The Long Term Housing, Maintenance and Scientific Curation of the National Fruit Collections

Defra Project code GC0147

Annual Report 2018/19

Appendix 2

Assessment of Duplication within the NFC Apple Collection – *update 2019*

Background

Between 2006 and 2010, Defra commissioned two projects (GC0139/40) at East Malling Research (EMR), to produce Simple Sequence Repeat (SSR) based genetic fingerprints across the apple and pear collections in the National Fruit Collection (NFC). A number of potential duplicate accessions were identified and detailed in the final project report. The potential duplicates identified within the pear collection were further explored within our previous assessment of the newly propagated pear collection (Appendix 3 to Defra project GC0143 final report, July 2014 and updated for inclusion in the GC0147 final report, 2019) and the potential duplicates in the apple collection will be explored further below. Again, the report was originally submitted to Defra as Appendix 3 of the 2016-17 annual report and is updated here to address the remaining issues.

The assessment consists of three main components: firstly, accessions which would be expected to be indistinguishable (in general sports and clones) were identified; secondly, accessions which were not expected to be indistinguishable were considered further, and thirdly, any accessions not considered in the above that remained in the observation plot were considered with the view to bringing any unique material into the collections. Further rationale is explained within each section:

1. Expected duplication within the collection

An initial study of the 'duplicate' list identified a series of known clones and/or sports of cultivars within the collection. These had generally been accessed on the basis of subtle, but valuable differences in the morphological characteristics of the tree or fruit (for instance, increased fruit skin colour) and would not be expected to be distinguishable by SSR or (practically) any other genetic fingerprinting technology. The following accessions were therefore accepted as indistinguishable and excluded from further consideration:

ACCENUMB	ACCENAME	Name in GC0140 Report
1925 - 021	Melba	10_05_Melba
1974 - 060	Hunter Melba	10_07_Hunter_Melba
1973 - 161	Red Melba	10_09_Red_Melba
1927 - 003	Savstaholm	10_25_Savstaholm
1927 - 009	P.J. Bergius	10_27_PJ_Bergius
1974 - 265	Wrixparent	04_05_Wrixparent
2000 - 096	White Transparent	11_09_White_Transparent
1954 - 054	Perrine Yellow Transparent	15_19_Perrine_Yellow_Transparent
1966 - 146	Beauty of Bath	11_25_Beauty_of_Bath
1975 - 303	Crimson Beauty of Bath	11_31_Crimson_Beauty_of_Bath
1976 - 175	Tim's Early	11_33_Tims_Early
1941 - 022	Benoni	12_03_Benoni
1969 - 065	Red Benoni	12_05_Red_Benoni
2006 - 013	Epicure	13_01_Laxtons_Epicure
1953 - 057	Epicurean	13_03_Epicurean
1974 - 343	Fortune	13_17_Laxtons_Fortune

1962 - 045	Fisher Fortune	13_19_Fisher_Fortune
1979 - 180	Red Fortune	13_21_Red_Fortune
1979 - 160	George Cave	13_25_George_Cave
1940 - 014	George Cave	13_27_George_Cave
1973 - 189	Discovery	12_23_Discovery
1982 - 272	Discovery	14_05_Discovery
1982 - 301	Discovery	14_07_Discovery
1978 - 314	Discovery spur type	19_23_Discovery
1974 - 349	James Grieve	14_03_James_Grieve
1957 - 067	Erich Neumanns Roter James Grieve	14_09_Erich_Neumanns_Roter
1963 - 105	James Grieve Lired	14_13_James_Grieve
1999 - 097	Redcoat Grieve	19_17_Redcoat_Grieve
1979 - 177	Miller's Seedling	15_01_Millers_Seedling
1979 - 182	Red Miller	15_03_Red_Millers_Seedling
1978 - 300	Lord Derby	24_31_Lord_Derby
1969 - 041	Lord Derby Spur Type	24_33_Lord_Derby_spur_type
2000 - 075	Peasgood's Nonsuch	25_01_Peasgoods_Nonsuch
1999 - 075	Crimson Peasgood	25_03_Crimson_Peasgood
1979 - 173	Lord Lambourne	29_03_Lord_Lambourne
1977 - 148	Lady Lambourne	29_05_Lady_Lambourne
1971 - 001	Russet Lambourne	29_07_Russet_Lambourne
1952 - 016	Black McIntosh	29_11_Blackmack
2006 - 014	McIntosh	29_13_McIntosh
1967 - 058	Alexis	29_15_Alexis
1967 - 063	Black Mickey	29_22_Black_Mickey
1974 - 064	Kimball McIntosh	29_25_Kimball_McIntosh
1974 - 260	Johnson McIntosh	29_28_Johhnson_McIntosh
1979 - 167	Rogers McIntosh	29_30_Rogers_McIntosh
1973 - 126	Starkspur McIntosh	29_31_Starkspur_McIntosh
1979 - 156	Charles Ross	32_15_Charles_Ross
1948 - 111	Red Charles Ross	32_17_Red_Charles_Ross
1952 - 034	Geeveston Fanny	34_09_Geeveston_Fanny
1970 - 020	Red Geeveston Fanny	34_11_Red_Geeveston_Fanny
1923 - 111	Millicent Barnes	36_27_Millicent_Barnes
1999 - 082	Millicent Barnes Sport	36_29_Millicent_Barnes_sport
1979 - 190	Sunset	39_19_Sunset
1963 - 104	Sunset Sport	39_21_Sunset_sport
2000 - 098	Wealthy	40_01_Wealthy
1950 - 123	Case Wealthy	40_05_Double_Red_Wealthy
1974 - 263	Loop Wealthy	40_07_Loop_Wealthy
1974 - 073	Stevenson Wealthy	40_09_Stevenson_Wealthy
1982 - 046	Ellison's Orange	42_31_Ellisons_Orange_McCarroll
1979 - 179	Red Ellison's Orange	42_34_Red_Ellison
1987 - 040	Red Elstar	40_35_Red_Elstar
1974 - 005	Elstar	42_35_Elstar
1987 - 003	Daliest	47_27_Daliest
2000 - 111	Reinstar	19_103_Reinstar
1999 - 016	Elnica	21_99_Elnica
1999 - 017	Elshof	24_91_Elshof
1999 - 005	Bel-El	25_111_Bel-el
1968 - 017	Ingrid Marie	43_21_Ingrid_Marie
1965 - 025	Red Ingrid Marie	43_23_Ingrid_Marie

1965 - 025	Red Ingrid Marie	43_23_Ingrid_Marie
1957 - 218	King of the Pippins	43_29_King_of_the_Pippins
1960 - 014	King Russet	43_31_King_Russet
1967 - 093	Rote Goldparmane	43_35_Rote_Goldparmane
1933 - 004	Norfolk Royal	45_05_Norfolk_Royal
1973 - 048	Norfolk Royal Russet	45_07_Norfolk_Royal_Russet_Sport
1973 - 158	Kidd's Orange Red	51_27_Kidds_Orange_Red
1971 - 046	Captain Kidd	51_29_Captain_Kidd
1979 - 164	Jonathan	52_01_Jonathan
1967 - 062	Blackjon	52_03_Blackjon
1957 - 004	Jonared	52_05_Jonathan_Matthews
1965 - 036	Jonathan	52_07_Jonathan_a
1965 - 043	Jonathan	52_09_Jonathan_b
1979 - 165	Kapai Red Jonathan	52_15_Kapai_Red_Jonathan
1974 - 257	Jonathan 15 Welday	52_19_Jonathan_15_Welday
1974 - 258	Jonathan 19 Welday	52_21_Jonathan_19_Welday
1976 - 141	Crimson Superb	52_23_Crimson_Superb
1973 - 067	Red Laxton's Superb	52_25_Laxtons_Superb
1961 - 099	Maxton	52_29_Maxton
1969 - 028	Russet Superb	52_31_Russet_Superb
1999 - 081	Laxton's Superb Sport	52_33_Laxtons_Superb_NFT_clone
1979 - 170	Laxton's Superb	52_35_Laxtons_Superb
1950 - 144	Red Statesman	53_25_Red_Statesman
1960 - 050	Statesman Red Sport	53_28_Statesman_Red_Sport
1974 - 351	Spartan	54_10_Spartan
1967 - 080	Spartan	54_11_Spartan_Scotland
1965 - 040	Spartan	54_13_Spartan_Sweden
1974 - 252	Spartan	54_16_Spartan_No3
1974 - 062	Hunter Spartan	54_17_Hunter_Spartan
1964 - 076	Spartan	54_19_Spartan_10C-6-43-l
1982 - 200	Dugamel	53_13_Dugamel
1952 - 019	Melrose (2)	55_15_Melrose
1982 - 197	Marstar	57_17_Marstar
1974 - 203	Dukat	10_37_Dukat
1982 - 257	Dukat Spur	12_43_Dukat_spur_type
1975 - 178	Testerspur Golden Delicious	13_39_Testerspur_Golden_Delicious
1977 - 142	Golden Auvilspur	13_41_Golden_Auvilspur
1979 - 189	Starkspur Golden Delicious	13_43_Starkspur_Golden_Delicious
1970 - 039	Goldspur	13_45_Goldenspur
1970 - 038	Yellospur	13_47_Yellowspur
1979 - 111	Golden Delicious kloon B	13_49_Golden_Delicious_B
1984 - 007	Courtagold	13_55_Courtagold
1979 - 162	Golden Delicious	14_37_Golden_Delicious
1974 - 346	Golden Delicious	14_39_Golden_Delicious
1973 - 166	Golden Delicious	14_41_Horst_No_2
1974 - 118	Goldensheen	14_43_Goldensheen
1974 - 054	Doud Golden Delicious	14_49_Double_Golden_Delicious
1978 - 312	Golden Delicious Russet	14_51_Golden_Delicious_Russet_Form
1978 - 343	Lysgolden	14_55_Lys_Gold
1971 - 054	Ed Gould Golden	14_57_Ed_Gould_Golden
1979 - 185	Smoothee	14_59_Smoothee
1999 - 029	Penco	15_39_Penco
1986 - 042	Elbee	24_89_Elbee
1968 - 070	Golden Delicious	26_85_Golden_Delicious_(Vinson)
2000 - 008	Cox's Orange Pippin	15_37_Coxs_Orange_Pippin
2006 - 010	Cox's Orange Pippin	15_41_Coxs_Orange_Pippin_LA_79
1953 - 144	Cox's Orange Pippin	15_43_Coxs_Orange_Pippin_Otago

1968 - 069	Cox's Orange Pippin Red Sport (Vinson)	15_45_Coxs_Orange_Pippin_Vison
1999 - 045	Clarke's Royal	15_50_Clarkes_Royal
1953 - 058	Queen Cox	15_51_Queen_Cox_Maclean
1976 - 148	Queen Cox	15_55_Queen_Cox
1960 - 039	King Cox	15_57_King_Cox
1957 - 238	Crimson Cox	15_59_Crimson_Cox
1970 - 012	Cox's Orange Pippin	16_37_Coxs_Orange_Pippin
1984 - 173	Cherry Cox	16_39_Cherry_Cox
1968 - 059	Kortegaard Cox	16_43_Kortegaard_Cox
1957 - 156	Cox's Orange Pippin Red Sport (Potter)	16_45_Coxs_Orange_Pippin_Potter
1982 - 202	Cox Rouge des Flandres	16_47_Rouge_des_Flandres
1984 - 176	Frydeland Cox	16_49_Frydeland_Cox
1987 - 037	Queen Cox	16_53_Queen_Cox
1966 - 148	Cox's Orange Pippin	16_55_Coxs_Orange_Pippin_LA_62D
1907 - 002	Cox's Orange Pippin	16_59_Coxs_Orange_Pippin_Wisley
1981 - 027	Cox's Orange Pippin Spur Type Alof	17_57_Coxs_Orange_Pippin_spur_type
2000 - 120	Cox La Vera	18_89_Cox_La_Vera
2000 - 121	Red Cox	18_91_Red_Cox_(93-019)
1999 - 066	Vegi Cox	20_111_Vegi_Cox
2000 - 014	New Fuji	48_19_New_Fiji
1963 - 019	Fuji	19_59_Fuji
2001 - 013	Fuji	18_95_Fuji_INRA_Nagafu
2000 - 011	Malling Kent	16_51_Kent
1964 - 031	Malling Kent	23_37_Kent
1967 - 061	Ben Davis	50_25_Ben_Davis
1967 - 060	Black Ben Davis	26_47_Black_Ben
1978 - 320	Pixie	29_47_Pixie
1989 - 001	Red Pixie	29_49_Pixie_red_sport
1980 - 076	Granny Smith Spur Type	25_50_Granny_Smith_spur_type
1976 - 145	Granny Smith	35_49_Granny_Smith
1976 - 144	Gala	45_49_Gala
1979 - 047	Tenroy	45_51_Tenroy
1998 - 017	Imperial Gala	20_93_Imperial_Gala
1994 - 009	Galaxy	23_89_Galaxy
1982 - 194	Prince Gala	24_105_Prince_Gala_Regal_Prince
1947 - 236	Cravert	49_38_Cravert
1947 - 237	Cravert Rouge	49_39_Cravert_Rouge
1930 - 044	Sandow	28_111_Sandow
1974 - 261	Hunter Sandow	28_113_Hunter_Sandow_(4n)
1957 - 207	Barnack Beauty	29_101_Barnack_Beauty
1944 - 012	Barnack Beauty Sport	29_103_Barnack_Beauty_sport
1963 - 025	Newtown Pippin	18_63_Newtown_Pippin
2000 - 103	Yellow Newtown Pippin	29_89_Yellow_Newtown_Pippin_(3n)
1974 - 410	Winston	33_97_Winston
1958 - 013	Winston coloured sport	33_99_Winston_sport
1951 - 102	Northern Spy	35_81_Northern_Spy
1950 - 151	Double Red Northern Spy	35_83_Double_Red_Northern_Spy
1974 - 058	Hunter Kinkead Spy	35_85_Hunter_Kinkead_Spy_(4n)
1967 - 071	Kinkead Red Spy	35_87_Kinkead_Red_Spy
1974 - 262	Loop Spy	35_89_Loop_Spy_(4n)
1967 - 065	Crimson Spy	35_91_Crimson_Spy
1943 - 007	Rome Beauty	36_73_Rome_Beauty
1969 - 064	Barkley Red Rome	36_75_Barkley_Red_Rome
1950 - 131	Double Red Rome Beauty	36_77_Double_Red_Rome_Beauty
1950 - 129	Glengyle Red	36_79_Glengyle_Red

1950 - 124	Red Rome	36_81_Red_Rome_(Australia)
1952 - 040	Ruby Rome Beauty	36_83_Ruby_Rome_Beauty
1967 - 079	Nured Rome	36_85_SeeandO_Red_Rome
1974 - 264	Perrine York	53_20_Perrine_York
1951 - 040	York-a-Red	36_99_York-a-Red
1973 - 140	Newton Wonder	44_95_Newton_Wonder
1957 - 177	Crimson Newton	44_97_Crimson_Newton_Wonder
1958 - 193	Red Newton Wonder	44_101_Red_Newton_Wonder
1925 - 005	Marston Scarlet Wonder	44_99_Marston_Scarlet_Wonder
1972 - 026	Alkmene	17_37_Alkmene
2000 - 115	Red Alkmene	19_112_Red_Alkmene
1994 - 008	Ceeval	23_83_Ceeval
1972 - 184	Falstaff	25_47_Falstaff
1998 - 019	Red Falstaff	20_97_Red_Fallstaff
1978 - 135	Rubin	19_29_Rubin
1999 - 007	Bohemia	21_89_Bohemia
1968 - 039	Aroma	25_65_Aroma
1999 - 001	Amorosa	22_113_Amorosa
1973 - 103	Delcorf	48_05_Delcorf
1994 - 010	Dalili	23_87_Dalili
1999 - 061	Chantecler	20_99_Chantecler
1999 - 008	Chantegrise	25_113_Chantegrise
1957 - 215	Gravenstein	27_07_Gravenstein
1960 - 055	All-Red Gravenstein	27_09_All_Red_Gravenstein
1960 - 060	Morkrod	27_11_Morkrod
1951 - 103	(Stayman's) Winesap*	54_30_Winesap
1950 - 140	Blaxtayman	32_45_Blaxtayman
1950 - 141	Dark Red Staymared	32_47_Dark_Red_Staymared
1952 - 041	Scarlet Staymared	32_49_Scarlet_Staymared
1973 - 133	Blenheim Orange	33_37_Blenheim_Orange
2000 - 022	Blenheim Orange	33_39_Blenheim_Orange_Wisley
1966 - 030	Red Blenheim (Wastie)	33_41_Red_Blenheim
1929 - 032	Aldenham Blenheim	33_65_Aldenham_Blenheim
1979 - 163	Holstein	36_37_Holstein
1973 - 086	Holstein	36_45_Holstein_Mahler
1973 - 087	Holstein	36_47_Holstein_Palloks
2000 - 010	Holstein	36_49_Holstein_sport
1973 - 169	Belle de Boskoop	39_79 _Belle_de_Boskoop_(3N)
1974 - 500	Red Belle de Boskoop	39_81_Red_Belle_de_Boskoop
1999 - 036	Bielaar	21_87_Bielaar
1989 - 041	Botden	24_113_Botden
1974 - 341	Bramley's Seedling	41_105_Bramleys_Seedling_(3n)
1941 - 026	Crimson Bramley	41_107_Bramley_(m_Crimson)(3n)
1983 - 081	New Jonagold	25_55_New_Jonagold
2001 - 009	Veekmans-Jonaster	17_109_Veekmans_Jonaster
2002 - 041	Excel	18_101_Excel
1982 - 204	Wilmuta	18_93_Wilmuta
2002 - 042	Jonagored Supra	18_99_Jonagored_Supra
2000 - 113	Jonagold	19_107_Jonagold_(EMLA)
2000 - 116	Red Jonaprince	19_113_Red_Jonaprince
1999 - 062	Jonagold Boerekamp	20_102_Jonagold_Boerekamp
1999 - 063	Josegold	20_103_Josegold
1999 - 065	Prince Jonagold D'H	20_107_Prince_Jonagold_DH

1998 - 015	Decosta	20_89_Decosta
2005 - 022	Jonagold AW2001	21_111_Jonagold_clone_AW2001
1994 - 019	Jomured	23_103_Jomured
2005 - 022	Jonagold AW2001	23_113_Orei* *(*mislabelled in report)*
1986 - 046	Rubinstar	24_107_Rubinstar
1999 - 037	Jored	24_99_Jored
1987 - 056	Jonagored	26_91_Jonagored
2000 - 012	Crowngold	26_93_Crowngold
2000 - 105	King Jonagold	26_95_King_Jonagold
1994 - 018	Jonica	26_97_Jonica
1980 - 144	Mutsu Spur Type	48_01_Mutsu_Spur_Type
1977 - 140	Mutsu	49_05_Crispin

* 1951-103 was determined to be an accession of 'Stayman's Winesap' (a triploid offspring of the original 'Winesap') as part of this process, and as discussed in Ordidge et al. (PLOS One 2018).

Fourteen further accessions were identified in the EMR analysis as being indistinguishable from one of the cultivars used as a standard by EMR, and a further three were found to be accessions present in both the observation plot and the main collection (from the records these had all been accessed into the collection shortly before the analysis was carried out). Some of these latter cases were slightly confused because they had been annotated based on an outdated accession name list in the EMR report and these are clarified below for samples labelled as Jonagold and Jonagold 1905:

ACCENUMB	ACCENAME	Name in GC0140 Report
Accessions matching genotyping standards		
n/a	n/a	*Delicious*
1979 - 046	Starkspur Supreme	43_55_Pagsup_spur_type
1982 - 188	Oregon Spur	43_59_Oregon_Spur
1979 - 184	Richared Delicious	44_45_Richared_Delicious
1951 - 034	Starking	44_49_Starking
1979 - 188	Starkrimson Delicious	44_51_Starkrimson
1977 - 164	Wellspur Delicious	44_57_Wellspur
1999 - 023	Lancraig	24_103_Lancraig
1999 - 019	Hared	24_95_Hared
1984 - 112	Averdal	26_113_Averdal
n/a	n/a	*Fiesta*
1983 - 038	Fiesta	29_33_Fiesta
n/a	n/a	*M9*
1999 - 049	M 9	25_83_M9
n/a	n/a	*Prima*
1972 - 019	Prima	47_31_Prima
n/a	n/a	*Worcester_Pearmain*
1973 - 192	Worcester Pearmain	14_15_Worcester_Pearmain
1976 - 151	Worcester Pearmain	16_21_Worcester_Pearmain
Accessions that had been recently brought in from the observation plot		
1999 - 099	Onibury Pippin	17_105_Onibury_Pippin
1999 - 099	Onibury Pippin	O_2_23_Onibury_Pippin
1995 - 015	Abbot's Early	26_87_Jonagold
1995 - 015	Abbot's Early	O_5_19 Abbot's_Early
1995 - 019	Queen Anne	26_89_Jonagold_1905
1995 - 019	Queen Anne	O_4_27_Queen_Anne

2. Further analysis of unexpected duplicates

The remaining list of potential duplicates consisted of 135 groups, representing a total of approximately 300 accessions (although 24 groups were associated with the observation plot). These were assessed further and are discussed in detail below.

Four main additional sources of evidence were considered:

1. In carrying out a study of genetic diversity we utilised Diversity Arrays Technology (DArT) to analyse genetic markers across the majority of the apple collection and this represented a fully independent set of genetic data. It had previously been noted that the SSR analysis, for reasons of practicality, had been based on a single leaf collection and any collecting errors would not be expected to be resolvable; similarly, the DArT analysis was based on unreplicated samples, but together these two independent analyses offered an opportunity to test the initial findings and identify potential experimental errors.
2. Morphological comparisons were made between genetically indistinguishable accessions. These were either carried out on samples collected specifically for the purpose (especially in cases where verification appeared complex) or made using existing morphological records via the standard studio images available in the NFC database.
3. Published literature was consulted to confirm the provenance of cultivars and published descriptions were used for further morphological comparison. It was noted that within the National Apple Register (Smith 1971) Muriel Smith commented on cultivars that were believed to be held within the NFC (at the time, NFT collection). This was taken as evidence of verification of trueness to type during previous curation and where Muriel listed cultivars as "in NFT collection" (rather than "in NFT collection if true") it was previously accepted that these were thought to be true to type in the NFC collection. We note that the register was produced in 1971 and that some accessions had been brought in and/or replaced since Muriel's work, and that the whole collection had also been repropagated in 1974 and that any errors in this process would undermine this judgement.
4. A number of observations were documented from previous curatorial work and verification. Where the observations of previous curators were helpful in resolving queries these were also taken into account. In many cases, these observations were extremely helpful, and having been made without hindsight of the results of genetic analysis these offered a further independent source of valuable evidence.

Comparison of two independent sources of genetic data

SSR analysis had been carried out across 12 unlinked and variable markers and potential duplicates were identified where all marker scores were identical (see Defra project GC0140 final report). DArT analysis was carried out across a larger number of markers (562) but these resulted in binary scores and some markers were potentially linked; comparisons were made by generating a Jaccard similarity score between each possible pair of accessions.
To establish a baseline from which to accept accessions as indistinguishable, an initial comparison was made utilising 22 known clones (or sports) of Cox's Orange Pippin from the collections. Similarity scores were calculated from comparison of each of the clones to one another. This resulted in scores ranging from 0.902 to 1 (see Figure 1 for example of comparisons to accession 2000-008 Cox's Orange Pippin [LA]). By comparison, the similarity score for any of the clones to any other accession in the collection ranged from 0.383 to 0.901 (again, scores from comparison to accession 2000-008 Cox's Orange Pippin [LA] are shown in Figure 1). The similarity of any of the non-clonal accessions to any of these clones was only scored in excess of 0.8 for 12 of the 2175 other accessions and each of these cases was considered briefly further:

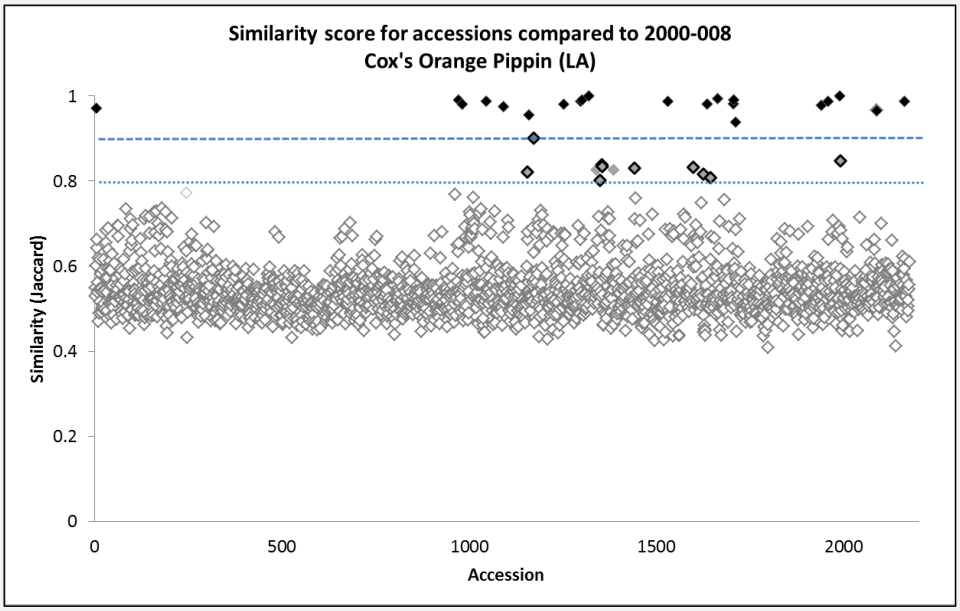

Figure 1. *Jaccard similarity scores from a comparison of all studied accessions with accession 2000-008 Cox's Orange Pippin (LA). Known clones and sports are indicated by black points on the chart. A series of 13 accessions which scored similarity to at least one of the Cox's Orange Pippin clones above 0.8 are indicated in grey with the 10 known complex triploids outlined in black. All other accessions are indicated in white. The dotted line is drawn at 0.8 and dashed line is at 0.901.*

From comparison of the SSR data and analysis of recorded pedigrees of the 12 accessions, and further analysis of similar examples for other cultivars, it was generally found that similarities ranging from 0.9 to 0.8 were indicative of either inbred relations or heteroploid relationships (where one accession is triploid and the other is its [diploid gamete donating] parent) as presented and discussed in detail in Ordidge et al., PLOS One 2018 .

On this basis, it was deemed generally acceptable that a similarity score of 0.9 or above could be taken as reasonable proof of indistinguishability by DArT and it was noted that accessions scoring in the region of 0.8-0.9 should potentially be checked further to assess complex genotypes if they could not clearly be resolved.

Having established a criterion to allow the comparison of genetic findings, the remaining duplicate samples are classified into groupings as supported by the data:

a. 223 accessions (plus related sports, where relevant) are considered within 103 groups on the basis of being identified as indistinguishable by both SSR and DArT analysis (of these, 72 groups were compared morphologically and 31 groups were considered without further checks [24 of the latter groups focussed on accessions in the observation plot]);
b. 17 accessions are considered within 7 groups on the basis of indistinguishability by SSR analysis alone;
c. 47 accessions (plus related sports) within 23 groups are considered on the basis of indistinguishability by DArT analysis alone;
d. 46 accessions (plus related sports, where relevant) are considered within 20 groups on the basis of indistinguishability by SSR but distinguishability by DArT analysis;
e. 11 accessions are considered as part of a series of additional or complex queries.

In addition, an assessment is made on the remaining accessions in the observation plot and 4 queries were raised by this assessment.

Rationale and summary of findings

Two independent findings of genetic indistinguishability are generally taken as a confirmation of duplication. Where only one set of genetic analysis was available, and within this accessions were found to be indistinguishable, they are accepted as duplicates only when morphology and/or additional information was clearly in agreement. Where genetic analysis was in disagreement accessions were considered further and compared morphologically where possible. DArT profiles were also checked for uniqueness within the DArT dataset to eliminate the possibility of misinterpreting collecting errors which had falsely replicated samples (e.g. from neighbouring trees rather than neighbouring accessions) although it was noted that a handling error resulting in two unique samples being swapped would not be resolvable without further analysis. A judgement was made based on this additional analysis where possible, but if in doubt, then judgements were based on further SSR analysis carried out in the analysis of the NFC 3 apple collection following repropagation.

The basic rationale then followed current accession/deaccession policy, and true duplicates are generally recommended for deaccession. Single accessions from duplicate groups are generally recommended for retention where they are true representatives of the cultivar with the strongest (oldest ≥ best documented ≥ most relevant in UK) provenance. Accessions in the observation plot are recommended for accession where they are found to be unique and recommended for deaccession where they are found to duplicate an accession currently in the collection. Cultivars are recommended to be retained in the most appropriate section of the collection (for example, accessions of cider cultivars in the cider collection are given preference over replicates in the main collection). If no clear judgement can be made on trueness to type then the accession judged most likely to be correct is recommended for retention.

Findings were initially classified according to a 'traffic light' system whereby green signified that queries were fully resolved; amber signified where actions could be pursued with an element of caution (for example where duplication was clear but further checks on provenance were required to judge on trueness to type); red signified queries that could not be resolved (and the majority of these were through discrepancies in genetic data that were expected to be resolved through further SSR analysis on the NFC 3 collection). Following this approach 113 of the queries described above were designated as green, 12 as amber and 14 as red. 123 accessions were proposed for deaccession and 33 were proposed for accession into the main collection from the observation plot (GC0147 Annual report 2016/17 Annex 3).

Subsequent analysis has addressed all outstanding queries and 150 accessions are proposed for deaccession with 35 proposed for accession into the main collection from the observation plot.

a) (i) Samples found indistinguishable by both SSR and DArT analysis and compared morphologically to establish trueness to type

1981-174 Nico and 1979-172 Lodi

Samples were morphologically indistinguishable. From comparison against published descriptions they appear most similar to Lodi, which also has older provenance (being raised in 1911). However, 1981-174 was supposedly sent to the NFC for PVR testing and so some uncertainty remains over the outcome of this process – nevertheless, 1979-172 should be retained as Lodi and 1981-174 should be deaccessed .

1946-022 Guelph and 1945-074 Peacemaker

Samples were morphologically indistinguishable. Neither could be distinguished further based on cultivar descriptions but Guelph was noted to have slightly older provenance (1912 as opposed to 1913) – 1945-074 should be deaccessed.

1931-011 Richardson (Ireland) and 1953-050 Histon Favourite
Samples were morphologically indistinguishable. Richardson has no published descriptions. Histon Favourite is older and the accession had already been verified as correct against Bunyard – 1931-011 should be deaccessed.

1947-231 Unknown and 1945-025 Barchard's Seedling
Morphologically, samples were extremely similar. Barchard's Seedling fits the published description by Hogg; 1947-231 had been sent in as Welford Park Nonsuch but its name removed as it did not match the published description (again by Hogg) – 1947-231 should be deaccessed.

1948-021 Merchant Apple and 1974-034 Ten Commandments
Samples were morphologically similar, although not identical; 1948-021 had generally darker red skin colouring, although little colour in the flesh, 1974-034 had some colouring in flesh and signs of pigment in vascular structures (for which the cultivar Ten Commandments is commonly known). It appeared that the two may be sports. 1974-034 was judged to be superior quality and Ten Commandments has stronger published provenance – 1948-021 should be deaccessed (and 1974-034 reclassified as Group 6).

1933-003 Lamb's Seedling, 1947-001 River's Nonsuch and 1968-061 Renown
Samples were morphologically indistinguishable. All three cultivars have provenance, dating to 1866, 1875 and 1908 respectively. Comparison to published descriptions excludes Lamb's Seedling as a late culinary. 1947-001 River's Nonsuch would seem the most appropriate to retain as it matches published description and has older provenance (although further analysis of SSR profile reveals the possibility that the accession could be a Peasgood Nonsuch x Cox's Orange Pippin seedling as per description of Renown; River's Nonsuch was supposedly selected as a seedling stock). From further consideration, 1947-001 should be retained as River's Nonsuch, being better described and matching descriptions – 1933-003 and 1968-061 should be deaccessed. -

1951-004 Red Musk and 1925-012 Seabrook's Red
Samples were morphologically similar. Previous curatorial notes contain some confusion over comparison to Hereford cider cultivar (NAR lists as a local apple from Surrey that was received by NFC in 1951). Seabrook's Red is claimed to have been raised by Seabrook & Sons prior to 1925 and appears to have the better provenance; descriptions are very similar – 1951-004 should be deaccessed.

1953-081 Devon Crimson Queen, 1979-036 Sops in Wine and 1992-133 Sops in Wine
Morphological analysis found small differences in the amount of striping, lenticel spotting and in the amount of red flesh (a character after which the latter cultivar is commonly known); 1992-133 had strong red flush, little striping and pale lenticel spots but greater amounts of red flesh. 1992-133 is also in the cider collection and Sops in Wine is mainly a cider cultivar – 1953-081 and 1979-036 should be deaccessed.

1951-184 Rosa del Caldaro and 1947-004 Mela Carla
Accessions in archive images appear very similar. Both cultivars have published provenance dating them back to 1889 and at least 1817 respectively. 1951-184 was checked against published descriptions in previous curation and deemed true, but descriptions of the cultivars are also extremely similar in the NAR. Initial comparison by Storti and Baric [pers. comm.] finds the profile to match that of Rosa di Caldaro in other collections. From further consideration, it was deemed that the accessions matched the description of Mela Carla by Hogg – 1951-184 should be deaccessed and Rosa del Caldaro noted as a potential synonym.

1973-114 Eri Zagarra and 1973-119 Jincoa Zagarra
Accessions in archive images appear similar. Previous curatorial work had noted that only a brief description was available for the former but confirmed the latter as matching a description. Since neither have further available

provenance the accession true to the strongest description should be considered correct – 1973-114 should be deaccessed.

1974-071 Shenandoah and 1974-203 Dukat
Samples were found morphologically very similar, but not identical (both accessions were also genetically indistinguishable from the sport Dukat Spur [1982-257]). From further analysis of SSR profiles, all supposed parents (Winesap x Opalescent) of Shenandoah could be excluded as well as Golden Delicious from the supposed parentage of Dukat (Golden Delicious x Cox's Orange Pippin). Both accessions had been found to match published descriptions in previous curation (against an entry in Brooks and Olmo and a description by Drobny, of CZ respectively). Both are supposedly relatively recent releases (1940/50s) and neither has strong published provenance available - 1974-071 should be deaccessed.

1952-047 Orleans and 1974-065 Quindell
Accessions in archive images appear similar. 1974-065 was noted in previous curatorial notes to match a brief description in Brooks and Olmo; Orleans is noted to be 'in the NFC' in the NAR, has published descriptions and provenance to being raised in 1912 as a seedling of Deacon Jones x Delicious. Quindell was apparently discovered in Arkansas in 1934. The accession bears similarities to Delicious and SSR data would allow Delicious to be accepted as a potential parent (Deacon Jones is not represented in the collection). Further consideration confirmed 1952-047 as matching a description of Orleans and found no indication that Quindell was a re-introduction and/or a previously unidentified sport – 1974-065 should be deaccessed.

1975-033 Nugget, 1976-066 Skinlite, Golden Delicious and its clones
Accessions in archive images appear similar. Both Nugget and Skinlite are listed as offspring of Golden Delicious, one discovered in 1954, USA and the other raised in 1947, Italy. Each has been introduced in 1966 and 1973 respectively. Neither has any recorded value over Golden Delicious and since both were maintained (falsely) as seedlings rather than sports – 1975-033 and 1976-066 should be deaccessed.

1947-047 Unknown and 1924-049 Old Pearmain (of Kelsey)
Accessions in archive images appear very similar. 1947-047 was noted as false (having been received as Foulden Pearmain) in previous curatorial notes. 1924-049 was noted to have been checked extensively in previous curation and the "(of Kelsey)" qualifier added to distinguish from the ancient cultivar – 1947-047 should be deaccessed.

1968-097 Sweet Caroline and 1922-015 Red Victoria
Accessions in archive images appear similar. Previous curatorial notes suggested that 1968-097 was likely false (as a propagation error) – 1968-097 should be deaccessed.

1967-081 Stark's Late Delicious, (1979-046 Starkspur Supreme, 1965-041 Idaho Delicious), Delicious and its clones
Accessions in archive images appear similar, although Stark's Late Delicious was not previously listed as a sport. Additionally, 1979-046 Starkspur Supreme was not listed as indistinguishable from Delicious and its clones in the EMR report but from further analysis of SSR data it was found indistinguishable and this was confirmed by DArT analysis. Idaho Delicious is a supposed tetraploid form but 1965-041 was distinguished from the Delicious clones by both SSR and DArT analysis and in both was found to be largely indistinguishable from 1927-013 Akero (one SSR allele consistently scored 2bp different) – 1967-081 should be retained and noted as a sport of Delicious in the future; 1965-041 should be deaccessed as a probable mislabelling of Akero.

1947-102 Parker's Pippin and 1976-178 Aromatic Russet (Scott)
Morphologically, samples were virtually identical. Aromatic Russet appears the cultivar better known in the UK with provenance back to 1830 and 1976-178 agrees with published descriptions (as also noted in previous curation); Parkers Pippin appears mainly known as Pepin de Parker and is detailed in French reference books with similar age

of provenance – 1947-102 should be deaccessed and Parker's Pippin/Pepin de Parker noted as a potential synonym (accepting that it is possible that two similar, but different cultivars did once exist and have since been mixed up).

1948-399 Sikulai-alma and 1948-647 Rosioare Calugaresti
Morphologically, samples were virtually identical. 1948-399 has been found to match two translated Hungarian published descriptions of Sikulai-alma well; no descriptions are available in the archive for Rosioare Calugaresti – 1948-647 should be deaccessed (and Rosioare Calugaresti noted as a potential synonym).

2000-028 Colonel Vaughan and 1946-088 Winter Marigold
Samples were morphologically identical. Both accessions match descriptions of their cultivar well (noting that Hogg describes Colonel Vaughan under the name Kentish Pippin). Colonel Vaughan appears to have older provenance (dating back to 1670) – 1946-088 should be deaccessed and Winter Marigold noted as a potential synonym.

1989-009 Leeder's Perfection and 1946-042 Maltster
Accessions in archive images appear similar. Leeder's perfection has no published description and is only mentioned as having been exhibited in the NAR; Maltster is a well described cultivar with provenance to 1830 – 1989-009 should be deaccessed.

1946-034 Flower of the Town and 1983-075 Lange's Perfection
Morphological comparison found samples not to be identical, but fruit from both was very varied and appeared of poor quality; many characters were consistent between the two. Archive notes highlight irregularities in "all descriptive aspects". Flower of the Town has published descriptions and provenance dating to 1831; Lange's Perfection has no provenance beyond being received by the NFC – 1983-075 should be deaccessed.

1948-105 Baxter's Pearmain and 2000-038 Golden Reinette
Accessions in archive images appear distinguishable. 2000-038 was agreed to match its published description during previous curation; Baxter's Pearmain is listed in the NAR and had been taken as true on this basis. Both cultivars have significant provenance dating to 1821 and the mid 1600's respectively (although noting that the latter has some historical confusion [not with Baxter's Pearmain]). Further investigation noted that both accessions produced variable, but overall similar fruit and deemed that they were most likely Golden Reinette (and this agreed with their identification as a potential parent of a number of triploids [Ordidge et al., PLOS One 2018]). Parallel analysis of the Baxter's Pearmain accession at Wisley found it indistinguishable (by SSR) to the NFC accession of Baxter (1930-027) and morphology agreed with this (pers. comm. FruitID.com); Golden Reinette at Wisley was found indistinguishable (by SSR) from 2000-038 – 1948-105 should be deaccessed.

1973-113 Apez Zagarra and 1957-074 Anisa
Accessions in archive images appear similar, although 1957-074 appears of better shape. Previous curatorial notes suggested to graft 1973-113 next to 1957-074 for comparison (suggesting that both appeared similar but 1973-113 was very shaded) and also suggested to check by SSR analysis. Neither cultivar name has strong provenance; Anisa is only listed as accessed from France in 1957 (with a synonym of Udarria Zagarra listed) and Apez Zagarra has no further provenance than being accessed from France in 1973 – 1973-113 should be deaccessed and potential synonymy noted.

1948-316 Beurriere and 1948-330 Normandie
Samples were morphologically very similar. Neither cultivar appears to have particular provenance although both cultivars/accessions are described as late flowering. 1948-316 was noted to agree with one description (in Pommes du Nord) of Beurriere; no descriptions are available for Normandie beyond listing the NFC accession in the NAR – 1948-330 should be deaccessed.

1982-285 Belle de France and 1973-170 Crawley Beauty

Accessions in archive images appear extremely similar and both have notably late flowering dates. The cultivar name Belle de France has little provenance apart from being received by NFC in 1982 from Switzerland. Crawley Beauty has published provenance to being discovered in 1870 (reported to have been found in a cottage garden) and introduced in 1906; published pomologies have suggested it to be an American or French cultivar and in the NFC it has previously been found identical to Nouvelle France, which has provenance to being recorded in 1888 and of being exhibited from Crawley in 1897. Some confusion in the background of the cultivar name clearly exists, but Crawley Beauty has been established for use in the UK – 1982-285 should be deaccessed and Belle de France noted as a potential synonym.

1950-058 Lemon Queen and 1950-286 Nottingham Pippin

Accessions in archive images appear similar (although ripeness is variable). Lemon Queen has no published descriptions beyond the NAR; Nottingham Pippin has published provenance to 1815 and 1950-286 was thought possibly true (matching on external, but not internal characters) in previous curation – 1950-286 should be retained (although previous suggestion was to retain 1950-058 on the basis of common knowledge) 1950-058 should be deaccessed.

1945-148 Patrick and 1946-108 Caroline

Samples were found to be morphologically identical although both were variable. Patrick has no provenance beyond being received by NFC and Caroline has published descriptions and provenance dating to 1822; both accessions were found to match the description of Caroline – 1945-148 should be deaccessed and Patrick noted as a possible local name in Norfolk (from where it was exhibited, and where Caroline originated).

2000-070 Mrs Phillimore and 1954-031 Sweet Merlin

Samples were not found to be identical morphologically but were differentiated by size and level of colour (which is more consistent in the NFC archive photograph). Mrs Phillimore has published provenance (although with confused parentage) dating to 1896; Sweet Merlin has no provenance beyond being received by NFC – 1954-031 should be deaccessed.

1973-052 Limoncella and 1958-129 Cola

Accessions in archive images appear very similar. 1973-052 was noted to agree with a published description from an “Italian congress” during previous curation; no published descriptions were known for Cola beyond the NFC accession being listed in the NAR – 1958-129 should be deaccessed and Cola noted as a possible synonym.

1958-110 Sovari Nobil (of Romania), 1948-363 Daru Sovari and 1948-373 Harang Alma

Morphologically, samples were found to be virtually identical. No published descriptions of Sovari Nobil or Daru Sovari could be found (although previous curatorial notes suggested 1958-110 matched a description of Sovari Nobil in a Romanian pomology [hence the qualification]); Harang Alma had been previously verified agains a published description (Bereczki 1882-87). Harang Alma appears most likely the true name as well as the oldest – 1958-110 and 1948-363 should be deaccessed (and colour classification possibly amended for the remaining accession).

1951-193 Martini, 1958-066 Red Martini and 1948-392 Marosszeki Piros Paris

Samples were found morphologically, to be extremely similar. Martini is reported as being found in 1875, although with relatively little provenance recorded in the NAR; Red Martini is a supposed sport although had relatively little additional colour on comparison; Marosszeki Piros Paris is described in various publications with provenance dating to 1598. From further investigation, 1948-392 appeared to agree with published descriptions for Marosszeki Piros Paris – 1951-193 and 1958-066 should be deaccessed and Martini noted as a potential synonym.

1967-086 Megumi and 1953-009 Megumi

Accessions in archive images appear identical. Previous curatorial notes had identified 1967-086 as morphologically identical to Megumi although it was still listed by its initial name of Hoe in the GC0140 report – 1967-086 should be deaccessed.

1955-005 Prins Bernhard and 1955-007 Lucullus

Morphologically, samples were found to be virtually identical. Neither cultivars have descriptions available beyond the NFC listing in the NAR; both were apparently raised from Jonathan x Cox's Orange Pippin in 1935 at Wageningen; Lucullus is listed as having been released in 1955. From further investigation, it was practically impossible to distinguish which, if either, is true to type but more information was available on Lucullus –1955-007 should be retained since Lucullus has records of being released (cultivar should be re-classified as Group 7) and 1955-005 should be deaccessed.

1948-223 Api Rose (Creuse) and 1950-154 Blandurette

Morphologically, samples were found to be virtually identical. Both cultivars have complex provenance with many synonyms or confusion with other cultivars; Api Rose has provenance (at least as a name) to before 1600. NAR listings also appear confused, recognising Blandurette as both 'in NFC' and as a synonym of Coquette de Meilhards (itself supposedly in NFC 'as Blandurette') although describing both independently, and differently. Further investigation found the query unable to be resolved fully as no clear description is available for Api Rose (Creuse) although Blandurette appeared not to fully match a limited description –1948-223 should be retained as a potential representative of the cultivar with older provenance and 1950-154 deaccessed.

1982-205 Betty Geeson and 1929-029 Broad-Eyed Pippin (of Bultitude)

Samples were found morphologically, to be extremely similar. Both accessions were found to match descriptions of Betty Geeson (by Hogg and Bunyard) well; previous curatorial notes, and further examination found neither to match Hogg's description of Broad-Eyed Pippin (hence the 'of Bultitude' distinction – because the NFC accession was described as the cultivar by Bultitude). Betty Geeson has provenance to 1854 whilst Broad-Eyed Pippin is thought to date to the late 1600's – 1929-029 should be deaccessed and noted that Bultitude's description is thought to be of a false accession later found to be Betty Geeson.

1952-116 Orenco and 1952-194 Ivo

Morphologically, samples were found to be extremely similar. Orenco is reported to have been catalogued in 1903 but said to possibly originate in 1840; Ivo is reported to have been found in approximately 1920. Neither cultivar has particularly strong provenance. Further investigation compared accessions to Orenco description in Brooks and Olmo and found it to match, but also to match the colour plate of Ivo in Vara Applesorter (Nilsson, 1986) – 1952-116 should be retained as an accession of the older cultivar and 1952-194 should be deacessed, noting Ivo as a potential synonym.

1929-024 Laxton's Pearmain and 1929-034 Taunton Cross

Samples were found to be morphologically identical. Each cultivar has documented provenance to 1897 and 1919 respectively; both accessions appear to match the descriptions of Laxton's Pearmain (especially in season and storage) – 1929-034 should be deaccessed.

1966-002 Geneva Ontario, Northern Spy and its clones/sports

Accessions in archive images appear similar, although not identical. The cultivar is supposedly a tetraploid periclinally chimeric (2-4-4-4) version of Ontario. NAR states "found in orchard of NY State Agricultural Experiment Station…Parent tree received as Ontario". Assuming ploidy is correct, it would seem this may possibly have been a mislabelled tree in the first instance – 1966-002 should be retained, but noted as a potential tetraploid version of Northern Spy.

1947-086 Franc Roseau and 1949-056 Desse de Buff

Samples were found morphologically, to be virtually identical. Franc Roseau is mentioned in several published works and has provenance to 1850; Desse de Buff is noted in archives (and NAR) as possibly Dessin de Boef, exhibited as a local apple in 1900 but without any significant published provenance or description – 1949-056 should be deaccessed.

1951-191 Meri Cretesti and 1958-099 Cretesc Rosu

Accessions in archive images appear extremely similar. Previous curatorial notes had noted 1951-191 as almost identical to 1958-099; 1958-099 had previously been accepted as matching published descriptions (and confirmed by local, Romanian, experts) – 1951-191 should be deaccessed.

1958-063 Prinz Albrecht von Preussen and 1967-069 Fairy (Cormack)

Samples were found to be virtually identical morphologically. 1958-063 had previously been verified as matching descriptions of Prinz Albrecht von Preussen, which give provenance to 1865; 1967-069 had been noted as not matching descriptions of Fairy by Hogg or RHS – 1967-069 should be deaccessed.

1970-085 Maid of Kent and 1948-653 Bismark

Accessions in archive images appear extremely similar. Maid of Kent has little published provenance (NAR lists only as exhibited 1942); previous curatorial notes are confused. Bismark has published descriptions and provenance to late 1800's is accepted as 'in the NFC' in the NAR and 1948-653 agrees with descriptions – 1970-085 should be deaccessed.

1979-125 Winter Peach and 1945-155 Devonshire Buckland

Samples were not found to be identical morphologically, although differences were only in size and amount of colour. Archive notes highlight that published descriptions of Winter Peach differ, but allowing for variability, 1979-125 broadly agrees; Devonshire Buckland is listed with synonyms including Winter Peach in the archive (but not NAR). Provenance for Winter Peach dates to 1853 (although records suggest there may be another independent Winter Peach) whilst Devonshire Buckland is dated to 1831 – 1979-125 should be deaccessed and Winter Peach noted as a potential synonym of Devonshire Buckland.

1948-301 Bouquepreuve and 1947-283 Bonnet de Comte

Accessions in archive images appear extremely similar. Bouquepreuve has published descriptions and provenance to 1884; Bonnet de Comte has no further provenance than being received by the NFC. Further investigation confirmed 1948-301 to match descriptions of Bouquepreuve – 1947-283 should be deaccessed.

1945-079 Brabant Bellefleur and 1950-161 Franc Bon Pommiere (Moselle)

Accessions in archive images appear similar, although not identical. Previous curatorial notes question the relationship between Franc Bon Pommiere and Bellefleur de France. Brabant Bellefleur is listed as 'in NFC' in the NAR, has published descriptions and provenance to the late 1700's; Franc Bon Pommiere is listed in the NAR with provenance to being received from France in 1950 (and grown in Moselle). This would suggest that Franc Bon Pommiere is likely either a synonym or misidentification of (possibly a clone of) the old cultivar Brabant Bellefleur. Further investigation confirmed 1945-079 to matched published descriptions of Brabant Bellefleur – 1950-161 should be deaccessed (and the name noted as a potential synonym).

1948-323 Bastien and 1948-292 Lagree

Accessions in archive images appear very similar. Bastien has published description in Le Verger Francais and provenance to 1948; Lagree has no further provenance than being received by the NFC (from France in 1948). Further investigation found 1948-323 in basic agreement with published description of Bastien (albeit not perfect) – 1948-292 should be deaccessed.

1996-017 Belle de Pontoise and 1939-018 Jeanne Hardy

Morphologically, samples were found to be extremely similar; previous curatorial notes suggested the two accessions appeared identical (as did the NAR), and suggested confirmation by genetic analysis. Both cultivars have published descriptions and provenance, to 1869 and 1878 respectively; accessions were compared and found to match descriptions of Belle de Pontoise best and initial analysis by Storti and Baric [pers. comm.] finds the profile to match with Belle de Pontoise in two other collections. It was noted that both cultivars are listed as open pollinated seedlings of Alexander and SSR allele profiles supported this – 1939-018 should be deaccessed.

2000-027 Cockle Pippin and 1992-006 Grey Pippin

Accessions in archive images appear very similar. Cockle Pippin has a range of published descriptions and provenance dating to c. 1800. Cockle Pippin was accepted as correct in the NAR. Grey Pippin only has published provenance of being exhibited (from Essex) in 1883 and brief description fits with Cockle Pippin – 1992-006 should be deaccessed.

1982-266 Coopers Seedling and 1993-008 Grimoldby Golden

Accessions in archive images appear similar (although the latter is only available as an image on the tree). Previous curatorial notes list 1982-266 to match published descriptions of Cooper's Seedling which has limited published description and provenance to being exhibited in 1934. Grimoldby Golden has no published provenance – 1993-008 should be deaccessed.

1999-096 Kingston Black and 1989-093 Kingston Black

Samples were found to be extremely similar morphologically. Both accessions match the published description, generally described as a cider apple (1989-093 is sited in the cider collection) – 1999-096 should be deaccessed.

1989-087 Gennet Moyle and 1952-182 Burr Knot

Accessions in archive images do not appear very similar although further checking confirmed that fruit are indistinguishable in the field (the 1952-182 image seeming better on this comparison). 1989-087 was noted in previous curatorial notes as different to the Genet Moyle (1977-002) in the main collection and this was confirmed by both SSR and DArT analysis. Two different accessions of Burr Knot are held in the collection on the understanding that there are many 'types' under this name. 1989-087 was also noted in previous curatorial notes to not agree with published descriptions of the cultivar – 1989-087 should be deaccessed.

1989-063 Unknown and 1989-082 EB 54

Samples were found to be morphologically identical. Some confusion remains over their relationship to Ball's Bittersweet (archive notes suggested EB 54 was; previous curatorial notes discounted this based on taste). Morphological analysis in this assessment suggested they could both be Ball's Bittersweet from morphology and 1989-063 was originally accessed as Ball's Bittersweet. However, Ball's Bittersweet is described as mature in November whilst in both 2014 and 2018, fruit was falling from both accessions in early September and largely fallen by early October – 1989-063 should be deaccessed and EB 54 noted as a potential sibling of Ball's Bittersweet.

1989-101 Pethyre and 1992-108 Broadleaf Norman

Samples were found to be morphologically identical. 1989-101 was found to match a (brief) description of the cultivar in the Bulmer's Pomona (as per previous curatorial notes); 1992-108 had been previously noted not to match the supposed synonym Broad-leafed Hereford – 1992-108 should be deaccessed.

1992-123 Langworthy and 1989-104 Reine des Pommes

Samples were found to be morphologically identical. Both cultivars have been verified against published description in the archive. Reine des Pommes appears to be the most documented and older name – 1992-123 should be deaccessed and Langworthy noted as a potential synonym.

1960-059 Kirke's Lord Nelson and 1948-406 Tordai Alma
Samples were found to be morphologically similar. Kirke's Lord Nelson is listed as a large fruited clone of Kentish Fillbasket but 1960-059 is clearly distinguishable from 1939-019 Kentish Fillbasket by SSR (no data were available from DArT analysis). Previous curatorial notes suggested 1960-059 could match published descriptions for Kirke's Lord Nelson but the accession was found to be considerably earlier ripening and more acid in this analysis (some confusion was noted in published descriptions of the cultivar). Tordai Alma has limited publications but provenance dates to c. 1771 and previous curatorial notes stated that 1948-406 mainly agrees with description – 1960-059 should be deaccessed.

1954-030 Sidney Strake, 1921-084 Tom Putt (main collection) and 1989-116 Tom Putt (cider collection)
Morphologically, samples were found very similar in this analysis (noting that, as per the previous curatorial notes 1954-030 is less highly coloured and more striped); further notes from previous curation detailed both accessions of Tom Putt as identical. Sidney Strake has no further provenance than being noted as received by the NFC (where it is also noted to look like a less coloured sport of Tom Putt); Hogg notes Tom Putt as an excellent culinary apple also widely used for cider production – 1954-030 and 1989-116 should be deaccessed.

1999-094 Stone's Mosaic and 2000-058 Loddington
Accessions in archive images appear similar, although not identical. Previous curatorial notes questioned the reason for accession of 1999-094 from Long Ashton; Stone's Mosaic has little provenance as a cultivar. Loddington has published descriptions and provenance dating to 1877 (Stone's and various derivatives are listed as synonyms). Further investigation confirmed 2000-058 to match published descriptions of Loddington – 1999-094 should be deaccessed.

1974-266 Dermen McIntosh and 1999-049 M9
Samples were found to be morphologically identical. Both accessions matched descriptions of M9 and also matched the sample of M9 used by EMR for standardisation of the SSR data. Archive notes suggested that the accession may have been lost to rootstock previously in 1971 (although it was thought to have been replaced) – 1974-266 should be deaccessed.

1948-040 New German and 1951-319 Lady's Delight
Samples were found to be morphologically identical. 1948-040 had been previously compared to published description of New German with unclear results (most of the sample did not agree, but a few did); 1951-319 had been compared to published descriptions of Lady's Delight and found true during previous curation, both findings were confirmed in this analysis. Both cultivars have published provenance, to 1851 and 1884 respectively – 1948-040 should be deaccessed.

1948-359 Csikos Orias Halasi and 1948-417 Vajki Alma
Samples were found to be morphologically identical. Csikos Orias Halasi has no provenance beyond being noted as received by the NFC in the NAR; Vajki Alma has published description translated in archive and both accessions match this description. Both accessions were also received together from the same source – 1948-359 should be deaccessed.

1981-149 Old English Round, 1979-158 Crimson King (main collection) and 1989-076 Crimson King (cider collection)
All samples were found to be morphologically similar (1981-149 and 1989-076 virtually identical, 1979-158 larger with generally more russet at base). Archive notes state that fruit of Crimson King is naturally variable and with that, all samples were judged to match archive descriptions. Old English Round has little available provenance (accompanying letter suggests "may be now known by other names"); Crimson King has published provenance and is recognised as a cider cultivar with potential provenance to 1895 (although NAR record is unclear) – 1981-149 and 1979-158 should be deaccessed.

1974-205 Libovicka Reneta and 1974-206 Ruzena Blahova

Samples were found to be morphologically identical. Available descriptions for both cultivars are brief, but very similar, and samples cannot be clearly distinguished as either cultivar. Libovicka Reneta is stated to be a chance seedling bred by V.Blaha in the 1950's; Ruzena Blahova is said to be raised by the same breeder in 1945 from Mother x James Grieve. Further analysis of SSR alleles excludes James Grieve but Mother is a plausible parent – 1974-206 should be deaccessed and 1974-205 noted as a potential open pollinated seedling of Mother.

1967-085 Wang Young, 1951-103 (Stayman's) Winesap and its sports

Accessions in archive images appear similar, although more so to 1950-141 Dark Red Staymared and 1952-041 Scarlet Staymared than 1951-103 (Stayman's) Winesap and 1950-140 Blaxtayman (which appear to have more solid flush and slightly flatter shape). DArT similarity also scores as 0.8 and 0.78 to 1951-250 McLiver's Winesap and 1974-052 Dermen Winesap respectively which is in agreement with the findings in Ordidge et al (PLOS One 2018) that the accession of 'McLiver's Winesap' is a sport of the original diploid parent 'Winesap' and that 1951-103 is of 'Stayman's Winesap', a triploid offspring, rather than the original cultivar; 'Dermen Winesap' is a tetraploid derived from the original diploid. Two additional alleles were reported for 1950-141 Dark Red Staymared in the EMR report and these were not scored in further SSR analysis. Wang Young has no provenance beyond originating in South Korea and being received by the NFC in 1967 without any clear distinction as a useful sport – 1967-085 should be deaccessed, additional SSR alleles should be amended in the SSR data and the accession name of 1951-103 should be amended to 'Stayman's Winesap'.

1948-358 Cigany Alma and 1948-409 Roter Stettiner

Accessions in archive images appear extremely similar. Cigany Alma only has provenance as received from Hungary; Roter Stettiner has extensive published provenance to 1598 and many published synonyms and was deemed to be 'in NFC' in the NAR. Further morphological comparison confirmed that the accessions are in agreement with descriptions of Roter Stettiner – 1948-358 should be deaccessed.

1961-043 Acklam Russet and 1948-610 Reinette de Macon

Samples were found to be morphologically identical. 1961-043 was found quite similar to a published description of Acklam Russet by Hogg, although archive notes suggest it was previously deemed false. 1948-610 was found to match published description for Reinette de Macon which gives provenance to 1628. Acklam Russet has published provenance to 1768 and supposedly originated in Acklam (therefore presumably not a synonym) – 1961-043 should be deaccessed.

1947-364 Pepin d'Or de Bovelingen and 1947-460 Rambour Podolskii

Morphologically, samples were virtually identical. Previous curatorial notes state that 1947-364 did not match the (brief) published description or photograph of Pepin d'Or de Bovelingen; 1947-460 was found to match the published description for Rambour Podolskii and this was confirmed in this analysis. It was noted that descriptions and provenance of Pepin d'Or de Bovelingen were limited, and could be interpreted to match as a potential synonym; Rambour Podolskii has published provenance to 1899 – 1947-364 should be deaccessed.

1967-009 Dick's Favourite, 1919-004 Sandlin Duchess and 1949-135 Grange's Pearmain

The original SSR analysis reported 1967-009 only to be distinguishable from the others by one missing (triploid) allele and this was judged as indistinguishable in the project report (the missing allele was later included in an EMR database update). 1967-009 was scored as having a similarity of approximately 0.88 to the others by DArT (the DArT similarity between 1919-004 and 1949-135 scored 0.92). Samples were morphologically very similar (1967-009 was noted as more mixed in shape: flatter and taller). Notes in the archive for Grange's Pearmain cite the RHS as stating that the cultivar is prone to producing fruit of two shapes (flat and conical). Neither Dick's Favourite nor Sandlin Duchess have available published descriptions (the NAR entry for the former is very limited). All three accessions agree with published descriptions of Grange's Pearmain which has provenance to before 1829 (Sandlin Duchess has

provenance to 1880) – 1967-009 and 1919-004 should be deaccessed (1949-135 Grange's Pearmain should be listed as group 3 C/D and potential synonyms noted).

1947-096 Stafner Rosen and 1921-086 Baldwin

Samples were found to be morphologically similar (1947-096 a little smaller). Stafner Rosen has limited provenance to published description in 1924 and is noted in the archive as a synonym of Esopus Spitzenburg but 1947-096 was found to be different in previous curation to the NFC accession of Esopus Spitzenburg and this was confirmed by both SSR and DArT analysis. Baldwin has published descriptions and provenance to 1740, was accepted in the NAR and is stated as triploid (also supported by SSR analysis) – 1947-096 should be deaccessed.

1956-065 Reinette Grise du Canada and 2001-125 Reinette du Canada

Samples were found to be morphologically similar with additional russet on 1956-065. Reinette Grise du Canada is noted as a probable sport of Reinette du Canada and the similarity between accessions would support this; both cultivars have published descriptions and provenance to early 1800's and 1771 respectively and both accessions were accepted in the NAR – both accessions should be retained.

1949-055 Earl Cowper and 1976-182 Tower of Glamis (Scott)

Morphologically, samples were found to be extremely similar although variable. Published descriptions of Tower of Glamis vary, in accordance with the variability in the samples and both samples match descriptions quite well. Earl Cowper has no available provenance beyond being noted as received by the NFC in the NAR; Tower of Glamis has published descriptions and provenance to before 1800 – 1949-055 should be deaccessed (and from assessment Tower of Glamis could be classified as mid-season culinary rather than late – as per the NAR).

1924-017 Excelsior and 1993-018 Rougemont (and 1948-743 Bellaqueeny, 1924-049 Old Pearmain [of Kelsey] and 1947-047 Unknown)

Only the first two accessions were reported as indistinguishable in the original SSR analysis (although a single additional allele was reported in the profiles for the latter). DArT analysis found the accessions indistinguishable and also found both to be indistinguishable from 1948-743 (which from checking original SSR profiles was only distinguished by a single missing allele). Furthermore 1924-049 and 1947-047 were scored with similarity between 0.86 and 0.88 to these accessions in DArT analysis. All accessions look similar in archive images apart from 1948-743 which is only available as an image on the tree and is unripe with little or no overcolour. Further analysis of the original SSR profiles revealed that the distinction from the latter two was based on seven missing alleles (six of which were triploid alleles in the first three profiles). Previous curatorial notes suggest that Bellaqueeny has little or no provenance and that 1948-743 is of poor quality, recommending deaccession; 1924-049 had been looked at extensively by previous curators and deemed likely not to be an ancient cultivar; 1947-047 was accessed as Foulden Pearmain and unnamed as was found not to match published descriptions. Excelsior and Rougemont both have published provenance to UK raisers in 1921 and 1888 respectively. Further SSR analysis confirmed allele profiles to match for the first three and confirmed that the latter two are diploid; investigation of similarity by DArT suggests that the diploid may be a parent (having donated a diploid gamete to the triploid offspring [Ordidge et al., PLOS One 2018]). Further morphological analysis found 1924-017 and 1993-018 to fit closest with descriptions of Rougemont on the basis of ripening time – 1924-049 should be retained as the better described of the diploid pair; 1924-017, 1948-743 and 1947-047 should be deaccessed.

1992-111 Captain Broad and 1949-287 Small's Admirable

Samples were found morphologically, to be extremely similar, although 1949-287 was much riper at the time of picking. Broadly, both accessions matched published descriptions of Small's Admirable, although descriptions are themselves variable. Captain Broad has little available published provenance; Small's Admirable has published descriptions and provenance to c.1850 – 1992-111 should be deaccessed (from the cider collection).

a) (ii) Samples found indistinguishable by both SSR and DArT analysis but not compared morphologically

1970-009 Chips, 1949-057 Queenby's Glory, 1947-511 Keed's Cottage and 1924-009 Nanny
Chips, Queenby's Glory and Keed's Cottage were noted in curatorial records as having no published descriptions (the latter two are mentioned in the NAR but with no further provenance than being received by the NFC). Nanny is listed as 'in NFC' in the NAR and is a known cultivar with provenance dating to 1842 – 1970-009, 1949-057 and 1947-511 should be deaccessed.

2000-092 Unknown (Summer Apple) and 1949-093 Margaret
Previous curatorial notes suggested 2000-092 should possibly be deaccessed, recommending comparison to Margaret by genetic markers as the two were deemed to look the same morphologically – 2000-092 should be deaccessed.

1950-289 Woodford and 1977-204 Woodford
1950-289 had been accessed as Winter Codlin, but noted in files as morphologically identical to 1977-204 Woodford and listed to deaccess – 1950-289 should be deaccessed.

1967-076 Red Fameuse and all McIntosh accessions (with the exception of Dermen McIntosh – see above)
The accession has no further provenance than being received by the NFC – 1967-076 should be deaccessed.

1971-052 Ozark Gold and 1971-053 Missouri
Ozark Gold was introduced in 1970 and 1971-052 had been found to match the published description in previous curation; Missouri had not been released according to notes although previous curation had also found the accession to match a description by Sansavini. Analysis of SSR profile would not disagree with the proposed parentage of Ozark Gold and a letter in the archive suggests Ozark Gold is the better of the two accessions – 1971-053 should be deaccessed.

1947-182 Unknown and 1947-183 Belle des Buits
Previous curatorial notes had suggested that Paradis du Limosin (which 1947-182 had been named after being originally received as Paradis) was a synonym of Belle des Buits; consequently the name had been removed – 1947-182 should be deaccessed and both Paradis du Limosin and Paradis noted as potential synonyms.

1929-039 Milton and 1999-022 Karina
Milton has published description and provenance to 1909; Karina has no published provenance and previous curatorial notes suggested to check against Milton due to similar blossom. Further investigation confirmed 1929-039 to match the published description for Milton – 1999-022 should be deaccessed.

Observation plot

2001-015 Hick's Fancy **and both accessions of Worcester Pearmain**
Previous curatorial notes had stated that 2001-015 in the observation plot was not Hick's Fancy (which is supposedly green/yellow with russet) as it has red fruit – 2001-015 should be deaccessed.

2003-031 Harvest Lemon **1978-300 Lord Derby**

Harvest Lemon is held in the observation plot. Lord Derby has stronger provenance (Harvest Lemon is listed only as exhibited in 1934) and further investigation confirmed 1978-300 to match published descriptions of Lord Derby – 2003-031 should be deaccessed.

2000-025 Christie Manson, *1995-019 Queen Anne* and 1982-035 Green Roland

Christie Manson was noted as having no substantial references by previous curators (although the accession had been in the collection since it was at Wisley in 1905) and 1995-019 was noted to not fit any descriptions of the name although had been accessed into the main collection as well as remaining in the observation plot (see above). 1982-035 had been accepted as true based on published description by the previous curators – 2000-025 and 1995-019 should be deaccessed; Christie Manson should be considered as a potential synonym for Green Roland since, despite Green Roland appearing to be the better recognised name, the naming of the accession Christie Manson dates substantially earlier than the earliest currently available record of the name Green Roland (i.e. Taylor, 1945).

***2001-006 Brak*, Fuji and its sports**

2001-006 is held in the observation plot, with the note that it was "being held in the observation plot until [it passes] European [plant variety] rights, when [it] will be transferred into the main collection". Since the collection no longer acts as a base for PVR testing – 2001-006 should be deaccessed.

***2002-001 Plum Vite* and 1944-004 Venus Pippin**

2002-001 was held in the observation plot and curatorial notes stated that "the last accession of this name turn[ed] out to be Venus Pippin" – 2002-001 should be deaccessed.

***2002-055 Wyken Pippin* and 2000-101 Wyken Pippin**

2002-055 was held in the observation plot, had been accepted under the name Whiting Pippin and renamed Wyken Pippin after identification by previous curators (and was noted for deaccession) – 2002-055 should be deaccessed.

***2002-008 White Melrose (Anton's Hill)* and 1987-094 King's Acre Bountiful**

2002-008 is held in the observation plot and previous notes state that the accession does not look like Melrose in the collection (White Melrose is listed as a synonym of one of two Melroses in the NAR [and NFC]); the accession matches neither Merose in the collection by SSR or DArT. Previous curatorial notes state that 1987-094 has been found to agree with published descriptions of King's Acre Bountiful which has published descriptions and provenance to 1904 – 2002-008 should be deaccessed.

***2002-007 White Melrose (Priorwood)* and 1967-057 Melrose (1) [listed as White Melrose by EMR]**

2002-007 is held in the observation plot and was noted to not match published descriptions, but apparently suggested by an associated researcher to match the accession of Melrose in the collection. Previous curatorial notes state that 1967-057 was accessed as White Melrose and was considered as Melrose (1) in the NAR where Muriel Smith questioned if true, but appeared to match published descriptions (with question over amount of ribbing) according to previous curators; notes also suggested to compare to accessions of White Melrose in the observation plot –2002-007 should be deaccessed (and label corrected in SSR data).

***2003-024 Costard (supposed)* and 1949-213 Pope's Scarlet Costard [listed as Costard (Howlett) by EMR]**

2003-024 is held in the observation plot. Previous curatorial notes suggested that 1949-213 matched descriptions of Pope's Scarlet Costard (and originated from the same area – Newbury/Reading); 1949-213 had been accessed as Costard and listed as Costard (Howlett) at one time (according to records) – 2003-024 should be deaccessed (and label corrected in SSR data).

***1999-060 Stead's Reinette* and 1957-246 Mabbott's Pearmain**

1999-060 was held in the observation plot and previous curatorial notes suggested it was identical to Mabbott's Pearmain in fruit (suggesting to deaccess after checking blossom) – 1999-060 should be deaccessed.

2004-001 Sam's Crab and 2002-053 Sam's Crab

Both accessions were held in the observation plot, but 2002-053 had also been propagated into the main collection (although only the accession in the obs plot was checked in the original analysis). Previous curatorial notes stated that 2002-053 was identical to published description and also identical to 2004-001. Further SSR analysis confirmed the main collection (NFC3) sample to also match the profile for both accessions – 2004-001 should be deaccessed.

2005-006 Rankthorn **and 1951-228 Rank Thorn**

2005-006 was held in the observation plot; Rank Thorn has no further provenance than being noted as received by the NFC in the NAR but 1951-228 was included in the main collection in 1951 – 2005-006 should be deaccessed.

2005-008 Wheaten Loaves (Hedge), 2005-009 Wheaten Loaves (Leaning) and 2000-144 Fallbarrow Favourite

All accessions are held in the observation plot. 2000-144 was noted to be believed true to descriptions by previous curators (with slight query over regularity of shape) and suggested for inclusion in the main collection; Fallbarrow Favourite has limited published provenance to 1936. Wheaten Loaves has little published provenance – 2005-008 and 2005-009 should be deaccessed and 2000-144 should be accessed into main collection.

2005-010 Wheaten Loaves (Tree 2) **and 1948-683 Transparente de Croncels**

2005-010 is held in the observation plot. 1948-683 is noted as having been verified against published description in previous curatorial notes and is listed as 'in NFC' in the NAR; Transparente de Croncels has published descriptions and provenance dating to 1869 – 2005-010 should be deaccessed.

2004-002 Wanstall Pippin (1) **and** ***2006-022 Wanstall Pippin (2)***

Both accessions are held in the observation plot. An error in the previous curatorial notes (and subsequently the NFC database) listed tree 3_25 (2004-002) as accession 1995-002 (Unknown – accessed as John Gidley's Pearmain and deaccessed 2002). Consequently, 2006-022 was found to be indistinguishable from the same sample incorrectly listed as 1995-002 in the DArT dataset; the accessions are otherwise unique in the collection – errors in labelling in the DArT dataset and NFC database should be noted and one sample of the accession brought into the main collection.

1995-009 Red Rolo **and 1921-011 Herring's Pippin**

1995-009 is held in the observation plot; previous curatorial notes suggest to question provenance as a Cornish cultivar with local experts. Herring's Pippin is listed as 'in the NFC' in the NAR and has published provenance to 1908 – 1995-009 should be deaccessed.

2005-004 Lady's Finger of Lancashire? (Gorman), 2005-005 Lady's Finger of Lancashire? (Wass Helmsley) **and 1949-176 Present van Engeland**

Both 2005-004 and 2005-005 were held in the observation plot; 1949-176 was noted in previous curatorial notes to agree with published description and the cultivar is listed in the NAR – 2005-004 and 2005-005 should be deaccessed.

2005-013 Sykehouse Russet (Far Tree) **and 1970-083 Court of Wick**

2005-013 was held in the observation plot; 1970-083 was noted as matching published descriptions of Court of Wick in previous curatorial notes – 2005-013 should be deaccessed.

1995-007 Reynold's Peach **and 1954-026 Polly**

1995-007 was held in the observation plot and previous curatorial notes suggested it did not match the published description (yellow and greasy vs carmine with heavy bloom); Polly has no further provenance than being listed in the NAR as received from Cornwall but is a greenish yellow apple – 1995-007 should be deaccessed.

***1995-017 Greasy Butcher* and 1957-175 Annie Elizabeth**

1995-017 was held in the observation plot and noted to compare to Fair Maid of Taunton (a supposed synonym); the accession does not match 1992-136 Fair Maid of Taunton by SSR or DArT analysis. Annie Elizabeth is listed in the NAR and has published descriptions and provenance to 1857 – 1995-017 should be deaccessed.

1975-317 Mother, 2004-049 Queen Mary and *1995-020 Queen Mary*

Only samples 1975-317 and 2004-049 were identified as indistinguishable by SSR whilst DArT found all three to be indistinguishable. 1995-020 was held in the observation plot and 2004-049 brought in more recently. Further analysis of the SSR data revealed that the distinguishing factor was a single third allele missing from the latter profile. No further signs of triploidy were present and neither of the two former accessions was confirmed as triploid in the report. It iwas felt most likely that this third allele was a scoring error although the single third allele was also scored in reanalysis of the NFC3 samples for 1975-317 and 2004-049 (1995-020 was not reanalysed). Queen Mary is a documented synonym of Mother (as well as of Duchess of Oldenburg) and Mother is noted as 'in NFC' in the NAR. Although previous notes suggested that 1995-020 was superficially similar, but different to Mother in fruit and blossom – 2004-049 and 1995-020 should be deaccessed.

***2000-107 Costard, 2002-003 Mainds Costard* and 1957-230 Thomas Rivers**

2000-107 and 2002-003 are held in the observation plot. There are various old Costard apples and provenance is confused (the NAR suggested the original was probably no longer grown). Mainds Costard has little or no available published provenance. Thomas Rivers has published provenance to 1892 and is listed as 'in NFC' in the NAR – 2000-107 and 2002-003 should be deaccessed.

2001-123 Profit (Tree 1)* and *2001-124 Profit (Tree 2)

Both accessions are held in the observation plot and were sent in under the same name (distinguished as two different source trees). Samples were found to be identical morphologically. Limited published descriptions are available for the cultivar Profit and neither accession appears to match clearly (although there was not felt enough evidence to reject). SSR analysis identifies the shared genetic profile as otherwise unique within the collection – 2001-123 should be accessed into the main collection and 2001-124 should be deaccessed (note as Early Culinary Group 3).

***2002-002 Red Ribbed Greening* and 1954-035 Cornish Pine**

2002-002 is held in the observation plot and previous curatorial notes state to check against Cornish Pine as Bunyard lists this as a synonym. Cornish Pine has published description, provenance to 1920 and was accepted as 'in the NFC' in the NAR – 2002-002 should be deaccessed.

b) Samples found indistinguishable by SSR only

1947-127 Grosse de Saint-Clement and 1947-128 Grand'mere

Data were not available from DArT analysis for 1947-128. Accessions in archive images are very similar morphologically although images are clearly at different ripening stages. Grosse de Saint Clement was accepted as 'in NFC' in the NAR with limited published description and provenance to 1895; 1947-127 matches the brief description of the cultivar (large and yellow) apart perhaps from suggested late season. Grand'mere is also listed as 'in NFC' in the NAR with published description and provenance to recording in 1915 (more detailed description but also large, late and yellow). Previous curatorial notes suggest that there are many cultivars by the name Grand'mere

and that 1947-128 doesn't agree with either of two cited published descriptions (neither of which are referenced in the NAR). Further SSR analysis confirmed both accessions to match original profiles and comparison to description in Leroy (deemed the most robust reference source for Grand'mere) found accessions to match the published description for Grand'mere – 1947-127 should be deaccessed (noting that it is possible this is a case of synonymy).

2000-020 Bedfordshire Foundling and 1914-021 (42_99) Missing Link (wrongly listed as 2000-068 in database)
Data were not available from DArT analysis for 2000-068 although from further checking there was an error in the database records and Missing Link should be accession number 1914-021 (which was included and clearly distinguishable by DArT analysis). Morphologically the accessions appear clearly different and both cultivars were accepted to be in the collection in the NAR. Accessions are sited side by side in the field (41_99 and 42_99) and further SSR analysis confirmed a new unique profile for 2000-020 – labels in SSR data should be corrected accordingly; no further action is required.

1948-604 Gronsvelder Klumpke and 1951-054 Rheinischer Krummstiel
Data were not available from DArT analysis for 1948-604. Morphologically the accessions appear slightly different in the archive images. 1951-054 appears distinguishable from all other available accessions through DArT analysis. Further SSR analysis confirmed the pair to be indistinguishable. Both cultivars were deemed to be 'in NFC' in the NAR although only Rheinischer Krummstiel appears to have significant further provenance (being described in 1821 and having multiple published references); Gronsvelder Klumpke is cited only as being received in 1948 and grown in Holland and Belgium but was thought to be a sport of Eisdener Klumpke (an accession of which was deaccessed having been found to be false) – 1948-604 should be deaccessed .

2005-023 Park Farm Pippin [listed as 21_109_Reinette_de_Caux by EMR] and 2005-023 Park Farm Pippin [listed as 23_111_Magnasuper by EMR]
2005-023 Park Farm Pippin was found identical at two sites in the main collection by SSR analysis (labelled as 21_109_Reinette_de_Caux and 23_111_Magnasuper respectively in the EMR analysis) and only one of these was analysed by DArT. The accessions at these sites had been previously replaced and both were correctly Park Farm Pippin at the time of analysis; only one of these representatives has been propagated into the new collection – labels in SSR data should be corrected accordingly; no further action is required.

1958-033 Contessa and 1941-021 Beauty of Kent
Data were not available from DArT analysis for 1941-021 and 1958-033 was otherwise unique. From archive images the accessions appear similar (although fruit are harvested at a different stage of ripeness [and indicated as early and late September respectively]). Contessa has no further provenance than being received from Italy in 1958 although initial analysis by Storti and Baric (pers. comm.)finds the profile to match that of Contessa in four other collections; Beauty of Kent has published provenance to 1820 and was listed as 'in NFC' in the NAR. Further morphological comparison found both accessions to agree with the published descriptions of Beauty of Kent. The NAR lists Countess of Warwick as a historical synonym of Beauty of Kent – 1958-033 should be deaccessed and Contessa noted as a potential synonym (derived from Countess of Warwick).

Observation plot

1945-191 Evagil, *1999-068 Charleston*, *2007-002 Kane's Seedling*, 1966-040 Yellow Pitcher and 1967-056 Sharleston Pippin
The first three accessions were also indistinguishable by DArT analysis (but unfortunately samples failed for the latter two) and all five appeared virtually identical morphologically. Evagil and Sharleston Pippin have the strongest provenance (dating to 1863 and 1888 respectively) and further investigation confirmed the accessions to agree with

descriptions of Evagil. 1999-068 and 2007-002 remained in the observation plot (and previous curatorial notes had identified the former as identical to Sharleston Pippin) – 1999-068, 2007-002, 1966-040 and 1967-056 should be deaccessed; 1945-191 should be retained as a representative of the oldest cultivar .

2001-003 Flanders Pippin **[listed as Costard by EMR] and** ***2001-003 Flanders Pippin*** **[listed as Sweet Cleave by EMR]**
2001-003 was represented twice in the observation plot at positions 1_29 and 2_35; all trees had been accessed as Sweet Cleave and renamed Flanders Pippin as they were found to match the description of this cultivar according to previous curatorial notes (which also noted Sweet Cleave as a previously published synonym and recommended accession into the main collection). These trees were found consequently to match in the EMR dataset, although incorrectly labelled as Costard and Sweet Cleave and the former was mistakenly reported as tree 2_29 Costard in the reported list of duplicates. 2001-003 was only included once and not found to match anything else in the collection by DArT analysis and was otherwise unique in the SSR dataset – 2001-003 should be accessed into the main collection and errors in labelling in the EMR report noted.

c) Samples found indistinguishable by DArT only

1981-095 Wilhelm Ley, ***1995-011 Veitch's Perfection*****, 1973-169 Belle de Boskoop and its sports**
1973-169 Belle de Boskoop was identified as indistinguishable from a number of known sports of the cultivar by SSR analysis (as detailed above). However, 1981-095 was not found indistinguishable (despite being a named sport of the cultivar). DArT analysis found 1981-095 and 1995-011 both to also be indistinguishable from the set and further analysis of the SSR data revealed that the two accessions were only distinguished by one missing (triploid) allele in the former and one additional allele (118bp in addition to 116bp) in both. These were deemed most likely to be a scoring error and an updated version of the EMR database contains all Belle de Boskoop accessions and the above scored identically. 1995-011 was held in the observation plot and previous curatorial notes stated that it appeared similar to Belle de Boskoop in both fruit and blossom – 1995-011 should be deacessed and profiles should be updated.

1951-009 Double-Red Baldwin and 1921-086 Baldwin
The former is listed as a colour sport of Baldwin and archive images would seem to agree with this. The original cultivar is a known triploid and accessions were distinguished in the original SSR data only by three missing (third) alleles. Further SSR data identified one of these alleles as present (although the two in the medium multiplex were not tested) – accessions should be retained and SSR profiles updated.

1949-077 Summer Blenheim and 1924-054 Beauty of Hants
The accessions appear similar in archive images and were only distinguished by a single missing marker in a triploid profile within the original data; from rechecking this was identified as a scoring anomaly (caused by an off scale peak error). Summer Blenheim has no further provenance than being received (from Wisley) in 1949; Beauty of Hants has published provenance to being raised prior to 1850 and 1924-054 was considered to match published descriptions (apart from a comment on seeds) by previous curators – 1949-077 should be deaccessed.

1947-298 Galloway Pippin and 1934-001 Siddington Russet
The latter was distinguished only by only three alleles in a triploid profile and Siddington Russet is documented to be a russeted sport of Galloway Pippin. Further analysis of the original and new SSR profiles found all alleles to match as expected – accessions should be retained and SSR profiles updated.

1989-122 Morgan Sweet and 1941-049 Morgan Sweet

The accessions had already been identified as duplicates based on morphology by previous curators and were distinguished only by a single third triploid allele – 1941-049 was already scheduled (and actioned) for deaccession from the main collection.

1948-041 Pinner Seedling and 1944-001 Wheeler's Russet

The accessions are relatively similar in archive images, although the amount of russet differs markedly, and were noted as indistinguishable in the NAR. Differentiation in the original SSR data was based on two missing (triploid) alleles and one differential score (206 bp vs 208 bp). From checking both original and new profiles the two missing alleles can be found although the 206/208 bp difference appears real. Pinner Seedling has published provenance to being raised in 1810; Wheeler's Russet has provenance to being known in 1717. 1948-041 was judged to match the limited description available for Pinner Seedling by previous curators and 1944-001 was found both to agree and disagree with published description of Wheeler's Russet – both accessions should be retained and 1948-041 noted as a potential sport with an SSR allele mutation.

1947-468 Hohenzollern and 1947-245 Calville des Femmes

Accessions are reasonably similar in archive images and were distinguished only by a single allele in a triploid profile (scored as 147/148 bp vs 148/148 bp in the original SSR data). From rescoring and reanalysis the profiles were judged to be identical (possibly 147 bp only). Calville des Femmes has published provenance to being found in a garden (Angers, 1850) and Hohenzollern only has provenance to being received from France in 1947. From further morphological analysis, the accessions broadly agree with descriptions of Calville des Femmes – 1947-468 should be deaccessed.

2000-021 Bietigheimer and 1948-406 Tordai Alma

Accessions are reasonably similar and were distinguished only by two missing alleles in triploid profiles. Both are in the medium multiplex (which had not been further checked) but all other markers agreed in new analysis. Further analysis of the original profiles identified both of the missing alleles to be present, making accessions indistinguishable. Neither cultivar has particularly strong provenance and both have been found to broadly match published descriptions; Bietigheimer appears to have slightly older provenance to being introduced to Canada from Germany around 1870 – 1948-406 should be deaccessed and Tordai Alma noted as a potential synonym.

1950-075 Bloody Butcher and 1948-417 Vajki Alma

Accessions appear reasonably similar in archive images and were distinguished only by a single missing allele in a triploid profile in the original analysis. The missing allele was in the medium multiplex (which had not been further checked) but all other markers agreed in the new analysis. Further analysis of the original profile found the additional allele (137 bp) to be an incorrect call and the two profiles to be indistinguishable. Bloody Butcher has provenance to recording in 1951 whilst Vajki Alma was only listed as received 1948 in the NAR (although found to match a description by previous curators). Further investigation revealed provenance for Vajki Alma to before 1871 and also noted that neither accession displays the darkest crimson associated with Bloody Butcher – 1950-075 should be deaccessed.

1977-095 Catherine and 1948-745 Warren's Seedling

Accessions do not look completely alike in archive images but were distinguished only by a single missing allele in a triploid profile in the original analysis; the missing allele was identified as present and correct in further SSR analysis. Catherine has no further provenance than being received from East Suffolk in 1977 and Warren's Seedling has provenance to being recorded in 1934. 1948-745 was judged to match the published description of Warren's Seedling by previous curators – 1977-095 should be deaccessed.

1958-042 Verdese and 1949-153 Galantine

Accessions appear broadly similar, although variable, in archive images and were distinguished only by a single missing allele in a triploid profile in the original SSR data. The missing allele was also missing initially in reanalysis but was called as present after further scrutiny. Verdese has no provenance beyond being received from Italy in 1958 whilst Galantine has published provenance to being described in 1934. Previous curators found 1949-153 to be in basic agreement with published descriptions – 1958-042 should be deaccessed.

2000-023 Byeloborodovka and 1949-166 Antonovka-kamenichka

Accessions appear broadly similar in archive images and are distinguished only by a single third allele in an otherwise apparently diploid profile in the original SSR data; the additional allele was not scored in the reanalysis. Byeloborodovka has published provenance to 1842 whilst Antonovka Kamenichka has provenance recorded to 1889. Both are listed as in the NAR. Further morphological assessment noted that all fruit were overripe and fallen by early October, in agreement with archive records which report both as early ripening; Antonovka Kamenichka is reportedly a late apple that hangs well on the tree whilst Byeloborodovka is documented to be early ripening – 1949-166 should be deaccessed.

1989-075 Court Royal and 1958-017 Lorna Doone

Accessions appear broadly similar and were distinguished only by two missing alleles in a triploid profile. These alleles were both included in an updated version of the East Malling database (pers. comm.) and were accepted on rescoring of the original data here, although could not be checked further as the amended allele calls were in the cider accession. Lorna Doone has little published provenance available beyond being received from Hereford in 1958; Court Royal has published provenance to being grown at the beginning of the 1900s – 1958-017 should be deaccessed and SSR data updated.

1974-346 Golden Delicious and 1973-092 Golden Morspur

The latter is documented, and appears as a sport of Golden Delicious, and profiles were distinguished only by one different (217 bp vs 219 bp) and one missing allele in the original data. Further analysis also scores these alleles as different/missing and this was confirmed after further scrutiny – irrespective of this slight discrepancy the accessions should both be retained as the original cultivar and a potentially useful sport (further analysis might consider the possibility of aneuploidy/mutation).

1957-225 Roundway Magnum Bonum and 1947-474 Breitling

Accessions appear similar, but not identical in archive images, but were only distinguished by a single missing allele (147bp vs 147/148bp) in a triploid profile in the original data The missing allele is in the medium multiplex so was not rechecked in the initial reanalysis but was identified from rescoring of the original data. Roundway Magnum Bonum has published provenance to being raised in 1864 and is listed as 'in NFC' in the NAR; Breitling was not recognised as a cultivar name in the NAR but was listed as a synonym of Rambour Franc and Roter Cardinal (both with published provenance to the 1500s). Previous curators felt that 1947-474 may well be Rambour Franc but it was felt to match a published description of Breitling (by Hogg). Further checks found the accessions to be broadly indistinguishable in the field – 1947-474 should be deaccessed and potential confusion in names noted.

1951-201 Steirischer Roter Marschansker and 1948-397 Pusztai Sarga

Accessions appear similar, but not identical in archive images and were missing data in the original SSR analysis. Further analysis identifies them to have matching (and otherwise unique) profiles for the small and large multiplex and the fruit to be practically indistinguishable in the field. Steirischer Roter Marschansker has limited provenance to being received from Germany (but notes refer to Steirischer Marschansker as a German cultivar); Pusztai Sarga has provenance to being received from Hungary in 1948. 1951-201 was found to match a published description of the variety (albeit a synonym); 1948-397 was found to match a published description for Pusztai Sarga, both by previous curators. Neither cultivar has particularly clear provenance and Steirischer Roter Marschansker is suggested to be a synonym of Stajerski Mosancelj which has been suggested (in correspondence) to potentially date to around 1700;

Pusztai Sarga was supposedly named having been received as a graft in 1865 – 1948-397 should be deaccessed (and the potential confusion in names noted).

1999-098 Redcoat Grieve and 1957-067 Erich Neumanns Roter James Grieve
Accessions appear similar, are listed as sports of James Grieve and are distinguished only by a single third allele in an otherwise diploid profile in the original data (which on checking appeared plausible in the original data). The third allele was not scored in reanalysis – both accessions should be retained as named sports of the cultivar and new, matching, profiles used in future.

2000-113 Jonagold and 1998-018 Jorayca
The latter is a documented sport of Jonagold and was distinguished only by a single missing allele in a triploid profile; the allele in question was scored as present in reanalysis – both accessions should be retained and profiles updated.

2006-014 McIntosh and 1984-137 Wijcik
The latter is a known sport of McIntosh but no data were present in the initial analysis; no data were generated in the reanalysis due to difficulties in repropagation of the accession but there is no reason to question the DArT finding – both accessions should be retained.

1997-014 Unknown and 1979-123 Glasbury
No images are available but the accessions were only distinguished by a single missing allele in a potentially tetraploid profile; the missing allele was called as present in both accessions in reanalysis. Glasbury has relatively little published provenance but is dated to before 1872 and previous curators judged that 1979-123 matched the basic description of Glasbury that was available – 1997-014 should be deaccessed.

Ornamentals

1980-104 Purple Wave and 1975-330 Eleyi
The accessions were noted as broadly similar red crab apples although no SSR data are available – accessions should be noted as likely duplicates.

1992-092 Gibb's Golden Gage and 1975-332 Golden Gem
The accessions were noted as broadly similar yellow crab apples although no SSR data are available – accessions should be noted as likely duplicates.

1992-064 Oekonomierat Echtermeyer and 1977-169 Oekonomierat Echtermeyer
Accessions were known to be duplicates and therefore confirmed as such – 1992-064 should be deaccessed (unless the other accession is more healthy in the field).

d) Samples found indistinguishable by SSR but found distinguishable (and unique*) by DArT

*unless stated otherwise.

1950-097 Autumn Harvest and 1979-183 Reverend W. Wilks

Accessions were not compared morphologically but descriptions are similar. Reverend W. Wilks has been accepted based on inclusion in the NAR and Autumn Harvest has been accepted as possibly true although no published descriptions are available. Further SSR analysis found the profiles to be different, and the original profile to be correct for 1979-183 only – both accessions should be retained and the SSR dataset updated.

1974-347 Grenadier and 1927-018 Guldborg

From archive images the accessions appear clearly morphologically different and as neighbouring accessions in the field (05_15 and 05_17) this was deemed most likely to be a collecting error in the SSR analysis. Further SSR analysis confirmed that the original profile was correct for 1927-018 only – both accessions should be retained and the SSR dataset updated.

1927-016 Karinable and 1924-001 Maidstone Favourite

From archive images the accessions appear clearly morphologically different. Although these are not neighbouring accessions in the field this was deemed likely to be a collecting or experimental error in the SSR dataset. Further SSR analysis confirmed that the original profile was correct for 1924-001 only – both accessions should be retained and the SSR dataset updated.

1944-005 Tewkesbury Baron and 1923-114 Thomas Jeffrey

These accessions were not compared morphologically, but as neighbouring accessions (10_31 and 10_33) were deemed likely to represent a collecting error in the SSR data. Further SSR analysis confirmed the profile was correct for 1944-005 only – both accessions should be retained and the SSR dataset updated.

1951-266 Willie Sharp and 1960-056 Beacon

From archive images, accessions are clearly different. 1960-056 was also unique within the DArT dataset. 1951-266 was however, indistinguishable from 1957-084 Canvada in the DArT dataset which is at position 32_7 and is similar, although not identical in the archive images to 1951-266 (possibly due to different ripeness stages). From further analysis, the original SSR profile is correct for 1951-266 and 1957-084 Canvada was confirmed to match; it would appear that samples were swapped because the original profile reported for 1957-084 is actually correct only for 1960-056. Neither Willie Sharp or Canvada have particularly strong provenance (both being 'received from') but Canvada having been described in 1926. Further morphological verification found a description for Willie Sharp from 1917 which both 1951-266 and 1957-084 were in agreement with; no further descriptions could be found for Canvada – 1960-056 and 1951-266 should both be retained and 1957-084 should be deaccessed with Canvada noted as a potential synonym for Willie Sharp.

1951-056 Biesterfelder Renette and 1949-115 Calville Rouge du Mont d'Or (and 1979-156 Charles Ross)

From archive images the first two accessions appear clearly different morphologically. Both were distinguishable from 1979-156 Charles Ross by DArT analysis (and 1979-156 Charles Ross was distinguishable from all others apart from 1948-111 Red Charles Ross as expected). Although these are not neighbouring accessions this was deemed to be a possible error in the SSR dataset. Further SSR analysis confirms that both accessions have different profiles and the original reported profile was correct for known Charles Ross accessions only – both accessions should be retained and the SSR dataset updated.

1952-113 Jefferis and 1945-063 Jennifer Wastie

These accessions were not compared morphologically, but as neighbouring accessions (35_19 and 35_21) were deemed likely to represent a collecting error in the SSR data. Further SSR analysis confirmed the original profile was correct for 1952-113 only – both accessions should be retained and the SSR dataset updated.

1999-086 San Peinte, 1950-041 Sandew and 1973-251 Kansas Queen

Only 1973-251 was also found to be indistinguishable from 1999-086 by DArT; 1950-041 Sandew was found to be distinguishable from both. San Peinte has no further provenance than being received by NFC (with no record of acquisition); 1973-251 has been verified as correct for Kansas Queen morphologically. 1999-086 and 1950-041 are neighbouring accessions (38_29 and 38_31) and the similarity in original data was deemed likely to be a collecting error. Further SSR analysis found the original profile to be correct for 1973-251 (although 1999-086 was not retested) and a new profile was found for 1950-041 – 1999-086 should be deaccessed and 1950-041 retained.

1951-179 Gustavs Dauerapfel and 1948-368 Gyogyi Piros (and 1967-073 Love Beauty, 1948-226 Mauss Reinette)
DArT analysis found the two accessions to be distinguishable but found 1951-179 to have similarity of 0.855 to 1967-073 Love Beauty and 1948-368 to be indistinguishable from 1948-226 Mauss Reinette. From archive images 1951-179 and 1967-073 are morphologically very similar, as are 1948-368 and 1948-226 but both pairs are clearly different. It appeared most likely that two of the profiles had somehow been swapped although none of the accessions are neighbouring. Gustavs Dauerapfel has published provenance to 1899 and is stated as 'in NFC' in the NAR; Love Beauty has no further provenance than being received from Scotland. Gyogyi Piros has published provenance to 1860 and had been previously checked against a published description; Mauss Reinette has published provenance to 1874 and was accepted as 'in NFC' in the NAR. From checking original SSR profiles only a single allele (scored at 121 vs 123) separated the reported profiles of 1967-073 and 1948-226 which further suggested a direct swap (and this difference between the profiles was noted in the EMR report). Further SSR analysis confirmed that 1951-179 and 1967-073 are indistinguishable, as are 1948-368 and 1948-226 and the original profiles were correct for 1951-179 and 1948-226. Further morphological comparison found 1948-368 and 1948-226 to both match a published plate and description of Gyogyi Piros (itself described to be a synonym of Rosii de Geoagiu); Mauss Reinette has relatively little further provenance available although is said to have been raised by Mauss – 1967-073 and 1948-226 should be deaccessed and 1948-368 should be renamed as Rosii de Geoagiu (with synonym Gyogyi Piros and potential synonym Mauss Reinette noted); SSR profiles should be adjusted in the dataset.

1950-145 Lundbytorp, 1951-232 Mitchelson's Seedling and 1957-213 Chelmsford Wonder
Only 1951-232 and 1957-213 were also indistinguishable by DArT analysis; similarly, 1951-232 and 1957-213 appeared morphologically identical whilst 1950-145 appeared different and tree form also appeared different. DArT analysis also found the two accessions to be indistinguishable from 1964-037 Horsford Prolific and this was also broadly similar in archive images. The original SSR data found 1964-037 to be clearly distinguishable but data from reanalysis found it to match as per the DArT finding; further SSR analysis provided a new profile for 1950-145. Mitchelson's Seedling, Chelmsford Wonder and Horsford Prolific share very similar descriptions in the NAR. Mitchelson's Seedling was described by Hogg in 1884 and has published provenance to being raised prior to 1851 (by Mitchelson) whereas Chelmsford Wonder is recorded as being introduced in 1891; Horsford Prolific has relatively little published provenance and is listed as found (in a garden) 1913 in the NAR. Accessions match the published description of Mitchelson's Seedling – 1950-145 should be retained as a presumed collecting error in SSR analysis and both 1957-213 and 1964-037 should be deaccessed as the more recent introductions (Chelmsford Wonder and Horsford Prolific should be noted as potential synonyms/renamings of Mitchelson's Seedling and both should be reclassified as Group 3); the SSR dataset should be updated .

1982-291 Jonagold LA78A and 1948-611 Minister von Hammerstein
From archive images accessions are clearly different morphologically and DArT analysis found 1982-291 to be indistinguishable from a whole series of Jonagold clones/sports. 1948-611 was found to be unique within the DArT dataset. Further SSR analysis confirmed that the reported profile was correct only for 1948-611 and that 1982-291 is indistinguishable from other clones of Jonagold – no action is required but profiles should be updated in the SSR dataset.

1947-137 Pomme d'Amour and 1950-172 Pomme de Fer

From archive images the two accessions appear clearly different morphologically and accessions are neighbouring in the field (38_49 and 38_51) so were deemed likely to be a collecting error in the original SSR analysis. Further SSR analysis confirmed the profile was correct for 1947-137 only – both accessions should be retained and the SSR dataset updated.

1958-029 Cavallotta and 1947-207 Champ Gaillard

From archive images the two accessions appear different morphologically and accessions are neighbouring in the field (42_65 and 42_67) so were deemed likely to be a collecting error in the original SSR analysis. Further SSR analysis confirmed the profile was correct for 1958-029 only – both accessions should be retained and the SSR dataset updated.

1945-101 Green Purnell and 1952-108 Gros Api

From archive images the two accessions appear clearly different morphologically and accessions are neighbouring in the field (45_65 and 45_67) so deemed likely to be a collecting error in the original SSR analysis. Further SSR analysis confirmed the profile was correct for 1952-108 only – both accessions should be retained and the SSR dataset updated.

1996-073 Telamon and 1987-046 Trajan

From archive images the two accessions appear similar. Both are relatively modern releases from EMR although neither were accessed directly (and the former was accessed from a commercial nursery); both accessions are close together in an area with a slightly different planting layout (51_B and 51_F). Further SSR analysis confirmed that the original profile was correct for 1987-046 and initial comparison by Storti and Baric [pers. comm.] suggests that 1987-046 matches with an accession under the same name in Sweden but no profile has yet been generated for 1996-073 so this cannot yet be fully resolved – since DArT analysis finds both to be unique, it would be reasonable to assume this is either a collecting or handling error in the original analysis and further SSR analysis would be expected to resolve with a new profile for 1996-073; no further action required.

1947-216 Gazerau and 1951-204 Gelber Trierer Weinapfel

From archive images the two accessions appear reasonably different morphologically and accessions are neighbouring in the field (46_77 and 46_79) so were deemed likely to be a collecting error in the original SSR analysis. Further SSR analysis confirmed the profile was correct for 1947-216 only – both accessions should be retained and the SSR dataset updated.

2002-038 Rodluvan and 2002-039 Royal Blush

Accessions appear reasonably different in archive images and accessions are neighbouring in the field (18_105 and 18_107) so were deemed likely to be a collecting error in the original analysis. Further SSR analysis confirmed the profile was correct for 2002-039 only – both accessions should be retained and the SSR dataset updated..

1984-001 Hockings Green and 1992-011 John Broad

DArT analysis found 1984-001 to be distinguishable from all accessions in the available dataset; 1992-011 was found indistinguishable by DArT from 1989-079 Dove, although conversely this accession was found to be unique in the SSR analysis. 1992-011 is noted to not be true to John Broad (as a supposed synonym of Captain Broad) in previous curatorial notes; Hocking's Green has provenance as a cultivar to being raised in Cornwall. Both 1992-011 and 1989-079 are sited in the cider collection (trees 5_17 and 5_7 respectively). Further SSR analysis confirmed that the original profile was correct for 1984-001 but the cider trees have not yet been rechecked. Further morphological analysis however, confirmed that 1984-001 and 1992-011 were morphologically indistinguishable; 1989-079 was clearly different – 1992-011 should be deaccessed and a collecting error noted in the DArT dataset.

1975-344 Luzhanka, 1947-122 Unknown and 1958-061 Hibernal

Only 1958-061 was found to be indistinguishable from 1975-344 by DArT. 1975-344 and 1958-061 were also found to be morphologically identical, whilst 1947-122 was clearly different. 1975-344 and 1947-122 are neighbouring accessions in the field (42_23 and 42_25) and this was presumed to be a collecting error in the SSR analysis. Further SSR analysis confirmed that the original profile was correct for 1975-344 and 1958-061 only and a new profile was obtained for 1947-122 (from further checking, two profiles were listed in the original SSR dataset and the match was to the original version, with the newer version being corrected). Luzhanka is noted as ancient in the archive, but has no further published provenance available; Hibernal has published descriptions and provenance to around 1880. 1958-061 was found to match the descriptions of Hibernal –1947-122 should be retained and the SSR dataset updated; 1975-344 should be deaccessed.

1974-068 New York (E18) and 1974-070 New York (E232)

DArT analysis also found 1974-070 to be distinguishable from all other accessions in the dataset; 1974-068 was found to be indistinguishable by DArT from 1965-039 Unnamed (accessed as Einset 8) at position 21_47 in the collections. 1974-068 and 1974-070 are neighbouring accessions in the collection (positions 55_7 and 55_9 respectively) and their indistinguishability in the SSR analysis was deemed likely to be a collecting error; unfortunately the profile for 1965-039 was missing from the original SSR dataset. 1965-039 has little further information apart from being noted by previous curators as tetraploid and to apparently not appear in the USDA GRIN database (although it was received from Balsgard). 1974-068 and 1974-070 are also listed as tetraploid and supposedly open pollinated seedlings of Red Gravenstein and Blaxtayman respectively. From the SSR profile, tetraploidy is apparent (and this was confirmed for both accessions by cytometry) but Blaxtayman can be excluded as a parent on the basis of 5 markers; Gravenstein can be accepted as a potential parent where all alleles of (triploid) Gravenstein are present in the profile (apart from a potentially mis-scored allele at 147 in addition to 148bp) suggesting that the profile is likely correct for 1974-068 and not 1974-070. 1974-068 is also noted to match a published description in previous curatorial notes and scores a similarity above 0.8 against all three clones/sports of Gravenstein in the collection in comparison of the DArT data. 1974-070 also scores a similarity of between 0.73 and 0.82 in comparison to a series of relatives of Blaxtayman (all sports or tetraploid forms of either 'Winesap' or its triploid offspring 'Stayman's Winesap') suggesting from this DArT profile that the accession is correct, according to its parentage. Further SSR analysis confirmed that the profile was correct for 1974-068 and that 1965-039 was indistinguishable; a new profile was generated for 1974-070 – both accessions should be retained and the SSR dataset updated; only one of 1965-039 and 1974-068 should be retained in the future unless additional value or provenance for the establishment of tetraploidy can be found.

e) Additional and/or complex queries

1951-250 McLiver's Winesap and 1974-052 Dermen Winesap

Dermen Winesap is supposedly a tetraploid sport of Winesap (as per Dermen, H, 1955, A homogenous tetraploid shoot from a 2-2-4 type chimeral Winesap apple J. Hered 46 p. 244). Interestingly, whilst the original profiles of these two accessions were indistinguishable, the standard Winesap accession in the NFC is triploid. Analysis of the SSR profile of these accessions in comparison to the triploid accession found that they consisted entirely of alleles which were present within the triploid profile, but were missing a third allele where one was detected; consistently with the above, the similarity by DArT was also scored at 0.83-0.84. Further analysis of the DArT findings led to the conclusion that 1951-250 was in fact a sport of the original 'Winesap' and that the triploid NFC accession was actually of 'Stayman's Winesap' (a known triploid offspring) and this then agreed with the similarity of the triploid and the indistinguishability of the tetraploid form (1974-052) from the original diploid (1951-250) in further SSR analysis (and as detailed in Ordidge et al., (PLOS One 2018) – all accessions should be retained and the status of McLiver's Winesap as a sport of Winesap should be noted.

1948-375 Herceg Batthyanyi Alma and 1947-288 Unknown [Reinette Franche in EMR dataset]

Accessions were indistinguishable in the original SSR analysis. DArT similarity was scored at 0.86. 1948-375 had no other similarity scores above 0.8 within the DArT dataset; 1947-288 was found to have 0.80-0.86 similarity to seven other accessions and shared many alleles with these in the SSR data, although all of these could be excluded by at least 3 alleles (and generally more) from independent markers (note: six of the seven were triploid). The conclusion from DArT analysis (Ordidge et al., PLOS One 2018) was that the accessions scoring similarity of 0.80-0.86 were triploid offspring, and that the two (diploid) accessions here were correctly identified to be indistinguishable; further SSR analysis supported this – both accessions should be retained (in case of the need to test conclusions in the DArT paper) although one of the two should be deaccessed in the future.

34_93 Feuillot [in the EMR dataset] and 1957-235 Fosters Seedling

1947-175 Feuillot had been deaccessed from position 34_93 as a likely propagation error in 2003 and no tree was in existence at the time of the original SSR analysis. 1957-235 Foster's Seedling is the neighbouring accession (35_95) to the empty plot. This must have been a collecting error (and name allocation based on an outdated accession list) – error should be noted in the SSR dataset.

1947-138 Unknown [24_45 Reinette Grise de Saintonge in the EMR dataset], 2001-023 Rushock Pearmain, 1946-095 King Charles Pearmain, 1998-020 Polan 2 and 2001-022 Reinette de Bordeaux

The GC0140 report claims 24_45 Reinette Grise de Saintonge to be indistinguishable from 18_113 Rushock Pearmain and 34_111 King Charles Pearmain to be indistinguishable from 19_81 Polan 2 and these claims are supported by the original SSR data. However, tree 24_45 is correctly labelled 1947-138 Unknown (having been accessed as Reinette Grise de Saintonge and deemed incorrect some years previously). DArT analysis finds accession 1947-138 Unknown to be indistinguishable only from 2001-022 Reinette de Bordeaux which is planted at position 18_111 (the neighbouring accession to the matching sample in the SSR report). Furthermore, the DArT analysis finds 2001-023 Rushock Pearmain (tree 18_113) to be indistinguishable only from 1946-095 King Charles Pearmain (tree 34_111). DArT analysis finds 1998-020 Polan 2 (tree 19_81) to be distinguishable from all accessions in the available dataset. Conversely, the SSR data finds 2001-022 Reinette de Bordeaux to match nothing else in the collection. The NAR lists NFC accessions of Rushock Pearmain and King Charles Pearmain as indistinguishable and previous curatorial notes highlight a suggestion from the Marcher Apple Network that Rushock Pearmain and King Charles Pearmain were thought to be confused historically (having possibly been wrongly described as two cultivars by Hogg); the two look very similar in archive images of fruit on the tree. Rushock Pearmain has stronger provenance, being documented as raised in 1821, whilst King Charles Pearmain has provenance of being received by Hogg in 1876; further analysis of 1947-140 Reinette Grise de Saintonge finds it to match none of the above by DArT or SSR analysis. From further SSR analysis, the profile for 1947-138 is correct and indistinguishable from the profile for 2001-022; the profile for 1946-095 is also correct and indistinguishable from the profile for 2001-023 although a new profile is yet to be produced for 1998-020 (having not been repropagated). It would appear that there was a mix up in either the original SSR data or sampling; that 2001-023 and 1946-095 are indistinguishable (and by implication Rushock Pearmain and King Charles Pearmain are synonymous) and that the unknown accession is Reinette de Bordeaux (which has published descriptions and provenance to 1840) – 1947-138 and 1946-095 should be deaccessed and the synonymy of Rushock Pearmain and King Charles Pearmain noted.

Assessment of the remainder of the observation plot

The two independent sets of genetic analysis presented the opportunity to carry out a final assessment of the remaining (i.e. not detailed in the analysis above) members of the observation plot. The basic rationale proposed below (in line with that followed in the assessment of the pear collection) is that accessions are compared to the main collection and where found to be unique they are recommended for accession; any accessions found not to be unique are recommended for removal. The following accessions were found to be distinguishable by both SSR and DArT analysis and are therefore recommended for accession into the main collection:

ACCENUMB	ACCENAME	ROW	TREE
1999-055	Ampney Red	2	9
1997-010	Arch Grove	4	19
2003-032	Bardsey Apple	2	19
1996-074	Beebench	3	21
1996-036	Blake	4	21
1996-028	Bossom (Loxwood)	5	21
1999-100	Boucasse de Bres	2	21
2005-003	Bradley's Beauty	3	5
2002-051	Chatley Kernel	1	3
2005-002	Edith Cavell	3	3
1998-035	Hargreaves Green Sweet	2	7
2002-012	Hitchin Pippin	1	11
2006-021	Hunthouse (M9)	2	5
2004-154	Lady's Finger? (Shropshire)	3	1
2002-010	Mary Hamilton	1	15
2002-011	Nelson's Codlin	1	17
2004-043	Nelson's Glory	5	29
2002-052	Newland Sack	1	7
2007-019	Ovington	4	7
1999-056	Pride of the Orchard	2	11
2002-050	Sayer - No. 23	1	27
1995-008	Snub Nose	4	31
1995-018	Soppy Withers	5	31
2005-021	Strawberry Pippin	2	3
1995-023	Strawberry Pippin (Street)	3	33
2004-046	Sugar-Loaf Pippin	4	37
2005-014	Sykehouse Russet (Near Tree)	4	3
2005-007	Taylor's Favourite	3	13
1995-005	Tregonna King	3	35
2002-009	Wex Apple	1	31
2007-018	Wheelers Russet of Gloucestershire	4	9
2002-054	White Paradise	2	1
2002-164	Winter Queening	1	37

A small number of further queries were raised in this analysis and these are detailed below:

1995-003 Omega

The accession was found to be indistinguishable from 1923-085 Jersey Beauty by DArT analysis and further analysis of the SSR data confirmed that the two accessions were distinguished by only a single allele (scored as 180 and/or 178 bp) for marker CH01f02; further analysis of the original SSR profile agreed with both accessions to be scored as 178 bp only and therefore to match fully. 1923-085 is in the main collection and Jersey Beauty has published provenance to 1896 and is reported to be ‘in NFC’ in the NAR; Omega has little provenance as a cultivar – 1995-003 should be deaccessed.

1995-006 Plympton Pippin

The accession was found to be indistinguishable from 1995-006 Plympton King by DArT analysis and further analysis of the SSR data confirmed that the two accessions were distinguished by only a single (triploid) allele (scored as 127 and/or 129/115 bp) for marker CH01h01. The accession had been studied morphologically, confirmed as Plympton King and accessed into the main collection (having been accessed originally as Plympton Pippin) by the previous curators. From further SSR analysis, the profile was confirmed to contain alleles at 115, 127 and 129 bp – tree 3_27 in the observation plot should be removed.

1995-004 Sack of Sugar

The accession was found to be indistinguishable from 1941-001 Lucombe's Seedling by DArT analysis but no SSR data were available. 1995-004 was noted to not match descriptions of Sack of Sugar by the previous curators. Further SSR analysis finds the profile of 1941-001 to agree – 1995-004 should be deaccessed and the SSR dataset updated.

1995-012 Wax Apple

The accession was found to be indistinguishable from 1947-039 Baker's Delicious by DArT analysis and further analysis of the SSR data confirmed that the two accessions were distinguished by only a single allele (scored as 205 and/or 203bp) for marker CH01f02. Further analysis of the original data revealed that scoring was difficult (and that alleles should possibly both be 204/205 bp) but that either way, the profiles were indistinguishable. 1947-039 is in the main collection and Baker's Delicious has published provenance to being found and introduced in 1932 and is reported to be 'in NFC' in the NAR; Wax Apple has limited published provenance to being described in 1831 – 1995-012 should be deaccessed and allele scores confirmed in further SSR analysis; consideration should perhaps be made as to whether Baker's Delicious could have been a rediscovered Wax Apple although provenance for the accession as Wax Apple was apparently not particularly strong (Bob Lever, pers. comm.).

1994-001 Mrs Wilmot

The accession remained listed in the catalogue but was noted to be missing data in both analyses (and from further checking the tree had been lost in the observation plot) – the catalogue should be amended accordingly.

Matt Ordidge & Penny Hale May 2019