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Corehead Orchard Tree Establishment and Grazing Damage Survey 2013

Report to the Borders Forest Trust
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Introduction

Traditional orchards are a comparatively rare component of Scotland's landscape with estimates suggesting that they covered an area of approximately 250 ha in 2010 (Maddock 2008). Despite their relative scarcity today orchards were once a common part of Scotland's landscape with evidence that fruit production, centred around abbeys and monestaries, dates back to the 5th Century AD (Robertson 2007, Hayes 2010). However changes in the rural economy since the start of the 20th Century, including the decline of rural estates and the loss of traditional estate orchards and walled gardens (Robertson 2007), mean that these landscape features are now increasingly rare. Traditional orchards in England are known to have declined in area by 63% since 1950 (Natural England 2008) whilst a survey of orchards in the Forth Valley in Scotland (Hayes 2010) identified 45 extant traditional orchards but concluded that the majority were neglected and had remained unmanaged for at least the last 50 years. The loss of traditional orchards is closely linked to their declining commercial viability which may have always been precarious (Robertson 2007). In the Clyde Valley of Scotland, for example, problems include: greater overheads than intensive orchards due to high maintenance and harvesting costs, lack of crop reliability, the availability of large quantities of foreign fruit at low prices, lack of a local market and wholesalers' preferences for cost, reliability, appearance and size over fruit flavour (Ironside Farrar 2004). This decline in traditional orchards in Scotland has caused the loss of a staggering diversity of native varieties (Robertson 2007).

Although traditional orchards are a cultural landscape with a history of low-intensity management, a range of studies have demonstrated their biodiversity importance (e.g. Smart & Winnall 2006, Robertson & Wedge 2008, Bailey et al. 2010). This includes their use as habitat for a range of species including important or rare invertebrates (Alexander 2008), specialist plants such as mistletoe (Briggs 2008) and lichens (Henderson 2008). Traditional orchards can also hold a diverse array of local and heirloom fruit varieties which may provide an important potential economic and genetic resource for agriculture in a changing climate. Traditional orchards can thus provide a range of ecosystem services including carbon sequestration in growing trees (e.g. Wu et al. 2012) and a food resource that can be exploited by local communities or commercially. The biodiversity importance and increasing rarity of traditional orchards is recognised within the UK Biodiversity Action Plan (Maddock 2008) where targets include no net loss of orchards up to 2020 and an objective of increasing the cover of traditional orchards by 50% (UK Traditional Orchards Group 2010).

In Scotland the total current and historical extent of traditional orchards remains uncertain though historic maps show they once existed in areas that might today be considered marginal for fruit production. Fruit production in Scotland was, and remains, focused around the Clyde and Forth valleys and Tayside (Robertson 2007). Here recent surveys reveal the extent of the decline: in the Clyde valley tree fruit orchards declined from 308 ha in 1908 to 163 ha in 1963 and possibly as low as 30 ha by 1987 (Jamieson 2001); in Tayside 55% of orchards have been lost and of those remaining little more than a third were in satisfactory condition (Tayside Biodiversity Partnership 2009); in the Forth valley of 45 historic orchards identified and surveyed only 25 had any remaining fruit trees, none were managed commercially, fruit from only very few was actually used by the owners or local communities and the majority were in an unfavourable condition (Hayes 2010).

Given the importance of the ecosystem services provided by traditional orchards there is growing interest amongst communities in establishing or re-establishing these lost landscape elements. Existing research regarding orchard management is strongly centred on their intensive, commercial management. Restoration of, or research on, traditional orchards is most active in the historic fruit-growing regions of theUK in the southern and central England (e.g. Atkinson et al. 2008, Worcestershire Biodiversity

Partnership. 2008, Hertfordshire Orchard Initiative 2010, South Somerset Orchard Project n.d.) and the Scottish lowlands (e.g. Ironside Farrar 2004, Tayside Biodiversity Partnership. 2009, Hayes 2010). Comparatively little work has been documented for more marginal upland locations (such as the Scottish Southern Uplands) and what does exist has mostly been published on-line and in the grey literature. It is notable that at the time of writing, a search for recent habitat actions connected to traditional orchards on the UK Biodiversity Action Reporting System (http://ukbars.defra.gov.uk) reveals 125 "instances" of monitoring or outreach action regarding this habitat; habitat creation on 13 sites and restoration on 64 sites. None of these actions were located in Scotland, northern England or north Wales. Thus, though there is good basic knowledge to inform restoration efforts (e.g. Natural England 2010) little quantitative evidence from the field exists.

Community groups and organisations attempting ecological restoration projects of any kind often have limited resources with which to work and there is thus an urgent need to document and assess the success of existing practices. The establishment of fruit trees in remote, upland areas faces a number of challenges not least from a more marginal climate and the potential for damage to trees from exposure to strong winds, cold temperatures and grazing damage from wild deer and domestic stock. We also have comparatively little information on the establishment different fruit species and varieties in these conditions or on how planting and subsequent management affects their performance. Some of these issues can be managed to an extent by, for example, staking saplings, utilising tree guards and erecting stock and/or deer fencing but trade-offs are likely to exist with regards to the financial and labour costs associated with different management regimes.

Methods

Site description

Research was completed at a site on Corehead Farm near Moffat in the Southern Uplands of south-west Scotland (Latitude 55.4008° N, Longitude-3.4802° W; elevation 200 m a.s.l.). Locally rainfall averages 1635 mm/year with average annual maximum and minimum temperatures of 11.0 °C and 3.6 °C respectively (Adair 2009). The site was formerly a traditional upland hill farm but current management aims to maintain upland sheep farming on half of the property whilst the majority of the rest is part of a project to restore native woodland. Areas of lower ground are managed for a range of conservation and community engagement objectives and this has included the establishment of two small orchards each of ca. 180 apple and/or plum trees. Soils at the orchard site location are brown earths and pre-planting vegetation was classified as *Lolium perenne - Cynosurus cristatus*, NVC community MG6 (Rodwell 1992), grassland (Adair 2009). Soils vary from blanket peat on high plateaus, peaty podzols on gentler slopes and around the shoulders of hills, freely draining brown earths on steep slopes, imperfectly drained brown earths on lower, gentler slopes and level ground through to gleyed profiles in hollows and ill drained stretches of level ground.

Planting design

The varieties planted were selected on the basis of their hardiness, availability and with a bias towards traditional varieties thought to be suitable for Scotland or northern England (Table 1, Appendix I). Trees were planted during spring 2012 in mono-varietal blocks of five individual plants with a spacing of approximately 3 m between trees within blocks and ca. 8 m between blocks (Appendix II). The placement of blocks within each orchard was random. All trees were planted unstaked, with a plastic mulch mat and protected by only a short (ca. 5 cm) vole guard to prevent damage from small mamalls. The planting areas were protected from grazing by domestic stock but initially were not protected from deer grazing. A deer fence was however erected around one of the orchards during February 2013.

At the end of April and following all first year monitoring (see below) the blocks of trees for each variety were assigned to either a prune or no-prune treatment (see Appendix III). No prune trees will be left to follow natural patterns of growth with no intervention except to, for example, remove diseased shoots and to cut-back any main stems that were killed by grazing. Pruned trees will be managed following traditional practice for the variety's fruiting pattern (Table 1) in order to create half-standard sized trees with an open "bush" structure.

Monitoring

Individual trees were georeferenced and assigned a unique identification code based on their block number and variety. All trees were monitored between October 2012 and April 2013 prior to the start of the second growing season. Trees were surveyed to provide a baseline for subsequent analysis of growth and performance. The following variables were recorded: maximum stem length (to tip of leader); number of side shoots, number of side shoots showing evidence of being browsed, the % of the stem circumference subjected to bark damage (stripping or fraying by deer), the maximum height of any bark damage and whether the tree showed signs of being windblown (standing with main stem at an angle > 20° off vertical or with a prominent hole at based caused by continuous post-planting movement).

Statistical analysis

Box plots were used to describe patterns in key variables between and within each of the varieties. Correlations between the variables we recorded were examined graphically. Analysis to date has been purely descriptive and no statistical tests have been completed to, for example, examine the signficance of differences between varieties. It is anticipated thar future analyses will be able to use General Linear Models to examine the effect of site (orchard – upper or lower), variety, grazing damage and pruning treatment on growth rates and fruit yield (number and mass).

Results

We recorded details on morphology and grazing damage for 181 individual trees. There was substantial variation in tree size between varieties (Figure 1). For the apples, Discovery, James Grieve, John Downie, Red Windsor and Sunset were comparatively small. Victoria plums were noticeably larger than Opal and Blue Tit varieties. Within varieties most stock were of a fairly consistent size though it was noticeable that the apples Arthur Turner, James Grieve and Orleans Reinette showed quite considerable variation. A number of very small outliers were recorded, these were sometimes caused by the main stem having been killed and the tree producing new shoots from the base. Wind-blow was a substantial issue with 31% of the trees surveyed affected to some degree.

Tree morphology differed between varieties (Figure 2). Most apple varieites had a fairly consistent, relatively sall number of branches though the varieties Fortune, James Grieve, Red Windsor and Sunset had, on average, roughly three times the number of the others. For the plums Opal was noticeably less branched than Blue tit or Victoria. Across all varieties the number of side branches did not seem to be related to tree size (Figure 3).

Browsing damage was not equal between varieties (Figures 4 and 5) though there was no clear explanation for the patterns observed. Some varieties appeared to be completely untouched whilst others had suffered considerably. Overall 41% of trees showed signs of browsing damage whilst 22% showed signs of bark stripping and/or fraying. Four individuals were completely top-killed by such damage though all were found to have subsequently re-sprouted. The apple Sunset and the plum Opal were the worst affected with regards to the browsing of side shoots with the apples Fortune and James Grieve and the plum Victoria suffering considerable bark damage. Whilst the number of side branches browsed increased with greater branching the proportion of branches browsed was, on average, fairly constant (Figure 3). There was a weak suggestion (Figure 3) that a greater numbers of side branches offered some protection from bark damage though this apparent trend is likely just the result of three outliers that had few branches but very substantial bark damage. Taking just those trees that suffered bark damage, the extent of damage appeared to be signficantly reduced (Pearson's $r = -0.4$,$P = 0.01$) where a greater number of shoots were browsed. The mean maximum height of bark damage was 55 cm (median 52 cm; range 20 cm - 104 cm).

Discussion

These early results were recorded during the trees' first year of establishment and do not yet provide information on variation in varietal/species performance. Although substantial differences in the size and architecture of the trees were recorded this is likely to be a reflection of differences in stock as supplied from the nursery. Further monitoring in future years will however yield useful insghts into how variety, pruning and post-planting stress (due to grazing damage) affect growth and fruit productivity. Monitoring will also record of tree canopy architecture in greater detail (e.g. Costes et al. 2006) as pruning can be expected to affect shoot extension, the growth of both fruiting spurs and vegetative side-branches and to cause differences in growth allocation between fruits, leaves and woody stems. Such recording could include the number and length of primary and secondary branches, the position of fruiting spurs and flowering buds and branching angles. We will also aim to record both the number and yield (fresh mass) of apples produced by each tree.

Significant differences in fruit yield and tree growth between different pruning systems have been documented in commercial orchards (e.g. Robinson & Lakso 1991). Pruning of established trees that allows greater light penetration into the fruiting spur canopy has been shown to improve overall yield (e.g. Kappel & Quamme 1993, Baugher et al. 1994, Wünsche et al. 1996). We expect that in the short-term, pruning may reduce total yield (especially for those varieties that are partial tip-bearers, see Table 1) but will lead to improved fruit quality and yield in the future. Improvements in yield and fruit quality will, however, have to be off-set against the labour costs of maintaing the trees.

The results presented here demonstrate the substantial damage caused by grazing and wind-blow during the first year of the orchard's establishment. A small number of trees were entirely top-killed, and though these have resprouted, for a number it was not easy to discern whether the shoots originated from the rootstock or the grafted variety. Since monitoring was completed the orchard has been protected by a deer fence and the majority of trees should recover from damage. On-going monitoring will reveal whether this has any long-term effects on growth and production. Given that the mean height of damage by bark stripping and fraying was, on-average, 55 cm it may be that protection using tree guards, rather than deer-fencing, would be a more cost-effective strategy for protection in future plantings. The degree of grazing protection needed longer-term will depend to some extent on the manner in which trees are pruned and managed but trade-offs will exist between protecting trees from grazing and ease of maintenance in unfenced areas. Trees grown as standards or half standards will typically have their first lateral branches (and thus fruit-bearing spurs) above the browse line, access to fruit and pruning will however be difficult as such trees grow. Alternative options for pruning such as the central-leader or spindle bush systems, which have shown improved light-penetration and productivity (Wünsche & Lakso 2000) and are typically low-growing and easy to maintain, often have relatively low first laterals that would restrict the use of tree guards potentially exposing the trees to browsing damage. The relationship between tree branching pattern, branch browsing and the extent of bark damage was interesting and deserves further attention. Though there was no discernable pattern in which trees were targetted by deer it did seem that, for those trees where stripping/fraying occurred, bark damage was reduced where greater attention was paid to browsing side shoots. It did not appear that side shoots acted as a physical hindrance to bark stripping as there was no relationship between the number of shoots and

The trees planted to date had been protected from grazing by domestic stock since the orchard was established. Given the potential for on-farm diversification and growing interest regionally in sourcing local food it would be interesting to examine the potential for fruit tree-establishment in nearby fields currently retained as part of the farm's hillsheep management system. Furthermore existing research suggests that extensively managed orchards may help to reduce the effects of habitat fragmentation on remnant woodlands at least for mobile species such as invertebrates (e.g. bailey et al. 2010, Herrmann et al. 2010).. The potential therefore exists to increase tree cover within productive agricultural landscapes to the benefit of areas being managed for forest restoration by increasing their connectivity to other wooded elements within an otherwise agricultural landscape. The potential for orchards or mixed planting of orchards and native trees to develop multiple ecosystem services (e.g. carbon sequestration, economic diversification, community participation, education, biodiversity) through the creation of wood-pasture deserves further research.

A number of recommendations for future management can be made:

- Future planting should aim to ensure that all trees are provided with stakes and guards from the outset
- As a precaution, if trees have to be left unguarded/fenced they should not be pruned to remove side-branches until sufficiently established to resist bark stripping/fraying. This recommendation requires further research.
- Though we have not monitored the upper orchard we expect that it will be worthwhile to protect those trees from grazing using guards
- Structurally, traditional orchards are normally distinguished by the wide spacing (> 8m) of large, mature trees (UK Traditional Orchards Group 2010). Though not requiring action for some time, it may be desirable to consider thinning the current stock once the trees are established and the best performing individuals can be identified.
- Future planting should be designed to better-replicate the spacing and structure of traditional orchards
- Preference should be given to planting Scottish and local varieties. Robertson (2007) provides and exhaustive list and a number he mentions are commercially available. Alternative sources include, for example, the National Fruit Collection, Butterworth Organic Nursery and The Commonwealth Orchard both of which hold a number of traditional Scottish varieties.
- Development of plans for the use of the fruit is recommended, this could include working with organisations aimning to supply local, organic produce (e.g. Lets Eat Local) or providing the harvest to local schools.

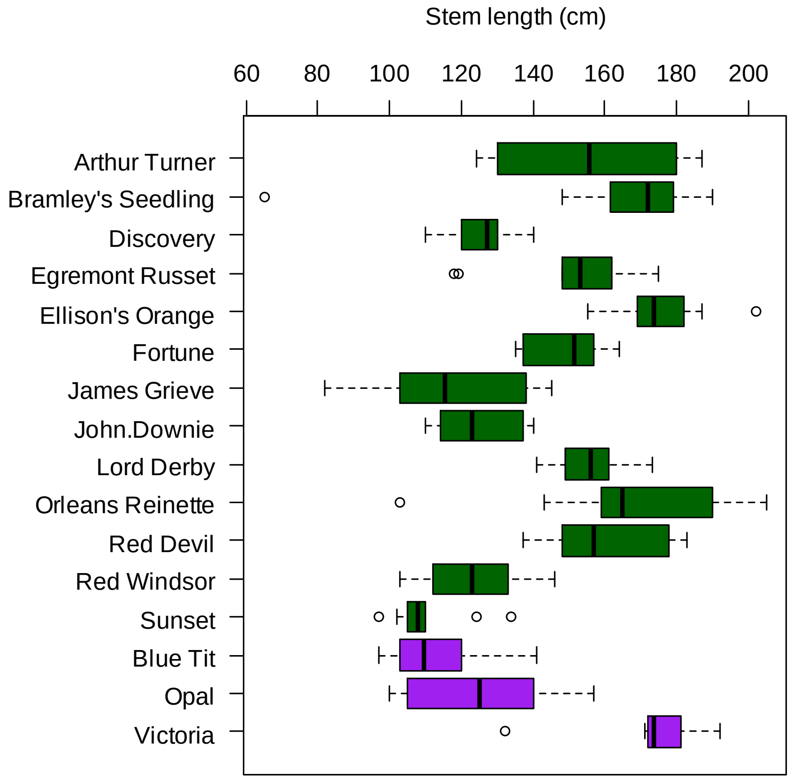

Figure 1: Box plot showing variation in tree stem length within and between 16 fruit tree varieties (apples = green; plums = purple). The boxes show the median (horizontal bar), interquartile range (box), general range of the data (whiskers) and any outliers (circles). Sample size varied between varities (Table 1).

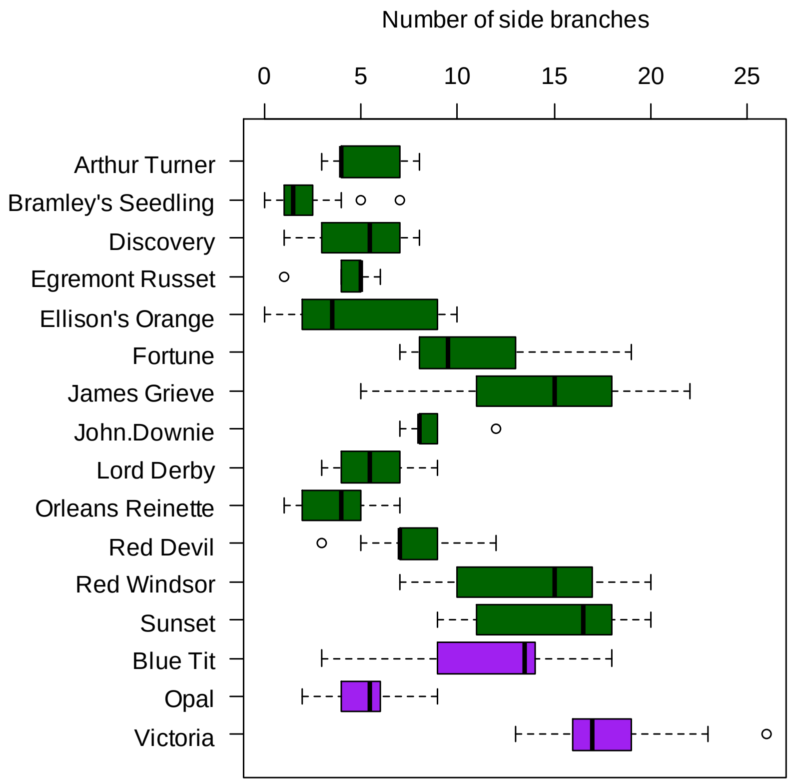

Figure 2: Box plot showing variation in the number of side branches > 2cm for 16 fruit tree varieties (apples = green; plums = purple). The boxes show the median (horizontal bar), interquartile range (box), general range of the data (whiskers) and any outliers (circles). Sample size varied between varities (Table 1).

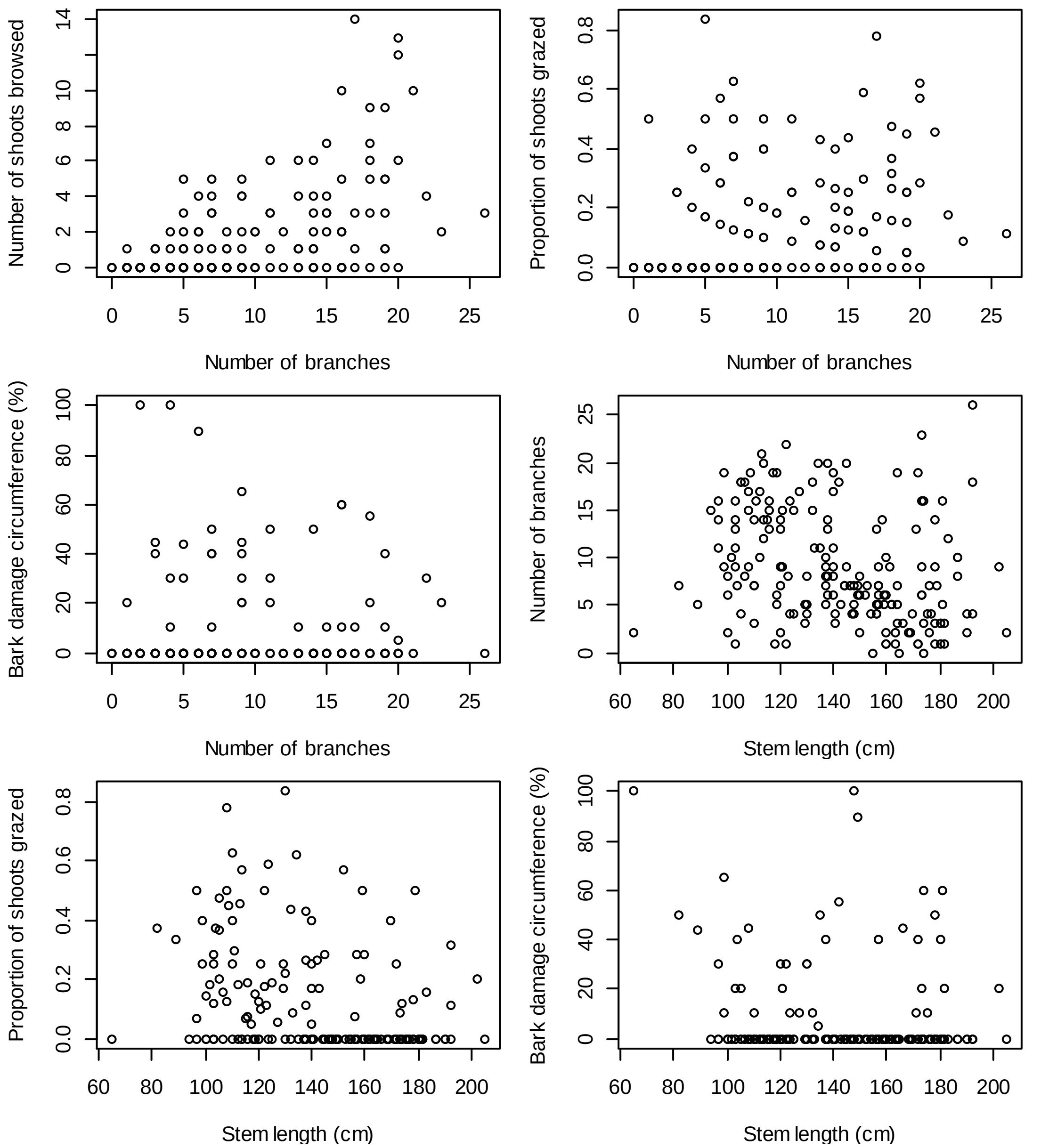

Figure 3: Scatter graphs showing the relationships between tree morphological characteristics (stem length, number of side branches) and the extent of grazing damage suffered (number of shoots browsed, proportion of shoots browsed, extent of bark stripping/fraying). All species and varieties monitored are shown.

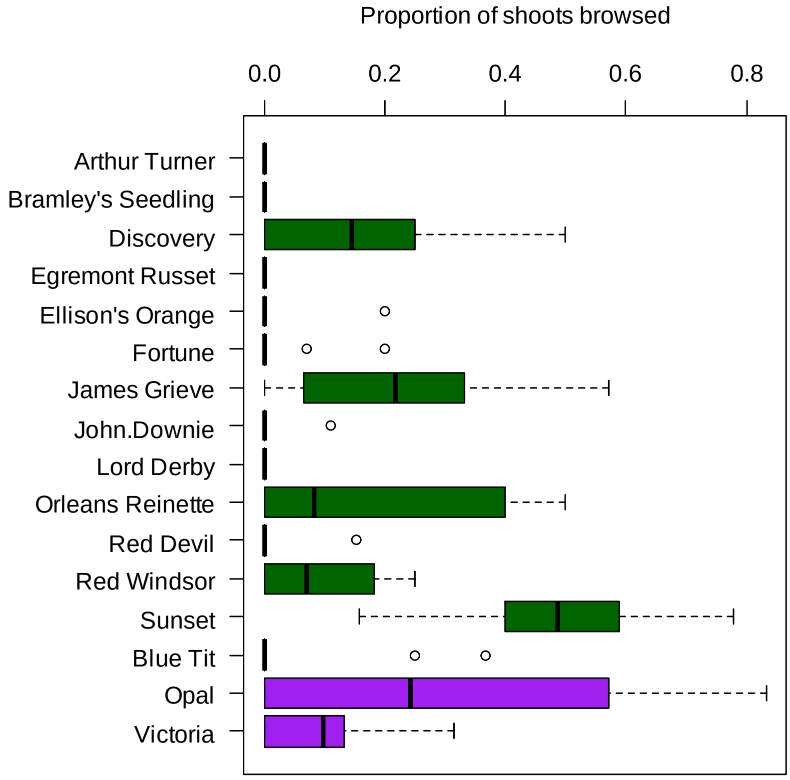

Figure 4: Box plot showing variation in the proportion of side branches showing signs of deer browsing for 16 fruit tree varieties (apples = green; plums = purple). The boxes show the median (horizontal bar), interquartile range (box), general range of the data (whiskers) and any outliers (circles). Sample size varied between varities (Table 1).

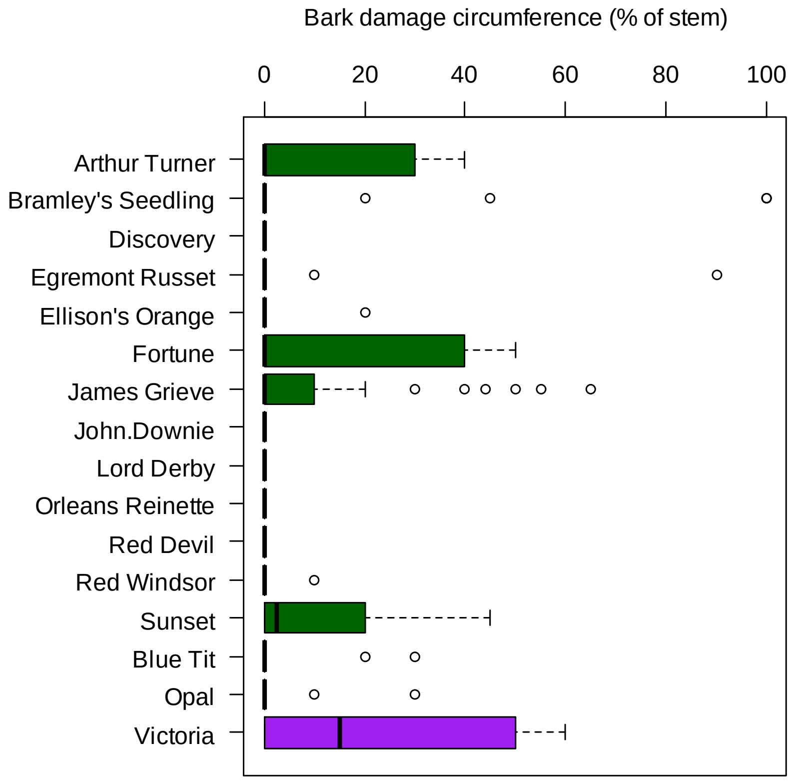

Figure 5: Box plot showing variation in bark damage for 16 fruit tree varieties (apples = green; plums = purple). The boxes show the median (horizontal bar), interquartile range (box), general range of the data (whiskers) and any outliers (circles). Sample size varied between varities (Table 1).

Table 1: Description of the fruit tree varieties planted in the Corehead orchard. Information was from sources in Appendix I.

Species	Variety	Trees/ blocks	Cont/Bare	Rootstock	Hardyness	Ploidy	Flowering	Self Fert?	Year	Origin	Fruiting	Use
Apple	Arthur Turner	5 (1)			H6 (hardy)	Diploid	3	No	1915	UK	Spur	Cooking
	Bramley's seedling	20 (4)			H6 (hardy)	Triploid	3	No	1837	England, Notts.	Partial	Cooking
	Discovery	10 (2)			H6 (hardy)	Diploid	3	No	1900-1949	UK	Partial	Desert
	Egremont Russet	10 (2)			H6 (hardy)	Diploid	2	Partial	1872	England (Sussex?)	Spur	Desert
	Ellison's orange	10 (2)			H6 (hardy)	Diploid	4	Partial	1890	England, Lincs.	Spur	Desert
	*Fortune	10 (2)					3?		1962?	USA?		
	James Grieve	30 (6)			H6 (hardy)	Diploid	3	Partial	1893	Scotland	Spur	Cooking/ Desert
	Lord Derby	10 (2)			Hardy	Diploid	4	No	1850-1899	England, Cheshire	Spur	Cooking
	Orleans Reinette	10 (2)			Moderate	Tripolid	4	No	1770s	France	Spur	Desert
	Red Devil	10 (2)			Hardy	Diploid	3	Yes	1975	England	Spur?	Desert
	Red Windsor	10 (2)			Moderate	Diploid	2	Yes	1985	UK	Spur	Desert
	Sunset	10 (2)			H6 (hardy)	Diploid	3	Yes	1918	England, Kent	Spur	Desert
Crab apple	John Downie	5 + 1? (1)			H4 (hardy)	Diploid	4	Yes	1875	England	Spur	(Cooking)
Plum	Blue Tit	10 (2)			H4 (hardy)	-	4	Yes	1938	England Beds.	Spur	Cooking/ Desert
	Opal	10 (2)			H4 (hardy)	-	3	Yes	1925	Sweden	Spur	Desert
	Victoria	10 (2)			H4 (hardy)	-	3	Yes	1840s	England, Sussex	Spur	Desert

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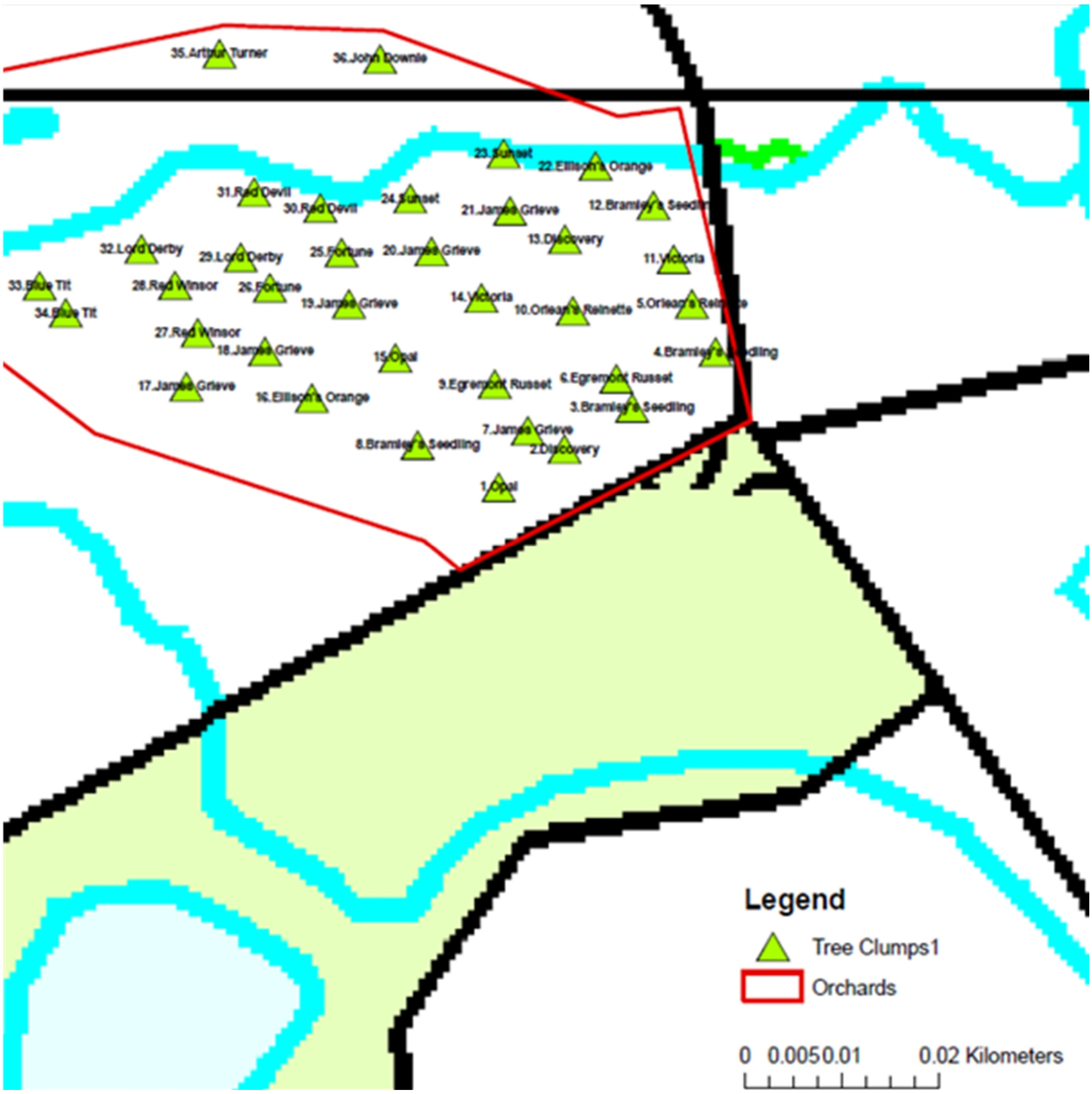
Appendix I

Sources of information on planted varieties

Species	Variety	Links
Apple	Arthur Turner	http://apps.rhs.org.uk/plantselector/plant?plantid=5790 http://www.orangepippin.com/apples/arthur-turner
	Bramley's seedling	http://apps.rhs.org.uk/plantselector/plant?plantid=1239 http://www.orangepippin.com/apples/bramley
	Discovery	http://apps.rhs.org.uk/plantselector/plant?plantid=1240 http://www.orangepippin.com/apples/discovery
	Egremont Russet	http://apps.rhs.org.uk/plantselector/plant?plantid=5978 http://www.orangepippin.com/apples/egremont-russet
	Ellison's orange	http://apps.rhs.org.uk/plantselector/plant?plantid=6082 http://www.orangepippin.com/apples/ellisons-orange
	*Fortune	http://www.orangepippin.com/apples/fortune
	James Grieve	http://apps.rhs.org.uk/plantselector/plant?plantid=5866 http://www.orangepippin.com/apples/james-grieve
	Lord Derby	http://www.orangepippin.com/apples/lord-derby
	Orleans Reinette	http://www.orangepippin.com/apples/orleans-reinette
	Red Devil	http://www.orangepippin.com/apples/red-devil
	Red Windsor	http://www.orangepippin.com/apples/red-windsor
	Sunset	http://apps.rhs.org.uk/plantselector/plant?plantid=1247 http://www.orangepippin.com/apples/sunset
Crab apple	John Downie	http://apps.rhs.org.uk/plantselector/plant?plantid=1251 http://www.orangepippintrees.co.uk/crab-apple-trees/john-downie
Plum	Blue Tit	http://apps.rhs.org.uk/plantselector/plant?plantid=4584 http://www.orangepippin.com/plums/blue-tit
	Opal	http://apps.rhs.org.uk/plantselector/plant?plantid=1534 http://www.orangepippin.com/plums/opal
	Victoria	http://apps.rhs.org.uk/plantselector/plant?plantid=1536 http://www.orangepippin.com/plums/victoria

Appendix II

Streamside Orchard fruit tree plot positions (mapped 22/10/12)



Appendix III

Details of the application of pruning treatments to each plot (C = control, T = treated).

Plot number	Variety	Status
1	Opal	C
2	Discovery	T
3	Bramley's seedling	C
4	Bramley's seedling	T
5	Orleans reinette	T
6	Egremont russet	C
7	James Grieve	T
8	Bramley's seedling	C
9	Egremont russet	T
10	Orleans reinette	C
11	Victoria	C
12	Bramley's seedling	T
13	Discovery	C
14	Victoria	T
15	Opal	T
16	Ellison's orange	C
17	James Grieve	C
18	James Grieve	T
19	James Grieve	C
20	James Grieve	T
21	James Grieve	C
22	Ellison's orange	T
23	Sunset	T
24	Sunset	C
25	Fortune	T
26	Fortune	C
27	Red Windsor	T
28	Red Windsor	C
29	Lord Derby	T
30	Red Devil	C
31	Red Devil	T
32	Lord Derby	C
33	Blue Tit	C
34	Blue Tit	T
35	Arthur Turner	half treated
36	John Downie	2 treated