsidence claims in the presence of Ash Chalara disease.

The data will now be utilised to assess the land use coverage by vegetation type and further will be statistically modelled with the support of the Airbus Intelligence Group to look at wider trends and applications within the data.

This data will be of interest to insurance claims managers, to loss adjusters, engineers, arboriculturists, planners, architects and others planning management of trees in urban areas. The data indicates geographical concentrations, distance to damage data, species contributing, land controls, land ownerships and age classes which will prove invaluable to others researching in this area. PRI continues to collect this type of data through a bespoke application for onsite field surveying.

The 2018 initiating event is also within the planning horizon for climate change modelling and will be of interest to those wishing to model increasing or decreasing impacts from subsidence of low-rise buildings based on the current key climate change assumptions.

Conclusion

It is hoped that this introductory paper may allow forward planners to better understand the potential for changes occurring to the “state” of soils, such that decision making can be informed and effective. The dry phase clearly has affected approximately 4 of every 10 years since the 1970s. Although the traditional paradigm is to locate events by the initiating event year (i.e. 1976, 1995, 1991, 2003, 2018), we would suggest that this approach is simplistic and that it would be better to analyse dry periods as a continuum beginning with the *Alpha* Event. Given climate change modelling scenarios, this will be an even more important issue over future decades, and we begin from the starting point that letterbox level data will prove invaluable for researchers and decision makers.

Clearly, the ability of insurers to overlay this model against claims experience, particularly with access to the statistical data available to the authors covering thousands of tree-related subsidence cases, would prove invaluable to strengthen the model's scientific base.

Interestingly from the completed analysis, the popular image of subsidence cases involving very large, publicly significant amenity trees is not reflected in the data from the 2018 *Alpha* year but may be more prevalent during dry years of low claim numbers. Equally, there are issues that require investigation associated with any extension of an event beyond the *Gamma* year and the impact on soils and tree strategies and survival in any extended event of that severity, particularly given climate change modelling.

We would hypothesise that the current wider climate models, predicting as they do overall elevated temperatures against a background of sudden sharp changes in the "state" of the weather over increasingly short periods, will only potentially exaggerate the magnitude and duration of the *Alpha* – *Gamma* phase state. It is the authors' contention that the overall model is robust and capable of testing and further refinement.

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