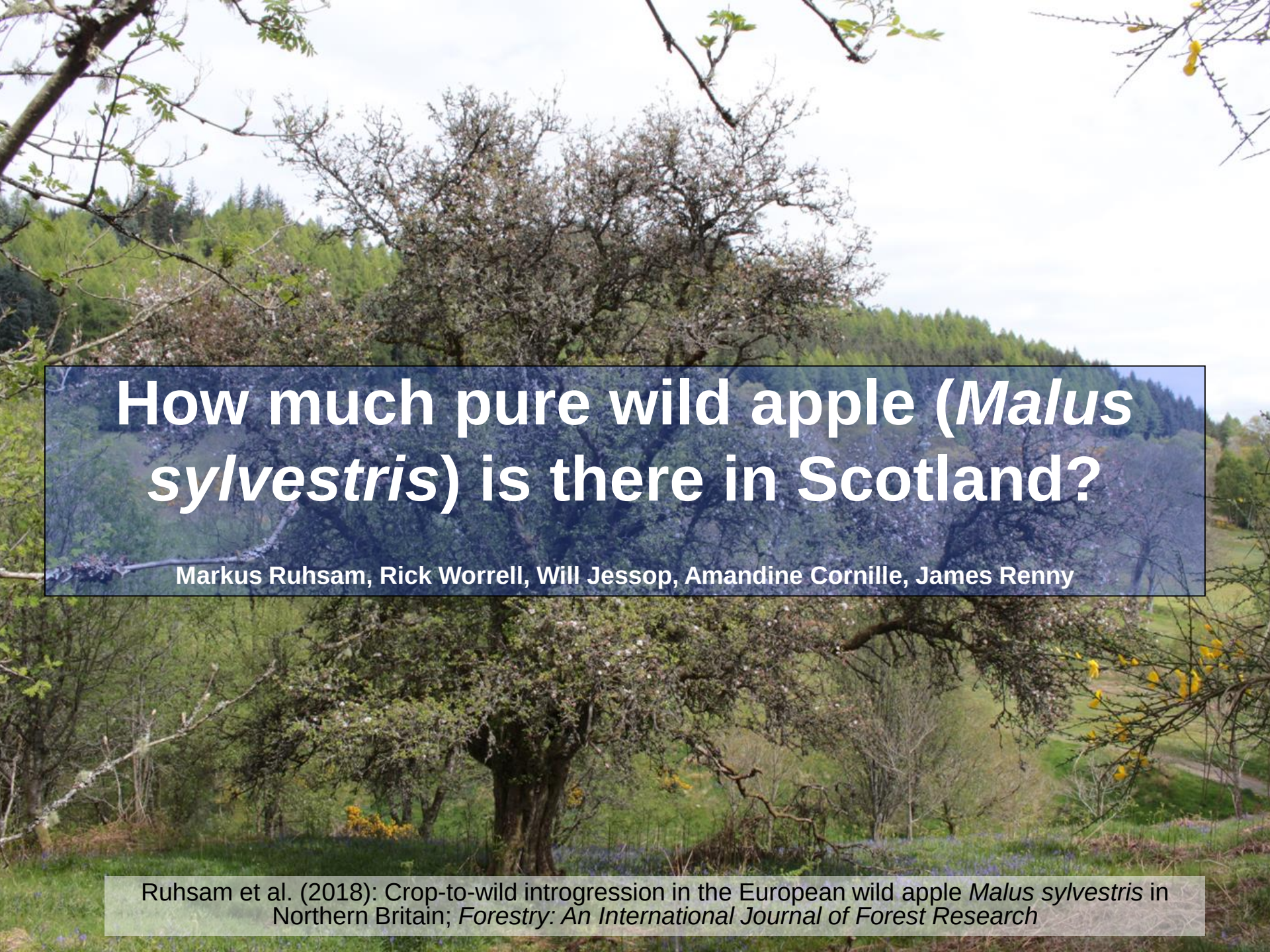
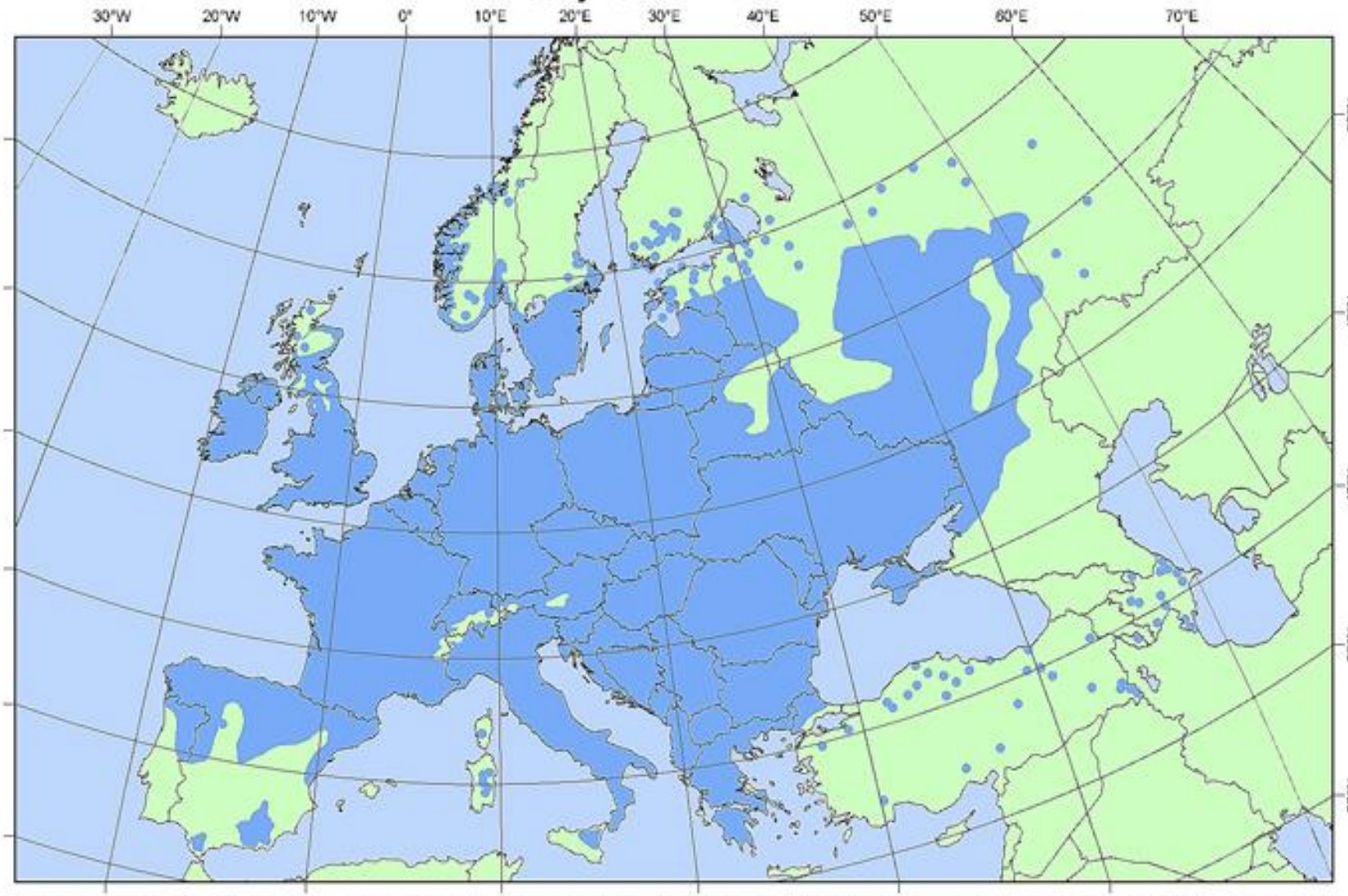


How much pure wild apple (*Malus sylvestris*) is there in Scotland?

Markus Ruhsam, Rick Worrell, Will Jessop, Amandine Cornille, James Renny

Ruhsam et al. (2018): Crop-to-wild introgression in the European wild apple *Malus sylvestris* in Northern Britain; *Forestry: An International Journal of Forest Research*

Malus sylvestris



EUFORGEN

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and other maps at
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This distribution map, showing the natural distribution area of *Malus sylvestris*, was compiled by members of the EUFORGEN Networks based on an earlier maps published by:
(i) Meusel H., Jäger E. Weinert E. 1965. Vergleichende Chorologie der Zentraleuropäischen Flora. Veb Gustav Fischer Verlag, Jena, 1. Karten, pp. 258
(ii) Wagner, I., 1995: Identifikation von Wildapfel (*Malus sylvestris* (L.) MILL.) und Wildbirne (*Pyrus pyraster* (L.) BURGSD.) Voraussetzung zur Generhaltung des einheimischen Wildobstes. Forstarchiv 66: 39-47.
and was published in: Stephan B. R., I.Wagner and J.Kleinschmit. 2003. EUFORGEN Technical Guidelines for genetic conservation

Citation: Distribution map of Wild apple (*Malus sylvestris*) EUFORGEN 2009, www.euforgen.org.

First published online in 2004 - Updated on 30 July 2008

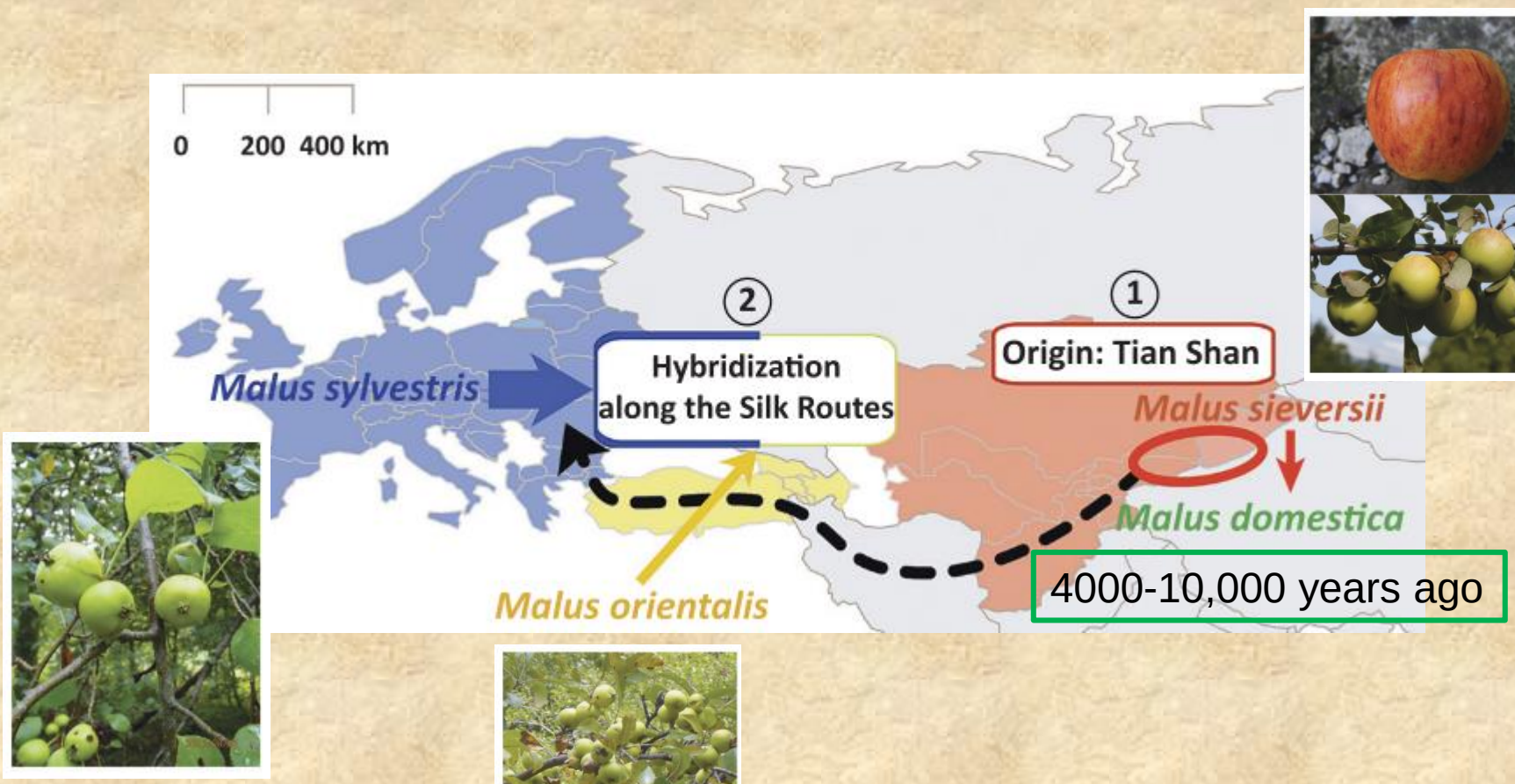
Km
0 250 500 1,000

Wild apple is a rare tree species in Europe…..

- Single trees scattered throughout the landscape
- It is red-listed in
  - Belgium
  - Finland
  - Germany (an estimated 5500 trees are left in the wild)
  - part of conservation efforts in Denmark

…and it hybridises with the cultivated apple (*M. domestica;* syn. *M. pumila*)

What is *M. domestica*?



Morphological differences

Clive Stace (2010): New flora of the British Isles, 3rd ed.

3 Leaves glabrous when mature; pedicels and outside of calyx glabrous **1. M. sylvestris**

3 Leaves hairy on lowerside; pedicels and outside of calyx hairy **2. M. pumila**

1. M. sylvestris (L.) Mill. - *Crab Apple*. Tree to 10m, often spiny; twigs glabrous; leaves 3-5cm, ovate to elliptic, glabrous when mature; petiole 1.5-3cm; pedicels and outside of calyx glabrous; petals pinkish-white; fruit apple-shaped, yellowish-green, c.2-3cm; (2n=34). Native; woods, hedges and scrub; probably throughout BI N to Shetland but very rare in N Sc; some claim very rare throughout BI. Much over-recorded for *M. pumila* and often very difficult to separate from it. Morphological intermediates are frequent, but molecular evidence suggests that the 2 spp. are distinct and that they rarely hybridise; there are no confirmed hybrid records from BI.

2. M. pumila Mill. (*M. domestica* Borkh. nom. illegit., *M. sylvestris* ssp. *mitis* (Wallr.) Mansf.) - *Apple*. Tree to 10(20)m, not spiny; similar to *M. sylvestris* but larger in most parts; leaves up to 15cm, hairy on lowerside, with relatively shorter petiole; fruit up to 12cm, variously coloured; (2n=34). Intrd-natd; much grown and often natd in hedges, scrub and waste ground; throughout BI and much commoner than *M. sylvestris*; garden origin. Self-sown plants usually have small, yellowish, sour fruits.

Hybridisation

Hybridisation in various countries

- 36.7% Europe wide (Cornille et al., 2013)
- 23.1% Europe wide (Cornille et al., 2015)
- 13.9% Germany (Wagner et al., 2014)
- 13.5% Luxembourg (Wagner et al., 2014)
- 11.2% Denmark (Coart et al., 2006) and Belgium (Larsen et al., 2006)

So there is a conservation concern regarding the genetic integrity of wild apple

No data on wild apple in the UK or Scotland

Aims of our study

Given the opportunity *M. domestica* and *M. sylvestris* have had to hybridize in Scotland we asked

(1) What is the frequency of pure *M. sylvestris* and hybrid trees in the wild?

(2) How reliable are the morphological field characters in identifying pure and hybrid samples?

Materials & Methods

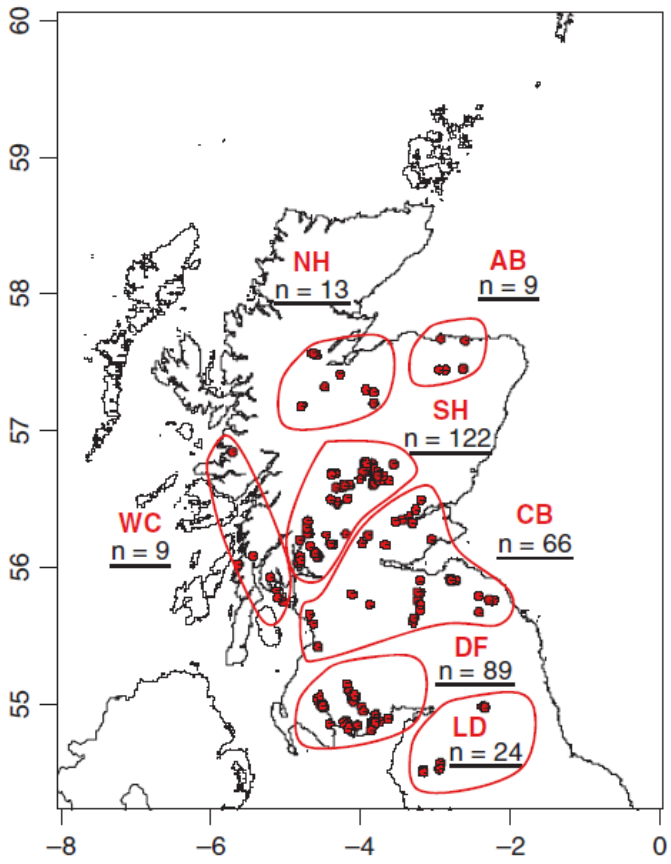


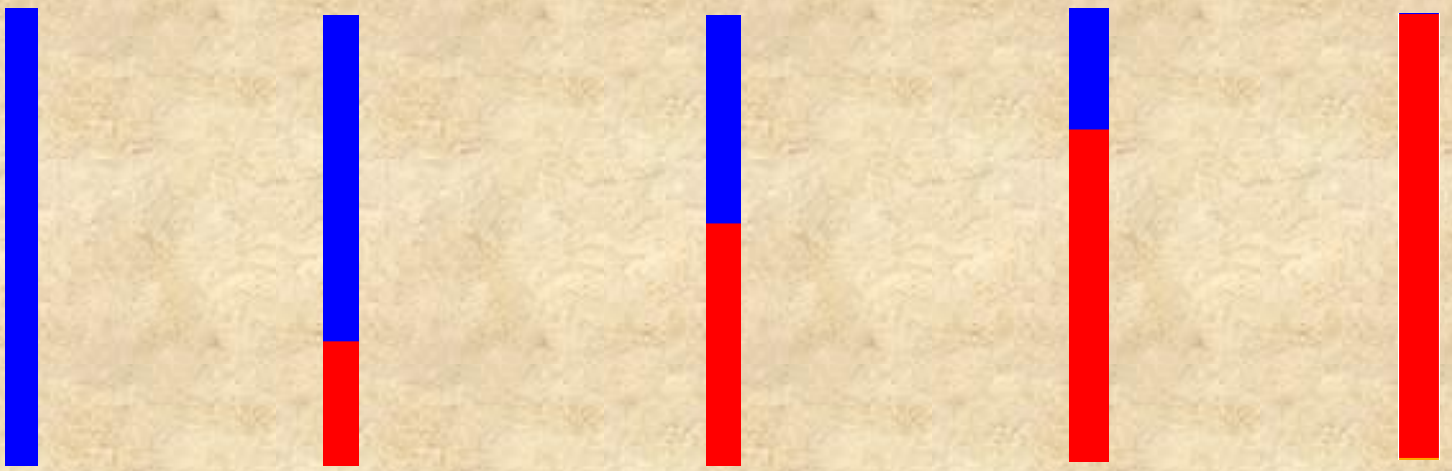
Figure 1 Sampling locations and broad geographical regions of 332 *Malus* trees collected in the field in Northern Britain. Lake District (LD, $n = 24$), Dumfries (DF, $n = 89$), Central Belt (CB, $n = 66$), Southern Highlands ($n = 122$), West Coast (WC, $n = 9$), Aberdeenshire (AB, $n = 9$) and Northern Highlands (NH, $n = 13$, including one sample from Shetland).

332 samples from 'the wild'

screened for 14 genetic markers (microsatellites) and analysed the data using the software STRUCTURE and NEWHYBRIDS

Results

Red – *M. domestica*
Blue – *M. sylvestris*



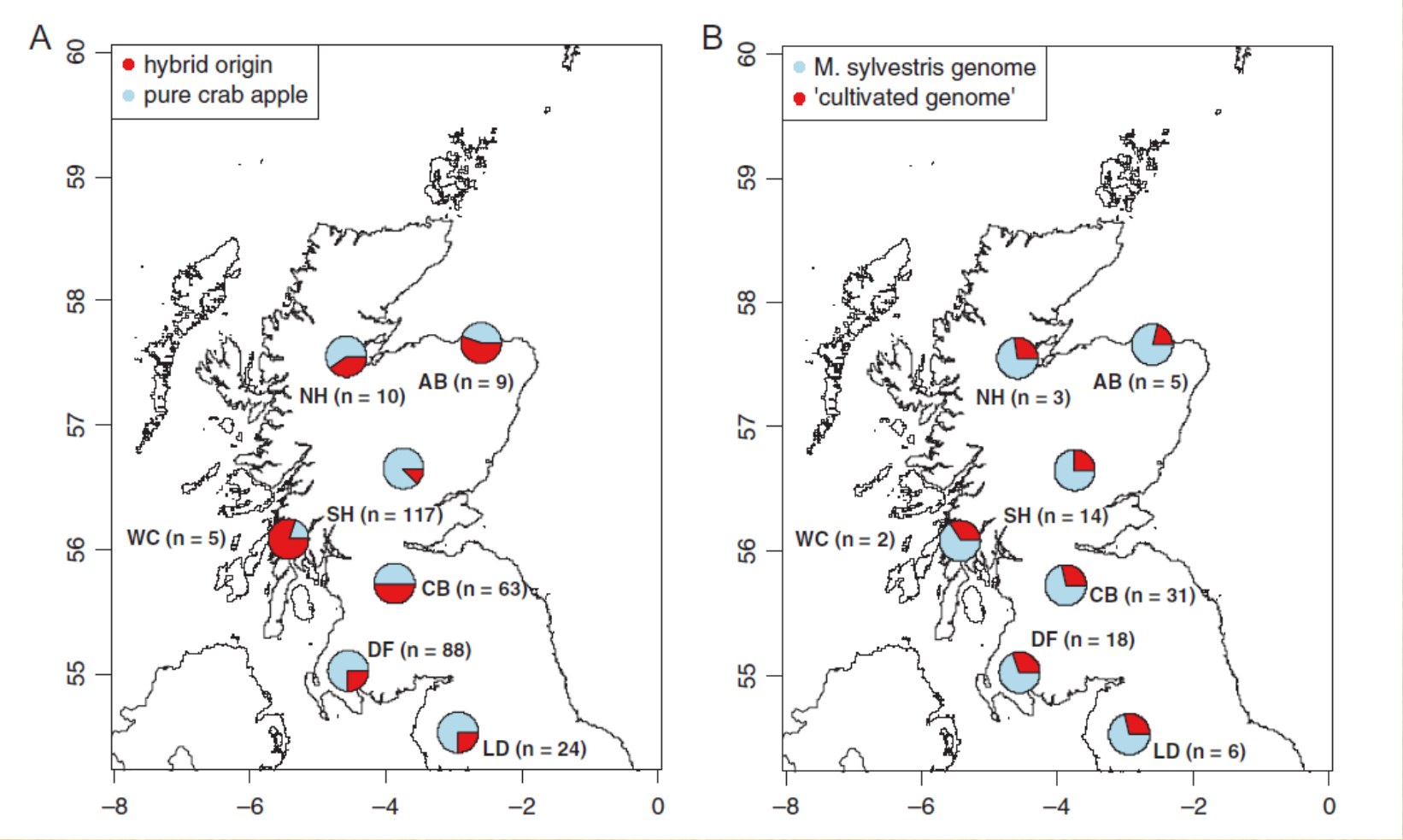
	Pure *M. sylvestris*	Backcross to *M. sylvestris*	F1	Backcross to *M. domestica*	Pure *M. domestica*
	($P_{dom} \leq 0.1$)	($0.10 < P_{dom} < 0.45$)	($0.45 < P_{dom} < 0.55$)	($0.55 < P_{dom} < 0.90$)	($P_{dom} \geq 0.9$)
STRUCTURE	70.0%	21.4%	2.8%	2.4%	3.4%
NEWHYBRIDS	68.0%	19.6%	2.8%	0.9%	4.0%

~70% of our samples are pure wild apple
~20% are backcrosses to wild apple
~3% are F1 (first generation hybrids between pure wild and cultivated apple)

Results by geographic region

Frequency of pure and hybrid trees

Mean genetic make-up of hybrids



Why so many backcrosses when there are so few F1s?

There are two likely reasons for this

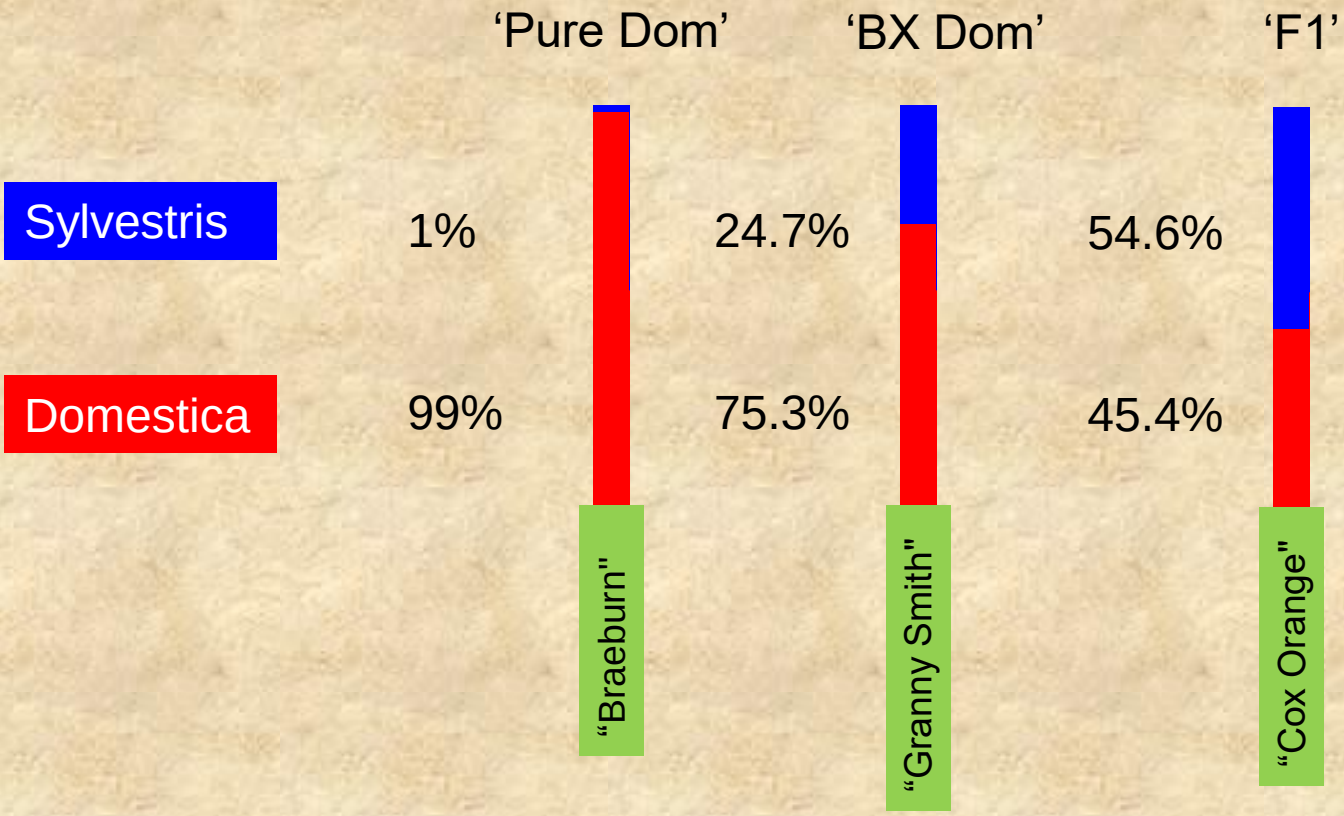
1. Reflection of the genetic make-up of cultivated apple and people's habits
2. Reflection of the historical use of wild apple and the purity of nursery stock

1. Genetic make-up of cultivated apple is not uniform

OPEN ACCESS Freely available online PLoS GENETICS

New Insight into the History of Domesticated Apple: Secondary Contribution of the European Wild Apple to the Genome of Cultivated Varieties

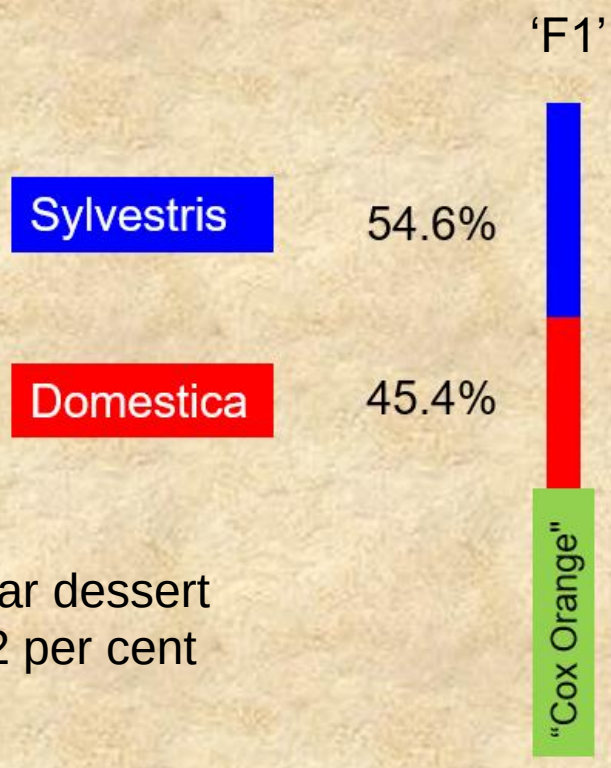
Amandine Cornille[1,2,3]*, Pierre Gladieux[1,2,3], Marinus J. M. Smulders[4], Isabel Roldán-Ruiz[5], François Laurens[6,7,8], Bruno Le Cam[6,7,8], Anush Nersesyan[9], Joanne Clavel[1,2,3], Marina Olonova[10], Laurence Feugey[6,7,8], Ivan Gabrielyan[9], Xiu-Guo Zhang[11], Maud I. Tenaillon[12], Tatiana Giraud[1,2,3]



→so an F1 in the wild is not necessarily the product of a natural hybridisation event and might be a reflection of people's habits (i. e. throwing apple cores out of a car window!)

7 out of 8 F1s were collected

-) along roads
-) abandoned railway lines
-) foot paths



The Cox is the UK's most popular dessert apple and accounts for about 42 per cent of the UK's apple production

2. Historic use and nursery stock

- Wild apple has been used for
  - cider making
  - jam and jelly making
  - animal fodder

→ so is likely to have been planted widely

This is a country road in the Central Belt with a mixture of pure wild apple and backcrosses to wild apple. All of them are very likely planted trees so were probably supplied by a nursery which have been shown (in France) to sell a lot of hybrid instead of pure wild apple trees

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ORIGINAL ARTICLE

WILEY Evolutionary Applications Open Access

Crop-to-wild gene flow and its fitness consequences for a wild fruit tree: Towards a comprehensive conservation strategy of the wild apple in Europe

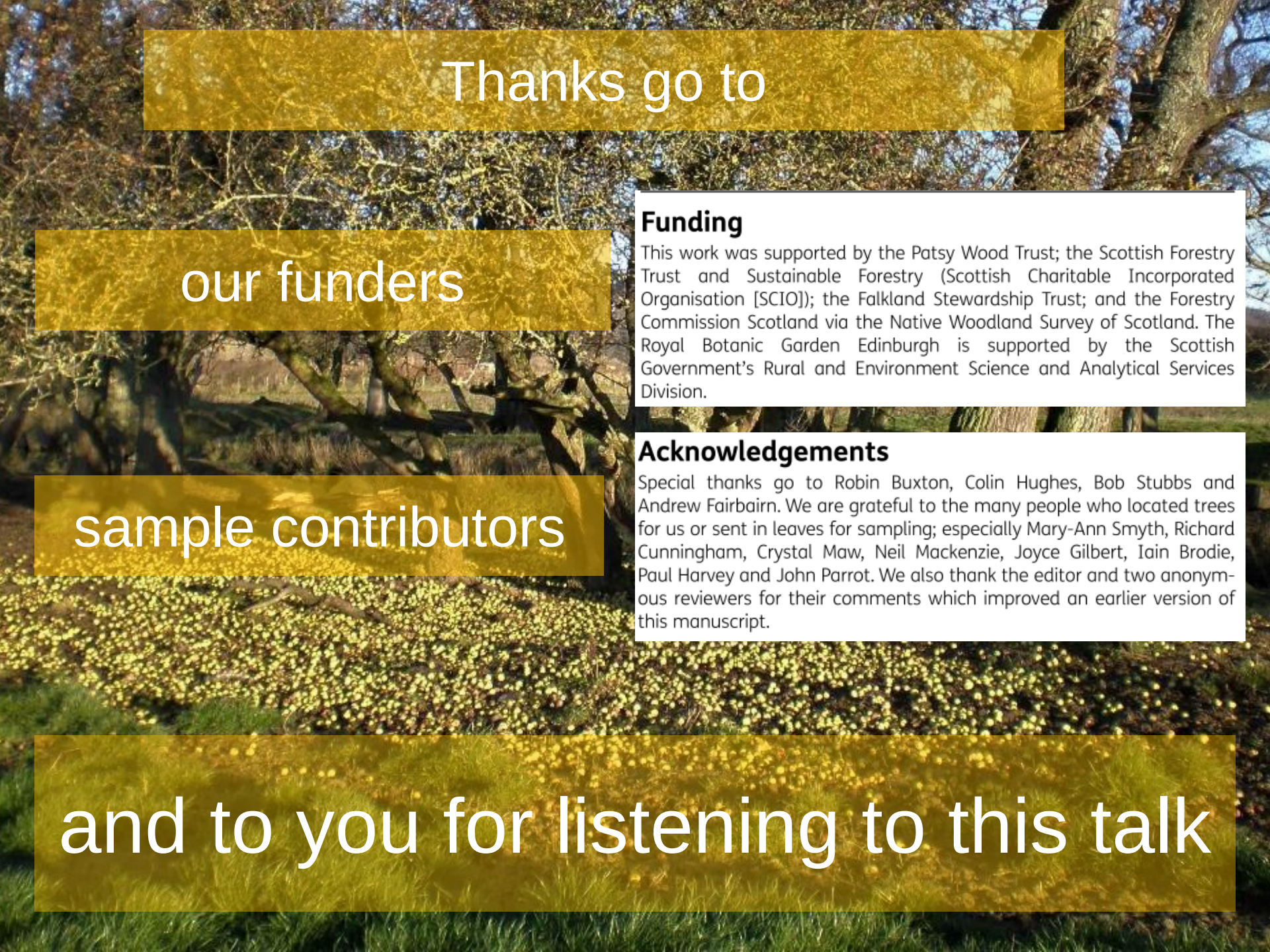
Alice Feurtey[1] | Amandine Cornille[1,2,3] | Jacqui A. Shykoff[1] | Alodie Snirc[1] | Tatiana Giraud[1]

well-known cultivated varieties. Every seed we could genotype coming from these companies had a *M. domestica* ancestry level of more than 0.3 (and very often more than 0.9), regardless of the name used. This means that buying genuine *M. sylvestris* seeds is extremely difficult if not impossible in the private sector. Indeed, identification

The hybridisation rate of ~30% is probably not an accurate reflection of natural processes and likely to be an overestimate because of intentionally and ‘unintentionally’ planted trees

Reliability of morphological field assessments

Category	Number of samples	Percentage
Morphological identification as 'crab apple' correct	119	49.8%
Morphological identification as 'hybrid' correct	16	6.7%
Morphological identification as 'cultivated apple' correct	4	1.7%
Correct identification with confidence	*139*	*58.2%*
Morphological identification as 'possibly crab' correct	18	7.5%
Morphological identification as 'possibly hybrid' correct	6	2.5%
Correct tentative identification	*24*	*10%*
Total 'correct'	**163**	**68.2%**
Morphological identification as 'crab apple' not correct	23	9.6%
Morphological identification as 'hybrid' not correct	25	10.5%
Morphological identification as 'cultivated apple' not correct	11	4.6%
Incorrect identification despite confidence	*59*	*24.7%*
Morphological identification as 'possibly crab' not correct	4	1.7%
Morphological identification as 'possibly hybrid' not correct	13	5.4%
Incorrect tentative identification	*17*	*7.1%*
Total 'not correct'	**76**	**31.8%**
Total samples	239	100%



Thanks go to

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sample contributors

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and to you for listening to this talk