A Comparative Study of Wind Damage to the Leaves of Ash (*Fraxinus excelsior* L.) and Sycamore (*Acer pseudoplantanus* L.)

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SUMMARY

Wind damage to the leaves of Ash (*Fraxinus excelsior* L.) and Sycamore (*Acer pseudoplantanus* L.) was assessed on 15 trees of each species growing together at the same site, about 5 km from the coast in Co. Londonderry, at the end of the growing season in september, 1986.

99·2% of all leaves of Sycamore and 88·8% of all leaves of Ash showed some degree of wind damage. The mean area of damage for all the sycamore leaves was 2·41% whilst that for Ash was significantly lower at 1·38%. The damage to Sycamore leaves consisted of a combination of discoloured areas, lesions, tears and actual loss of lamina area whilst damage to the Ash leaves was largely confined to the leaflet tips which were either dead or missing. It is suggested that in the case of Ash the damage was the result of excessive drying-out of the leaflet tips whilst for Sycamore the damage seemed to be the result of abrasion with adjacent leaves and twigs.

Regression analysis established that there was a positive relationship between percentage damage and leaf area in Sycamore but the relationship for Ash was not significant.

INTRODUCTION

Both Ash (*Fraxinus excelsior* L.) and Sycamore (*Acer pseudoplantanus* L.) are extensively planted around farmsteads etc. in the north of Ireland. Mitchell (1982) described Sycamore as being able to stand up to the most severely exposed conditions of coastal areas better than any native tree species and this point was reiterated in Edlin (1968) who noted that Sycamore is wind-firm and is capable of withstanding the very worst exposure either inland or near the sea. Caborn (1965) has also described Sycamore as an important, dependable and outstanding shelter tree. Much of the usefulness of Sycamore as a shelter species derives from its well-formed canopy and dense foliage. However, the costs to the tree are also high and extensive wind pruning leading to canopy deformation is a common feature of Sycamore growing in coastal or otherwise windy areas. Under such conditions Sycamore still manages to attain a reasonable height and to maintain a dense though distorted canopy and it is this ability which makes Sycamore such a useful tree. Wilson (1980, 1984) and Rushton and Toner (1988) have shown that as well as these more obvious features of wind damage on Sycamore, individual leaves themselves may sustain extensive damage due to abrasion with other leaves or twigs.

Opinion regarding the usefulness of Ash as a shelter species is rather more mixed. Edlin (1968) concluded that Ash was a poor shelterbelt tree though he did point out that it is very hardy and may survive in hilly areas. Mitchell (1982) emphasised this point and noted that it grows well when exposed to sea winds. Caborn (1965) regarded Ash as a wind resistant tree only if it was on good sites and that in coastal areas it may do well but that it is affected by sea winds.

A limited study of two Sycamore trees by Wilson (1980) indicated that damage to individual leaves by wind could be extensive and that few leaves actually escaped damage completely. Rushton and Toner (1988) were able to demonstrate, for a much wider sample of 75 trees covering five sites with differing degrees of exposure, that the levels of leaf damage caused by wind were related to general site exposure. The present paper reports a comparative investigation of the levels of wind damage to the leaves of both Ash and Sycamore trees growing at one site in Northern Ireland.

The Site (Grid reference C841345)

Although both Ash and Sycamore are relatively common trees in the north of Ireland (Webb 1977), sites which contain more or less equal numbers of mature specimens of the two species are difficult to find. The site chosen for study was an area of open land to the north-west of the main campus of the University of Ulster at Coleraine (Fig 1A). The general campus site is relatively flat and about 20m above sea level. To the north and north-west, there is little shelter afforded to the campus and to the south runs the valley of the River Bann. The site is about 5 km from the coast and it is conceivable that because of the lie of the land some winds, particularly from the north-west coming down the Bann

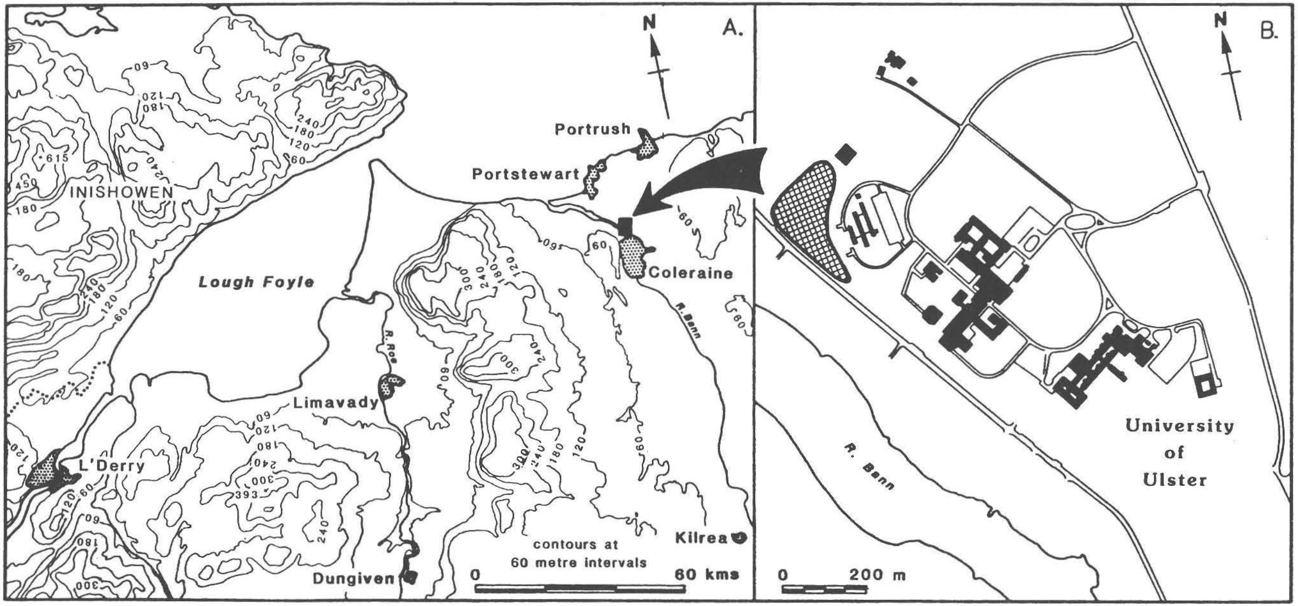

Figure 1 Location of the study site. A. General area showing main topographic features. B. Site location (hatched) in relationship to the main university buildings (black).

estuary, could carry salt. To the west and south-west, the land rises to over 300m whilst to the east, the nearest high ground is the Glens of Antrim, which rise generally to 400m and are about 30 km away. In between, the land is relatively flat and is generally less than 100m high.

The sampled trees lie on an area which gently slopes down to the River Bann (Fig 1B). The nearest buildings of any major size are at least 100m away to the east and the very large campus buildings are about 400m away. Consequently, most winds approaching the site are likely to be laminar, and turbulence due to buildings or other obstructions is likely to be low. Nevertheless, some of the more mature trees on the site do show evidence of wind pruning (assessed by general canopy asymmetry) as do many others on the rest of the university campus. In these cases, the general direction of pruning would appear to correlate with winds from the west and north-west.

Sampling and Scoring

Trees were sampled in September, 1986. Fifteen trees of Ash and fifteen trees of Sycamore of comparable size were chosen at random. From each tree 25 leaves were removed from a height of about 6m; all aspects of the canopy were represented in the sample and effort was made to ensure equal representation of all canopy aspects. Due to the effects of wind pruning this was not always possible and some error may have been introduced at this stage. Small twigs were cut and, from these, the pair of lateral leaves at the terminal bud were removed and lightly pressed in newspaper in order that flat specimens were available for scoring. Scoring of damage was carried out within a few days of collection and before any deterioration of the leaves.

Wilson (1980, 1984) has described the patterns of damage on Sycamore leaves caused by wind. These include lesions, leaf distortion and lamina tearing which can, in extreme cases, lead to loss of lamina. Levels of damage was assessed by placing over each leaf a transparent grid ruled in 0·5cm squares. Total leaf area was estimated by counting grid squares. The total area of damage was estimated by counting the total number of squares showing more than 50% damage. This is likely to provide a slight underestimate of damage since very small areas (less than about 0·25cm x 0·5cm) would not be counted. However, most damage was greater in area than this and therefore the error is probably not serious. From the total leaf area and area of damage a value for percentage damage was calculated for each leaf. In cases where portions of the lamina had been lost the lamina outline

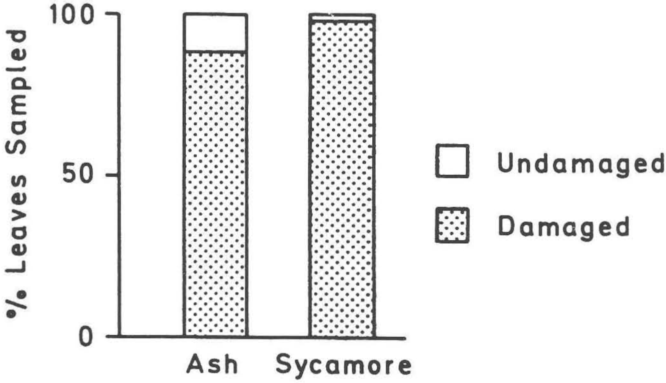

Figure 2 Percentage of leaves showing wind damage and percentage of undamaged leaves of Ash and Sycamore sampled in September, 1986.

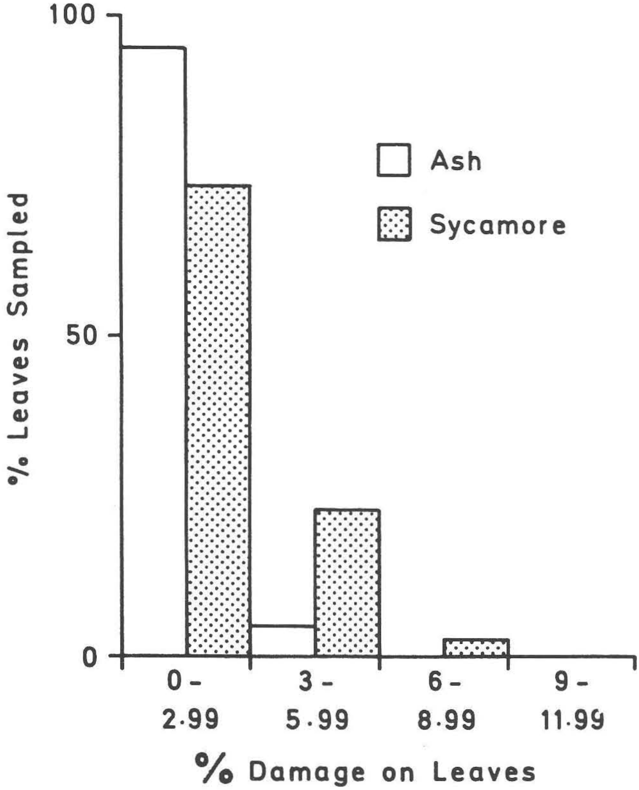

Figure 3 Percentage wind damage to leaves of Ash and Sycamore sampled in September, 1986.

was reconstructed from the remaining portions and an estimate for the damaged area derived. This procedure follows Wilson (1980). Whilst this constitutes another source of error, very few leaves were so badly damaged.

Whilst estimating damage, care was taken to exclude damage attributable to other sources, in particular front damage and grazing damage by insect larvae (see Rushton and Toner 1988). Despite the resistance of Sycamore leaves to low temperatures (-2·5°C) (Sakai and Larcher 1987), in some years very late air frosts might be sufficiently low to cause frost damage in the Coleraine area thought in most years, this would not be a problem. Since Ash leafs considerably later than Sycamore, frost is unlikely to cause any damage to Ash leaves.

Results

Fig 2 shows the percentage of damaged and undamaged leaves of Ash and Sycamore. Most leaves of Sycamore (99·2%) and a substantial number of leaves of Ash (88·8%) showed some signs of damage. In the case of Ash, damage was largely confined to the leaf tips which were either dead or missing. The damage to Sycamore leaves was more extensive across the whole lamina surface and consisted of discoloured areas, lesions, tears and loss of lamina area although arc-shaped tears seemed to be the most common.

Examination of the actual percentage damage levels on individual leaves (fig 3) indicated that not only were more leaves of Sycamore damaged compared with Ash, but that greater areas of damage were sustained per leaf. This difference proved to be significant (Table 1). The mean levels of percentage damage per tree re-inforced this conclusion: only one Ash tree had a mean percentage damage in excess of 2% whilst 10 out of the 15 Sycamore trees sampled had damage greater than 2%.

Regression analysis of percentage leaf damage on leaf area was carried out and is presented in Fig 4 and Table 2. The regression for Ash proved to be non-significant; that for Sycamore showed a positive significant relationship. The damage to leaves of Ash was remarkably constant (fig 4) regardless of leaf area which ranged from less than 100cm^2 to over 240cm^2. On the other hand the much smaller range of leaf areas of Sycamore, from 68cm^2 to 138cm^2, was accompanied by increases in leaf damage from 1·28% up to 3-4%. Regression analysis of percentage leaf damage on leaf area was also carried out on the results from individual trees. Where these proved significant, the trees have been individually identified in Fig 4. Five trees, three Sycamore

Table 1 Means, standard deviations and % coefficients of variation for percentage damage to leaves of Ash and Sycamore, and their analysis.

	Mean	Standard deviation	% coefficient of variation
Ash	1·38	0·94	67·9
Sycamore	2·41	1·52	63·2

Source of variation	Degrees of freedom	Sums of squares	Mean square	F-ratio	Probability
Between species	1	196·8	196·8	61·3	0·001
Within species	373	1196·9	3·2		
Total	374	1393·7			

(Data were transformed using the arc-sine transformation prior to analysis (Sokal and Rohlf, 1969).)

Table 2 Regression analysis of percentage leaf damage on leaf area for Ash and Sycamore.

	Explained sums of squares	Unexplained sums of squares	F-ratio		Regression equation a	b
Ash	0·1547	2·8342	1·41	NS		
Sycamore	4·7073	5·1986	11·77	**	-1·2470	0·0078

NS=non significant; **, p=0·01-0·001.

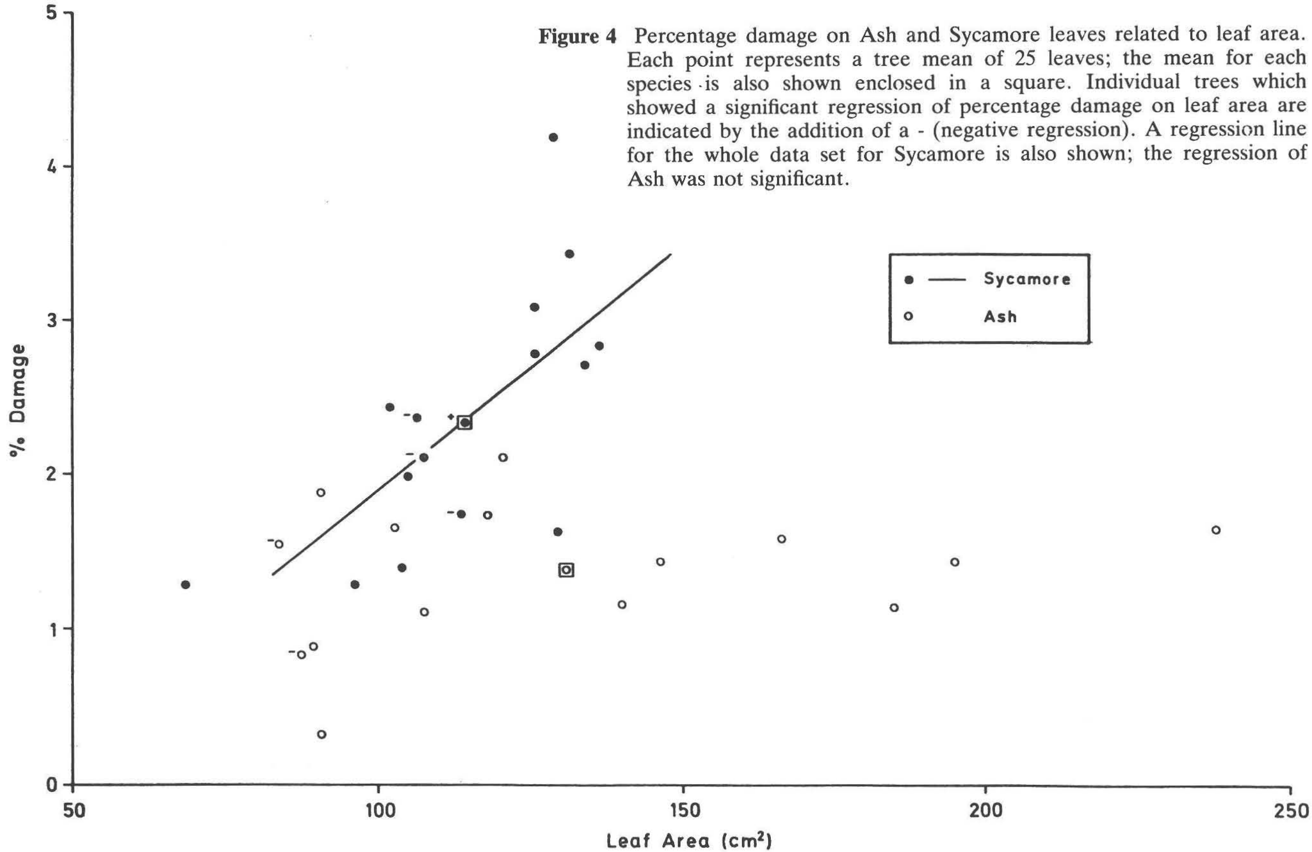

Figure 4 Percentage damage on Ash and Sycamore leaves related to leaf area. Each point represents a tree mean of 25 leaves; the mean for each species is also shown enclosed in a square. Individual trees which showed a significant regression of percentage damage on leaf area are indicated by the addition of a - (negative regression). A regression line for the whole data set for Sycamore is also shown; the regression of Ash was not significant.

and two Ash showed significant relationships and in all cases, the relationships were negative. In the case of the two Ash trees, these also had the smallest leaf areas (Fig 4).

Discussion

The general levels of damage on the leaves of Sycamore are more or less in agreement with those observed by the present authors when recording damage at a number of sites along the north coast (Rushton and Toner 1988). In that survey, five populations were studied and the mean percentage damage for the populations were 1·30%, 1·68%, 3·59%, 4·12% and 4·65% for leaves sampled in September, 1986. The two populations with the lowest percentage damage were well-sheltered, whilst the other three sites were more exposed and, in the case of the population showing the highest damage levels, the site was probably subjected to considerable turbulence. The level of damage recorded here for Sycamore (2·41%) lies between the sheltered and exposed values recorded previously.

The very different levels of damage sustained by Ash and Sycamore could have a number of explanations. It would be tempting to argue that the differences between the species are related to leaf morphology and that the broader, more entire leaf form of Sycamore was more susceptible to wind damage than the well-separated, small leaflets of Ash and this is almost certain to be the case for damage sustained during the main part of the growing season once the leaves have unfolded and hardened. However, it is felt that a more likely explanation for the differences probably lies in phenological differences between the two species.

Rushton and Toner (1988) and Wilson (1980) have recorded leaf expansion beginning in late April/early May for Sycamore and Wilson (1980) observed that nearly all leaves sustained damage during the 2-3 weeks following bud-break and that by the end of May, most damage had already occurred to Sycamore leaves. Similarly, Rushton and Toner (1988) showed that there was little increase in damage to Sycamore leaves between samples taken in June and September indicating that most wind damage to leaves occurs early in the growing season when the leaves are expanding and not sufficiently hardened to resist the buffeting against adjacent leaves and twigs brought about by gusting. In contrast, Ash leafs much later and the leaves would not generally be expressed from the buds before early May (Mitchell 1979). Along the north coast of Ireland and at the site studied here, Ash leafs even later than this and it would be mid- to late-May before leafing takes place. This Ash would appear to avoid the damaging spring winds that cause significant damage to the leaves of Sycamore.

The damage to Sycamore leaves is undoubtedly due, for the most part, to abrasion of the lamina surface with adjacent leaves and twigs. In the case of Ash, the localisation of damage to the leaflet tips suggests that the damage here may be a more indirect effect of increased transpiration during windy conditions which results in excessive and lethal water loss in those areas furthest from the water supply i.e. the leaflet tips. Thus although the damage to Ash leaves had the general appearance of physical damage, it is felt that the death of leaflet tips is more likely due to lack of water.

The results presented in Fig 4 confirm the previous work by the current authors. They were able to show (Rushton and Toner 1988) that in sites which were probably exposed and subject to turbulence, there was a negative relationship between percentage damage and leaf area – it was suggested that this was because excessive damage early in leaf expansion prevents leaves expanding to their full extent (see Parkhurst 1972). At less exposed sites there was either no clearly established relationship or the relationship was positive. It was suggested in this latter case that the levels of damage were insufficient to inhibit leaf expansion and the leaves expanded to full size. This would appear to be the case with Sycamore leaves at the site studied here.

It should however be noted (Fig 4) that three of the eight smaller-leaved Sycamore trees (i.e. trees with mean leaf areas less than 114cm^2, the population mean) had significant negative relationships between percentage leaf damage and leaf area and that of the remaining five smaller-leaved trees, four showed a negative relationship although these were non-significant. Conversely, of the seven large-leaved Sycamore trees (with mean leaf areas in excess of 114cm^2) only two showed negative relationships although again these were non-significant. Thus inhibition of leaf expansion by wind damage is also demonstrated by these data even though the general population trend for Sycamore is positive.

The relationship between percentage damage and leaf area was overall non-significant for Ash though the two trees with the smallest leaf areas did show a significant negative relationship.

It would appear therefore that one of the reasons why Ash may survive in windy areas and in particular in upland sites is that the leaves are produced so late in spring that they escape most of the windier conditions in late winter and early spring and the leaves are thus comparatively free of wind damage. Sycamore, on the other hand, leafs much earlier and therefore suffers much higher wind damage levels. This may of course be compensated for by the longer growing season that Sycamore experiences through earlier leafing but the actual effects of wind damage to leaves on the growth rates of Sycamore trees remains unknown.

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