

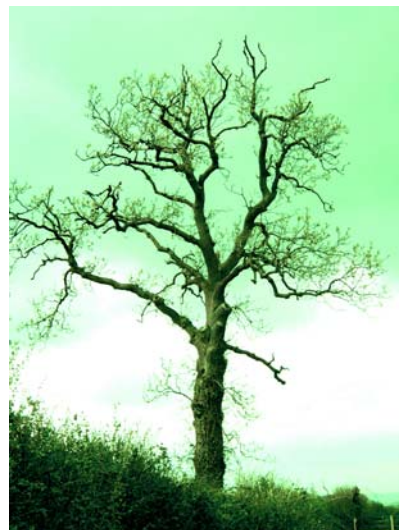
At Treework Environmental Practice we have surveyed many thousand ancient trees. Most surveys that we carry out are required to record the range of habitat (veteran) features present in old trees, and to undertake assessments of tree viability and population dynamics. We have used the Specialist Survey Method (SSM), which was developed for English Nature (Fay & de Berker 1996) and have recently expanded this system to be able to analyse populations of veteran/ancient trees for a range of purposes. Level 3 of the SSM identifies eleven principal dead wood (saproxylic) features required for recording. One such field refers to 'Tears, scars & lightning strikes, as a particular habitat type. While, stag-heading as such is not recorded in the SSM, a range of survey fields in combination covers this feature. These are 'Live Growth' (Partial or residual canopy); 'Crown Loss' (Partial outline) and 'Dead wood attached to the tree' (counted in units of 1mx0.15m).

In one survey of some 840 oaks at Richmond Park, population analysis showed that approx. 13% of the population had been struck by lightning at some point in their lives, with 11% of lapsed pollards and 16% of maiden veterans showing incidence of lightning scars. Interestingly, many lightning strikes appeared to be associated with watercourses. While, many trees that show evidence of lightning strikes also show a stag-headed tendency, there are many other stag-headed ancient trees without any obvious signs of being struck by lightning.

The problem in linking lightning strikes to stag headed appearance is that the presence of dead wood in the crown is also a feature of the natural ageing process in healthy trees. As crown dieback occurs naturally in the ageing process it is used, diagnostically, to recognise the stage immediately beyond full maturity when there is a re-distribution of growth regulating hormones. This corresponds with the loss of apical dominance in the crown and is a natural response to the precursor stage, when the fully developed crown has extended beyond the capacity of the root system to resource further peripheral extension. This natural process of crown dieback is also termed 'crown retrenchment'. Following dieback, increased light penetrates the lower regions of the crown resulting in rejuvenated growth in these areas. The first naturally occurring retrenchment phase (termed 'Early ancient') marks the beginning of the ancient stage of the ageing process.



Ash tree with trunk lightning scar (Somerset).



Ash tree showing lightning induced retrenchment (Somerset).

However, when crown retrenchment is artificially induced through organic (biotic) or inorganic/physical (abiotic) causes, this usually reflects circumstances where the tree has been placed under stress. This then may be considered as accelerated or precocious ageing and is often described as 'veteranisation'. Circumstances where trees present precocious ageing symptoms as a result of stresses derived from impairment of root or vascular function, are often confused with natural ageing in trees. Appropriate arboricultural experience and knowledge of growth conditions are necessary to carry out a reliable ageing diagnosis.

Crown die back may appear sporadic and random or may be localised on one aspect of the crown. Dieback may show varying degrees of intensity or extensiveness, affecting in extreme cases both lower and higher order branches. Dieback may occur over short or protracted periods of time. Therefore grades of dieback may reflect traumatic events followed by recovery (seen as accelerated veteranisation) or may reflect the natural ageing process of the tree species.

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**Lightning strike showing multiple branching.**  
(Photo ©australiasevereweather.com 1993)



**Lightning discharge from cloud to ground.**  
(Photo ©All You Need To Know About Lightning.com)

A stag headed condition arising from the natural ageing would typically show the presence of 3<sup>rd</sup> or 4<sup>th</sup> order dead limbs in old trees evenly spread above a live healthy partial crown. Often the current live crown outline extends to at least 50% (and typically 75% or more) of the likely former peak crown outline. This has usually become apparent some time after retrenchment has occurred.

The sporadic and uneven presence of dieback or the presence of rapid death of 4<sup>th</sup> or 5<sup>th</sup> order branching (up to twig level) is often a sign of vascular dysfunction, which may be attributable to a wide range of causes. These including diseases such as Dutch elm disease, sudden crown exposure, drought or water logging, soil compaction or root damage, ice damage, de-icing salt or other toxic effects.

Vascular dysfunction may also be caused by physical damage to roots, trunk or branches by for example ploughing, trenching and lightning strikes.

Therefore, lightning strikes are but one of many possible causes of dieback and eventual -stag-headed appearance in trees. The position is further complicated by the varied ways in which lightning affects trees. Effects may range from there being no visible sign of a strike, to total explosive tree destruction.



(Photo © All You Need To Know About Lightning.com)

This variety of response is not surprising as lightning is the result of complex environmental circumstances. The prelude to a strike involves events where the electronic potential within clouds exceeds the insulating properties of the air. The build up of negative charge at the bottom of the cloud is mirrored in a positively charged 'reflection' on the ground. Eventually, a negatively charged stroke descends down a path of least resistance (as a 'stepped cloud-leader'). When stepped leaders are within 50m of a positive charge a return stroke branches upwards from the source toward the cloud (as a ground streamer energy source). These two strokes generally meet at about 50m above the ground.

The upward stroke flows from tall structures (though positive charges may collect at ground level, on buildings, people, flagpoles, mountaintops and of course on trees) creating a channel for discharge for the return stroke. Up to this point as observers, while we may have been experiencing prickly heat and other strange sensations, these events are invisible to the naked eye. It is only after the charge connection is made that we are able to witness the visible return stroke (or strokes, for there may be many, which may be seen to follow a range diverse pathways from a single flash). The complex zigzag appearance of lightning corresponds to the many invisible stepped-leader, exploratory pathways that have descended from the cloud (Rose1990).





Turville Heath ancient small-leaved limes: 1990 storm

Units associated with these events refer to values such as 100 million volts (Harris et al 2003), 200 megawatts (Rose 1990) to describe the order of magnitude of return strokes. Quoted temperatures may range between 25,000 Fahrenheit for 'hot-bolts' (Pirone 1988) and 50,000 Fahrenheit at the core of a stroke (Coder 1996) with 'cold lightning' strike speeds at 20,000 miles per second (Pirone). Cloud leaders are claimed to travel to ground in excess of 400,000 mph with return strokes travelling at 30% of the speed of light (Coder 1996).

These measurements may not mean much in the abstract but the reality of the energy produced by these events may cause trees to burst into flames, sap to instantaneously and explosively boil and internal wood to explode.

Lightning may travel over-bark to the root system with minor adverse effects, discharge via the cambial zone (scoring out furrows, grooves and notches) or appear to travel erratically about the tree. The effects can range from negligible visible evidence to the throwing of crown parts distances of hundreds of metres. Some species, such as oak, ash and elm show high susceptibility to strikes, while others including beech and birch show low susceptibility. This is said to relate to whether the species have a tendency to starch or oil richness, respectively.

Other factors considered to affect susceptibility to damage include bark rugosity and topography, (and conversely bark smoothness), the presence of rain splashing or surface saturation available to direct and distribute the discharge about the bark surface to the ground; branch architecture and apical dominance; crown exposure within a group-canopy and in relation to surrounding structures, and the presence of water courses whether above or under ground.

When a strike causes bark stripping and scores out a groove (this may sometimes flow along a spiral grain path or even show damage along a route corresponding to the presence of dormant bud distribution), the tree may react by partially or completely occluding the wound site with callus growth. The timing of the strike will influence the effectiveness of this process. The impact will be far greater if the strike occurs during the growing season. The availability of carbohydrates for wound compartmenting and tissue growth will influence the capacity for trauma recovery in the tree.

The above is an outline of how the course of ageing includes the phenomenon of die back and the presence of aerial dead



Mawley oak (photograph by Roy Finch)

wood and involves inherent physiological processes that correspond to developmental stages in the tree. Such natural processes involve a dynamic between the tree and its environment. In some circumstances ageing may be accelerated by unsympathetic human practices or natural events. As these developmental stages progress, there is an increased diversity in the properties of wood within the structure of the tree and therefore of the range of habitats available to colonising organisms. The complexity and extensiveness of dead wood habitats are directly proportional to the level of biodiversity potentially offered by the tree. The agency of lightning strikes is a natural traumatic event that has the potential to influence the ageing process and the tree ecology.



When reflecting on the impact of lightning strikes on trees, it may be worth looking at some broader considerations. In the field of environmental arboriculture there is a growing attempt to understand the tree as a complex of organisms, that includes the tree itself and all the species that come to occupy it or live in its range, including other trees. This field of arboriculture, while in its infancy, is attempting to explore the possibilities of these interactions in terms of co-evolutionary relationships (Fay 2002). The lightning that affected the ancient trees at Richmond Park, it is particularly interesting because these trees are ancient oak pollards, i.e. they have survived these events. There are many sites now where we have begun to see that trees have the capacity not only for serial retrenchment over a considerable period of time through crown rejuvenation but also through stem or crown partial collapse followed by layering and rooting (and a range of other 'phoenix' strategies), old trees can display a potential for longevity that suggests a tendency to immortality. Therefore the notion of 'senescence' as a stage in the ageing process may be flawed, and if so may be an anthropogenic projection imposed on the tree. In the light of these concepts, the question then arises, whether lightning strikes (apart from cataclysmic damage) may have an evolutionary function.

It is worth considering that since midnight, to the present time of writing (1300 hours), a total of 1354 lightning strikes have occurred in the UK, according to Karlsruhe Weather Centre website, (though none of these are recorded to be strong strokes). Worldwide 100 strikes take place per second and a NASA website boasts 40 million strikes per year in the US alone. The energy from lightning strikes converts gaseous nitrogen and oxygen to be accessible in combination with water, thus able to fertilise the soil. Furthermore, according to recent research lightning bolts are thought to create conditions for gene transfer in bacteria in the soil by altering cell membrane permeability, thereby fundamentally influencing evolution at a microorganism level (Demenache et al. 2003),

Trees are nature's lightning rods and contain biological records of past events in their 'body language' and morphological characteristics. The presence of so many ancient trees with evidence of lightning strikes, whilst being a record of past events could also be a testimony to the evolutionary function of lightning strikes. If so could this 'relationship', for trees capable of surviving the trauma, have contributed to the property of longevity in individual trees and eventually in the species? Given such a possibility this interaction between trees and the phenomenon of lightning may have served to foster the complex relationships between trees and colonising species by transforming the tree into nature's version of Noah's ark capable of offering colonising species the means to voyage across the centuries.

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