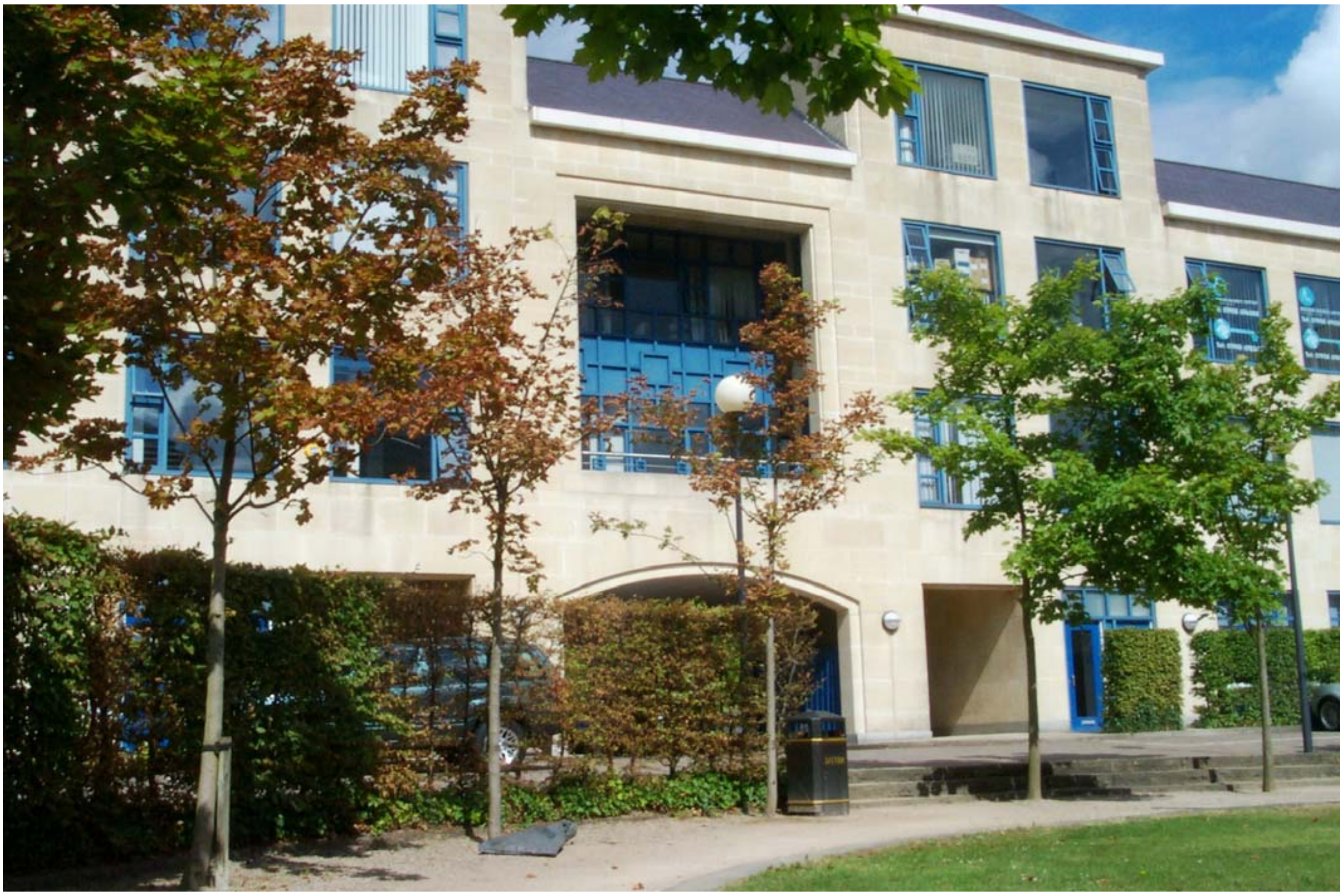
De-icing salt damage to trees



De-icing Salt Damage

Introduction

Rock salt, sodium chloride (NaCl), has been used in increasing quantities since the Second World War for de-icing roads and paths. Unfortunately, these continuing annual applications of salt can have major detrimental effects on the environment, affecting water-courses, plants and especially trees. Following hard winters, large quantities of salt are used and the resulting damage to trees can be considerable. In 1971 it was estimated that de-icing salt was directly responsible for the deaths of over 700 000 trees annually in Western Europe (Flückiger & Braun, 1981), and more salt is used to de-ice thoroughfares in Britain than in any other European country. In the past, during severe winters in Britain (such as in 1979–80 and 1981-82), the total application of salt per square metre of roadway could easily exceed 5 kg. Since then, improvements in the calibration of equipment and better predictions of icy conditions have dramatically reduced the amount of salt used. But the risk of high rates still exists from repeated applications and from hand spreading.

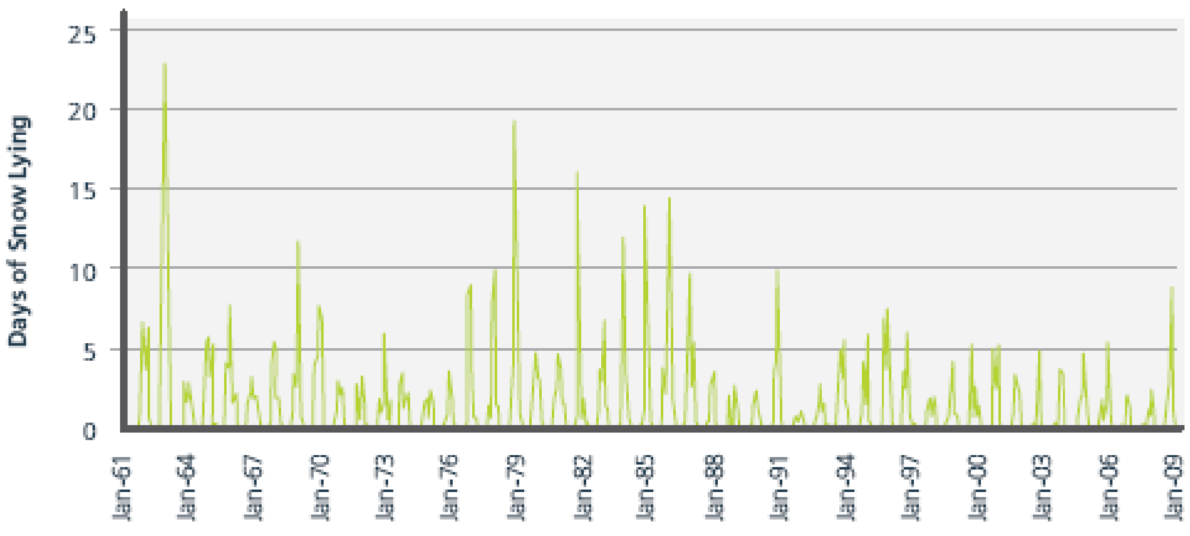


Figure 1. UK snowfall since 1961 (provided by UKRLG, 2009)

Figure 1 shows that since the winter of 1990/91 annual snow fall reduced consistently. This played a part in reducing salt use as well as the improvements in the techniques of salt spreading. It also led to a reduction in the size of salt stocks held at the various depots throughout the country. However, recent severe winters have seen a dramatic rise in the use of de-icing salt such that stocks began to run low. Use on roads had to be reduced by 25% in order to conserve stocks and ensure that major roads were kept clear. The reduction was necessary in both 2008/09 and 2009/10 as the snow and frost periods were much longer than in recent years. The winter of 2008/9 was the snowiest since 1991 and 2009/10 was the snowiest since 1978/9; 2010/11 acknowledged as the coldest for 31 years with winter snows starting very early in November.

Symptoms on deciduous trees

Salt damage can occur either through salt-contaminated soil or through salt spray. The symptoms which result can affect entire trees, or may just be confined to individual branches.

Soil salt

Damage from salt-contaminated soil occurs most frequently in urban areas where large amounts of salt are used for de-icing roads and pavements. Trees close to roads can be directly exposed to splash, runoff and ploughed snow which can contain considerable quantities of salt. This salt is taken up by the roots and subsequently transported to the shoots.

In deciduous tree species the chloride from the salt tends to accumulate in dormant twigs and buds, with concentrations peaking just prior to budburst (Hall *et al*., 1972; Lumis *et al.*, 1976). Depending on the sensitivity of a particular species and the concentration of accumulated Cl^-, often the first visible result in spring is the failure of the buds to open and so entire branches are devoid of leaves (Hofstra *et al*., 1979). Alternatively the buds may open but the developing leaves then wither and die, a process known as 'post flushing dieback' (Gibbs & Burdekin, 1983). Typically, these dead leaves then remain attached to the shoot (Figure 1).

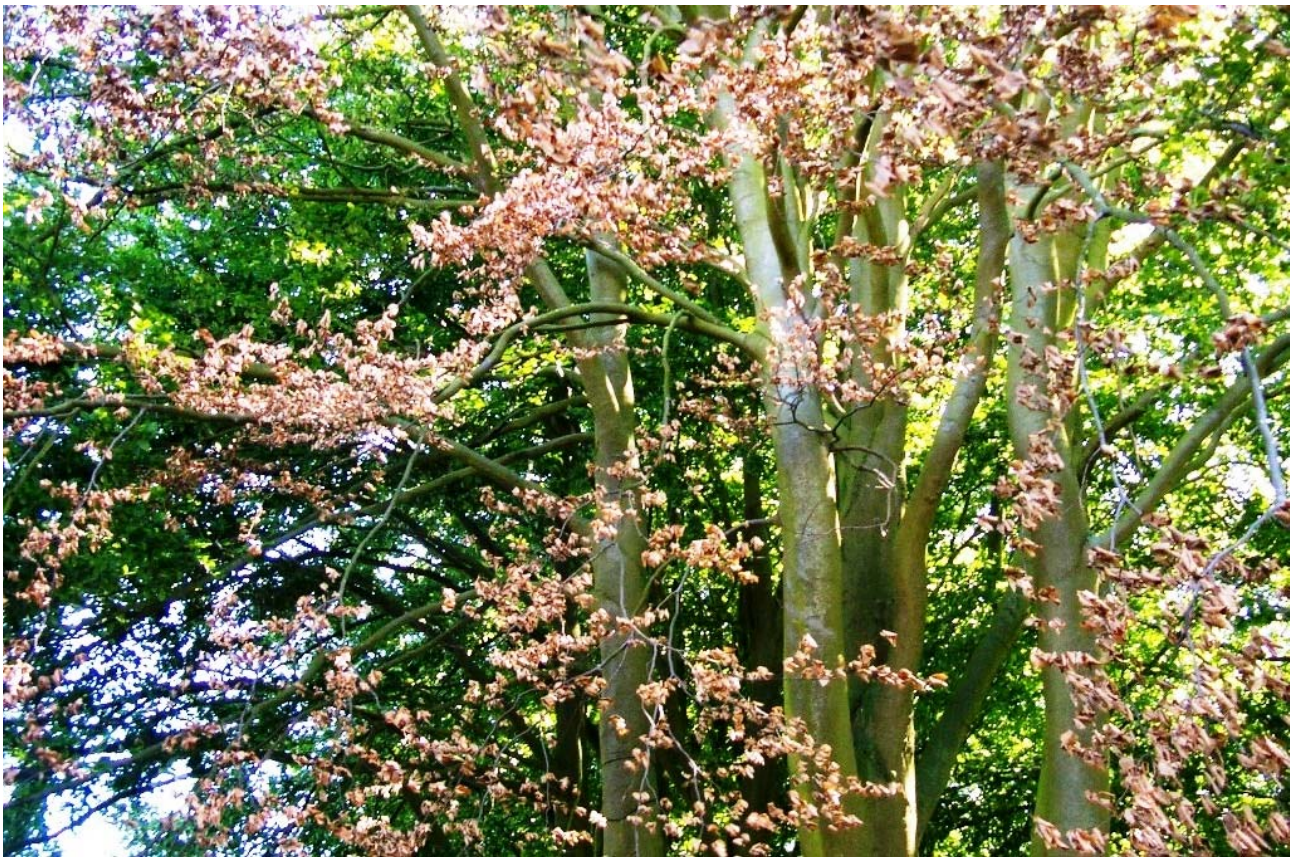


Figure 1. Dead, partially flushed leaves of beech still present in July

When buds die before or shortly after flushing, leafing-out may occur later in the season from dormant or adventitious buds and may give branches a ‘tufted’ appearance. Alternatively, if the salt damage is less severe, the buds may flush up to 3–4 weeks late but the leaves can remain small for the rest of the growing season.

Symptoms of salt damage may also develop on apparently healthy branches or trees where initially foliage developed normally. However, leaves may begin to show marginal browning and necrosis from June onwards and then wrinkle and curl. The necrosis then extends into the inter-veinal tissue so by August trees can have an autumnal appearance with premature leaf fall by the end of September (Figure 2a).

With very severe salt damage, crown dieback including leaf, shoot and limb death is not unusual. This may occur very quickly over a few months and lead to the death of whole trees (the latter is especially common on young and newly planted trees), or it may involve a more gradual decline.

Figure 2. Symptoms of salt damage: (a) Fully developed leaves of London plane with marginal and inter-veinal necrosis as a result of salt contaminated soil; (b) Tip-burn of needles of Monterey pine caused by salt spray

Salt spray

Trees can also sustain damage from salt spray, most noticeably along motorways and trunk roads with fast moving traffic. Dormant twigs intercept the salt which may then reach living tissue by entering via leaf scars (Sucoff, 1975). This results in the death of buds and may cause dieback of the previous years twig growth. Due to the death of apical buds, lateral buds on wood more than one year old may be released leading a ‘witches broom’ appearance. However, in contrast to damage from salt in the soil, marginal necrosis of leaves rarely occurs. It is also rare for salt spray to cause the outright death of trees, but annually recurring damage tends to keep crowns narrow and stems thin.

Symptoms on evergreen trees

Symptoms associated with soil-salt toxicity are generally similar to those from salt spray. One indication of soil salt damage rather than salt spray damage is the failure of buds to flush and the browning of needles in the summer that they emerge (Sury & Flückiger, 1983). Another indicator of damage from salt in the soil is when needles in the upper crown show proportionately greater damage than those lower down.

Damage from salt spray first becomes apparent on one-year-old needles as 'tipburn' (Spotts *et al.*, 1972). The tips of the needles first turn yellow, then bronze and subsequently become brown and necrotic (Figure 2a). There is generally a clear demarcation between the basal green and the terminal brown tissue. Through spring and summer the necrosis progresses towards the base of the needle. Buds of pines are rarely affected by salt spray and flush normally in the spring with new needles remaining green and healthy throughout their first year.

Practical diagnosis of salt damage

Some of the symptoms described above can be caused by stresses other than salt. For example, marginal necrosis of leaves can also be due to drought, or desiccation by strong winds. Therefore a thorough evaluation of the symptoms and consideration of all the environmental conditions at a particular site is needed before de-icing salt can be singled out as the cause of damage. Location of the injured tree and distribution of damage within a tree are valuable guides when assessing the possible contribution of salt to damage of roadside trees. Tree species also vary considerably in susceptibility to salt damage (Figure 3) and the appendix lists the relative susceptibility of most common tree species.

Figure 3. Tolerance to salt - shoots of *Pinus nigra* (tolerant) and *Pinus contorta* (intermediate)

The following are general injury patterns that have been identified and may apply equally to salted paths and pavements as to roads (see also Dobson (1991) for more details).

- Trees close to roads are generally the worst affected. Damage is most severe within 5 m of the road but there is frequently a distinct injury gradient with distance; damage becoming minimal at about 30 m from the road. Keep in mind however, that where roots penetrate drains carrying salty runoff damage may occur at a considerable distance from roads.
- Trees on the downhill side of a road suffer more damage than those on the uphill side.
- Trees planted in depressions or with depressions around their base (e.g. where planting soil has settled) suffer more damage than trees in raised planting sites.

On high-speed roads (e.g. motorways), where salt spray rather than runoff is the major cause of injury, the following distribution of damage can be seen.

- Trees on the downwind side of the carriageway show greatest injury.
- Injury is greatest on the side of the tree facing the road.
- Trees sheltered from spray, e.g. by fencing between trees and road, lack injury symptoms.
- Injury is greatest on the lowest branches. Branches above the spray-drift zone are not injured or are less injured.
- Flowers may only come out on the side of the tree facing away from the road. This is because flower buds are more sensitive to salt spray than leaf buds.
- Where deep snow lies for significant periods of time (which rarely occurs in most parts of Britain), injury does not occur beneath the snow line.

Where foliage is showing signs of salt damage, analysis of chloride levels within the foliage can confirm that salt was involved. Gloves should be worn when collecting samples for analysis to avoid any contamination of the sample by salt present in sweat on the skin surface.

Conclusions

Considerable progress has been made in the recognition of salt damage symptoms since the first investigations in the 1950s so that general patterns of injury are now fairly well understood. There is also a substantial body of data in the literature concerning the concentrations of sodium and chloride associated with foliar injury.

Over the years salt usage has reduced as it is now stored and spread more efficiently. The lack of de-icing salt damage to trees after the 2008/9 winter was notable as this was the snowiest winter for 18 years. Likely reasons for this are that the quantity of salt used was much lower than in previous bad winters and also the spreading techniques have been vastly improved. However with prolonged periods of snow and ice, as have been experienced in the recent winter of 2009/10, there is still a possibility that salt can accumulate in the soil to levels that might cause severe injury to trees. Apart from this, the main risk of salt injury exists in areas where salt has to be spread by hand. In these, and other sensitive areas, the use of alternative de-icing materials such as urea and CMA (calcium magnesium acetate) has been used to great effect to prevent damage to trees.

D. Rose and J. Webber
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This Note was adapted from Forestry Commission Bulletin 101: De-icing Salt Damage to Trees and Shrubs by M C Dobson

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Appendix: Tolerance to soil salt of common tree species

Tolerance	**Species**
Tolerant	*Alnus glutinosa*
Tolerant	*Elaeagnus angustifolia*
Tolerant	*Gleditsia triacanthos*
Tolerant	*Pinus nigra* (all varieties/subspecies)
Tolerant	*Picea pungens*
Tolerant	*Quercus robur*
Tolerant	*Robinia pseudoacacia*
Tolerant	*Salix alba*
Tolerant	*Ulmus glabra*
Intermediate	*Acer campestris*
Intermediate	*Alnus incana*
Intermediate	*Crataegus monogyna*
Intermediate	*Carpinus betulus*
Intermediate	*Fagus sylvatica*
Intermediate	*Fraxinus excelsior*
Intermediate	*Picea abies*
Intermediate	*Pinus contorta*
Intermediate	*Pseudotsuga menziesii*
Intermediate	*Sorbus aucuparia*
Intermediate	*Thuja occidentalis*
Sensitive	*Acer pseudoplatanus*
Sensitive	*Aesculus* species
Sensitive	*Betula pubescens*
Sensitive	*Cornus* species
Sensitive	*Corylus* species
Sensitive	*Larix decidua*
Sensitive	*Platanus* x *hispanica*
Sensitive	*Prunus avium*
Sensitive	*Tilia cordata*
Sensitive	*Tilia platyphyllos*

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