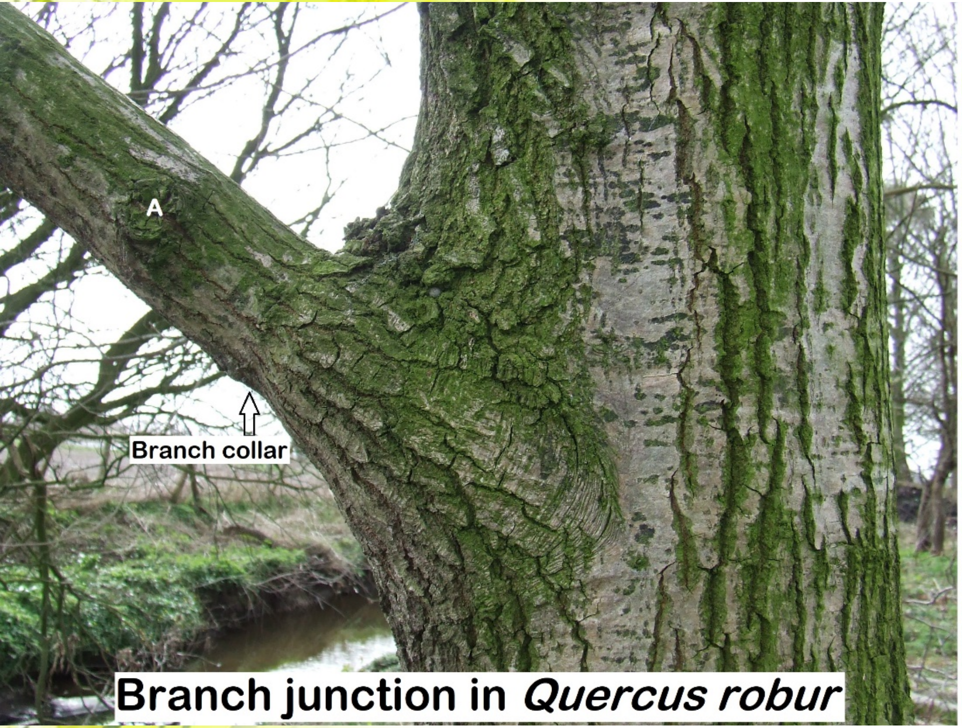
Natural Bracing & Branch Junctions in Trees:
TECHNICAL UPDATE

Duncan Slater BSc BA MEd MSc PhD MArborA MICFor

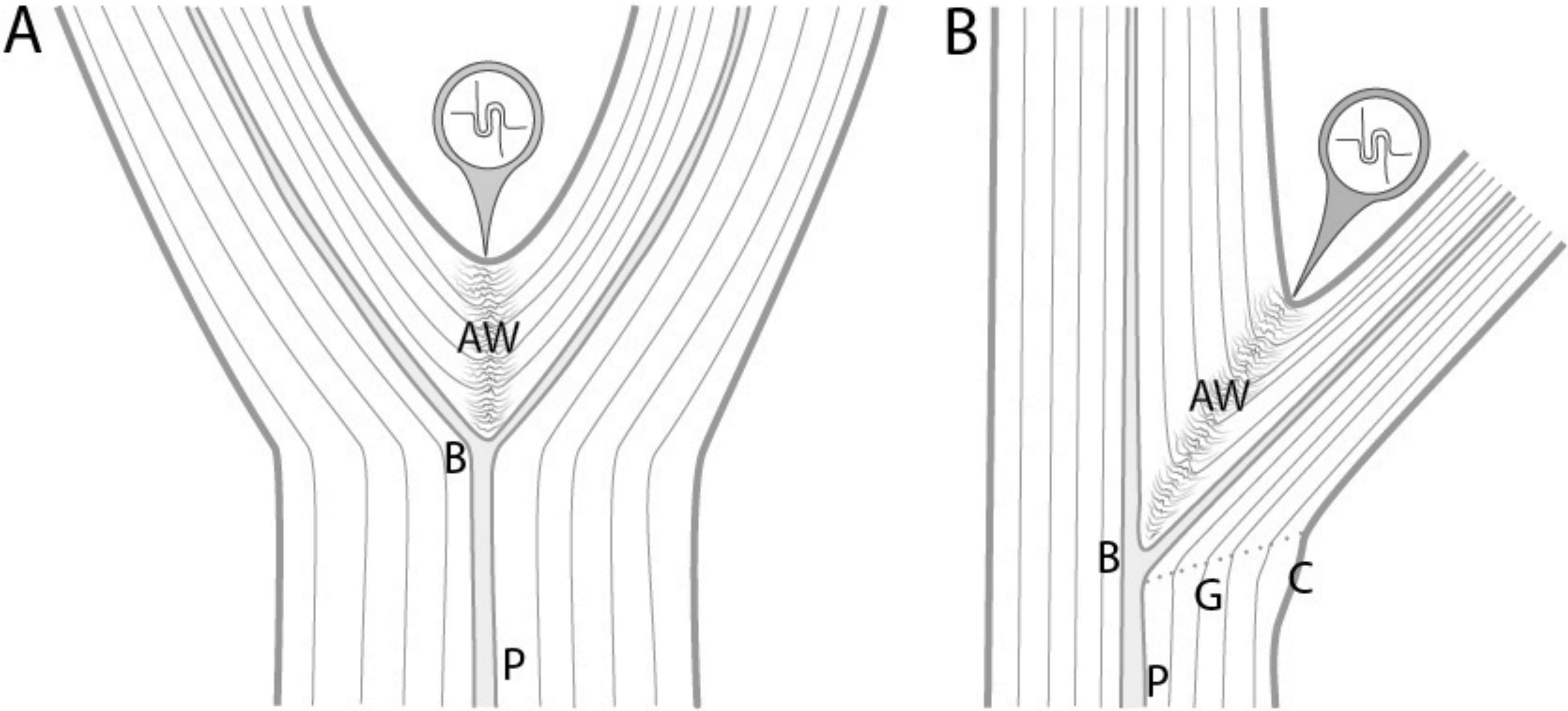
Talk Summary

- Modeling branch attachment
- Axillary wood – a new reaction wood
- The effects of natural bracing
- Is a big bulge better?
- Is a fork in a tree a defect?
- Conclusions



Modeling Branch Attachment

Branch attachment model



AW = Axillary wood
P = Pith
B = Bifurcation of the pith

C = Branch collar
G = Grain capture zone

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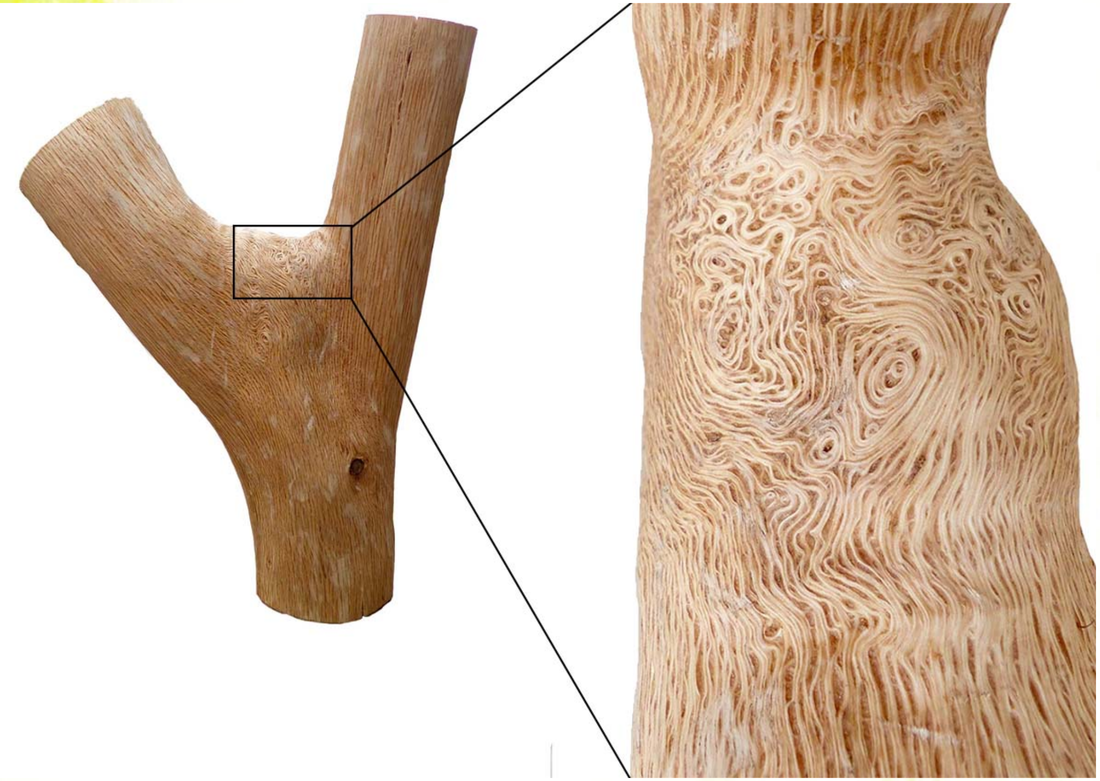


Axillary Wood

A New Reaction Wood

Currently recognised reaction woods:

- Compression wood
- Tension wood
- Flexure wood

- Axillary wood develops in the axil of branch junctions and also has a unique anatomy and purpose

Characteristics of reaction woods:

Axillary Wood

- ✓ Formed due to specific strain scenarios acting on the tree
- ✓ Specialised anatomical changes
- ✓ Unstable when dried out
- ✓ Part of the "posture-control system" of trees

Responding to Strain

Specialised Anatomy

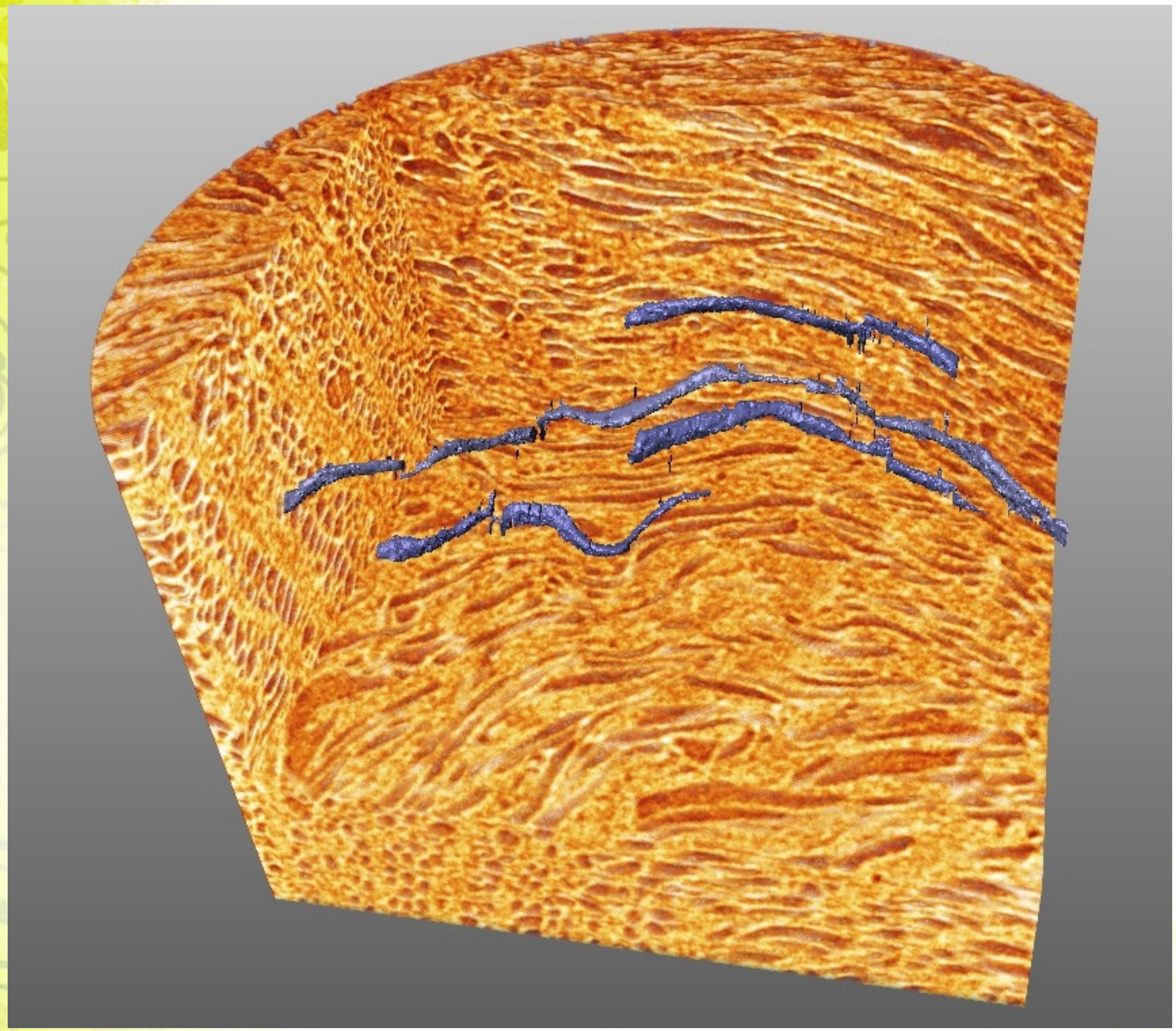
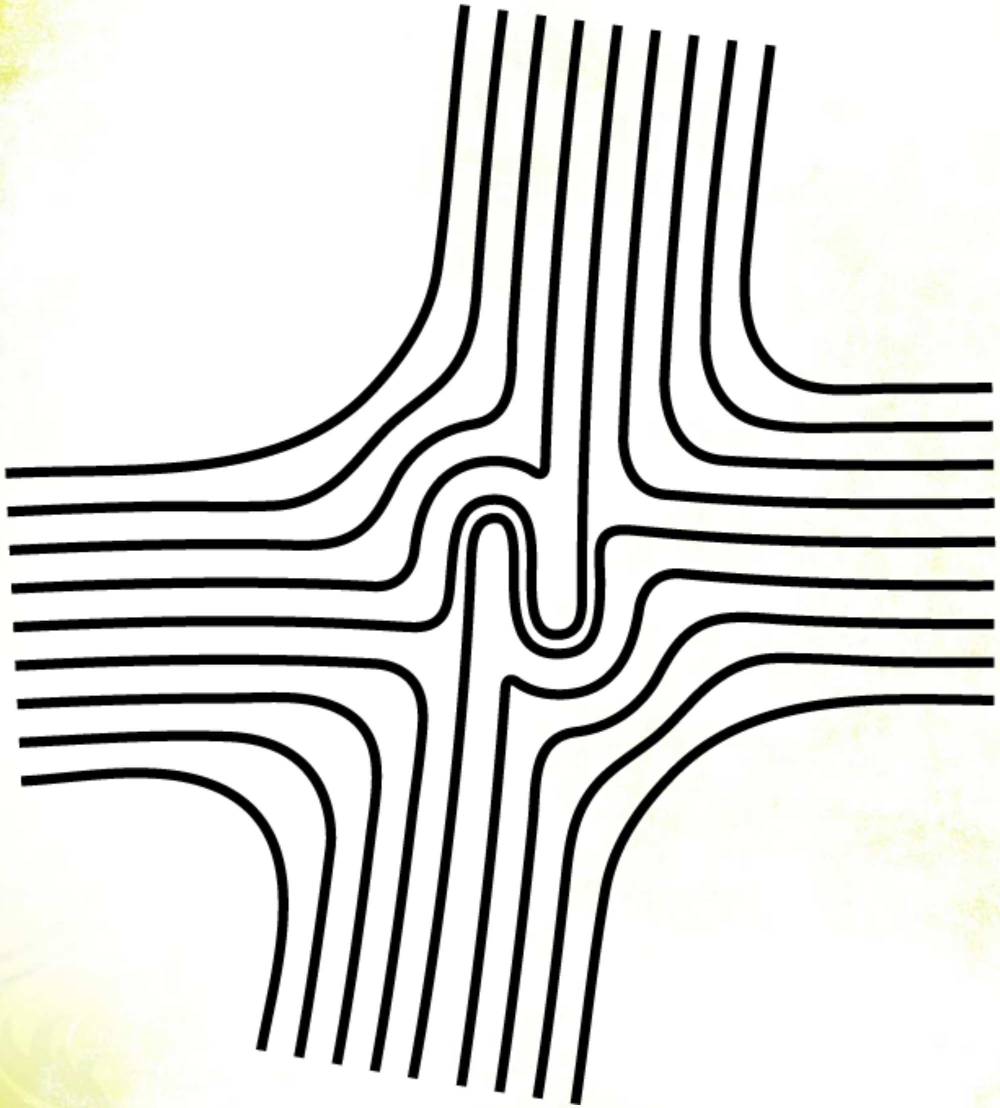
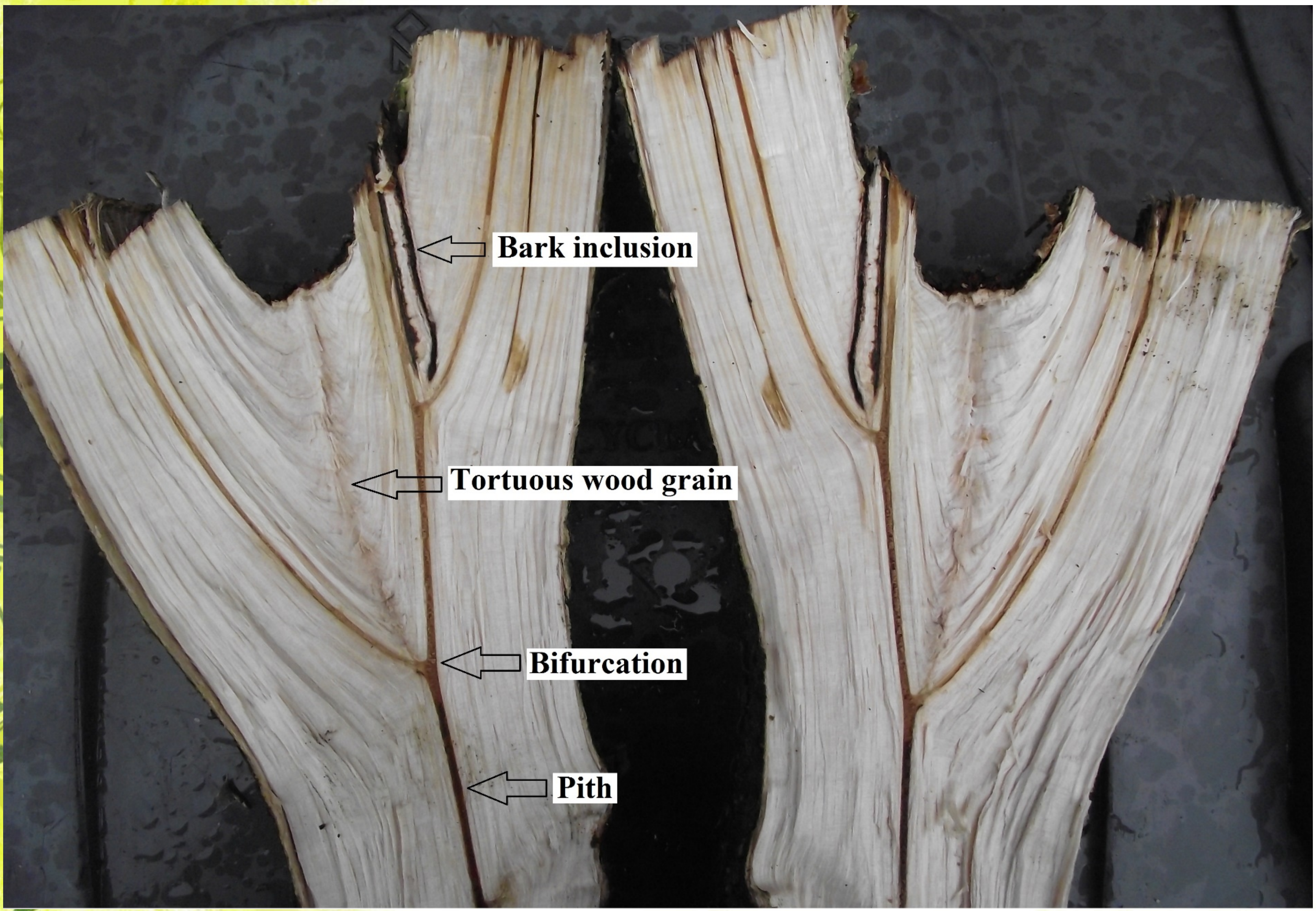


Image courtesy of the Manchester X-Ray Imaging Facility

Specialised Anatomy



Specialised Anatomy



Unstable when dried out

Part of the tree's posture control

Heading cut on young variegated sycamore

Ten years later...

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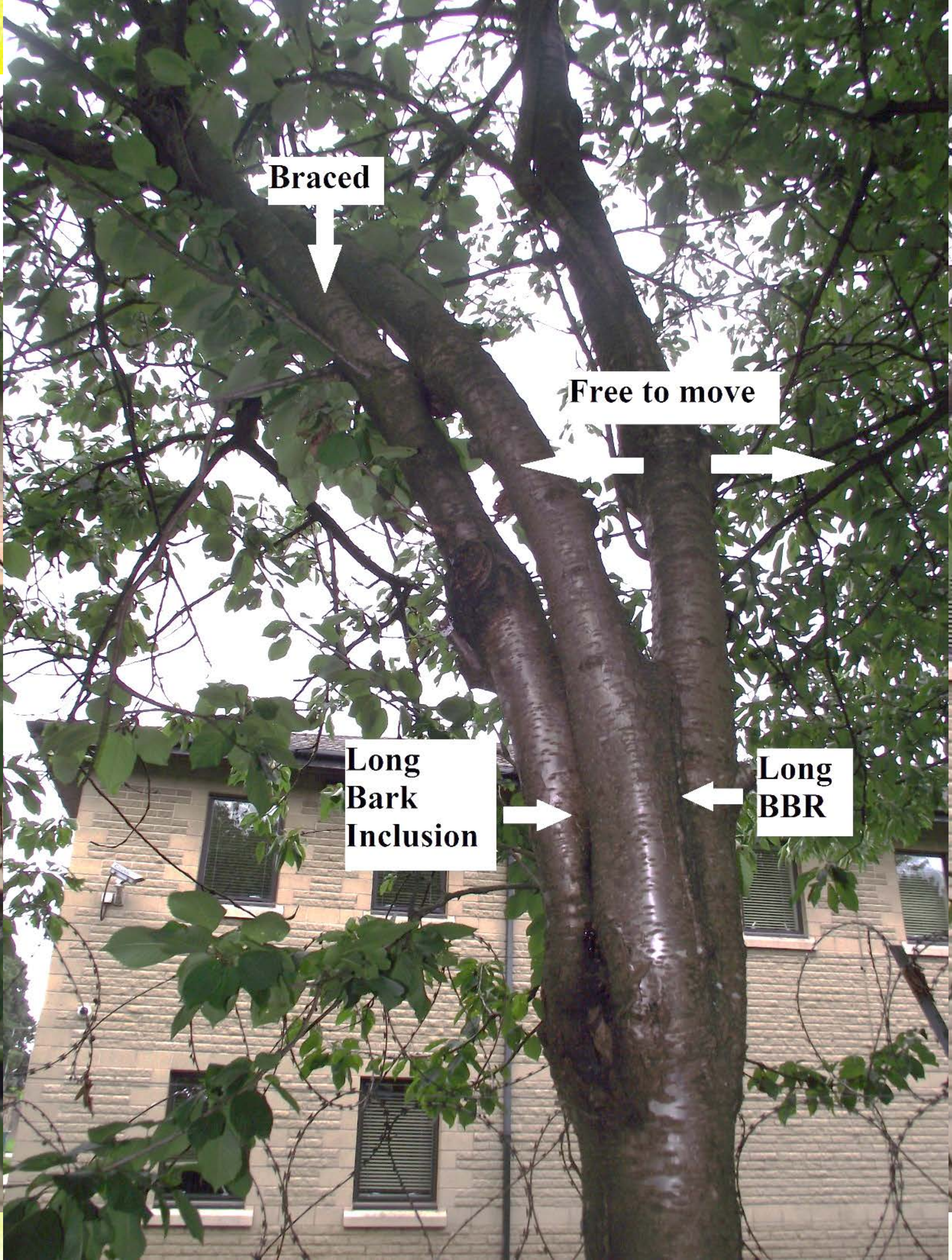
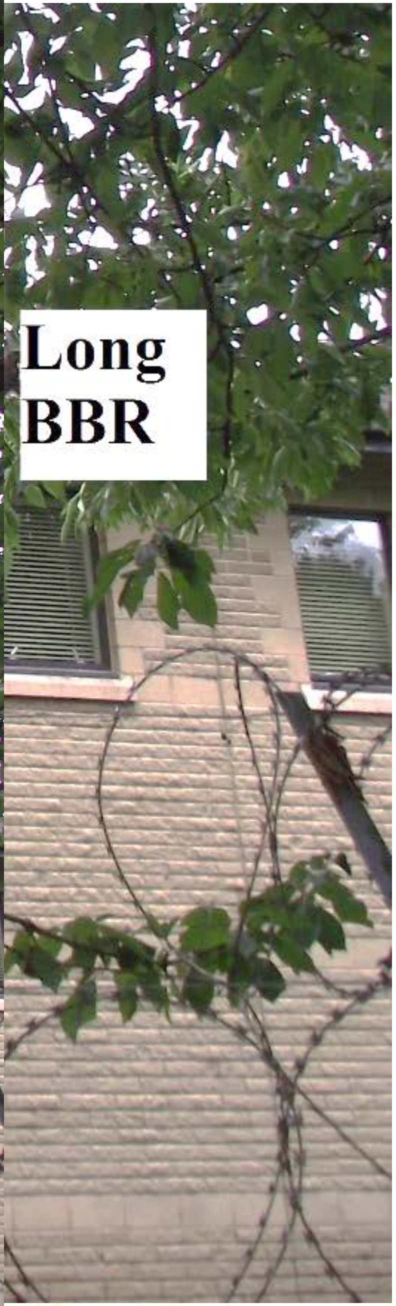
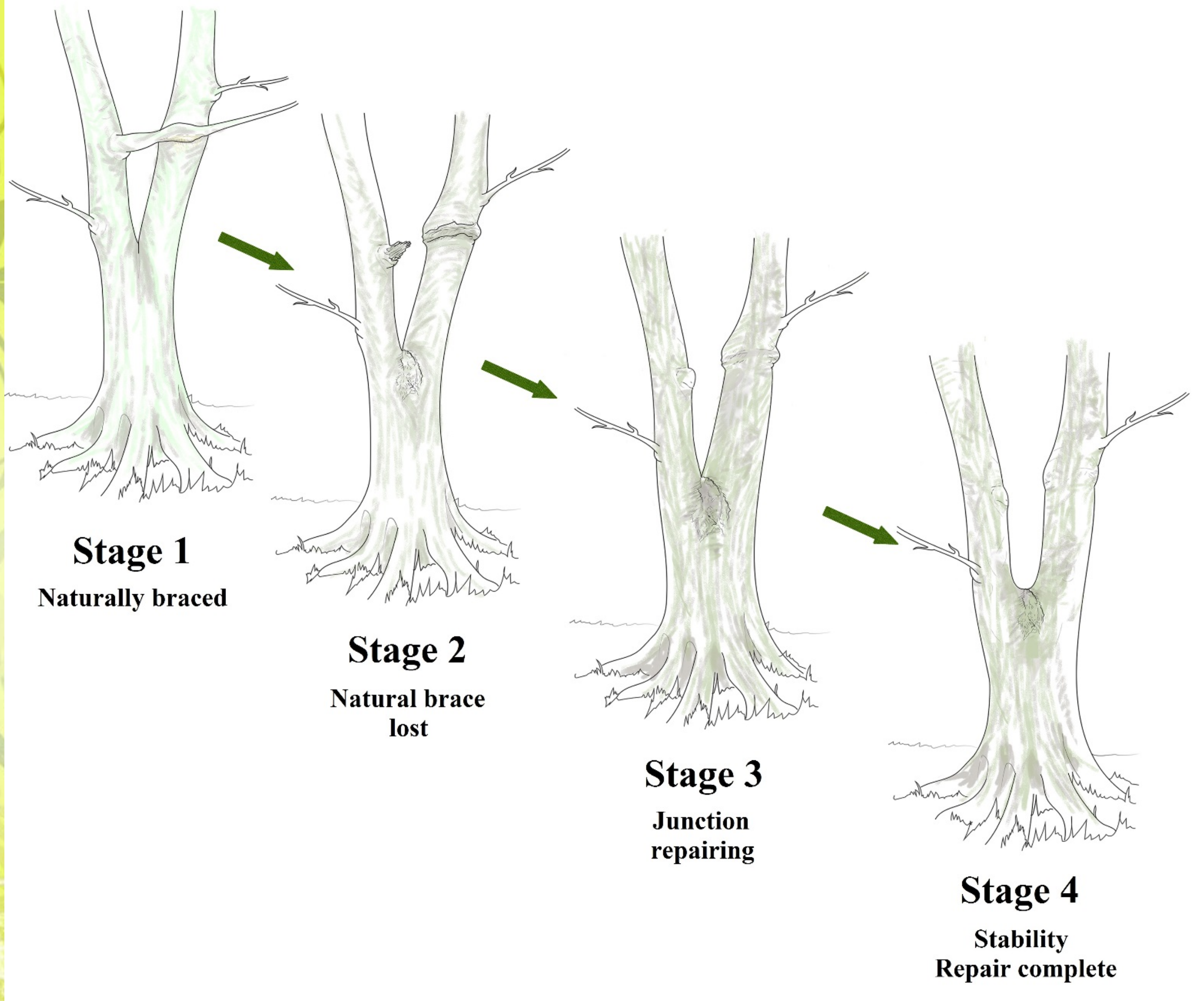
The Effects of Natural Bracing

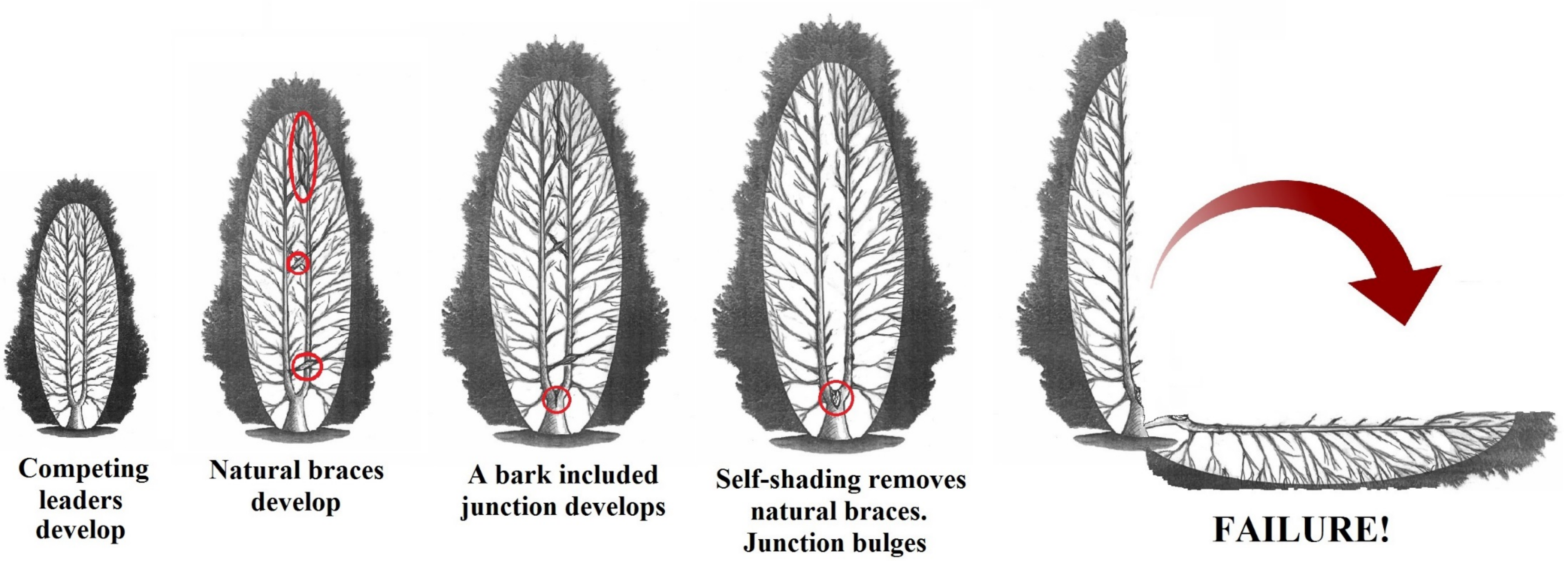

Braced
Free to move
Long
Bark
Inclusion
Long
BBR


Long
BBR

Stages of natural bracing…

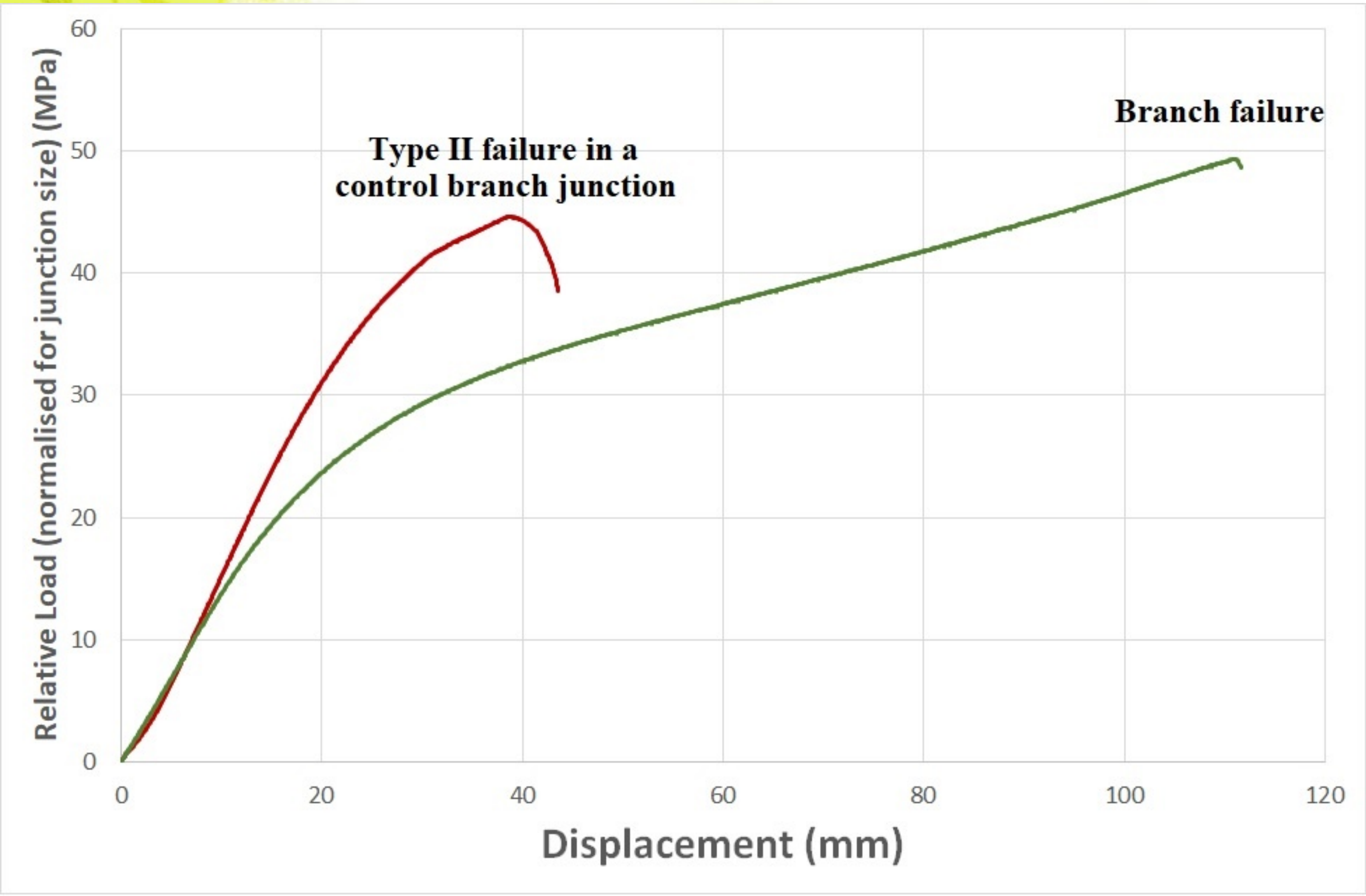


Natural bracing can explain a lot of tree morphology and failures

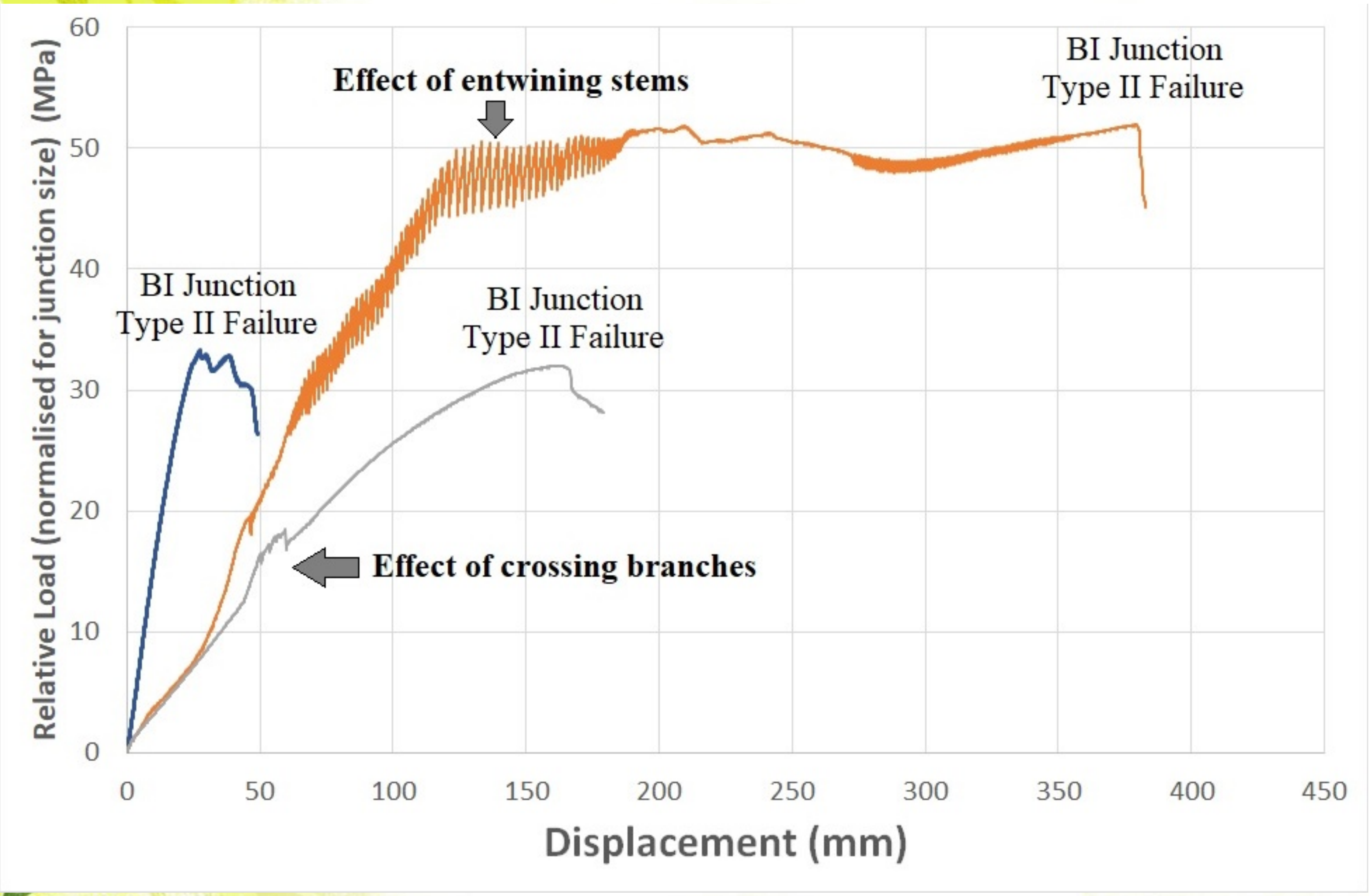


Tothill & Slater 2019

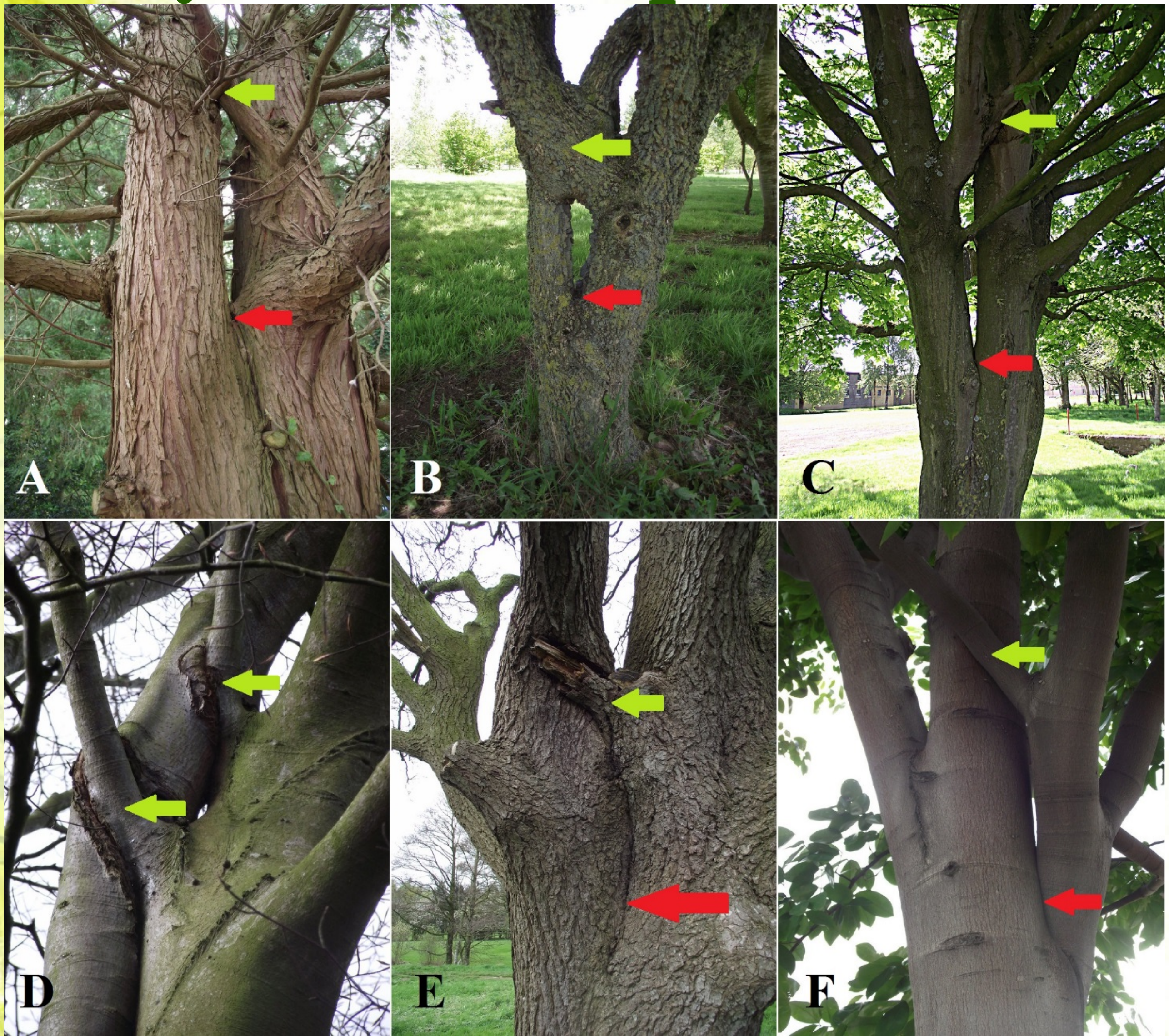
Meadows & Slater 2019



Meadows & Slater 2019



Natural bracing:
A very common phenomenon

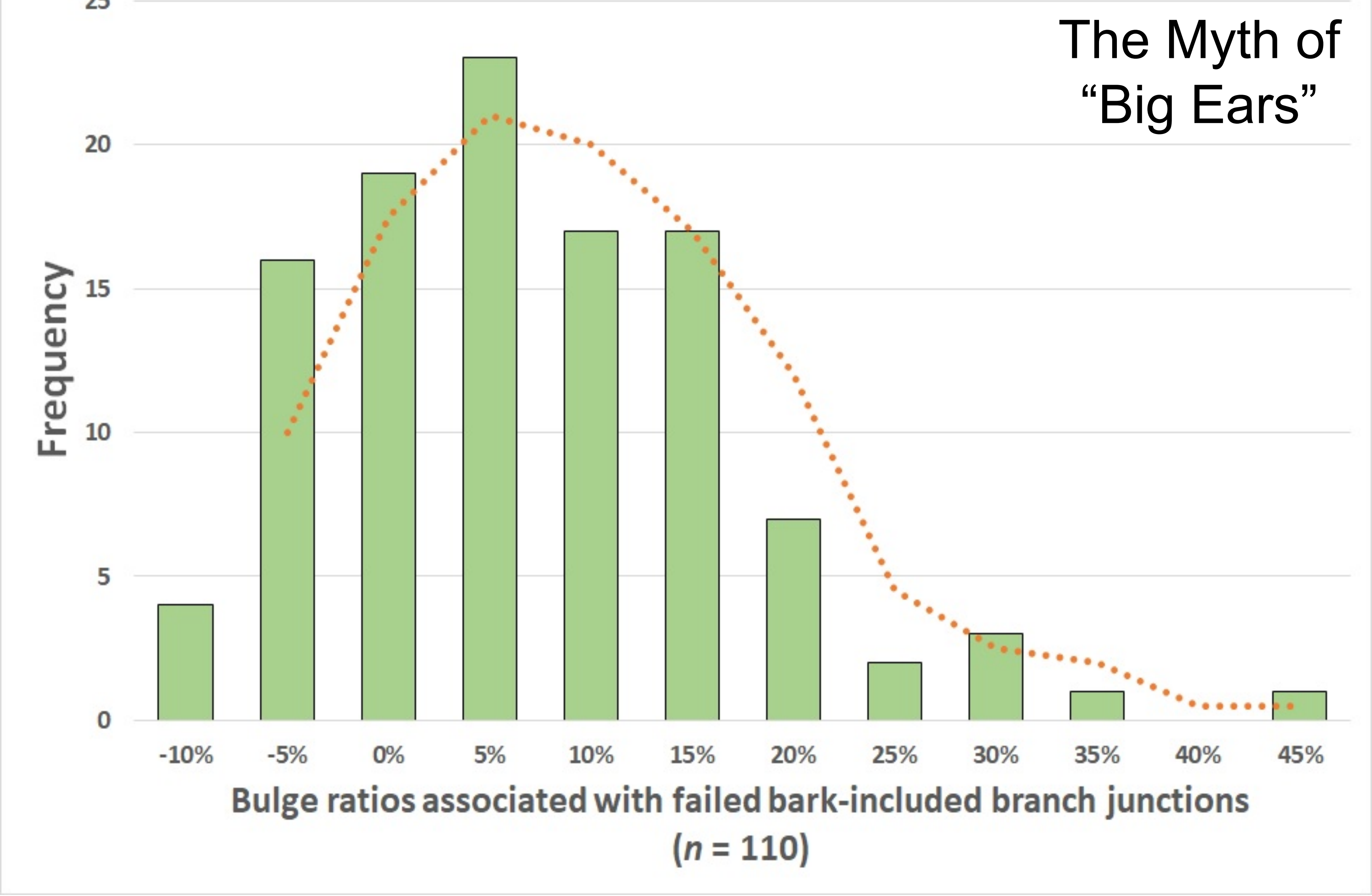


A need for education…

Is a big bulge better?

Big Ears?

Claus Mattheck suggested that a bark inclusion with large bulges (‘ears’) was more prone to failure. (Mattheck, 1998)



Frequency of BI failures against different extents of bulging

Modelling in hazel junctions

Branch Junction Type	Mean bulge ratio ± SE	Correlation between bulging ratio and peak bending stress
Control	10.63% ± 1.25% SE [a]	$R^2 = 0.15\%$; $p = 0.862$
Embedded bark	17.84% ± 2.7% SE [ab]	$R^2 = 9.54\%$; $p = 0.283$
Cup union	25.4% ± 1.78% SE [bc]	$R^2 = 3.66\%$; $p = 0.188$
Wide bark inclusion	32.43% ± 2.68% SE [c]	$R^2 = 1.18\%$; $p = 0.568$

The extent of the bulging was not a significant indicator of the bending strength of the branch junctions tested

BULGING = **NOT** SIGNIFICANT TO BENDING STRENGTH

ISA GUIDANCE

"The presence of response growth at a [bark-included] union indicates that the union is under strain. If there is enough response growth, the likelihood of failure may be reduced."

Dunster et al., 2017, pp. 105-106

Bulging around cracks or bark?

Is a fork a defect?

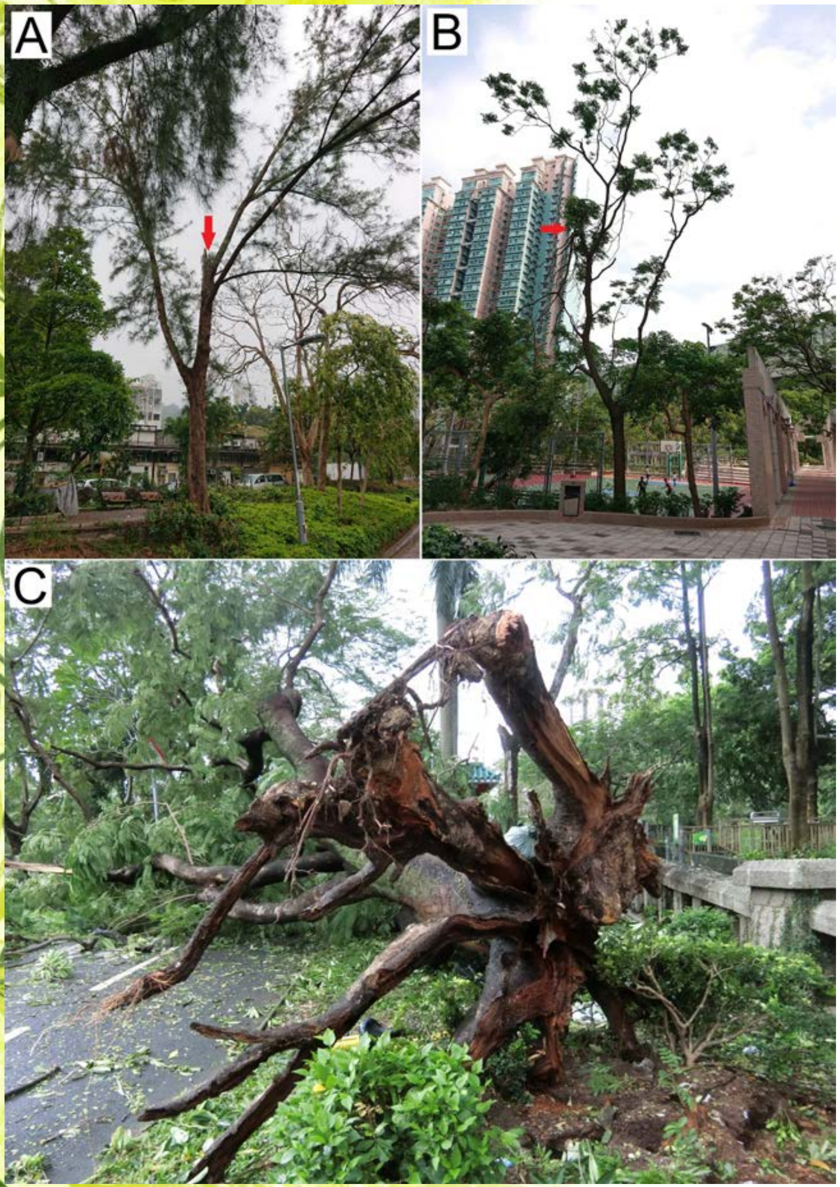
Should this be classed a defect?

Are normal branch junctions a big problem in trees?

Branches	Bases	BI junctions	Root plates	Stems	Normal junctions	Elongated Branches
3.3	2.3	2.8	2.0	1.6	1.0	1.9
Frequent	Occasional	Frequent	Occasional	Occasional	Rare	Occasional

n = 348 delegates

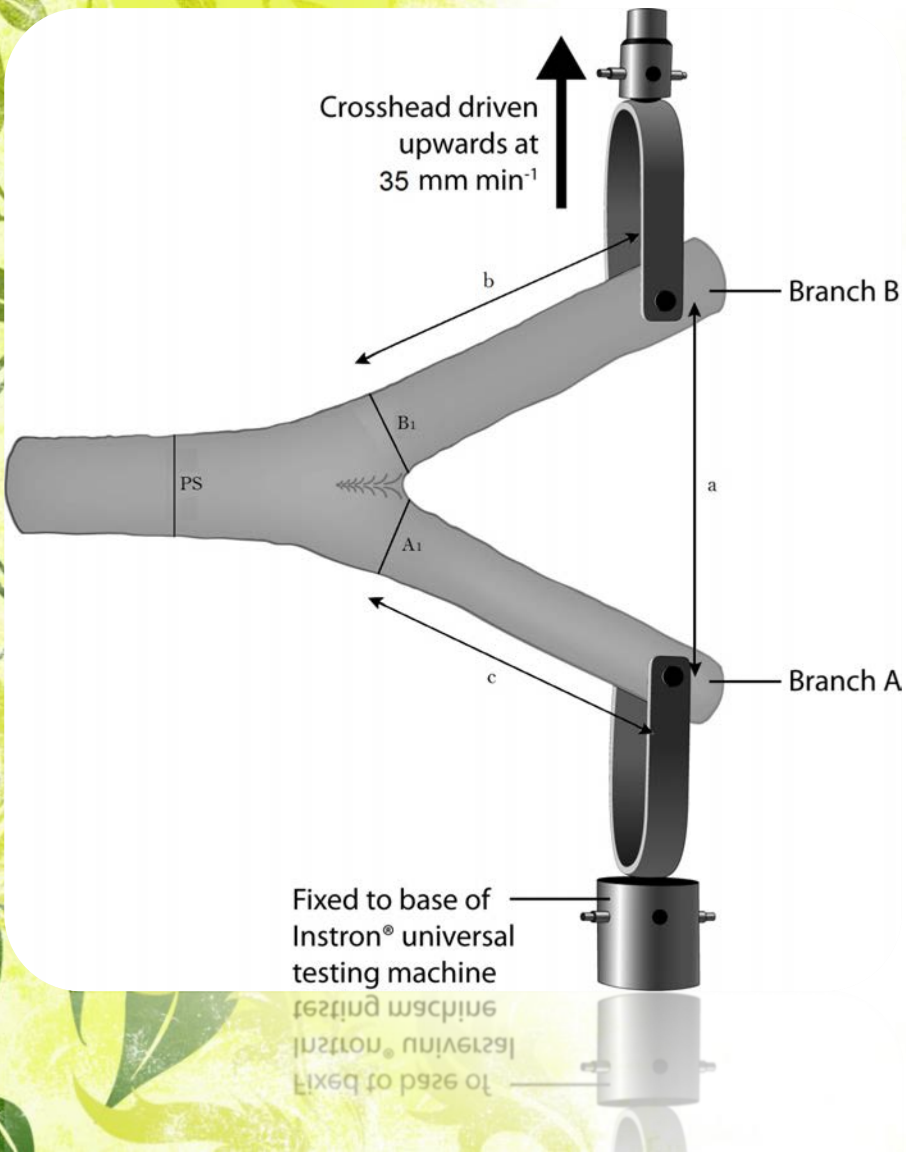
Data from a Super Typhoon



- Super Typhoon 'Mangkhut' hit Hong Kong 16th September 2018 – causing a lot of tree damage!
- Our storm survey identified this distribution of failures (*n* = 1,014 damaged trees):
  - 66% branch failures
  - 13% root plate failures
  - 11% stem failures
  - 10% branch junction failures
    - 4.7% BI junctions
    - 4.9% Epicormic branches
    - 0.5% Normal branch junctions

To Make Trees Safe: Remove All Their Branches! ;-)

Challenging old theories



- Static testing often done with c. 50 mm of branch lengths
- We are testing at:
  – 100 mm,
  – 200 mm,
  – 400 mm
  – 800 mm
- Failure mode changes

SUMMARY – Part One

- The primary cause of BI junctions is via natural bracing
- We can formatively prune trees to prevent the creation of BI junctions
- BI junctions should be assessed by taking into account any natural bracing – they do not inevitably fail
- Tree pruning guidelines and standards need to be updated

SUMMARY – Part Two

- Big bulges at a bark inclusion indicate there is definitely a defect inside
- Big bulges at a bark inclusion do not mean it is more likely to fail
- If you consider forks as defects in trees – YOU WILL CONDEMN MOST TREES! Fortunately, scientific analysis doesn't support this theory.

NEW GUIDANCE

I hope to “package up” a lot of this work together in a new

AA Guidance Note

WITH THANKS TO…

- All 348 respondents to my fork questionnaire undertaken in 2016
- Former students: Ching Yuen Lee, Dean Meadows & Ruth Tothill
- Have a safe journey ☺

Duncan Slater BSc BA MSc MEd PhD MArborA MICFor