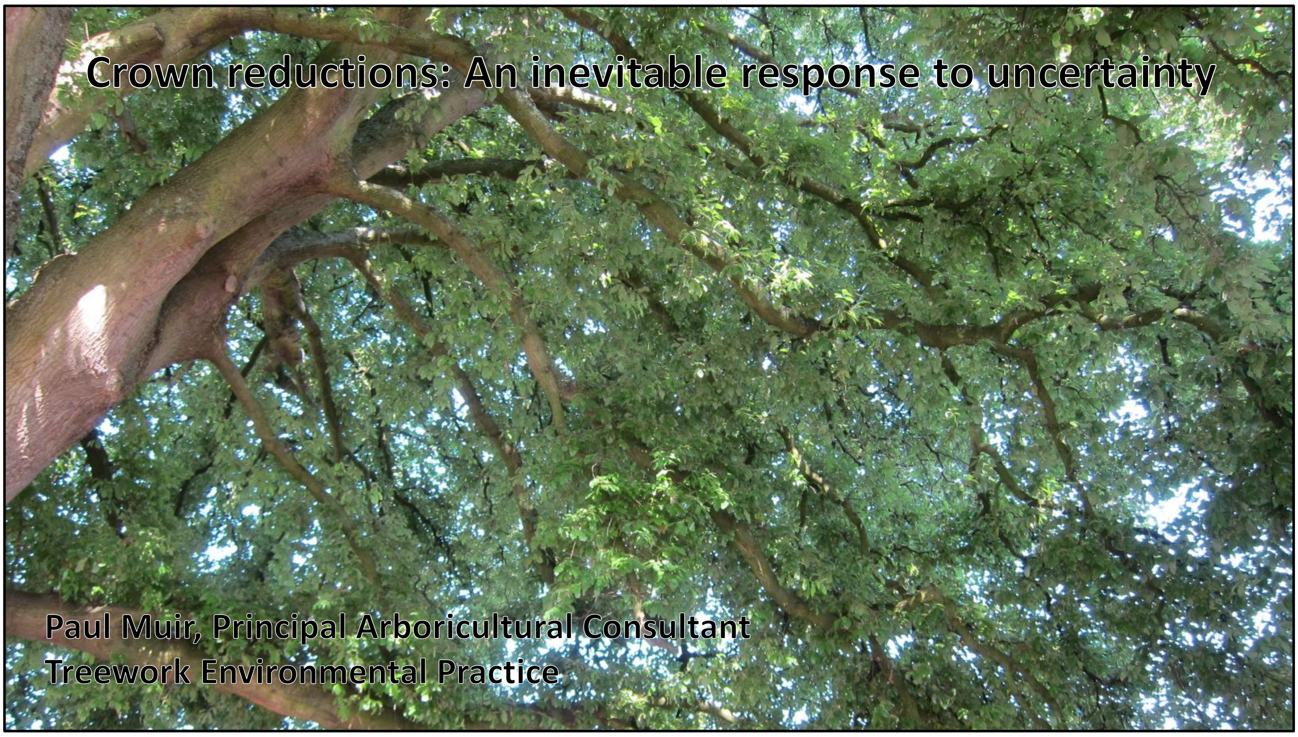

Crown reductions: An inevitable response to uncertainty
Paul Muir, Principal Arboricultural Consultant
Treework Environmental Practice

I have been assessing trees using the tree statics model (developed by Wessolly and Sinn) for 15 years.

Treework Environmental Practice have been commissioned to carry out static load tests on 250 trees over this period.

The experience of applying the model to help make decisions about the likelihood of whole tree failure has fundamentally changed the way we assess and manage trees at our practice. This shift in approach applies equally to visual assessments carried out during routine tree surveys and inspections.

There are two key principles at the core of the statics model that have driven us to change the way we assess the likelihood of whole tree failure.

One of the main outcomes is that we rarely recommend crown reductions to manage the risk of whole tree failure.

The first principle that has resulted in us changing our approach is that we now assess whole tree failure, primarily in terms of safety factors and not strength loss.

Trees with significant strength loss can (and often do) have acceptable safety factors.

Trees with significant strength loss can (and often do) have higher safety factors than defect-free trees, particularly young defect-free trees.

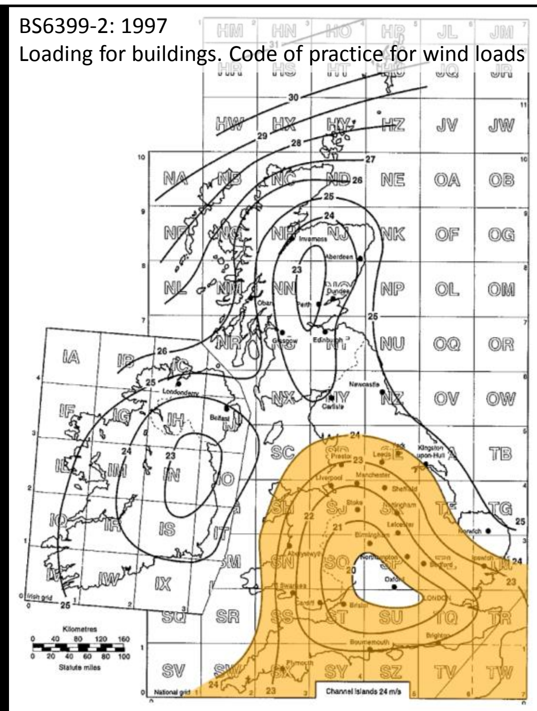


Figure 6 — Basic wind speed V_b (in m/s)

Estimating a safety factor requires us to define a load. We have to pick a storm event.

A structure does not have one safety factor, it has a series of safety factors in different scenarios.

It is appropriate that we reference resources outside the arboricultural industry to define a relevant extreme wind event, derived from a sector with the expertise to provide such guidance and based on data. This guidance may change or evolve as typical weather conditions change. That's not our industry's responsibility.

BS 6399-2: 1997 presents average wind speeds experienced in the UK during a 1 in 50 year storm event. This is more accurately described as a series of wind zones where there is a 2% chance that the quoted wind speeds are exceeded.

Think about how well defined the event is that you are considering when you make a visual assessment? What storm do you have in mind? What do you require a tree to withstand?

Contrary to the alarmist rhetoric that is often reported in the arboricultural industry we are involved with informing risk management decisions.

We deal with probability, not certainty or prediction.

There is no expectation from the courts that we need to guarantee that a tree won't fail under any circumstances.

This image is from the Bahamas after the (very) recent hurricane Dorian, a category 5 event. Sustained wind speeds of 185 mph were reported with gusts up to 200 mph.

Such an event has a likelihood of occurrence. It has a return period. But it is not a reasonably foreseeable event in the legal sense. There is no expectation that we should manage trees to withstand these conditions.

So, we make management recommendations based on data with clearly defined failure criteria.

Here are two late mature oak on a prestigious estate.

Concern was raised regarding the possibility of soil compaction in the light of crown dieback and decline that might be attributable to activity associated with a large annual event. We were asked to advise on the possible implications for root stability.

If the stems were defect-free with those dimensions we'd expect these trees to be able to withstand 15-20 times the loads that a 1 in 50 year storm would exert on them.

The reactions to the test loads applied showed that the trees both had stem defects. This is not a surprise for trees in the late mature life stage.

Strength loss in the stems was shown to have reduced safety factors for stem fracture very significantly…but the test data showed clearly that the stems still had huge safety margins.

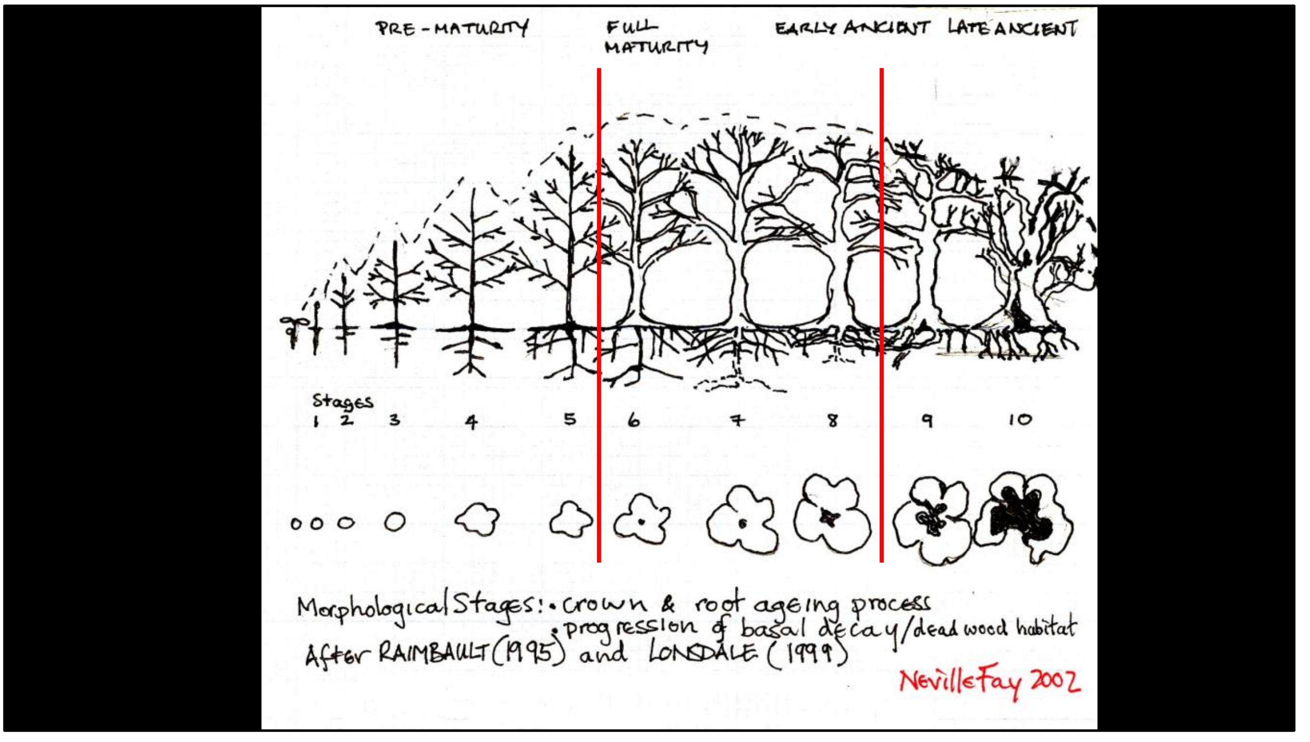
The majority of residual safety factors for uprooting for the tree on the left were between 3.0 and 3.5 with the lowest safety factor for uprooting of 2.3.

We did not apply enough load to get inclination reactions sufficient to calculate a safety factor for uprooting for the tree on the right. The tree just didn't move in response to the applied test load!

This is typical of our experience of undertaking static load tests. The analysis often reveals significant strength loss and dramatically reduced residual safety factors but these are frequently still very high. This is accompanied by the occasional surprise – the data revealing defects that just cannot be observed.

Expressing the outcome of any quantification of the likelihood of failure in terms of a safety factors give really clear guidance on the best management approach to take.

The tree on the left will need to be monitored and tested again within perhaps 3 years to determine whether stability deteriorates further. The tree on the right does not really need any further consideration in terms of stability.



Detailed investigations are expensive. The static load test is particularly time consuming. As a consequence a high proportion of the trees that we have tested have been mature or late mature, because the costs of assessment generally need to be justified by the amenity value offered by the trees.

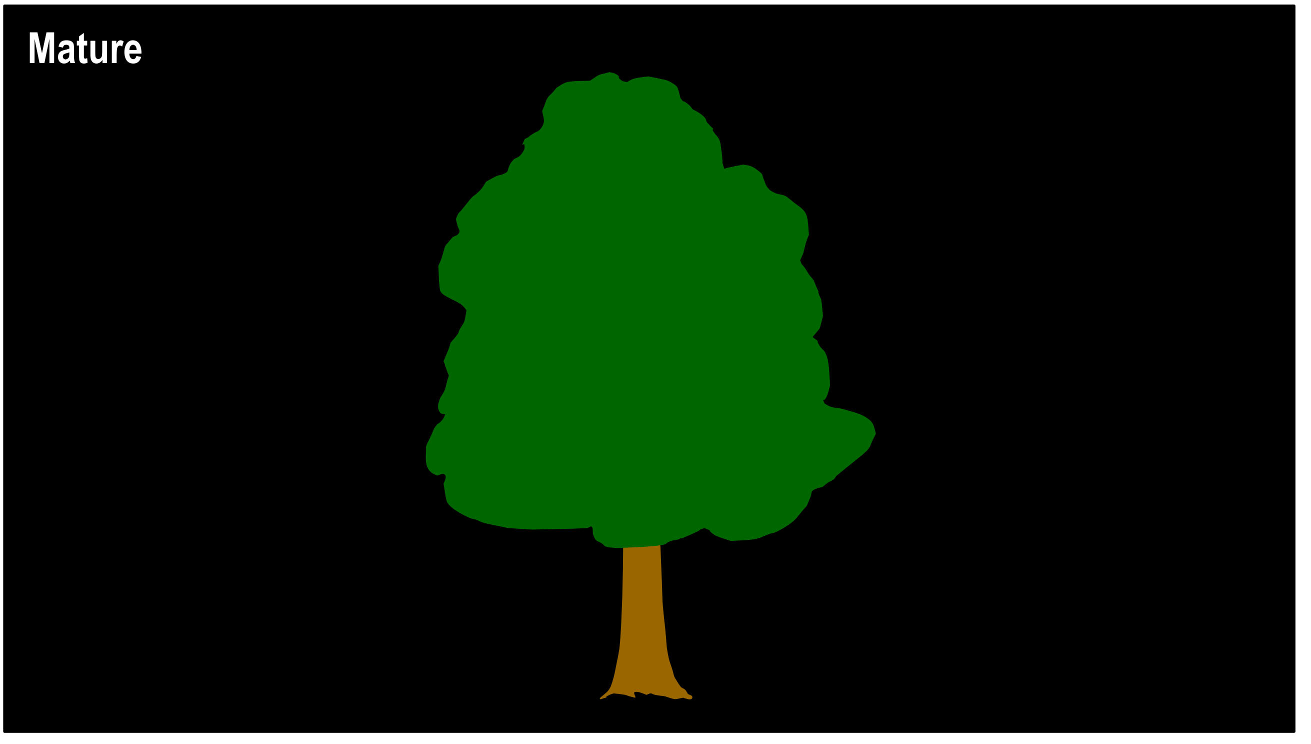
Trees in the mature phase of development have high basic safety factors. The basic safety factor is based on the external dimensions of the stem, before defects are taken into account.

During the mature phase of development the scale of the crown and consequently the wind load remains constant but the stem gets progressively larger. This is not initiated by mechanical stimulus. This is a physiological, developmental process. As a consequence the basic safety factor for a mature tree increases during the mature phase with every annual ring laid down.

The influence of stem diameter on a tree's ability to carry load is the second key principle behind the concept of tree statics that has shifted our approach to the assessment of whole tree failure.

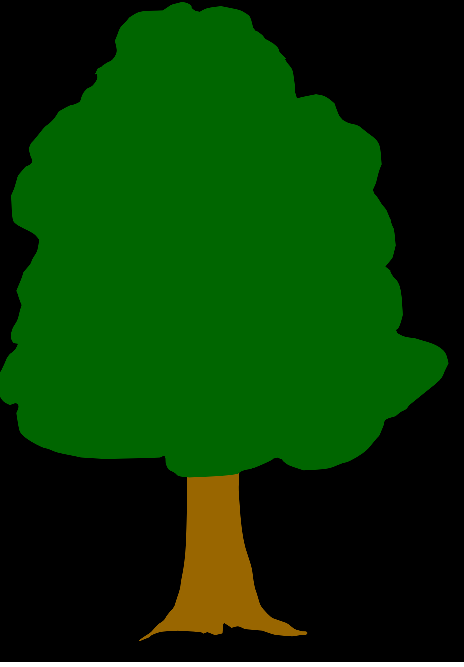
Taking an individual tree and progressing through its life stages...

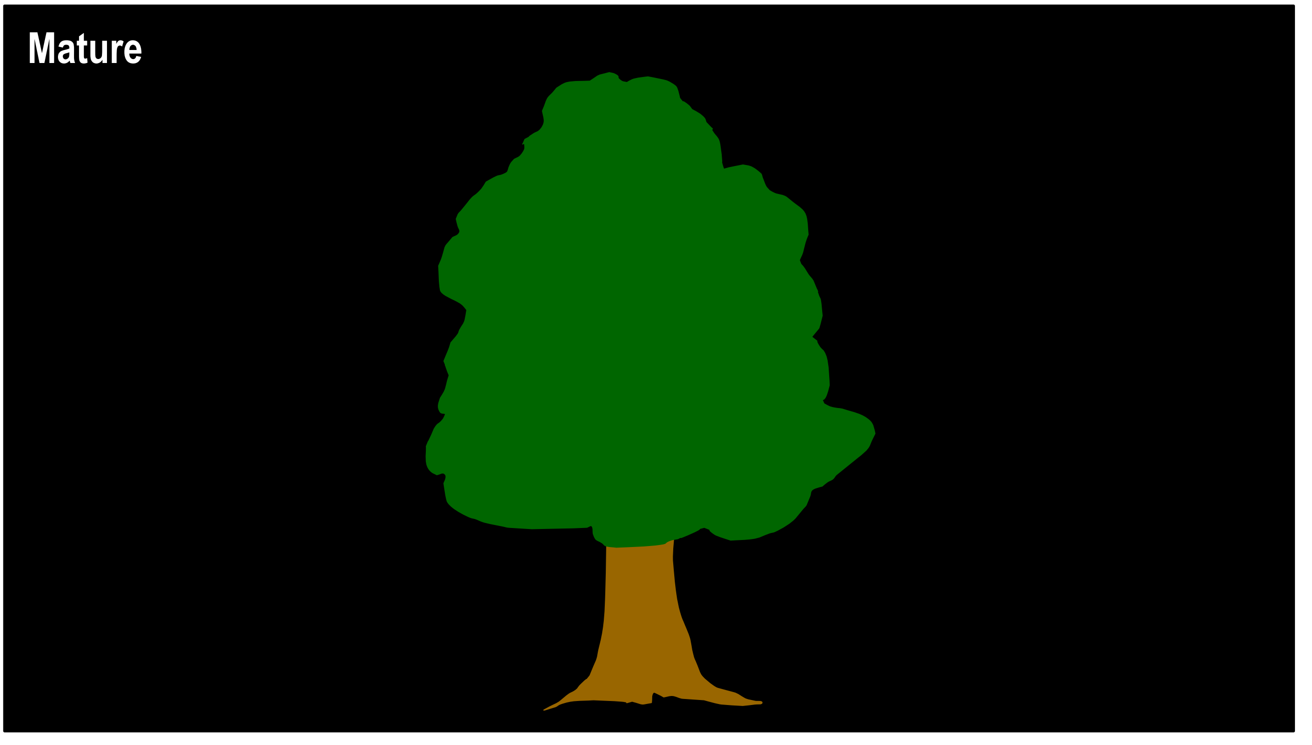
We reach a maximum height at early maturity.



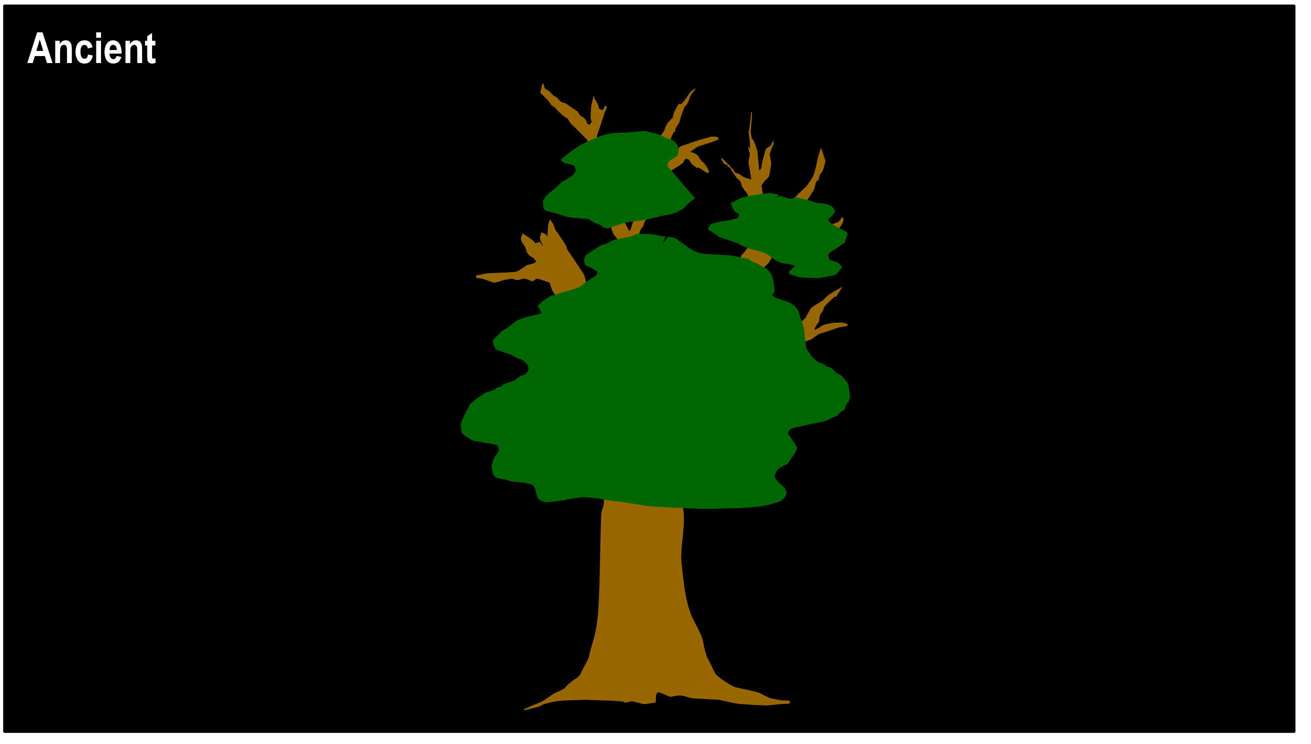
Maybe the crown extent increases during the first part of the mature phase...

Mature

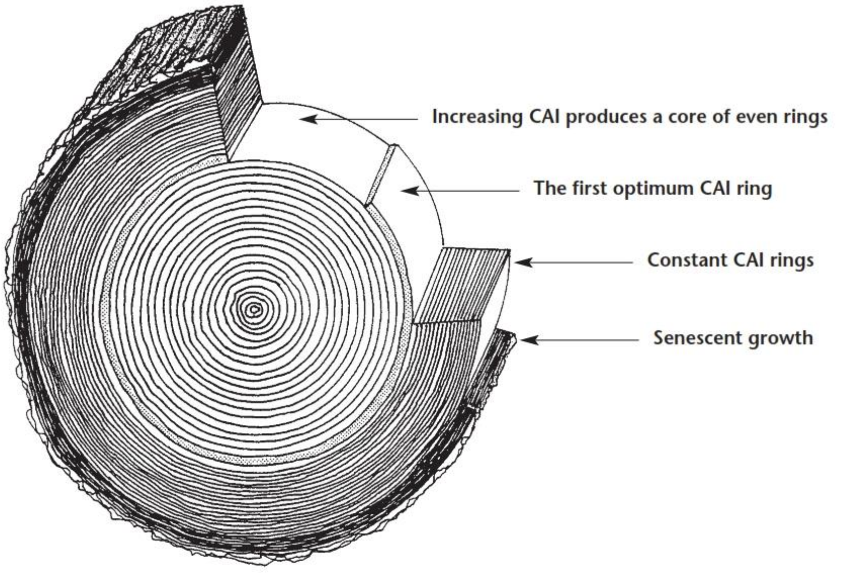



Mature

...but then we have hundreds of years of current annual increment with a constant crown extent and therefore a constant load.



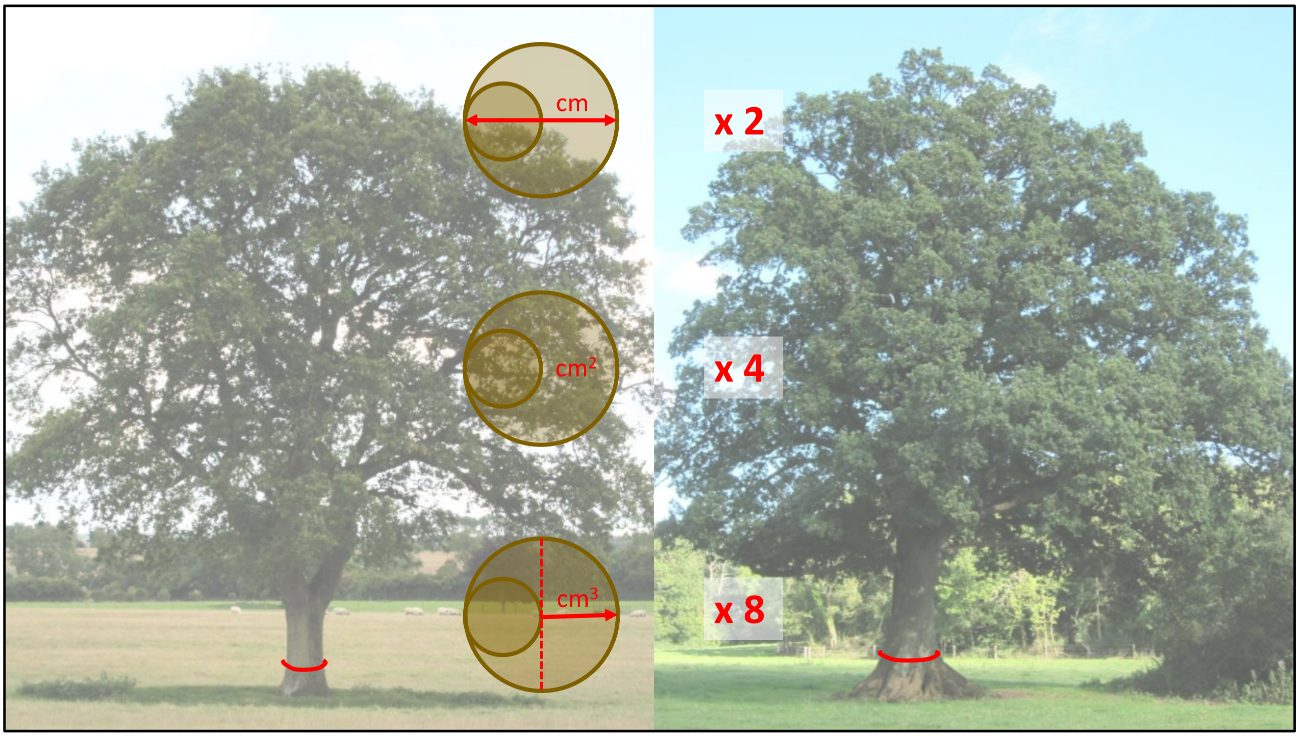
...and then a drastically reduced load.



John White’s model for estimating the age of a tree very neatly illustrates this development process.

The rate of change of annual increment over the life stages is linked to crown scale and resource availability.

I would encourage you to take another look at this model in relation to clarifying developmental life stages and the implications for safety factors rather than as a tool for estimating age.



For a circular cross section with uniform material properties - If we double the stem diameter, the area of the cross section increases by a factor of 4, but the ability to carry a load, in bending, increases by a factor of 8.

This can be illustrated by bending a wooden ruler in two planes. The ruler is flexible and weak if it is bent with the thin plane parallel to the load being applied, but it is stiff and strong if the thin plane is perpendicular to the load being applied. The material hasn't changed. The area hasn't changed. But the distribution of the material across the section in relation to the load has implications for strength and stiffness.

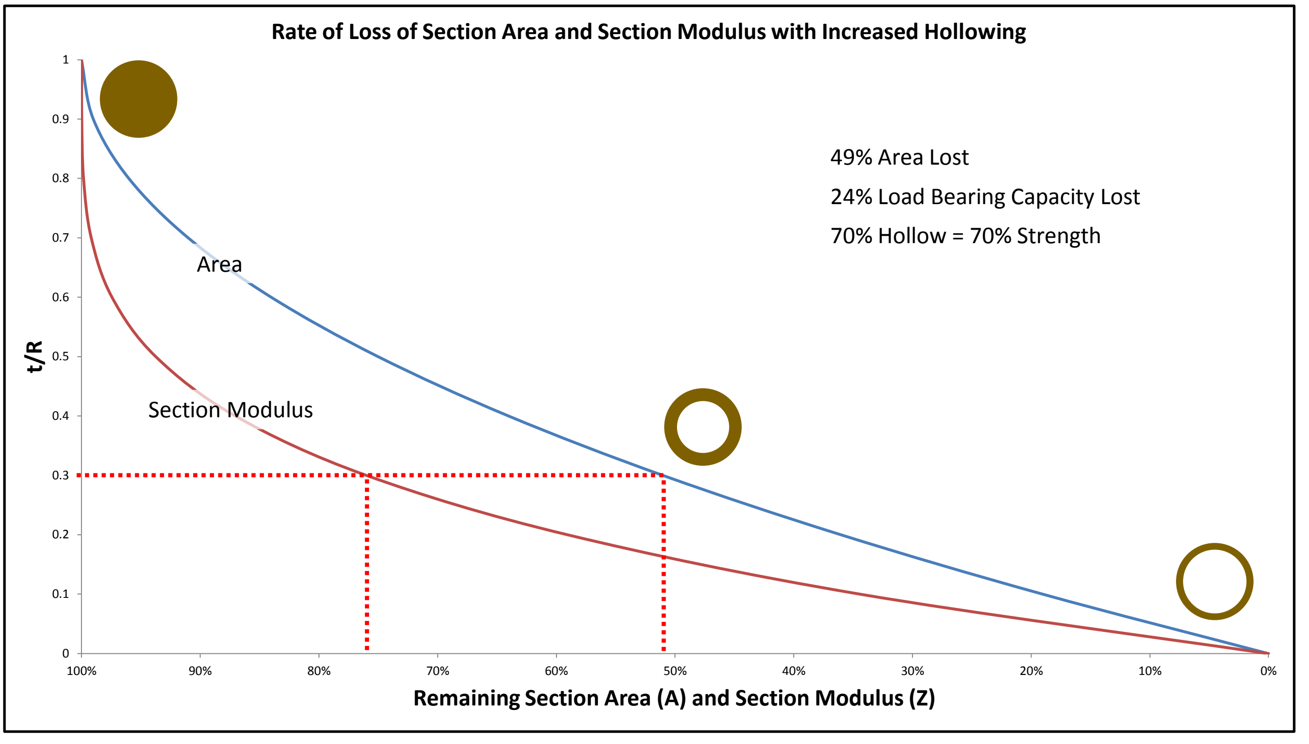
A further illustration is the increase in stability if one stands with feet together when pushed that can be achieved by spreading one's stance. Feet apart confers a mechanical advantage.

Section modulus weights each unit area of a cross section in terms of mechanical advantage, i.e. according to it's distance from the neutral axis – typically the centre of the cross section.

So for the same wind load safety factors increase exponentially with every extra cm of diameter.

This photo shows an open grown early mature tree, adjacent to two ancient pollards at Richmond Park. The veterans will be hollow with open cavities but they probably still have higher residual safety factors, for stem fracture, than the defect-free, thin-stemmed younger tree.

The magnitude of residual safety factors taking into account defects, or strength loss, clearly depends on where you started from.

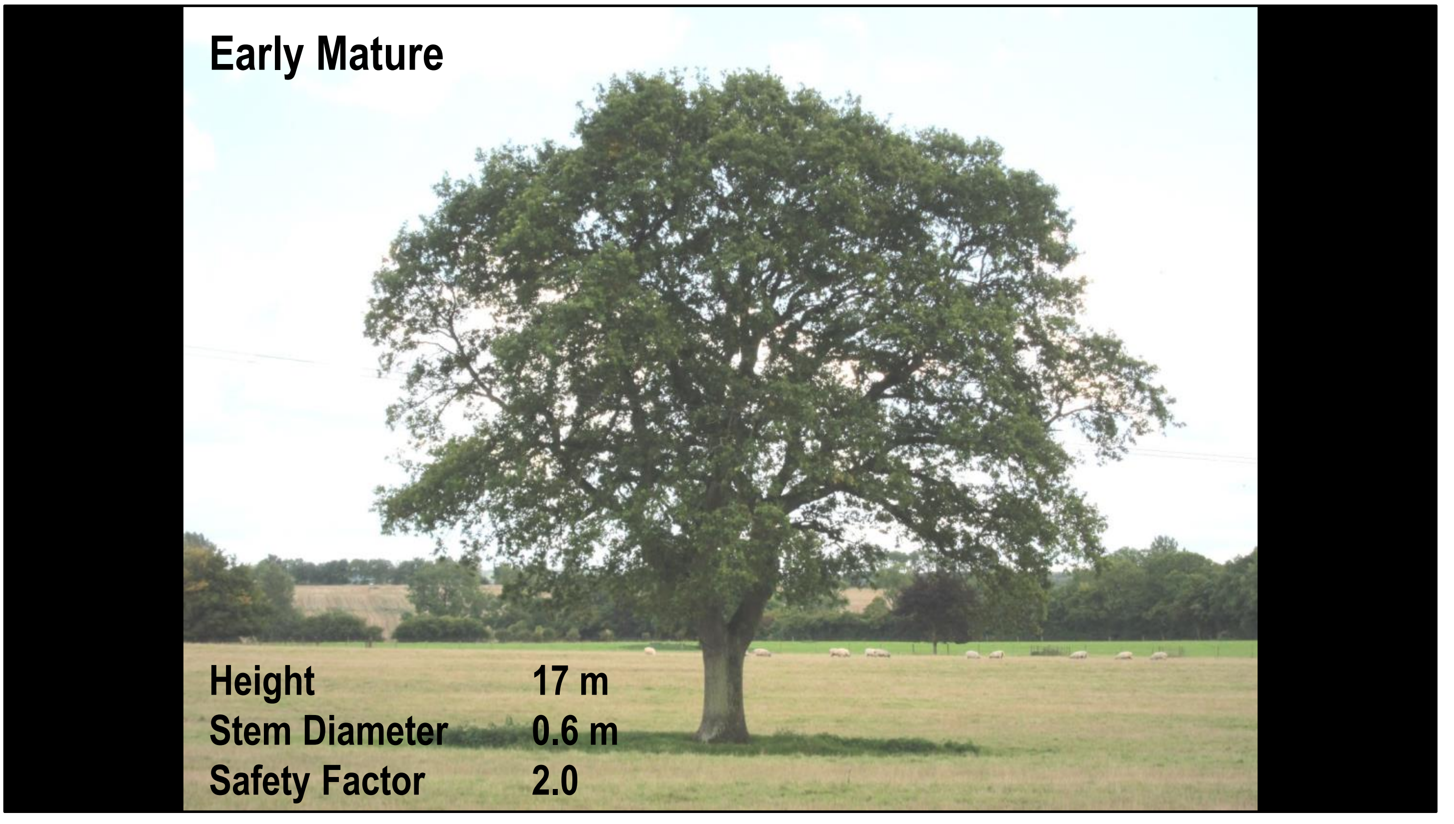


This graph shows the change in area and the change in section modulus, in percentage terms, with increasing hollowing as we move to the right.

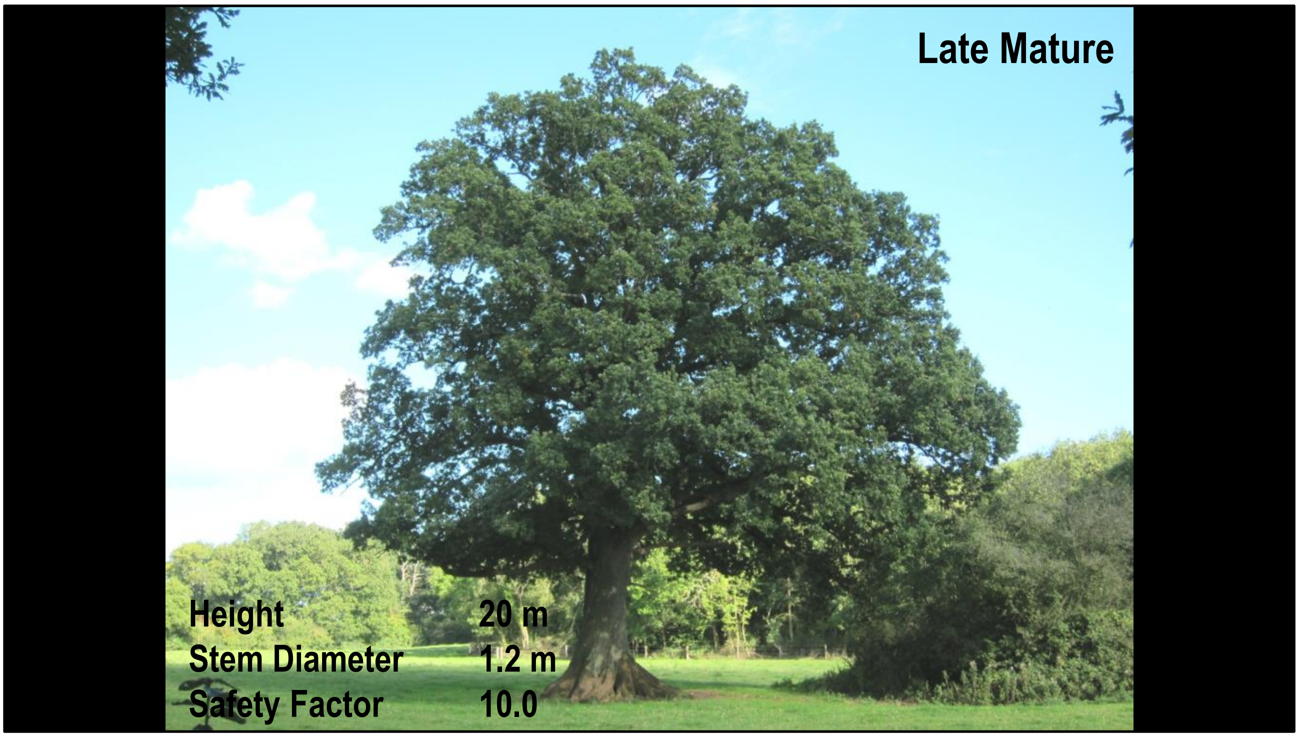
At a t/R ratio of 0.3 (the one third rule), the area of a stem falls by 49%, but the ability to carry a load in bending falls by only 24%.

In other words when a stem is 70% hollow it retains more than 70% of it's strength.

Trees have to be very hollow to start losing significant strength.

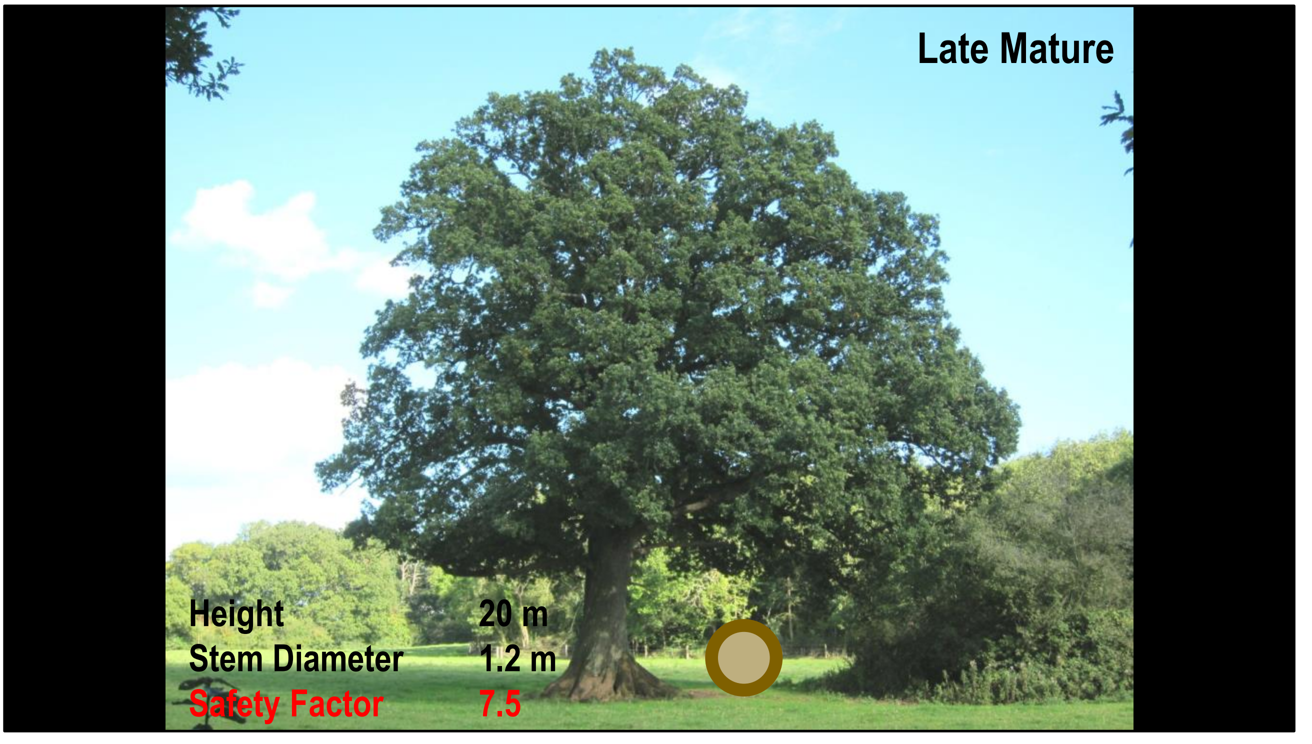


A basic safety factor for a typical early mature oak might be 2.0.

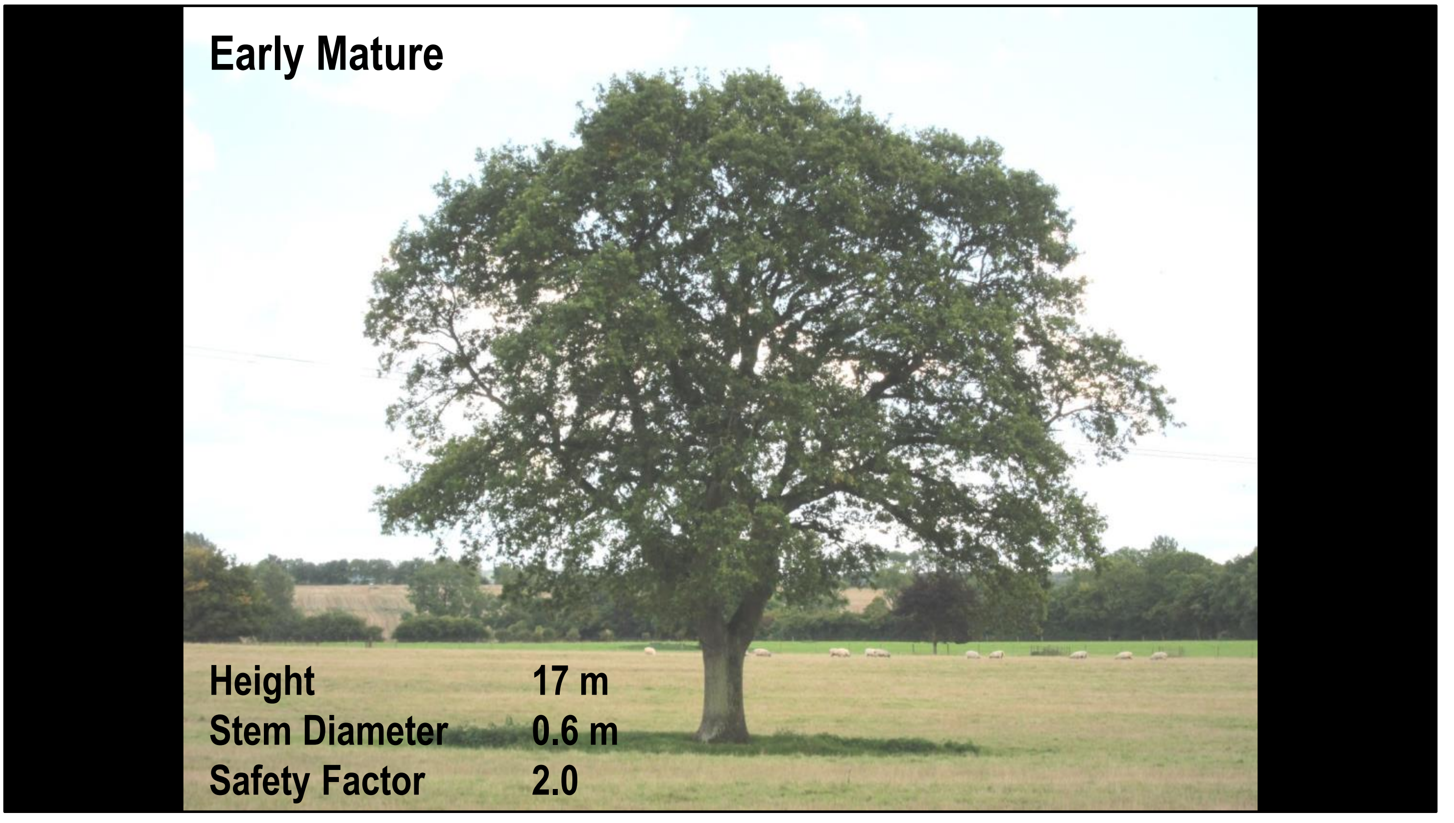


A basic safety factor for a typical late mature oak might increase to as much as 10.0 or more.

If your starting position is a very high safety factor, strength loss is very unlikely to use up the margins.

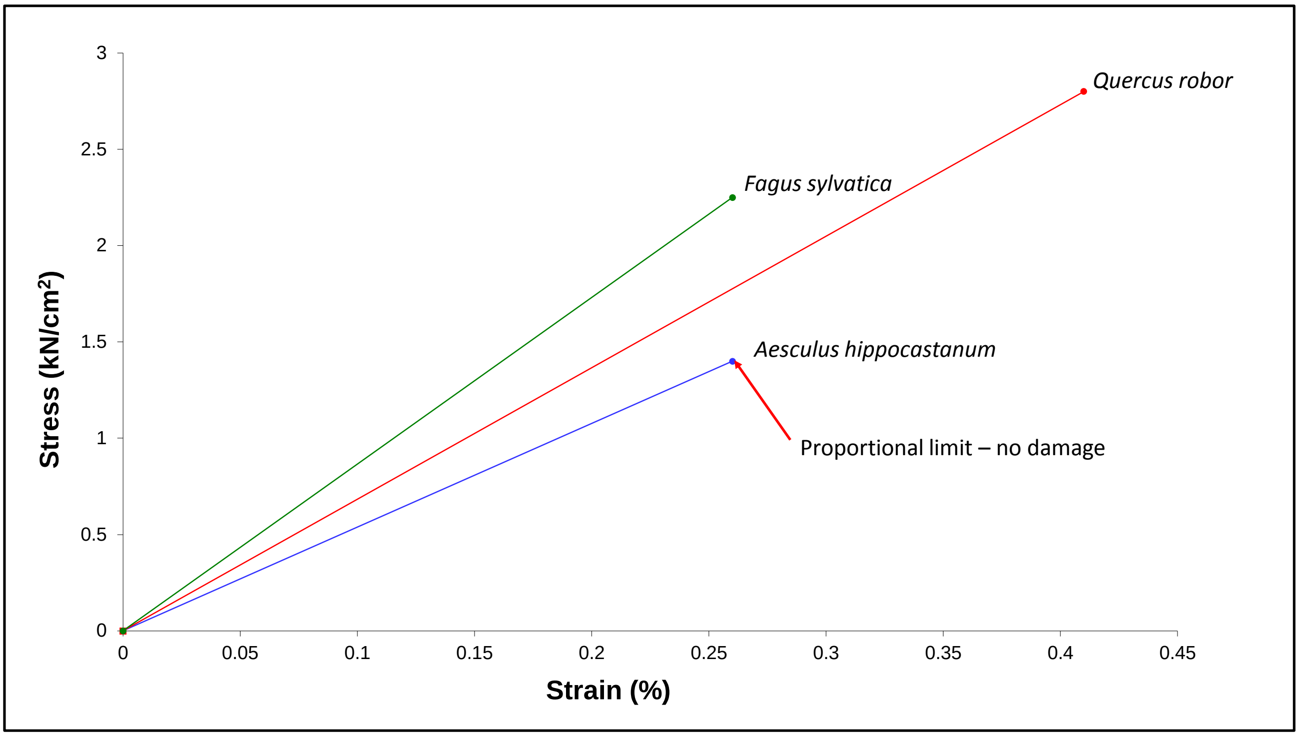


25% strength loss applied to this example, consistent with the one third rule, would reduce the safety factor to 7.5.



A residual safety factor of 7.5 would still be significantly higher than for the defect-free early mature tree with a safety factor of 2.0.

If you are comfortable with the likelihood of failure of the early mature tree, it makes no sense to be concerned about the late mature tree with moderate strength loss.



But we haven't yet considered material properties that vary between species!

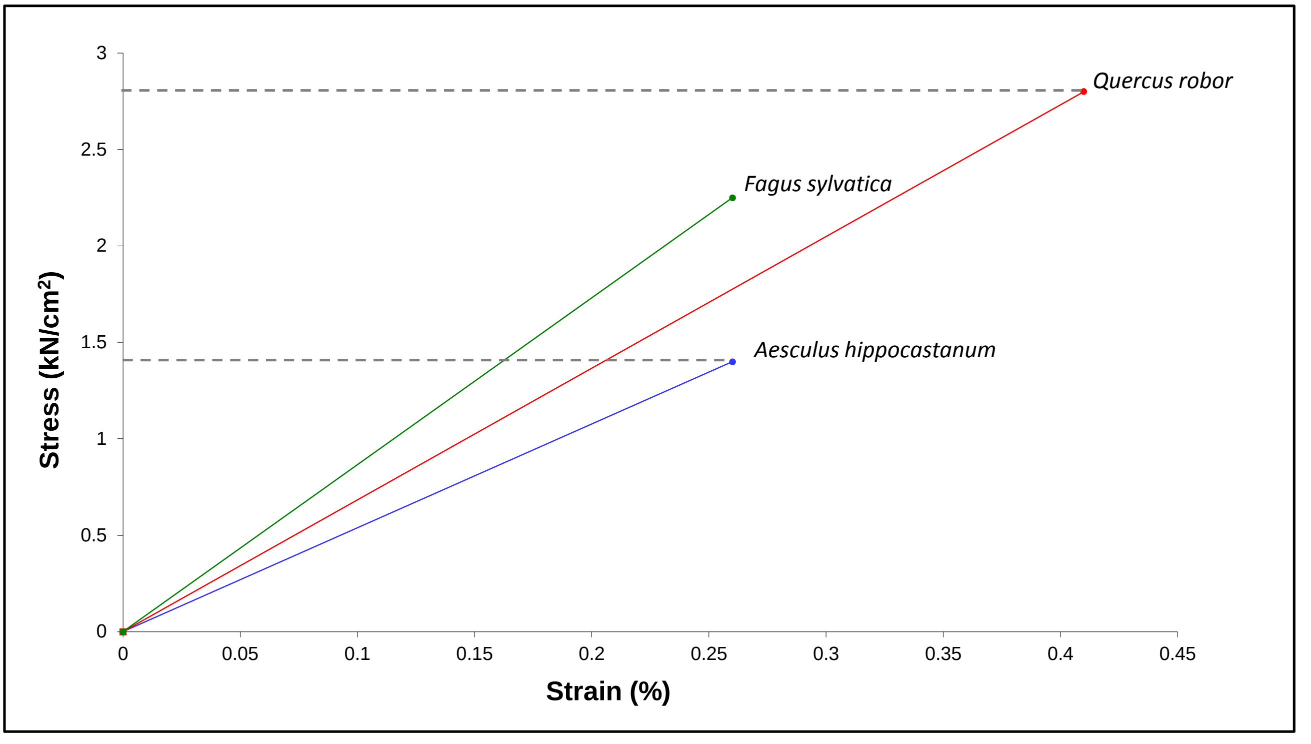
This is a representation of a stress-strain curve that would be derived from materials testing of wood samples when loaded in pure compression or compression tested in bending.

Stress or load per unit area on the y-axis.

Strain or how much the material deforms on the x-axis.

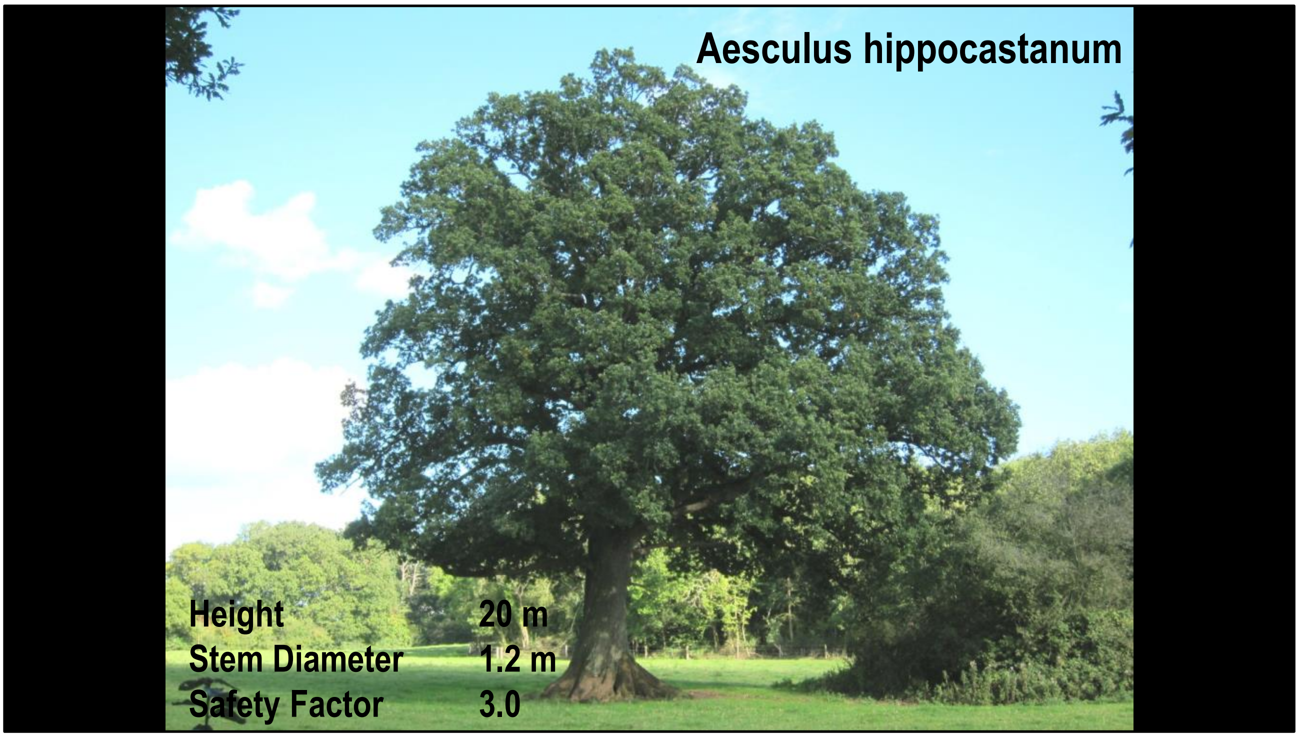
There is a linear relationship up to the proportional limit. When the load is removed the material recovers, undamaged.

This is fundamental to the failure criteria incorporated into the statics model. No damage is allowed. We operate within the elastic range of deformation.



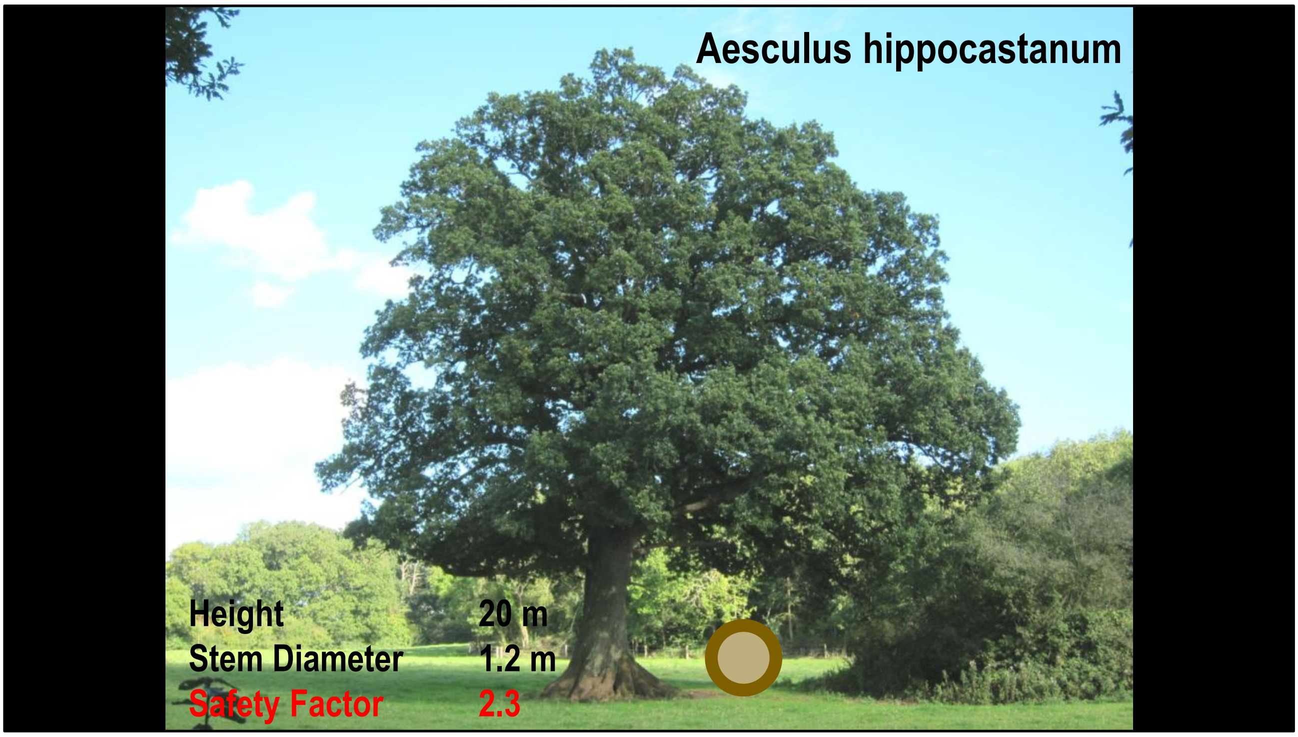
Oak is approximately twice as strong as horse chestnut.

28 MPa and 14 MPa respectively.



So if we consider a horse chestnut with the dimensions of the previous example of a late mature oak…

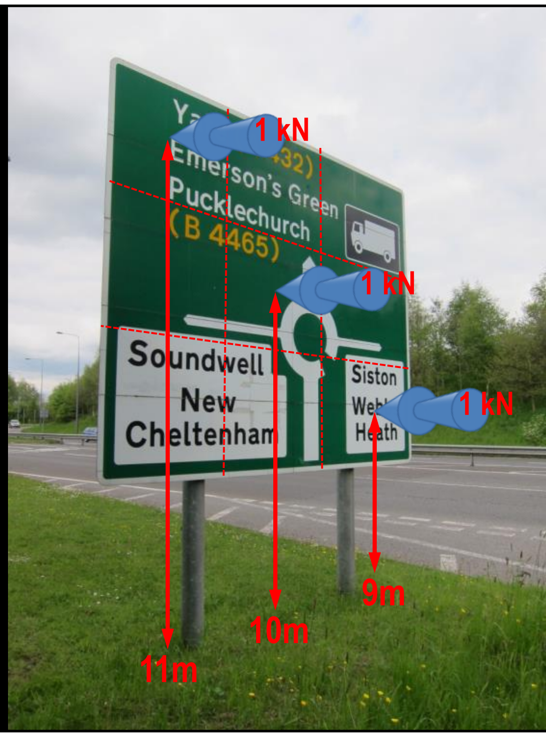
The basic safety factor would be 3.0 not 10.0.



…and when hollow, with a t/R ratio of 0.3, the residual safety factor for stem fracture would be 2.3 rather than 7.5.

But safety factors are not halved!

This is because horse chestnut is both 50% weaker in terms of wood strength but it also has a disadvantageous coefficient of drag. Stiff twigs at the crown periphery and large leaves means that the loads transferred from the wind flow are greater than for the oak.

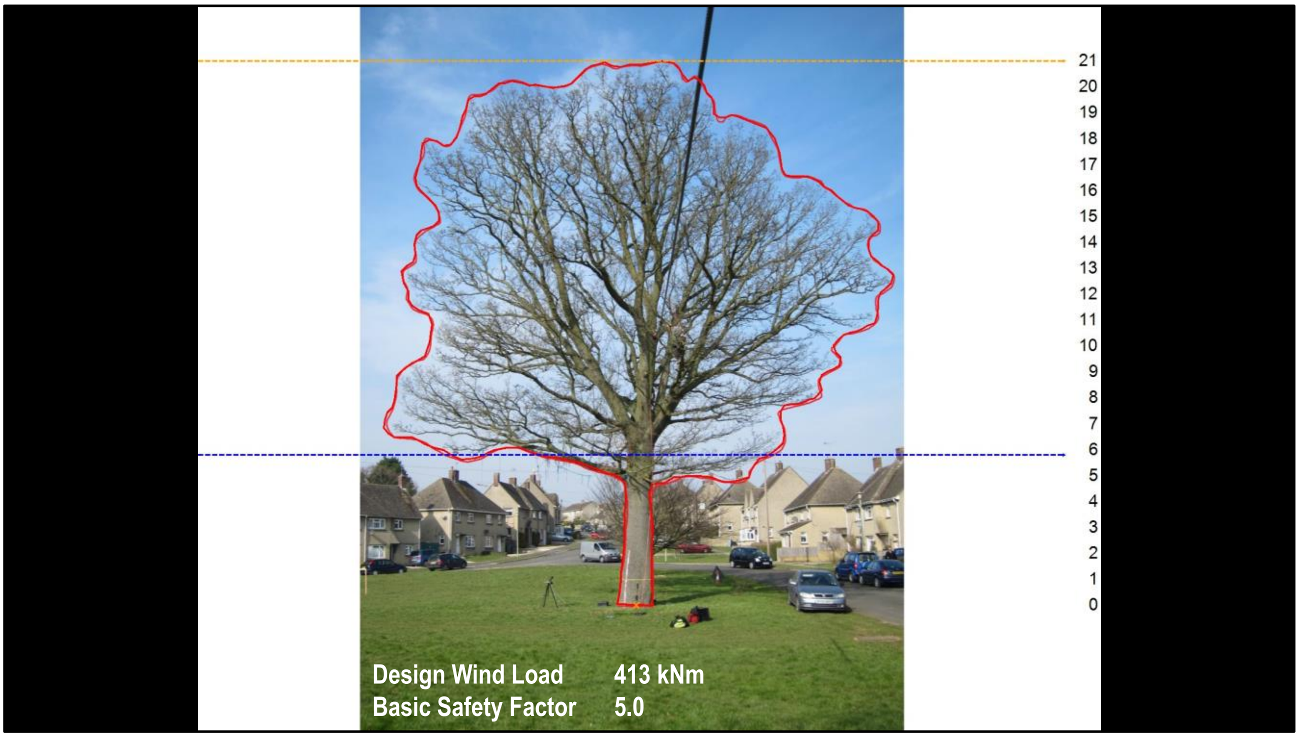


Mature trees have high basic safety factors and high safety margins. So for most trees we can make an estimate of the residual safety factor (taking into account defects) and demonstrate that a crown reduction is just not necessary.

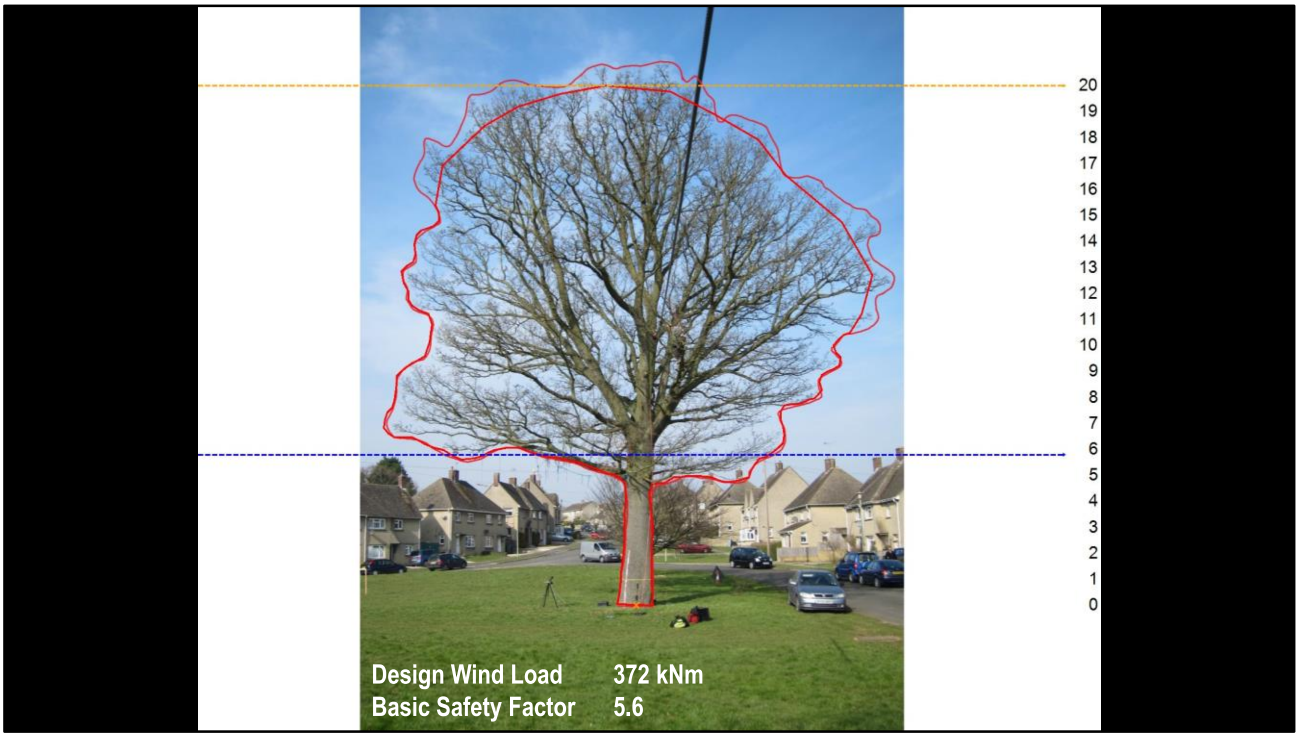
But here's why the idea of pruning seems appealing.

If we divide this sign into equal areas and assume an equal wind load of 1 kN is exerted on each area, then each section at the top of the sign would contribute 11 kNm to the total moment at the base whereas each section at the bottom of the sign would contribute 9 kNm to the total moment.

Removal of foliage at the top of the crown of a tree has a disproportionate contribution to the total resulting moment derived from wind load at the base and roots.



We can show the impact of incremental crown reductions on the design wind load and the basic safety factor for a tree with defined dimensions.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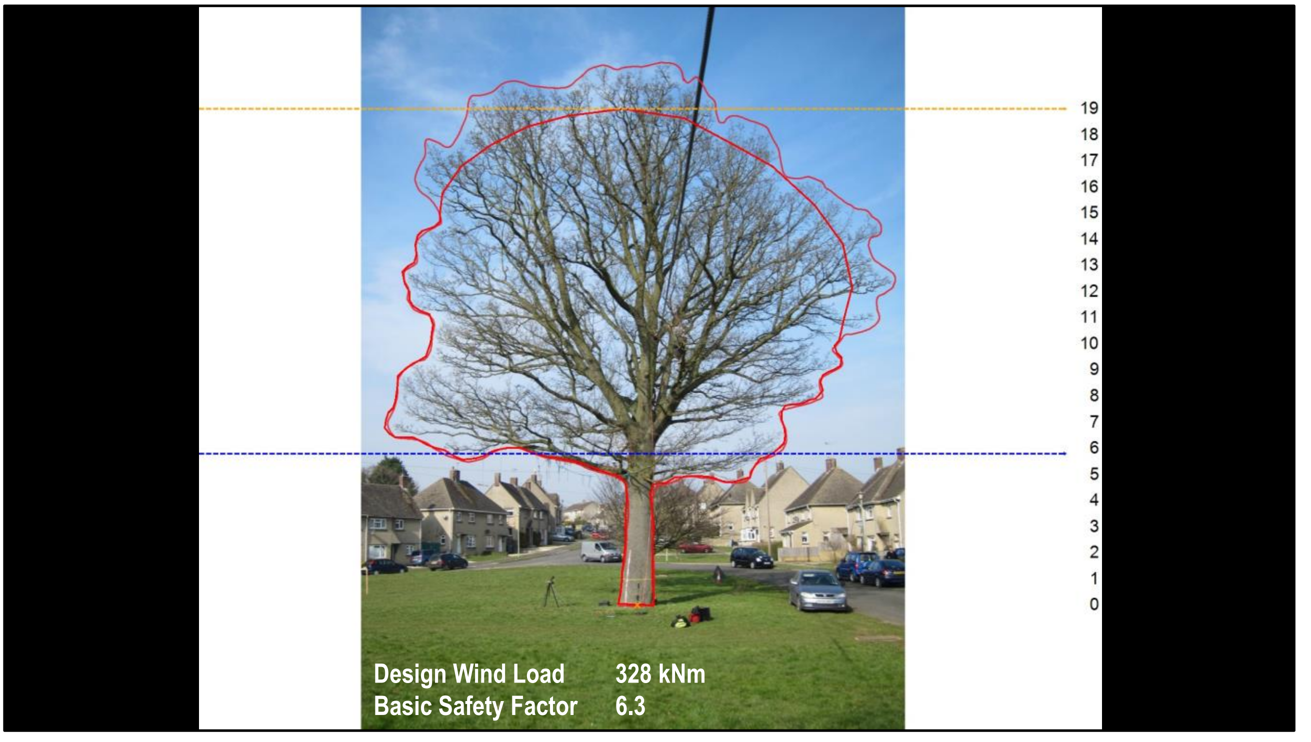
Design Wind Load 372 kNm
Basic Safety Factor 5.6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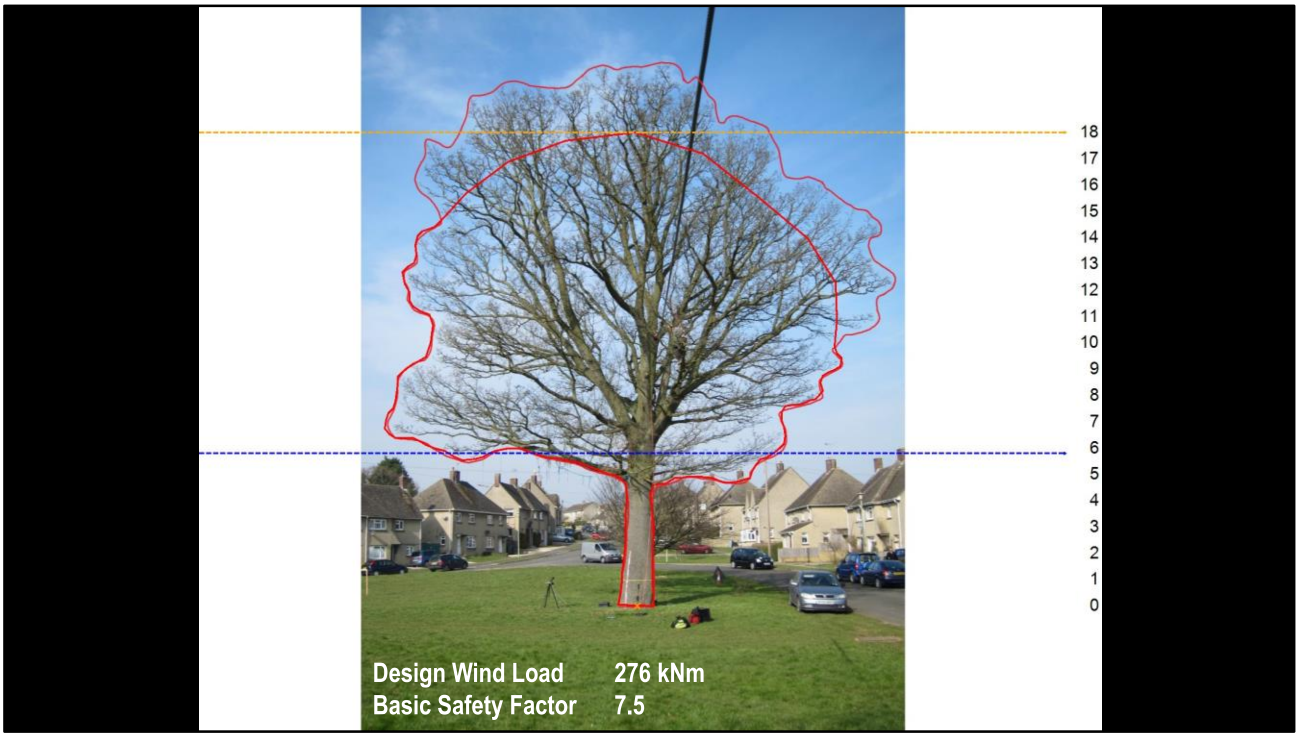
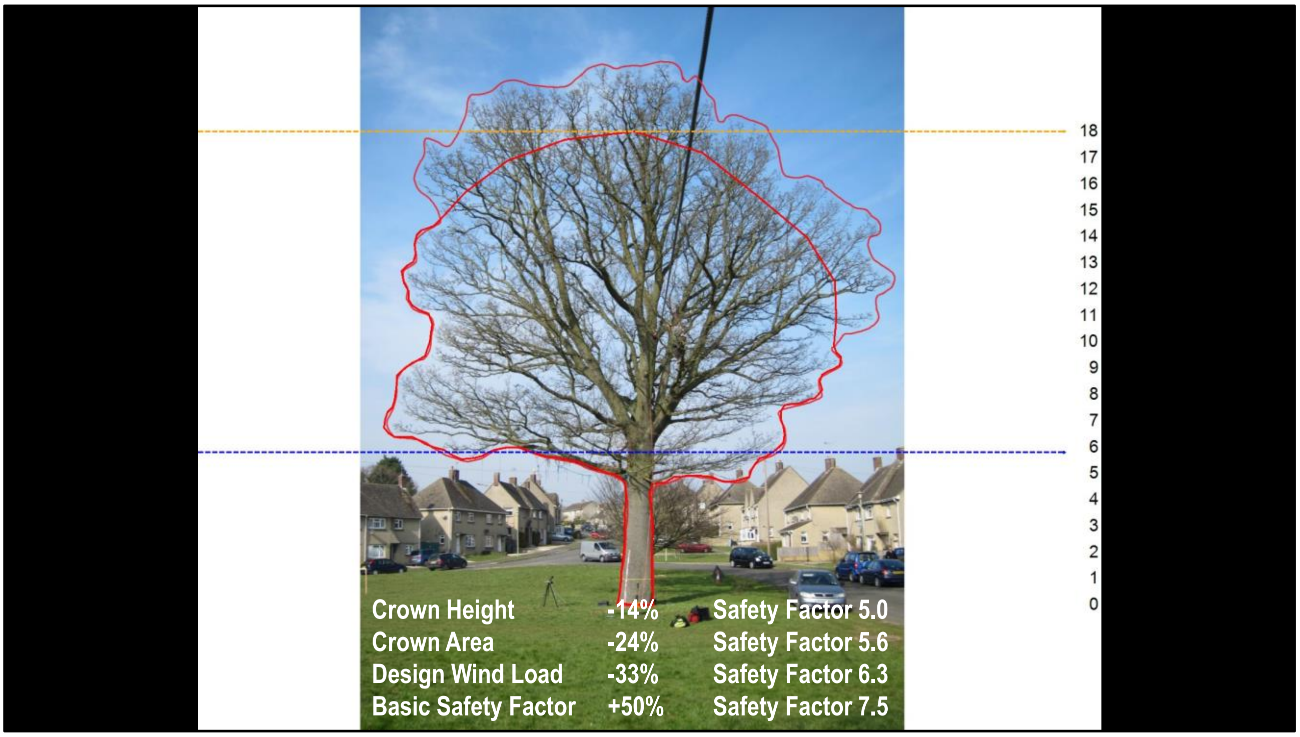
Design Wind Load 328 kNm
Basic Safety Factor 6.3



The design wind load falls from 413 kNm to 276 kNm.

The basic safety factor increases from 5.0 to 7.5.

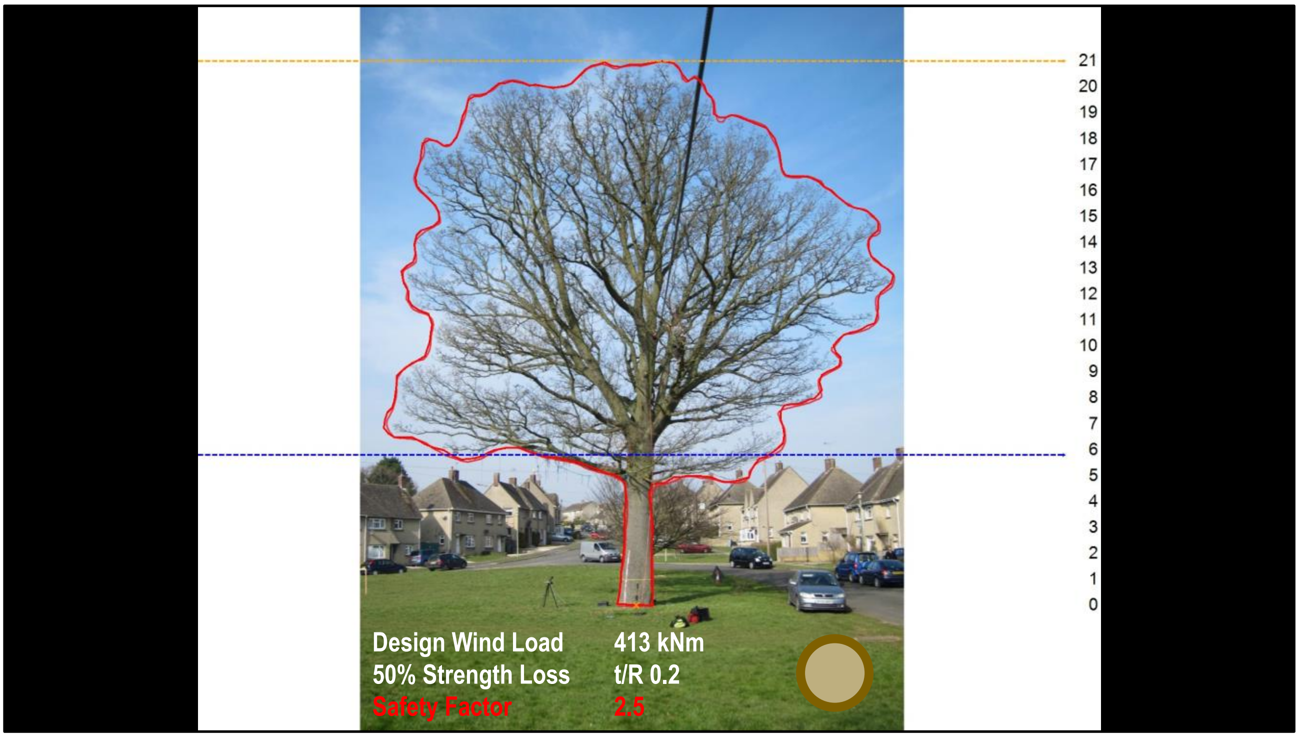


A small height reduction has a disproportionately large impact on the load and the safety factor.

Apparently these slides have been used in the U.S. to promote precautionary crown reductions.

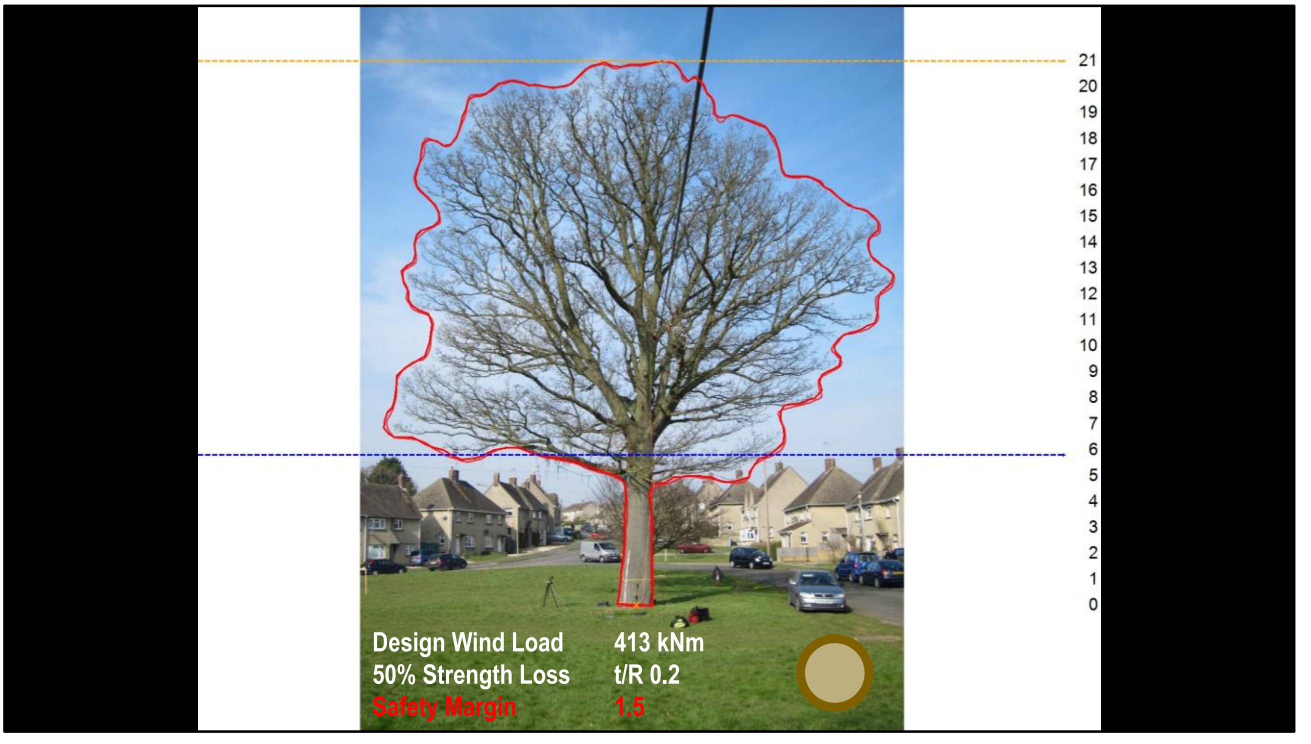
There's a fundamental problem with using these slides for that purpose.

Look at the impact of pruning on safety factors!



50% strength loss (a t/R ratio of 0.2 or hollowing equivalent to 80% of the stem diameter) would result in a residual safety factor reduced to 2.5 for the tree in this example.

No crown reduction would be required with that extent of decay.



So trees generally have margins of safety before defects are taken into account. Mature trees can have really high margins for safety.

They can consequently afford significant strength loss.

And pruning has a significant negative physiological impact.

There are consequences for water transportation.

Pruning is likely to kill roots.

There is a risk of localised cambial death.

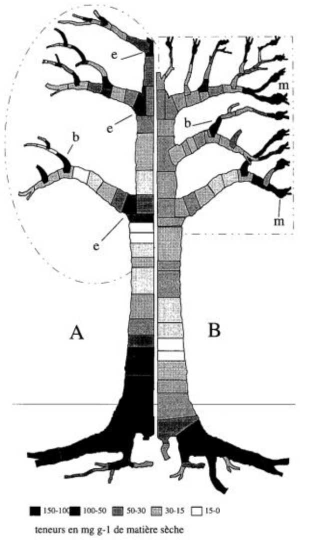


Figure 1. Comparative cartography of the distribution of starch in unpruned (A) and curtain-like pruning (B) plane trees. B: base of branches of 5-10 cm in diameter, c: trunk-branch junction, m:short head. Data correspond to monthly means setting up during two years.

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Clair-Maczulajtys, Le Disquet and Bory (1999)

There are implications for the movement and storage of starch reserves…

…and the removal of those parts to which carbohydrates have been moved during subsequent pruning operations.

And there will be a reduction in the resources available to produce adaptive growth.

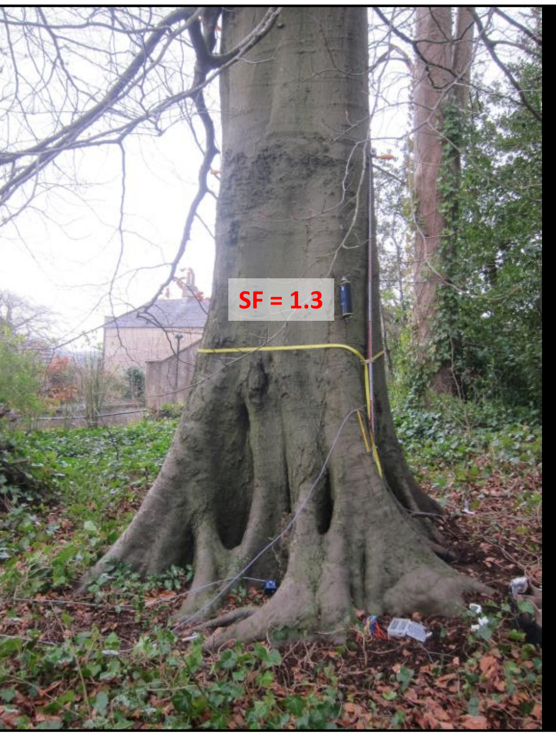
We shouldn’t be so casual about prescribing pruning as a precautionary measure.

We can often show that a crown reduction is unnecessary.

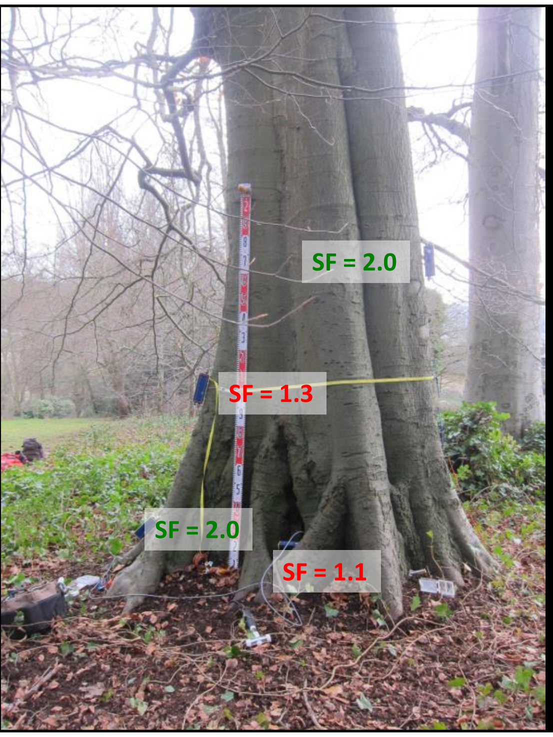
There are physiological costs to the tree.

There are long-term implications for the relationship between the tree and the development of decay. Pruning promotes and accelerates the spread of decay.

So this is the approach that we would take when testing trees.



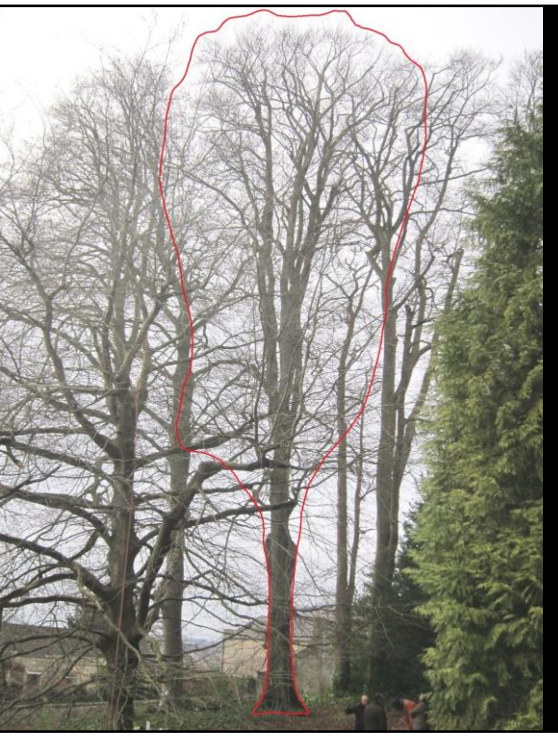
This tree fails the test with significantly reduced safety factors, that fall below the minimum threshold of 1.5, at around 1.0-1.2 m on the stem.



…and has a lowest safety factor for uprooting of 1.1.

This tree has decay processes involving both *Ganoderma* sp. and *Kretchmaria deusta*.

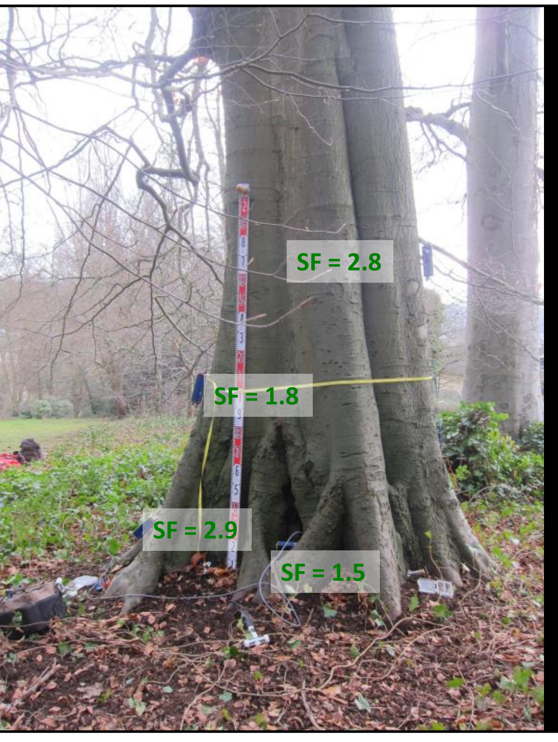
The tree has been managed by a consultant for over a decade with the aid of tomography, up to the point that he no longer felt confident to retain it, and he asked us to offer data to support his intuitive understanding that the tree could still be retained.



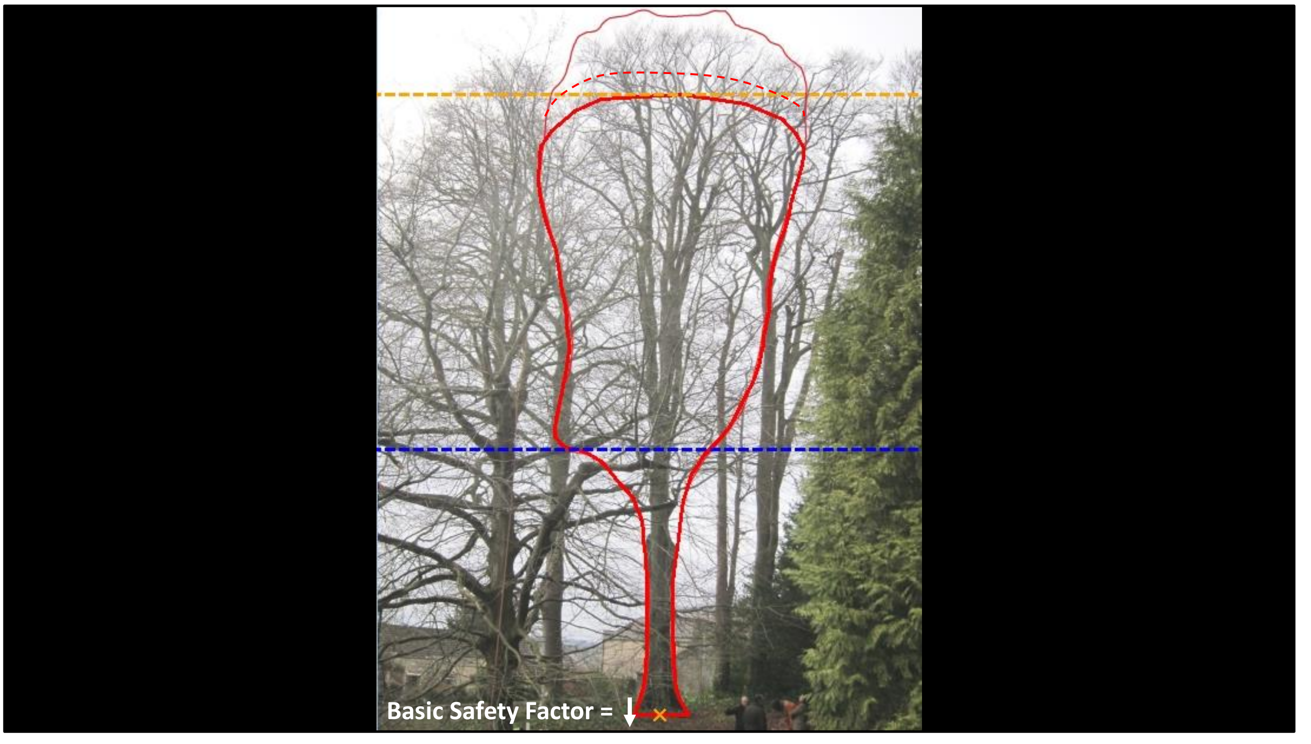
We could reduce the load by pruning.

The model shows this is the level of pruning required to increase the lowest safety factor (for uprooting) from 1.1 to the minimum required at 1.5.

The crown reduction reduces the design wind load and increases the basic safety factor…



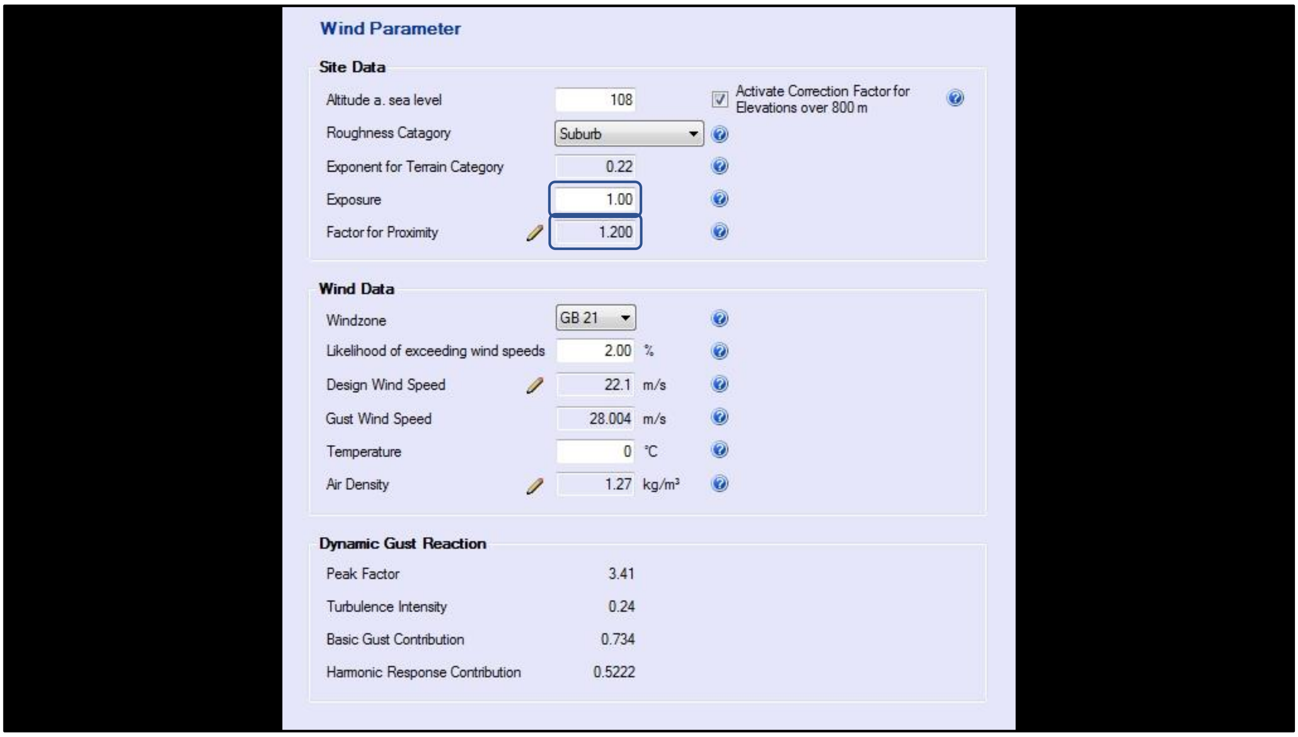
…and with a reduced load all of the other tested residual safety factors increase proportionally.



But the crown grows back.

Very quickly the tree dips back below the 1.5 safety factor threshold.

At the same time the physiological impact of the pruning is likely to have implications that support an acceleration of the development of decay.



The safety factors that have been presented to this point have been based on the standard wind load analysis model for a tree in the suburbs.

The model is conservative.

A default factor for proximity of 1.2 increases gust wind speeds generated from adjacent buildings by 20%.

There are no buildings adjacent to this tree.

An exposure factor of 1.0 assumes no shelter - the whole crown is exposed to the forces exerted by the wind.

This tree is part of a close group.

Instead of pruning we can “reduce” the wind load simply by attempting to more accurately quantify it.

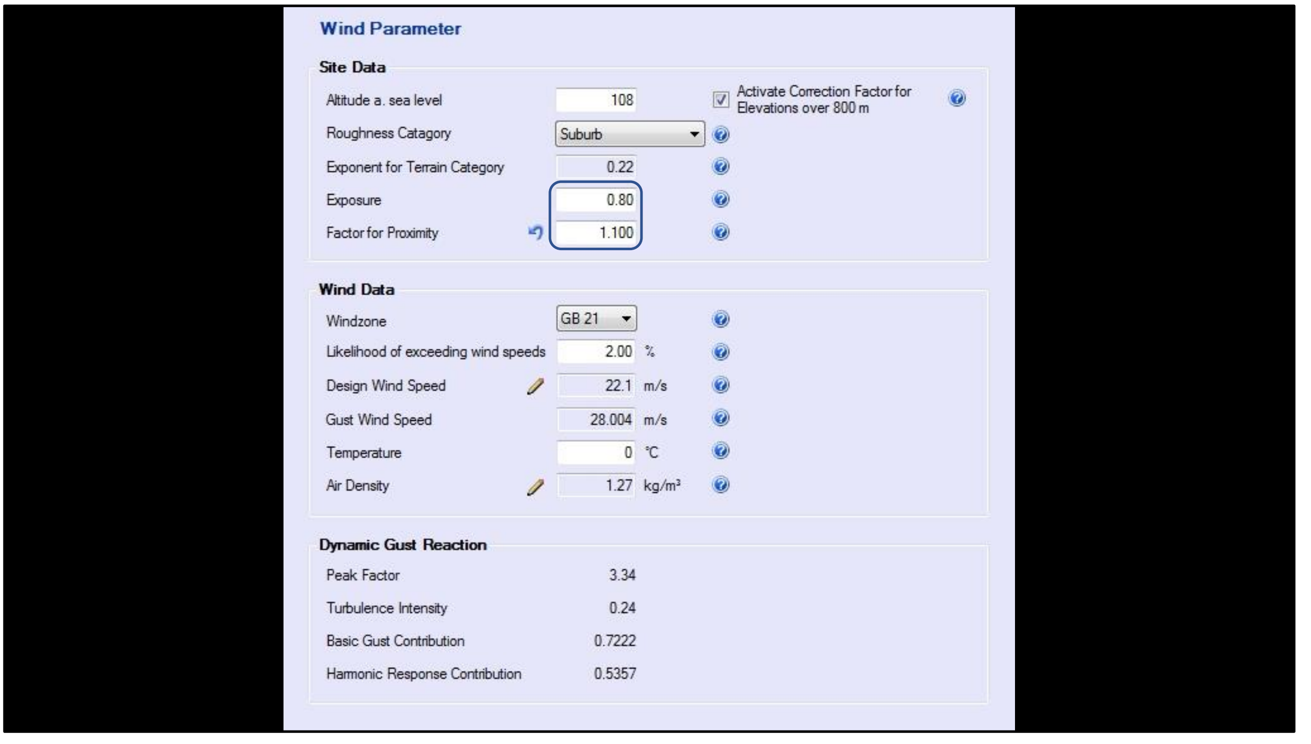
Most of us consider the wind interacting with a tree crown in terms of the wind pressure against the face of the crown. The idea of the crown as a sail.

However forces are also transferred to the crown in terms of friction as wind flows over the crown periphery.

And vortex shedding or drag occurs as the wind pulls the tree along with the flow.

These are approximately equal components of the total force exerted by the wind on the tree.

So wind pressure only accounts for a third of the resulting moment at the base.

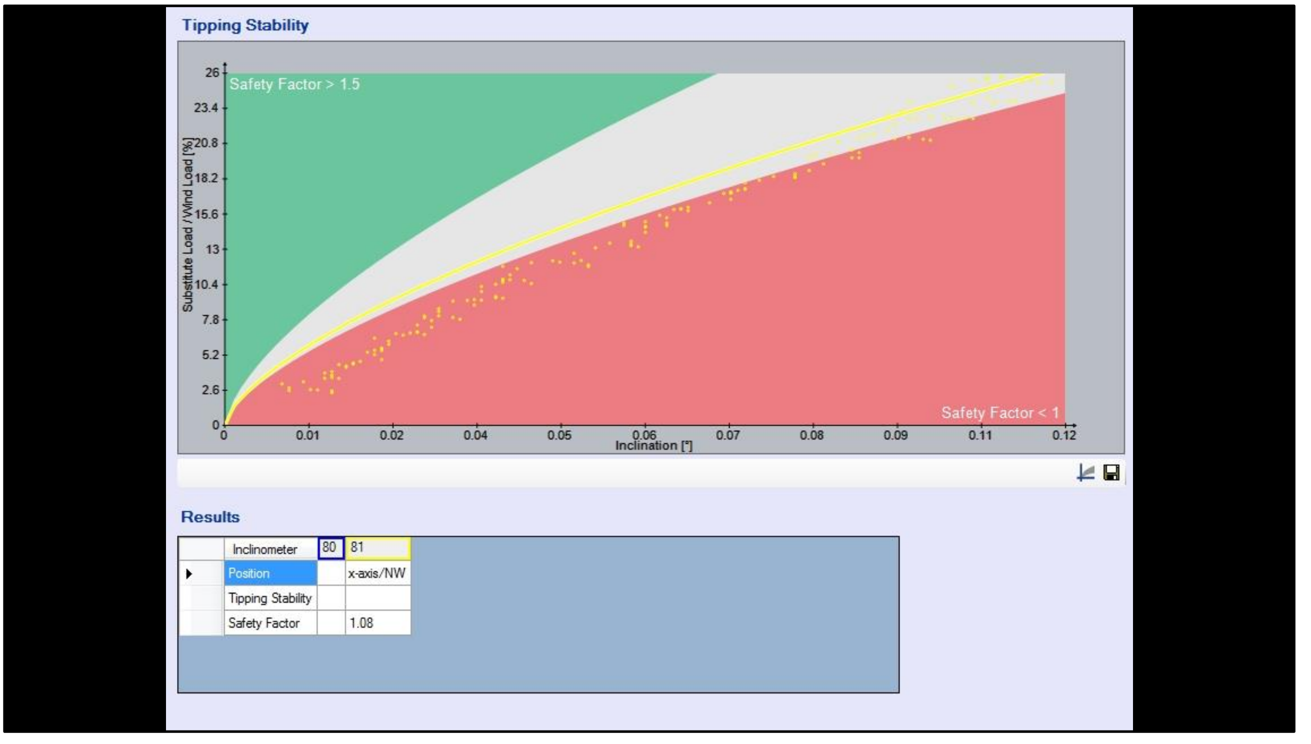


In this example we can confidently reduce the factor of proximity from 1.2 to 1.1, consistent with the open countryside roughness category (where gusts from adjacent trees are incorporated into the wind load analysis).

We can also reduce the exposure factor from 1.0 to 0.8 consistent with the trees on either side of the subject tree reducing the friction component of the wind.

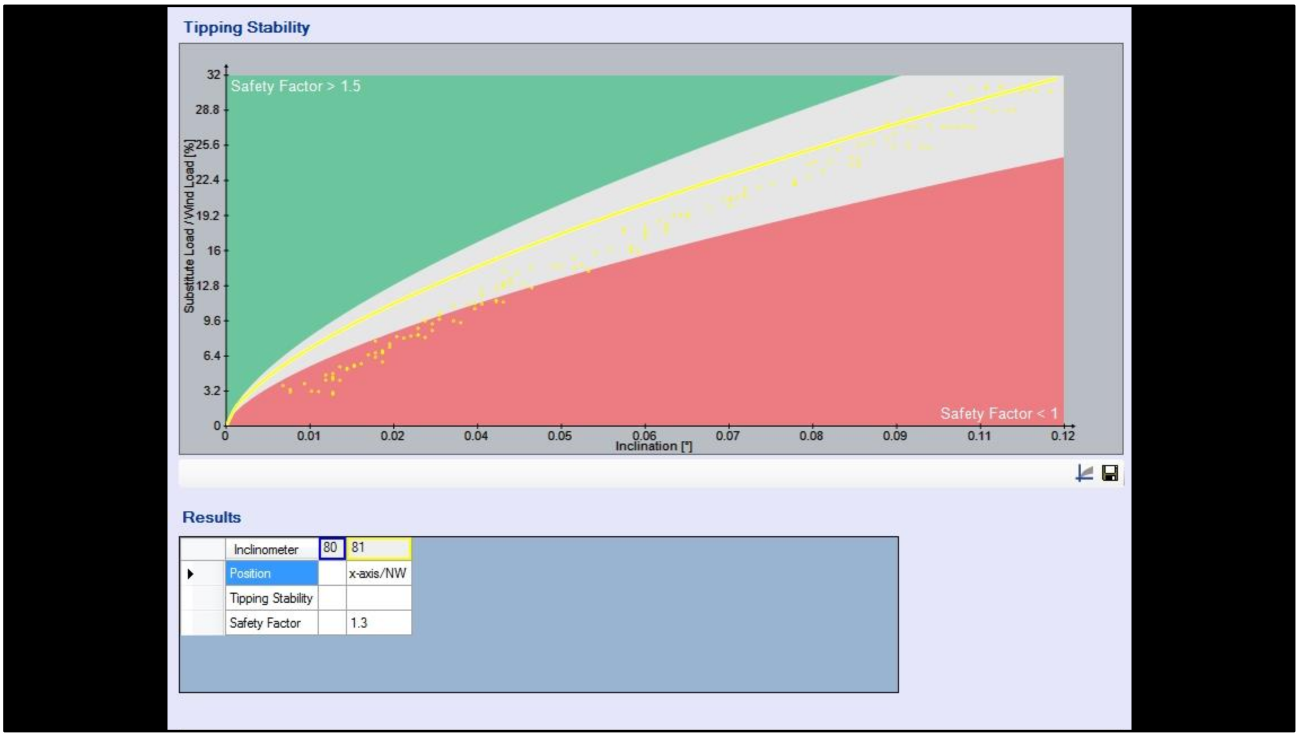
This shows the impact of adjusting the factor for proximity, followed by the exposure factor, on the design wind load and the basic safety factor within the wind load analysis.

Of course, all of the measured residual safety factors increase proportionally with the reduced design wind load.

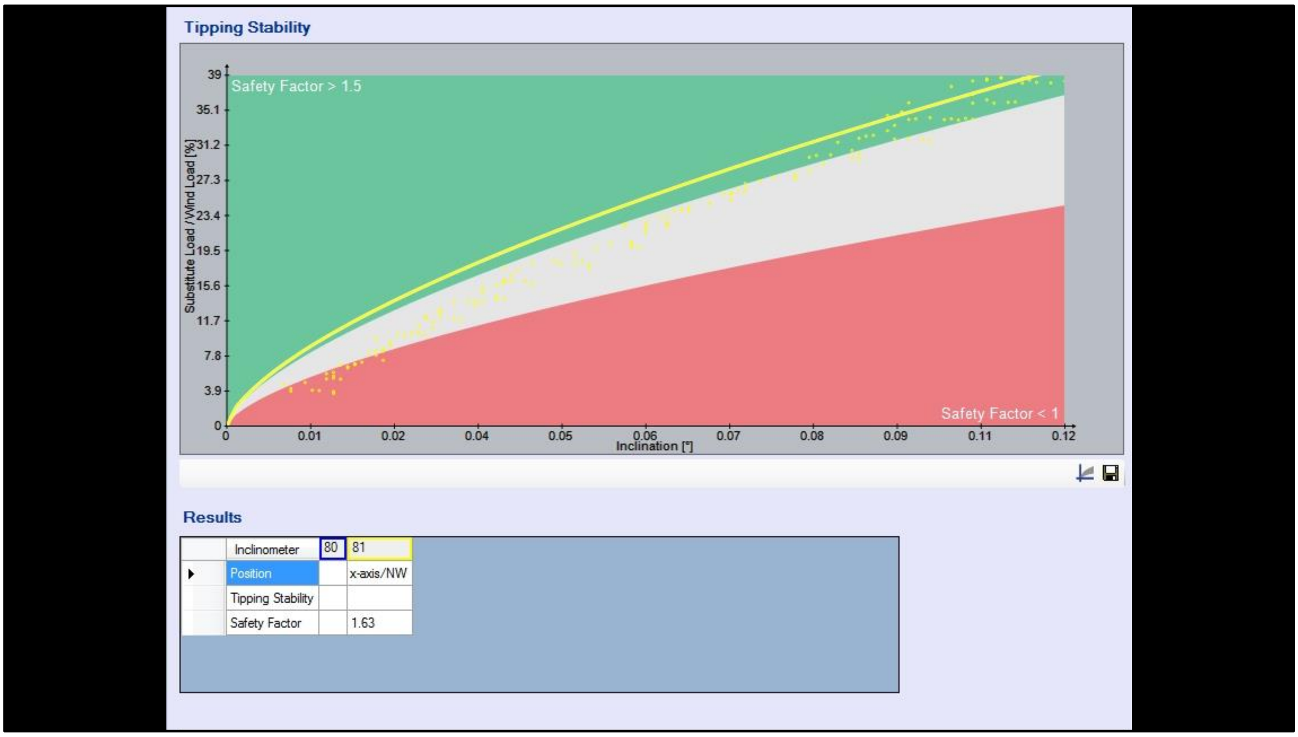


This shows the impact of those adjustments on the lowest uprooting safety factor.

The original residual safety factor for uprooting of 1.1…



…is increased to a residual safety factor of 1.3 following the adjustment to the factor of proximity…



…and to a residual safety factor of 1.6 after taking account of the shelter afforded by the adjacent trees.

We have increased the lowest safety factor to an acceptable level without pruning. We have just given some careful thought to what the wind load might reasonably be expected to be.

I realise that some of you may be uncomfortable with these changes, and with how much difference they can make. How can they be justified? What are they based on?

Actually these changes are probably conservative.

Take a step back and think of the basis of the model.

Remember that these are safety factors for a 1 in 50 year storm event.

We are requiring a safety margin. The threshold safety factor is 1.5.

And the safety factor is the point of no permanent material damage. If those thresholds are reached then the peripheral fibres in a stem permanently deform, or a slightly lower gust is required to keep increasing root plate inclination.

The tree - the whole structure - does not immediately and dramatically fail.

If we aren't entirely confident about these adjustments within the wind load analysis, or we want to base them on some reference data, then we can use Tree Motion Sensors.

We can compare the reaction of the tree in terms of inclination during a real wind event, to the reaction that we would expect to that event given that we have inclination recorded against a measured load from the static load test. We can deduce the impact of shelter on the inclination readings.

There are further considerations.

Here is a copper beech 27.5 m high with low basic safety factors of 3.3 and 3.7 according to the standard wind load analysis model. These seem to be unexpectedly low for a beech in the mature phase.

Meripilus giganteus fruiting bodies have been observed. Residual safety factors for uprooting were estimated to be between 2.0 and 3.0.

The tree does not fail the test. But we don’t know how quickly this situation might change, and the margins are not very comforting.

But the tree is surrounded by three and four storey buildings.

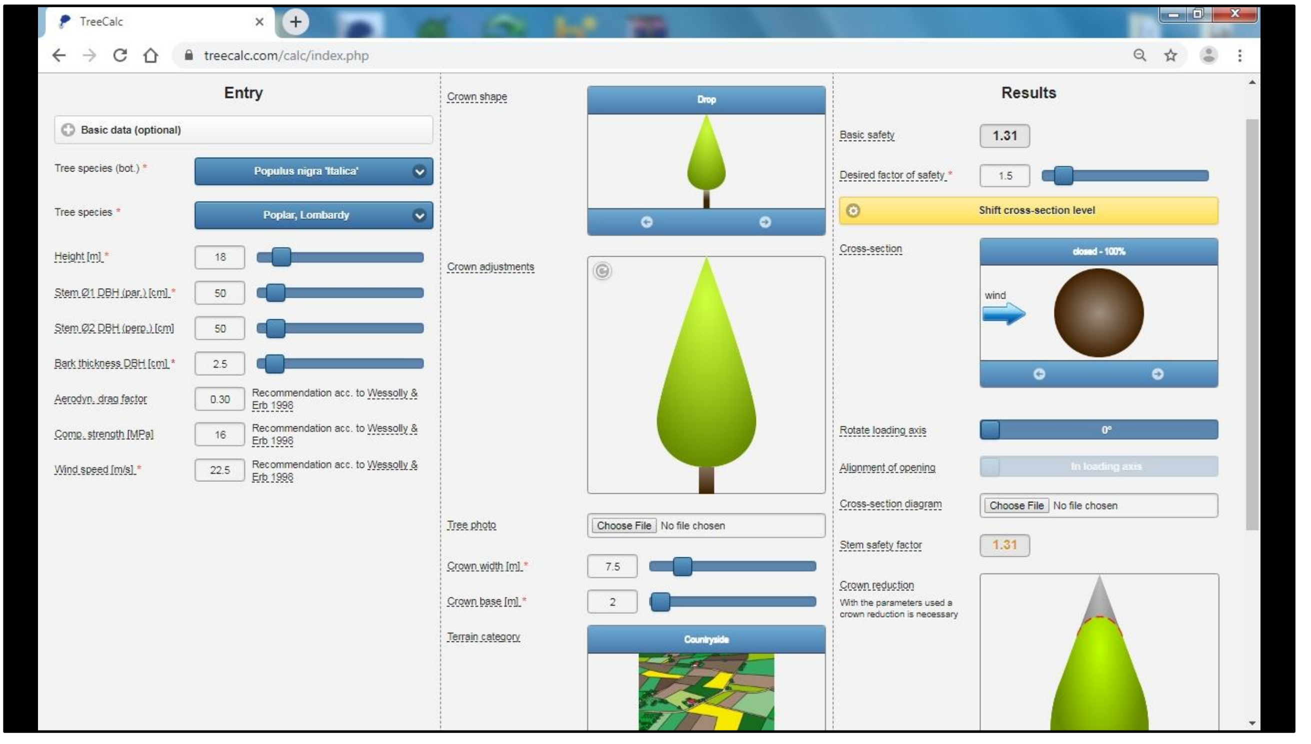
The factor proximity can confidently be reduced from 1.2 to 1.1 because the buildings are not close enough.

If we reduce the exposure factor to 0.85, then basic safety factors increase to 4.6 and 5.3. These seem to be more reasonable for a tree at this point in development.

Residual safety factors for uprooting are now between 3.0 and 4.0.

This changes how confident we might feel about the management recommendations that we make.

But remember the tree already passed the test with the precautionary, default factors. We are not making rash decisions or operating at the margins of the model.



Some defect-free trees will not meet the failure criteria demanded by the model.

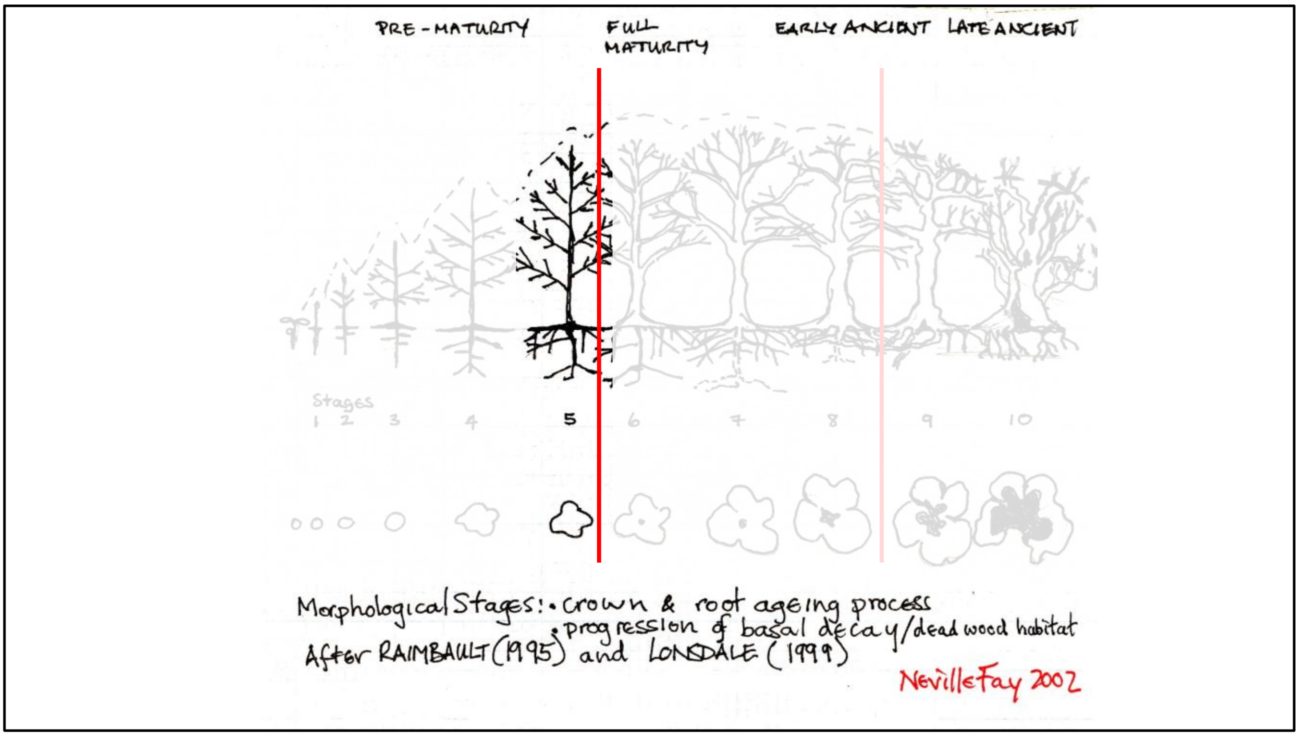
One could choose to use this to discredit the approach.

But the model is conservative. The threshold safety factor of 1.5 is precautionary.

The mutual shelter offered, for example, by a row of trees in line with the prevailing wind is not incorporated into this calculation. Accounting for shelter increases the safety factor.

But these are positive attributes not problems!

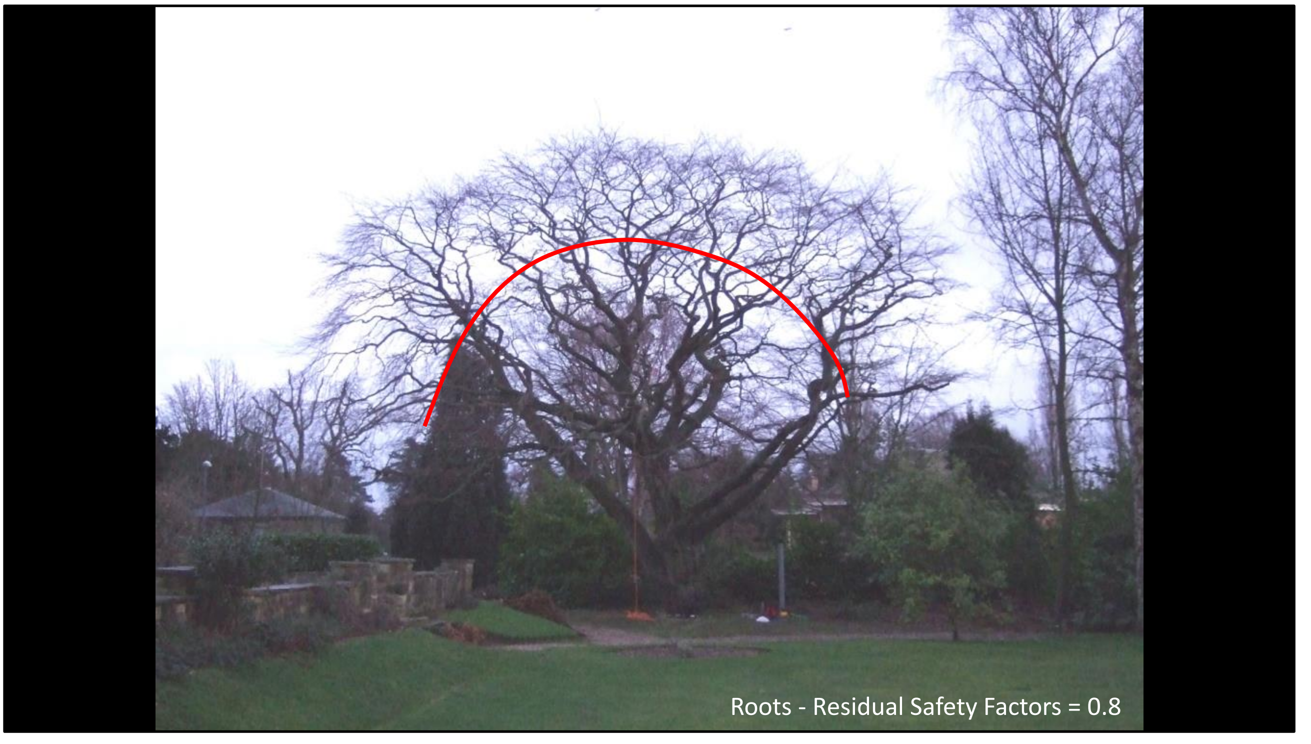
To apply the model appropriately it is essential to understand the circumstances within which it holds, how the elements interact, what the outputs mean. The results sometimes need to be modified. They always need to be interpreted.



And actually a low basic safety factor in this scenario is realistic and to be expected.

Trees prior to early maturity have very low safety factors. They can't afford defects. They are operating close to the margins in structural terms.

And if you are happy to leave these trees unpruned, it makes no sense to prune mature trees with much higher residual safety factors.



The results from a static load test make it very clear when a tree needs to be felled.

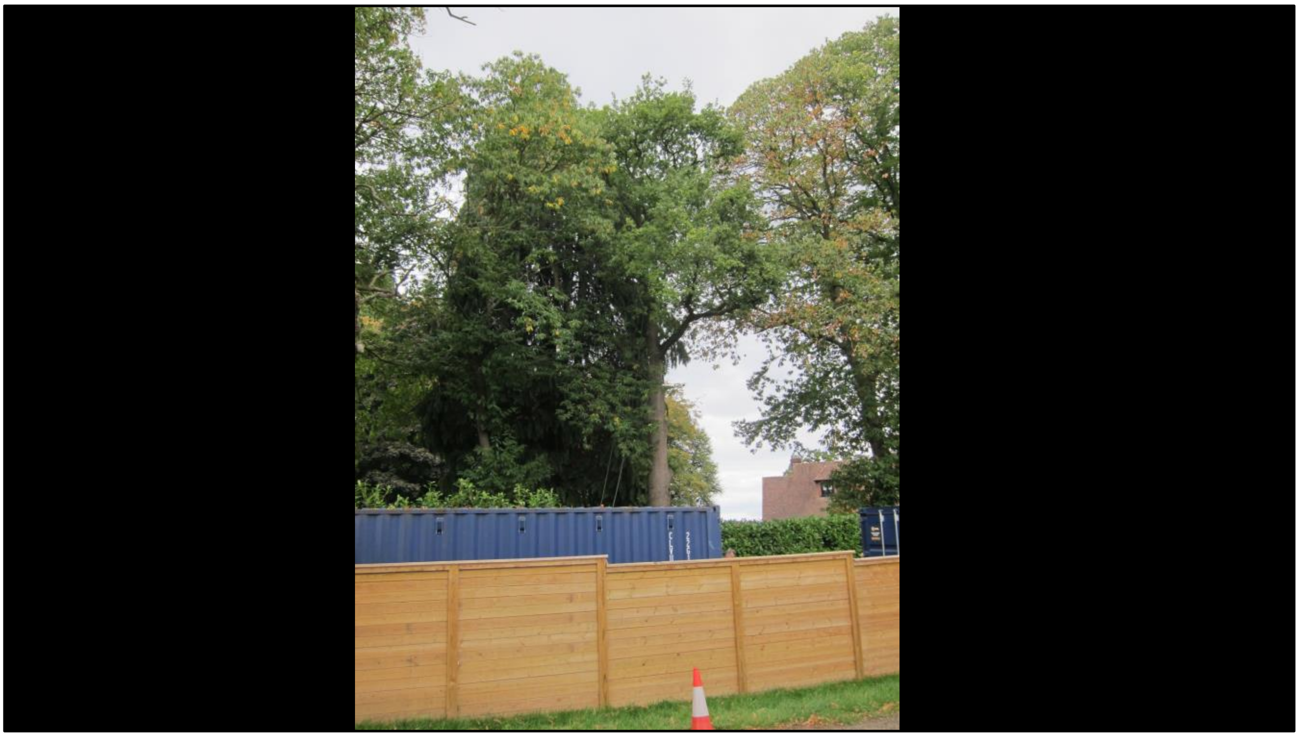
This tree had root decay issues that would have required a very significant crown reduction.

Our recommendation was that this was not viable…

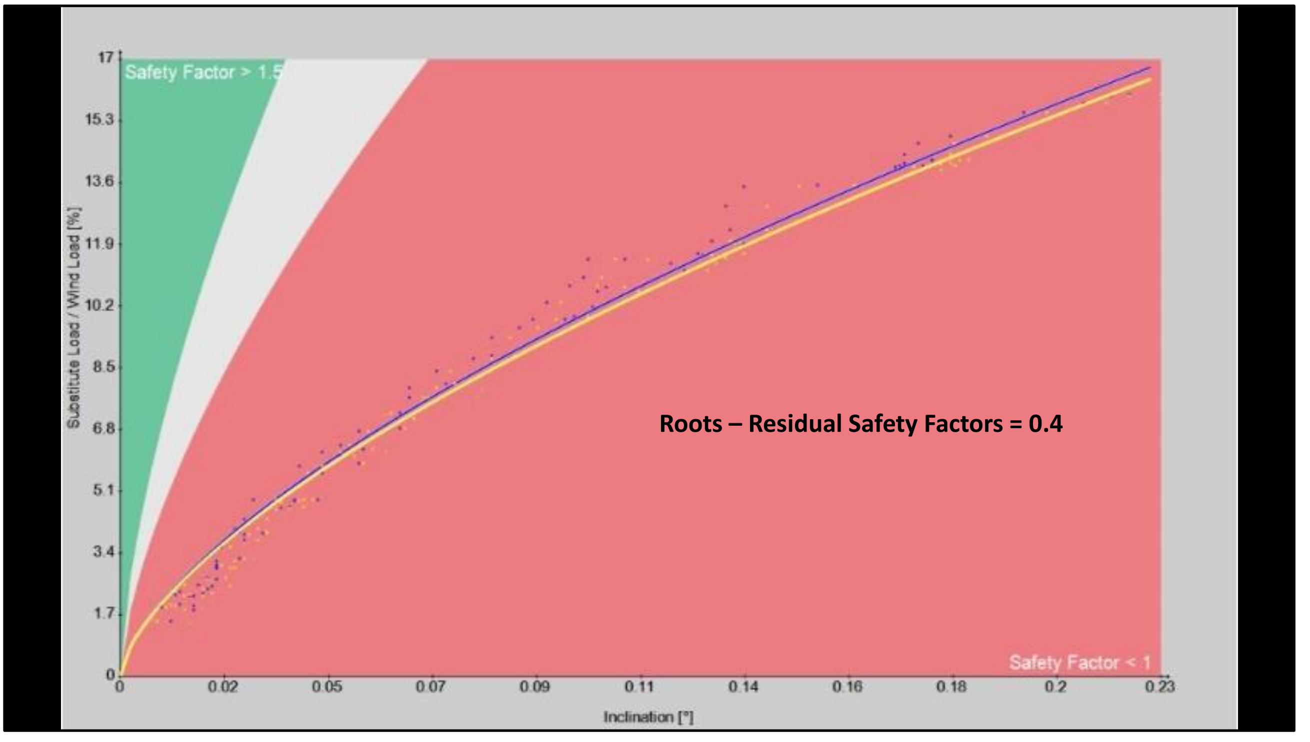
…but the client questioned the basis on which we had made our recommendation.

We tested an avenue of trees adjacent to which a new drive had been installed.

All the trees had sufficient, and fairly unaffected safety factor, which was not a particular surprise given our experience of the test…



Apart from the last tree tested!

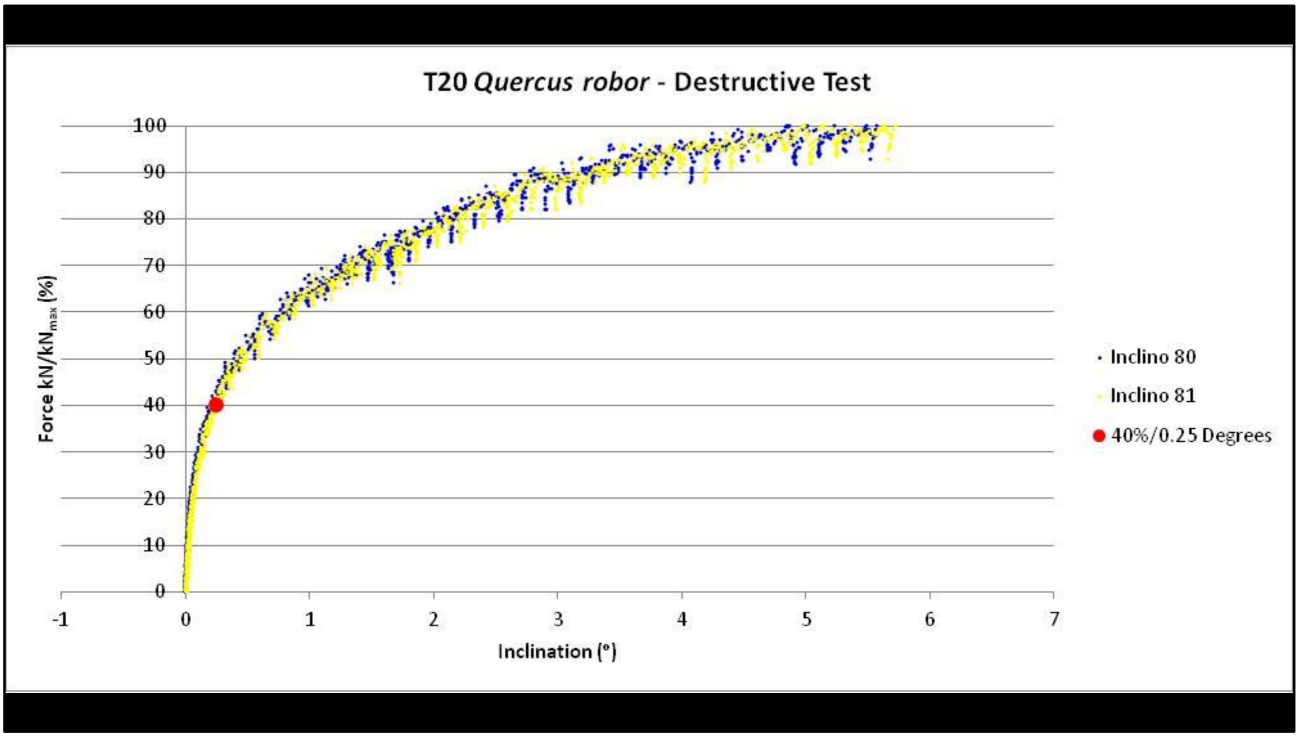


This tree had a residual safety factor of 0.4.

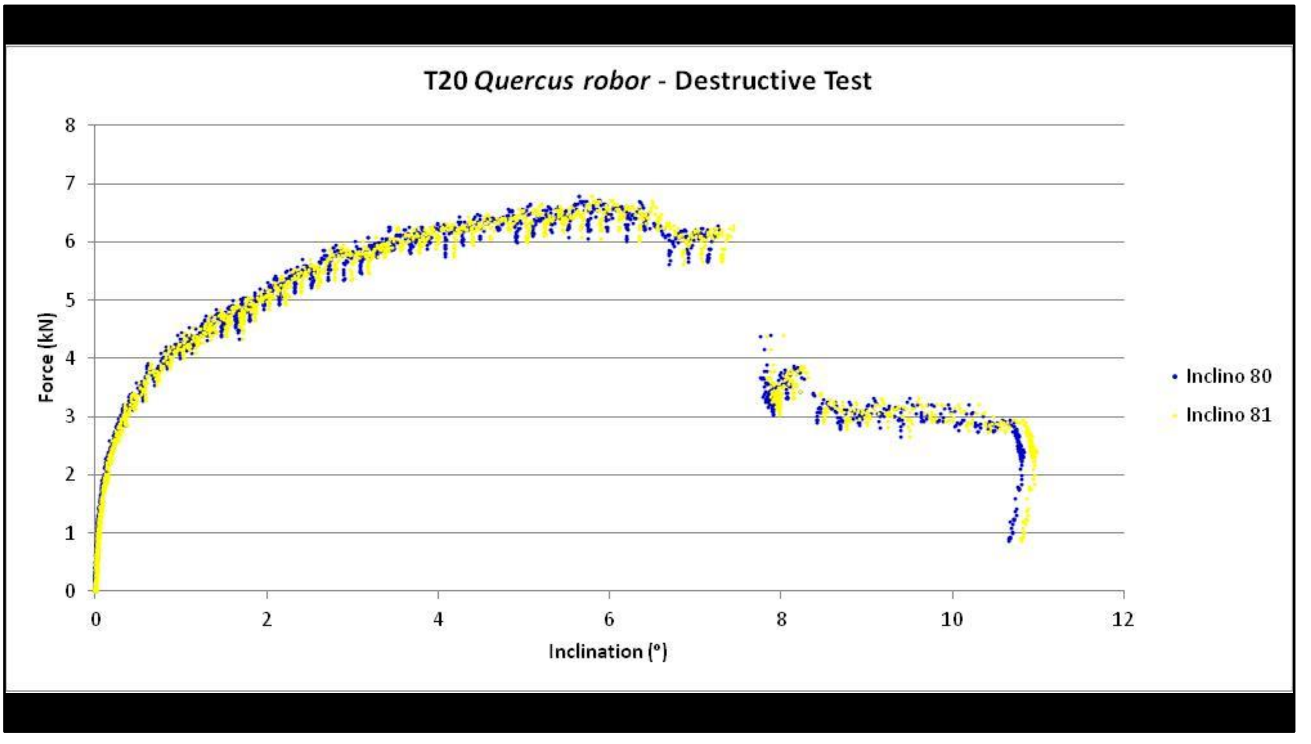
0.25º inclination (the limit applied during any test to avoid root damage) was reached at 4 kN (only 0.4 tons).

Excavations showed why.

We took the opportunity to carry out a destructive test…



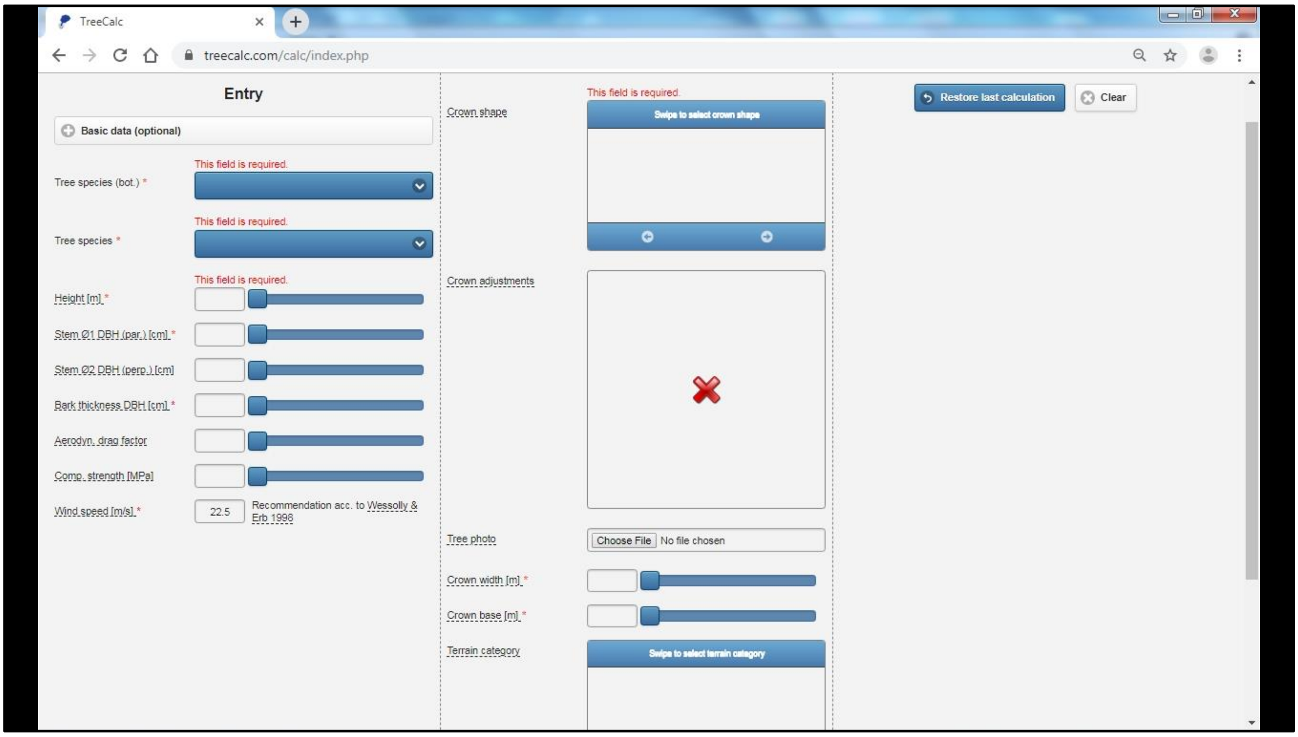
...and got some great data that verified the generalised tipping curve.



Peak force applied was just over 6 kN.

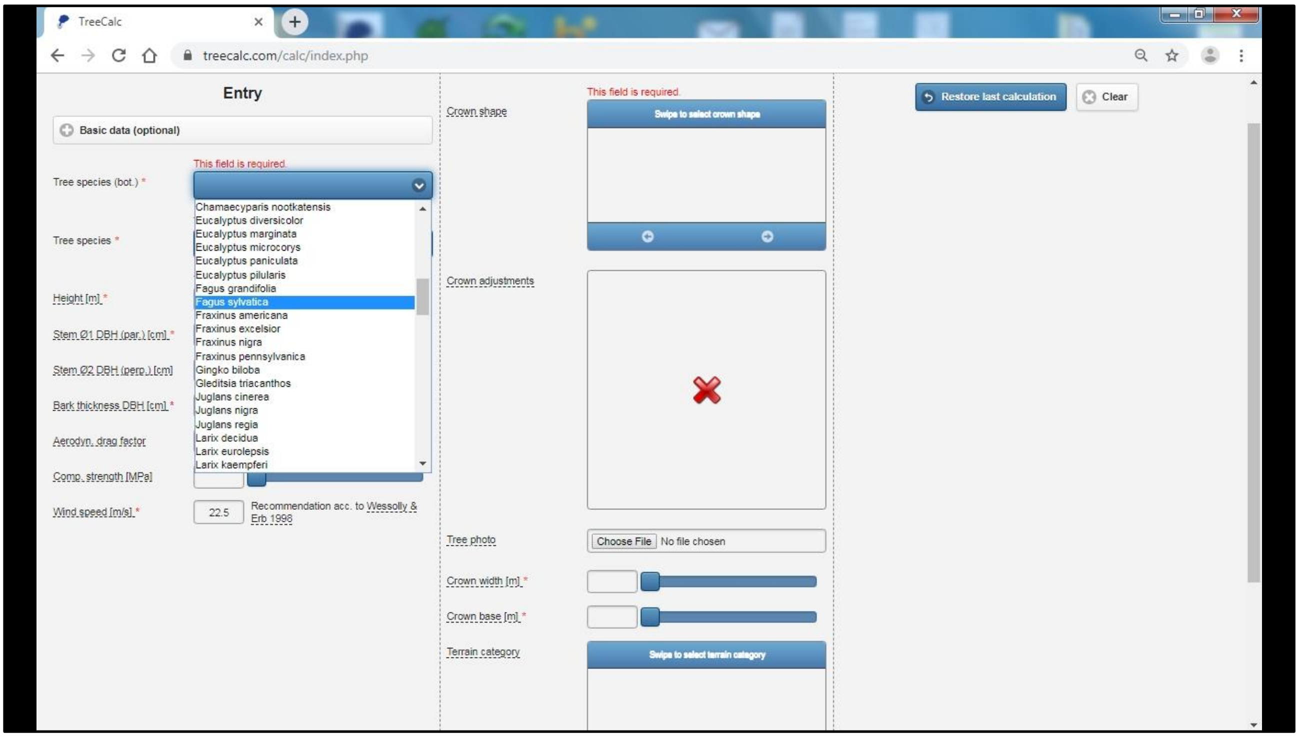
A major root broke at 8º

Beyond this point 3 kN was needed to keep pulling tree over.

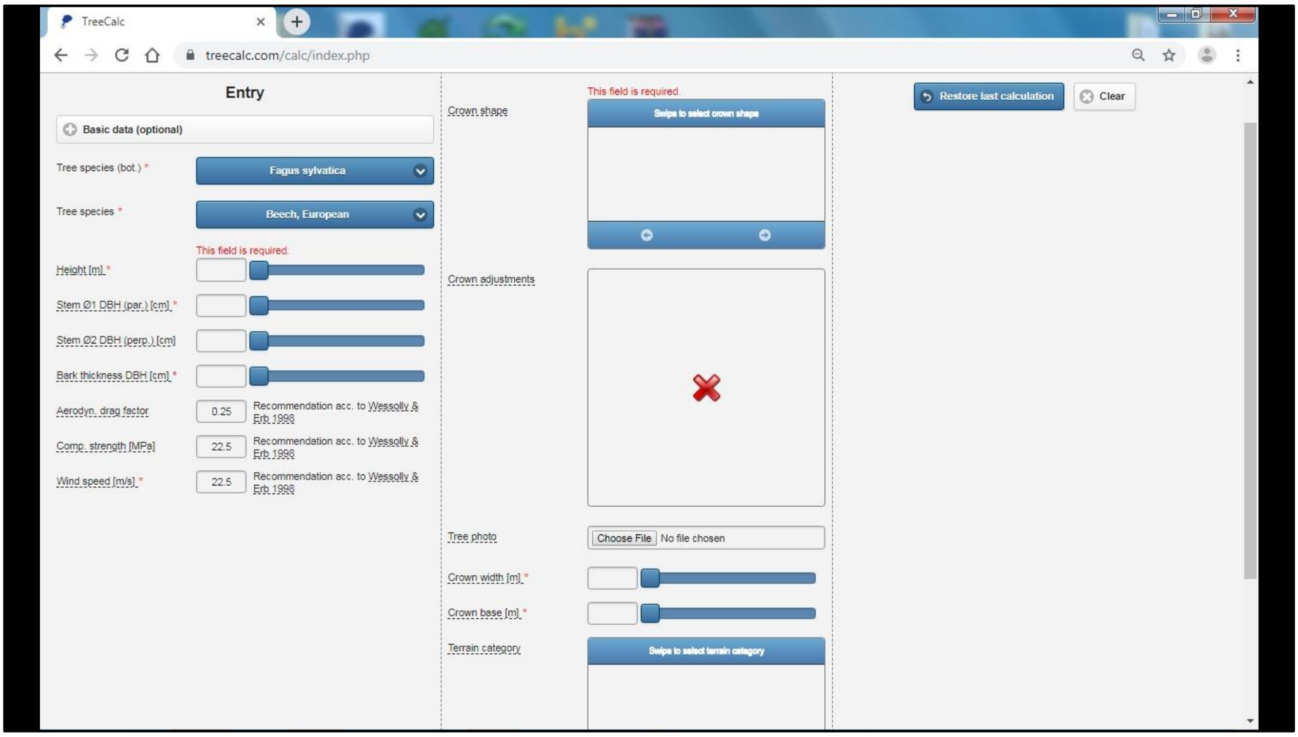


So here's a tool that you can use to help give you the confidence not to prune a tree.

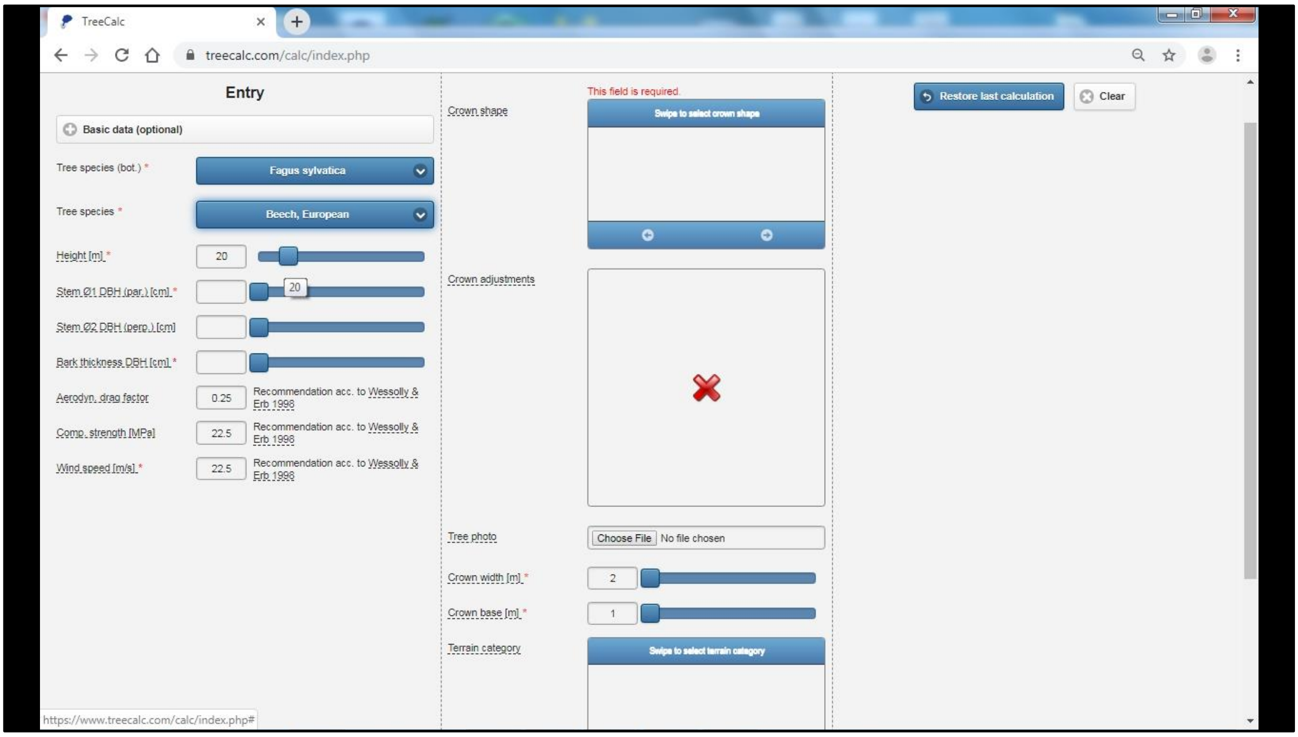
There’s a link on our website (it isn’t our software).



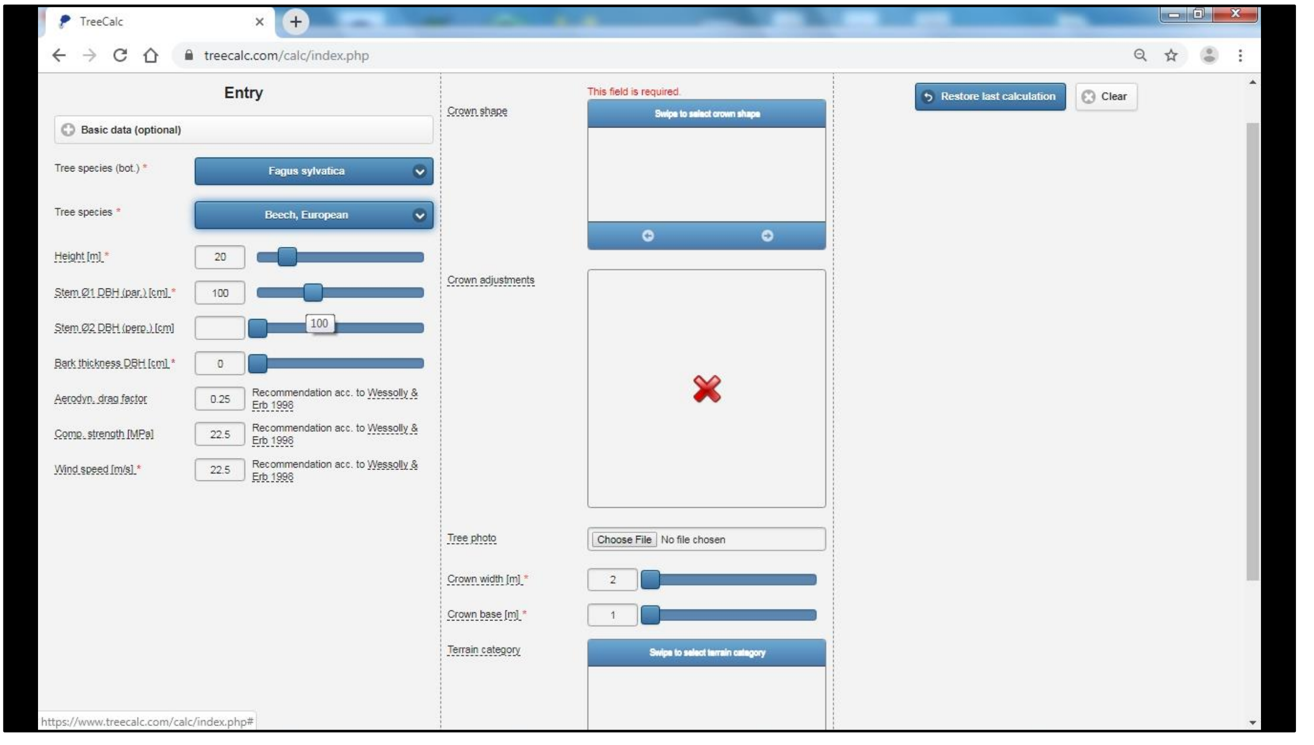
Populate the tree species.



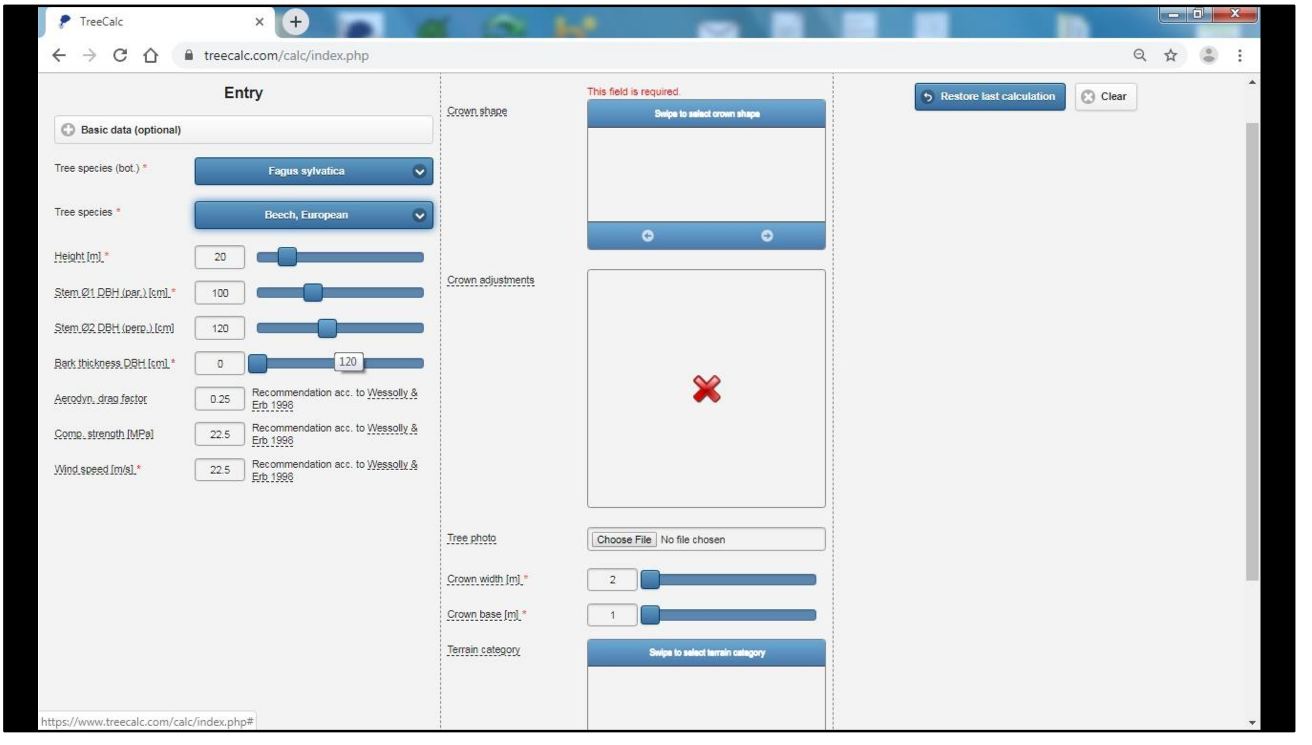
The drag factor and compressive strength for that species are auto-filled…but these can be changed according to other sources, if required.



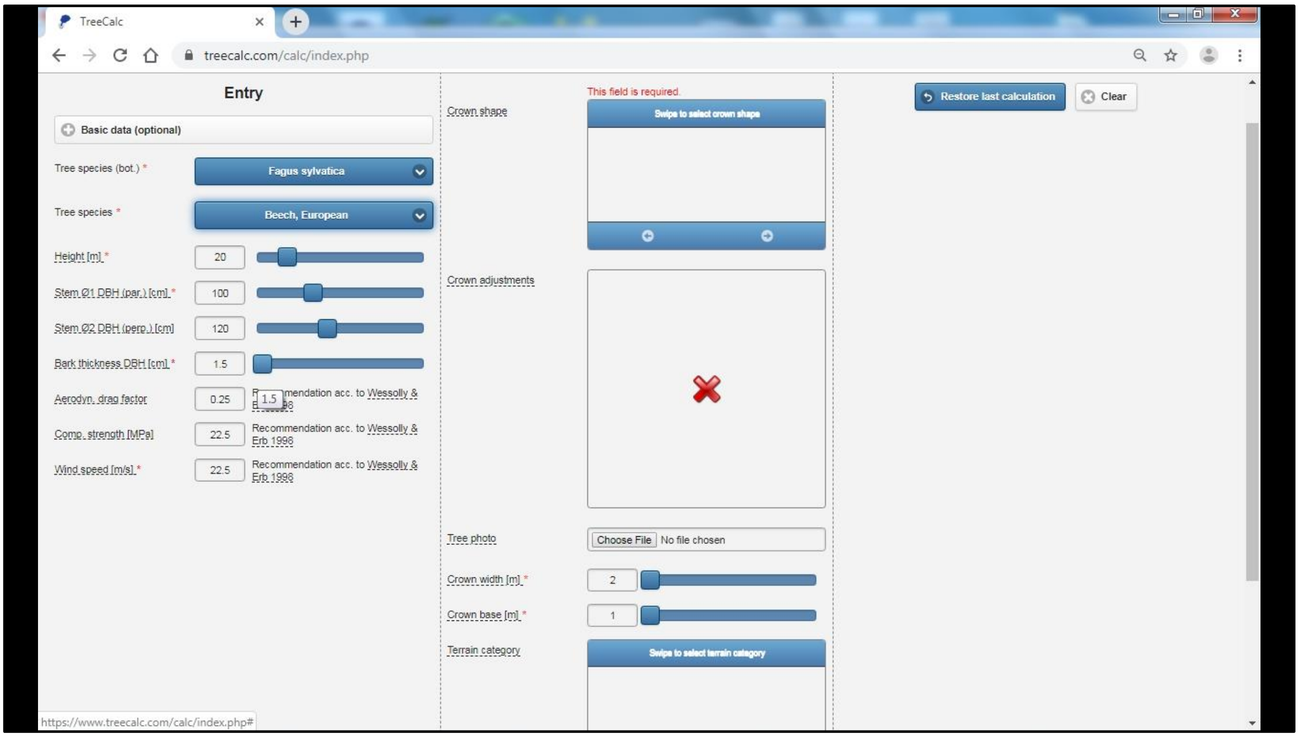
Populate basic dimensions…height…



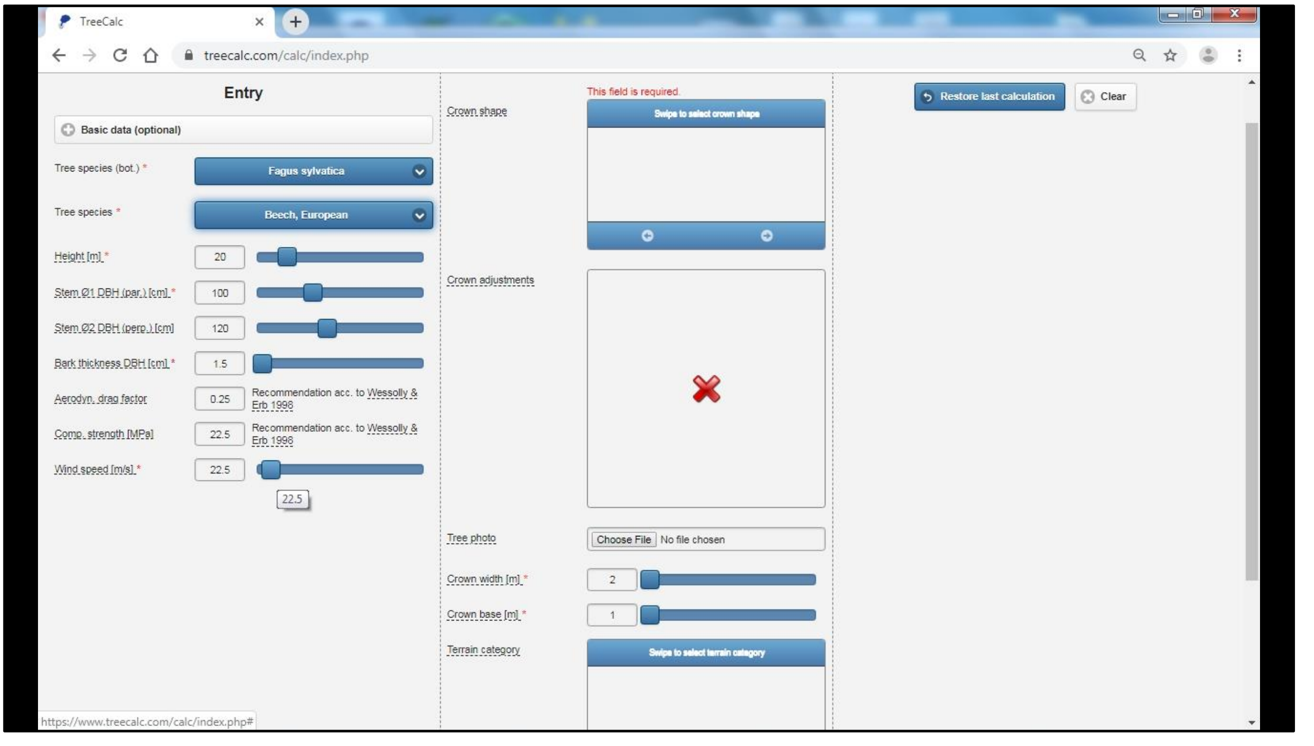
…stem diameter parallel to the load direction…



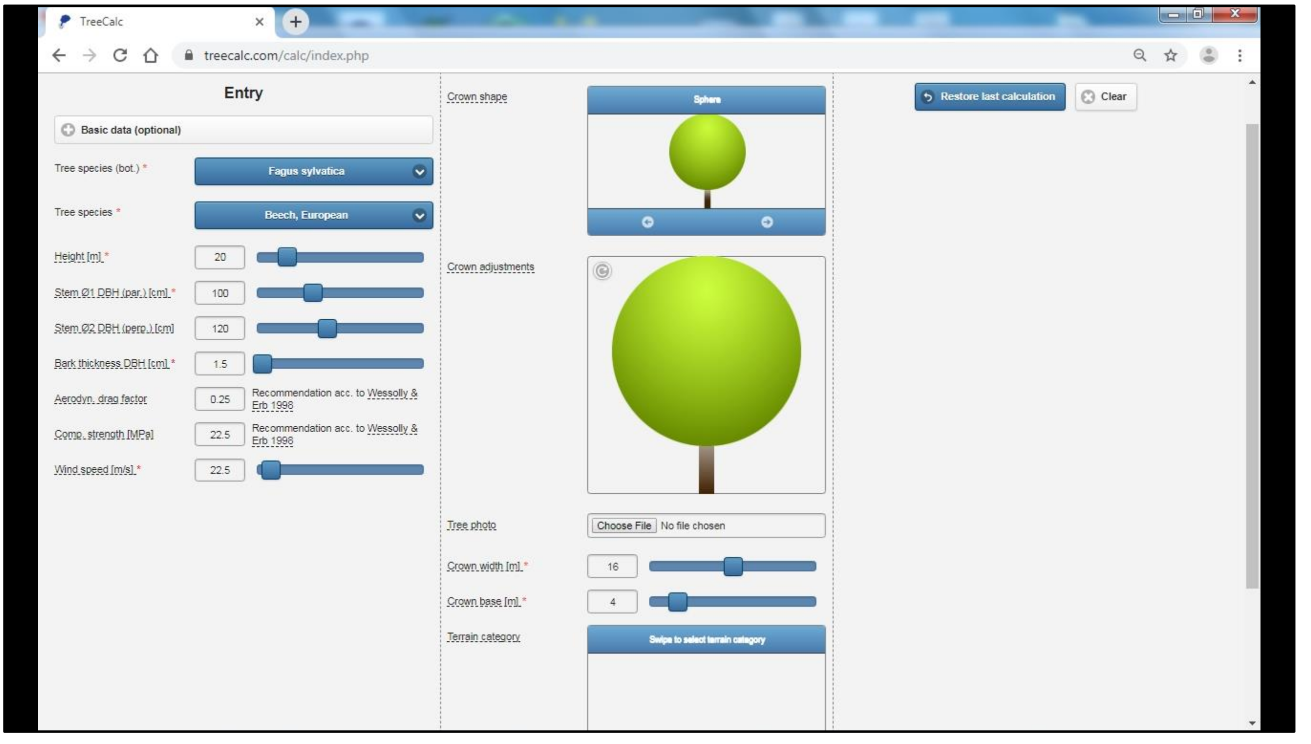
…stem diameter perpendicular to the load direction, to define an elliptical stem shape…



…and bark thickness (bark is not load bearing and needs to be excluded).

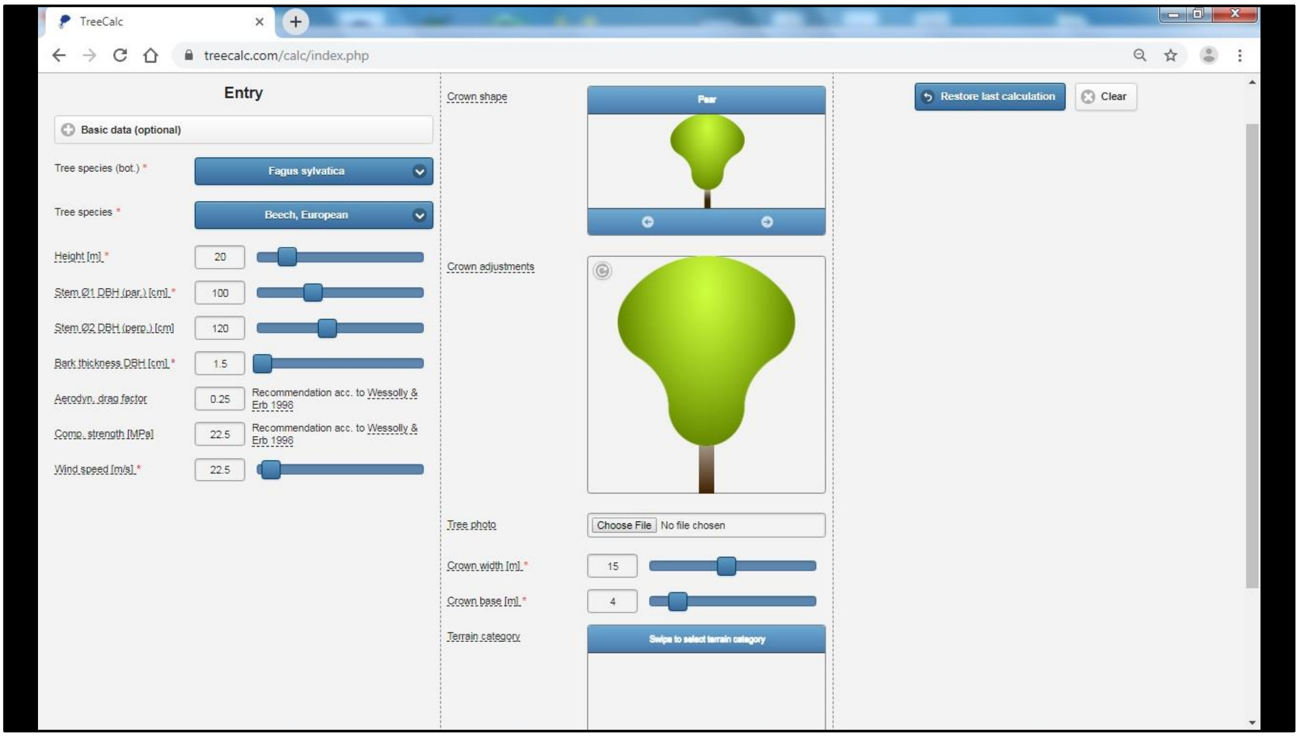


TreeCalc defaults to mean wind speeds consistent with the bottom of a Beaufort 12 storm event, but this can be altered according to the relevant wind zone.

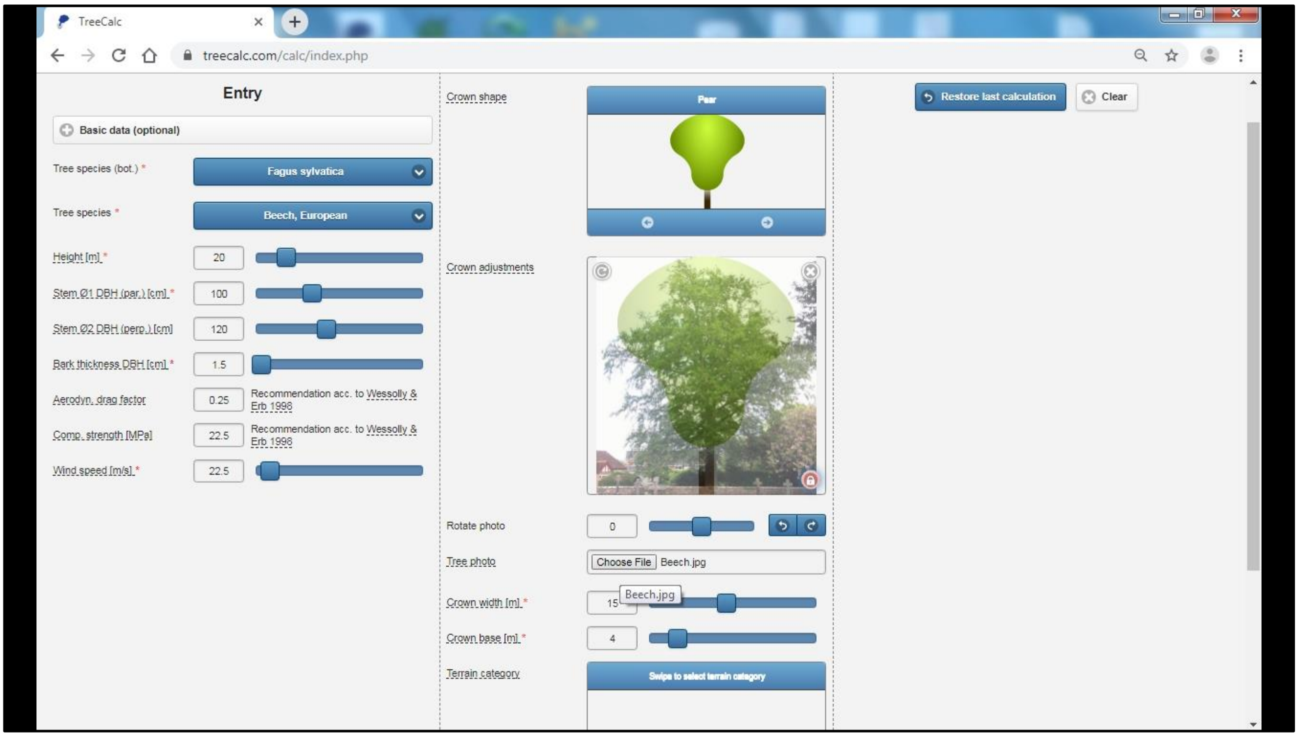


Choose an appropriate crown shape.

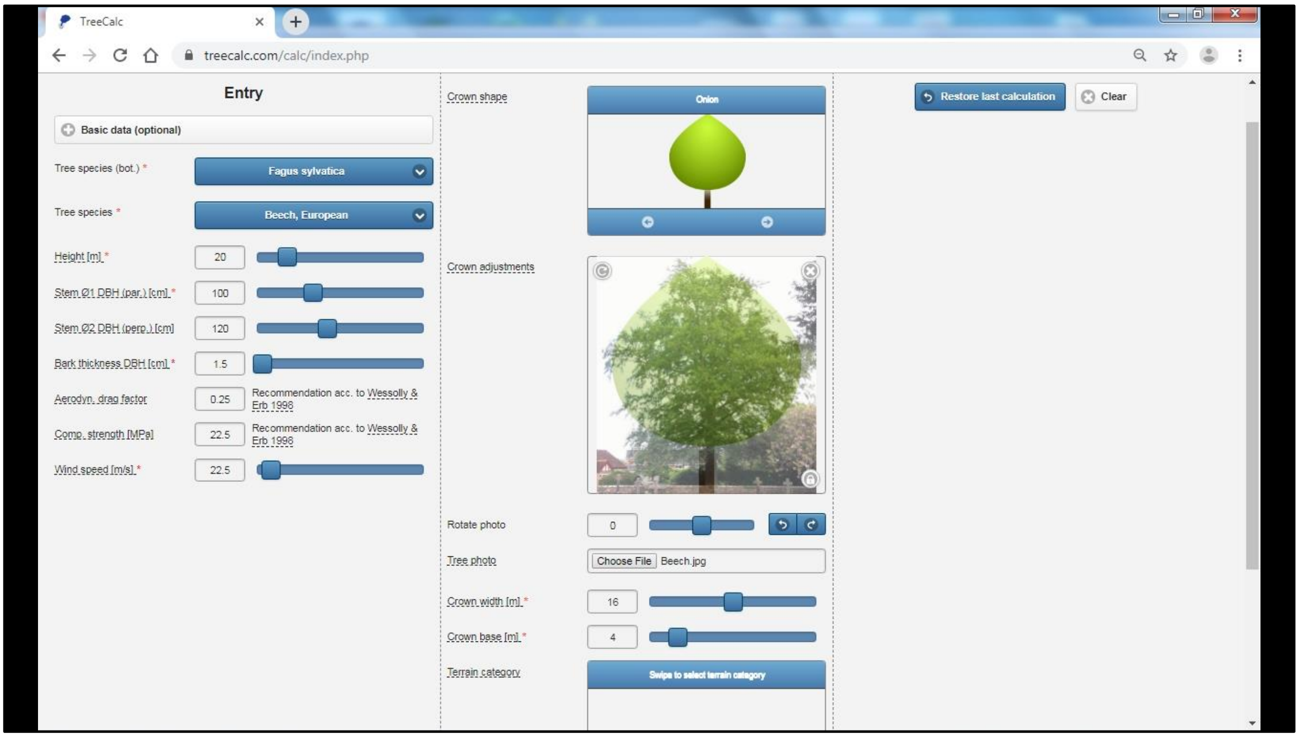
People struggle with the apparent simplicity of these shapes.



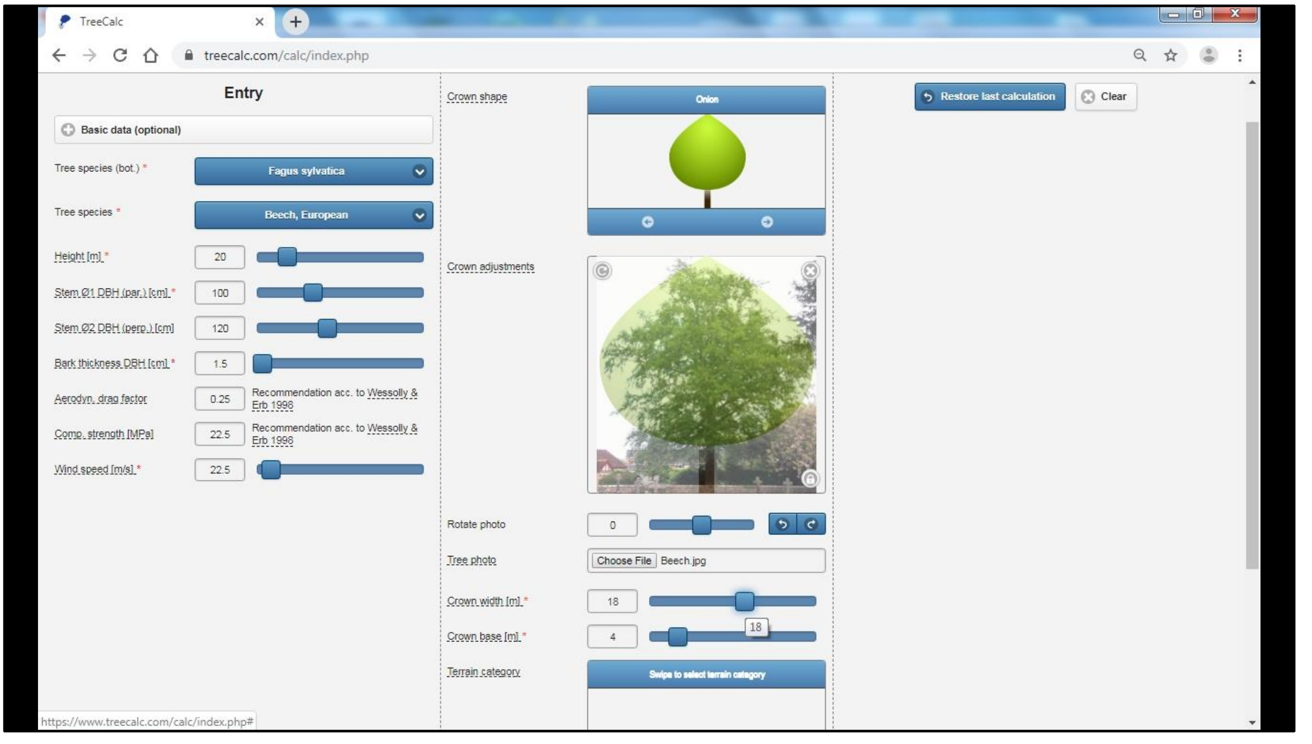
But we are just defining the proportions of the crown. It is important to know where the widest part of the crown is, as it affects the magnitude of the moment at the base…think of the road sign.



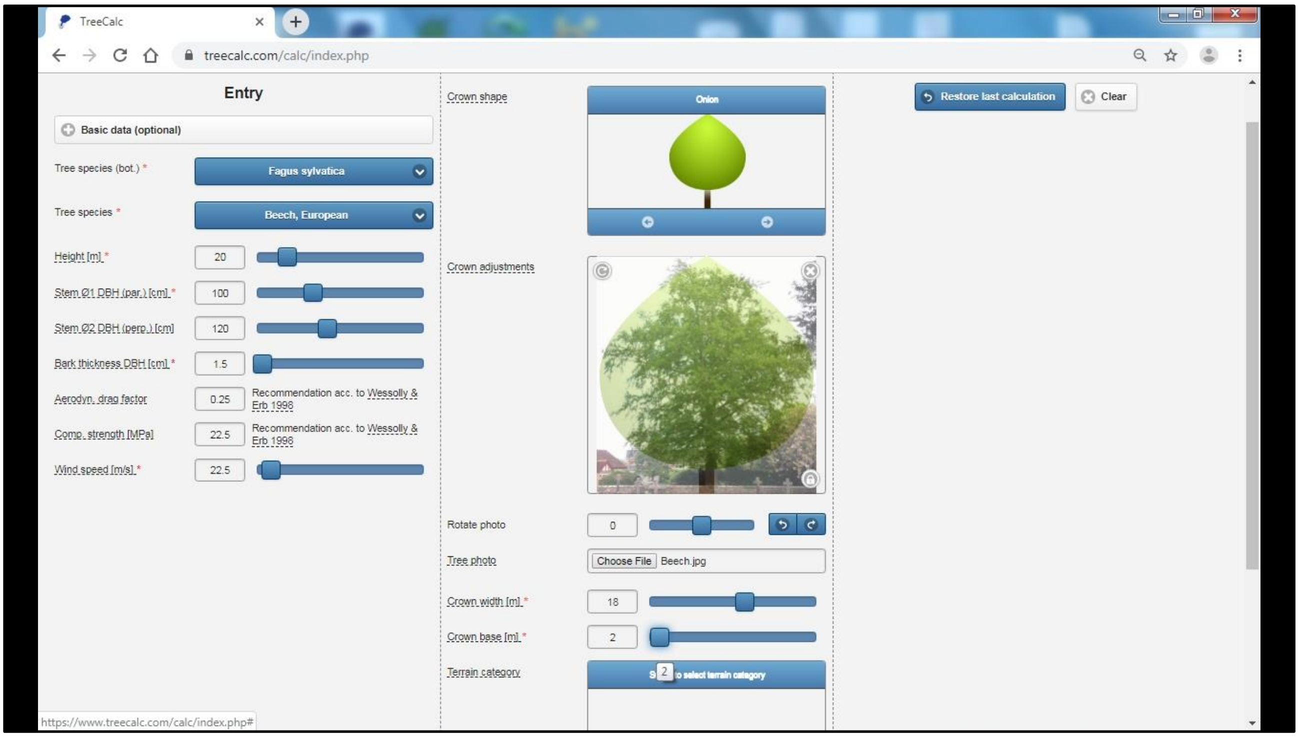
You can upload a photo and this will start making sense…



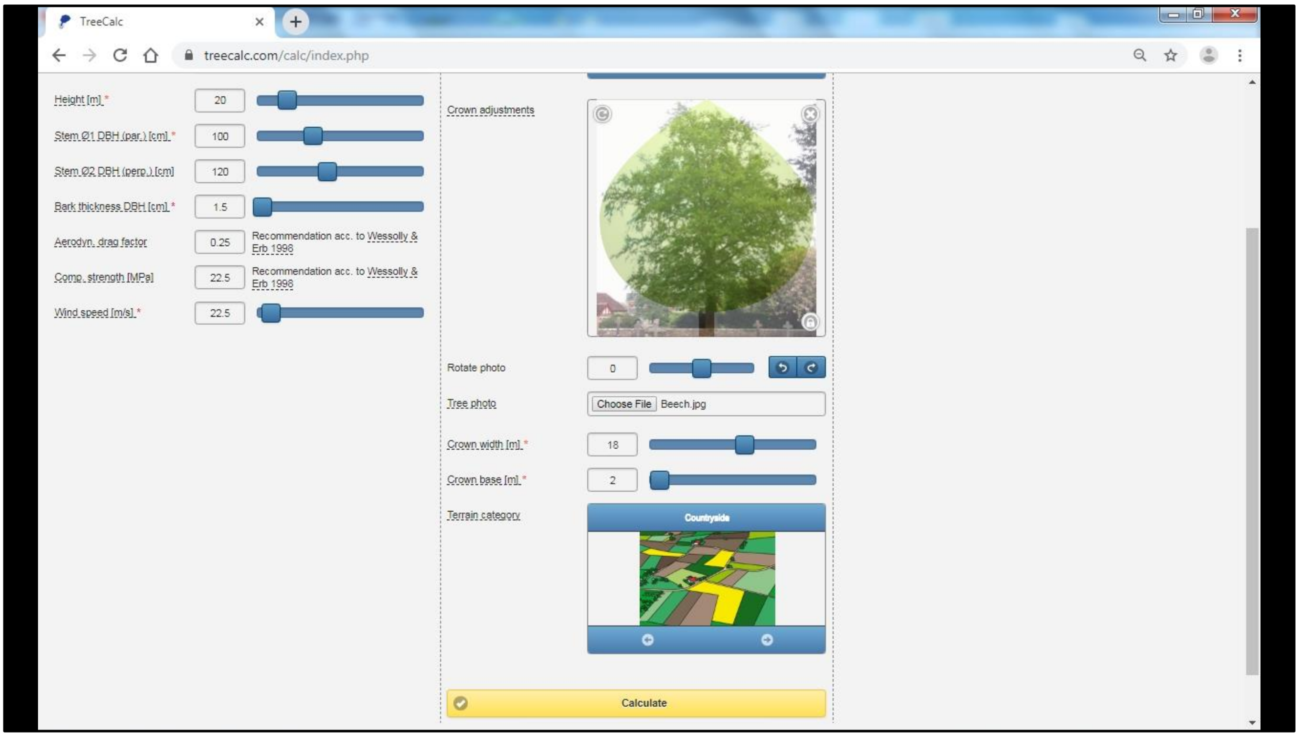
This shape fits better…



…even more so when we adjust the crown width and…

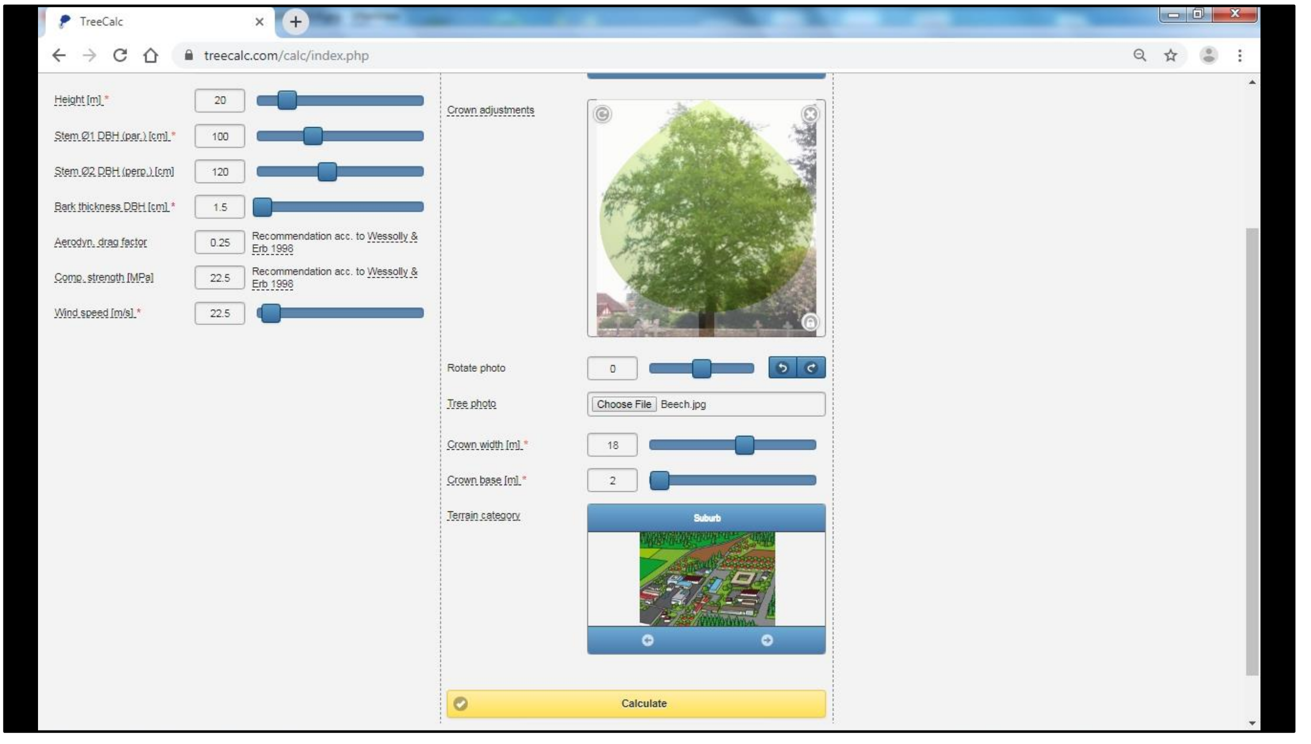


…the crown base.



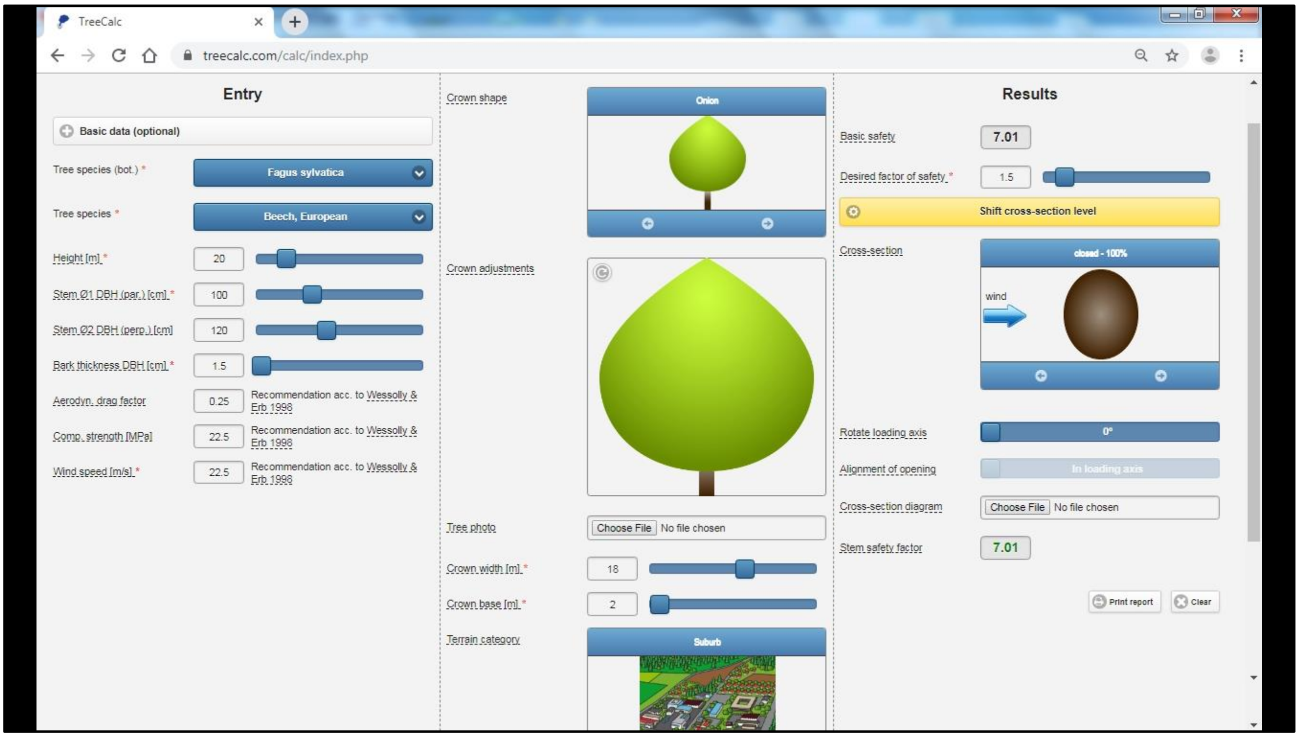
You then need to choose a roughness category.

This adjusts the mean and gust wind speeds in the calculation consistent with the 22.5 m/s event chosen.



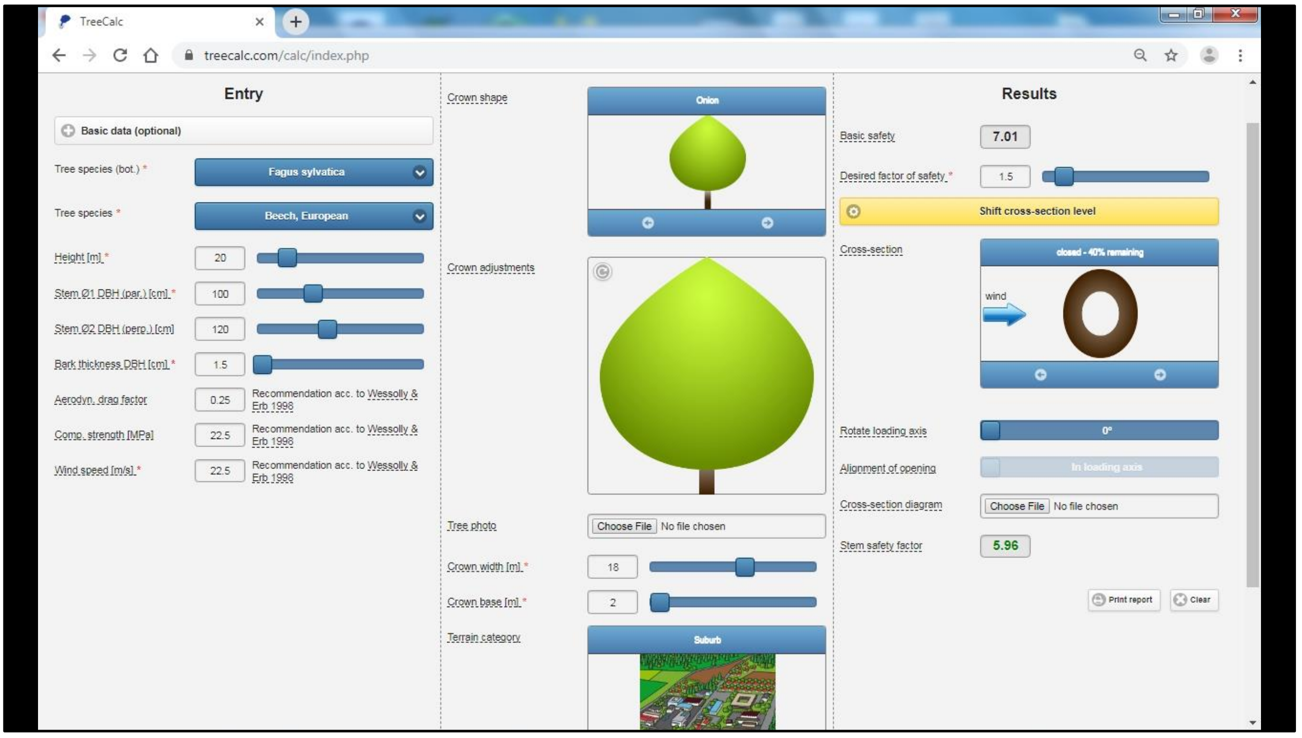
This tree is in the suburbs, where average wind speeds are lower but gusts are higher.

Calculate!

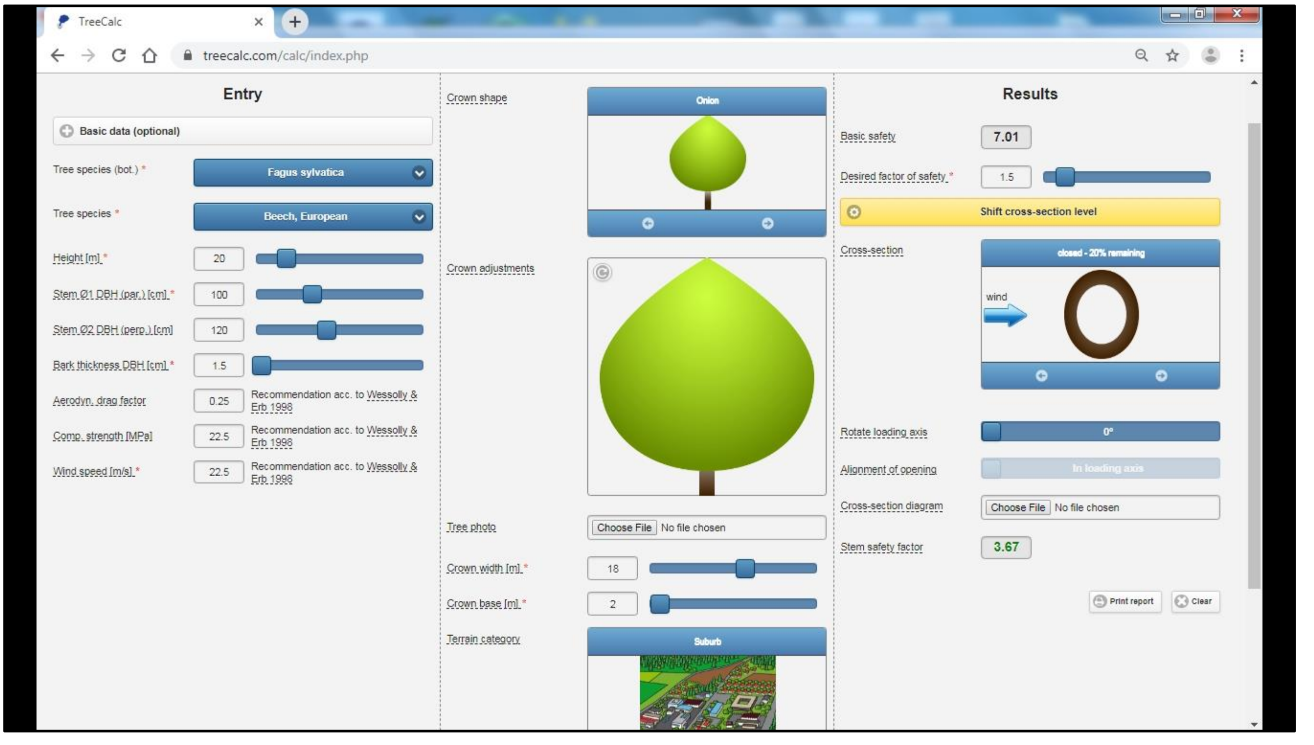


In this example we have a basic safety factor of 7.0.

A beech tree with these dimensions, in this load environment can be expected to be able to carry a wind load 7 times greater than the event we are considering.

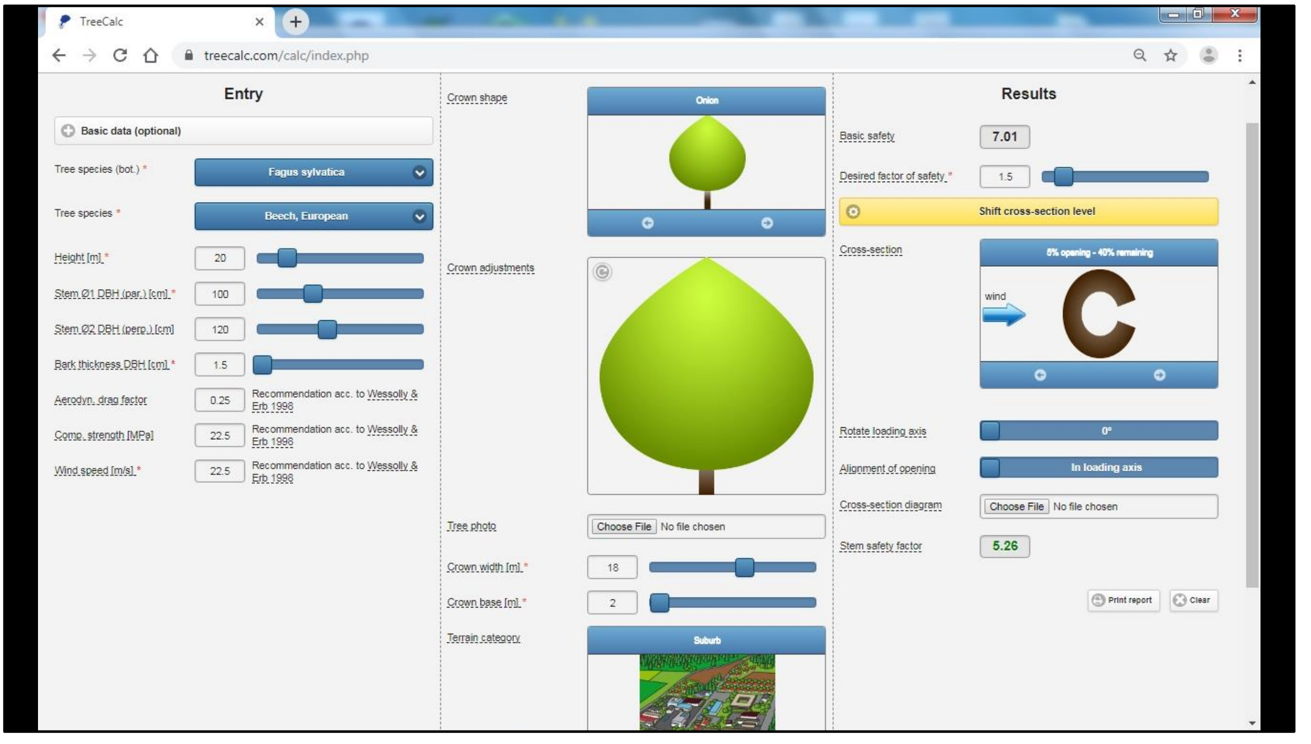


There are then a series of defect scenarios that we can scroll through.

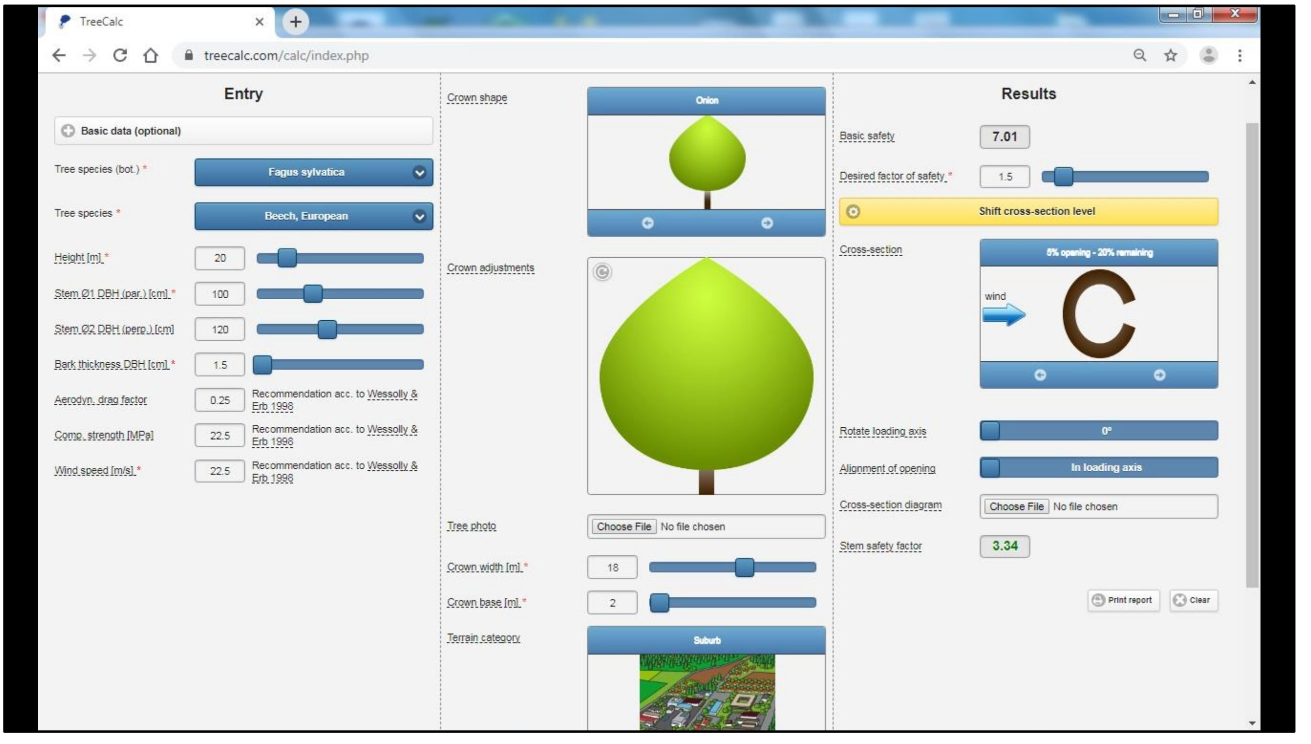


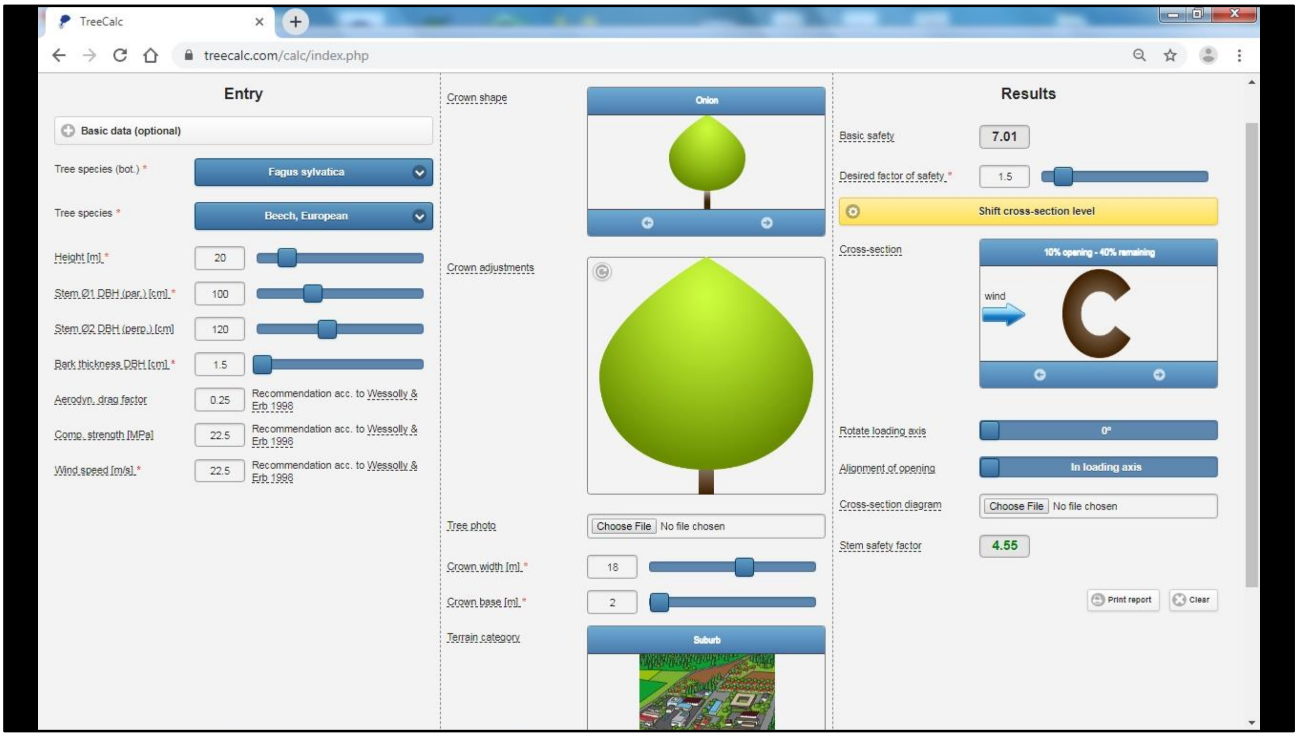
There are two ways to apply this.

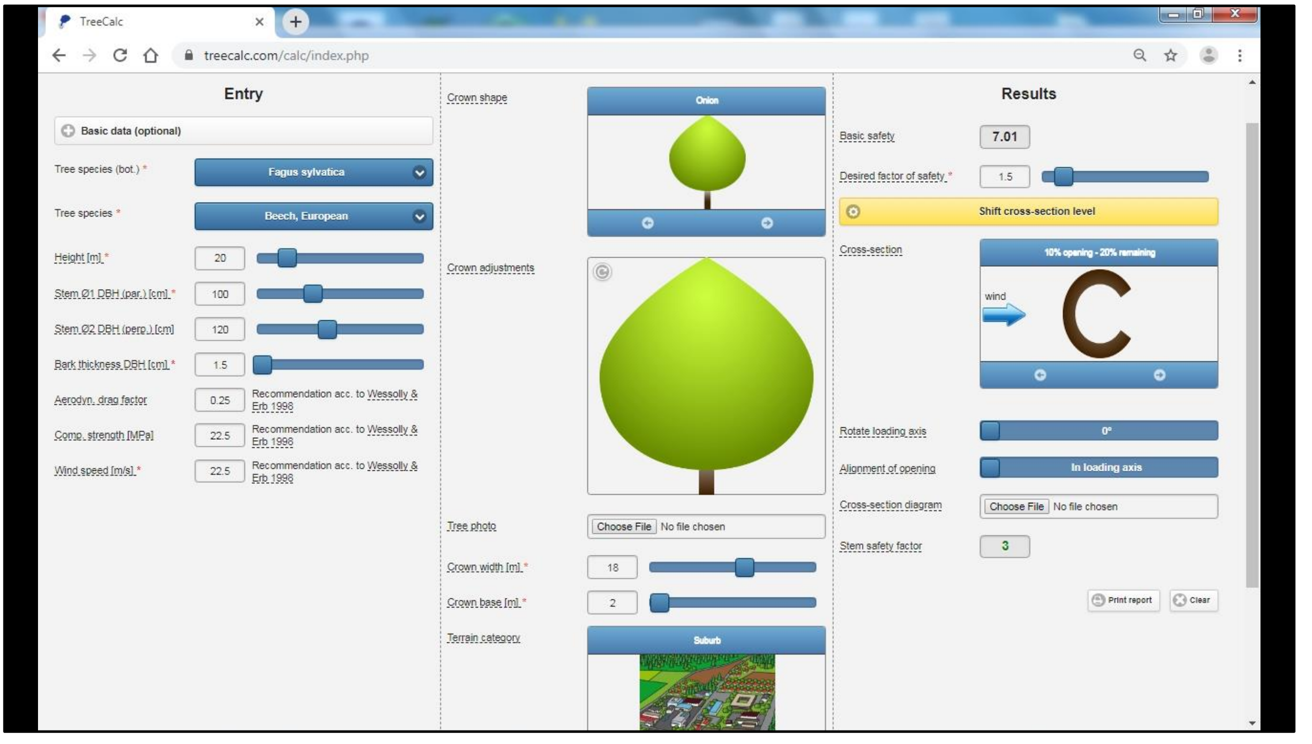
I can take the view that my tree has a t/R ratio of 0.2 and conclude that the safety factor would fall to 3.7.

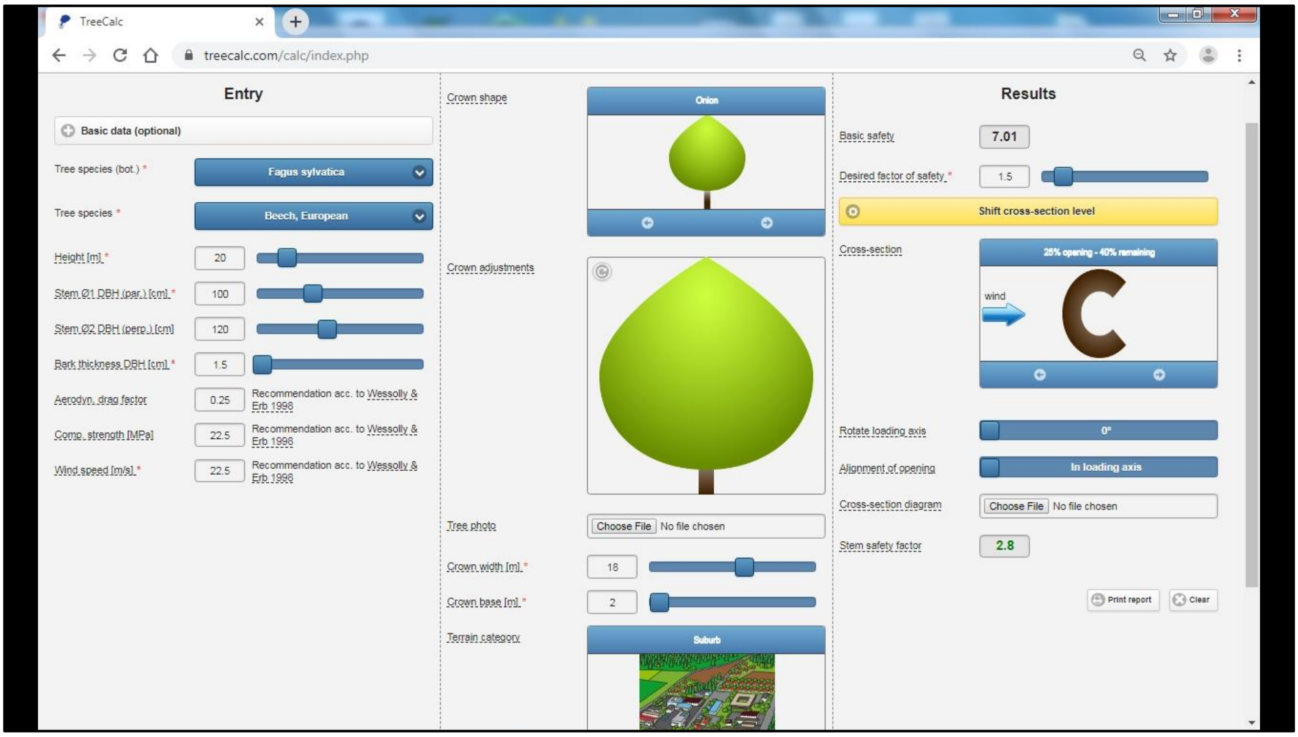


Or I can scroll through the scenarios to see what happens to the safety factor…


TreeCalc
treecalc.com/calc/index.php
Entry
Basic data (optional)
Tree species (bot.) *
Fagus sylvatica
Tree species *
Beech, European
Height [m] *
20
Stem Ø1 DBH (par.) [cm] *
100
Stem Ø2 DBH (perp.) [cm]
120
Bark thickness DBH [cm] *
1.5
Aerodyn. drag factor
0.25
Recommendation acc. to Wessolly & Erb 1998
Comp. strength [MPa]
22.5
Recommendation acc. to Wessolly & Erb 1998
Wind speed [m/s] *
22.5
Recommendation acc. to Wessolly & Erb 1998
Crown shape
Onion
Crown adjustments
Tree photo
Choose File No file chosen
Crown width [m] *
18
Crown base [m] *
2
Terrain category
Suburb
Results
Basic safety
7.01
Desired factor of safety *
1.5
Shift cross-section level
Cross-section
wind
Rotate loading axis
0°
Alignment of opening
In loading axis
Cross-section diagram
Choose File No file chosen
Stem safety factor
3.34
Print report
Clear

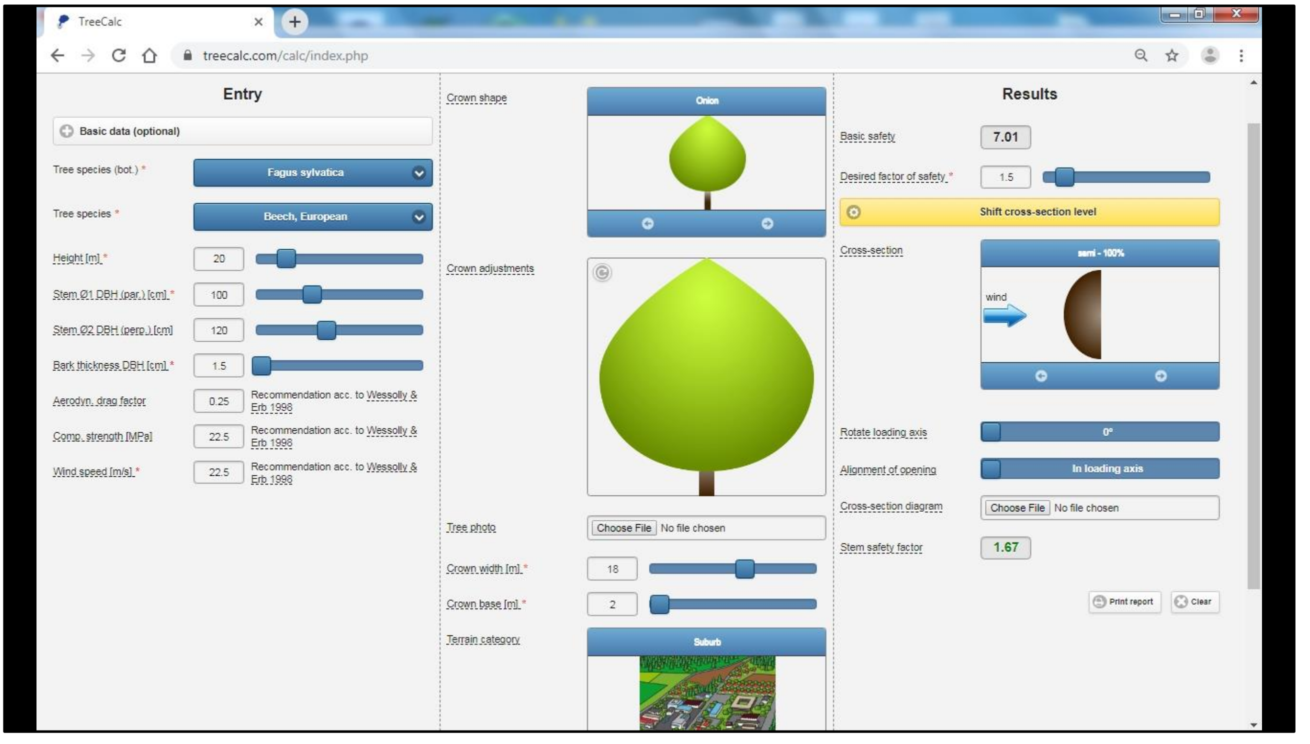

TreeCalc
treecalc.com/calc/index.php
Entry
Basic data (optional)
Tree species (bot.) *
Fagus sylvatica
Tree species *
Beech, European
Height [m] *
20
Stem Ø1 DBH (par.) [cm] *
100
Stem Ø2 DBH (perp.) [cm]
120
Bark thickness DBH [cm] *
1.5
Aerodyn. drag factor
0.25
Recommendation acc. to Wessolly & Erb 1998
Comp. strength [MPa]
22.5
Recommendation acc. to Wessolly & Erb 1998
Wind speed [m/s] *
22.5
Recommendation acc. to Wessolly & Erb 1998
Crown shape
Onion
Crown adjustments
Tree photo
Choose File No file chosen
Crown width [m] *
18
Crown base [m] *
2
Terrain category
Suburb
Results
Basic safety
7.01
Desired factor of safety *
1.5
Shift cross-section level
Cross-section
10% opening - 40% remaining
wind
Rotate loading axis
0°
Alignment of opening
In loading axis
Cross-section diagram
Choose File No file chosen
Stem safety factor
4.55
Print report
Clear


TreeCalc
treecalc.com/calc/index.php
Entry
Basic data (optional)
Tree species (bot.) *
Fagus sylvatica
Tree species *
Beech, European
Height [m] *
20
Stem Ø1 DBH (par.) [cm] *
100
Stem Ø2 DBH (perp.) [cm]
120
Bark thickness DBH [cm] *
1.5
Aerodyn. drag factor
0.25
Recommendation acc. to Wessolly & Erb 1998
Comp. strength [MPa]
22.5
Recommendation acc. to Wessolly & Erb 1998
Wind speed [m/s] *
22.5
Recommendation acc. to Wessolly & Erb 1998
Crown shape
Onion
Crown adjustments
Tree photo
Choose File No file chosen
Crown width [m] *
18
Crown base [m] *
2
Terrain category
Suburb
Results
Basic safety
7.01
Desired factor of safety *
1.5
Shift cross-section level
Cross-section
10% opening - 20% remaining
wind
Rotate loading axis
0°
Alignment of opening
In loading axis
Cross-section diagram
Choose File No file chosen
Stem safety factor
3
Print report
Clear


TreeCalc
treecalc.com/calc/index.php
Entry
Basic data (optional)
Tree species (bot.) *
Fagus sylvatica
Tree species *
Beech, European
Height [m] *
20
Stem Ø1 DBH (par.) [cm] *
100
Stem Ø2 DBH (perp.) [cm]
120
Bark thickness DBH [cm] *
1.5
Aerodyn. drag factor
0.25
Recommendation acc. to Wessolly & Erb 1998
Comp. strength [MPa]
22.5
Recommendation acc. to Wessolly & Erb 1998
Wind speed [m/s] *
22.5
Recommendation acc. to Wessolly & Erb 1998
Crown shape
Onion
Crown adjustments
Tree photo
Choose File No file chosen
Crown width [m] *
18
Crown base [m] *
2
Terrain category
Suburb
Results
Basic safety
7.01
Desired factor of safety *
1.5
Shift cross-section level
Cross-section
25% opening - 40% remaining
wind
Rotate loading axis
0°
Alignment of opening
In loading axis
Cross-section diagram
Choose File No file chosen
Stem safety factor
2.8
Print report
Clear

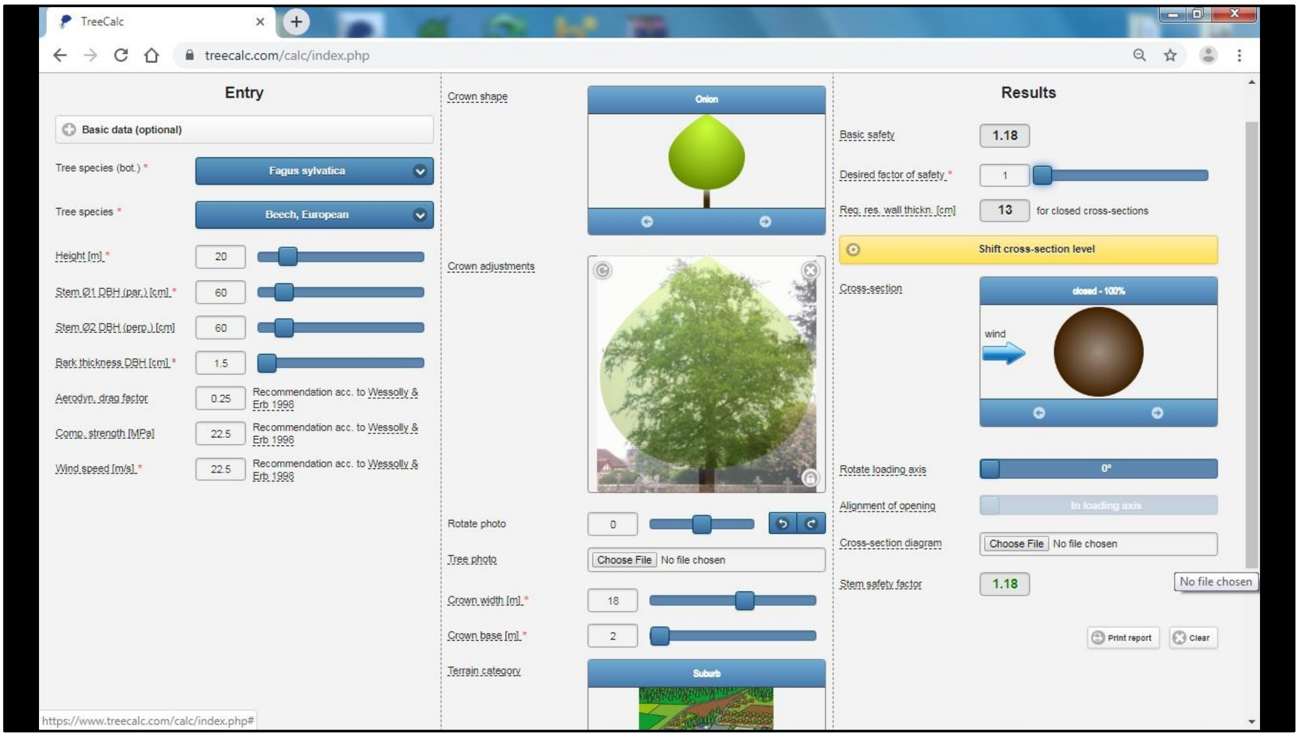
And stop here…the tree still just about has acceptable safety factors.

I can say “my tree is nowhere near that bad, so it must have a greater safety factor than this”.

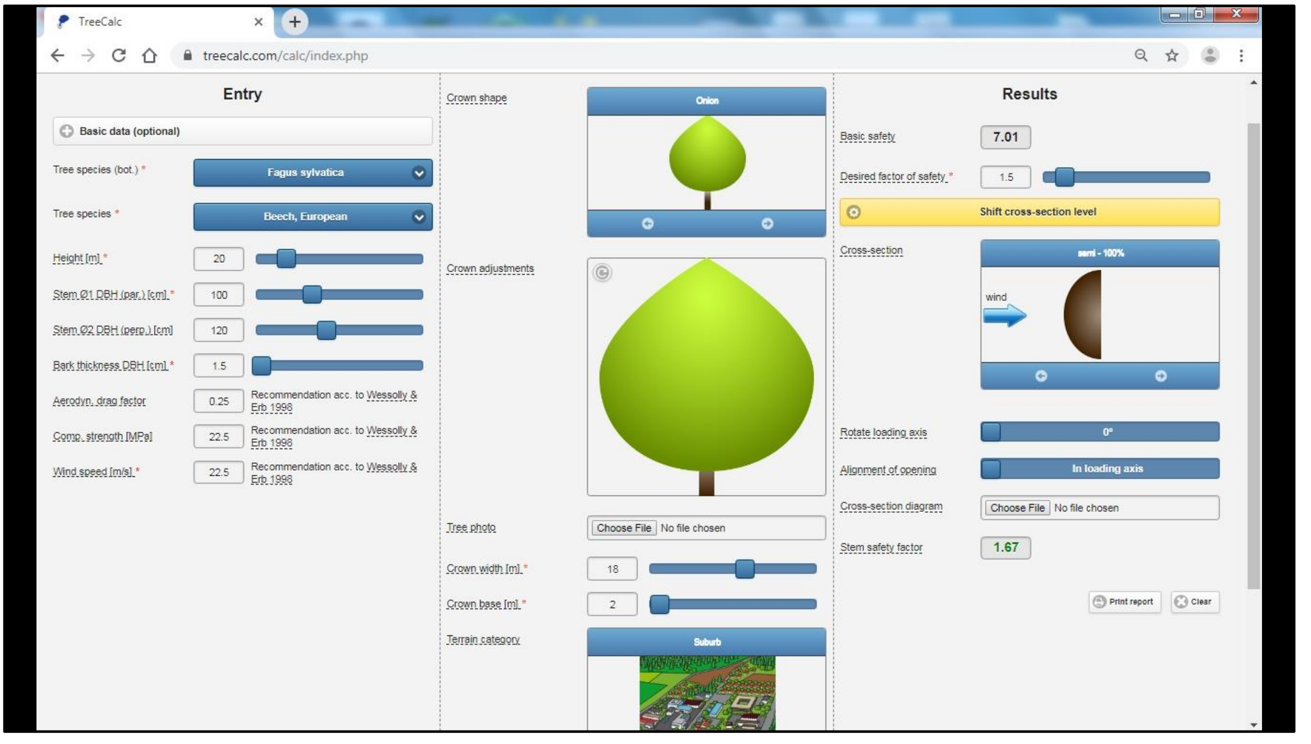


Continuing through the examples…this might seem extreme and unlikely.

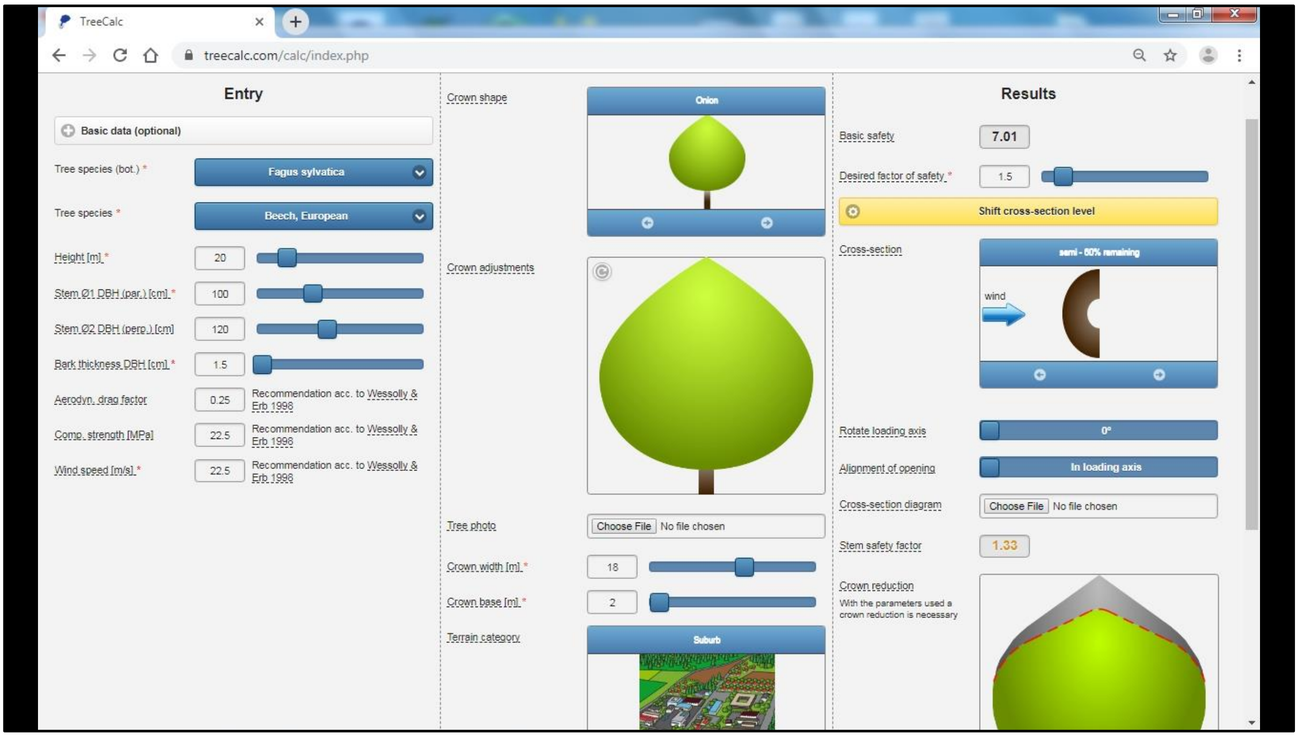
…but if I had entered the stem dimensions of an elliptical defect-free tree I'd have got this result.



And if I use a very small but round stem diameter of 60 cm, this is similarly too small to carry the load of the large crown.

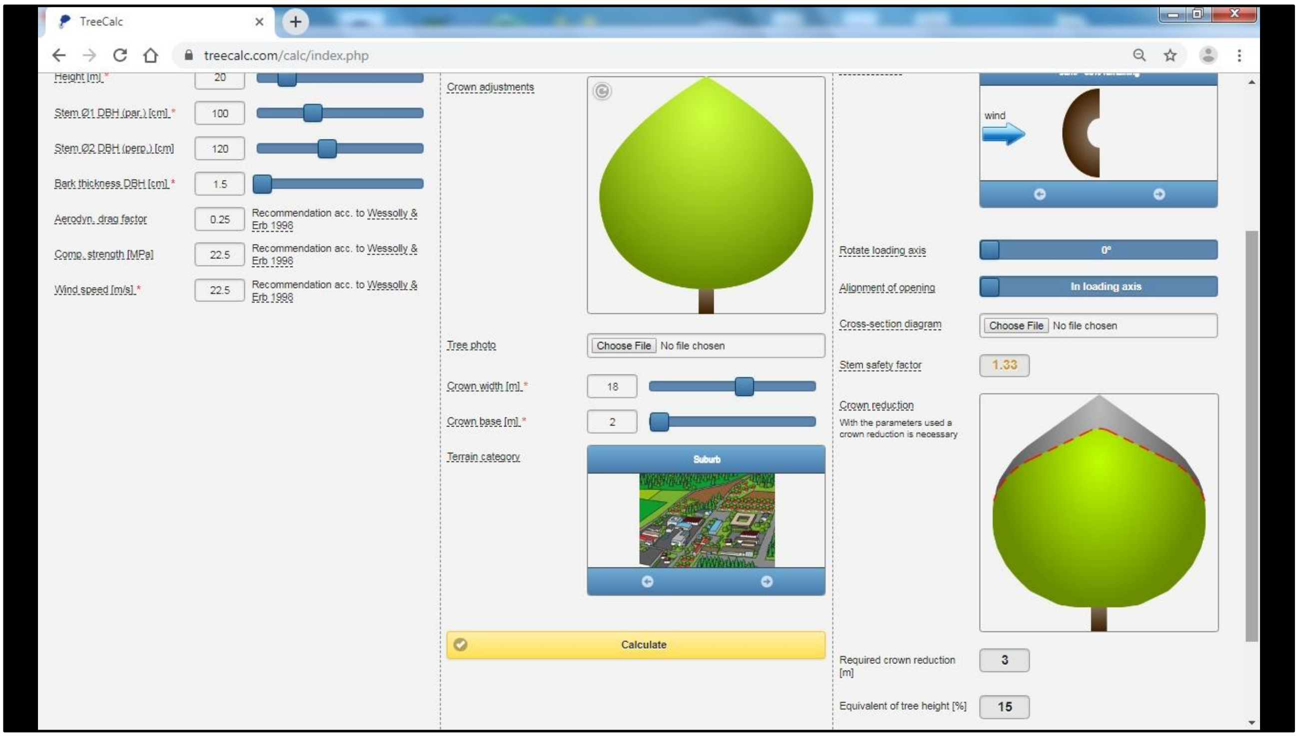


Returning to the scenario that is just about acceptable…



…any greater defect tips the safety factor below 1.5 and a crown reduction is required.

TreeCalc offers a minimum specified requirement. In this case a 3.0 m height reduction to bring the tree back to a safety factor of 1.5.



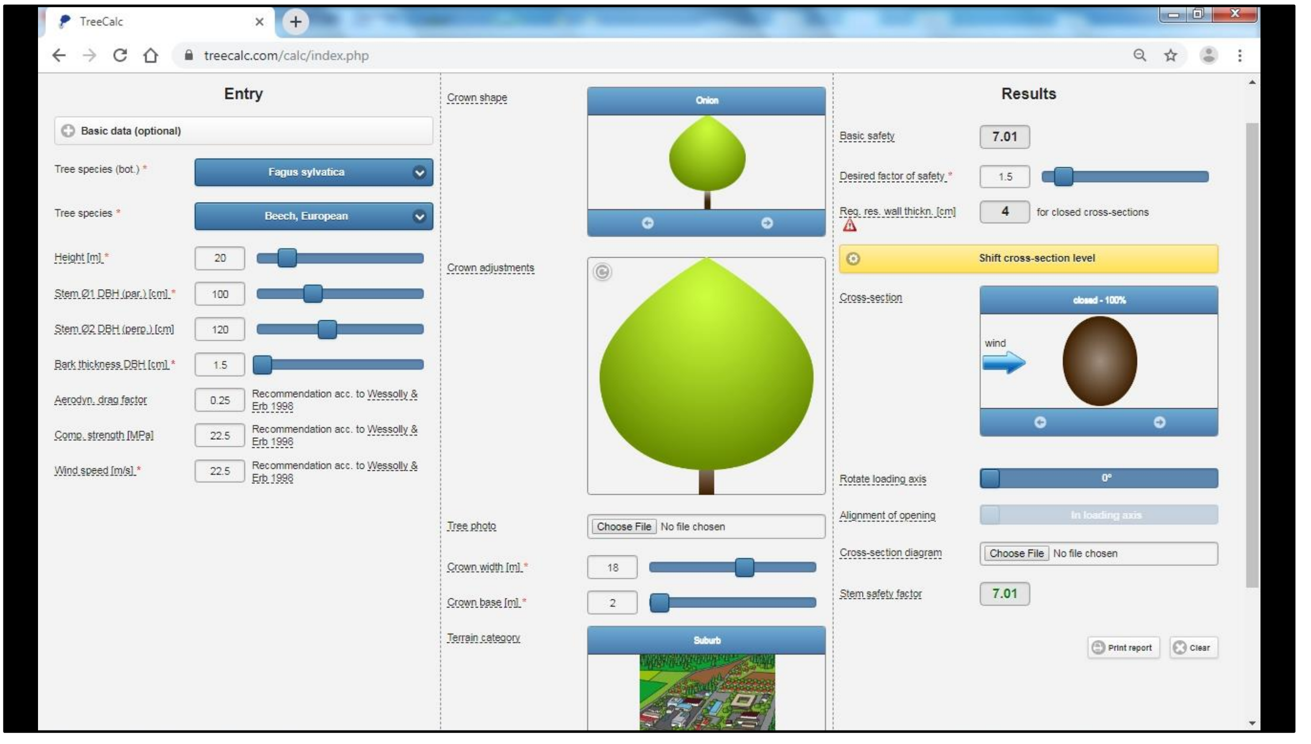
This defect scenario is an extreme example and the proposed crown reduction is not really a viable management approach.

Generally you will find that TreeCalc provides evidence showing that no crown reduction is necessary. The earlier defect scenarios are far more likely. Once you get to the extreme strength loss scenarios further data or investigations would generally be required.

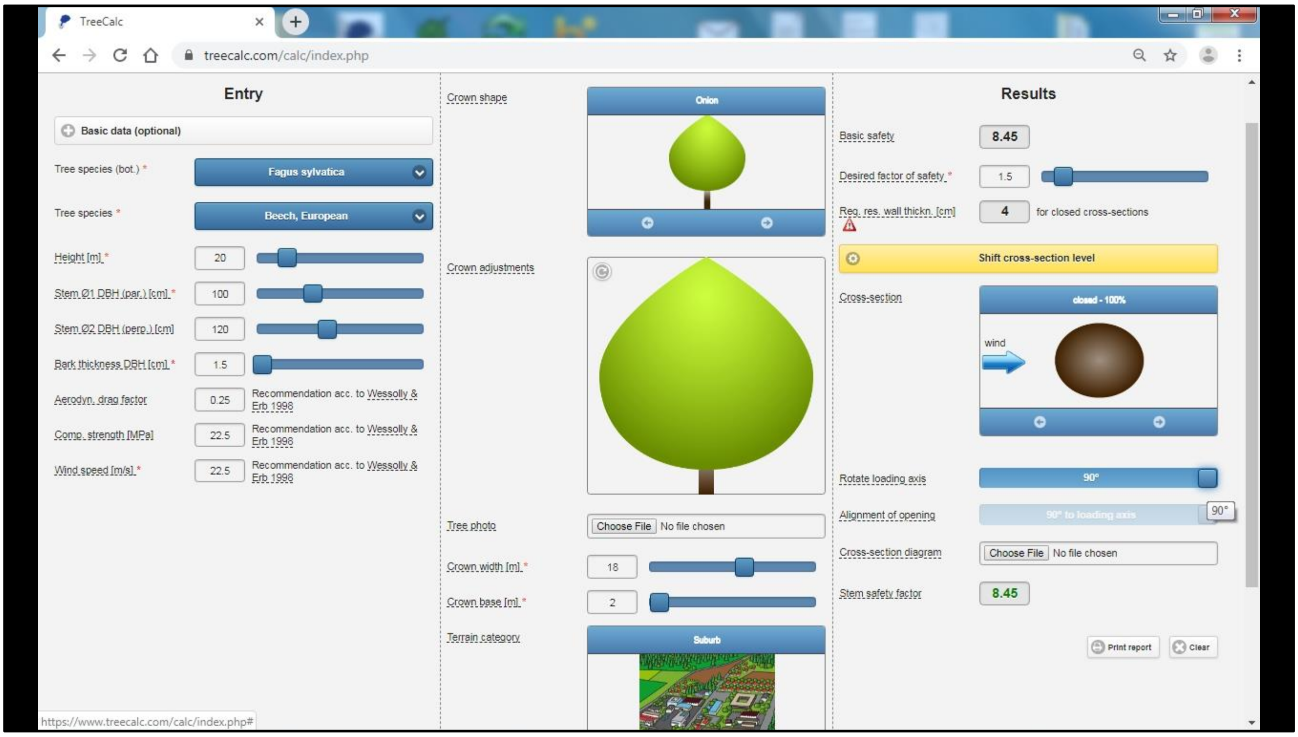
In this extreme example we would typically recommend removal.

If circumstances allowed and retention was possible we would initiate a retrenchment pruning regime with the aim of a far smaller crown over the long-term. Hovering around a safety factor of 1.5 in this situation would not be appropriate.

Crown reductions for trees at early maturity will, of course, become necessary with much less severe defects…because these trees have lower safety margins that are more quickly used up.

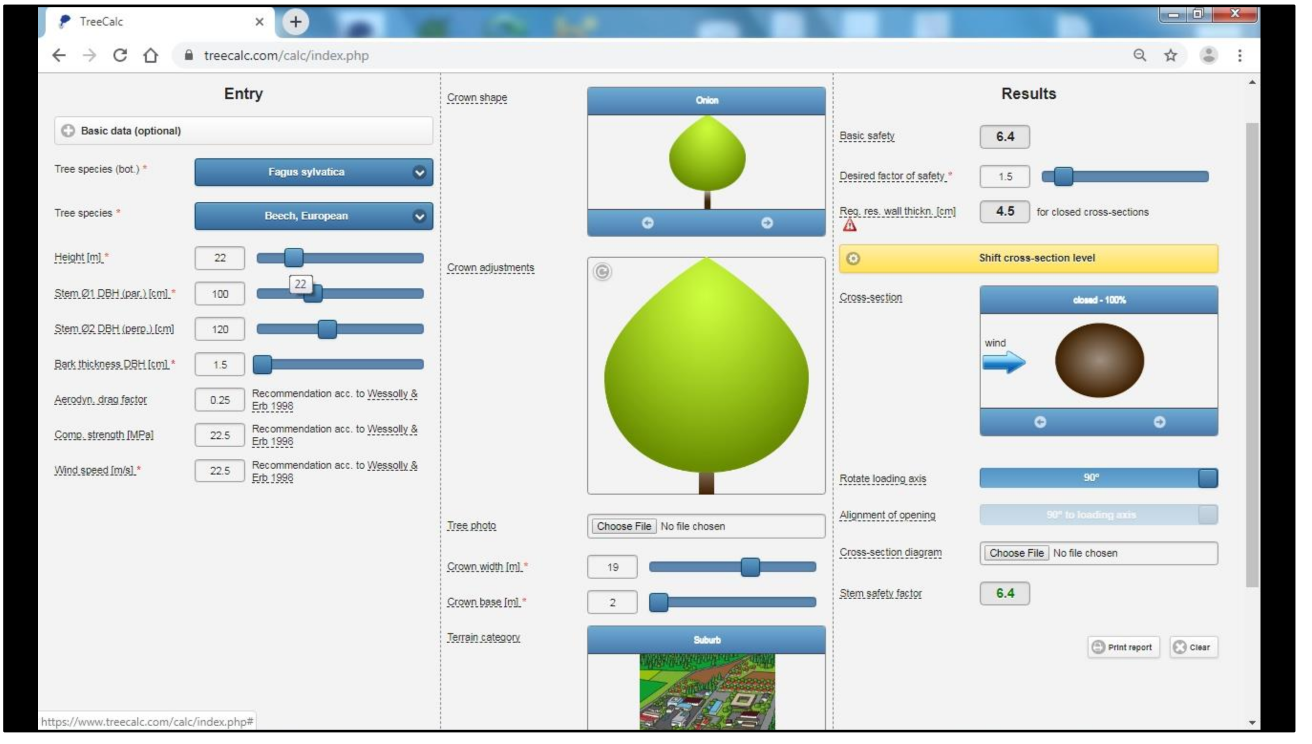


Back to the original tree.



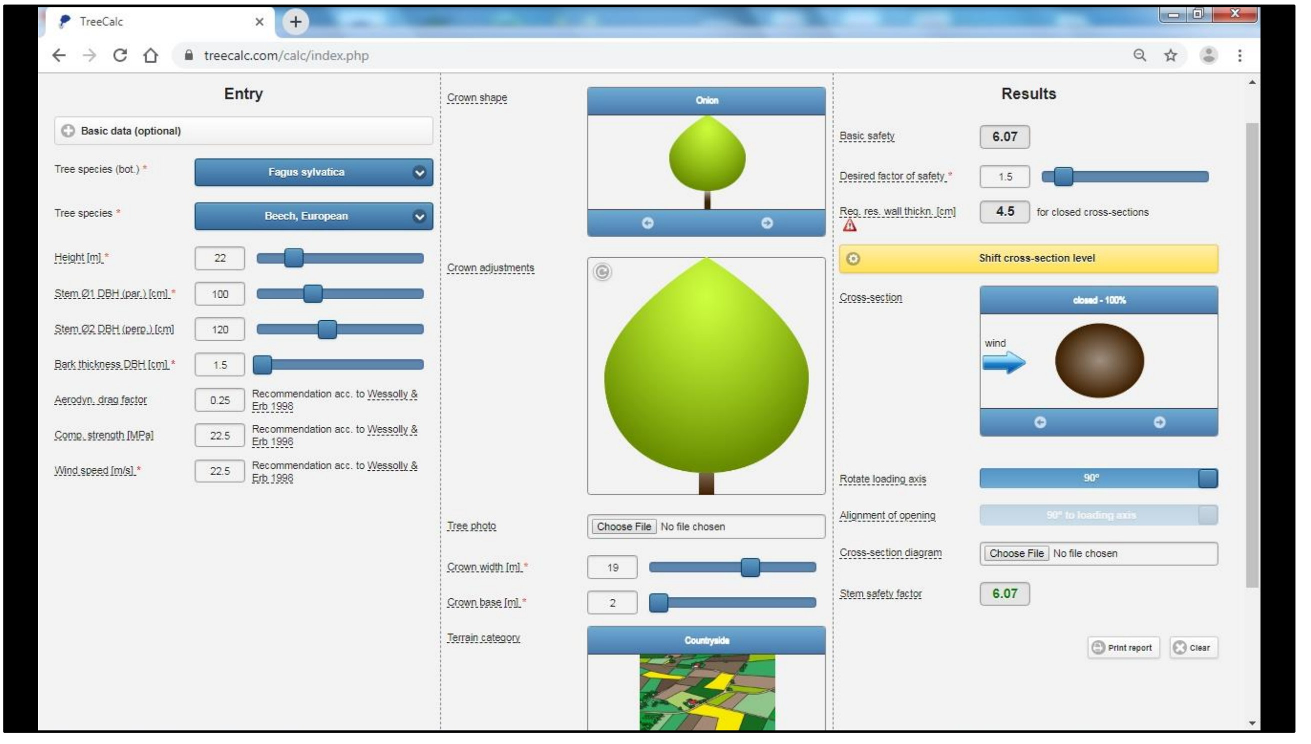
If I rotate the stem so that the larger diameter is parallel to the load direction the safety factor goes up.

The stem is stiffer and stronger in this direction.

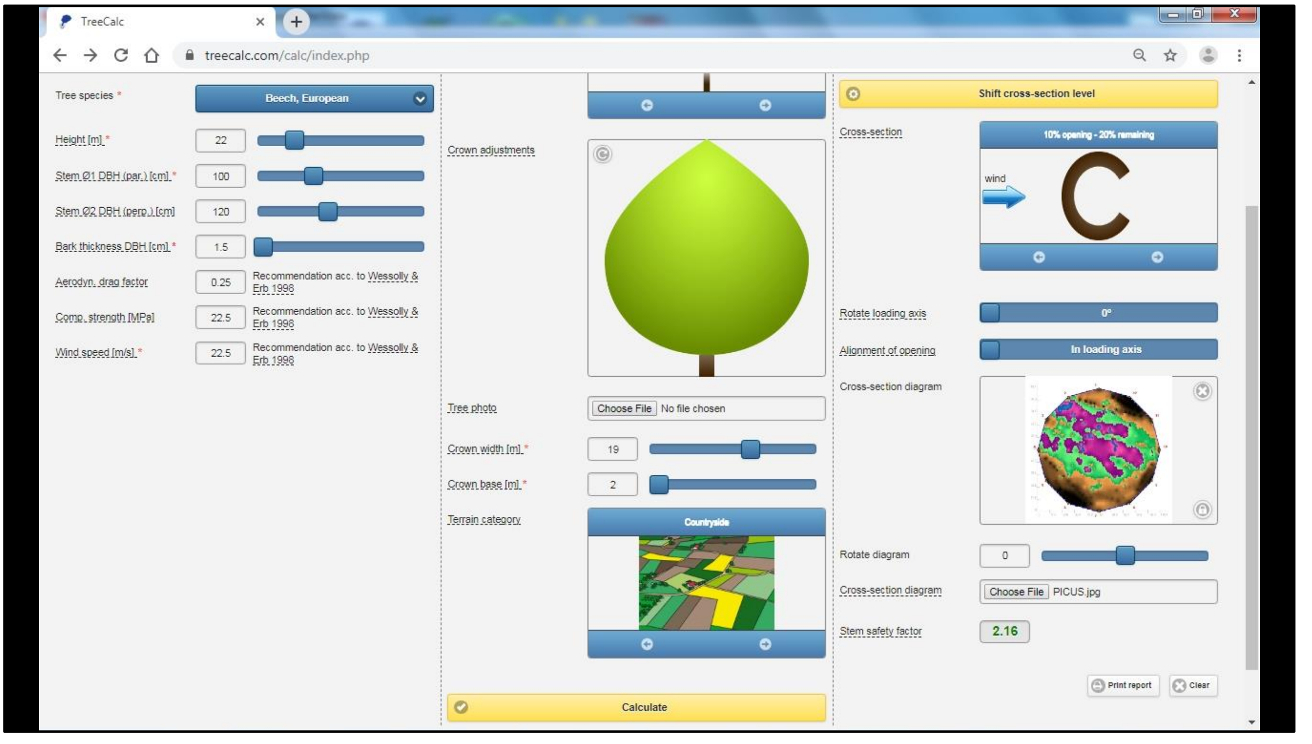


If I increase the height by 2.0m the safety factor falls…quite significantly.

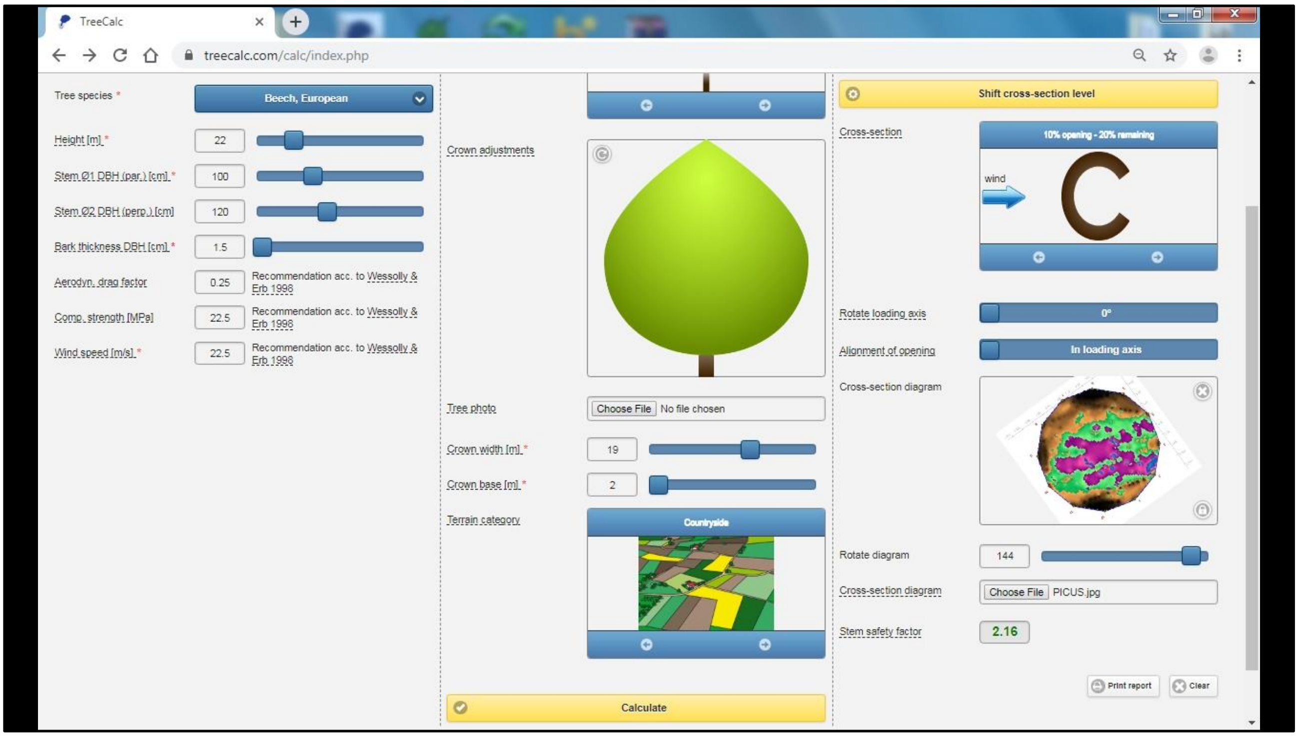
Tree height is an important component. Make sure it is accurate.



If I change the roughness category, the safety factor changes.



You can load in images of tomographs…



…rotate them to match the defect scenarios

…and print a report to demonstrate why that extent of decay is acceptable, neatly expressed in terms of safety factors.

How much real experience do you have of the natural progress of decay in trees? Decay takes place over decades. It has been developing for decades before we ever see any sign of it.

How many trees have you observed, with decay that has been developing for decades, that have not been pruned?

I think it highly likely that we have a significantly distorted understanding of the rate of progression of decay in trees, because the trees that we observe have usually been pruned.

If we don't prune, and trees have sufficient resources and good vitality, they generally respond to decay by producing highly effective adaptive growth.

Don't justify pruning in terms of reducing the likelihood of failure. It generally isn't necessary.

You can show it isn't necessary through calculations or collecting data.

Trees can usually manage strength requirements perfectly well without our interference.

Large old, mature trees have comfortable margins for safety.

A final example. I presented this case study at the Arboricultural Association Conference in 2015.

We were asked to offer a second opinion on the stability of a Lucombe oak.

The tree was reported to have had root decay issues.

Investigations involved excavations using an air-spade.

The decay was reportedly extensive. Apparently every woody root was soft.

We carried out static load tests in 2009 and 2012 (a retest was recommended within 5 years…but hasn't been commissioned).

The tree had a basic safety factor of 20.0 reduced to a safety factor of 4.0 for roots. This represents a huge loss of stiffness in the root plate. But this is still a high residual safety factor.

The stem diameter is 2.0 m, so the buttressing is 3.0 m plus at ground level.

No pruning was recommended on the basis of the evidence of the static load test data.

Without the test data how much would you have pruned this tree? What would the long-term prospects have been as a result of those pruning operations?

This photo is the tree last month (August 2019).

Vitality is great.

I expect that the tree is producing a whole new root system.

If the next static load test shows that uprooting safety factors have not fallen since 2009 then I would not consider a further test to be necessary as long as vitality is maintained.

Assessments involving quantification that support a recommendation of no pruning should not be viewed as doing nothing.

Protecting your liability does not require a chainsaw!

Treework Environmental Practice

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