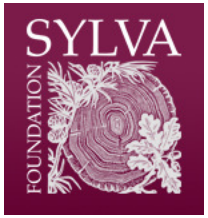
Living Ash Project

Yorkshire Wildlife Trust
Appleton-le-Moors

Jo Clark
Jo.Clark@futuretrees.org

13th June 2018



Overview

- The Host
  - Distribution
  - Relevance in Yorkshire
- The pathogen
  - How it got here
  - Lifecycle
  - Spread in UK
  - Management
- The Living Ash Project
  - What we've done
  - How you can help
  - Reference material

Fraxinus species native to Europe

F. excelsior
Common ash

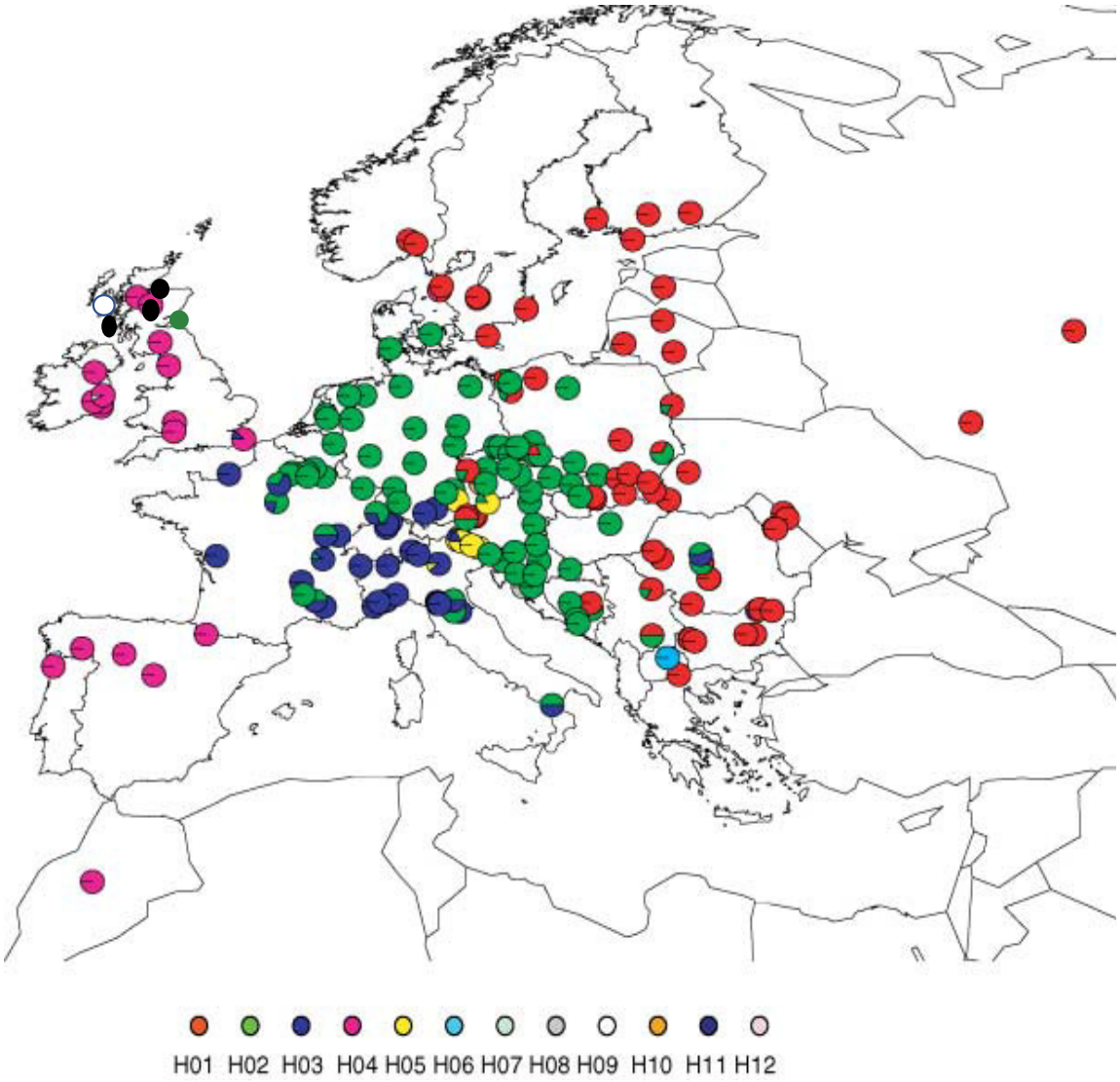
F. angustifolia
Narrow leaved ash

F. ornus
Manna ash/ flowering ash

Ash – *Fraxinus excelsior*

- 3 species ash native to Europe – we have just the one, *F. excelsior*
  - *F. excelsior*
  - *F angustifolia*
  - *F. ornus*
- Major component of woodlands and hedgerows throughout UK
- Ecologically important (Mitchell et al 2014)
  - 955 species associated with ash;
  - 44 obligate species - 4 lichen; 11 fungi; 29 invertebrates
  - 62 highly associated species – 13 lichen; 19 fungi; 6 bryophytes; 24 invertebrates
- Genetically diverse

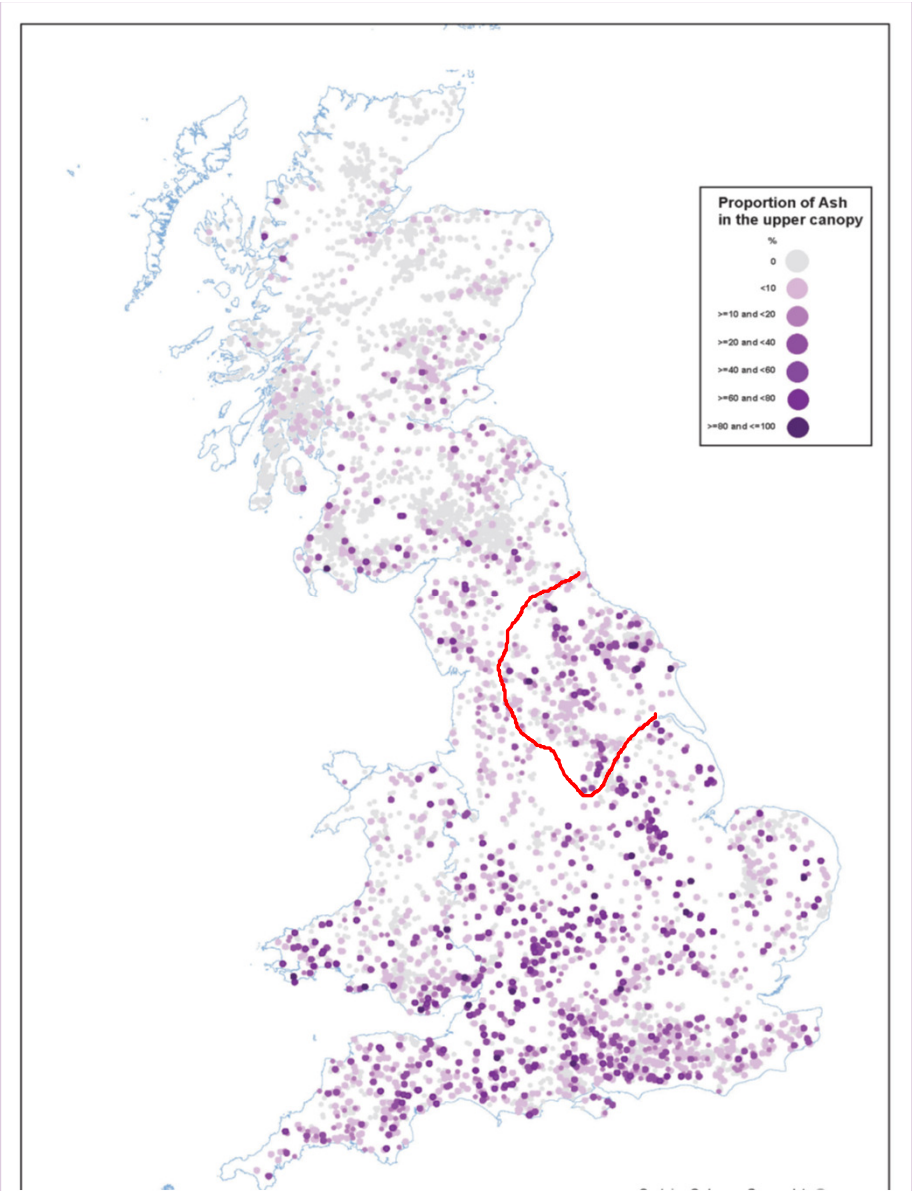
Geographic distribution of chloroplast microsatellite haplotypes for common ash



Heuertz et al 2004.
Haplotypes H1 – H12
Mol. Ecol **13**: 3437-3452

FRAXIGEN 2005
H2 found at Settrington

Sutherland et al 2010
H9 from Slovakia
H13-15 new
Mol. Ecol. **19**: 2196-2211



Ash Woodland In Great Britain

GB Forest Cover = 1.3 million ha

142,000 ha ash

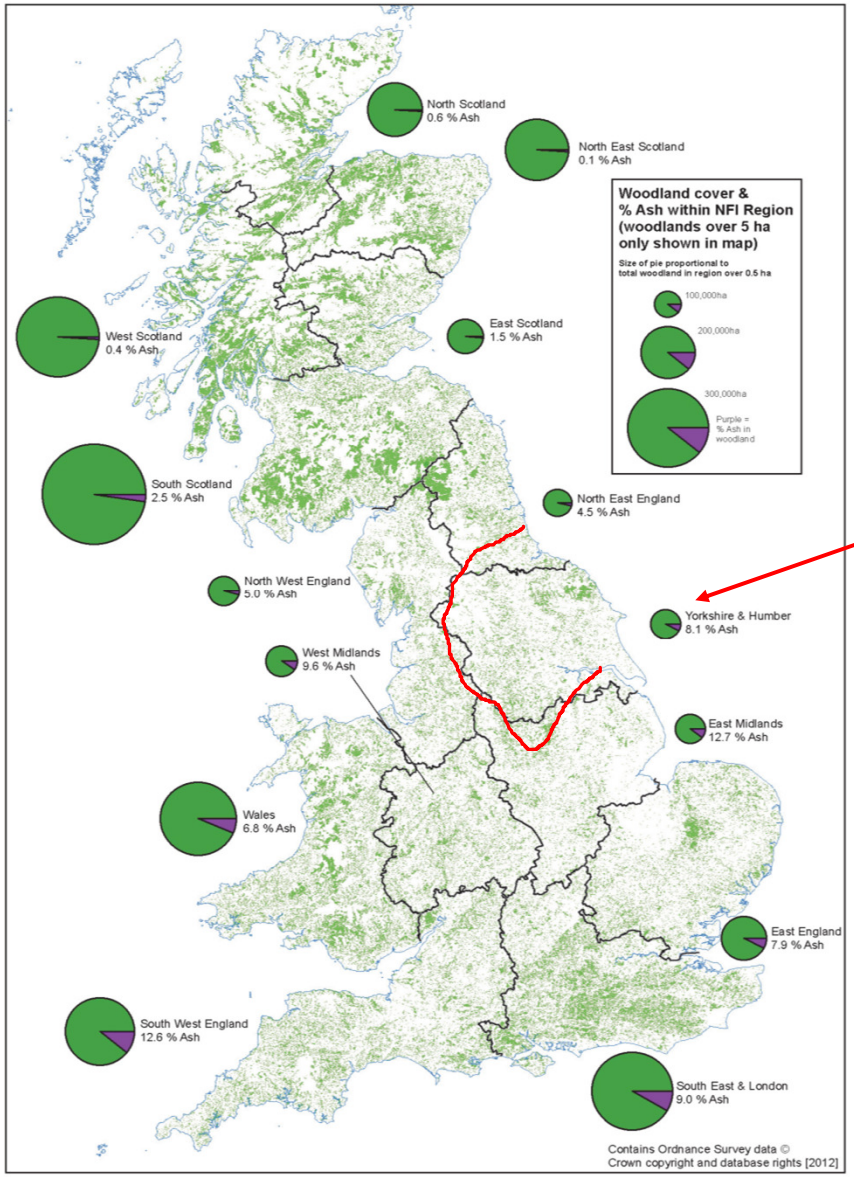
11% of broadleaves / 5% of total tree cover

126 million trees (in woodlands)

And

4.2 billion saplings and seedlings, of which 40% are ash – 1.6 billion!

REF: NFI 2013 – special focus on ash



Woodland cover and % ash within NFI regions

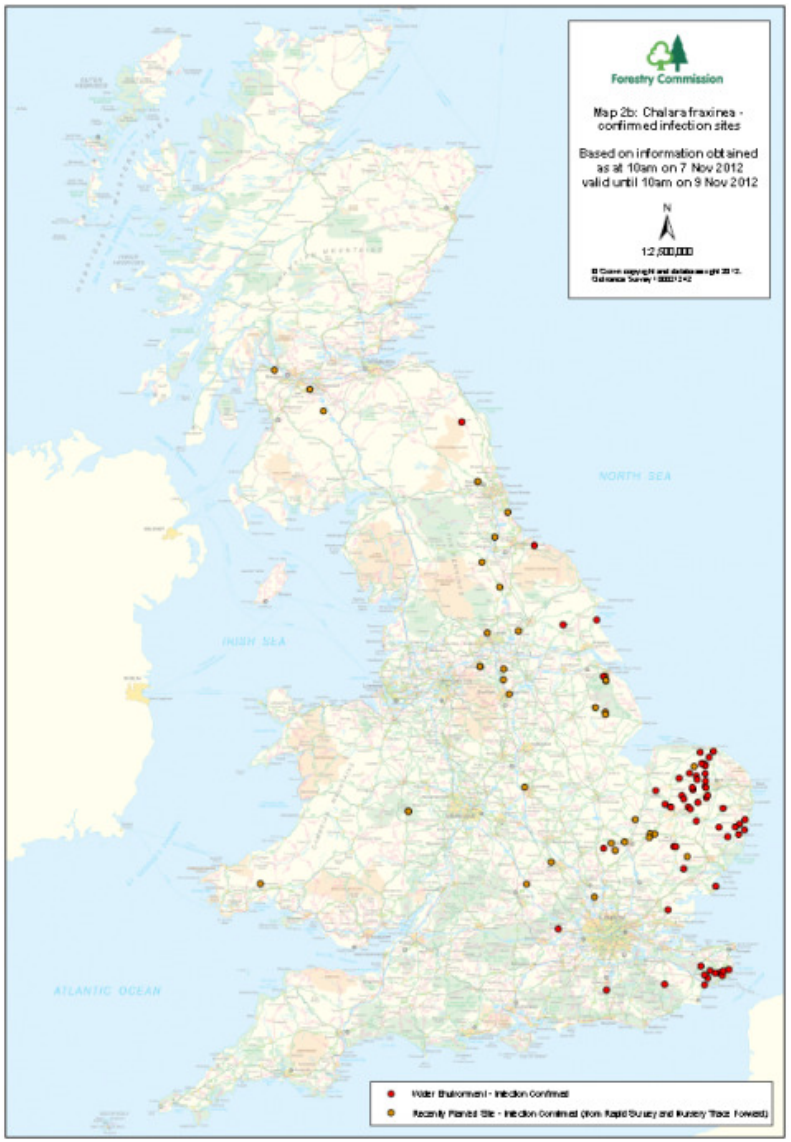
8.1% ash in Yorkshire

REF: NFI 2013 – special focus on ash

Ash Dieback Locations
6 November 2012

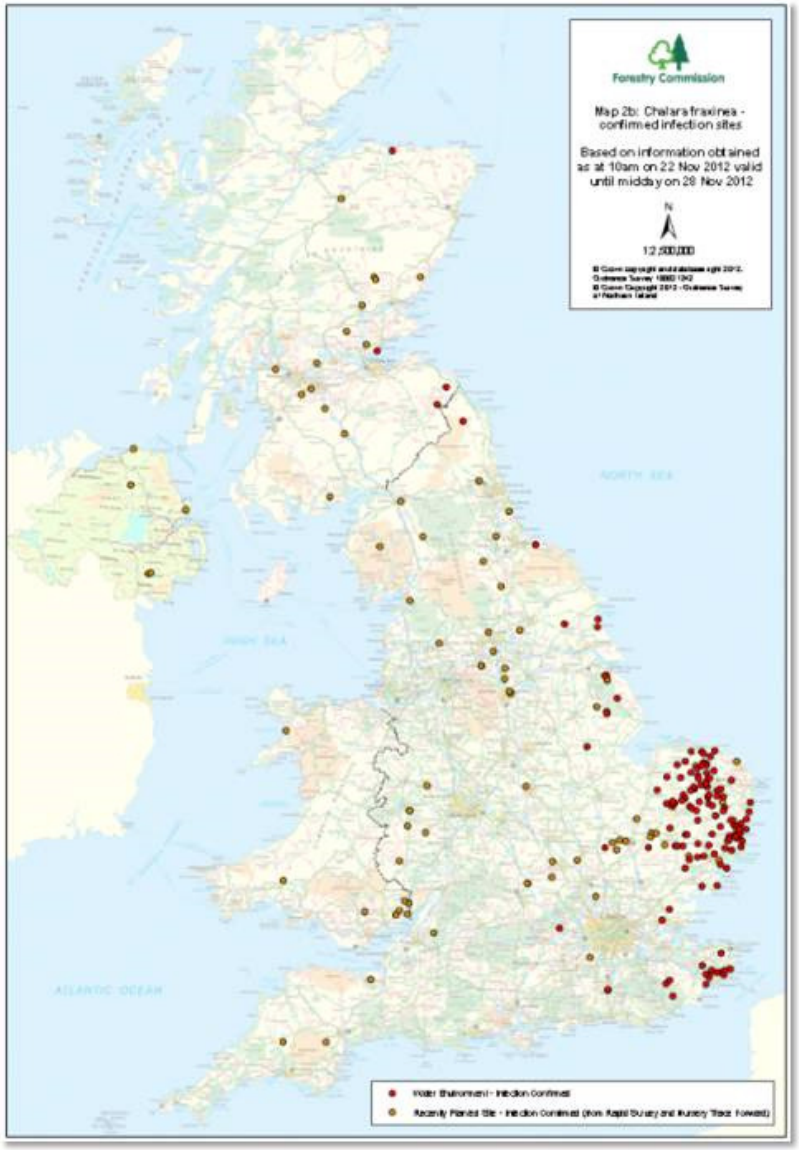
- Wider Environment
- Newly Planted/Nurseries

Source: Forestry Commission



Ash Dieback Locations
22 November 2012

- Wider Environment
- Newly Planted/Nurseries

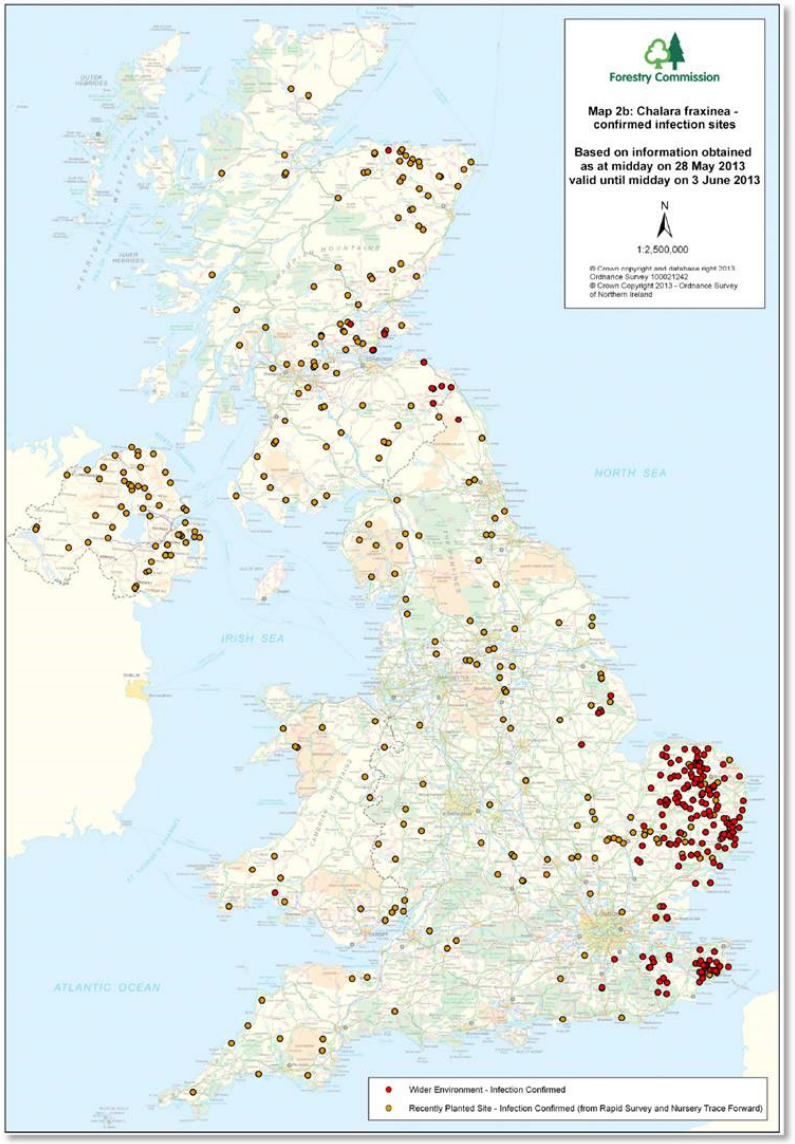


Source: Forestry Commission

Ash Dieback Locations
28 May 2013

- Wider Environment
- Newly Planted/Nurseries

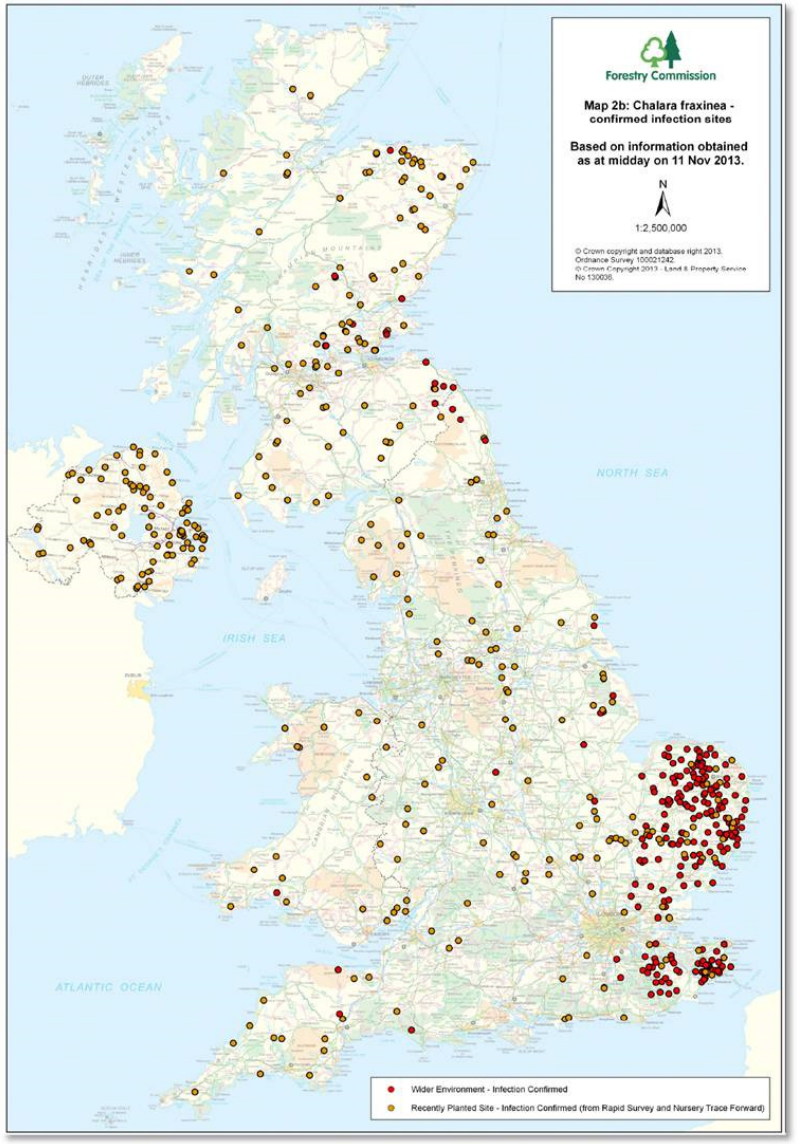
Source: Forestry Commission



Ash Dieback Locations
11 November 2013

- Wider Environment
- Newly Planted/Nurseries

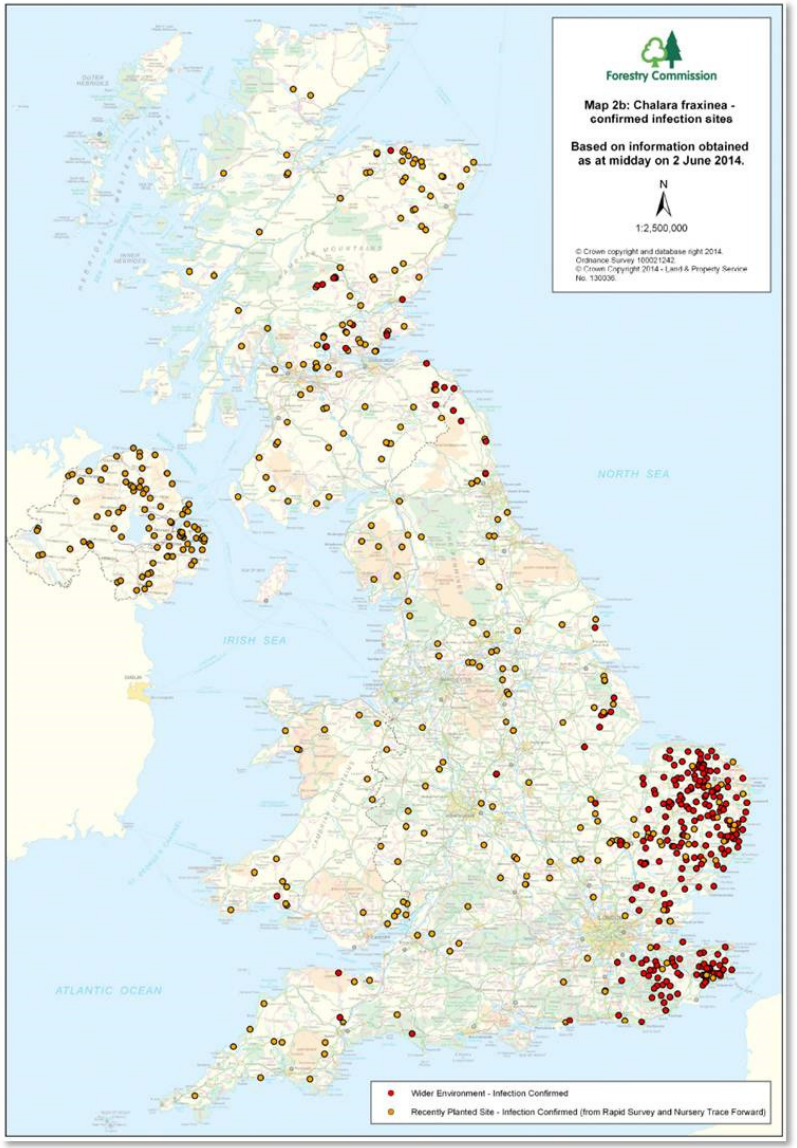
Source: Forestry Commission



Ash Dieback Locations
16 June 2014

- Wider Environment
- Newly Planted/Nurseries

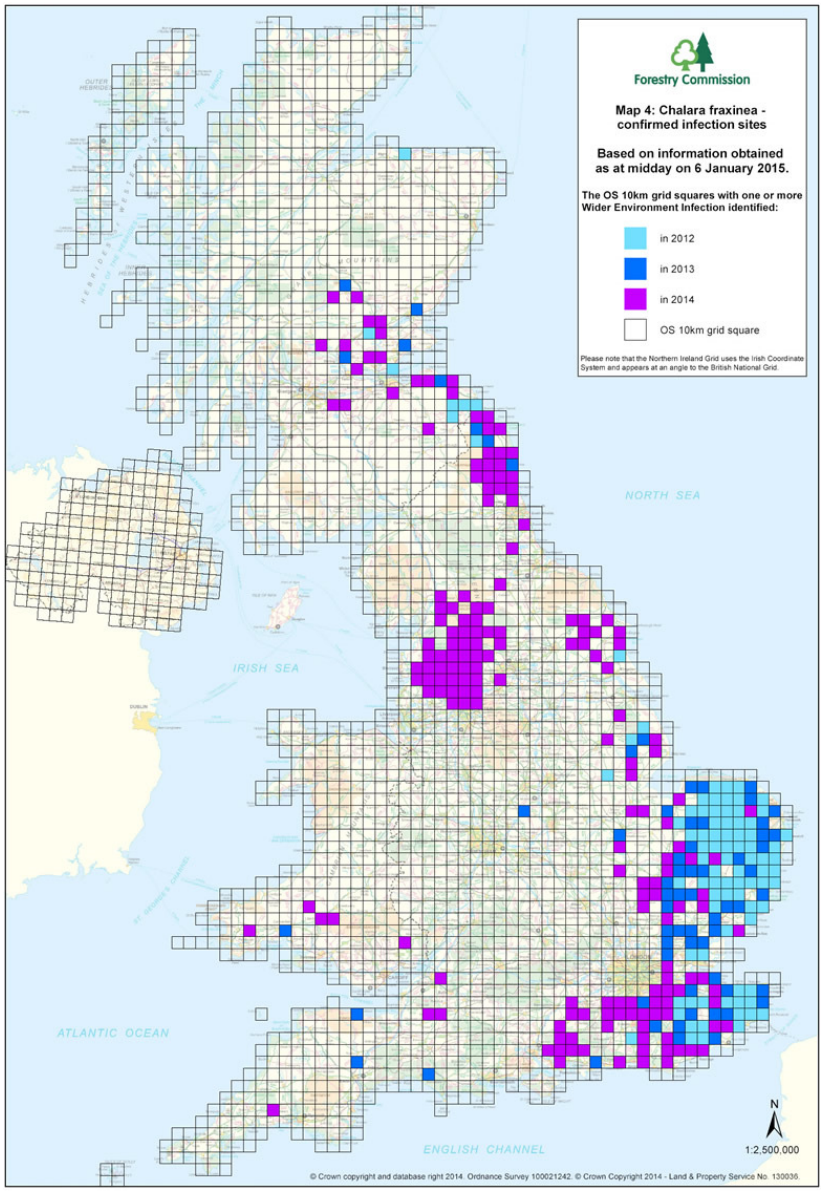
Source: Forestry Commission



Ash Dieback Locations
6 January 2015

2012
2013
2014

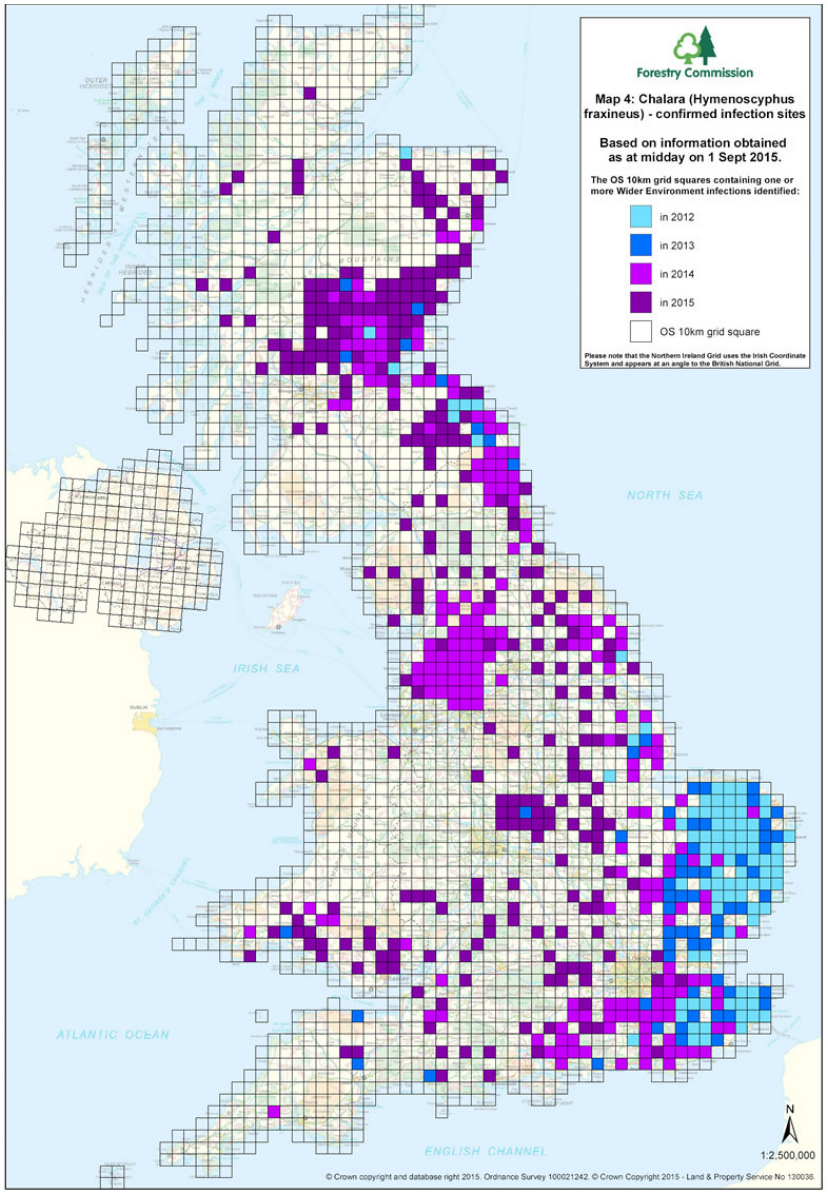
Source: Forestry Commission



Ash Dieback Locations
1 September 2015

2012
2013
2014
2015

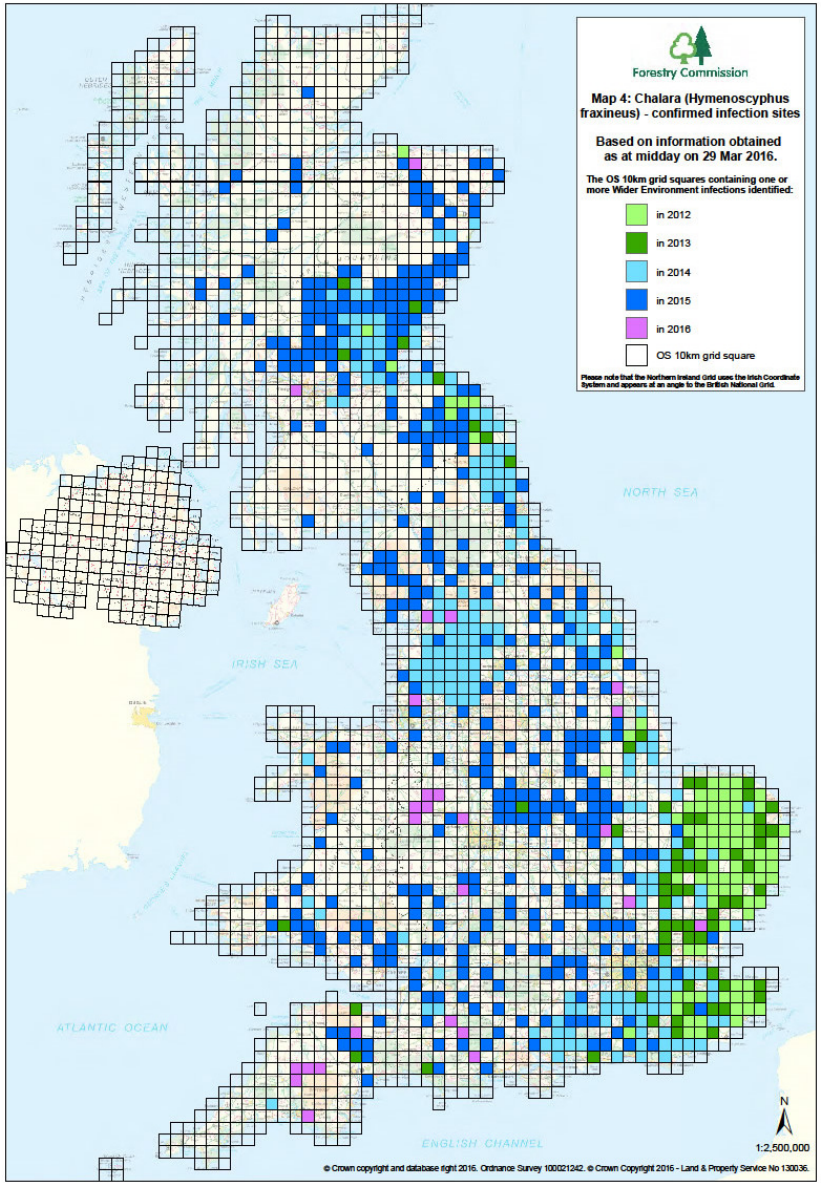
Source: Forestry Commission



Ash Dieback Locations
29 March 2016

- 2012
- 2013
- 2014
- 2015
- 2016

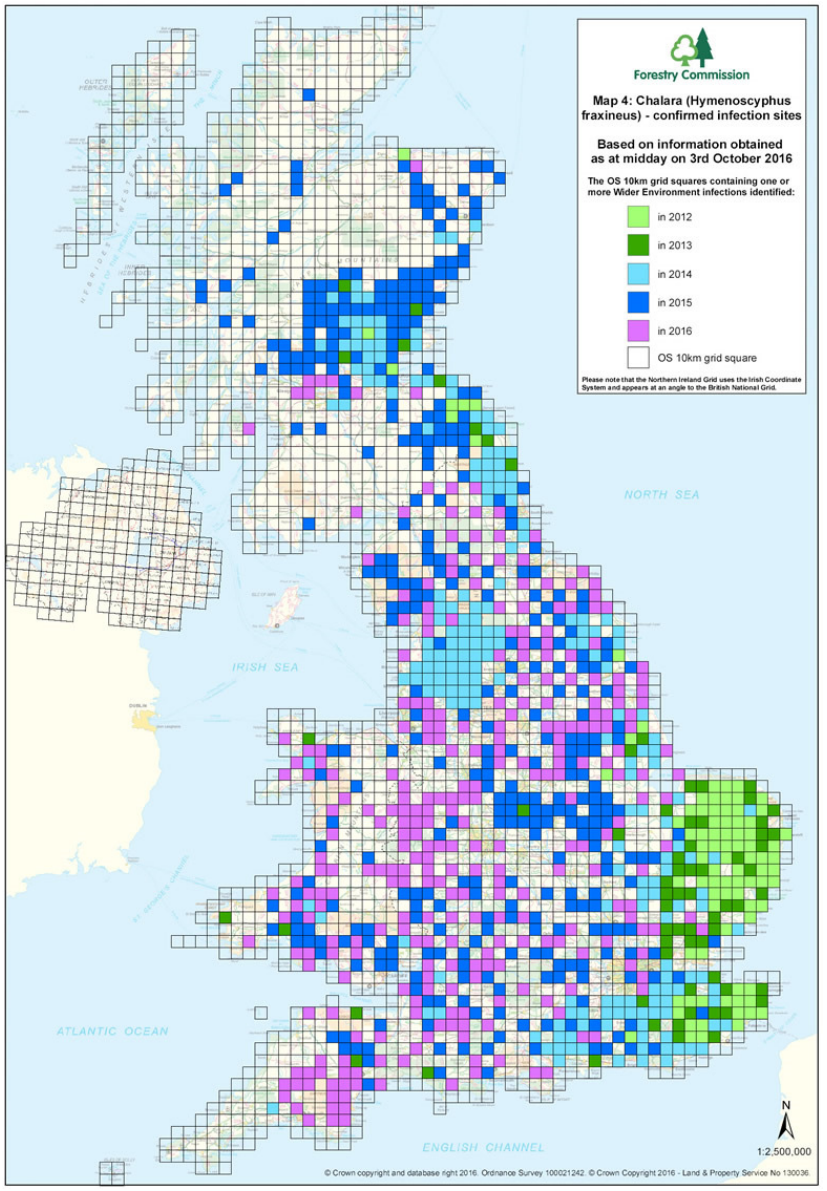
Source: Forestry Commission



Ash Dieback Locations
3 October 2016

- 2012
- 2013
- 2014
- 2015
- 2016

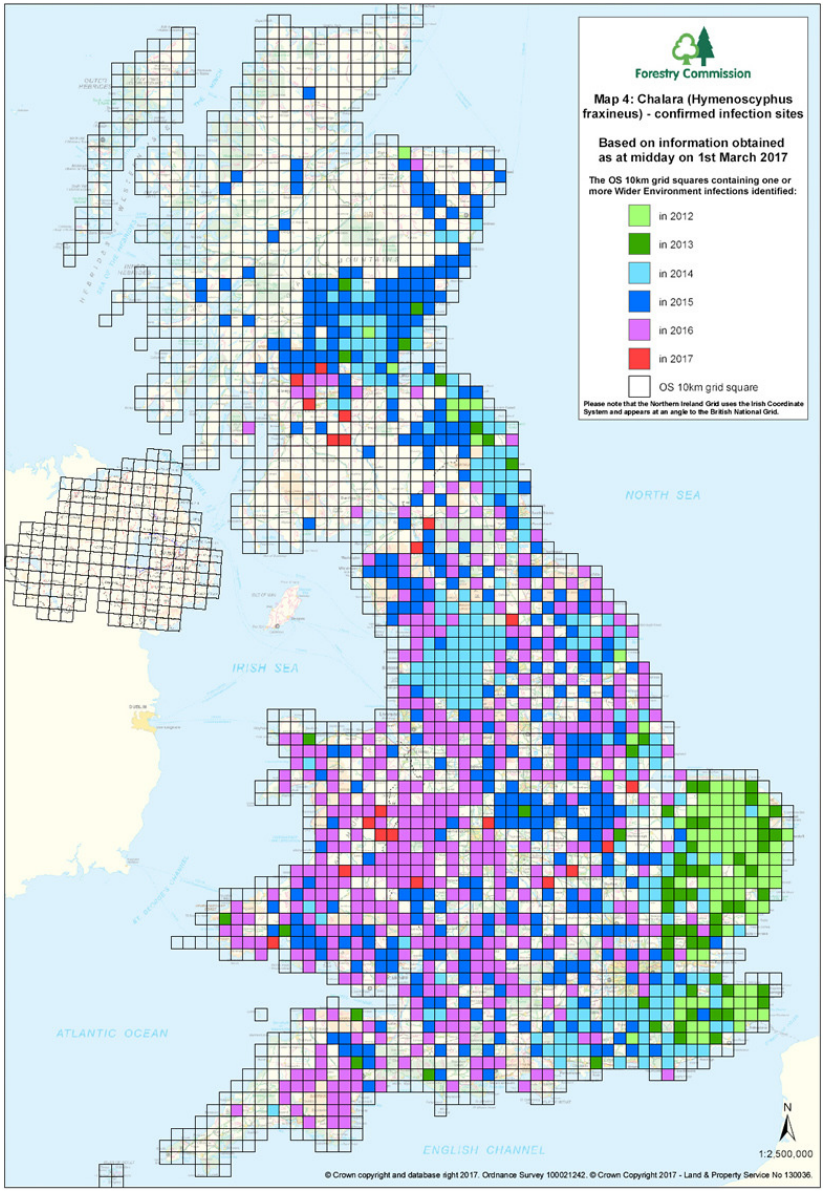
Source: Forestry Commission



Ash Dieback Locations
7 March 2017

- 2012
- 2013
- 2014
- 2015
- 2016
- 2017

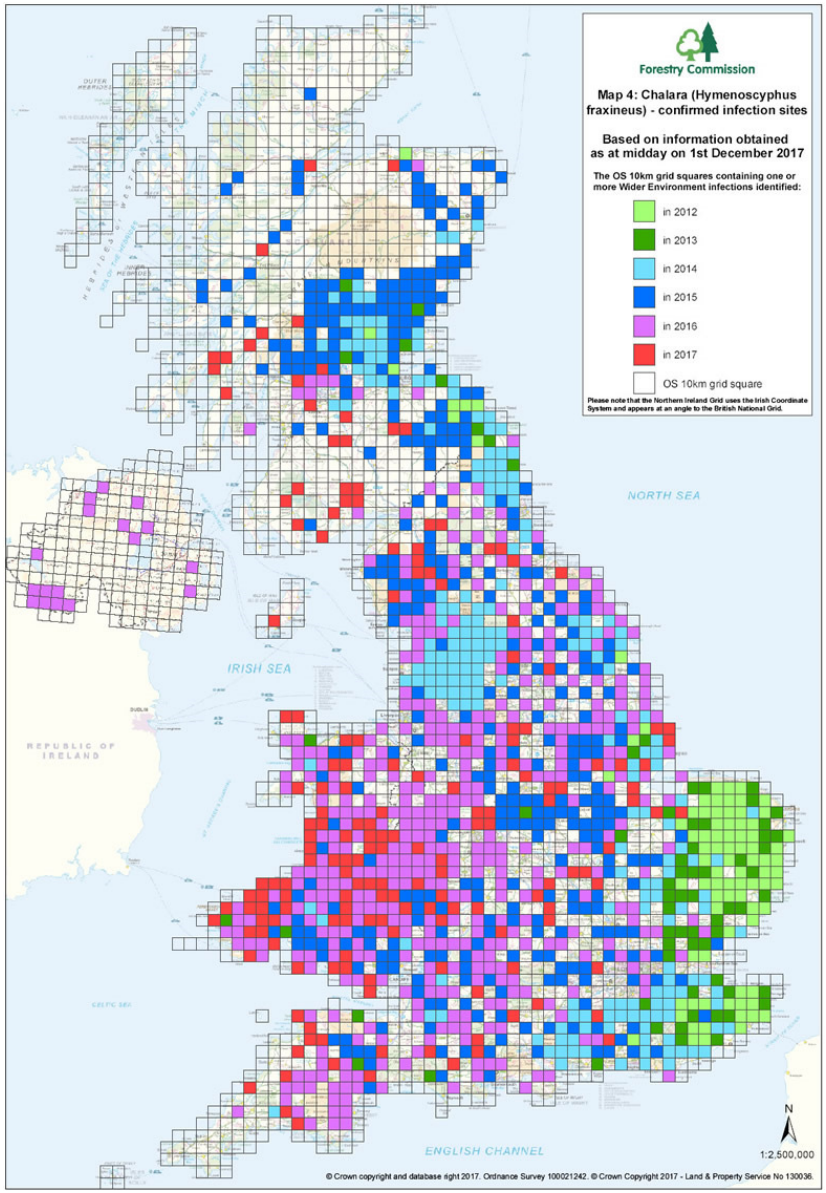
Source: Forestry Commission



Ash Dieback Locations
1 December 2017

- 2012
- 2013
- 2014
- 2015
- 2016
- 2017

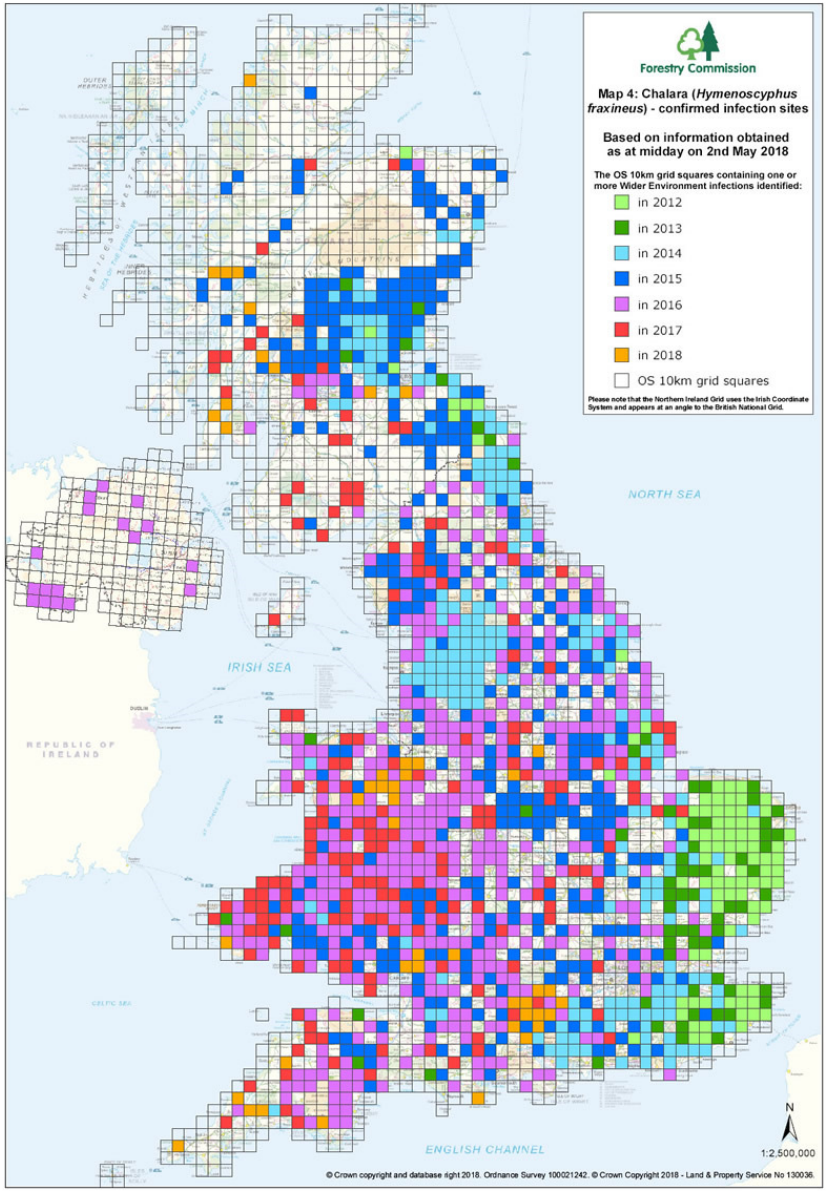
Source: Forestry Commission



Ash Dieback Locations
2 May 2018

- 2012
- 2013
- 2014
- 2015
- 2016
- 2017
- 2018

Source: Forestry Commission



Number of 10-kilometre grid squares with one or more infections confirmed in the wider environment

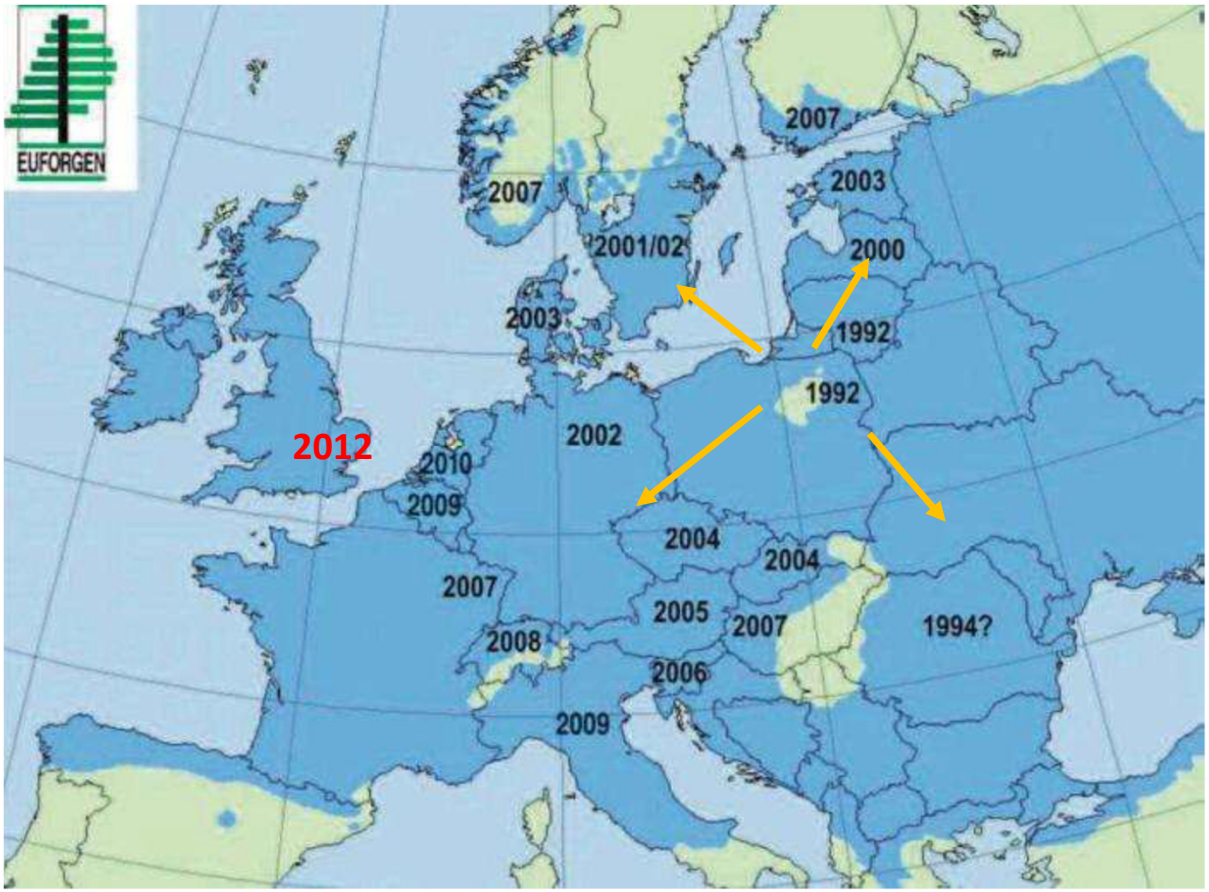
	2012	2013	2014	2015	2016	2017	2018	Total	% of 10K squares in country
Scotland	7	5	33	125	10	27	12	219	19.9
England	82	60	161	224	310	86	23	946	64.4
Wales	0	2	5	31	96	64	12	210	79.2
N. Ireland	0	0	0	0	17	0	0	17	9.1
UK TOTAL	89	67	199	380	433	177	47	1392	46.0%

Forest Research

History of *Hymenoscyphus fraxineus* (formerly *Chalara fraxinea*)

Date	
1992	New lethal disease of ash observed in Poland
1992 -	Spread to other regions in Europe; causal agent unclear
Early 2000s	A *Chalara* fungus isolated from many infected trees
2006	Asexual state of the fungus (the anamorph) identified and named *Chalara fraxinea (*Kowalski 2006*)*
2009	Sexual state (the telomorph) thought to be *Hymenoscyphus albidus*, a wide-spread and previously non-lethal fungus on ash (Kowalski and Holdenrieder 2009)
2011	Molecular research later confirmed the sexual state is a new species – *Hymenoscyphus pseudoalbidus* (Quelzol et al 2011)
February 2012	Confirmed arrival of ash dieback in GB, on nursery stock in Buckinghamshire
October 2012	Confirmed in wider environment in Norfolk. Ban on moving live ash material including seed put in place. Firewood OK to move.
May 2014	Revised nomenclature for the fungus has led to new name – *Hymenoscyphus fraxineus*

Natural range of ash (*Fraxinus excelsior*) in Europe



Dates indicate the spread of infection across Europe, with the earliest cases being confirmed in Poland (1992). Ref: EUFORGEN

There appears to be variation among *Fraxinus* spp. in their resistance to ash dieback

Highly susceptible	*Fraxinus excelsior*
	Fraxinus angustifolia
	Fraxinus niger
Moderately susceptible	*Fraxinus ornus*
	Fraxinus pennsylvanica
Least susceptible	*Fraxinus americana*
	Fraxinus mandschurica

Anatomy of an ash leaf

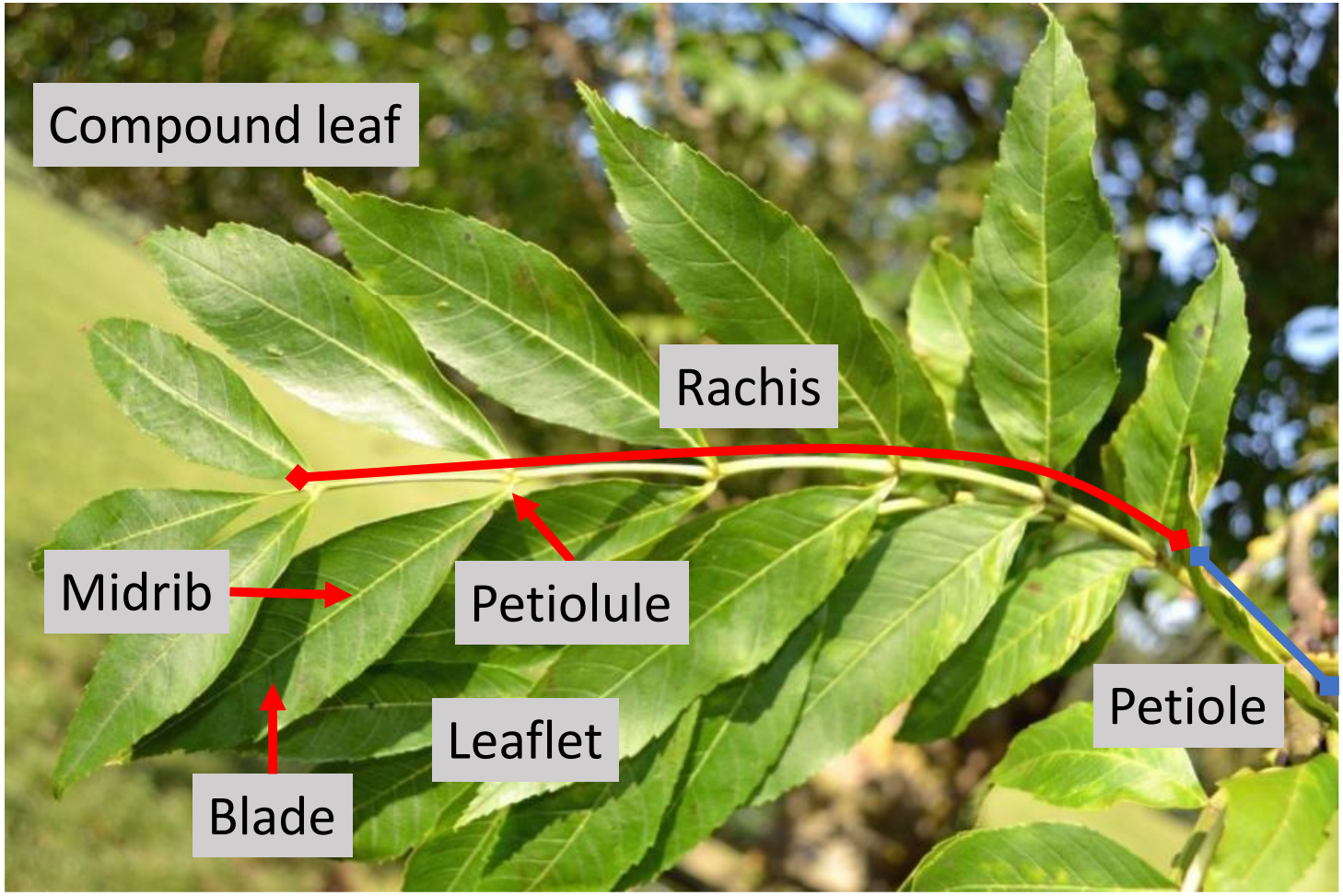
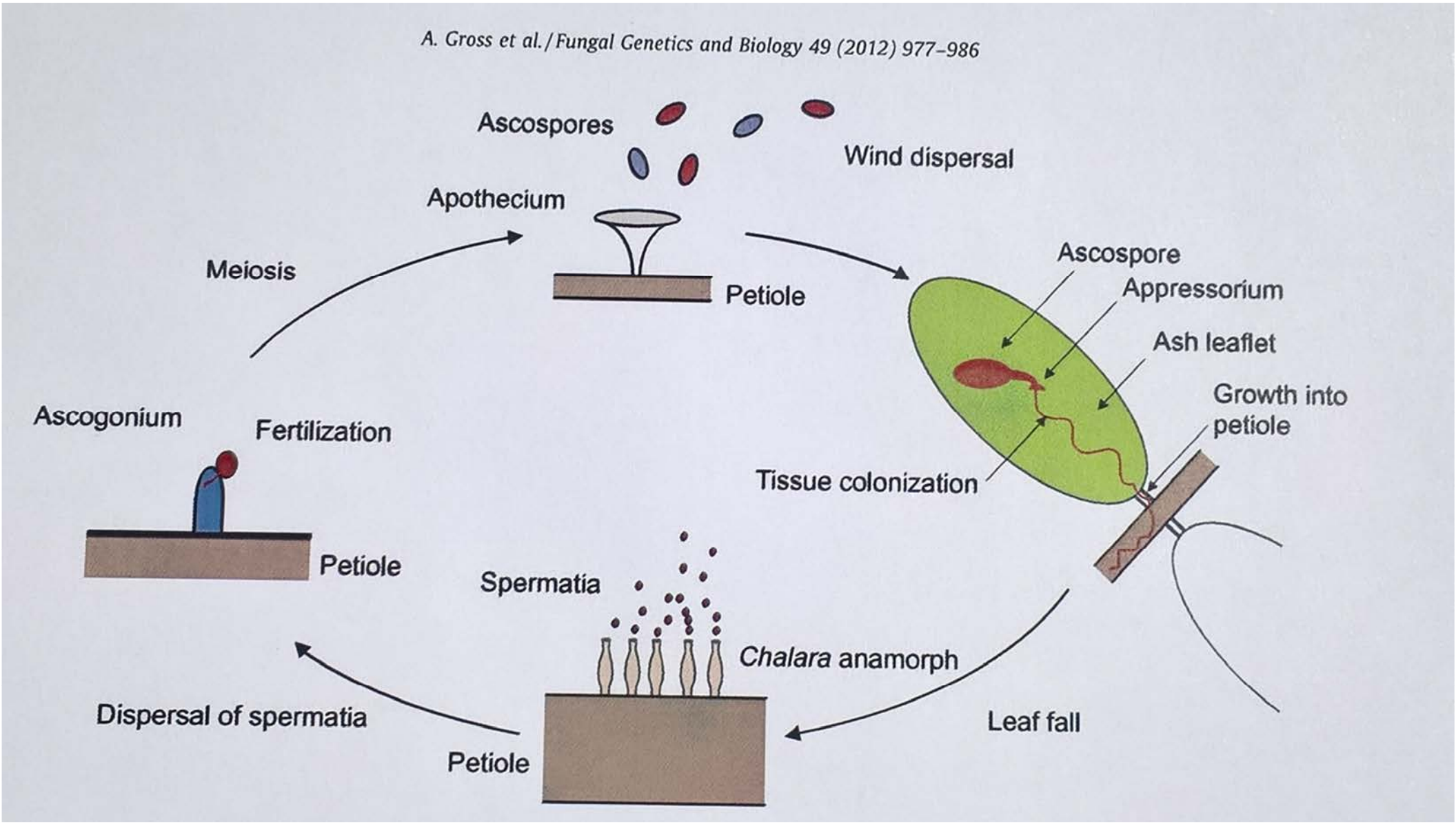
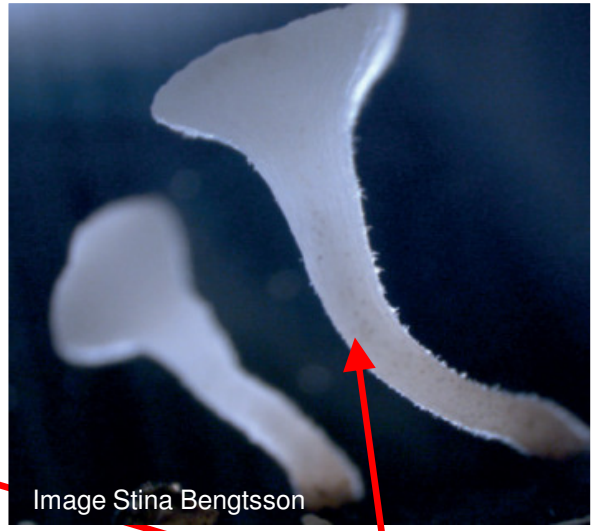


Photo: Wilson 2013


Ascospores
Wind dispersal
Apothecium
Meiosis
Petiole
Ascospore
Appressorium
Ash leaflet
Growth into petiole
Tissue colonization
Ascogonium
Fertilization
Petiole
Spermatia
Chalara anamorph
Dispersal of spermatia
Petiole
Leaf fall

Lifecycle of *Hymenoscyphus fraxineus*



***H. fraxineus* fruit bodies on fallen ash rachises produce ascospores**

Images courtesy of I Thomsen and L McKinney

Disease symptoms


Ascocarps on rachises
24th July 2017

Stages of collar lesion and bark and wood discolouration (1)

Early stage necrosis and red-brown discolouration of stem bark

Mid stage collar lesion with depression and one or few cracks in bark

Late stage collar lesion with depression and many cracks in bark

Source: Skovsgaard et al 2017

Stages of collar lesion and bark and wood discolouration (2)

Early stage collar necrosis caused mainly by *H. fraxineus*

Mid stage collar necrosis due to *H. fraxineus* and *Armillaria* sp., with white mycelium of *Armillaria* sp.

Advanced collar rot and discolouration in wood, with black zone lines due to *Armillaria* sp.

Source: Skovsgaard et al 2017

Stages of collar lesion and bark and wood discolouration (3)

Early stage brown discolouration of wood due to *H. fraxineus* (in this case entering through an epicormic branch)

Mid stage discolouration due to *H. fraxineus* (entering at the root collar) and *Armillaria* sp.

Late stage brown discolouration of the stump due to *H. fraxineus* and *Armillaria* sp., with black zone lines due to *Armillaria* sp. in progressively decaying parts of the wood.

Source: Skovsgaard et al 2017

Caroline's Wood
Norfolk
January 2018

- the spores are unlikely to survive for more than a few days
- spore dispersal on the wind is possible from mainland Europe
- trees need a high dose of spores to become infected
- spores are produced from infected dead leaves during June to September
- there is a low probability of dispersal on clothing or animals and birds
- the disease will attack any species of ash
- the disease becomes obvious within months rather than years
- wood products would not spread the disease if treated properly
- once infected, trees cannot be cured
- not all trees die of the infection - some are likely to have genetic factors which give them tolerance of, or resistance to, the disease.

REF: https://www.forestresearch.gov.uk/tools-and-resources/pest-and-disease-resources/ash-dieback-hymenoscyphus-fr

Forest Research

Management objectives

- maintain the values and benefits associated with ash woodlands and iconic trees;
- secure an economic return where timber production is an important objective;
- reduce the presence and rate of spread of ash dieback;
- maintain as much genetic diversity in ash trees as possible with the aim of ensuring the presence of ash in the long term; and
- minimize impacts on associated species and wider biodiversity.

Grants available under countryside stewardship for replacing ash trees

Forest Research

Management Guidance (1)

What are your objectives – conservation or production or both?

Conservation

Consider leaving areas of non intervention. This will allow natural processes to select tolerant trees over time which will produce next cohort. Also allows best option for other ash associated species. Dead trees also provide habitat. NB – not practical in areas of high public access.

Timber production

Young stands – thin heavily to reduce likelihood of infection, favouring most healthy trees.

Older stands – if 50% of crown infected, consider removing to realise economic value in tree and reduce spore load.

Health and Safety

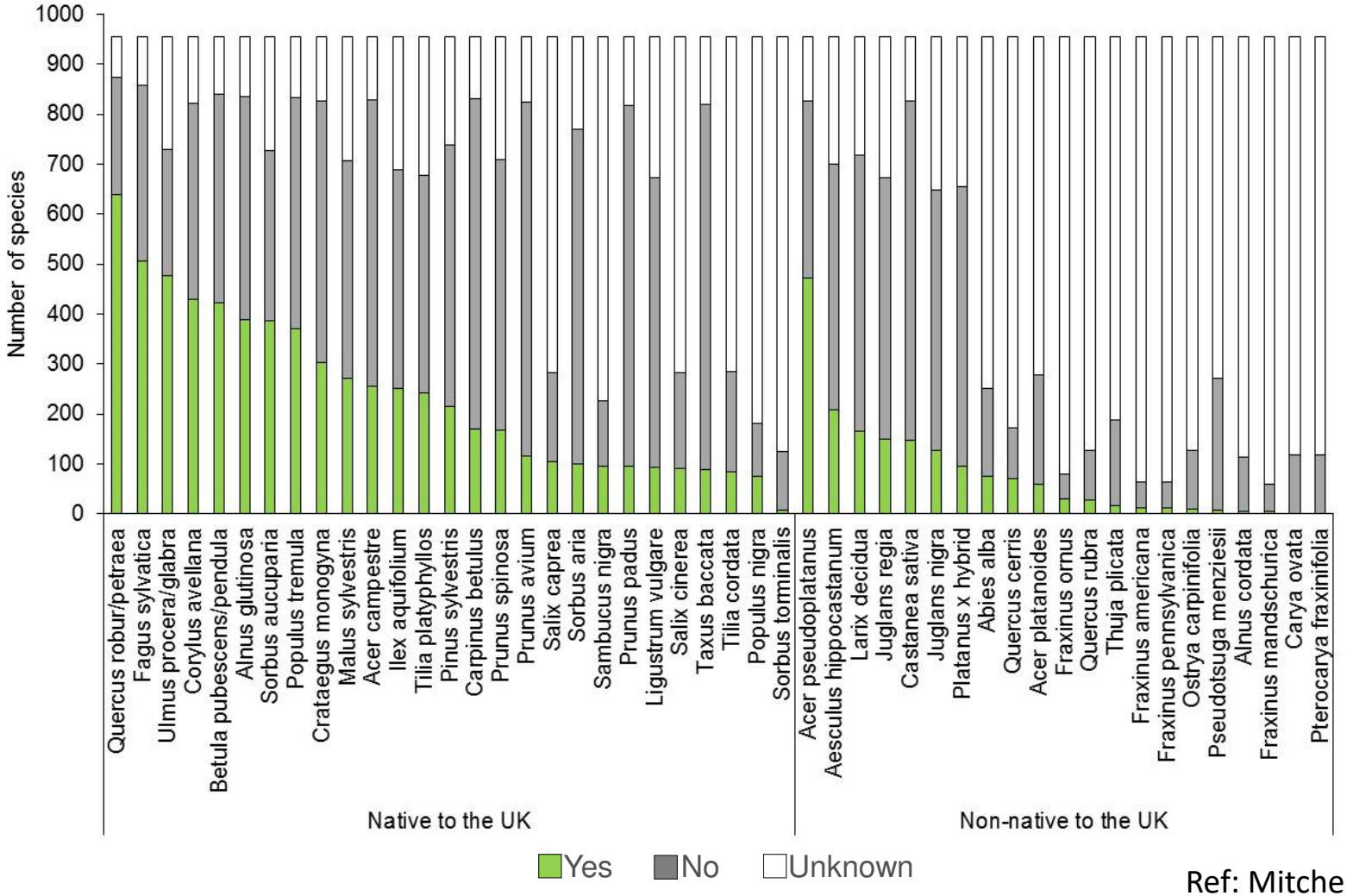
Carry out annual survey along roadsides. Important to check stem for basal lesions as top can still be green. Fell any trees with basal lesions as these can fall/ snap unexpectedly.

Always try and retain any healthy looking trees if possible and practical

Management Guidance (2) – increasing woodland resilience

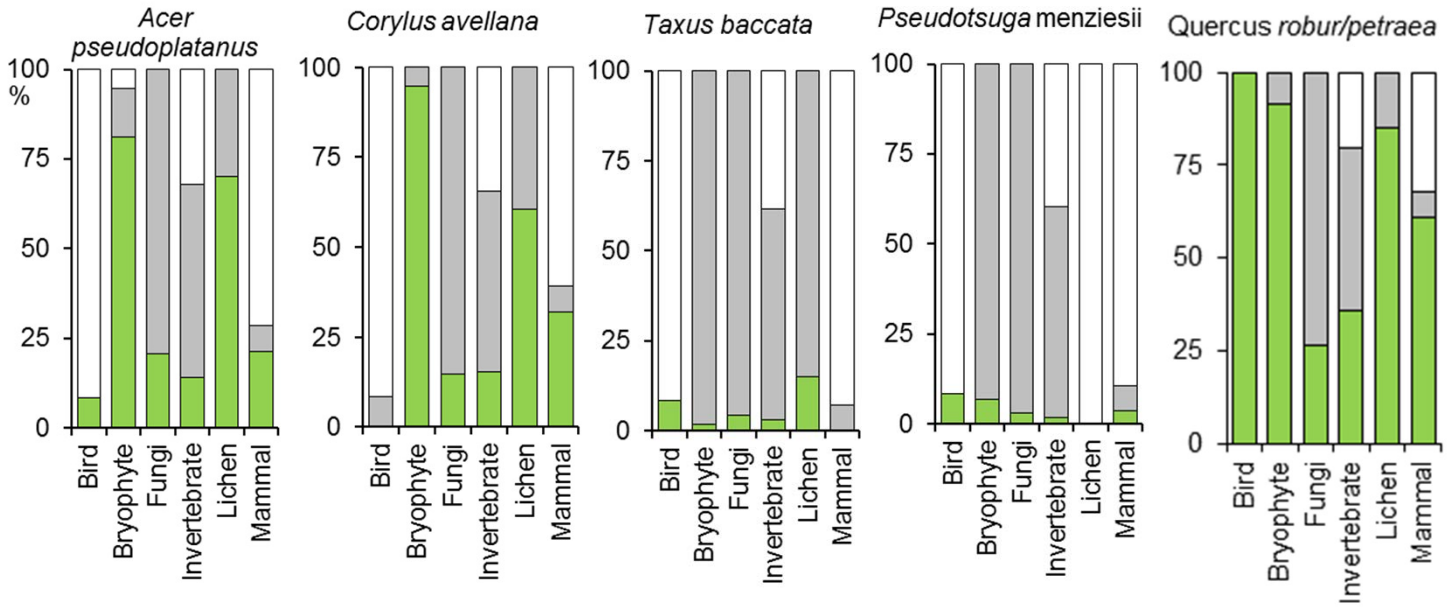
- Increase species diversity – plant other tree species appropriate to the site – use ESC to help http://www.forestdss.org.uk/geoforestdss/esc4m.jsp
- Increase genetic diversity (diversity within a species). Local isn't necessarily best
- Diversify stand structure – consider using continuous cover forestry http://www.ccfg.org.uk/

Alternative tree species: species use



Ref: Mitchell et al 2014

Alternative tree species: species use



- Some tree alternatives only "good" for certain groups of ash-associated species
- Conifers generally not "good" for ash-associated species
- Oak "good" for many ash-associated species

Yes

No

Unknown

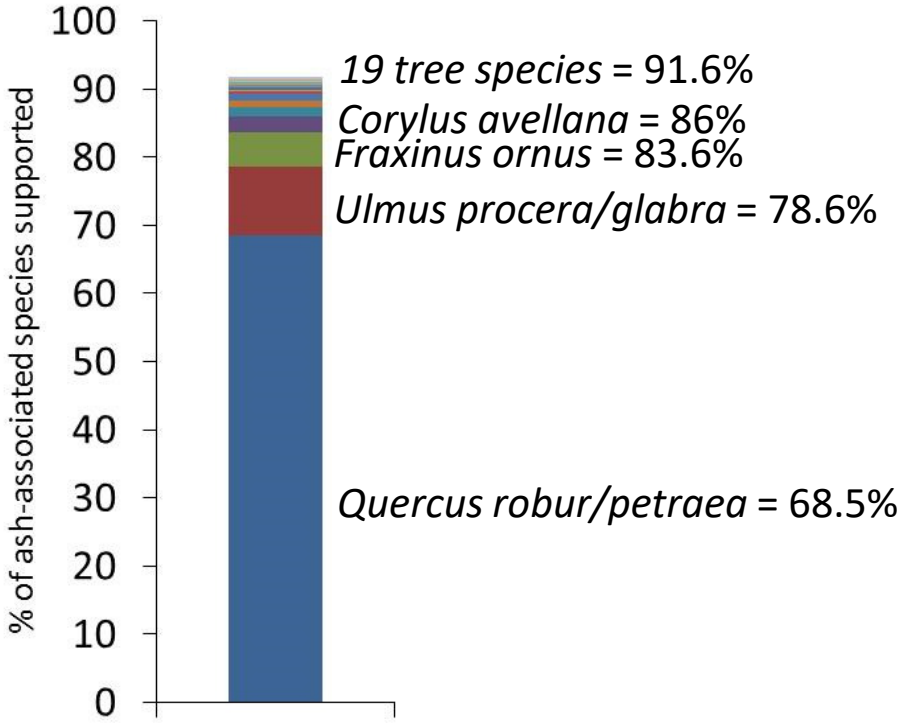
Ref: Mitchell et al 2014

Alternative tree species: species use
Top 10

Tree	% Ash-associated species supported
Quercus robur/petraea	69
Fagus sylvatica	53
Ulmus procera/glabra	50
Acer pseudoplatanus	50
Corylus avellana	45
Betula pubescens/pendula	44
Alnus glutinosa	41
Sorbus aucuparia	41
Populus tremula	39
Crataegus monogyna	32

Ref: Mitchell et al 2014

Mixtures of species: the way forward?

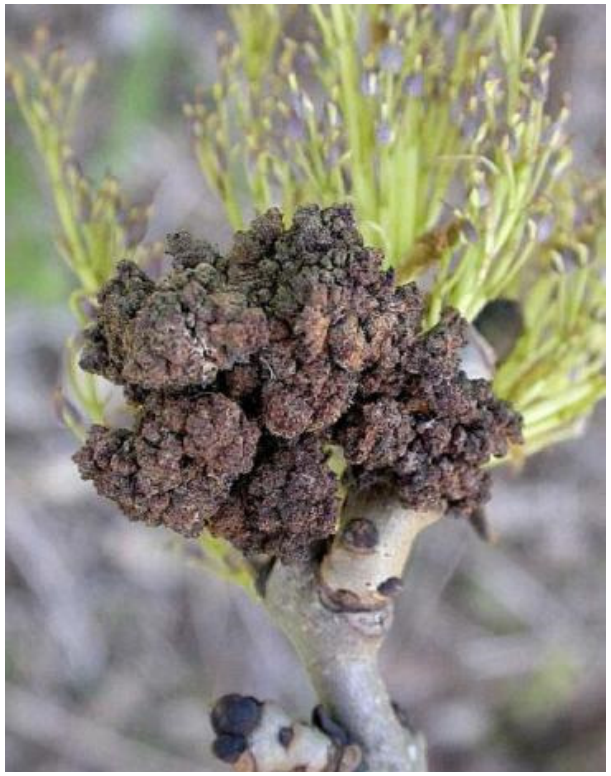


Ref: Mitchell et al 2014


Other pests and diseases of ash
Dasineura fraxini
the ash midrib gall midge
Photo: Wilson 2013

Other pests and diseases of ash

The ash bud moth *Prays fraxinella*, is a native micromoth.



Ash key gall caused by the eriophyid mite *Aceria fraxinivora.*

Other pests and diseases of ash

Nectria canker is caused by the fungus *Neonectria galligena*.

8 – 10 mm long

Emerald Ash Borer (Agrilus planipennis) **is currently NOT present in UK.**

Emerald ash borer damage to American white ash, *Fraxinus americana*.
Scarborough neighbourhood, Toronto, Ontario, Canada. Photo: E. R. Wilson 17 June 2015

Pheromone trap being installed in an ash tree.
Town of Oakville, Ontario, Canada. Photo: Wilson 16 June 2015

What's been done?

- Modelling spread of ash dieback - University of Cambridge
- Mass screening trials TH0132 – Forest Research
- Sequenced genome of ash - QMUL
- DNA markers for tolerance - Nornex consortium
- Investigation of possible fungicides – FERA
- Chalara in non-woodland settings – The Tree Council
- Selection and breeding of ash – Living Ash Project

Mass Screening Trials – TH0132

- 155,000 trees planted on 14 sites during spring 2013
- 15 provenances: 10 British, 2 Irish, 2 European, 1 seed orchard
- Differences between sites (80% healthy at Mill Farm – the most western site compared to 0.5% at Cotton),
- and provenances (24% French healthy compared to 10% of NSZ 304)

Forest Research

Results from mass screening trials

Damage Score	2013	2014	2015	2016	2017?
1 (Dead from ADB)	4%	9%	20%	40%	? 80%
2 (Alive but infected)			30%	45%	
3 (no disease symptoms)			50%	15%	? 1% = 1500 trees

Graft 1500 in archive spring 2018

Forest Research

Living Ash Project

- 5 year project funded by Defra – TH0133

'Screening and selection of common ash for resistance to *Chalara fraxinea*'

- Earth Trust, Forest Research, Sylva Foundation & Future Trees Trust
- £788,687
- Finishes July 2018
- Main objective: 400 tolerant genotypes.

WP1 – Citizen Science and AshTag

- Initial good uptake of Tags. Many records placed on database
- Rapid drop off, as media coverage stops
- Relaunch of Ash Tag in 2016 via forestry press – another good uptake of free tags. More records on database
- Users asked to undertake LAP survey.

WP1 – results

- 1200 users of AshTag
- 1735 records
- 474 took additional LAP survey
- Filtered to records with LAP survey, unlikely to have ADB and located within a woodland = 144 records
- All contacted for access - 35 respondents.

WP1 - outputs

- 20 woodlands visited across GB
- Workshop in 2014: *Harnessing Enthusiasm*
- MSc dissertation '*Understanding public participation in tree health monitoring*'
- Paper in prep:

  Tree health citizen science: opportunities and challenges surrounding the creation of a national network supporting policy and evidence in the UK

WP2 & 4 – existing resource

- 26 research trials and seed orchards screened annually
  - Provenance trials
  - Seed zone trials
  - Clonal and seedling seed orchards
- 12 sites screened extensively 2017: 21,000 trees; 245 selected for grafting = 1%
- Plus trees revisited
- AshTag woodlands visited

earth trust

Disease progression in a provenance trial p2004

	January 2017		August 2017		March 2018	
Score	Count	%	Count	%	Count	%
0	938	71	761	57.5	233	17.6
1	207	15.5	230	17.5	218	16.5
2	127	9.5	230	17.5	452	34.2
3	51	4	95	7	420	31.7
4	0	0	7	0.5	0	0
Total	1323	100	1323	100	1323	100

0= healthy
1 = one to three small infections on side branches
2 =multiple infections on branches
3 = infection in main stem
4 = dead from ADB

earth trust

Plus Tree Visits: Settrington (Yorkshire) 12th June 2017

earth trust

Millington Woods LNR & SSSI, Yorkshire 12th June 2017

High Public Access

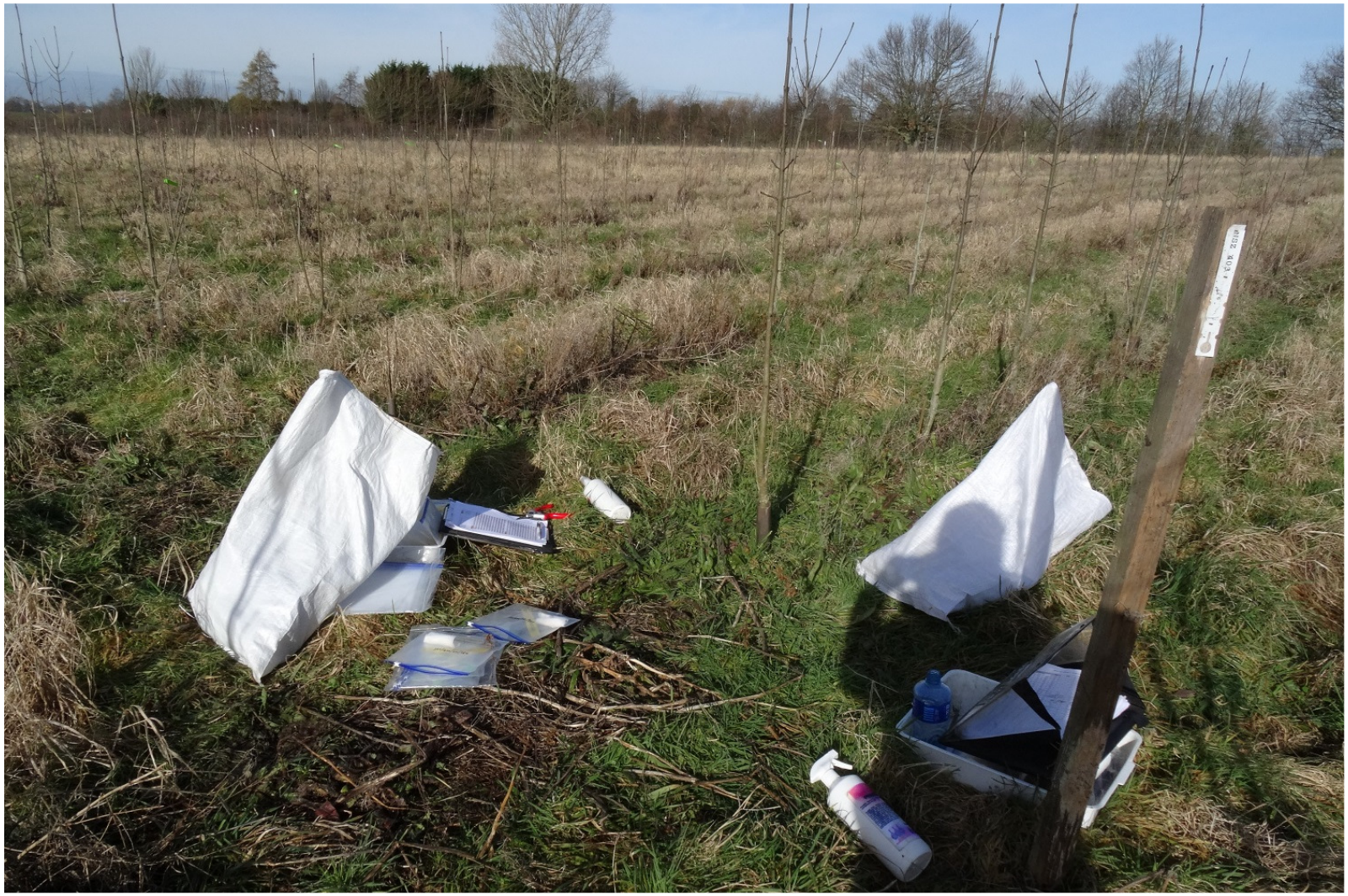
earth trust

Collecting grafting material:

- Woodland Trust sites
- Wildlife Trust sites
- Tree Health monitoring sites

earth trust

4 year old mass screening trial



earth trust

WP3 – heritability of tolerance

- 3 progeny trials established with 46 families, planted April 2016

Site	Trees	% Survival 2016	% Survival 2017	% Score 5 2017
Hucking (Kent)	7360	76	87	13
National Forest †	7360	100	99	N/A
West Deans (Andover)	7360	100	86	19

† survival only assessed

- Year 3 data used to calculate heritability of tolerance. Important to see if we can breed our way out of this

Forest Research

WP6 – Tissue Culture

1. Collect rapidly extending green shoot
2. Soak overnight in fungicide
3. Trim back leaves and surface sterilise with bleach for 10 minutes
4. Place in nutrient media with antibiotics to stimulate shoot growth
5. Freshly growing shoots are excised
6. Plantlets rooted in own media

Forest Research

LAP Outputs

- Several peer reviewed and popular press papers
- MSc and other student projects
- 3 new progeny trials to look at heritability of tolerance
- Archive on public forest estate – available to other researchers e.g. EAB
- New protocols for tissue culture
- Several workshops on i)citizen science and ii) ash dieback and site management
- Contributors to Fraxback https://www.cabi.org/ISC/FullTextPDF/2018/20183360941.pdf

Living Ash Project grafts
February 2018, EMR

TH0132 mass screening grafts
May 2018, NRS

Living Ash Project grafts
June 2018, EMR

Archive site for tolerant selections, to be planted winter 2019

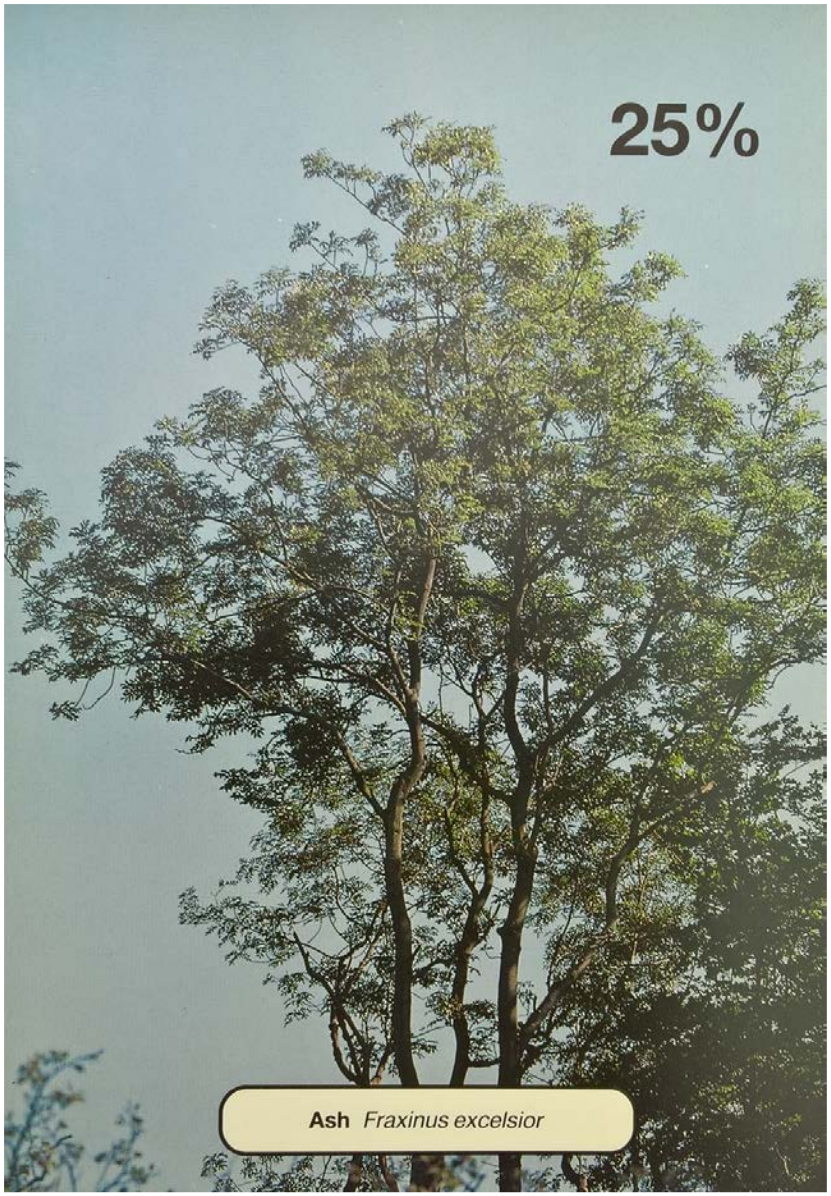
How you can help

- Monitor woodlands over time – summer observations
- Note any trees looking better than others
- Need to keep public access routes clear and safe
- Where you have no public access, retain areas on non intervention to allow natural processes to occur
- Where public access occurs, fell trees with 50% + crown dieback; retain as many green trees as possible
- Mark up and monitor healthy (ish) trees.
- Fill out the data sheets and report them to me

Assessment of Tree Condition

Forestry Commission Field Book 12

https://www.forestry.gov.uk/PDF/FCFB012.pdf/$FILE/FCFB012.pdf


25%
Ash Fraxinus excelsior


40%
Ash Fraxinus excelsior


55%
Ash Fraxinus excelsior

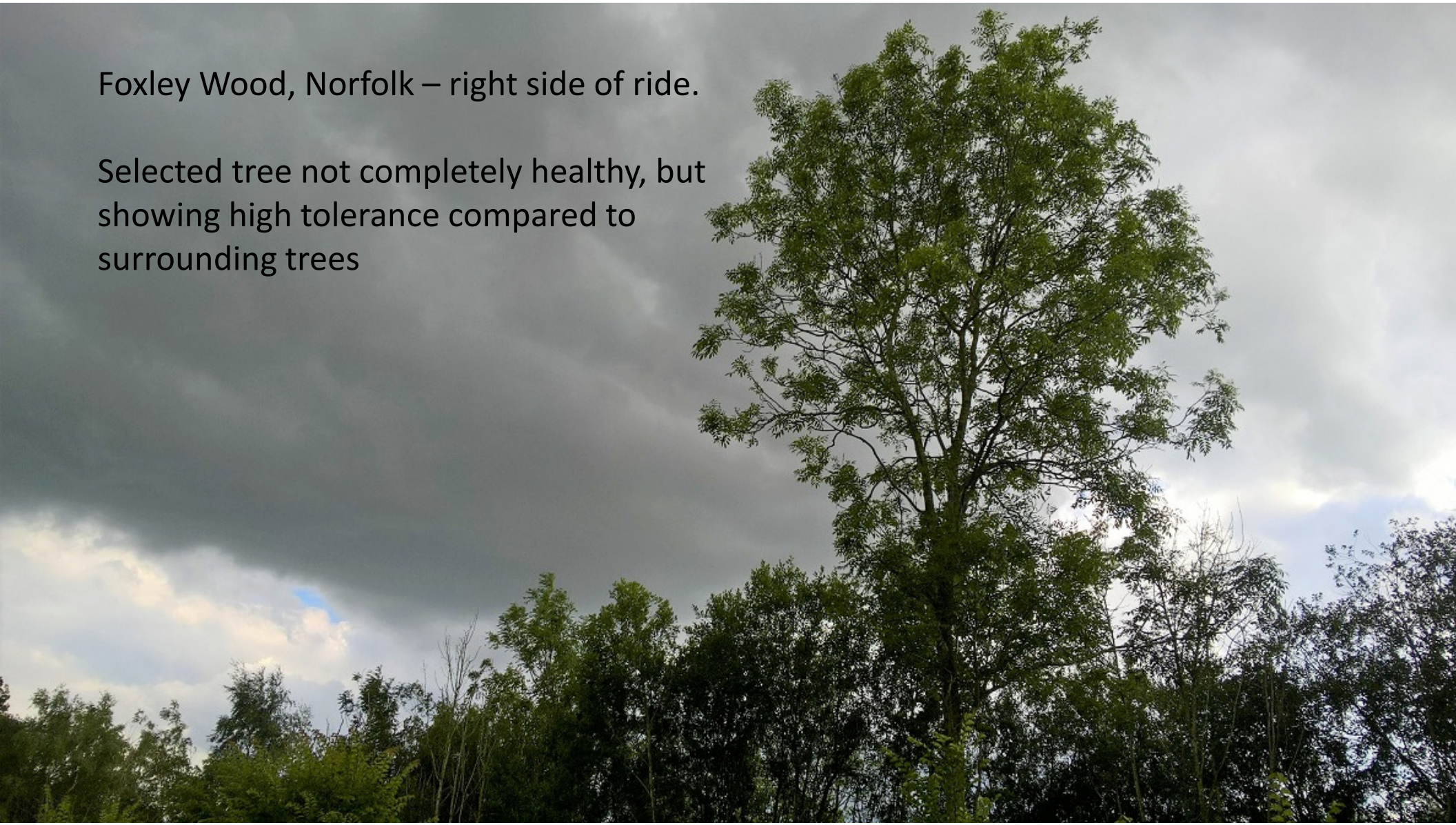

75%
Ash Fraxinus excelsior

We want those in the 10% category, surrounded by others with lesser crowns

Record details and send to me: Jo.Clark@futuretrees.org

Selected tolerant tree, heavily infected trees behind


Foxley Wood, Norfolk – left side of ride


Foxley Wood, Norfolk – right side of ride.
Selected tree not completely healthy, but showing high tolerance compared to surrounding trees

Ash tree data sheet –

Ash dieback tolerance selection

Estate Details	Estate Name		
	Owner	Manager	
	Owners Address	Managers Address	
	Telephone	Telephone	
	E mail	E mail	
Tree Location	Wood	Selected By	Date
	Grid Ref	GPS	County
	Comments on tree and stand		
Stand and Site Characteristics	Stand Type	Stand Age	% ash in woodland
	Aspect	Slope/deg	Alt/m
	Soil Type	Drainage	
	Vegetation Type		
Tree Characteristics	Tree ID	Seed Zone	
	Height (m)	Timber height (m)	DBH (cm)
	Straightness to 10m 0 1 2 3 4 5 6 7 8 9 10		
	Fluting	Basal sweep	Circularity
	Crown dieback %	Basal lesions	Stem lesions
	Other ark defects/disease		
	Flowering/seed		

Relocation Map

Directions

History

Date	Sex	Seed Present	Comments

Useful references

Pathogen

- Gross et al 2012. Reproductive mode and life cycle of the ash dieback pathogen *Hymenoscyphus pseudoalbidus*. *Fugal Genetics and Biology* **49**: 977-986.

Host and Ecology

- Broome and Mitchell 2017. Ecological impacts of ash dieback and mitigation methods. Forestry Commission Research Note 029.
- Mitchell et al 2014. The potential ecological impact of ash dieback in the UK. JNCC report 483. 245pp.
- Heuertz et al 2004. Chloroplast DNA variation and postglacial recolonization of common ash. *Molecular Ecology* **13**: 3437-3452
- Fraxigen 2005. Ash species in Europe. Oxford Forestry Institute. 128pp.
- Forestry Commission 2012. National Forest Inventory: special focus on ash. 115pp.
- Stocks et al 2017. A first assessment of ash susceptibility to *H. fraxineus* throughout the British Isles. *Scientific Reports* **7**: 16546

Host Management

- Dobrowlska et al 2011. A review of European ash (*Fraxinus excelsior* L.): implications for silviculture. *Forestry* **84**: 133-148.
- Skovsgaard et al 2017. Silvicultural strategies for ash in response to dieback caused by *H. fraxineus*. *Forestry* **00**: 1-18
- Managing Chalara Ash Dieback in England. Forestry Commission leaflet available online at https://www.forestresearch.gov.uk/tools-and-resources/pest-and-disease-resources/ash-dieback-hymenoscyphus-fraxineus/chalara-manual-2-managing-ash-trees-and-woodland-including-logs-and-firewood/

livingashproject.org.uk

Project partners: