How to Survey Individual Trees

Forest Research

Treezilla
The monster map of trees

The Open University

natural apptitude

Treework Environmental Practice

About this guide

This guide has been developed by The Open University, Forest Research, TreeWork Environmental Practice and Natural Apptitude as part of the COMMUNITREE project, funded by the Geospatial Commission, as a resource to support surveys of individual trees. This guide provides step-by-step instructions on how to measure all the elements of a tree that will be required for a survey using Treezilla. Surveying trees is a great way to get out and learn more about the nature around you. By following the methods outlined here, you can ensure that you record the right things and collect good quality data that will tell you most about your trees, and help us in our efforts to map, measure and monitor trees across the UK.

Why participate in a Treezilla survey?

As well as taking in carbon dioxide, urban trees provide a number of **important economic benefits** - or eco-benefits - to the more than 80% of the UK population that live in towns and cities. Trees take-up air pollution and reduce flood-risk by increasing the evaporation of rain before it reaches the ground and channeling of water into the soil instead of letting it flow over the surface. Trees also reduce the 'urban heat island' effect, making cities cooler in the heat. So, they can both help to address the causes of climate change and mitigate its effects. More than this, urban trees are vital parts of our natural and cultural heritage: think of the Plane trees that line the Mall in London or the Sycamore tree at Hadrian's Wall, one of the most photographed trees in the UK.

Trees also play an important role in supporting our mental as well as physical well-being. With all these benefits, you might think that urban trees are well documented, cared for and protected, but this couldn't be further from the truth. Despite recent commitments to planting and spending on maintenance, urban trees are very poorly monitored and it's not known whether the amount of urban tree canopy is increasing or decreasing. What is known is that the average lifespan of an urban tree is substantially less than its rural counterpart, and urban tree-felling in some places greatly exceeds the recommended rate and has resulted in public protests.

Insufficient urban tree data for monitoring reflects issues with land ownership - many trees are privately owned and therefore not routinely monitored - and inconsistent data collection methods used by tree officers employed by local authorities. Furthermore, many local authorities do not have comprehensive tree inventories and only a tiny fraction of the inventories

The Bosco Verticale, or Vertical Forest, in Milan. A building covered in trees and other plants developed to tackle air quality issues. Image: Bailey Parsons.

Urban trees are valuable both for their eco-benefits and the physical and mental wellbeing benefits they bring to urban communities.

that do exist are publicly available. In 2013 Treezilla (www. Treezilla.org) was created, a citizen science project that aims to map every tree in the UK and make the data publicly available, with the aim of being a one-stop-shop for urban tree data for use by the public, researchers, government and business. Participants are simply asked to record tree species, location and stem circumference in order to obtain estimates of a tree's eco-benefits and amenity value.

There are now 1 million tree records in the Treezilla database, making it one of the biggest collections of information on trees in the world. If you'd like to contribute to growing this important resource, then download the app from the Apple or Google Play app stores and start mapping.

Treezilla is used by everyone from citizen scientists through to professional surveyors for carrying out surveys of individual trees. Image **

Be Safe, Be Responsible

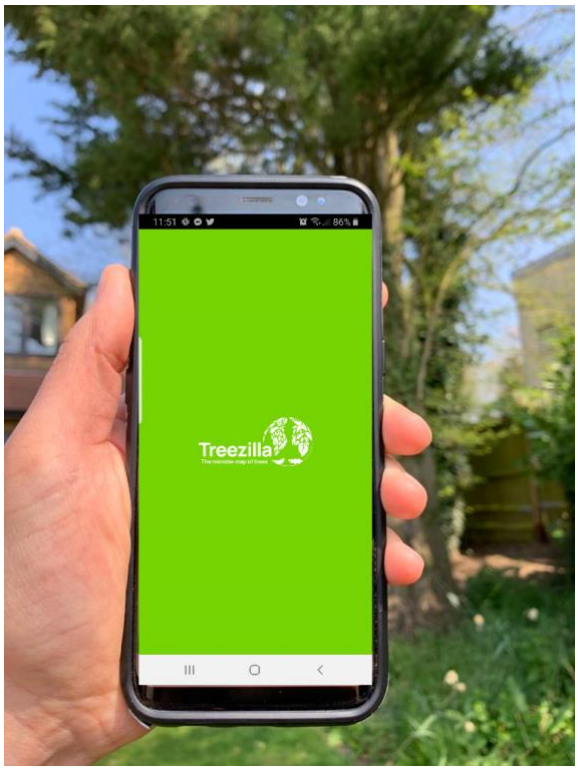
Always look out for traffic, particularly when carrying out surveys of street trees.

Do not carry out surveys of trees on a windy day, and always make sure there are no loose branches that could fall on your head.

Do not climb trees.

Do not break of branches or leaves.

Wash all equipment that you use during a tree survey (e.g. wellies, tape measures) as these can transmit pests and diseases between trees.



Treezilla allows you to calculate the eco-benefits of individual trees as well as their amenity value.

Equipment requirements

The following is a list of the equipment that might be needed for carrying out tree surveys, dependent on the data you're collecting and the equipment you have available.

Data record

You will need a means to record your measurements, this could be either on paper, a spreadsheet or in the Treezilla app.

Laser rangefinder

A laser rangefinder (also known as a laser distance meter) uses a laser beam to calculate distance to a target object. It can used for measuring Tree Height and Crown Diameter. Some of the more expensive options come with a built-in clinometer (i.e. function for calculating angles).

A laser rangefinder can come with or without a built-in clinometer and is used for measuring tree height and crown diameter.

Clinometer

A clinometer is an instrument that measures the angle of elevation. They can vary greatly in cost. A clinometer is used in surveys of Tree Height (see the SINE Method under the 'How To Measure' section) where a laser rangefinder lacks a built-in clinometer. However, this is not an essential piece of equipment and an estimate of tree height can be obtained with only a ruler (see the RULER Method).

Clinometers are used – along with a laser rangefinder – for calculating tree height. They can vary significantly in price.

Don't have a clinometer, why not make your own: https://www.instructables.com/id/Basic-Clinometer-From-Classroom-Materials/

Ruler

A ruler of any size can be used for obtaining an estimate of tree height for situations in which you don't have access to either a laser rangefinder or clinometer. It is also useful for when identifying trees as you're often required to know the approximate size of a leaf, bud, fruit or flower.

Measuring Tape – Dressmaker's or Surveyor's

A measuring tape is an essential bit of equipment for tree surveying and is needed when measuring Stem Circumference and Crown Diameter. While I dressmaker's tape is acceptable, a surveyor's tape will make life easier when measuring wide trees or Crown Diameter.

A surveyor's measuring tape commonly used for measuring crown diameter.

Thumb Tacks

A few thumb tacks are helpful for holding measuring tapes in place, for example when trying to wrap a measuring tape around an especially wide tree stem.

GPS Device

A GPS device will be needed to obtain coordinate measurements for the tree. If you're using the Treezila app then the tree's coordinates will be automatically assigned as you enter the survey information. If you're not using the Treezilla app then you can obtain coordinates using a map app on your smartphone (e.g. Google Maps). If you don't have a smartphone then you will need a hand-held GPS device (e.g. Garmin e-Trex).

A hand-held GPS device.

Camera

You will need a camera for taking pictures of the tree, leaves, fruits and flowers and any other notable features. A camera phone is more than adequate and comes with the added advantage that it assigns location data to each picture which means you can always easily assign pictures to a location at a later date.

Tree Species ID Guide

You will need a means to identify tree species. Checkout out our Treezilla Tree Identification Guide available on the Resources page of our website.

Pest and Disease Identification Guide

If you choose to record the presence of pests and diseases, then we recommend using the Observatree ID guides and posters (https://www.observatree.org.uk/resources/download-and-read/guides/) to help identify some of the most common. The posters make an ideal field resource as they print on to a single A4 sheet, while the guides provide you with more extensive information on each pest and disease.

How to Measure

Below we present methods or resources to help you measure the variables you'd come across if carrying out a tree survey using the Treezilla app. They are presented in the order you'd come across them in the app.

Tree Location

If using the Treezilla app and as long as you have a GPS signal, then your location (and therefore that of the tree you're surveying) is automatically assigned. If the level of accuracy isn't great, then you can switch the map to satellite view and drag and drop the pin on top of the tree.

A screenshot from the new Treezilla app interface. The blue pin indicates the survey tree's location and can be dragged into position.

Tree Species

Please refer to the Treezilla Species ID Guide available on the Resources page of our website. The ID guide works through a series of questions that are based on the characteristics of the tree's leaf, so surveys are best undertaken when the tree is in leaf. However, the guide also presents images of each species' bark which can be used to aid identification during winter months.

Tree Height

Tree Height is the most basic measurement needed to assess tree growth and estimates of a tree's ecosystem services.

SINE Method

First, we present what is commonly referred to as the SINE method for estimating tree height. This method requires four measurements as shown in Figure 1: 1) distance to top of the tree (D1) 2) angle to the top of the tree (A) 3) distance from your eye to the bottom of the tree (D2) 4) angle to the bottom of the tree (B).

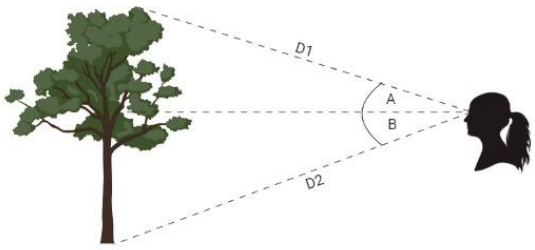


Figure 1: The measurements required for the SINE method.

Below we present different options for obtaining the distance and angle measurements needed for the calculation.

Option One: Using a LASER RANGEFINDER (with built-in facility for measuring angles as well)

- Step One: Find a location where you have a clear view of the top and the base of the tree. You will need to stand in the same spot while you take all the following measurements.
- Step Two: Measure both the distance (D1) and the angle (a) to the top of the tree and note it down (please refer to the manufacturer instructions on how to do this as this will differ between different makes and models of instruments).

  Note that this might be difficult for trees without significant foliage at the top as the laser needs to 'hit' significant foliage in order to make an accurate reading. To ensure you are measuring the target point on the tree, take the measurement several times. If it varies significantly then you know that the laser is missing the target.
- Step Three: Measure both the distance (D2) and the angle (b) to the base of the tree and note it down.
- Step Four: Now estimate the height of your tree using the following equation:

  Tree height = (sin(A) x D1) + (sin(B) x D2)

Hint: to calculate the sin of a & b you can either use a standard calculator (also available on smartphone calculators) or a free online trigonometry calculator like this one https://www.omnicalculator.com/math/trigonometry.

Option Two: Using a LASER RANGEFINDER (that has no facility for measuring angles) and a CLINOMETER.

- Step One: Find a location where you have a clear view of the top and the base of the tree. You will need to stand in the same spot while you take all the following measurements.
- Step Two: Using the laser rangefinder, measure both the distance to the top (D1) and the base of the tree (D2). Note that this might be difficult for trees without significant foliage at the top as the laser needs to 'hit' significant foliage in order to make an accurate reading. To ensure you are measuring the target point on the tree, take the measurement several times. If it varies significantly then you know that the laser is missing the target point.

- Step Three: Using the clinometer (please refer to the manufacturer instructions for details on how to use these instruments), measure the angle to the same top (a) and the bottom (b) points of the tree.

- Step Four: Follow Step Four as described under Option One.

RULER Method:

You will ideally need two people for this method.

- Step One: Holding your ruler up and out in front of you, step back from the tree until the top of the tree lines up with the top centimetre (cm) line on the ruler (i.e. 30cm if using a 30cm line), and the highest point of the ground at the bottom of the tree lines up with the 0cm line (Figure 2).

Figure 2: Align the top centimetre line with the top of the tree, and the 0cm line with the bottom of the tree as shown by the dotted lines.

- Step Two: Now ask the other person to walk towards the tree and using their finger guide them to point on the tree trunk where it lines up with the 3 cm line on the ruler (i.e. 10% of the total tree height if using a 30 cm ruler) (Figure 3).

Figure 3: Guide the second person to point out on the tree trunk the point that lines up with 3cm on the ruler.

- If the 3 cm line is too high to point out, then try asking the person to point out the 1.5 cm line (i.e. 5% of the total tree height if using a 30 cm ruler). If you don't have a second person, then it might be possible to find a notable feature on the tree trunk that you could use as a marker instead (e.g. a branch that starts at 4 cm.

- Step Three: While the second person keeps pointing to the 3 cm or 1.5 cm point on the tree trunk, using a measuring tape the first person needs to measure from the highest part of the ground at the bottom of the tree (i.e. the point that was lined up with the bottom of the ruler) to where the second person is pointing; note the measurement in centimetres (Figure 4).

- Step Four: To estimate total tree height use the following calculation:

If you used the 3 cm marker: Total Tree Height (cm) = (Measurement from Step 3 in cm) x ([Length of the ruler in cm]/ 3cm)

If you used the 1.5 cm marker: Total Tree Height (cm) = (Measurement from Step 3 in cm) x ([Length of the ruler in cm]/ 1.5cm)

If you are using the Treezilla app you will now need to convert this to metres and round to the nearest 0.1m.

Figure 4: Measure from the ground to where the person pointed out the 3cm point on the tree stem.

Stem Circumference/ Diameter

Stem Circumference/ Diameter is used to assess tree growth and the eco-benefits provided by a tree. Below are methods for measuring stem circumference for both single-stem trees and multi-stem trees (where there is more than one stem at 1.5 m above ground-level).

Single Stem Trees

- Step One: Measure 1.5 m from the highest point of the ground, up the trunk of the tree (see Figure 5).
- Step Two: Now measure the circumference (also known as Circumference at Breast Height (CBH)) by taking a tape measure all the way around the tree stem at 1.5 m from the ground (see Figure 5), using the thumb tacks to hold one end of the tape measure in place (only necessary if the tree is so wide it is difficult to wrap your arms around).

If you have an especially wide tree (i.e. wider than one tape measure) you could use the thumb tacks to mark where the tape measure starts and ends and take the tape measure around the tree however many times is needed.

If you need to obtain a measure of trunk diameter (commonly referred to as Diameter at Breast Height, DBH) then you simply divide your measure by Pi (3.14):

Diameter at Breast Height = Circumference / 3.14

Note, Treezilla automatically does the conversion for you from CBH to DBH.

Multi-Stem Trees

For trees with more than one stem, then you simply n eed to measure the circumference of the tree at the narrowest point immediately above the root flare as shown in Figure 6.

Figure 5: The red dotted lines indicates where to take the circumference measurement on a single-stem tree.

Figure 6: An aerial view of a crown with a uniform and irregular diameter.

Photographs of Key Features

Photographs of the tree's key features can be used both for validating the species, and where the pictures include other notable features - such as road signs – relocating the tree for future surveys. We recommend obtaining photographs of the:

- Whole tree
- Leaf
- Stem
- Fruit/ Flowers

Photographs should be clear image of the whole subject (i.e. tree, leaf, flower), and where possible include an object of known size to provide context as to the subject's size and/ or location e.g. building, letterbox, road sign.

Height to Base of Crown

The Height to Base of Crown measurement is used - in combination with Tree Height, Crown Diameter and Crown Shape - for calculating the volume of the crown. Volume of the crown is used for generating accurate estimates of ecosystem services. To measure Height to Base of Crown, simply identify the lowest hanging significant branch with foliage on the tree and measure from the ground to the foliage (see Figure 7). This measurement would normally be taken towards the periphery of the tree. Where the foliage is higher than can be safely reached, we would recommend using a stick of known length to reach the lowest foliage. You then simply add the distance from the ground to the end of your vertically extended arm to the length of the stick.

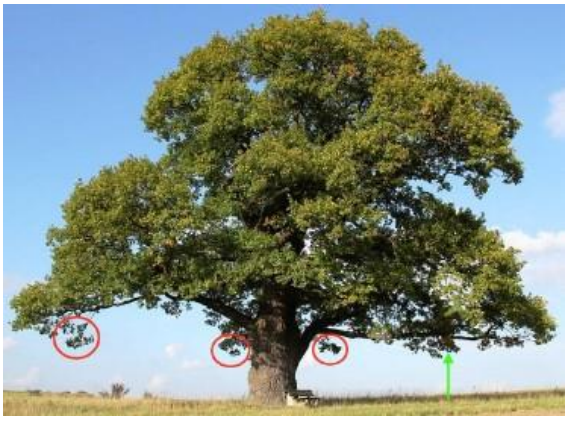


Figure 7: The green arrow represents where the Height to Base of Crown measurement should be taken. The red circles highlight other low-hanging foliage that wouldn't be considered significant.

Crown Diameter One

As mentioned under Height to Base of Crown, Crown Diameter is used to calculate the volume of the crown, resulting in estimates of ecosystem services.

Only measure Crown Diameter when the tree is in leaf as the leaf foliage can make a significant difference to the diameter measurement.

It would be easier to use two people with a surveyor's measuring tape but can be done with one person with a dressmaker's tape.

If the crown has a roughly uniform diameter (as shown in Figure 8) all the way round the stem, then you only need to take one measurement for the crown. If the diameter is irregular (as shown in Figure 8), then you will need to take two measurements, one across the narrowest width and the other across the widest width and create an average diameter.

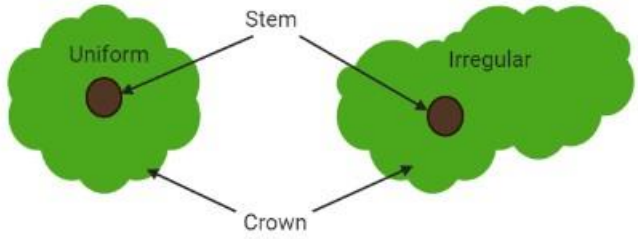


Figure 8: An aerial view of a crown with a uniform and irregular diameter.

Uniform Diameter

To measure crown diameter for a crown with a uniform diameter all the way round, follow these steps:

- Step One: Either have one person hold one end of the surveyor's measuring tape and stand immediately under the drip line or place a marker on the ground (see Figure 9).

- Step Two: Holding the other end of the surveyor's tape, the second person should now stand under the drip line on the directly opposite side of the tree, or simply place a marker on the ground under the drip line on the opposite side (see Figure 9).

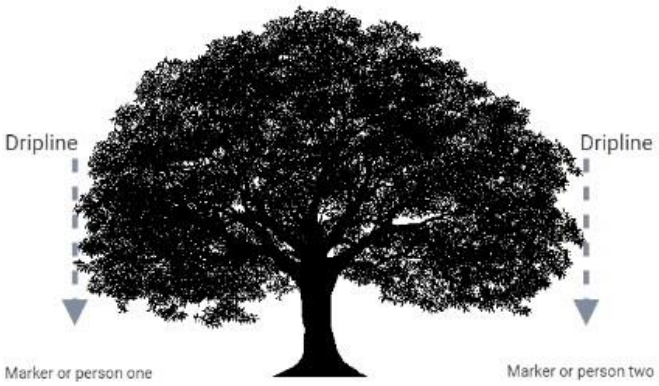


Figure 9: An illustration of the procedure for measuring Crown Diameter.

- Step Three: If using two people, simply record the length on the surveyor's measuring tape. If you are on your own, now measure the distance between the two markers (using either the surveyor's measuring tape, a laser rangefinder or a dressmaker's measuring tape). Be sure to record the diameter to the nearest 0.1m.

Irregular Diameter

If the crown has an irregular diameter then repeat the steps described for a crown with a uniform diameter but firstly across the widest part of the tree and then across the narrowest part of the tree. Now create an average crown diameter using the following calculation:

Average crown diameter (m) =

(Widest crown diameter (m) + narrowest crown diameter (m)/ 2)

Crown Shape

Crown Shape simply describes the shape of the trees crown and is used to further refine estimates of ecosystem services as it helps to refine the calculations of crown volume. For the purpose of a survey using Treezilla you will be asked to determine which of the crown shapes shown in Figure 10 most broadly represents the crown of the tree you're surveying.

Crown Missing

Crown Missing is the proportion of a hypothetical full crown that is not present. **As with the other data fields relating to the shape of the crown, Crown Missing helps to improve the accuracy of estimates of the crown volume.**

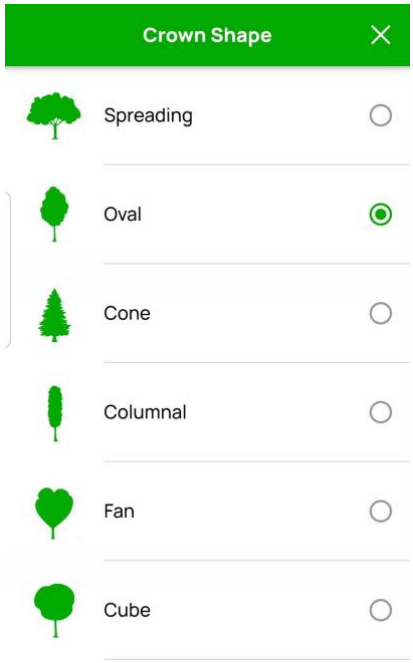


Figure 10: The Crown Shape options you are asked to choose from when using Treezilla.

To assess the proportion of the crown that is missing:

- Step One: imagine an outline of the crown shape you selected for the tree you're surveying around the crown (depicted by the red line in Figure 11).

- Step Two: Estimate a percentage to describe the amount of space within the Crown Shape outline that is not occupied by foliage. In the Figure 11 example we would estimate that approx. 35% of the crown is missing.

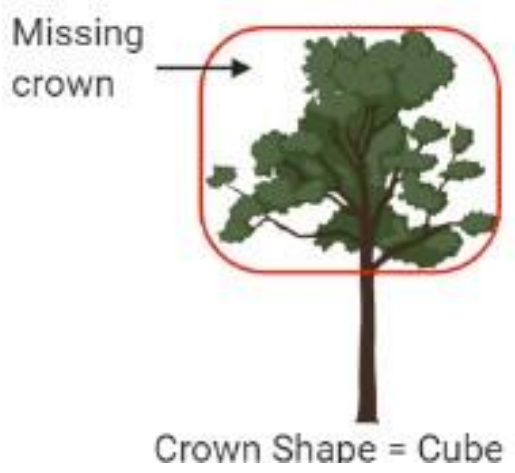


Figure 11: To assess Crown Missing create an outline of the Crown Shape around your tree's crown and estimate the amount of space that's not occupied with foliage.

Crown Damage

Crown Damage is used to describe the proportion (%) of the crown (i.e. branches, twigs and leaves) that is not in good health. When completing the Crown Damage data field in Treezilla you will be asked to estimate the proportion of the crown that is in poor health to one of the following bands:

- No, or very minor, disease or damage of remaining crown: 0-5%
- Up to a quarter of remaining crown with disease or damage: 6-25%
- Between a quarter and half of remaining crown with disease or damage: 26-50%
- More than half, but less than three quarters of remaining crown with disease or damage: 51-75%
- More than three quarters of remaining crown with disease or damage: >75%

To estimate the proportion that is in poor health subtract your estimate from crown that is present, not a hypothetical full crown that fills the Crown Shape outline.

Cause of Crown Damage

Information on the cause of damage to the crown can be used for monitoring tree health. When completing the Cause of Crown Damage field in Treezilla you will be asked to assign the damage to one of the following categories:

- Vertebrate
- Insect
- Fungal/ Bacterial
- Human
- Unknown

Vertebrate (animals with a backbone) damage is normally caused by squirrels and is visible as chewing and stripping of leaves and branches. Deer damage to the crown normally comes in the form of chewed lower branches, known as a Browse Line, that are within the deer's reach.

Insect damage can vary considerably depending on the species of insect. The most common signs of insect damage are holes in the leaves. Please see the Observatree guides (https://www.observatree.org.uk/resources/download-and-read/guides/) on signs of damage from the most common insect pests.

Fungal and bacterial damage can also vary considerably depending on the species causing the damage, the affected species and the stage of the disease. For example, the fungus *Dothistroma* needle blight that affects species of *Pinus*, can start with discolouration of the needles, leading to loss of needles and eventually death of the entire tree. While Acute Oak Decline, a complex disease caused by both bacteria and a bettle, results in a dark, sticky substance oozing from cracks in the the bark of the tree's stem. Please see the Observatree guides (https://www.observatree.org.uk/resources/download-and-read/guides/) on signs of damage from the most common bacterial and fungal agents.

Human damage to the tree's crown comes in the form of removal of the tree's branches and leaves. It will differ from vertebrate damage in that it is often characterised by cut marks or the snapping of branches instead of chew marks.

Trunk Condition

Trunk Condition is used to describe the proportion (%) of the tree's trunk/ stem that is not in good health/ damaged. For Treezilla you will need to assign your estimate to one of the following bands:

- Very good: 0-5% No significant signs of disease, damage or decay
- Good: 6-10% of trunk has signs of disease, damage or decay
- Fair: 11-25% of trunk has signs of disease, damage or decay
- Poor: 26-50% of trunk has signs of disease, damage or decay
- Very poor: 51-75% of trunk has signs of disease, damage or decay
- Moribund: >75% of trunk has signs of disease, damage or decay

Please note this data field refers to the trunk only and not the branches.

Cause of Trunk Damage

As with Crown Damage, data on the Cause of Trunk Damage is important for monitoring tree health. When completing this data field using Treezilla you will be asked to select one of the following options:

- No damage visible
- Animal
- Mechanical
- Tree tie
- Vandalism
- Weather/ lightning
- Unknown

Animal damage to the trunk is typically caused by deer and squirrels (mid to upper trunk) and rabbits (lower trunk). Most often it is visible as chewed bark as seen in Figure 12.

Figure 12: Animal damage to the trunk is normally in form of chewed bark and caused by deer and squirrels.

Mechanical damage is most commonly caused by lawn mowers and strimmers and so appears as lacerations/ removal of bark on the lower trunk.

Tree Tie refers to the situation in which the tie used to support structurally unstable trees (most often young trees) has constrained the growth of the tree trunk, as seen in Figure 13.

Figure 13: An example of tree tie damage in which the support tie has constrained growth of the trunk.

Vandalism normally comes in the form of removal of the bark in a band around the stem (known as girdling; Figure 14) which kills the tree above the gridle line, or tree carving (Figure 15).

Figure 14: An example of tree girdling. Image credit: Lamiot.

Figure 15: An example of tree carving. Image credit: Peripitus.

Weather/ Lightning strike damage can be difficult to detect in that no it leaves no obvious major external damage to the tree, or it can cause the tree to explode or fall down.