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Landrace conservation strategy for the United Kingdom

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Summary

During the last 100 years, European agriculture has undergone a sea change. In the early 1900s, agriculture was mainly based on traditional cultivation systems, where most of the inputs and products (including seed) came from the farm itself; now, the many genetically diverse traditional crop varieties (or landraces) that were once grown by European farmers have been largely replaced by fewer genetically uniform commercially bred cultivars, which now dominate agricultural production. The extent of loss of crop genetic diversity associated with the loss of landraces is difficult to quantify accurately, but we do know that both worldwide and in Europe there has been a massive loss of named landrace varieties that is thought to equate to a significant loss of crop genetic diversity. This erosion of an agrobiodiversity resource that may be critical for future food security has been recognized in a number of international legal instruments, including the Convention on Biological Diversity and the International Treaty on Plant Genetic Resources for Food and Agriculture. As a signatory to these treaties, the UK has an obligation to take steps to secure the full range of its plant genetic resources for food and agriculture, including the diversity of UK landraces.

An initial scoping exercises for UK crop landraces indicated that there remains a significant wealth of landrace diversity in the UK but that it is often highly geographically localized and critically threatened with extinction. There the present review focused primarily on landrace diversity in the UK cereal, vegetable and forage crops and current knowledge of *in situ* landrace maintenance throughout the UK is limited—hence the need for research in this area and the production of a corresponding inventory and conservation strategy. The inventory is needed to provide the baseline data to a) identify conservation needs, b) enact the systematic conservation of landraces *in situ* and *ex situ*, c) monitor change (including the assessment of genetic erosion), and d) enhance their use in meeting changing market demands and in promoting UK food security.

Landrace data were collated from a wide range of sources, including existing data sets from four UK seedbanks that are central to the maintenance of landrace diversity *ex situ*, and traditional varieties included in the UK National Lists of Varieties, 'B' List. Other data were collated following media releases and advertisements and by using a questionnaire, internet searches, email correspondence, telephone calls and face to face meetings, capturing a broad range of interest groups, companies and individuals.

Results of analysis of seedbank data do not yet reflect the full range of UK landrace diversity available in *ex situ* collections maintained in the UK, mainly because a proportion of landrace germplasm is not yet recognized in the seedbank information management systems. Nonetheless, the analysis is an important first step in the process of consolidating *ex situ* collections data for inclusion in the UK landrace inventory. 'B' List varieties collectively form another important component of the inventory; there may be challenges in the future in keeping this part of the inventory of *in situ* maintained material updated due to a dependency on data provision by a number of commercial companies who are the official maintainers of a large proportion of the varieties.

The project identified and created an inventory of 67 wheat, barley and oats, 569 English and Welsh vegetables and 7 forage landrace populations. A number of key *in situ* maintainers of UK landrace diversity have been identified and these include commercial seed companies, non-governmental organizations, individual farmers, allotment-holders and home gardeners. Critically, this research has highlighted the fact that while the genetic diversity of our crops may have been impoverished through the loss of many traditional varieties in the past—diversity that is irreplaceable—new variation is currently being created through grower-based breeding. This may be as a result of deliberate or passive variety improvement through repeated cycles of selection and seed-saving or occasionally through accidental or deliberate cross-pollination leading to the production of a new variety. Therefore, while the loss of old varieties and the diversity that has gone with them is of concern, and recognizing that any new variation will not replace what has been lost, it is important

to acknowledge that we may now be in a new period of expansion of locally-based crop diversity and therefore need to put in place strategies to capture this diversity and nurture the culture that is responsible for creating and maintaining it.

The study concludes with a number of recommended actions that will be necessary to secure the diversity of UK landraces as an agrobiodiversity resource critical for future food security, as well as a vital component of our biodiversity and cultural heritage. In summary these are:

- Establish and maintain a comprehensive inventory of UK landraces;
- Improve and standardize the management of landrace data;
- Establish and maintain a list of landrace maintainers and key contacts;
- Open and maintain dialogue with key groups and individuals;
- Initiate a landrace protection scheme in England and Wales;
- Enhance *ex situ* landrace collections;
- Stimulate landrace use by plant breeders;
- Carry out research into landrace diversity in the context of climate change;
- Educate and raise public awareness of local landrace diversity;
- Review opportunities for supporting landrace cultivation through policy and legislative instruments.

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Contents

1. Introduction

1.1 The importance of landrace diversity for UK agriculture and food security

During the 20th century, European agriculture, like agriculture in other areas of the world, went through a significant change—in the early 1900s, agriculture was mainly based on traditional systems, where most of the inputs and products (including seed) came from the farm itself; now, the genetically variable crop varieties that were once traditionally grown by European farmers have been largely replaced by the many genetically uniform commercially bred cultivars that dominate agricultural production (Negri *et al*., 2009). In the past, farmers would select and save a proportion of seed of their crops at each harvest to sow and cultivate in the next growing season, selecting the seed from the plants that performed best in their local environment and sometimes selecting different types characterized by desirable traits (e.g., different ripening times, particular tastes and winter-hardiness). These cycles of selection were often repeated over many years on the same farm, and resulted in crops that were genetically heterogeneous because of repeated exposure to both natural and human selective pressures. These crops are known as 'landraces', but are sometimes also referred to as 'farmer varieties', or 'local', 'primitive' or 'traditional' varieties. The diversity both within and between landraces was key to food security for generations because it allowed farmers to service a diversity of needs and purposes and to obtain a harvest regardless of adverse weather conditions or pest and disease attacks (Negri *et al*., 2009). However, landraces were (and are) not only maintained by farmers—they have also been important in home gardens, allotments and market gardens, and continue to this day to be widely cultivated, albeit on a relatively small scale.

Landrace diversity is important on a number of levels. Firstly, for farmers (and gardeners) that continue to grow landraces, they are benefitting from the ability to save their own seed (cutting out the cost of buying fresh seed for each new growing season), the security of knowing that the crop is less likely to fail completely through adverse weather conditions or pest and disease attack due to local adaptation and the wide genotypic variation present in the population (yield stability – Frankel, 1977), a wider cropping window, the ability to select for traits that are of interest to them, and potentially, a crop that is unique and may attract a niche market. At a time when we face the threat of a changing climate and the uncertainty that it brings with it, the diversity of landraces is likely to be ever more important as a buffer against crop failures and ultimately as insurance against food insecurity. Secondly, landraces are generally suited to use in low input, sustainable farming systems due to their ability to adapt to marginal conditions, which are often typified by exposed environments, low nutrient soils and disease stress (Harlan, 1992; Frankel *et al.*, 1995; Brown, 1999; Green, 2008); therefore, there are both environmental and cost benefits associated with their cultivation. Thirdly, one of our objectives in conserving landraces is to make the genetic diversity inherent in these varieties more easily available for use by plant breeders. Modern varieties are very uniform (at the expense of diversity), so they will not provide a broad gene pool for future breeding. This presents a paradox: plant breeders developing better and higher yielding varieties unwittingly cause the loss of genetic diversity, but at the same time they are dependent upon the continued availability of a broad gene pool of diverse genetic material for success in their work (IPGRI, 1993; Frankel *et al.*, 1995; Hawkes *et al*., 2000; Green, 2008; Negri *et al*., 2009). As Esquinas-Alcazar (1993) wrote, "*The heterogeneous varieties of the past have been and still are the plant breeder's raw material. They have been a fruitful, sometimes the sole, source of genes for pest and disease resistance, adaptation to difficult environments, and other agricultural traits like the dwarf-type in grains that have contributed to the green revolution in many parts of the world".* While examples of the use or potential use of landraces in crop improvement can be found in the literature (e.g., Shetland cabbage – Crute and Pink, 1989; sorghum – Li and Li, 1998; lupin – Raza *et al*., 2000; pearl millet – Yadav *et al*., 2000; oats – Hammami *et al*., 2007; wheat – He *et al*., 2007; and cassava – Raji *et al*., 2008), the range of published examples does not reflect the true extent of the use of landraces as gene donors because plant breeders do not always publish their findings with specific

reference to the variety used being a landrace as distinct from a modern cultivar[1]. However, Frankel *et al*. (1995) reported that the literature on breeding for resistance to insect pests and diseases is rich with examples of landraces as donors of resistance genes and that the majority of resistance sources used by breeders in the past were undoubtedly landraces or their derivatives. Therefore, landraces are undeniably an important agrobiodiversity resource needed for crop improvement and future food security. Finally, the *in situ* maintenance of landrace diversity goes hand in hand with the maintenance of cultural diversity and is therefore important for keeping our heritage alive.

1.2 The causes and consequences of loss of crop genetic diversity

The extent of loss of crop genetic diversity associated with the loss of landraces is difficult to accurately quantify, but we do know that both worldwide and in Europe there has been a massive loss of named landrace varieties and estimates of genetic erosion within and between landraces (e.g., of maize and rice) have been documented (see Negri *et al*., 2009). In a study of rice landraces in India, Ford-Lloyd *et al*. (2008) found a strong link between the numbers of extant landraces and genetic diversity; therefore, the number of landraces was found to be a clear indicator of genetic diversity health. While we cannot directly correlate the loss of named varieties with the loss of genetic diversity unless results of genetic diversity studies are available to back up this assumption, (particularly when dealing with commercially available varieties that may be marketed under different variety names), we can reasonably assume that when we are dealing with the loss of hundreds of varieties, this is likely to equate to a significant loss of crop genetic diversity.

The primary cause of loss of crop genetic diversity is attributed to the replacement of landraces with modern, high yielding varieties. The modernization of agriculture during the 1900s brought with it the need for uniform, high-yielding crops that could be produced on a large scale, meeting the requirements of mechanical harvesting (e.g., uniform height and cropping date) and handling, as well as the demand from the processing industry for uniformity in size, colour and texture, which are particularly relevant for vegetables. Worldwide, the number of landraces in cultivation has declined not only because of replacement with modern varieties, but also because of the ageing farming population who have historically been the maintainers of landrace diversity on-farm—unfortunately, when these farmers pass on, the landraces that they maintain are often lost (Maxted, 2006). This situation has also been reported in the UK where a compounding factor is that many younger farmers in areas where landraces are grown are working part-time in other jobs (Green, 2008).

For these reasons, it can be argued that landrace diversity is the most threatened element of biodiversity (Maxted, 2006); yet, worldwide, the systematic conservation of landraces has been neglected—indeed, there are no known complete national landrace inventories (Maxted and Scholten, 2007), let alone comprehensive national landrace conservation strategies. This is partly attributable to the fact that landrace conservation falls outside the remit of conventional conservation agencies and the agricultural community has tended to focus its conservation efforts on *ex situ* seedbank maintenance of landraces without taking a systematic approach (Maxted, 2006).

The consequences of the loss of crop genetic diversity, as described by Negri *et al.* (2009), are encapsulated in Box 1.

Box 1. The consequences of the loss of crop genetic diversity

(From Negri *et al*., 2009)

"The first 'modern' [crop] varieties were bred in maize and wheat (in the USA and Italy, respectively) in the early 1900s. Since then, breeding activities have increased, involved other species, and continued to take advantage of the progress made in genetics (see a critical review on the topic in

[1] This may be because a) the material they used in their breeding programme was not distinguished as being of landrace status in the seedbank from which it was sourced, b) they wish to protect their intellectual property rights, or c) they do not see it as necessary or important to make this distinction. However, it is worth noting that the plant breeding community is an important source of knowledge on landrace diversity, since plant breeders and researchers often spend much time talking with farmers and other growers (M. Ambrose, JIC, pers. comm., 2009).

Gepts, 2002). Modern varieties are bred to be genetically uniform (they often are pure lines or F1 hybrids) to maximize production ability under those inputs that make the environment best suited to the crop (irrigation, fertilization, pest control, etc.) as well as to meet the increasing demands of mechanized harvesting and handling, and meet supermarket quality controls. The high yielding modern varieties represent the most spectacular success of genetics applied to agriculture and contributed to alleviate historical rural poverty. From the early 1900s to now, wheat productivity has increased from an average of 1.2 t ha^{-1} to 4 t ha^{-1} in Europe (and over 10 t ha^{-1} have been recorded in some countries) and about half of this increase is estimated to be due to breeding activities (Grigg, 1994). It is also because of their good yielding performances (at least in some agro-ecosystems) that modern varieties substituted the genetically variable, often lower yielding, locally adapted strains or landraces in the fields of farmers. Thus, uniformity replaced diversity, and is still replacing it to this day.

This is alarming for both geneticists and breeders, since lack of diversity severely impairs future improvement of crops and/or the possibility to face new forthcoming production constraints. Breeding for uniformity is an Achilles' heal for the cultivars in that if the disease or pest evolves to overcome the resistance bred into the cultivars, significant production loss results. Famously this battle was lost in the mid-1800s in Ireland. An infection of late potato blight (*Phytophthora infestans*) wiped out the potato crop, which led to the Great Potato Famine of 1845–49, and the starvation and emigration of millions of people. The existing varieties of potato at that time had no resistance to *P. infestans*, which has subsequently been found in several wild potato species—particularly *Solanum demissum* Lindl., from Mexico (Hawkes *et al.*, 2000). If the plant breeder is to maintain the upper hand, he or she must maintain access to as wide a genepool as possible and attempt to avoid detrimental genetic uniformity, which is referred to as 'genetic vulnerability'. This need of the breeder to utilize the broad genepool is essentially a paradox, which may be seen as a fundamental confrontation between conservation and development. Plant breeders developing better and higher yielding varieties unwittingly cause the loss of genetic diversity, while on the other hand these same plant breeders are dependent upon the availability of a broad genepool of diverse genetic material for success in their work. The loss of genetic diversity within crop plants, although not accurately documented, is believed to be extensive and therefore there has been increasing realization of the need to actively conserve the crop genepool.

Besides the obvious practical breeding and conservation consequences of the loss of landrace genetic diversity, scholars of human sciences are also alarmed because of the loss of crop related culture. This culture can be of use not only in breeding activities, but also for developing further culture for the community (see for example Worede *et al.,* 2000; Negri, 2003; Torricelli *et al.,* 2009). The disappearance of landraces not only means local genetic erosion but also 'local cultural erosion'—thus, both biological and cultural evolution is hampered.

Finally, the continued erosion of crop genetic diversity hampers agro-ecosystem functioning and its provision of services (e.g., pest and disease control, pollination, soil processes, biomass cover, carbon sequestration and prevention of soil erosion) (Cardinale *et al.*, 2006; Hajjar *et al*., 2008) as well as potential innovation in sustainable agriculture (Jackson *et al*., 2007)."

In Europe, a further cause of loss of landrace diversity has been attributed to plant variety legislation and seed certification schemes (Negri *et al*., 2009), which are intended to protect growers and consumers to ensure that they are buying seed of a variety that meets the DUS (distinct, uniform and stable) criteria and which has a valid name. For example, in the UK, the National Lists (which came into force in 1970) are lists of varieties of the main agricultural and vegetable species which are eligible for certification and marketing in the UK and in the European Union—the European Commission compiles Common Catalogues of varieties on the National Lists of all EU Member States (see further details, section 1.4.3). According to Negri *et al*. (2009), at European level this legislation has had the unintended consequence of drastically reducing the numbers of cultivars grown because of the costs associated with maintaining varieties on the lists. For example, Velvé (1992) estimated

that 1500 vegetable varieties representing 23 crops were immediately lost due to the requirement to register varieties prior to sale in the European Community. However, in the UK, these costs did not apply to traditional vegetable varieties that were in existence when the UK National Lists were established, and because DUS standards were more liberal for traditional varieties[2], N. Green (SASA, pers. comm., 2009) believes that they are unlikely to have caused the reduction in the number of varieties—rather, he maintains that the reduction was most likely due to a rationalization in the industry and the removal of variety synonyms.

1.3 The global response to crop genetic erosion and national obligations

Globally, it is widely acknowledged that agrobiodiversity is a finite world resource that is being rapidly eroded and lost—the need to conserve agrobiodiversity has been encapsulated in the Convention on Biological Diversity (CBD) (CBD, 1992), the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) (FAO, 2003) and the Global Strategy for Plant Conservation (GSPC) (CBD, 2002a). The objective of the ITPGRFA is the "*conservation and sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of the benefits arising out of their use*". Article 5 states that each Contracting Party shall: "*Survey and inventory plant genetic resources for food and agriculture, taking into account the status and degree of variation in existing populations, including those that are of potential use and, as feasible, assess any threats to them*" … "*Promote or support, as appropriate, farmers and local communities' efforts to manage and conserve on-farm their plant genetic resources for food and agriculture*" (http://www.fao.org/Ag/cgrfa/itpgr.htm). The GSPC includes the global target: *"70 per cent of the genetic diversity of crops and other major socio-economically valuable plant species conserved, and associated indigenous and local knowledge maintained"* by 2010 (http://www.cbd.int/gspc/), while in Europe, the European Plant Conservation Strategy (EPCS) has recently been updated and published as the European Strategy for Plant Conservation 2008–2014 (ESPC) (Plant Europa, 2008) and includes the target "*Prepare a European inventory of traditional, local crop landrace varieties*", which is to be achieved by 2014.

The Conference of the Parties (COP) to the CBD established the 2010 Biodiversity Targets (CBD, 2002b), which draw attention to the need for conservation of the genetic diversity of crops and committed the parties "*to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on earth*", with an explicit target of "*70 per cent of the genetic diversity of crops and other major socio-economically valuable plant species conserved*" (http://www.cbd.int/2010-target/). If this target is considered in conjunction with the first UN Millennium Development Goals (http://www.un.org/millenniumgoals/) of eradicating extreme poverty and hunger, then there is an obvious link between the conservation and use of socio-economically important plant species, commonly referred to as plant genetic resources (PGR)—the "*genetic material of plants which is of value as a resource for the present and future generations of people*" (IPGRI, 1993).

Therefore, those countries that are signatories to both the CBD and the ITPGRFA have an obligation and responsibility for the conservation of their potential or actual agrobiodiversity resources. Furthermore, if the CBD 2010 Biodiversity Target is to be met, along with the requirements of other relevant international, regional and national strategies and legislation, we need to be able to

[2] When traditional varieties were added to the UK National Lists, the DUS criteria were confirmed in growing tests undertaken between 1975 and 1978 and failure was very rare. The standards applied for distinctness allowed similar landrace varieties to be registered as approved maintenances, which were different but not clearly distinct from each other, and allowed them to continue to be marketed. The standards for uniformity were also more liberal as uniformity is assessed in relation to the method of reproduction—high for hybrids and lower for cross-pollinated varieties. (N. Green, SASA, pers. comm., 2009)

produce comprehensive inventories and systematically conserve agrobiodiversity both *ex situ* in seedbanks and *in situ* (on-farm and in home gardens), as well as promoting their use.

1.4 Landrace conservation and use in the UK: current state of the art

1.4.1 *In situ* landrace maintenance

Current knowledge of *in situ* vegetable landrace maintenance throughout the UK is limited—hence the need for research in this area and a corresponding inventory. In a study by Camacho Villa (2003) a few vegetable landraces were highlighted, but the main findings were for cereal and forage crops, while Lever (2006) focused only on landraces in the Shetland Islands. Undoubtedly, many traditional vegetable varieties previously cultivated on a large scale have been abandoned in favour of modern hybrids, probably for the simple reasons that the modern hybrid varieties have been bred to be higher-yielding and more resistant to pests and diseases, to overcome the problems of lack of uniformity of open-pollinated varieties, to meet processor and consumer demand and to be capable of withstanding mechanical handling and transportation; hence, farmers have chosen to convert to cultivation of these varieties to maintain their businesses in a competitive market. Part of this transition may also be due to the inception of the National Lists making it illegal to market unregistered varieties—though how much is attributable to this factor is unknown. Apparently, peas and beans are two of the vegetable crops that have been less affected by the introduction of modern hybrids[3]—many other vegetables, such as Brussels sprouts, cabbage, cauliflower, calabrese, leeks and parsnips are now dominated by modern hybrid varieties (G. Lakin, Church of Bures, pers. comm., 2009). However, while we know that modern hybrid varieties have largely dominated the vegetable production industry over the last 50 years or so, we currently have no real knowledge of how many vegetable landrace varieties are still maintained by farmers, smallholders and market gardeners and how extensive landrace cultivation is throughout the UK.

The most prominent example of an extant vegetable landrace that has been maintained for more than three centuries in the UK is Shetland cabbage (*Brassica oleracea* L.) (Box 2). Because of the length of time that this landrace has been maintained in the same location *in situ*, it is probably unique amongst the vegetables maintained in the UK. Although we are unlikely to unearth a new example of a vegetable landrace like Shetland cabbage, there are likely to be other vegetable landraces that have been maintained in the same location, albeit for a shorter of period time, that we are currently unaware of. What we do know is that many traditional vegetable varieties are still grown on a relatively small scale in home gardens and allotments, so it is likely that in the last few decades there has been a shift in *in situ* vegetable landrace maintenance from large-scale farm production to subsistence use and small-scale local commerce. Traditional varieties have also survived as part of the custom in the UK to grow vegetables for exhibition and competitions.

Box 2. Shetland cabbage: conservation and characterization

(Source: http://www.scottishlandraces.org.uk/cabbage.htm)

"Shetland cabbage, a landrace of unknown origin, has been grown on the Shetland Islands since at least the 17th century (Fenton, 2007). First used as a vegetable, it has also been widely grown as winter feed for cattle and sheep. In the last 30 years however, there has been a very steep decline in the landrace locally known as Shetland cabbage or Shetland kale.

Seed of Shetland cabbage is not sold commercially[4] and the survival of this, and other, landraces is entirely dependent on farm saved seed from cabbage growers. Community Action plans, such as that for Yell (Grey, 2003) have advocated support for Shetland cabbage.

[3] According to N. Green (SASA, pers. comm., 2009), it was not economic to sell hybrids of peas and beans and sources of male sterility are rare.

[4] Although seed is not sold commercially, plants from two local sources can be purchased at local garden centres in Tingwall and Lerwick (Lever, 2007). These are grown under glass and it has been argued that this has resulted in selecting against the variety's tolerance to cold and windy conditions (Lever, 2007). This presents a problem in terms of continued *in*

Its life cycle has been well documented (Fenton 1978; Anderson 2001). Traditionally, plantie crubs, small circular stone-walled enclosures, were used for raising cabbage seedlings (Anderson, 2001), which were then transplanted into larger kale yards, also often with stone walls. Many of these structures have now been abandoned or are used for other purposes, but can be seen all over the islands.

Shetland cabbage seed was collected in the 1980s and deposited at the vegetable genebank at Warwick HRI in Wellesbourne. Accessions were screened for Clubroot (*Plasmodiophora brassicae*) resistance and plants were selected for having specific race resistance (Crute and Pink, 1989). Seed, collected from 17 growers from different parts of Shetland, is now conserved at SASA in Edinburgh. Of the 25 accessions stored, 23 qualified for participation in the Scottish Landrace Protection Scheme and 22 of these have been given consent for general distribution by donors. Characterization of 13 accessions, collected on the Shetland mainland and the islands of Foula, Yell and Whalsay in 2006 (Lever, 2006; Scholten *et al*., 2008), started at SASA in 2007. Visual assessment and preliminary analysis of field-grown material shows wide morphological variation within and between accessions for traits such as foliage colour, head formation, head density and powdery mildew resistance. An overview of this work can also be seen on the European Cooperative Programme for Plant Genetic Resources (ECPGR) *In Situ* and On-farm Conservation Network website (http://www.ecpgr.cgiar.org/Networks/Insitu_onfarm/OnfarmTF_intro.htm). Molecular characterization is planned to start in summer 2008 as part of a PhD project."

1.4.2 *Ex situ* landrace conservation

The main UK seedbanks notable for maintaining landrace material are Garden Organic's Heritage Seed Library (HSL), Warwick HRI's Vegetable Genebank (WHRI), Science and Advice for Scottish Agriculture (SASA), The John Innes Centre (JIC) and the Department of Agriculture and Rural Development (DARD) (Northern Ireland). Landraces/traditional varieties are donated to these seedbanks by seed companies and to a lesser extent, individuals—some may also be collected by seedbank staff or researchers and added to the holdings. Most of the collections are safety duplicated. SASA is one of the UK's statutory testing centres for varieties included in the National Lists (see section 1.4.3). The importance of the genetic diversity contained in the traditional varieties available when the National Lists came into existence was recognized and samples were conserved in these collections—varieties which are withdrawn from commerce/the National Lists also continue to be conserved—therefore, the statutory seed collections are an important reservoir containing a wide range of cultivated plant variation (Green, 1997).

The availability of germplasm for distribution and use in research and breeding programmes varies between seedbanks. For example, at SASA, availability depends on the registered and maintenance status of the varieties, as follows (N. Green, SASA, pers. comm., 2009):

- Varieties registered on a National List can be obtained from the official maintainer, but not from SASA.
- Obsolete (i.e., previously registered, but not necessarily traditional varieties) are only available if permission is granted by the last known maintainer or if no objections are raised following advertisement in the Plant Varieties and Seeds Gazette for their release in the public domain.
- Unregistered (donated or collected) accessions and registered varieties for which SASA is an official maintainer are available for *bone fide* use.

The role of the HSL in vegetable diversity conservation is particularly noteworthy since it was established in the 1970s with the sole aim of conserving and making available traditional vegetable varieties in response to the loss of varieties available in commerce following the inception of the National Lists. In 1998, the Henry Doubleday Research Association (HDRA – now Garden Organic)

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situ conservation of Shetland cabbage populations but it is almost impossible to stop the marketing of these plants (N. Green, SASA, pers. comm., 2009).

Seed Search was launched with support from the then Department for Environment, Transport and the Regions (DETR) to gather together as many traditional varieties as possible from growers around the country, secure them in the HSL, record their performance and characteristics, and multiply the seed to make the varieties more widely available to members (Stickland, 2001). The HSL currently maintains around 800 open-pollinated vegetable varieties (http://www.gardenorganic.org.uk/hsl/index.php).

Recently, SASA has initiated the Scottish Landrace Protection Scheme (SLPS) which provides *ex situ* back-up of seed that can be made available to the grower should they need it (Green, 2008; Green *et al*., 2009). This seed is also available for distribution and use if the consent of the donor is given. At present, for vegetables this applies only to Shetland cabbage, for which 26 accessions have been collected. The SLPS may provide a beneficial and workable framework for the conservation and use of other UK crop landraces.

Currently, not all landrace accessions maintained by UK seedbanks are distinguished from modern cultivars or breeding lines in the seedbank database management systems. However, this situation is improving with moves by some seedbank managers to classify accessions according to their biological status (see details regarding progress made within UK seedbanks, section 3.2). However, in addition to good information management, landrace collections also need to be characterized and evaluated to be available for use (Ambrose and Green, 1991). To this end, current activities include the creation of legume crop demonstration plots at the JIC that plant breeders are invited to view in order to assess their potential for use in crop improvement programmes (M. Ambrose, JIC, pers. comm., 2009), characterization of the HSL vegetable collections (in collaboration with The University of Birmingham), and characterization of Shetland cabbage accessions at SASA (http://www.scottishlandraces.org.uk/cabbage.htm) in collaboration with the Scottish Agricultural College (SAC).

1.4.3 The UK National Lists and varieties in seed commerce

UK National Lists are registers of varieties of the main agricultural and vegetable species which are eligible for certification and marketing in the UK. To be added to a National List, a variety must be distinct, uniform and stable (DUS) and, for agricultural crops, have satisfactory value for cultivation and use (VCU). This legal requirement seeks to ensure that no new variety can be marketed unless it is genuinely new and, for agricultural species, an improvement on varieties already being sold. (http://www.fera.defra.gov.uk/plants/plantVarieties/nationalListing/index.cfm) The European Commission compiles Common Catalogues of varieties on the National Lists of EU Member States which are eligible for certification and marketing throughout the EU (Defra, 2005).

The National Lists are published in periodic special editions of the UK Plant Varieties and Seeds Gazettes (see http://www.fera.defra.gov.uk/plants/publications/gazette.cfm). Section A lists varieties of agricultural plant species and section B lists varieties of vegetable plant species. Some species fall into both sections; for example, within *Beta vulgaris* L., sugar beet, fodder beet and mangels are treated as agricultural crops (section A), while beetroot is treated as a vegetable crop (section B). Similarly, within *Pisum sativum* L., field pea is included in section A, while wrinkled pea, round pea and sugar pea are included in section B; within *Vicia faba* L., field bean in included in section A, while broad bean in included in section B; within *Brassica oleracea*, fodder kale is included in section A, while Brussels sprout, cabbage, cauliflower and curly kale are included in section B. Potatoes, swede, rape and some kales are classed as agricultural crops and are therefore included in section A only. Some vegetables are not included in the National Lists (e.g., broccoli, chives, sweetcorn and rhubarb)—the UK applied for an exemption to the legislation for these and some other crops on the grounds that there is no breeding in the UK and therefore not much seed sold (N. Green, SASA, pers. comm., 2009).

Section B comprises two lists—A and B. Seed of varieties in list A may be certified as either 'basic' or 'certified seed' or controlled as 'standard seed', while seed of varieties in list B may be controlled as 'standard seed' only (Fera Plant Varieties and Seeds Office, 2009). List B is the section of the National

Lists that deals with the marketing of older varieties and is known as the Vegetable 'B' List (http://www.fera.defra.gov.uk/plants/plantVarieties/nationalListing/index.cfm). The Vegetable 'B' List mainly comprises varieties that were in commerce before the inception of the Nationals Lists of Vegetable Varieties in 1973, although some varieties were added at later dates (in these cases, the dates of their additions are shown in the published lists). While the 'B' List includes some hybrid varieties (indicated in the published list), the majority of varieties are of landrace origin or can be classed as traditional varieties. 'B' List varieties known prior to the creation of the National Lists were not subject to formal DUS testing and no fees are payable by maintainers to keep their varieties on the 'B' List.

The National List Regulations require that a variety on a National List is maintained by at least one person or company who can maintain the variety according to accepted practices (Defra, 2005). Maintainers can give notice that they no longer wish to maintain a variety at any time and this information is published in the Gazette. If they are the sole maintainer, a notice inviting applications from anyone who wishes to maintain the variety is published in the Gazette. If no applications are received to maintain the variety within a specified period, the policy is that the variety will be deleted from the list; however, in the past, if the only maintainer of a 'B' List vegetable variety gave notice that they no longer wished to maintain the variety then it was not automatically removed from the list—the variety remained on the list without an official maintainer. This meant that commercially obsolete vegetable varieties continued to be published in the National Lists, but that seed was not available. However, the 'B' List recently underwent a major review which in 2007 led to 19 varieties being deleted and a major change in responsibilities regarding the official maintenance of the remaining varieties with SASA taking on the maintenance of a significant proportion (see further details later).

In an analysis comparing the number of vegetable varieties in the National Lists in 1974 and 2003, Scholten *et al*. (2003) reported a decline of more than 50% overall and a corresponding reduction from 56 varieties per crop[5] to 29 in the same time period. The authors noted that the only crops that had not seen a significant reduction in the number of varieties were white cabbage, carrot and onion, while the strongest decline in numbers was found in wrinkled pea, French bean, Brussels sprout and spinach. However, this analysis did not distinguish between hybrid and non-hybrid varieties and included varieties listed on both the 'A' and 'B' Lists of vegetable species. As relatively few 'B' List varieties have been removed from the National Lists in the last 20 years (J. Edgley, Fera, pers. comm., 2009), these reductions were presumably earlier or mainly attributable to the 'A' List. However, the National Lists alone are not a true indicator of vegetable crop varieties that may be available and we currently have no reliable way of assessing the number of vegetable landraces/traditional varieties that are still available in the market. For example, J. Edgley (Fera, pers. comm., 2009) reported that seeds of around 1000 unregistered vegetable varieties are available in the UK from companies only supplying small seed packets for the amateur gardening market[6], while the National Institute of Agricultural Botany (NIAB), with reference to their publication, 'NIAB Veg Finder' (NIAB, 2008) reports that "contrary to perceived wisdom the number of varieties available to gardeners is not shrinking but increasing with 230 extra entries this year" and that "the total list contains over 6000 names of which just over 400 are herbs and the balance vegetable varieties" (http://www.niab.com/shop/publications). The Veg Finder includes both hybrid and non-hybrid varieties[7] and is the result of trawls through 35 garden seed catalogues, including those of some of the key UK seed companies responsible for supplying seed of traditional vegetable

[5] Based on crop vernacular names (i.e., not crop species).

[6] The UK National Authorities are in dialogue with the European Commission and Member States to ensure that while quality assurances are in place, such marketing is exempted from the full requirements of marketing directives as they relate to sales to commercial growers (J. Edgley, Fera, pers. comm., 2009).

[7] Hybrid varieties are flagged in the Veg Finder but without a manual count of the number of hybrid and non-hybrids listed, it is not possible to quote the relative proportions.

varieties (e.g., W. Robinson & Son, Thomas Etty Esq., Demeter Seeds Stormy Hall and Seeds-by-Size). While some of this increase is likely to be due to synonymy (i.e., different companies giving the same varieties different vernacular names), it could also be partly attributable to an increase in demand for traditional varieties by amateur gardeners.

1.5 Project objectives

The purpose of the project is to begin to build a UK landrace inventory as a step towards securing this important agrobiodiversity resource for the benefit of future generations. The aim was to instigate the establishment of an inventory of UK landraces to provide the baseline data needed to a) identify conservation needs, b) enact the systematic conservation of landraces *in situ* and *ex situ*, c) monitor change (including the assessment of genetic erosion), and d) enhance their use in meeting changing market demands and in promoting UK food security.

To a) identify conservation needs and b) enact the systematic conservation of landraces *in situ* and *ex situ*, we not only need an inventory of extant landraces, but details of who is responsible for maintaining them and where. With this knowledge, the PGRFA conservation community can identify and fill gaps in *ex situ* PGR collections and sustain contact with *in situ* landrace maintainers to ensure that if they cease to maintain them in the future, material is passed on to another grower and/or seedbank. Further, we need to understand the socio-economic reasons for the perceived overall decline in landrace maintenance and conversely, why some growers continue to maintain them—information that will be critical to support *in situ* landrace conservation through promotion of their cultivation and use. A landrace database is needed that will provide the means of linking variety names, maintainers and sites together, which will be critical for c) monitoring change over time, including genetic erosion assessment, either utilizing molecular genetic techniques or proxy measures such as landrace distribution and frequency. This information and infrastructure is necessary to monitor change over time—currently, no baseline data are available to achieve this.

To d) enhance landrace use in meeting changing market demands and in promoting UK food security, we need to understand why landrace cultivation has decreased (leading to a loss of landrace diversity and a presumed loss of plant genetic diversity) and conversely, what drives current maintainers to continue to cultivate them. A review of the underlying reasons for landrace loss is needed and the major groups responsible for continued landrace maintenance (as well as of their reasons for doing so) need to be identified, to provide the baseline information required to enhance landrace use.

2. Methodology

A generalized methodology for creating a national landrace inventory has been proposed by Maxted *et al*. (2009). This general approach was used to guide the development of the UK landrace inventory. Other studies of UK landraces have also informed the current project (see Camacho Villa, 2003; Scholten *et al*., 2003; Lever, 2006; Kell *et al*., 2009). Systematic inventorying of landraces is not straightforward; however, a general model for a systematic approach is needed to continue to build the UK landrace inventory in as efficient a way as possible and to undertake periodic reviews. Such a model may also serve as a useful benchmark for other European countries.

The approach used for the creation of the landrace inventory is detailed below under the following headings:

- Experts' meeting
- Scope of the inventory—defining 'landrace'
- Designing the landrace database: descriptors and structure
- Strategy for accessing landrace information
    - Accessing existing data: 'B' List and seedbank records
    - Accessing novel landrace data

2.1 Experts' meeting

An experts' meeting, primarily involving key members of the UK PGR Group was convened to discuss the general project strategy and to share existing knowledge of how to obtain information on UK landraces, how to make contact with landrace maintainers, and a possible strategy for obtaining germplasm samples for *ex situ* conservation.

The specific objectives of the meeting were to:

1. Provide an introduction to the project and discuss the proposed project strategy, including the following specific objectives:
    a. Review official government documentation and scientific/popular literature
    b. Review NGO and commercial company knowledge and holdings of landrace diversity
    c. Review *ex situ* seedbank holdings of landraces
    d. Discuss landrace diversity with landrace maintainers.
2. Share knowledge of how to achieve each of the above objectives (e.g., specific contacts, literature sources, government documents, relevant NGOs, commercial companies and seedbanks).
3. Discuss a procedure for obtaining germplasm samples for *ex situ* conservation and outline a strategy for ensuring sufficient material is duplicated in the appropriate seedbanks.
4. Provide examples of existing successful on farm landrace conservation projects in the UK (or elsewhere) that can be used for reference purposes when formulating conservation recommendations for other landraces.
5. Provide examples of the use of landrace germplasm in formal crop improvement programmes that can be used for reference purposes in the final report to Defra.
6. Discuss improvements to the UK's Information Portal on Genetic Resources for Food and Agriculture.

The experts' meeting was attended by ten participants representing the University of Birmingham, WHRI, the HSL, SASA, the JIC and the Institute of Biological, Environmental and Rural Sciences (IBERS).

A full report of this meeting is available on request.

2.2 Scope of the inventory—defining 'landrace'

The issue of how to define a landrace was discussed at the experts' meeting and it was agreed that keeping an open definition from the outset was desirable in order to capture as full a range of traditional varieties in the inventory as possible. Furthermore, there is not always a clear defining line between a 'landrace' *sensu stricto* and a 'traditional variety' or 'old variety', nor between crops grown on a subsistence basis or on a small scale for local commerce or seed production. The defining characteristics of a landrace have been proposed by Camacho Villa *et al*. (2006); a landrace should have some of these characteristics but not necessarily all of them:

- Historical origin
- High genetic diversity
- Local genetic adaptation
- Recognizable identity
- Lack of formal genetic improvement
- Associated with traditional farming systems

A further characteristic of landraces that could be added to this list is that a landrace is "associated with the traditional uses, knowledge, habits, dialects, and celebrations of the people who developed and continue to grow it" (Negri, 2007).

Terms to classify different 'types' of landraces in the database are proposed as follows:

- **Primary landrace**: a crop that has developed its unique characteristics through *in situ* grower selection and that has never been subjected to formal plant breeding[8]; primary landraces can further be divided into autochthonous and allochthonous types:
  - **Autochthonous landrace**: a crop that is grown in the original location where it developed its unique characteristics through grower selection; its genetic and socio-economic characteristics are associated specifically with this location.
  - **Allochthonous landrace**: a crop that has developed its unique characteristics in a specific location through grower selection but has subsequently been transferred to another location for continued cultivation.
- **Secondary landrace**: a crop that has been developed in the formal plant breeding sector but which is now maintained through *in situ* grower selection and seed saving.

The inclusion of varieties that have been introduced to the UK was also debated at the experts' meeting and it was agreed that differentiating between varieties developed in the UK and those imported from other countries would be difficult. Furthermore, some varieties that are grown in the UK are known to have as many as twelve different vernacular names and are therefore important from a socio-economic perspective; therefore, if a variety is grown in the UK it can be included in the inventory, regardless of its origin. In this context, knowing the history of a crop is important in order to trace its origins and movements. For example, the pea landrace 'Glory of Devon' is reported to have been a popular main-crop variety in the West Country more than 100 years ago and to have won an award in 1899 from the RHS (Royal Horticultural Society). It was produced by Veitch's nursery which later moved from Devon to London. It is not known when the variety ceased to be cultivated in the UK but seed had been conserved by the USDA (United States Department of Agriculture) and was repatriated in 1998 by William Woys Weaver from this collection. It is now conserved at and made available by the HSL. (N. Munro, HSL, pers. comm., 2009).

2.3 Designing the landrace database: descriptors and structure

A key objective of this study was the design of a database to manage landrace information. A simple database structure was designed and used for the collation of landrace data by Scholten *et al*. (2003)—the current study provided an opportunity to broaden the scope of this database and propose appropriate data standards for the collation and management of landrace data, with the long-term aim of providing an information system that can continue to be developed and updated as further information becomes available.

It is widely accepted within the PGR conservation and user community that a major factor hindering effective conservation is lack of easy access to data, as well as obstacles to information exchange due to the many different approaches in managing data (Kell *et al*., 2008). The adoption of data collection and information management standards has been achieved to a large degree for the management of *ex situ* collections data using standard data descriptors such as the FAO/IPGRI Multi-crop Passport Descriptors (MCPD) (http://www.bioversityinternational.org/Publications/pubfile.asp?ID_PUB=124); however, these standards do not adequately cater for the full range of data types that are of relevance to landrace maintenance. Significant progress has been made in the development of minimum descriptors for the documentation of on-farm conservation and management activities within the context of the ECPGR *In Situ* and On-farm Conservation Network by the Romanian Genebank and University of Perugia (see http://www.ecpgr.cgiar.org/Networks/Insitu_onfarm/Docs/OnfarmDescr_DRAFT271107.pdf). These descriptors have been designed to record the landrace(s) present on farm, as well as to describe aspects of farm management practices (e.g., agricultural system, cropping management and farm

[8] By 'formal plant breeding', we mean breeding in an institutional context, as opposed to breeding undertaken by independent landrace maintainers.

labour division by gender) (Maggioni and Lipman, 2009). Descriptors to describe the seed supply system, the farmer's criteria for distinguishing landraces, selection criteria, seed storage practices and crop uses, amongst others, are included. This descriptor set is currently under review and the long-term aim is to create a European documentation system for on-farm data (Maggioni and Lipman, 2009). In addition to passport descriptors, the International Plant Genetic Resources Institute (IPGRI – now Bioversity International) and the International Union for the Protection of New Varieties of Plants (UPOV) have published internationally agreed characterization descriptors for crop species; varieties which have been tested for DUS will have official descriptions based on these descriptors (N. Green, SASA, pers. comm., 2009)[9].

With partial reference to the draft minimum descriptors outlined above, a set of descriptors for the management of data associated with the maintenance of UK landrace/traditional variety data were drafted (Annex 1). These require further development, particularly to ensure that existing MCPD data standards are built in to work in harmony with existing seedbank data management systems. However, they provide a comprehensive basis for further discussion and development. While it will not always be possible to obtain data to complete all fields in the database, it is important to start with an information management structure that will cater for the management of detailed landrace data from the outset that can be adapted and refined over time. Critically, the descriptors include provision for recording both site environmental data, which are important for characterization of landraces, and socio-economic data, which are vital for continued maintenance of populations *in situ*.

The UK landrace inventory will be made available via the UK's Information Portal on Genetic Resources for Food and Agriculture (http://grfa.org.uk/). Until a more comprehensive inventory is available, only a subset of the proposed descriptors will initially be made accessible via the Portal and these are likely to be those selected for inclusion in the landrace questionnaire (see section 2.4.2 and Annex 5), which aimed to collate the core data needed to build a meaningful picture of the current state of *in situ* landrace maintenance in the UK.

A database was created to record the novel data collated in this project (Annex 2). This includes the landrace descriptors as shown in Annex 1, although not all the descriptors were recorded in this study. The database is relational and all crop population records are referenced to a landrace maintainer via site locations. Environmental data are described in a separate table for each site recorded, while socio-economic data, cultivation details and conservation status are related to individual crop population records.

2.4 Strategy for accessing landrace information

Information on landraces is available from wide range of sources, but retrieving it presents a number of challenges. Firstly, in existing databases, such as those managed by plant seedbanks, landrace accessions are generally not distinguished from modern varieties, although this issue is now being addressed to some degree (see Section 2.4.1). Secondly, different people have different definitions of landraces, so what is a landrace to one is not to another. Thirdly, the crop variety name can sometimes be used to guide decisions as to whether a variety is a landrace (for example, the name of a landrace is often directly associated with a particular geographic location), but this is not a reliable method because modern varieties can also be given similar names. Furthermore, obtaining information about varieties that people grow for business purposes can be hindered by issues of commercial sensitivity, concerns about the potential legal repercussions associated with national listing of unregistered varieties and insufficient time and resources available to the business to respond. These challenges are not insurmountable but they do demand a carefully considered and tested approach (particularly with regard to obtaining information from commercial enterprises) and

[9] The statutory authorities should be able to supply official descriptions for any variety they have registered or protected (N. Green, SASA, pers. comm., 2009).

a considerable amount of time. These issues will be revisited in Section 4.0, Discussion—here, we review the data sources consulted and how the data were retrieved. Data were collated from various sources, including PGR experts, governmental documents, NGOs, commercial companies, seedbanks, websites, literature, and landrace maintainers. Key sources of information and how they were accessed are outlined below.

2.4.1 Accessing existing data: 'B' List and seedbank records

The National List: 'B' List varieties

The value of including varieties registered on the 'B' List of the United Kingdom National Lists of Varieties of Plant Species (the 'B List) in the UK landrace inventory was discussed at the experts' meeting. It was concluded that inclusion of the 'B' List varieties was important, since these are mainly traditional varieties[10] that pre-date National List Regulations and are therefore scientifically, historically and culturally valuable.

The most recent 'B' List data (February 2009) were provided by SASA in tabular format[11]. These data are published in the public domain in the special editions of the Plant Varieties and Seeds Gazettes (http://www.fera.defra.gov.uk/plants/publications/gazette.cfm) in PDF format. Section B of the Gazettes is the United Kingdom National Lists of Varieties of Vegetable Plant Species (Lists A and B); Section D is the list of maintainers and their contact details.

Accessing historical 'B' List data (i.e., varieties that have been taken off the 'B' List since the inception of the National Lists) is also of interest for this project since many of these varieties may still be grown. Accessing data on their date of registration and withdrawal from National Lists is not so straightforward since records are stored in a variety of different forms (paper, scanned documents, spreadsheets and other databases). In addition, and all the commercially obsolete 'B' List varieties have not yet been coded in the SASA seed collections management system (N. Green, SASA, pers. comm., 2009).

Seedbank data

There are four main seedbanks in the UK with English and Welsh holdings: the HSL, the JIC, SASA and WHRI. In addition, The Department of Agriculture and Rural Development (DARD) (Northern Ireland) maintains some old varieties of potatoes that are not maintained by SASA (S. Carnegie, SASA, pers. comm., 2009). The Scottish Crop Research Institute (SCRI) maintains potatoes but all accessions in their collections are from South America (G. Ramsey and J. Bradshaw, SCRI, pers. comm., 2009). Government funded work on *Brassica* conducted by SCRI was terminated in 1991 and any valuable germplasm was transferred to WHRI (J. Bradshaw, SCRI, pers. comm., 2009).

A common limitation of seedbank collections data is that it is not always straightforward to distinguish between landraces and modern cultivars for all records. For example, at WHRI some landraces may have been automatically classified as modern varieties simply because they have been donated by a seed company; however, WHRI has to date identified a number of varieties in their collections that are landraces and may be able to identify further landraces from codes for donors that pre-date 1975 (D. Astley, WHRI, pers. comm., 2009). SASA are in the process of applying the EURISCO (European Internet Search Catalogue of *Ex Situ* PGR Accessions) sample status codes to their collections[12]; however, only one crop (turnip) has been classified to date (N. Green, SASA, pers. comm., 2009). The JIC maintains some landrace material of peas and faba bean. There is no clear distinction made in the faba bean collection database between synthetic and open-pollinated varieties; however, records of material donated by individuals could be identified and these could

[10] Some early hybrid varieties that were available before the National Lists were set up are included in the 'B' List (G. Campbell, SASA, pers. comm., 2009).
[11] Defra are only able to provide the data in the format in which they are published online in the Plant Varieties and Seeds Gazettes.
[12] For the purposes of classification of the SASA collections, a landrace is considered to be any material that pre-dates the National Lists.

then be included in the landrace inventory since they are likely to be landraces (M. Ambrose, JIC, pers. comm., 2009). It is more likely that there is a greater number of faba bean landraces in the JIC collections than of peas, since faba beans are maintained as mixed populations, whereas peas are highly inbred (M. Ambrose, JIC, pers. comm., 2009). However, despite their self-pollination, there are many old varieties of peas that were maintained as mixed populations (N. Green, SASA, pers. comm., 2009).

Data for inclusion in the landrace inventory were provided by the seedbank managers of the HSL, the JIC, SASA and WHRI and imported into the landrace database for analysis.

2.4.2 Accessing novel landrace data

Varieties listed in the 'B' List and those maintained by seedbanks form two major components of the landrace inventory. However, the biggest challenge lies in obtaining information on other landraces extant in England and Wales that are not in the 'B' List and may not already be conserved in one of the UK's gene banks, as well as detailed information on 'B' List varieties themselves, such as who is growing them, where they are being grown, on what scale, and under what environmental conditions. A number of methods were used to seek out this information, including media releases and advertisements, a questionnaire, internet searches, email correspondence, telephone calls and face to face meetings. Contact was made with a range of individuals, commercial companies and NGOs. These methods are described below.

Media coverage

Press releases were sent to a number of agricultural and horticultural periodicals, as well as to local newspapers in key landrace growing regions, national and regional radio stations, and news agencies. Media releases (see Annex 3) were issued from both project partners (Warwick HRI and the University of Birmingham), working in collaboration to target as many relevant outlets as possible (Table 1). The media release from the University of Birmingham was also transmitted to BBC Radio 4, Radio West Midlands and Radio Scilly. Two BBC Radio 4 programmes identified that may be interested in the story are Farming Today and The Food Programme, while Radio Scilly was targeted because landraces are known to be associated with island communities (e.g., Shetland cabbage, which is thought to have been cultivated on the islands for centuries (Scholten *et al.*, 2008)) and the Isles of Scilly are the largest group of offshore islands in England.

Advertisements (see Annex 4) were placed in three periodicals: Farmers' Weekly, Horticulture Week and The Vegetable Farmer (Table 1). A 'button' advertisement[13] was also placed in The Grower Bulletin published by Horticulture Week—this is a bulletin that growers subscribe to and receive by email.

Questionnaire

A standard questionnaire (Annex 5) was designed and made available to a range of individuals and organizations, including the 'B' List variety maintainers (Annex 6). As the media information advertising the questionnaire was sent to a range of organizations (some of which passed on news of the project and/or questionnaire to their members) and the questionnaire was widely publicized and advertised via the media, it is not possible to provide an accurate sample size; however, the questionnaire was sent directly to 166 recipients and it is estimated that it was made available indirectly to a further 1000 recipients and potentially several thousand individuals through media coverage and advertising.

The questionnaire was designed with the aim of collecting the minimum data needed for the landrace inventory, while at the same time being quick and simple for the respondent to complete. Asking for too much information is likely to be counter-productive; therefore, respondents were asked whether they may be contacted for further information with a view to contacting those that

[13] The advertisement 'flips' between five images, with the final image providing a web link to follow for further information online.

had provided information of interest for the inventory in order to collect a more detailed data set. A paper and online version of the questionnaire were created, giving respondents the option to complete the questionnaire by hand and return it by post, to type responses directly into the document and return it by email, or to complete it online. The online questionnaire was made available via SurveyMonkey.com (http://www.surveymonkey.com/). Questionnaires sent by post and email were accompanied by a cover letter (see sample, Annex 5).

Advice on issues of data protection was sought from Legal Services, University of Birmingham. Certain clauses should be included in a questionnaire of this type in order to meet the requirements of the Data Protection Act 1998. Further, the aims and objectives of the questionnaire must be clear, as well as stating that the survey is voluntary and providing an indication of how long the survey will take to complete. Before circulation, the questionnaire was formally approved by the Defra Survey Control Liaison Unit—this took several weeks following the submission of a survey notification form.

Internet, email, telephone and face to face meetings

The internet was searched extensively for information about traditional varieties and contact was made with a wide range of organizations and individuals by email and telephone. Face to face meetings were also pre-arranged and impromptu interviews conducted at a seed-swap event. Contacts were identified by consulting a previous study on UK landraces (Camacho Villa, 2003), the internet, through expert advice and ideas passed on during the process of the research. A full list of organizations and individuals consulted, along with their contact details is available in the project database maintained by the University of Birmingham[14]. These include contacts that initiated communication after reading about the project in the media.

Table 1. Media outlets in receipt of press releases, indicating those that picked up and ran the story, and outlets used for project advertising.

Media outlet	**Press release** (D = sent directly, A = sent via news agencies, – not applicable)	**Coverage** (E = editorial, I = broadcast interview, – no coverage or not applicable[15])	**Advertisement**
National			
Farmers Weekly	D	–	√
Farmers Guardian	D	–	–
Fresh Produce Journal	D	E	–
The Grower/Horticulture Week	D	–	√
The Grower Bulletin	–	–	√
The Vegetable Farmer	D	E	√
Regional news papers			
Evesham Observer	D	–	–
Evesham Journal	D	–	–
Ormskirk Champion	D	–	–
Ormskirk & Skelmersdale	D	–	–

[14] Access to these data is subject to the Data Protection Act 1998.
[15] No coverage was reported by the press offices.

Advertiser			
Lancashire Evening Post	D	–	–
Lancashire Telegraph	D	–	–
The Citizen (Ormskirk)	D	–	–
The Bolton News	D	–	–
Bury Times	D	–	–
Isle of Thanet Extra	D	–	–
Isle of Thanet Gazette	D	–	–
Bedfordshire on Sunday	D	–	–
Bedfordshire Times & Citizen	D	–	–
Bedfordshire Luton Herald & Post	D	–	–
Luton News	D	–	–
Dunstable Gazette	D	–	–
Biggleswade Chronicle	D	–	–
Marshwood Vale Magazine (Dorset)	D	–	–
Bognor Regis Observer	A	E	–
Buxton Advertiser	A	E	–
Eastbourne Herald	A	E	–
Evening Leader	A	E	–
Gainsborough Standard	A	E	–
Lancaster Guardian	A	E	–
Luton Today	A	E	–
Lynn News	A	E	–
Market Rasen Mail	A	E	–
Milton Keynes Citizen	A	E	–
Wakefield Express	A	E	–
Worksop Guardian	A	E	–
Radio			
BBC Radio West Midlands	D	I	–
BBC Radio 4	D	I	–
Radio Scilly	D	–	–

3. Cereal Inventory

3.1 Background

Historically, only one reference has been found to 'landraces' in UK cereals. Hunter (1952) describes in 'The Barley Crop' two form of indigenous varieties or 'barleys from the country'[16], these were Old Irish and Scotch Common. The latter is described as a very mixed population including two well defined types. Perceval (1934), Beaven (1947) and Findlay (1956) do not refer to 'landraces', however, all three authors describe cereal varieties with characteristics which can be recognised as defining landraces and all three report on landraces survival into the 20th century.

Cultivation of cereals in the UK dates back to the Neolithic Age. From the Iron Age, English archaeological findings included Emmer (*T. dicoccum*), Spelt (*T. spelta*), a barley 'chiefly of the kind known as Bere' (*H. vulgare*) and oats (*A. strigosa* and *A. brevis*) were known (Perceval, 1946). Two types of barley (*H. hexastichum and H. distichum*) and Emmer are known from Stone and Iron Age sites on the Shetlands (Fenton, 1999). Both bere barley and small oat are part of a very old Celtic agricultural heritage (Ernle, 1961; Seebohm, 1927). Neolithic and Iron Age remains of six-rowed barleys were recently found on Orkney (Jarman, 1996).

Formal breeding of wheat, barley and oat commenced in the late eighteenth – early nineteenth century with the selection of single ears (or off-types) Early breeding was the domain of farmers, clergymen, merchants and farm labourers alike and as the century progressed increasingly by professional breeders. For wheat, barley and oat this seems to have been a general, parallel trend. A milestone was achieved in the mid 19th century with the first controlled crosses and in 1851 hybrid wheat was exhibited in London (Paterson, 1925), although attempts at hybridization were undertaken by Knight as early as the 1790's (Lupton, 1992).

All widely grown English wheats of the 19th century were selections from individual ears: Chidham, Fenton, Hunter's White, Browick, Squarehead's Master[17] were descended from 'rogue' plants (Perceval, 1934). Perceval recognized only two types of wheat being cultivated in twentieth century Great Britain: Rivet or Cone (*T. turgidum*) and Bread (*T. vulgare*) (Perceval, 1946). We can therefore assume that none of these earlier wheats as spelt or emmer survived as farmer's material into the 20th century in the UK. Perceval does provide examples of medieval landraces, commenting that by the end of the 18th century almost every market town had its own favourite species and that in the mid-19th century almost a hundred names for wheat varieties were in use. Zeven (1990) believes that based on the information provided by Perceval (1934) we would recognise 25 landraces. Although Perceval did not himself use the term landrace, Schindler's book on landraces appears among his references and he must have been familiar with the concept, he may just have preferred to use the term *Old Form*. Some of these Old Forms are described as mixtures with local adaptation. 'Old Welsh Wheat' is for example described as a mixture of many varieties and being adapted to the damp climate of Wales (Perceval, 1946).

The extent of survival of wheat landraces and their selections into the 20th century is discussed in Perceval (1934): of the 51 contemporary popular varieties listed for Wheat in Great Britain, 25 can be regarded as landraces, 26 as cultivars (Zeven, 1990). The relative popularity of some historical wheat landraces (i.e. Rivet) had dropped to less than 3% in the 1920's (Wellington and Silvey, 1997). The rivet landraces were still cultivated early 20th century but gradually replaced (Letts, 2000). Long-straw wheat was gradually replaced by high yielding dwarf varieties, less prone to lodging. Nevertheless, Squarehead's Master survived more than 30 years after 1923, Rivet 17 years (Srinivasan, 2003).

[16] With an explicit reference to the German 'Landgersten' in Atterberg

[17] The position of Squarehead is ambiguous. Perceval states that its origins are obscure. Zeven lists it as a cultivar in his analysis of British wheats, but treats it as a landrace in his catalogue of Dutch landraces and old cultivars (Zeven 1990).

Squarehead's Master or Red Standard or Standard Red were still the most widely grown wheats as Perceval was writing 'Wheat in Great Britain' (first edition 1934, second 1948):

> *"Most farmers and seedsmen assume that these are all alike and do not hesitate to sell the same wheat under either name."*

However, "a comprehensive study of crops from a great many parts of the country has revealed certain differences in the wheats" and although the constancy of these traits was not clear, Perceval grouped Squarehead's Master in two groups. The Squarehead's Masters 13/4 is described separately, as a single ear selection from a collection of commercial stocks at the Plant Breeding Institute.

From Beaven's monograph on British barley, two varieties stand out as landraces in his listing of barley varieties before 1914: Scotch Common and Archer. Both are described as composed of a large number of mixed races, the former being common in Scotland, the latter 'probably the old English common narrow-eared barley of the country, and as generally met with is composed of a large number of slightly differing races and is therefore not uniform in quality' (Beaven, 1947, p. 91). Besides these, Plumage is listed as an old land variety (Lupton, 1987).

Bere barley is in the older literature often classified as four-rowed barley. McConnell (1904) describes four types of these: common bere, Black 4-row, Victoria and Winter White Bere. Apparently only the common bere survives today. Neither Beaven nor Hunter mention bere as a distinct variety or old form, the reason being that they both use 'bere' as a general term for a six-rowed barley (*H. vulgare*), classified under *Hordeum polystichum*. All other barleys, the two landraces Old Irish and Scotch Common included, listed by Hunter are of the *H. distichum* type: two-rowed barleys.

> *In Scotland, where both winter and spring sorts are cultivated, barleys of the vulgare type are known as 'Bere' or 'Big', words most probably derived from 'byg', the Scandinavian word for barley. It is also cultivated as a spring crop in upland soils in Wales where it is known as Haidd Garw, literally 'coarse barley'.*
>
> *At times, forms of vulgare produce malting barley of fair quality, but they are most commonly grown and the grain utilised for stock-feeding.* (Hunter 1952: page 52)

Peachy (1951) describes bere (commercial 6 row) as 'an old commercial six-row barley which has been reselected by many people, including W. Findlay Esq. of the North of Scotland Agricultural College. It is a very old Scottish variety, grown more in the North of Scotland then elsewhere. Here, the name appears as a variety name. Summarising, bere has been referred to as a generic term, as a type and as a commercial variety. Jarman (1996) points out that Perceval used 'bere' in the first, generic way: he labelled a six-row barley ear as 'Winter bere' and another with black pigmented lemmas and paleas as 'Black bere'.

Bere barley seems never to have been part of breeding programs. Hence Jarman's conclusion that bere barley described by Fitzherbert is probably the same today and that its origin may be in the Scandinavian invaders of the 8th century (Jarman, 1996). However, although bere may not have undergone formal breeding, Peachy (1951) refers to many selections having taken place. The degree of relationship of today's bere and medieval or pre-historic bere still has to be established.

While for oat, Findlay (1956) states that before 1800 probably all stocks were mixtures of several varieties and few had specific names. Earliest classifications of oats before 1800 have only three types of oat for Scotland: White, Black and Grey, covering the hexaploid *Avena sativa* and the diploid *Avena strigosa* (Gaelic: *Corc baeg*). *Avena strigosa* Schreb. is an annual diploid oat including both wild and cultivated forms. It is thought to be native to the North Atlantic area (Baum, 1977). Cultivated forms include *A. brevis* Roth, *A. nuda* L. and A. *hispanica* Ard. (Ladizinsky, 1989; Leggett, 1992). These forms are inter-fertile, but crosses with the hexaploid *A. sativa* are difficult. Marquand (1922) describes three subspecies within *A. strigosa*: subspecies *pilosa* is the variety cultivated in Wales under the name Ceirch Llwyd, the subspecies *glabrescens* of which the var. *cambrica* is 'the predominant variety of the mixed aggregate cultivated in Wales' and thirdly the subspecies *orcadensis*, cultivated in some parts of Scotland, particularly Orkney and Shetlands, 'sometimes known as the 'small oat'' with three varieties dependent on the colour of the grain.

Most of the oats grown in Great Britain and Ireland until the 17th century was small oat (Findlay, 1956) but at the end of the 18th century the Small or Grey oat cultivation was almost entirely restricted to some of the poor soils on the higher grounds in central Scotland, to Orkney and Shetlands and the islands of the west coast (Findlay, 1956). The seed production of this diploid oat was very poor, sometimes not even two to three times the amount of seed (Findlay 1956). *Avena strigosa* was used for human food, horse and cattle feed, the straw for furniture, thatch and basketry. Hexaploid oat landraces called Black, White and Grey Winter and Black Tartar survived into the first half of the 20th century as testified by NIAB statistics (Wellington and Silvey, 1997).

Barley oats, Black Tartarian[18], Murkle, Potato oat and Sandy were important pre-1900 varieties that were still grown until the 20th century. Black Tartarian is taxonomically *A. orientalis* and represents a 17th century introduction from Eastern Europe. Potato oat was discovered in 1788 and was probably a natural line from Essex. It was the most widely grown oat for a century in Scotland, started as a pure line but degenerated. Many pre-1900 farmers' oat varieties however were short-lived (Findlay, 1956). Eighty to ninety percent of 19th century barley grown was Chevalier, a single ear selection. However, there were several types of Chevalier as it was not genetically uniform (Ridout, 2001). Other widely grown varieties were Goldthorpe, a single ear selection from Chevalier and Spratt-Archer, a cross from Irish Archer with Spratt, and Plumage Archer, a cross between Plumage and Archer. Unlike the other major cereals, formal breeding for *A. strigosa* did not start until the early 20th century. Selections were developed in the 1920's and grown in Wales: Ceirch Llwyd and S. 171 or Ceirch Llwyd cwta, a cross between *A. brevis* and *A. strigosa*. The latter cultivar was trialed on some of the Western Isles (Findlay, 1956). Findlay also mentions the Scottish Plant Breeding Station attempts to produce higher yielding varieties for the Western Isles. The most recent oat breeding trials for the western Isles were probably carried out in 1974 –1975 but were not followed up (Cameron and Phillips, 1974; 1975) due to mildew problems (R. Ellis pers. comm.).

Among the surviving oat landraces is *A. strigosa*. Findlay, earlier describing its performance as very poor, describes – with some surprise - its survival into the twentieth century:

> *"Even now (*emphasis authors*) there is as much as 500 to 600 acres grown on these Western Isles and fully that amount in some of the Orkney Islands (Sanday etc) but there is a reason for this. The flat low-lying fields of light soils (called machair lands) are very alkaline, and this is possibly intensified by the large amounts of seaweed which have been applied almost every year for a long time.*
>
> *So far, under these conditions, no varieties have been found that will produce a crop of any kind except this oat. Another feature of this oat is that it stands up to high winds so common in the Western Isles and it is not easily shaken" (page 18)*

Findlay lists in this quotation as many as three reasons for the survival of *Avena strigosa* in the Western Isles, all relating to its adaptation to a range of local growing conditions unfavourable to common oat. A botanical survey on *A. strigosa* in Cardiganshire was undertaken in the early 1990's by Chater (1993). He found it twice in the southwest of the county, in both cases as a crop contaminant (Chater, 1993). He also found the hexaploid cultivars S.220 and S.221 or Maldwyn, first released in the 1940's and both long withdrawn. One farmer still had seed although she had stopped farming in 1980 (Chater, 1993). One farmer grew Supreme until 1985. The naked oats only occurred as casuals.

For rye there is no account of the origin of older varieties before the early 20th century literature. Paterson (1925) lists the chief British varieties in 1925 as a Winter or common rye, Giant rye, Mammoth White rye and the St. John's Day of Midsummer rye, the latter being the only summer rye. He does not give descriptions of their pedigree. Perceval states that 'no well-marked races of rye are

[18] There was evidence in this assessment that Black Tartarian survived into the second half of the 20th century, at least on Islay

met with and the number of constant varieties is small' (Perceval, 1946) and he lists only the St. John's day or Midsummer Rye and Winter Ryes.

Modern UK spring barley varieties have been shown to be largely a subset of 19 landraces and key progenitors (Russell, 2000). The historical importance of some of these landraces and their selections is reflected in the Rothamsted long term trials: one, Chevalier was tested for 28 years from the very start of the Rothamsted experiments, while Archer crosses comprised 70 years of experimental field trials and institutional research interest in Squarehead's Master also spans a remarkable 90 years of field experimentation on Broadbalk. It was grown (selections from it included) and tested in 36 growing seasons[19]. Squarehead's Master survived commercially for 35 - 40 years, measured in terms of acreage shares (Srinivasan *et al*., 2003). Both their extended cultivation and their contribution to the oldest agricultural field trials make these cultivars of global as well as UK agricultural heritage significance.

Letts (2000) gives an overview of cereal types historically used for thatching: the rivet wheats landraces, with solid piths and the improved Rampton Rivet, along with the bread wheat landraces Squarehead's Master, Chidham, Lammas, cultivars Yeoman, Little Joss, N59, Elite Lepeuple, Chalk, Squarehead's Master have been widely used, along with rye and both cultivated and wild oat types. Regional differences in the composition of smoked black thatch suggest different agricultural practices in medieval times: bread wheats were present in all samples from Devon, while Rivet wheat was present in non-Devon samples, however, rye was very common for thatching throughout (Letts, 2000). Maris Widgeon and Maris Huntsman are the most popular among thatchers today, but Letts found older varieties such as Squarehead's Master, Little Joss, N59, Elite Lepeuple and Chalk are still grown on a small scale (Letts, 2000).

Field trials on Chevalier barley have been conducted in order to test its malting quality (Ridout and Thomas 2001). Diversity in bere barley has been studied morphologically and through electrophoresis by Jarman (1996) and an MSc project of the University of Birmingham (Standen, 1994). Jarman investigated ten bere accessions, three from Orkney and Shetland, and the other seven with unknown UK origin, ranging in age from 1932 to 1995. The 1932 accessions originated from the Perceval collection, as part of the NIAB historical reference collection, however, the seeds were no longer viable so could not be multiplied. Jarman compared the bere barley accessions with modern six-rowed varieties and discovered that two accessions on the basis of visual inspection and electrophoresis were not bere barley. He also found a high correspondence between the 1932 and 1995 (Orkney) accessions. Jarman concluded that 'true' bere is a mixture of two morphotypes, identified by the presence or absence of spicules, and that Bere is probably unique among European six-rowed barleys in not having hairs in the ventral furrow of the grain (Jarman, 1996). Standen (1994) studied sixteen bere accessions from the John Innes Centre collection. One was a Tiree-six row, three from Orkney, two from Shetland and the remaining ten did not have geographic passport data but listed the institution of origin (i.e. NIAB, East Craigs, etc). The Tiree accessions were morphological distinct from all the other accessions. Five of the sixteen accessions clustered closely and this group included two of the three Orkney accessions. The Shetland accessions were distinct suggesting regional differentiation between the islands (Standen, 1994). Interestingly neither the Jarman nor Standen studies included bere germplasm from the Outer Hebrides. Bere barley is currently part of a trial on Orkney set up by the University of the Highlands and Islands. Its primary aim is to multiply seed and test beer's potential for human consumption, particularly in traditional whisky production (www.uhi.ac.uk/).

While *Avena strigosa* remains important for its earliness and stress resistance. The relevance of diploid oats for resource-poor environments was demonstrated by Stevens *et al.* (2000). In glasshouse experiments it produced a much larger root mass than traditional (hexaploid) oats, and as

[19] Rothamsted data, kindly made available by Dr. Paul Poulton, Rothamsted

such it may have a role in soil erosion control (Stevens, 2000). Current research on its potential for sustainable agriculture is carried out by the University of Warmia and Mazury in Olsztyn in Poland (Zielinski, pers. comm.). The morphological and isozyme diversity of European and South American *A. strigosa* cultivars has been studied by Podyma (1994) using herbarium and gene bank material. From the UK he included the old WPBS cultivars S.75 and S.171 but no UK landraces were included in his comparative analysis (Podyma, 1994).

UK wheat landraces were collected by Perceval in the 1930s. However, not all the landraces collected by Perceval are currently conserved in the national cereal germplasm collection (Ambrose, pers. comm.). The Watkins wheat collection at the John Innes Centre does not have any of the UK landraces listed by Perceval in 1934 (Miller, pers. comm.), the UK national collecting priority for wheat germplasm was primarily oriented towards collection in the centre of diversity for wheat, for a summary of current UK landrace holdings see Table 2.

Table 2. British land varieties in the BBSRC cereal germplasm collection (Ambrose pers. comm.).

Cereal	UK Provenance			Total landraces
	England	Wales	Scotland	
Wheat	4	1	0	1047
Barley	20	16	8	166
Oat	6	3	14	80

The relative under-representation of UK wheat landraces in *ex situ* conservation is likely to act as a bottleneck for their potential re-introduction. However, examples of reintroduction of landraces are known from the thatching straw industry (Camacho Villa, 2003). Bere barley and Murkle oat have recently been sourced from the BBSRC cereal germplasm collection for re-introduction (Martin, pers. comm.)

Oat and barley are relatively better represented by UK landraces in the BBSRC cereal germplasm collection. Of the listed Scottish oat landraces, eight are Murkle oat; three are Scottish Berlie and two Scottish Chief and one *A. strigosa*. Some accessions are landraces known from the literature, such as Grey Winter, but not listed as such. From pedigree information for cultivars, it can be seen that there are many more selections from landraces than 'pure' landraces; there are 4 Scotch Berlie selections, 9 Potato selections, 6 Sandy accessions, etc. Of the twelve accessions with *A. strigosa* in their pedigree, 6 are derived from the Welsh cultivars Ceirch Llwyd Bach and Ceirch Llwyd Cwta (the hybrid between *A. strigosa* and *A. brevis*), two are Piley Corn. Besides these there are 23 *A. strigosa* accessions with no recording pedigree data. Further collecting of bere was undertaken for the Scottish Heritage Collection at SASA in the mid 1990's and is currently being undertaken for small oat and bere (Hall, pers. comm.).

In conclusion for historic landraces it can be concluded that:

- Most 19th century cereal varieties were selections from landraces.
- Few historical landraces survived into the 20th century.
- Few cereal landraces were collected for *ex situ* conservation, particularly wheat is under-represented.
- Passport documentation could be improved on the basis of literature.
- Surviving (selections from) landraces declined dramatically in late 20th century.
- Re-introduction of landraces will be limited by the germplasm collecting earlier in the 20th century.

3.2 Cereal landraces in mainland Great Britain

Long-straw wheat

Of the primitive wheat species, currently emmer was only found grown in museums or for research purposes. Spelt is a nationally listed species and the varieties commercially available are all cultivars. The latter is grown organically on about 100 hectares by an unknown number of farmers, most of whom obtain seed by personal contract (Younie, 2002). Neither of these 'primitive' wheats can be considered to have extant landraces.

In the past many materials have been used for thatch, ranging from heather to oat, but nowadays only two types of material are used: reed and wheat straw. Water reed or Norfolk reed (*Phragmites australis*) is used by the majority of the approximately 900 thatchers (Sanderson and Prendergast, 2002), thus the approximately 30 000 thatched buildings in England are thatched with water reed. Of the long-straw thatchers, half use Triticale (a wheat / rye cross) and the majority of the other half use 'Maris Widgeon' (Letts, pers. comm.). Sanderson and Prendergast estimated that there are about sixteen growers of long-straw wheat for thatch (Sanderson and Prendergast, 2002). Long-straw wheat and wheat reed refer to different techniques in thatching: combed wheat reed is a winter grown cereal straw; it may be wheat, rye or a hybrid. Long straw is on the other hand not combed and has passed through the drum of the threshing machine (English Heritage, 2000). Maris Widgeon and Maris Huntsman are two medium-length wheat cultivars used by thatchers; the latter was recently withdrawn from the National List. Annually 80–90 tonnes of Maris Widgeon seed is bought by approximately 80 –110 farmers per year (Prickhard, pers. comm.) and it is the main wheat variety used for long-straw thatching. It is, however, also used for (organic) milling. The fact that Maris Huntsman was recently de-listed means that the number of commercially available long-straw wheat varieties for thatching has been reduced to one. In order to assess the scale of thatching wheat growers, thatching organizations were approached for numbers, however, they hold no central data on numbers. Individual thatchers and farmers were contacting through gene bank contacts, thatching organisations members' lists and personal contacts and they were approached by phone or email. As the traditional area for combed wheat reed thatch was Devon, data collation was focused in this area and some of the major growers in this area were approached. A network of five to six small scale long-straw wheat growing farmers is also to be found in Suffolk and Norfolk, traditionally associated with long straw thatching.

Seven farmers had 'Squarehead's Master', the most prevalent variety, Other varieties mentioned were 'April Bearded' (2), 'Rampton Rivet' (3), 'Blue cone'(1), 'Little Joss'(1), 'Rivet'(1) and N59 (2). Some varieties were family inheritances, some seed was bought when it was still commercially available, and some originated from the John Innes Centre. The areas grown varied between 0.3 and 300 acres, the majority however around 5 acres and only a couple of growers cultivated more than 20 acres. Many informants emphasized the risky character of growing thatching wheat, especially Squarehead's Master, as a crop. Agricultural soils nowadays were said to be 'too rich' for cereals from a low-fertility era which often resulted in lodging problems. Another often mentioned drawback of the older varieties is their lower yield compared with modern types such as Maris Widgeon. A relatively large number of the thatchers and farmers contacted had given up growing Squarehead's Master because of these reasons and because it was too labour-intensive. Those thatchers actually still growing Squarehead's Master, were, on the other hand, inclined to emphasise its superior straw 'with a different feel to it', compared with Triticale and the more recent Maris wheat types. All wheat grown for thatching is cultivated under a low nitrogen regime to prevent lodging. Some of the farmers use herbicide but many are organic.

There is concern among thatchers about seed availability. De-listing of existing varieties was seen as a problem for the future. For farmers with small acreages bulking-up of seed on their small plots was mentioned as a problem. Some expressed concern about the small number of varieties available and mentioned that thatchers either did not have the time or the acreage to bulk up more varieties from gene banks. One thatcher, instead of seed saving on-farm, bought Maris Widgeon

seed every year, partly because of the quality, partly because of political considerations, i.e. to support the seed producing company in order to safeguard the future availability of long-straw wheat.

A new use for the older long-straw wheats is for their flour: Holnicote Estate (National Trust) is currently testing bread made from traditional thatching wheat varieties grown on the Estate as a means of product diversification (BBC4 Inside Out 12/1/2004). Besides thatching and milling, one long straw wheat variety was used for church ceremonies. Acreage required is very small: the wheat variety in question was grown on only 1/3 of an acre. Long-straw wheat is also used in ornamental flower arrangements and for corn-dollies, although also modern cultivars are used. One farmer mentioned the use of long-straw wheat as suitable for the conservation of old, steam-driven tractors. The cultivation of older cereal varieties for the purpose of the conservation of older agricultural equipment was not further investigated but might have revealed more farmers cultivating older cereal varieties.

Barley

Many names of beers once bear reference to barley landraces and past cultivars (Archer Stout, Plumage Archer, Plumage Archer Special, Spratt's Special Bitter)[20] but I found only one barley variety seed saved on-farm 'Plumage-Archer' for brewing of beer. According to the Scottish Whisky Association the vast majority of barley for whisky is 'Optic' and no traditional barleys were currently used for whisky. Interest in traditional barley for whisky became evident in two emails sent in with a request for information on traditional barley varieties suitable for whisky distilling:

> *"… as a private distiller, we are using organic barley and others from the Inverness region with spectacular results. I would like to get hold of some of the older, original varieties, ideally persuade some one on Islay to grow them so that we can distil it …If you are able to direct me to any supplier / grower of these old varieties, I would be delighted. I have one farmer who would be prepared to grow some for me on Islay …"* (Email, distiller, current assessment)[21]

3.3 Extant cereal landraces on the Inner Hebrides

> *Bear (barley) and small oats are the common produce of Skie; but the island is too wet to ripen them to perfection; and the produce of the crops is very rarely in any degree proportioned to the wants of the inhabitants: the years of famine are as ten to one.* (Thomas Pennant visiting Skye in 1772, quoted in Steven 2003*)*

Of the two cereals associated with the Scottish Highlands and Islands, bere precedes oats in length of cultivation (Fenton, 1999). Bere barley was the main crop of the Highlands and Islands until the 18th century, while oat only came into fashion from the 18th century onwards. Bere, used for both bread and ale, was cultivated on raised peat beds, so-called 'lazy beds' and has been increasingly replaced by potatoes since the 18th century (Fenton, 1999). There is historical evidence of bere grown on Oronsay, Colonsay and Islay in the late 18th century (Clarke, 1991), with small oat cultivated on the latter during the same time period. Islay and Jura were reported to be self-supportive for oat and barley at the end of the 18th century (Walker quoted in Clarke, 1991). So much of the Bere on Colonsay was used for distilling that the islanders had to import meal for food. The area of cultivation of cereals changed historically, especially after the Sheep Clearances in the 19th century when large resettlements took place on small patches near the coast (Fenton, 1999). After the introduction of tractors, the cultivation of cereals on the so-called in-bye lands was ceased and only the machair was ploughed (crofters, pers. comm.).

The 'mosaic' pastoral mixed farming based on traditional methods has a important role in conserving wildlife on the islands (Bignal, 1988). Crofting agriculture typically involves small scale production of

[20] www.beermad.org.uk
[21] with kind permission to quote the email

lambs and cattle with cereals (barley and oats) and hay (Bignal, 1996). The combination of 'in-bye' land where crops of hay, silage, cereals and roots are grown and extensive grazing by cattle and sheep throughout the year is of great ecological importance as has been shown for the islands of Mull and Islay which are European strongholds for the marsh fritillary (Bignal,1999). The wildlife habitats associated with traditional crofting "have not been created by nature but are largely the result of generations working the land in the traditional crofting manner" (David Muir in The Crofter, January 2003). This traditional system however has now changed: the majority of croft fields has been turned into pasture or completely abandoned, e.g. for Shetland between 1972 and 1991 there was a 52% decrease in crops and fallow and for Orkney 31% decrease of 31% (Bignal, 1996). For the islands of Islay, Jura, Colonsay and Gigha long-term statistics are available for cereal (and root) cultivation from 1866 to 1989 based on agricultural return records for six parishes on the four islands (Clarke, 1991). Since 1866 85% of cornfields, 90% of root fields and 13% of grasslands were lost, and the rate of loss has increased dramatically since the 1950's. In 1870 27% of farmland was arable crops and 73% grass while in 1989 this was 5 and 95% respectively. This decline is paralleled by a decline of agricultural holdings on these islands (Figure 1) and a total decline of cultivated land by 33% (Figure 2).

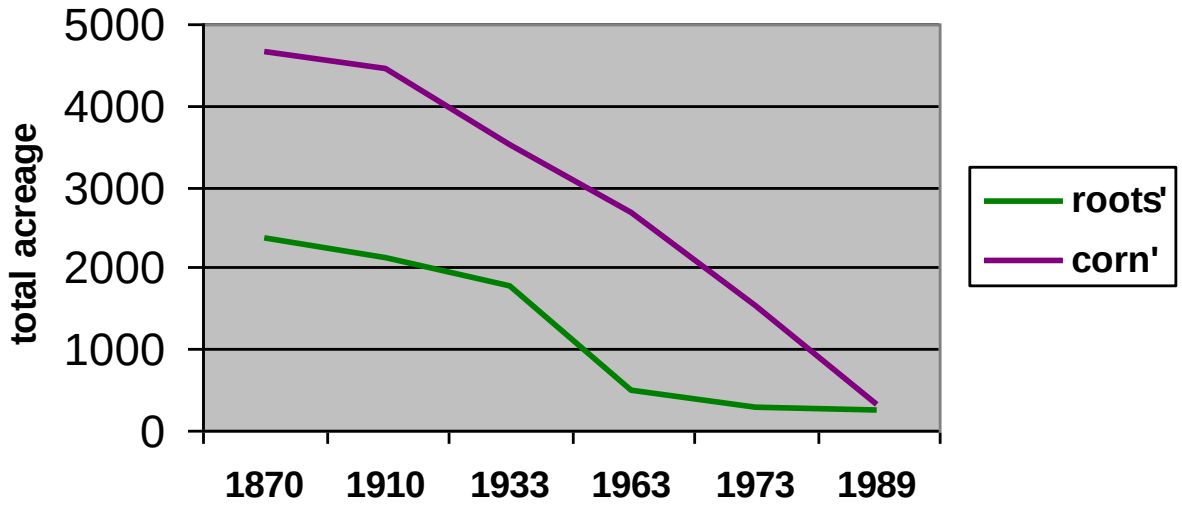


Figure 1. Number of agricultural holdings on Islay, Jura, Colonsay and Gigha 1866–1989 (Clark, 1991).

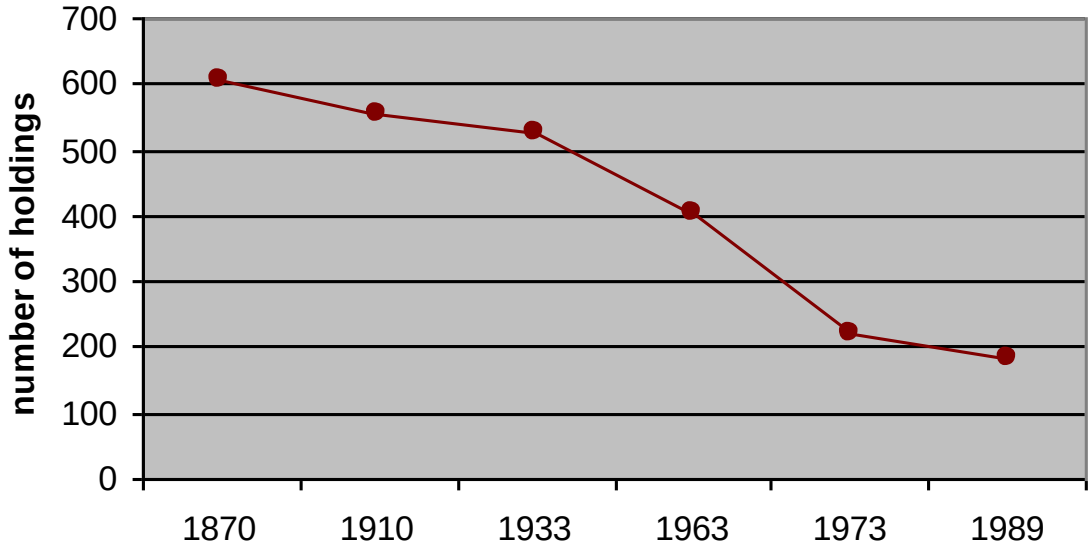
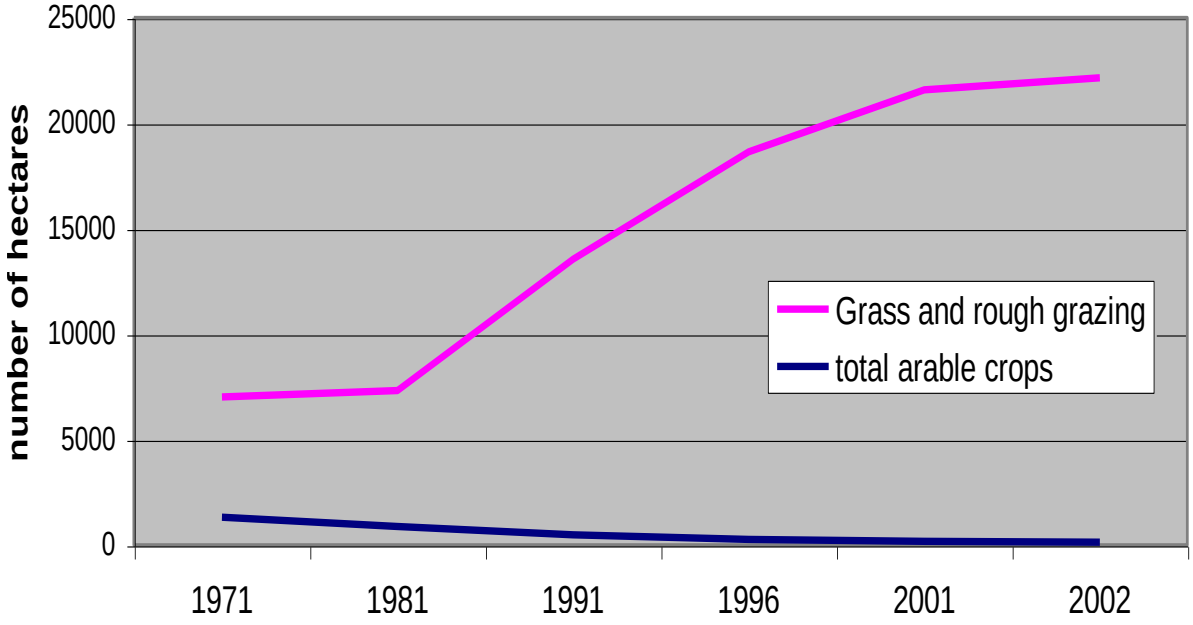


Figure 2. Cereals/root crops cultivation on Islay, Jura, Colonsay and Gigha 1866–1989 (Clark, 1991).

Associated with this change in agricultural practice is an associated decline of native birds, such as the corncrake, corn bunting and chough (RSPB Scotland, 2003). For the corn bunting the main threats are agricultural intensification, especially the loss of grain sources and early harvesting of crops. RSPB survey showed that the Uist population has more than halved since 1995. The corncrake is now dependent upon agro-environmental funding for maintenance of suitable habitat management. This trend in the relative areas under grass to arable crops is also reflected on Shetland (Figure 3).

> "*Overstocking with sheep and the decline of cattle numbers and cropping are the main concerns. Current funding schemes (esp. the Sheep Annual Premium) animal welfare regulations, a break-down of co-operative practices and an ageing cohort of crofters all operate to favour sheep ranching systems*." (Custodians of Change, 2002)

Figure 3. Relative areas under grass to arable crops is reflected on Shetland 1971 – 2002 (Shetland Council, 2003).



These factors have not been in favour of the cultivation of the traditional, labour-intensive landraces. Several interviewees gave this as the reason why cultivation ceased years ago in their particular area. On three of the Western Islands indications were present of incidental very small-scale cereal growing. These could however, not be verified within the timeframe of the assessment. On Tiree there might be perhaps 9 crofters with 10 –15 hectares under small oat, on Oronsay few, in co-operation with the RSPB and on Islay one. On the larger islands Skye and Colonsay, and on Argyll and Caithness, small oats cultivation had been given up, sometimes more than 50 years ago, according to my informants.

Isolated or incidental cultivation of traditional cereals creates a problem not only of harvesting logistics but also of identification and knowledge of the crops as witnessed by one farmer who stated that he had seen small or little or grey oat "Corky peg" grown on Islay last year. He had been asked to give advice on the grey oat and to identify a contaminant in the crop. Apparently he was the only farmer around with knowledge of these traditional crops. He recognised the contaminant as (small quantities of) bere barley. This farmer had started farming in the 1949 and had grown oat and barley, but no small oat. With regards to the future of bere barley and small oat, he said that the Inverness, East-Rosshire or Black Isle areas, which had a similar rainfall to Uist should be used to bulk up the seed, because 'if they have a couple of bad years, it will die'.

3.4 Extant cereal landraces on the Outer Hebrides

Cropping on the Outer Hebrides currently occurs entirely on the Machair, which falls entirely under Environmentally Sensitive Area schemes, for reasons given below:

> *"Machair is one of the rarest habitats in Europe. This distinctive coastal grassland is found only in north and west Scotland and western Ireland. The soil is mixed with wind-blown shell sand and is traditionally enriched with seaweed gathered from the beaches. The machair is often the main area of cultivation and may include grassland pasture, hay meadow, rotational arable and wetlands. The departure from traditional cropping, increased use of fertilisers and pesticides and more intensive stocking with sheep have led to a decline in the variety of plants and the characteristic animal species they support. The practice of leaving the area fallow for a couple of years while another area is cultivated allows annual and short-lived plants to germinate, flower and set seed. This helps to create the spectacular display of flowers for which the machair is well-known, and a very varied and rich habitat for other wildlife. Machair supports high numbers of breeding waders including: oystercatchers, lapwing, ringed plover, redshank, dunlin and snipe. It is also a critical habitat for corncrake. Earthworms, snails and flies, spiders, harvestmen and various bees are commonly found over the herb-rich machair."*
>
> (The Rural Stewardship Scheme, Scottish Executive, Edinburgh, 2003).

The machair soils are not only alkaline but also manganese-deficient and this is the very reason why small oat, rye and bere are grown as they can tolerate this condition. Both seaweed and compound fertilizer are used to fertilise the soils. Small oat and rye are grown as a mixed stand, the rye guaranteeing a crop in dry year, when the oat yields less. A 60 / 40 oat / rye ratio was mentioned but also 70 / 30 and for the darker soils a 50 / 50 half oat / rye and half barley mixture. Barley used to be grown as a single stand crop on the in-bye lands, but currently it is occasionally grown together with the other cereals as it was said to make good silage. One informant grew small oat as a single-stand because he found it easier to bale. On one larger croft Highland cattle were raised under certified organic management; more often crofters had faster maturing 'mainland' or continental breeds (Simmental, Charolais and Jersey). The small scale raising of Highland cattle was said to be the reserve of hobbyists because large scale production was necessary to make it economically feasible.

Scale of landraces cultivation

According to local crofters on North-Uist, Benbecula, South Uist and possibly Barra, the cultivation of small oat and to a much lesser extent, bere barley is, in contrast to the Northern Islands, still widespread and this proposition is supported by official statistics. Two sources of statistics were available to estimate the range of local cereal production, the Scottish Agricultural Census Summary Sheets by Geographic Area for June 2002 and ESA schedules contract data. These for 2002 estimate a total number of holdings growing cereals at 188 on 342 hectares. The SEERAD census 2002 figures were discussed while interviewing crofters, all agreed that the oat counted for in the statistics was small oat; and secondly that the area given by SEERAD was an underestimation of the small oat cultivation area. For South Uist only there were "more than a hundred" crofters growing small oat.

ESA statistics give for Uist in 2003 a total of 440 participants in ESA schemes; more than 400 of these are estimated to be crofts with cereals (Wilson, pers. comm.). The number of cropped hectares covered by these ESA schemes is more than 600 hectares. According to SEERAD the area under cultivation has almost doubled since the introduction of ESA schemes and 90% or more of this would be due to oat / rye mixtures. On the basis of these data there are likely to be 200 – 400 crofters growing small oat / rye mixtures on 300 - 600 hectares. Since Findlay (1956) described the area of cultivation of small oat in the early 20th century as 500 – 600 acres on the Western Isles, the total area under cropping seems to have increased.

Comparable data for bere barley were not available, thus it was harder to assess the scope of its cultivation. SEERAD statistics for 2002 show 7 holdings with barley on 25 hectares. This would all be bere barley, but again based on interviews with crofters, the SEERAD statistics is likely to be an underestimation. Bere barley is grown on North-Uist, Benbecula, South-Uist and Barra. Estimations differed considerably among crofters, ranging from 'a handful' to 'perhaps 25'. Field inspection during the growing season is required to accurately assess the number of growers and hectares. Earlier estimations of the bere barley cultivation based on the Northern Isles of 5 - 15 hectares in total (Jarman, 1996; Wright, 2002) may be an underestimation.

Varieties, seed origin and seed production on the Outer Hebrides

All cereals were referred to by their crop names: oat or small oat, rye and barley. *A. sativa* oat types were referred to as 'mainland' or 'white oats', of which few varieties were grown. No informant mentioned more than one landrace type for the islands. The small oat of Uist however was said to differ from the more black Shetland oats. One crofter had tried the latter, and although it yielded better, it did not stand-up to the winds. One crofter had grown two hexaploid oat varieties in the 1960s, which, after initial treatment with manganese, had developed a tolerance for the machair-conditions as they started to yield without treatment. Because of off-croft activities he had not been able to keep these varieties and they are not commercially available anymore. All informants gave as their seed origin 'from the island'. One informant mentioned an Aberystwyth small oat variety but this 'gave up after 6 years' and the farmer returned to the local variety.

Seed exchange seemed to be rather common. Seed swapping as a practice to rejuvenate or invigorate the crop also occurred. A small patch of single-stand cereal is grown for seed production. These small patches were mentioned to be particularly vulnerable to geese eating the seed after the rest of the crop has been removed as silage. Also the traditional stacks seemed not safe for geese as these were said to be able to pull out the grain from the stacks. In 2003 'acute seed problems were noticed'[22] on Uist, with geese decimating the cereal production. None of the interviewed crofters mentioned a seed shortage at the moment. Only in very dry years a seed shortage could occur but at the moment there was 'plenty of seed'. In West-Benbecula hand-binder was still used by a small group of neighbouring (older) crofters and harvested grain 'stooked' and afterwards stacked. These traditional stooks can be seen on postcards for sale in Balivanich. The majority of cereals are harvested as silage.

Threats

Geese were mentioned by all crofters as a problem for cereal production. Geese populations have increased on the island in the last twenty years, in the view of the crofters. They have started to over-winter on the islands and the migrating ones arrive earlier in fall. The two local RSPB nature reserves, the older of which was founded in the early 1950s, were mentioned more than once crofter as the source of the geese problem. In the 2004 RSPB bird count for North-Uist more than 1000 greylag geese were counted and more than 2000 barnacle geese. Cereal production concentrated on the west –and north shores, where about 100 active crofts are located. Hence the ratio crofter to geese is more than 30:1. For Uist the following specific problem was detailed: geese eat the seeds and the silage and subsequently dirtying the fields, so that the cattle refuse it. One of the reasons why silage is chosen instead of hand binding is that the threat of geese is less as the harvest is earlier (Mitchell, 2001). Geese Management Committees have been established on the islands, which during growing season send out live scarecrows for patrolling. Licenses to shoot greylag geese are given out but only for a limited number of geese. However, the number of guns on the islands was said to be very limited. Disease problems in cereals exist but were considered by crofters far less urgent than the geese problem. Black or loose smut was often mentioned as a problem, mostly in oats, lowering the germination rate of the cereals. Alternative cropping for the

[22] Am Paipear, June 2003, Ena MacNeill

traditional local cereals were only mentioned by one (young) crofter: he was considering experimenting with lupines on the machair and if these would give better protein content, it would be rational to switch to this crop.

The future of Hebridean cereal landraces as perceived by crofters

Asked specifically what the major threat for the future of bere and small oat production was, there was general agreement that the decline in active crofting in combination with the decline of cattle production would be the end of traditional cereals on Uist. The current ongoing decline of crofting is a complex of factors including: a general population decline on Uist, difficulty of making the croft economically viable and loss of off-croft-employment (army, salmon fishery). To what extent cereal cultivation is ESA dependent remains to be clarified? The forthcoming replacement of ESA schemes by Rural Stewardship Schemes was seen by most interviewees as a likely loss of income due to the new tier system. None of the interviewed crofters mentioned the CAP-reform as an option that would favour traditional crops.

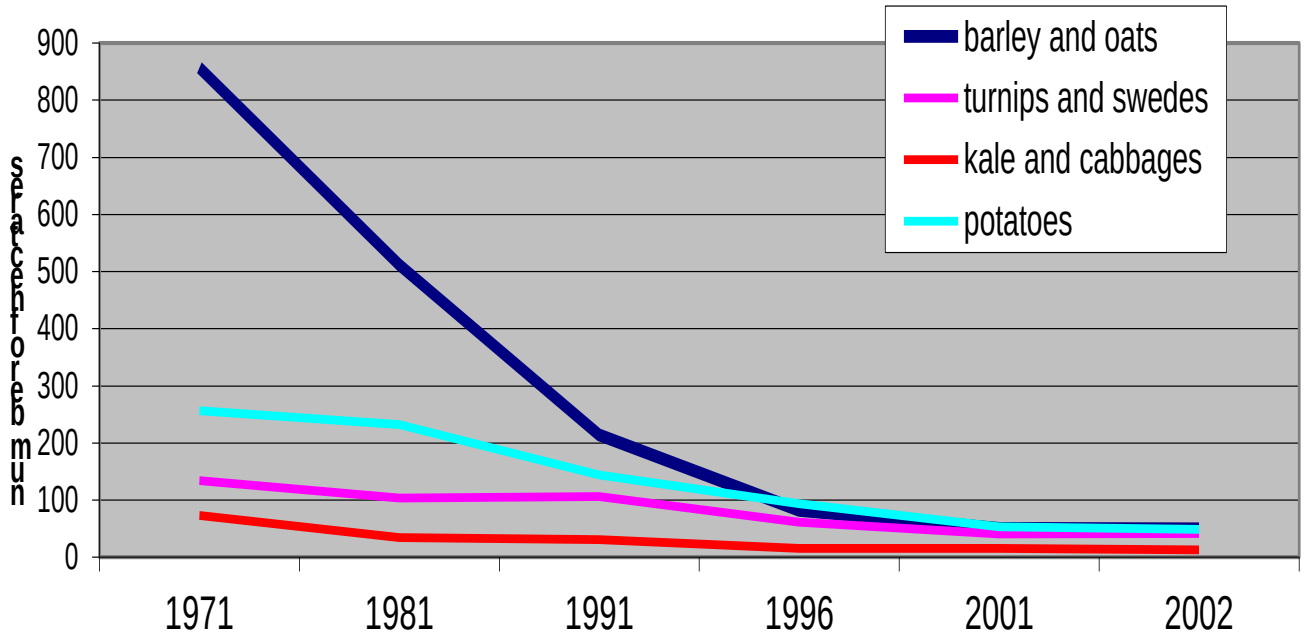
Other threats to the future of cereal cultivation were environmental issues as global warming and coastal erosion. Interviewed crofters (most in their 50-60's!) envisaged that small oats would still be grown in the next twenty years. One younger crofter envisaged the future as follows:

> *"cattle will stay, but there will be fewer crofters and the crofts will be bigger. Mainland cereals do not grow here unless they are treated and the treatment is tricky with wind blowing away the manganese."*

3.5 Extant cereal landraces on Orkney and the Shetland Islands

On Shetland, cereal production dropped from more than 800 hectares in 1971 to below 100 hectares in 2003. The decline of cropping is general, as can be seen in Figure 4 below. The cultivation of the traditional cereal landraces went through a bottleneck of two to three growers, both on Orkney and the Shetlands. The origin of the bere cultivated through this bottleneck period should be established as one informant suggesting that bere barley had been sent in from the Western Isles some ten years ago through the SAC after disease problems had wiped out a harvest. Some of the bere grown may have originated from the John Innes Centre collection. The oat on Shetland however seemed local in origin. Oat straw is still used for basketry and thatching.

Figure 4. Area (hectares) under arable crops on Shetland 1971 – 2002 (Shetland Council, 2003).



Orkney is currently the only location where bere barley is still produced for human purposes, for the traditional bere-meal and bannocks (Mason and Brown, 2004). Four to five farmers grow bere on Orkney on a small scale for feed. One individual organic grower and one (non-organic) growers group were involved, producing meal for a local Orkney mill and for a mainland. Both growers considered the production of bere safeguarded for extinction for the time being. The organic grower however had severe leaf stripe problems on the bere some years ago for which he required derogation from the certification body for seed treatment.

On Shetland an initiative has been set up to rescue the traditional cereal landraces and to encourage cropping in general. This initiative was taken by the Shetland Organic Producers Group[23] but is not limited to organic growers. The project description is outlined as follows and quoted to some length in order to show the complexity of a contemporary 'on-farm' conservation project, involving agricultural, wildlife, educational, social, historical, architectural and art components and with an explicit objective of linking respective communities and organisations:

> *"Currently, Bere is only sown regularly by two growers, consequently there is not enough seed to disperse or to build up a seed bank as insurance against a bad harvest. Orkney and Shetland are the only places in the UK still cultivating Bere and it has died out completely in Ireland. An ancient 'land race' there is evidence that Bere has been in Shetland since at least 1500 BC. The growing of oats has also declined and is symptomatic of a reduction in crop production that is having negative impacts on the biodiversity of the islands.*
>
> *This project will focus on safeguarding the future of these native species, as part of the living heritage of the islands. Planned over 5 years, it will begin with established growers consolidating their crop, minimising wastage, in order to maximise seed availability in 2004. New potential growers are being identified and, over autumn, winter the first of a series of 'skills transfer' sessions will take place. This training element of the project will help to ensure its sustainability.*
>
> *With help of the local wildlife rangers and the Living Shetland bio-diversity project, links will be established with primary schools to explain the role of crops island culture and to show their environmental importance. A series of 'on-the-croft' sessions is planned and the SOPG will digitally record every stage of the project, to create a research and educational tool.*
>
> *Aims:*
>
> *To save the native Bere barley from extinction and encourage the growing of Shetland oats, as part of the living heritage of the islands*
>
> *To encourage and promote interest in crop-growing in Shetland, particularly organic production*
>
> *To ensure a GM free fodder crop is available for organic growers*
>
> *Objectives*
>
> *To purchase 1 custom made seed drier and trailer for collective use by the project*
>
> *To transfer skills from established growers to new growers*
>
> *To produce a 'checklist' of do's and don'ts for new growers*
>
> *To produce a permanent records of the project, to be made available as a resource to schools, agencies and institutions*
>
> *To establish links with local primary schools*

[23] www.organics.shetland.co.uk

…The project is generating interest and support from environmental and wildlife organisations, such as the RSPB, who will carry out bird monitoring on the crofts involved and craft/heritage groups. Letters of support have been received from Shetland Art trust, SCFWAG and the Living Shetland project. Both the Amenity Trust and the Arts trust are keen to see an increase in the availability of Shetland oats for heritage restorations and the craft sector and the Quendale Mill, a community owned, restored watermill would take Bere for milling, if it was available."

Jane Thomas (May 2003)

Shetland cabbage, Shetland potatoes

Besides cereals, members of the SOGG also maintain local vegetable landraces of Shetland cabbage and Shetland Black Potato. Shetland cabbage, a *capitata* type, in contrast to the Shetland kale, which is *acapitata*, has been on the islands since the fifteenth century. Shetland cabbage is the only landrace I encountered with an associated growing space: the 'plantie-crub', small circular dry-stone enclosures for growing cabbage plants[24]. Shetland statistics for cabbage and kale are unavailable, however, Shetland cabbage is becoming increasingly rare according to the informants contacted during this survey. The valuable character of this cabbage was established by earlier research into its resistance to club root (*Plasmodiophora brassica*) (Anon. 1984). Twelve collections from disparate locations in Shetland were found to have considerable morphological variability but poor heading qualities and moderate levels of field resistance compared to control cabbages (Anon, 1984). HRI currently has 19 accessions of Shetland Cabbage and 2 of Shetland kale. The cultivation of Shetland Black Potato was considered to remain widespread.

3.6 *Avena strigosa*: a threatened species

A. strigosa is one of the few species in this assessment which occurs both as a weed and as a crop. As a weed it has been classified as a neophyte but also as a casual. As a weed, distribution data is available Preston *et al.* (2002), see Figure 5. The figures below from Preston *et al.* (2002) show on the left side the *Avena strigosa* distribution until 1970 and the right hand side the number of 10 by 10 km squares in which the species was found in the second botanical survey, from 1987-1999. The distribution data show a very steep decline over the last thirty years for Shetland, mainland Scotland and the Isle of Man, Northern Ireland, Cornwall, central England and East-Anglia.

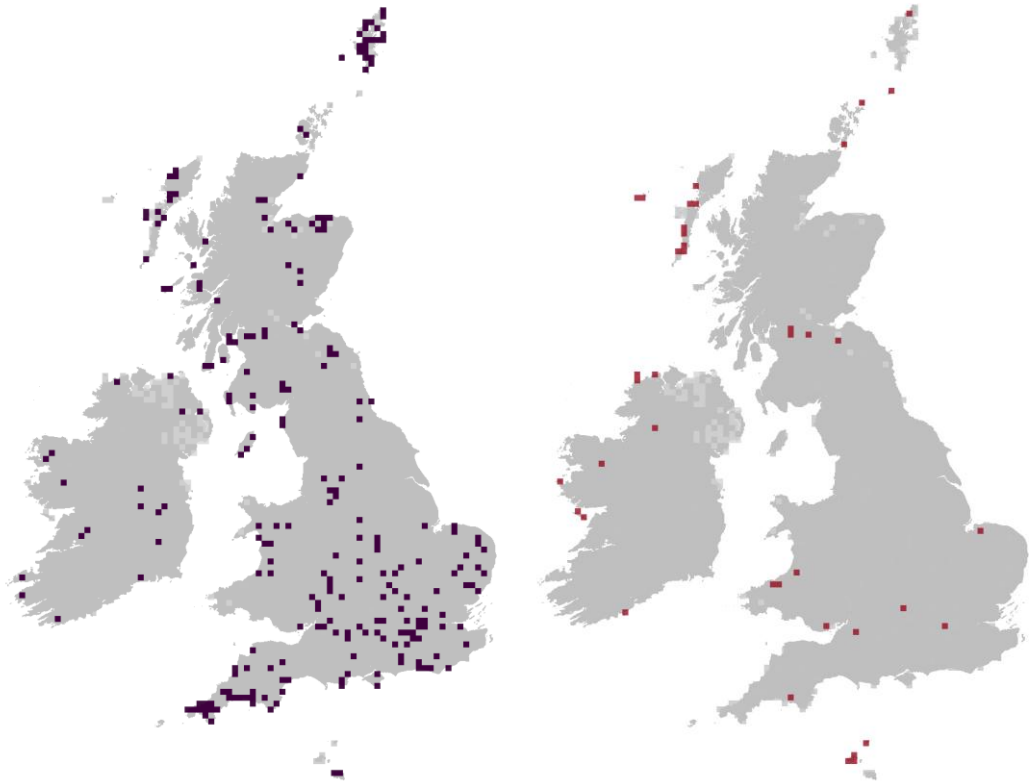
A. strigosa does not form permanent soil seed banks. For this reason, its wild distribution data can be used to trace *A. strigosa* current and historic cultivation, one of the sources of the seeds of the wild plants. Singular, isolated records should be interpreted as spills from bird feed (Chater, pers. comm.). The high number of adjacent records on the Outer Hebrides however, especially South-Uist, and possibly the Northern Islands, suggest (retrospectively) more than chance-findings, they suggest continuous use of the *A. strigosa* as a crop. This was confirmed in this assessment. The presence of *A. strigosa* on St. Kilda may be related to the National Trust 'cultivating' an oat / rye mixture on the island since the early 1970's. It had not been recorded there before as the map shows. The oat in question was Sandy oat, mixed with *A. strigosa*, bulked up in East Craigs and originating from the Western Isles (Hall, pers. comm.).

A similar pattern of a series of adjacent records is visible for Guernsey. Closer inspection of the BSBI records for the Channel Islands show 12 records since 1970 in which the species was classified as a casual, and 7 in which it was classified as a neophyte (Stace, 2003). Although the difference may mirror different interpretations of recorders, it may also indicate different population sizes: 12 casuals or singular plants and most significantly 7 naturalised populations. This could be an indication of the cultivation of *A. strigosa* as a crop. Verification fell out of the scope of this project. The agricultural advisor for the Channel Islands thought there was no cultivation anywhere on the islands. The small publicity campaign (an advertisement) did not yield positive responses either.

[24] from a Glossary to Shadowed Valley by J.J. Graham, Shetland Publishing Company, Lerwick, Shetland

The New Atlas data indicates *A. strigosa* is extinct in Northern Ireland, mainland Scotland, Cornwall, and has very few locations left in Wales. In the current assessment only one case of actual *A. strigosa* cultivation in Wales was found, however this result may indicate insufficient publicity in Wales for the assessment. There is anecdotal evidence that *A. strigosa* was still cultivated in North-western part of Northern Ireland in recent history. More intensive field surveying would give more accurate assessment. It would moreover, create an opportunity to research the full geographical range of *A. strigosa* within the UK.

Figure 5. *Avena strigosa* Distribution in 1970 and 1999 (Preston et al. (2002).



The relevance of this particular landrace / crop wild relative is wider than the British Isles. The scale of *A. strigosa* cultivation in Europe has declined to the point of extinction in many countries. In a recent survey of *Avena strigosa* survey in Denmark 20,000 fields were checked (0.8% of all arable land in Denmark) in the former strongholds of the crop. The field surveys were combined with herbarium studies, literature review and farmers interviews. The conclusion was that *Avena strigosa* was extinct in Denmark (Weibull, 2001). While in Lithuania four villages were the main sites for small oat cultivation in the country, the total area of cultivation being 9,000 square meter (Weibull, 2001). *A. strigosa* only occurs as a seed contaminant nowadays in Poland (Kièc, 2003) and is probably extinct in its former centre of origin Spain (Laguna, pers. comm.). The UK may therefore hold one of the single largest remaining areas of *Avena strigosa* cultivation in Europe.

3.7 Cereal research needs

It seems likely that there are distinct *Avena strigosa* varieties growing across the UK. On the Western Islands *A. strigosa* was referred to as 'small oat', 'black small oat' or 'little oat'. On Shetland, it is called 'Shetland oats' and at least one farmer referred to it as 'grey oat', remarking that there may be more than one type. Also oats from the Northern Islands introduced to Uist did not perform well. The current small oat germplasm collection held by the John Innes Centre lacks some passport data so it is unknown if the Western Isles are represented.

No bere has been reintroduced to the North from John Innes Centre germplasm collection over the last 10 years (Ambrose pers. comm.). As with *A. strigosa* it has been suggested that there may be

two types of Bere, that the types grown in the Western Islands are distinct and unsuitable for the Orkney and Shetland environment. Previous morphological and isozyme work on bere was hampered by the lack of passport data of the germplasm accessions available.

Rye has never been an important crop for the UK and no landraces are known from the historical literature, nor has any characterisation or collecting been undertaken on the small populations of rye currently grown on the Western Isles.

Research issues emerging from this assessment are:

- There is a need to clarify the origin of the cereal landraces cultivated on the Western, Orkney and Shetland islands.
- The process and extent of seed translocation and re-introduction between the Western, Orkney and Shetland Islands, and their interaction with gene banks holding needs investigation.
- There is a need to establish more precisely the number of hectares on which oat / rye and bere barley are grown on the Outer Hebrides and to establish a precise number of cereal growing crofters.
- To establish through characterisation and evaluation how much morphological and genetic variety is present in landraces between the West and North, and within the islands and how these UK cereal landraces relate to continental European landraces; this will involve fresh collection because of the lack of passport data for many currently conserved UK accessions.

3.8 Conclusions for cereal landraces

The differentiation between derived or secondary and original or primary landraces as proposed earlier in this report, proved useful. The time dimension of the found materials differed widely between the two classes and justified the distinction between derived landraces that were obsolete cultivars maintained as landraces and original landraces. Many of the criteria generally applied to define landraces were present for the Scottish landraces: historical origin, local adaptation, lack of formal improvement, seed saving on farm, distinct identities and at least between the islands, heterogeneity. Seed exchange and seed swapping were also practiced. Cereals have been cultivated in the Northern Islands over generations; seed saving occurred over generations; local adaptation is evident as the lack of formal improvement; the scale of cultivation was relatively large allowing mixing through seed exchange and seed replacement[25], the usage of mixtures to guarantee yield in bad years; and a relatively traditional agriculture, i.e. low-input agricultural management on small fields. The criteria of heterogeneity, important from a point of view of genetic diversity, could not be assessed as no field work was planned. The extent and periodicity of re-introductions needs to be established in further work. Usage of mixtures of species is a very traditional management: mixtures of species as maslin (wheat and rye), dradge (oat and barley) and beremancorn (rye, wheat and barley), are known from medieval times (Slicher van Bath, 1960).

In contrast, the majority of other cereals fall into the category of derived landraces. They have been documented as being selections from landraces or cultivars developed in the 19th or early 20th century. Among the long straw wheat varieties, only April Bearded and Rivet wheat are historical landraces. However, these can be considered reintroductions from germplasm collections. Home seed saving for this category ranged from 6 to 80 years. Local adaptation was only in few cases the particular reason for seed saving over a longer period. Traditional uses were present for all, ranging from church ceremonies to thatch. However, also potential new uses were suggested by inquiries: uses for ecologically friendly furniture, in organic agriculture.

An overview of the cereal landraces found present is given in Table 3. It is likely that bere barley, small oat and rye cultivated on the Outer Hebrides and the Northern Islands are centuries old and unique in a UK and even European context.

[25] This element was pointed out and emphasised by Dr. ir. A. Zeven

Table 3. Extant British Cereal Landraces 2003.

Variety	Pedigree	Number of farmers	Current use	Hectares	Location
Plumage-Archer	19th century	1	brewing	40.5	S. England
Sheriff Wheat	19th century	1	church	0.12	S. England
Squarehead's Master	19th century	7	thatch	221	S. England
Rampton Rivet	Early 20th century	3	thatch	10.2	S. England
April Bearded	old Welsh farmers' variety	2	thatch	10.1	S. England
Rivet	Centuries old	2	thatch	10.2	S. England
Little Joss	1908	1	thatch	2	S. England
Forward oat	1950	1	several on farm uses	8	Scotland
Several oat, rye	Obsolete cultivars	dozen	biodynamic	162	England
Bere barley	8th century (?)	< 50	food, feed	20.2	Orkney, Shetland, Outer Hebrides
Shetland oat	before 17th century	< 10	feed, basketry	1.6	Shetland
Small oat and rye	before 17th century	100-200	feed	Est. 121	Uists & Benbecula

So summarise it can be recommended that:

- Seed availability and the bulking up of seed for small producers is restricting obsolete varieties use.
- Actual or potential use of the varieties may be highly localised (e.g. Forwards oat), thus is too localized for commercial breeding. Networks of traditional cereal growers should be encouraged and seed exchange of obsolete and landraces legally.
- Many informants were not aware of the availability of landraces germplasm and the websites and the national germplasm collections should be more widely publicised.
- The benefits of growing long-straw cereals for landscape and biodiversity (low-input, small fields (many edges) and relatively extensive, prolonged harvesting) have not been researched nor credited in CSS and equivalent agro-environmental schemes.

4. Vegetable Inventory

4.1 The 'B' List

4.1.1 'B' List vegetable varieties of non-hybrid origin

There are currently 345 varieties of 20 vegetable crop species listed in the 'B' List of non-hybrid origin (Table 4). This includes varieties listed as approved maintenances, which are different

landraces within a broad type represented by the listed varietal name (e.g., onion 'Crosslings Seedling' is an approved maintenance of onion 'Ailsa Craig')[26]. The highest numbers of varieties are listed for cauliflower, white cabbage, onion, carrot and lettuce (each with more than 20 varieties), which accounts for 44% of the total. Nine crops (leek, tomato, broad bean, turnip, marrow, beetroot, runner bean, wrinkled pea and celery) each have 11–19 varieties listed, accounting for 38% of the total. The remaining 16 crops account for 18% of the varieties, each with 1–9 varieties listed (Table 4, Figure 6). The crop species with the highest diversity represented in terms of the number of varieties is *Brassica oleracea* with a total of 91 varieties of cauliflower, white cabbage, Brussels sprout, Savoy cabbage and curly kale, collectively; higher than any other crop species (Figure 7).

Relatively few vegetable varieties have been removed from the 'B' List in the last 20 years (J. Edgley, Fera, pers. comm., 2009). Nineteen were removed from the National List in 2007 as a result of a review of the 'B' List (Table 5)—no applications were received to take on the maintenance of these varieties and no seed stocks existed in the UK Official Reference Collection (Defra and the Plant Variety Rights Office, 2007a). According to G. Campbell (SASA, pers. comm., 2009), these may have already been commercially obsolete for 10–15 years before being deleted from the National Lists.

Table 4. Vegetable crops listed in the UK National List of Vegetable Varieties 'B' List with non-hybrid varieties and the number of varieties per crop in descending order, including approved maintenances (data source: G. Campbell, SASA, pers. comm., February 2009)

Crop	No. of vars.	Crop	No. of vars.	Crop	No. of vars.
Cauliflower	39	Beetroot	14	Dwarf French bean	4
White cabbage	34	Runner bean	12	Endive	4
Onion	30	Wrinkled pea	12	Sugar pea	3
Carrot	26	Celery	11	Spinach beet/chard	3
Lettuce	22	Radish	9	Curly kale	2
Leek	19	Brussels sprout	8	Melon	2
Tomato	17	Savoy cabbage	8	Black radish	1
Broad bean	17	Parsley	6	Climbing French bean	1
Turnip	16	Round pea	5	Gherkin	1
Marrow	14	Cucumber	4	Spinach	1
				Total varieties	**345**

[26] An approved maintenance is a subset of a variety that falls within the range of expression of that variety (G. Campbell, SASA, pers. comm., 2009).

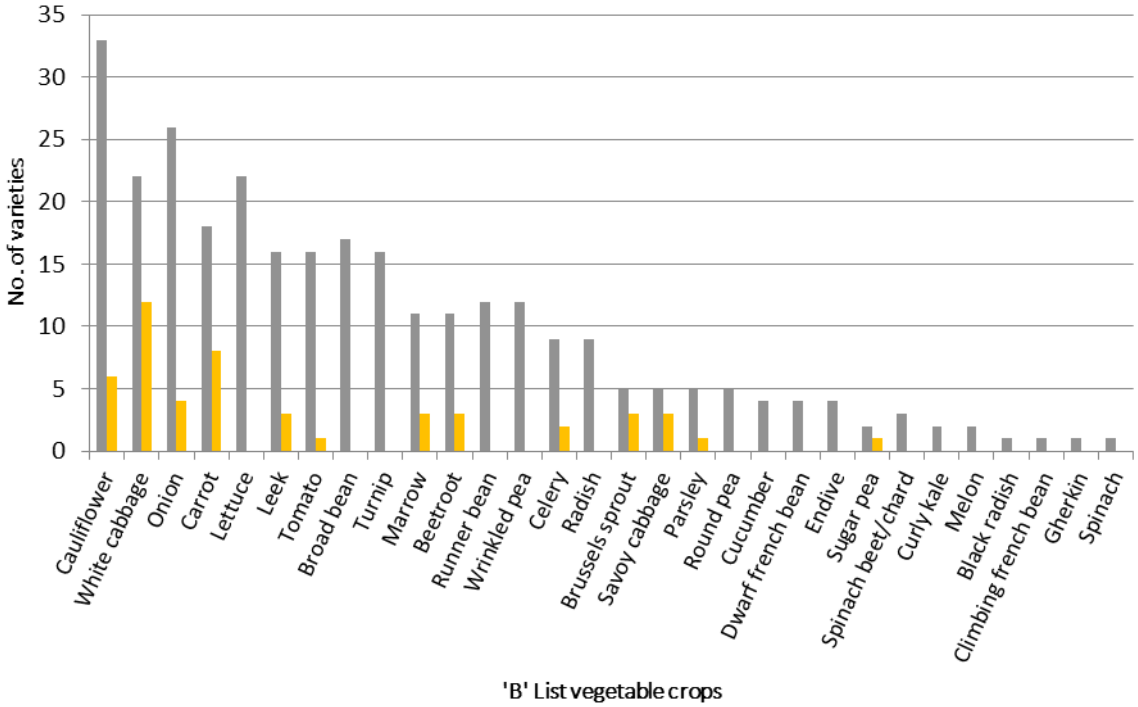


Figure 6. The number of 'B' List varieties per vegetable crop, showing listed varietal names in green and approved maintenances in purple. Crops are shown with the highest number of varieties overall on the left to the lowest number on the right (data source: G. Campbell, SASA, pers. comm., February 2009).

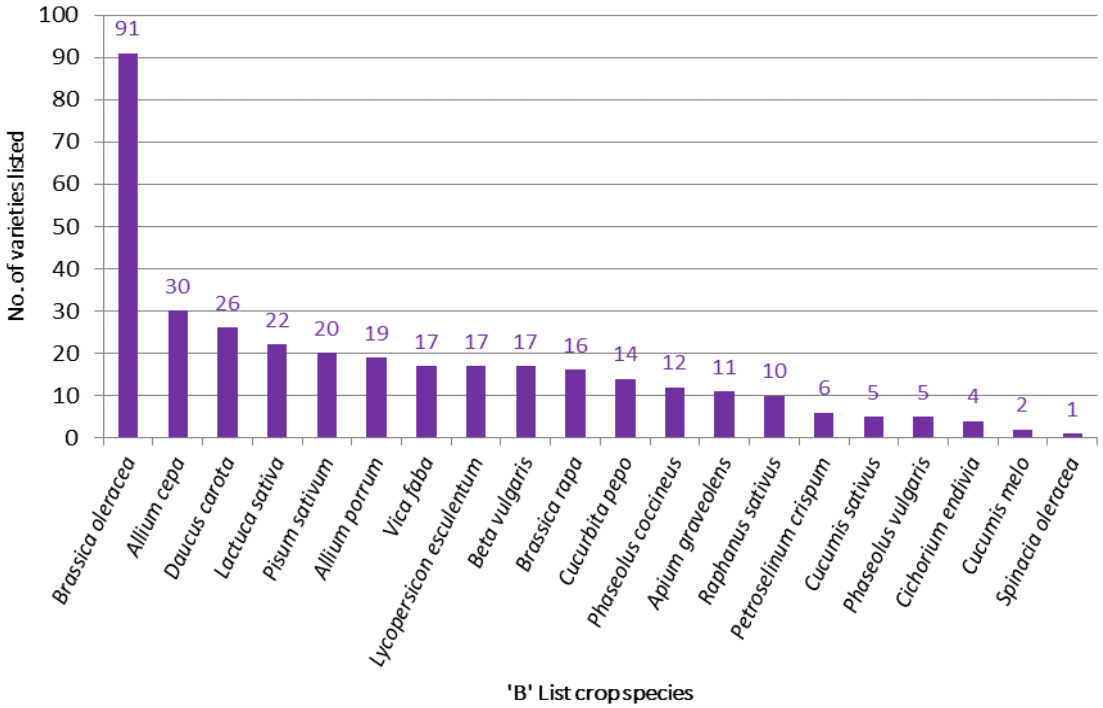


Figure 7. The number of 'B' List varieties per vegetable crop species, including listed varietal names and approved maintenances (data source: G. Campbell, SASA, pers. comm., February 2009).

Table 5. Varieties deleted from the UK National List of Vegetable Varieties 'B' List in 2007 (data source: Defra and the Plant Variety Rights Office, 2007a)

Crop	Variety
Cauliflower	Flora Blanca

	Autumn Glory
Climbing French bean	Purple Podded Climbing
	Romano
Cucumber	Lockies Perfection
	Marketeer
	Rocket
Dwarf French bean	Contender
Endive	Green Curled
	Moss Curled
Gherkin	Conda
Lettuce	Favourite
Spinach	Advance
Tomato	Heinz 1350
	Heinz 1370
	Mermande VR
	Roma VF
	Rutgers
	Urbana

4.1.2 'B' List vegetable variety maintainers

The names and contact details of the official maintainers of UK registered crop varieties are listed in Section D of special editions of the Plant Varieties and Seeds Gazette. Forty companies are listed as maintainers of 'B' List vegetable varieties; however, only 20 of these are based in the UK (18 in England and two in Scotland—one of which is SASA). Fifteen companies are based in other European countries (one in Denmark, one in France, four in Germany, two in Italy, one in Sweden and six in The Netherlands), while the remaining five are based in Japan (two) and the USA (three). The two Japanese companies have agents in Europe—likewise one of the USA-based companies; therefore, these companies were not contacted as part of this research. The Swedish company was also excluded from the survey as they have an agent in the UK, as was one of the companies based in England (Limagrain UK Ltd.) as they are listed as having an agent in the UK, which presumably acts on their behalf.

SASA currently maintains 42% (146) of the 345 vegetable varieties of non-hybrid origin (including approved maintenances) in the 'B' List. This information was published in 2007 following a major review of the 'B' List (see Defra and the Plant Variety Rights Office, 2007a) which revealed that some former maintainers had either gone out of business or no longer wanted to maintain the varieties (J. Edgley, Fera, pers. comm., 2009). E.W. King and Co. Ltd. maintains 22% (75) of the varieties, A.L. Tozer Ltd. 12% (40) and W. Robinson & Sons 4% (14). Eighty-four varieties (24%) are maintained by 27 companies, each responsible for maintaining between one and eight varieties (Figure 8). Note that some varieties are maintained by more than one company.

While some companies are only listed as official maintainers of one or a few 'B' List varieties, they may also maintain other 'B' List varieties for which they are not listed as official maintainers. For example, Church of Bures is only listed as an official maintainer of two 'B' List varieties; however, the company also maintains (through commercial production) other varieties in the 'B' List for which it is not an official maintainer (G. Lakin, Church of Bures, pers. comm., 2009). Conversely, E.W. King & Co. Ltd. is an official maintainer of 75 'B' List varieties, not all of which are now commercially viable—the

company continues to maintain some varieties in trial plots that it no longer produces commercially (P. Miller, E.W. King & Co. Ltd., pers. comm., 2009). Since 2006, E.W. King and Co. Ltd. has discontinued 14 'B' List varieties (P. Miller, E.W. King & Co. Ltd., pers. comm., 2009); however, the company is still listed as the sole maintainer of three of these varieties: curly kale 'Cottagers', round pea 'Pilot' and radish 'Summer Crunch' (see Fera Plant Varieties and Seeds Office, 2009).

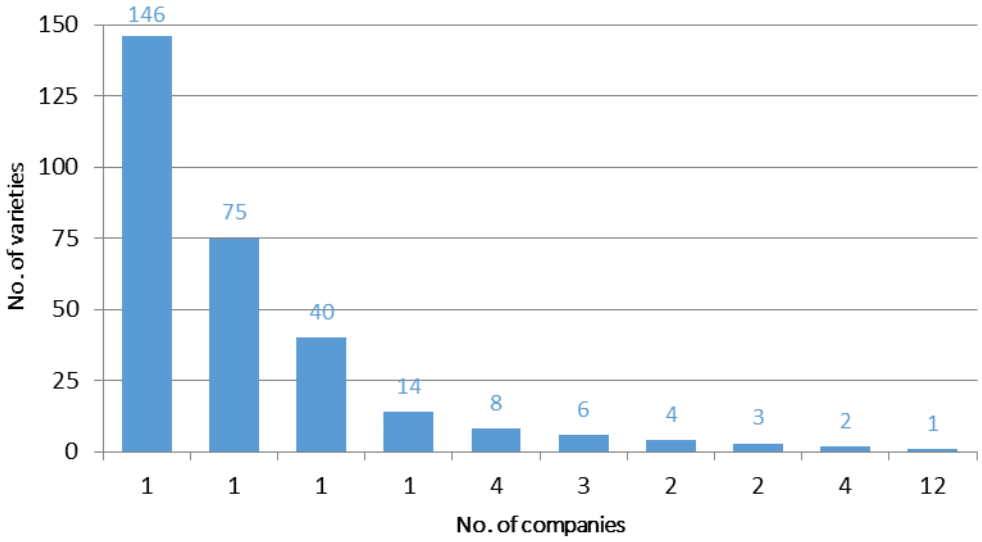


Figure 8. Company share of the maintenance of 'B' List non-hybrid varieties, showing SASA as the maintainer of 42% of varieties at one end of the scale, and 12 companies each officially maintaining only one variety at the other.

Four 'B' List maintainers made contact following receipt of the questionnaire (see Section 2.4.2). One of these was the German plant breeding company, Ernst Benary Samenzucht GmbH, who maintain one tomato variety on the National List—'Gardener's Delight' (also sold under the cultivar name 'Freude') (see Defra and the Plant Variety Rights Office, 2007b). The company informed us that because they only maintain one tomato variety, they would not be completing the questionnaire (H. Knobel, Ernst Benary Samenzucht GmbH, pers. comm., 2009). This tomato variety is in any case a relatively recent introduction to the UK—it was originally bred in Germany by Benary and introduced to the UK in the 1970s (G. Lakin, Church of Bures, pers. comm., 2009).

Two UK-based companies, Church of Bures and E.W. King & Co. Ltd. initially made contact by telephone. They both highlighted the fact that the questionnaire they had been sent was not really appropriate for them as they are wholesale seed merchants maintaining many varieties and producing seed on a large commercial scale. However, they supplied relevant information via telephone interviews and E.W. King & Co. Ltd. also followed up by sending a seed catalogue and list of the traditional varieties that they maintain (and have discontinued since 2006) by post. A third UK-based company, W. Robinson & Son (Seeds & Plants) Ltd., completed and returned the questionnaire by post, enclosing some additional notes along with the completed questionnaire. A complete (current) list of the varieties maintained by E.W. King & Co. in Essex is included in Annex 7, along with the six vegetable varieties that W. Robinson & Son provided details for[27].[28]

Vegetable expert B. Smith (Warwick, pers. comm., 2009) pointed out that very few varieties maintained by UK-based seed companies are now produced in the UK; rather, seed production is contracted out to companies overseas for economic reasons. E.W. King & Co. Ltd. is one such company that contracts out most seed production to overseas companies (in Europe, Asia and South

[27] W. Robinson & Son are willing to provide further information for the continuation of the vegetable landrace inventory.
[28] Church of Bures was unable to provide a list of traditional varieties that they maintain for reasons of commercial sensitivity.

America) (P. Miller, E.W. King & Co. Ltd., pers. comm., 2009) (see Box 3)—on the other hand, Church of Bures, based in Suffolk (Box 4) still produces the majority of its seed within the UK (G. Lakin, Church of Bures, pers. comm., 2009). All of the traditional varieties sold by W. Robinson & Son (Seeds & Plants) Ltd. are maintained solely by the company in Lancashire, including seed regeneration (M. Robinson, W. Robinson & Son Ltd., pers. comm., 2009). The company is a family run business and has been maintaining many of the same traditional varieties in the same location for several decades (the company will be 150 years old in 2010) (M. Robinson, W. Robinson & Son Ltd., pers. comm., 2009).

Box 3. E.W. King: a key maintainer of UK vegetable diversity[29]

E.W. King, a wholesale seed company based in Essex, is one of the UK's most prominent maintainers of traditional vegetable varieties. They are official maintainers of 75 'B' List varieties (including approved maintenances) of beetroot, broad bean, Brussels sprouts, carrot, cauliflower, celery, cucumber, curly kale, lettuce, marrow, melon, onion, parsley, radish, round pea, runner bean, Savoy cabbage, spinach beet/chard, tomato, turnip, white cabbage and wrinkled pea. However, not all of these varieties are commercially viable and some are only maintained as trials rather than being grown on a large scale for commercial seed production (P. Miller, E.W. King & Co. Ltd., pers. comm., 2009).

Most seed production is contracted out to overseas companies, both in Europe (particularly France and Italy) and further afield in South America and China, for reasons of economy; however, stock seed is maintained in the UK (Essex) in small plots, so selection is still carried out in the UK with mother seed sent to growers overseas for regeneration (P. Miller, E.W. King & Co. Ltd., pers. comm., 2009).

There are three roughly equal-sized market sectors for their seed: home gardeners and allotment-holders, small commercial growers and small packet seed companies. Probably the prime reason for the continued demand for seed of traditional varieties is the fact that they are a lot cheaper than modern cultivars (P. Miller, E.W. King & Co. Ltd., pers. comm., 2009). Amateur gardeners also value them because the variation inherent in traditional varieties leads to a longer cropping window (i.e., avoiding gluts).

Despite the continuing demand for traditional varieties, the company has discontinued maintenance of around 20 traditional vegetable varieties in recent years, partly due to a fading market, but also because of competition from overseas companies producing and selling seed for the UK market at a more competitive price (P. Miller, E.W. King & Co. Ltd., pers. comm., 2009). However, the company appreciates the importance of maintaining samples of traditional varieties to conserve genetic diversity, so they send seed samples of discontinued varieties to one of the UK's gene banks—usually Garden Organic's HSL. Two recent varieties that they have discontinued are round pea 'Gradus' and 'Pilot'.

Box 4. Church of Bures: maintaining vegetable diversity on UK soil[30]

Church of Bures, based in Suffolk, are official maintainers of two 'B' List varieties of wrinkled pea—'Early Onward' and 'Onward'; however, they maintain many more traditional vegetable varieties included in the 'B' List. Their main focus is on broad beans and old pea varieties; however, they also maintain other vegetable crops, such as fodder beet, swede, forage and oilseed rape, and kale. Founded in 1902, Church of Bures is a wholesale seed merchant that has been growing many of the varieties for decades in eastern counties of the UK. There are two primary markets for their seed—

[29] Based on a telephone interview with Peter Miller.

[30] Based on a telephone interview with Geoff Lakin and information from the Church of Bures Agricultural Seed Catalogue 2008.

small packet seed companies (for the amateur gardening market) and seed companies selling seed for agricultural production in low economy countries, mainly in Europe and N. Africa (G. Lakin, Church of Bures, pers. comm., 2009). There are various reasons why the market still exists for these older varieties. Firstly, amateur gardeners often prefer qualities such as taste and large pods (peas and beans) and the fact that they are less likely to get gluts of the crop at one specific time in the growing season than they are with modern cultivars. Many amateur gardeners probably also recognize the heritage value of these varieties and enjoy the satisfaction of knowing that they are helping to conserve them. For the buyers in the low economy countries, the seed is considerably cheaper than seed of modern hybrids as there are no additional fees to pay such as those incurred through plant breeders' rights (G. Lakin, Church of Bures, pers. comm., 2009). Furthermore, these buyers continue to buy seed from the UK year on year because it is more economical than producing the seed themselves. For example, in some countries, yield may be lower than in the UK due to environmental differences such as lower rainfall; therefore, the cost of the resources needed to produce sufficient seed for the next growing cycle is not feasible.

Most of the seed produced by Church of Bures is grown in the UK (in Suffolk, Essex, Norfolk and Cambridgeshire). Seed production is occasionally contracted out to companies overseas; however, the different environmental conditions in these countries do not usually affect the crops— although peas may be an exception (G. Lakin, Church of Bures, pers. comm., 2009). The varieties that Church of Bures maintains are grown on a vast scale (thousands of acres) and many of the varieties have been maintained by the same company in the same area for decades.

4.2 Landrace vegetable varieties of UK origin maintained by UK seedbanks

As already noted, a common limitation of seedbank collections data is that it is not always straightforward to distinguish between landraces and modern cultivars for all records, except in the case of the HSL which only maintains traditional and heirloom varieties. Further, the country of origin of the varieties maintained is not always known or is not recorded and when it is available it is not necessarily a reliable indicator of the true origin of the variety. This is partly because the movement of crop varieties around the world is not always traceable, but also because 'country of origin' may have a different meaning in different databases. In some it may refer to the place of development of the variety, while in others it may simply refer to the source of the accession, regardless of its true origin. The example of the pea landrace 'Glory of Devon' already cited (see Section 2.2) is an example of a vegetable variety that originated in the UK, but ended up in the USDA collections and was later repatriated to the UK by an individual enthusiast from the USA. In this case, the origin of the variety was traceable through historical records and the literature; however, this information is only available for a limited number of varieties.

WHRI, SASA and the JIC have made some progress in identifying landraces/heritage varieties in their collections. WHRI have identified 94 accessions of landraces originating from Great Britain; this is material that is known to have come from traditional agriculture or local growing areas, including material from amateurs. SASA are in the process of classifying their collections data using EURISCO descriptor 20, biological status of accession (SAMPSTAT) (Annex 8) and have achieved this so far for donated or collected (unregistered) turnip accessions (i.e., those that are not included in the list of 'B' List varieties maintained by SASA) and obsolete varieties. These accessions (unregistered and obsolete) are maintained by SASA in addition to the 'B' List varieties for which they are official maintainers. The JIC has classified a number of accessions of old cultivars of pea (*Pisum sativum*) and faba bean (*Vicia faba*) as heritage or heirloom varieties (see Box 5).

Box 5. Heritage peas (*Pisum sativum*) and broad beans (*Vicia faba*) maintained within the John Innes Collections[31]

[31] Contributed by Mike Ambrose, John Innes Centre

The John Innes *Pisum* Collection (http://www.jic.ac.uk/GERMPLAS/pisum/index.htm) and the *Vicia* Collection include many accessions of old cultivars that can be classified as heritage or heirloom varieties. While they may represent a small fraction of the overall collection they form a significant part of our collective cultural heritage.

Peas

Peas were one of the most highly prized vegetables not just because of their nutritional qualities but also for their ease of cultivation and the range of varieties that ensured a succession of fresh produce over an extended season from May to October (Ambrose, 2008). Seed catalogues from the 1800s contained many pages of descriptions of the varieties and in many, peas were placed at the front of the list (Sutton & Sons, 1852, 1899; Van Hotte, 1878–1879; E.W. King & Co., 1898). The Suttons catalogue of Vegetable seeds (Sutton & Sons, 1852) lists 53 varieties of peas compared to 14 broad beans whereas the E.W. King & Co catalogue lists 49 peas to only 8 broad beans (E.W. King & Co., 1898). Arthur Sutton in his paper on the progress of vegetable cultivation during Queen Victoria's reign, interestingly also starts with peas which he refers to as the 'Prince of Vegetables' (Stickland, 2001).

The highly inbreeding nature of peas means that once fixed, particular variants or lines were particularly easy to maintain and it is clear from descriptions and illustrations as far back as the late 1500s that peas such as parchmentless and fasciated types merited their own description and attributes (Gerard's Herbal, 1597). Prior to the rediscovery of Mendel's work on the basis of inheritance in the early years of the 1900s, there are clear references in the literature to selections being made from existing varieties as well as crossings between lines from which multiple forms were derived. In the absence of an understanding as to the underlying mechanism, the work was largely empirical and selections in segregating populations resulting from crosses would have been only fixed for major characters leaving plenty of scope for further selection in subsequent generations.

Such was the clamour for improved varieties from growers in a market where there was no restriction in seed marketing, references can be found that openly refer to the prolific development of synonyms. Sherwood (1898) noted the anomaly that "*while the number of listed varieties in catalogues was falling, the number of names of peas were ever increasing as more and more new varieties were being announced or shall I say old friends with new names*". This was a brave statement of what was a widespread practice and he goes on to say "*I need hardly say that they may easily be reduced to one fourth that number* (150) *as so many are only synonyms well known to those who test them each year: but it is not my intention to apply the pruning-knife, as I should most likely bring about my head a hornet's nest of protests from those who do not agree with me*." This from someone who was involved with the growing of nearly 700 rows of different marketed peas for comparison in1898 in his trial grounds in Essex.

A survey of the John Innes *Pisum* Collection for referenced names has revealed significant holdings relating to this period (Annex 9). The majority of these have been cross-referenced via donor or other information although this work is ongoing and will be subject to revision as further details come to light.

Faba beans

The high degree of outcrossing in faba beans means that the material has had a very different selection history to that of peas. Arthur Sutton (Stickland, 2001) reports on the popularity of cultivated forms of broad bean and recent advances but notes the slow progress in improving the crop in the middle to late 1800s noting that the improvements were almost entirely the result of selection rather than crosses. Broad beans were popular with growers and played an important role in crop rotation and animal and human diet but the range of variation was less extensive than in peas. A consequence of the breeding nature means that landrace material has continued to crop up as outcrossing and selection from progeny has occurred in farmers' self-saved seed. From this perspective landraces are not solely confined to pre-1900s.

A survey of old cultivars and landraces in the *Vicia* collection maintained at the JIC is presented in Annex 9.

Acknowledgment

The author is grateful for financial support for the John Innes Pea Collection from Defra (GCO142).

Annex 10 lists the landraces/heritage varieties[32] recorded as UK origin in the UK seedbanks housing major collections of vegetables (the HSL, the JIC, SASA and WHRI) (excluding potatoes[33]). The analysis reveals that there are 327 vegetable landrace/heritage varieties of 24 crop species that have been identified to date in the four UK seedbanks with major vegetable collections. It is important to note that the HSL and SASA maintain a larger number of landrace vegetable varieties than those listed in Annex 10. However, at the HSL the majority of records in the electronic database (79%) do not have an entry under country of origin, either because this information was not available when the sample was donated to the seedbank, or because some records have not yet been fully transferred to the database (the data exist in card files) (N. Munro, HSL, pers. comm., 2009); therefore, they are not included in the inventory. The HSL also has around 300 accessions that are either in the process of being assessed or awaiting assessment (N. Munro, the HSL, pers. comm., 2009). The SASA records do not fully reflect the extent of their landrace collections because they are in the process of identifying landrace accessions and coding them in their data management system. A large proportion (59%) of accessions identified as landraces in the WHRI collection do not have variety names recorded; therefore, only those crops for which at least one variety name is available are included in Annex 10. In cases where multiple accessions of a crop are recorded without a variety name, but identified by different donors, only one instance of the crop is included in this table to indicate that landraces of that crop are maintained in the collection.

Based on the available data (as recorded in Annex 10), Table 6 and Figure 9 indicate the number of vegetable landraces/heritage varieties currently known to be maintained by the HSL, the JIC, SASA[34] and WHRI, showing the number of varieties per crop species maintained by each seedbank. Note that apart from the record for Shetland cabbage (27 accessions), one turnip (*Brassica rapa*) variety of UK origin that has been identified as landrace material in the donated or collected (unregistered) collection and 17 in the obsolete varieties collection, all SASA records are 'B' List varieties for which they are official maintainers. Other varieties stored by SASA as part of the statutory collection of registered varieties are not included in this analysis.

[32] The use of the term 'heritage varieties' is introduced here because the JIC varieties included in the analysis have been identified as 'heirloom' or 'heritage' varieties and include some early hybrid varieties.

[33] SASA maintains the largest genebank collection of potato varieties of UK origin and is the UK DUS centre for testing for National List registration and Plant Breeders' Rights. However, currently the potato accessions are all classified as advanced varieties (even those which are fairly old—pre 1920) for the purposes of the European Cultivated Potato Database (ECPD – http://www.europotato.org) (S. Carnegie, SASA, pers. comm., 2009); therefore, they are not currently included in the vegetable landrace inventory. In a continuation project, it would be possible to search the SASA database for UK varieties which were not included in the National Lists (e.g., potato 'Shetland Black'), which would likely indicate traditional varieties (N. Green, SASA, pers. comm., 2009). Varieties which pre-date the EU lists could also give a broad idea of numbers of traditional potato varieties (N. Green, SASA, pers. comm., 2009).

[34] Including 'B' List varieties officially maintained by SASA but excluding varieties maintained as part of the statutory collection.

Table 6. Numbers of landraces/heritage varieties of 24 crop species currently known to be maintained by the HSL, the JIC, SASA and WHRI[35]

	No. of landraces/heritage varieties maintained				
Crop species	**HSL**	**JIC**	**SASA**	**WHRI**	**Totals**
Pisum sativum	17	69	7	–	93
Brassica oleracea	4	–	45	19	68
Brassica rapa	–	–	26	–	26
Vicia faba	6	7	4	1	18
Phaseolus vulgaris	11	–	3	3	17
Phaseolus coccineus	15	–	–	1	16
Allium cepa	2	–	7	5	14
Lactuca sativa	1	–	10	3	14
Daucus carota	–	–	11	2	13
Brassica napus	–	–	–	9	9
Lycopersicon esculentum	7	–	1	–	8
Allium porrum	–	–	4	1	5
Apium graveolens	–	–	5	–	5
Beta vulgaris	–	–	5	–	5
Cucumis sativus L.	1	–	3	–	4
Raphanus sativus	–	–	3	–	3
Cucurbita pepo	–	–	2	–	2
Asparagus officinalis	–	–	–	1	1
Cichorium endivia	–	–	1	–	1
Crambe maritima	–	–	–	1	1
Cucurbita moschata	–	–	–	1	1
Lepidium sativum	–	–	–	1	1
Petroselinum crispum	–	–	1	–	1
Zea mays L.	1	–	–	–	1
Totals	**65**	**76**	**138**	**48**	**327**

[35] The figures presented are based on the data available at the time of analysis. Further landrace varieties are known to be maintained in these collections but they could not be included in this analysis for reasons explained in the text.

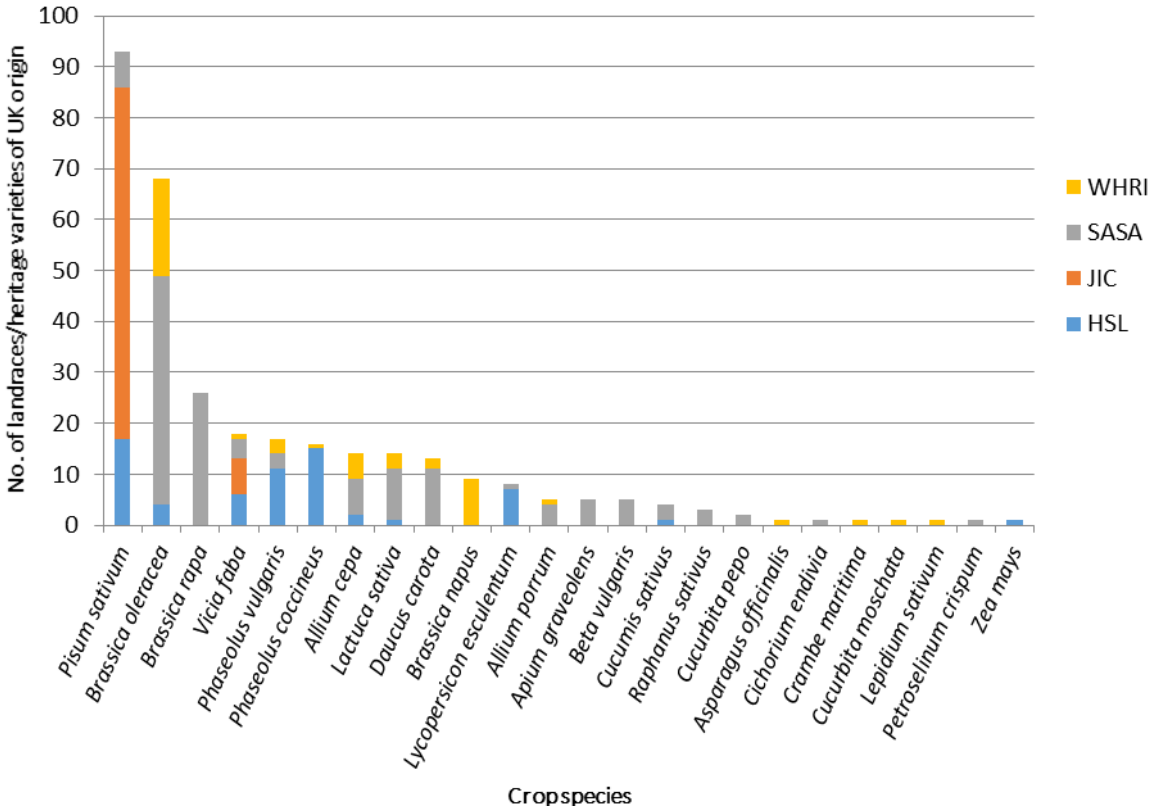


Figure 9. Vegetable landraces/heritage varieties maintained by the HSL, the JIC, SASA and WHRI of UK origin, showing the number of varieties per crop species maintained by each seedbank.

Figure 10 presents the same data, but arranged according to the number of varieties per crop using the vernacular names, rather than the number of varieties per crop species. This analysis shows the diversity of crop vernacular names recorded by the four seedbanks—some crops are undoubtedly duplicated as they are recorded with different vernacular names (e.g., WHRI has accessions of Cos lettuce, whereas at SASA, all lettuce accessions, including Cos types, are recorded as lettuce). However, only one pea variety is duplicated in two different seedbanks; therefore, the number of varieties per crop shown is an accurate reflection of the diversity of landrace/heritage vegetable material currently known to be conserved in UK *ex situ* collections[36].

Table 7 lists the vernacular names recorded by the four seedbanks, corresponding to the 24 crop species. It is worth noting that not all the species and/or vernacular names listed are subject to EU vegetable seed marketing legislation—these are annotated in Table 7.

4.3 Small-scale commercial companies maintaining traditional vegetable varieties

A number of small-scale commercial seed companies are notable as maintainers of vegetable landrace diversity in the UK; including Thomas Etty Esq. (http://www.thomasetty.co.uk/, Seeds by Size (http://www.seeds-by-size.co.uk/), The Real Seed Catalogue (http://www.realseeds.co.uk/index.html) (see Box 6) and Roguelands Vegetable Seeds Company (http://www.seedfest.co.uk/index.html). These companies produce seed for sale in small quantities to market gardeners and amateur gardeners.

As described above with reference to the wholesale seed companies, some of the small-scale seed companies also contract out some seed production to overseas companies; for example, Thomas Etty Esq. contracts out to companies in other parts of Europe and N. Africa (R. Warner, Thomas Etty Esq., pers. comm., 2009) and The Real Seed Catalogue contract out to companies in mainland Europe (B. Gabel, The Real Seed Catalogue, pers. comm., 2009). In both cases, the reason is

[36] Based on the currently available genebank records of landrace material.

economic, since seed production overseas is significantly cheaper. Carroll's Heritage Potatoes (http://www.heritage-potatoes.co.uk/) is noteworthy for maintaining traditional potato varieties—the company supplies restaurants, retailers, farmers' markets and individuals, and supplies both tubers and seed potatoes (see Box 6 and Annex 7).

Some small-scale seed companies claim only to sell 'B' List varieties, while others openly market unregistered varieties via their websites. Unfortunately, within the current project it has not been possible to obtain variety lists and associated information from any small-scale seed companies. Those that were contacted showed a keen interest in the project and in the aims of the research, but said that they were too busy to provide detailed information during the available time-frame. It is generally possible to access lists of available varieties via the company websites, but this is not usually a reliable source of information—firstly, because for those companies that sell a mixture of traditional varieties and modern cultivars, the distinction is not always clear in the seed catalogue or website list, and secondly, because without making the link with the maintainer, it would not be possible to ascertain where the varieties are being grown, in what quantities and under what environmental conditions—and importantly, whether they are varieties that have been maintained by the company for a number of years and whether they are likely to continue to grow them for the foreseeable future. Therefore, collating a list of names from seed catalogues and websites, while an interesting exercise in itself, would not contribute to the UK PGR inventory in any meaningful way. However, an exception was made for Carroll's Heritage Potatoes because almost all the varieties the company supplies are traditional varieties and it is easy to retrieve information from the company website; therefore, the list of varieties they maintain has been included in the inventory (see Annex 7). Details such as the length of time the varieties have been grown, the original source of the material, hectarage and detailed site information can only be collated by making direct contact with the grower—therefore contact should be made with the company to collate this information for inclusion in the inventory as part of a continuation project.

Box 6. Two examples of small-scale UK-based companies maintaining vegetable landrace diversity: Carroll's Heritage Potatoes and The Real Seed Catalogue

Carroll's Heritage Potatoes (Northumberland) (http://www.heritage-potatoes.co.uk/) grows over 17 varieties of Heritage Potatoes at Tiptoe Farm in the River Till Valley, Northumberland. **In addition to maintaining a number of varieties registered on the UK National Lists of Varieties of Agricultural Species (Section V), they also sell** several unregistered varieties of interest that are indicated as having a long history of being cultivated and developed in the UK, and sold as 'conservation' varieties. For example: 'Highland Burgundy Red' which "dates back to at least 1936 when it was used to add appropriate colour to a meal for the Duke of Burgundy in the Savoy"; 'Mr. Little's Yetholm Gypsy' which was "developed in the village of Yetholm, the Gypsy capital of Scotland and grown by the Little brothers, based in the Borders village" and is "the only variety to show red, white and blue in the skin"; 'Shetland Black' which "was added to the National Collection in 1923 but probably dates from Victorian times when there was a great deal of potato breeding using coloured varieties"; and 'Skerry Blue' which dates back to "before 1846" (http://www.heritage-potatoes.co.uk/).

The Real Seed Company (Pembrokeshire) (http://www.realseeds.co.uk/index.html) sells small packets of seed of a wide range of traditional vegetable varieties and some modern cultivars. Many varieties are imported from countries in mainland Europe and further afield from regions such as South America, but they also maintain a few UK varieties. The company is actively involved in variety improvement through selection and grower-based breeding and has a keen interest in creating diversity for future food security (B. Gabel, The Real Seed Catalogue, pers. comm., 2009). Uniquely, the company provides very detailed information via their website on how to select and store vegetable seeds, as well as providing advice on sowing seed the following year and on cultivation (this information is provided for each of the vegetable crops they sell). In addition, they have web pages dedicated to general information on seed saving, including useful resources and suggestions for establishing 'seed circles' to encourage more people to save and swap vegetable seeds.

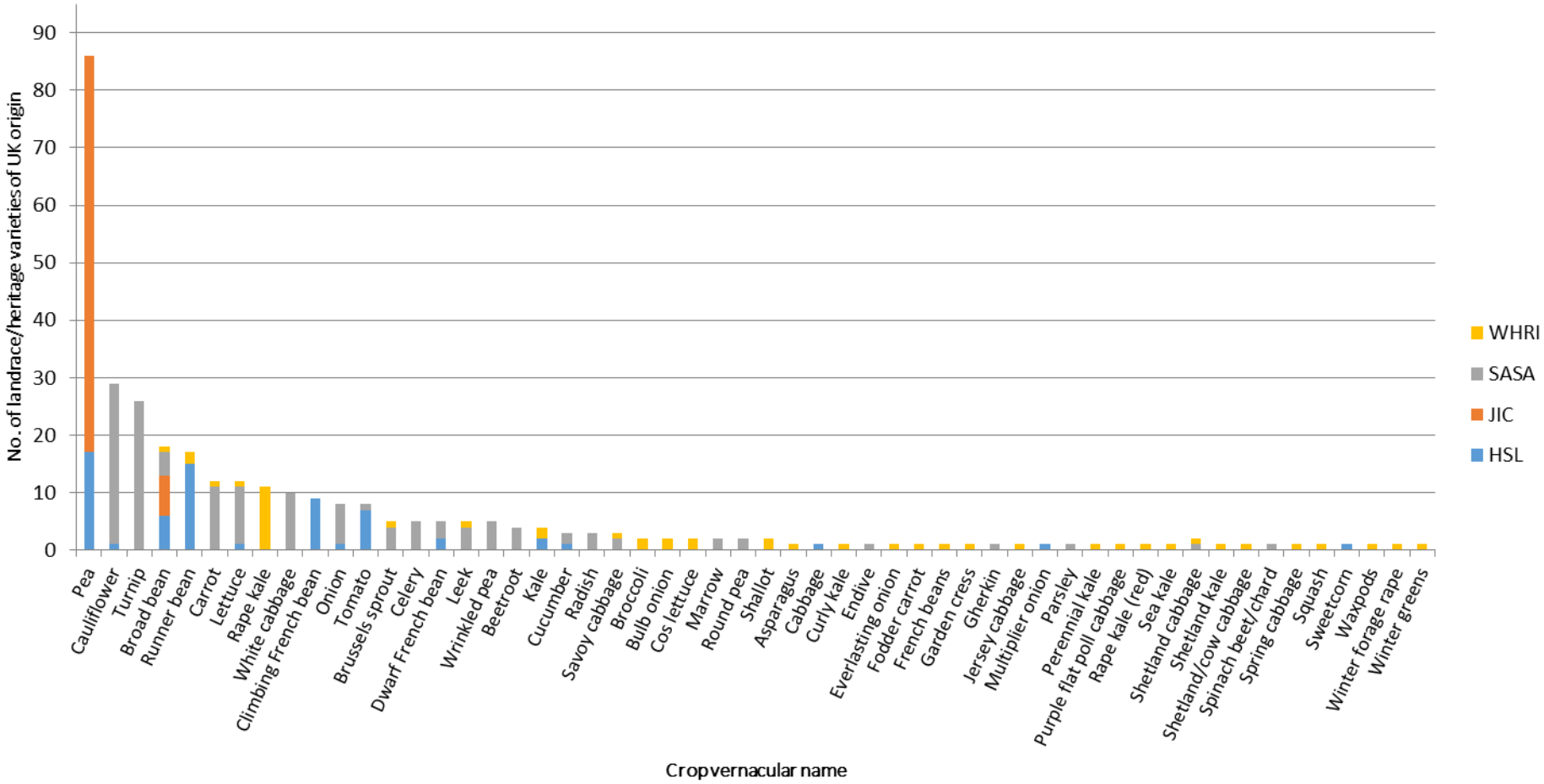


Figure 10. Vegetable landraces/traditional varieties maintained by the HSL, the JIC, SASA and WHRI, showing the number of varieties per crop maintained by each seedbank based on vernacular crop names recorded in the four seedbank database management systems.

Table 7. Crop vernacular names recorded by the HSL, the JIC, SASA and WHRI corresponding to 24 crop species of which landrace/heritage varieties of UK origin are maintained[37]. Species and/or vernacular names that are not subject to EU vegetable seed marketing legislation are indicated with an asterisk.

Genus	Species	Crop	Seedbank	Genus	Species	Crop	Seedbank
Allium	*cepa*	Bulb onion*	WHRI	*Brassica*	*oleracea*	White cabbage	SASA
		Everlasting onion*	WHRI			Winter greens*	WHRI
		Multiplier onion*	HSL	*Brassica*	*rapa*	Turnip	SASA
		Onion	HSL, SASA	*Cichorium*	*endivia*	Endive*	SASA
		Shallot	WHRI	*Crambe*	*maritima**	Sea kale*	WHRI
Allium	*porrum*	Leek	SASA, WHRI	*Cucumis*	*sativus*	Cucumber	HSL, SASA
Apium	*graveolens*	Celery	SASA			Gherkin	SASA
Asparagus	*officinalis*	Asparagus	WHRI	*Cucurbita*	*moschata**	Squash*	WHRI
Beta	*vulgaris*	Beetroot	SASA	*Cucurbita*	*pepo*	Marrow	SASA
		Spinach beet/chard	SASA	*Daucus*	*carota*	Carrot	SASA, WHRI
Brassica	*napus**	Rape kale*	WHRI			Fodder carrot	WHRI
		Winter forage rape*	WHRI	*Lactuca*	*sativa*	Cos lettuce*	WHRI
Brassica	*oleracea*	Broccoli*	WHRI			Lettuce	HSL, SASA, WHRI
		Brussels sprout	SASA, WHRI	*Lepidium*	*sativum**	Garden cress*	WHRI
		Cabbage*	HSL	*Lycopersicon*	*esculentum*	Tomato	HSL, SASA
		Cauliflower	HSL, SASA	*Petroselinum*	*crispum*	Parsley	SASA

[37] Note that WHRI records leek as *Allium ampeloprasum*. *A. ampeloprasum* var. *porrum* is a synonym of *A. porrum*; therefore, the WHRI record of *A. ampeloprasum* has been standardized to *A. porrum* in this analysis. HSL records tomato as *Lycopersicon lycopersicon*, which is a synonym of *L. esculentum*; therefore, the HSL records of *L. Lycopersicon* has been standardized to *L. esculentum* in this analysis.

Curly kale*	WHRI	*Phaseolus*	*coccineus*	Runner bean	HSL, WHRI
Jersey cabbage*	WHRI	*Phaseolus*	*vulgaris*	Climbing French bean	HSL
Kale*	HSL, WHRI			Dwarf French bean	HSL, SASA
Perennial kale*	WHRI			French beans*	WHRI
Purple flat poll cabbage*	WHRI			Waxpods*	WHRI
Rape kale*	WHRI	*Pisum*	*sativum*	Pea*	HSL, JIC
Rape kale (red)*	WHRI			Round pea	SASA
Savoy cabbage	SASA, WHRI			Wrinkled pea	SASA
Shetland cabbage*	WHRI, SASA	*Raphanus*	*sativus*	Radish	SASA
Shetland kale*	WHRI	*Vicia*	*faba*	Broad bean	HSL, JIC, SASA, WHRI
Shetland/cow cabbage*	WHRI	*Zea*	*mays*	Sweet corn	HSL
Spring cabbage*	WHRI				

4.4 Vegetable diversity maintained by NGOs and individuals

In addition to the commercial companies that maintain landrace diversity, a range of NGOs are central to the maintenance of vegetable diversity in the UK. Examples include:

- Garden Organic (http://www.gardenorganic.org.uk/) (nationwide) – Garden Organic is one of the UK's leading organic growing charities and is dedicated to researching and promoting organic gardening, farming and food. Members are mainly amateur gardeners growing vegetables in home gardens for their own use, sharing with friends and neighbours or small-scale commerce.
- Garden Organic's Heritage Seed Library (http://www.gardenorganic.org.uk/hsl/index.php) (nationwide) – The Heritage Seed Library conserves and makes available vegetable varieties that are not widely available—the collection mainly comprises European varieties. The HSL currently maintains around 800 accessions of open-pollinated varieties, of which about 200 are in the current seed catalogue, which is sent to members each year. Members can choose up to six varieties to grow each year and informal seed swaps between members also take place. HSL Seed Guardians are vital for the maintenance of the collections, being responsible for growing and regenerating 40–50% of HSL seed.
- Biodynamic farmers and gardeners (http://www.biodynamic.org.uk/) (nationwide) – biodynamic farmers and gardeners use sustainable and ethical methods. No hybrid seeds created using protoplast or cytoplast fusion techniques may be used on biodynamic farms and gardens; therefore, biodynamic agriculture and gardening relies on the use of traditionally developed vegetable varieties.
- Dyfi Valley Seed Savers (http://www.dyfivalleyseedsavers.co.uk/) (Wales) – led by HSL Seed Guardian Chloe Ward, Dyfi Valley Seed Savers are searching for vegetable varieties that gardeners have grown from their own saved seed in Wales with the aim of bringing together a collection of Welsh vegetable varieties to record their characteristics and history and make seeds available to gardeners across the country to preserve the precious diversity and heritage (C. Ward, Dyfi Valley Seed Savers, pers. comm., 2009) (see Box 7).
- Seedy Sunday (http://www.seedysunday.org/) (nationwide) – Seedy Sunday is the UK's biggest community seed swap and takes place every February in Brighton and Hove in southern England. Seedy Sunday has been taking place every year since 2002, and has now expanded to include talks, demonstrations and films on saving and growing seed, as well as on wider issues such as local food and biodiversity. Seedy Sunday campaigns to protect biodiversity and protest against the increasing control of the seed supply by a handful of large companies.
- The National Society of Allotment and Leisure Gardeners (http://www.nsalg.org.uk/) (nationwide) – allotment gardeners are undoubtedly important maintainers of traditional vegetable varieties. Many allotments have been established for several decades and there is a long-standing tradition of swapping and sharing seed amongst growers. Allotments are also important from the point of view of the diversity of ethnic origins and cultures of the people that tend them because this diversity is likely to lead to a greater diversity of crops and varieties that are maintained and developed by growers in the UK.

Box 7. Dyfi Valley Seed Savers, Powys, Wales[38]

Dyfi Valley Seed Savers (http://www.dyfivalleyseedsavers.co.uk/), based in Machynlleth, Powys, Wales and led by HSL Seed Guardian Chloe Ward, are searching for and maintaining vegetable varieties that are special to Wales. Their aim is to bring together a collection of Welsh varieties, record their characteristics and history and make the seed available to gardeners across the country. Varieties include those that have grown well in Wales for generations, the products of back-yard

[38] Based on information provided by C. Ward (Dyfi Valley Seed Savers, pers. comm., 2009).

plant breeding and traditional varieties with stories in their name. They encourage growers to carry out seed trials to increase the number of seeds available and to test varieties for their growing and eating qualities. Seedy Sunday and Seedling Saturday events are organized as a means of distributing the seed more widely.

A recent variety they have been trialling and multiplying is climbing French bean 'Melbourne Mini' (Figure 11). This variety was grown and saved by Syd Melbourne for 30 years since he was given a handful of seeds by a fellow allotment-holder in Sussex. He brought it to Wales in 2004 when he moved to Penegoes, near Machynlleth. Although the variety did not originate in Wales, it has thrived there, is productive and good to eat, and will continue to adapt to local conditions while the seed is grown and saved. Climbing French bean 'Melbourne Mini' has been grown at the Centre for Alternative Technology and continues to be grown by Syd Melbourne in Penegoes (Powys). A sample has been sent to the HSL and is awaiting assessment[39].

Figure 11. Climbing French bean 'Melbourne Mini' trial carried out by Dyfi Valley Seed Savers. *Photo courtesy of Sophie Holdstock*.

A number of individual farmers maintaining vegetable landraces have also been identified within the current project, indicating that there is still significant vegetable landrace diversity maintained by farmers throughout England and Wales:

- P. Watkin (F. Watkin & Son) grows 'Throws' winter field beans (*Vicia faba* var. *equina*) as a main crop over an area of 2.5–5 ha in Suffolk and estimates that the crop has been self-saved for 40 years or more. The beans are used on farm for cattle feed and some are also sold to other farmers for use in animal feed. Although this crop is used for fodder and is therefore classed as an agricultural crop, it is in the same gene pool as broad bean (*V. faba* var. *faba*) and is therefore important as a vegetable landrace resource. The variety was inherited and is thought to have originally been obtained from Throws Farm in Essex some time after 1940[40]. P. Watkin mainly

[39] Assessment of donated accessions involves: a) finding out as much information as possible from the donor, b) checking to see if the variety is a synonym, included in the National Lists or available from other suppliers, c) looking through historical lists/publications for information about the variety, d) growing the variety to see if it is similar to any others held in the collection, and e) characterizing and assessing the variety (day to maturity, taste, growth habit, etc.) (N. Munro, HSL, pers. comm., 2009).

[40] There are several references to winter field bean 'Throws M.S.' in the literature—this is the most likely origin of the variety that is being maintained on this farm. 'Throws M.S.' was the first synthetic (blended) commercially available winter faba bean cultivar. Developed by RHM (Agriculture) Ltd., it was constituted from four parent stocks that were originally collected from farms in Essex and Scotland. A complex breeding method was used to harness and maximize the known

grows this variety for reasons of tradition and 'sentimentality'. At one stage, he was concerned that he might have lost the variety, but managed to successfully germinate three-year-old seed and continue to maintain it. He is 'undecided' whether he is interested in the long-term conservation of the variety (questionnaire, question 12) but indicated that he would consider passing on material to another grower (question 13). He is also happy for samples to be collected and maintained at JIC[41]. (P. Watkin, F. Watkin & Son, pers. comm., 2009) It is likely that P. Watkin's son will continue to run the farm in the future (T. Watkin, F. Watkin & Son, pers. comm., 2009).

- P. Brinch grows traditional vegetables in East Sussex for seed production for supply to biodynamic farmers and gardeners, as well as growing vegetables for his own consumption. The seed carries Demeter Certification, which requires full compliance to organic standards and is fully recognized by Defra as an organic certification body (http://www.biodynamic.org.uk/demeter/certification.html). A traditional variety that this farmer has recently been developing is beetroot (*Beta vulgaris*) 'Cheltenham Green Top' (a 'B' List variety), which has good taste, high yield, good storage qualities, as well as storing well in the ground. The variety forms a cone-shaped root similar to sugar beet but narrower, with at least 80–90% of the root in the earth; the long tap root draws up important minerals and nutrition from the ground. The variety was obtained from another grower and has been grown as a main crop over an area of <0.5 ha for 1–5 years. P. Brinch is interested in the long-term conservation of the variety and would consider passing on material to a relative, another grower, a seed swap event or a seedbank. (P. Brinch, pers. comm., 2009)
- B. Lever grows traditional vegetable varieties in Norfolk and Cambridgeshire, including onion (*Allium cepa*) 'Batun', which he has been growing for 6–10 years for his own consumption. The seed of this perennial onion was passed on to him from another grower. It has good taste, provides onion flavouring for use when home grown onions are not available and can be propagated vegetatively or from seed (if kept separate from other seeding onions). The variety is "somewhere between a shallot and a Welsh onion in habit" and is "probably of little 'commercial' worth as a cash crop at present, but is very useful for anyone interested in self sufficiency" (B. Lever, pers. comm., 2009). This farmer hopes to continue to conserve the variety for as long as possible, both on the grounds of biodiversity value and its usefulness. To this end, he gives away as much propagation material as he can. (B. Lever, pers. comm., 2009)
- E. Cormack is a member of the Biodynamic Seed Growers' Group, producing Demeter Certified seed. Vegetable varieties that he maintains include parsnip (*Pastinaca sativa*) 'Avon Register' and carrots (*Daucus carota*) 'James Scarlet Intermediate' and 'Chantenay Red Cored'. He has grown each of these varieties as a main crop over <0.5ha for 1–5 years from seed originally sourced from a commercial supplier. He grows the crops at two sites—one in Hampshire and the other in Dorset. In Hampshire, he carries out selection and production of 'elite' seed, while in Dorset he bulks the seed for sale. Parsnip 'Avon Register' and carrot 'James Scarlet Intermediate'

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benefits of improved growth and vigour with respect to yield which start to decline with successive increasing levels of inbreeding in later generations. The precise details of the original Essex and Scottish farm material is not presently known but is being investigated, as are more precise details as to the specific agronomic traits that were used in the evaluation and selection of progeny rows in the breeding programme. (Lawes *et al.*, 1983; D. Bond, PBI/Unilever (retired), pers. comm., 2009; M. Pope, Breeding Consultant, pers. comm., 2009; M. Ambrose, JIC, pers. comm., 2009) However, it is clear that the original source of this crop is no longer relevant as not only was it a blended cultivar at the start, it has further crossed within itself and with other varieties grown in adjoining fields for many crop generations—nonetheless, it does represent a heterogeneous mixture from which specific lines might be drawn (M. Ambrose, JIC, pers. comm., 2009).

[41] This was indicated in a face to face interview with P. Watkin in June 2009. Currently, no samples of this crop population are conserved at JIC; however, P. Watkin will be supplying the JIC with seed samples at harvest in the current growing season (M. Ambrose, JIC, pers. comm., 2009).

are grown because of a strong market demand—the parsnip variety is disease resistant, while carrot 'James Scarlet Intermediate' is valued for its good taste. All three varieties are also grown because of historical interest/tradition. Carrot 'James Scarlet Intermediate' was historically a fodder crop (used for horses – D. Astley, WHRI, pers. comm., 2009) and has been improved by E. Cormack for human consumption (P. Brinch, pers. comm., 2009). E. Cormack is interested in variety conservation and indicated he would consider passing on material to another grower.

Varieties maintained by maintainers who responded to the survey are included in Annex 7.

4.5 Growers' reasons for maintaining vegetable landraces

As already noted, in order to develop strategies for *in situ* landrace conservation, knowledge of the socio-economic reasons underlying landrace maintenance is vital, as well as related information such as the origin of the crop material, the length of time grown and whether seed is exchanged with other growers. As part of this study, growers were asked to provide information on how long they have been growing a traditional variety, for what purpose, on what scale, where they obtained the original crop material, whether they save seed for the next cropping cycle, whether they have exchanged material with other growers, and the particular qualities of the varieties that make them want to grow them (see questionnaire, Annex 5—questions 7 to 10). They were also asked whether they plan to continue to grow the variety for the foreseeable future, whether they are interested in the long-term conservation of the variety (and why), and whether they would consider passing on propagation material to other growers or a seedbank (questions 11 to 13). While relatively few questionnaire responses were received (see discussion, section 4.4), it is possible to provide a preliminary indication of why maintainers value traditional varieties and their views on their long-term conservation; however, a larger sample is needed to draw firm conclusions from answers to the other questions. Note that in a more detailed study, further socio-economic data need to be recorded, as suggested in the draft descriptors for the management of data associated with the maintenance of UK landrace/traditional variety data (Annex 1).

Figure 12 shows the qualities assigned to traditional vegetable crop varieties by survey participants and as drawn from the 2009 seed catalogue of E.W. King & Co. and the website of Carroll's Heritage Potatoes. Apart from the 'other' category which was assigned to 37% of the varieties, the highest number of varieties was recorded for good taste (26%), followed by historical interest/tradition (15%), high yield (13%), strong market demand (3%), good storage (2.5%), disease resistance (2.5%) and pest resistance (1%). It is notable that out of the 248 varieties of 24 crop taxa included in this analysis, very few traditional varieties are recorded for disease or pest resistance, while a high proportion are recorded as having good taste. The qualities recorded for the two commercial seed companies included in the analysis may change when provided by the company themselves; for example, some may be recorded by the company as being grown due to 'strong market demand' but without company input it is not possible to make this assumption. 'Other' qualities include good texture (e.g., beetroot 'Crimson King' and Savoy cabbage 'Best of All'), winter hardiness (e.g., broad bean 'Aquadulce Claudia'), early cropping (e.g., pea 'Early Onward' and 'Feltham First'), good for exhibition (e.g., parsnip 'Tender and True' and carrot 'St. Valery'), attractive/interesting colour (e.g., potato 'Highland Burgundy Red', tomato 'Tigerella' and Brussels sprout 'Red Rubine'), long roots (e.g., radish 'French Breakfast 3' and parsnip 'Hollow Crown') and long pods (e.g., broad bean 'Masterpiece Green Longpod' and 'Bunyard's Exhibition').

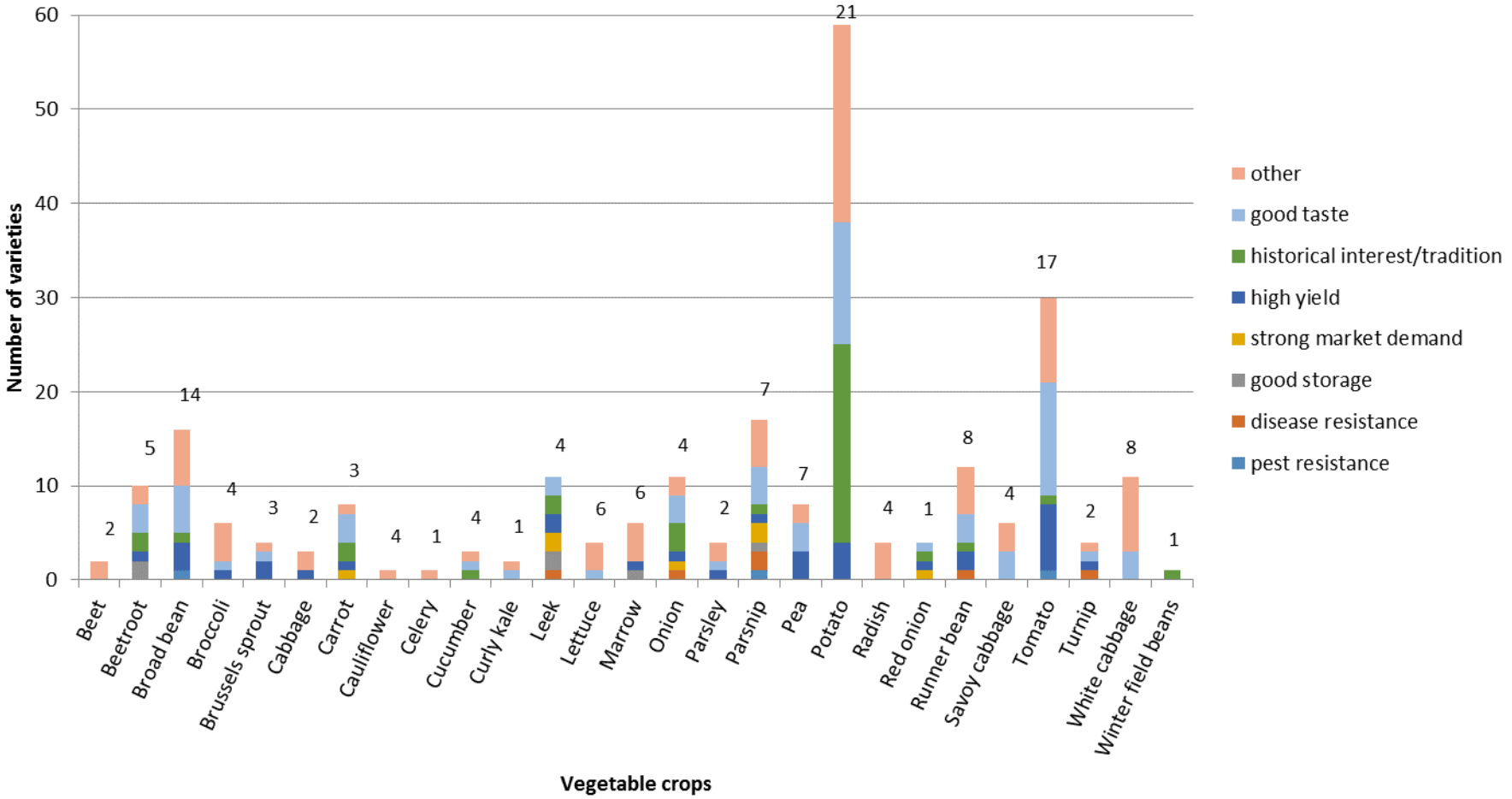


Figure 12. Qualities assigned to traditional vegetable varieties recorded in the project survey, showing the number of varieties recorded for each crop according to the different qualities assigned. Note that some varieties were recorded with multiple qualities—the total number of varieties recorded in the survey for each crop is shown above each bar.

All survey participants consulted stated that they were interested in the long-term conservation of the traditional varieties that they grow, except for one individual farmer who was 'undecided'.

4.6 Discussion

4.6.1 *In situ* maintenance of English and Welsh vegetable landrace diversity

Figure 13 shows the names and locations of some of the commercial companies, NGOs and individuals maintaining vegetable landrace diversity *in situ* in various counties of England and Wales that have been identified within the context of the current project. Details of their activities and examples of vegetable landraces that they maintain (if available) can be found in sections 3.1 (W. Robinson & Son Ltd., Church of Bures and E.W. King & Co.), 3.3 (Carroll's Heritage Potatoes and The Real Seed Catalogue) and 3.4 (Dyfi Valley Seed Savers, F. Watkin & Son, P. Brinch and E. Cormack). Detailed information, including variety lists were not forthcoming from all the maintainers included, but in each case, the respondent showed a keen interest in participating in the research, and given more time, further information could undoubtedly be obtained.

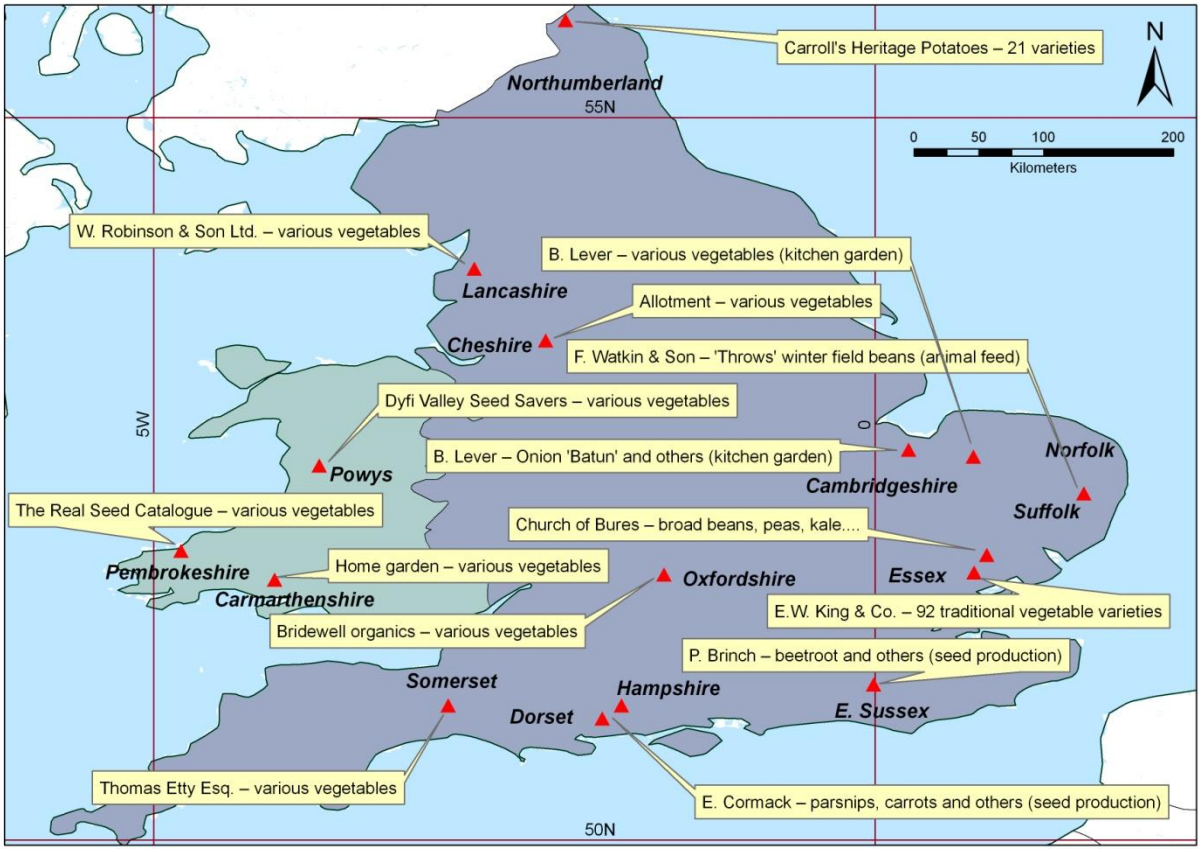


Figure 13. Commercial companies, NGOs and individuals maintaining vegetable landrace diversity in various locations of England and Wales that have been identified in the current project[42].

The three commercial seed supply companies (W. Robinson & Son Ltd., Church of Bures and E.W. King & Co.) who are official maintainers of 'B' List varieties, are notable as *in situ* maintainers of UK vegetable landrace diversity, as are a number of other commercial companies. All the varieties that W. Robinson & Son Ltd. maintain are landraces or traditional varieties and are selected and regenerated *in situ* in Lancashire—many of the varieties have been maintained in the same location for several decades (M. and S. Robinson, W. Robinson & Son Ltd., pers. comm., 2009). Church of Bures maintain most of their traditional vegetable varieties in the eastern counties of the UK, though a small proportion of seed regeneration is contracted out to overseas companies (G. Lakin,

[42] The location indicated for Church of Bures is not the actual location where the crops are maintained. The company maintains vegetable varieties in four counties: Suffolk, Essex, Norfolk and Cambridgeshire.

Church of Bures, pers. comm., 2009), and while E.W. King & Co. contract most seed production to overseas companies, the varieties are effectively maintained in the UK in stock seed plots from which selection of mother seed is carried out[43]. Carroll's Heritage Potatoes maintain a range of landrace varieties *in situ* in Northumberland, The Real Seed Catalogue in Pembrokeshire and Thomas Etty Esq. in Somerset. While the latter two companies also contract out seed production to overseas companies, we assume that stock seed is maintained and selected in the UK[44]. In addition to being key *in situ* maintainers of vegetable landrace diversity, these companies are also fundamental to vegetable landrace conservation by making seeds available to both professional and amateur growers, and their existence and success is evidently a reflection of the ongoing demand for vegetable landrace seed. Indeed, small commercial companies that supply local vegetable seed were highlighted by Crisp and Ford-Lloyd (1981) as a rich source of genetic diversity. However, a major threat to the continued maintenance of vegetable landraces by UK-based seed companies is the fact that they face competition from overseas companies marketing seed at lower prices—presumably as a result of EU vegetable seed marketing legislation. Maintenance of landraces by seed companies requires a high input of resources and is costly; with competition from overseas companies, it is becoming increasingly difficult to justify the continued maintenance of these varieties due to the costs involved (P. Miller, E.W. King & Co., pers. comm., 2009). According to P. Miller, many varieties sold in the UK by overseas companies are of inferior quality and are not true to type. It appears that there is currently no means of solving this problem but the issue needs to be addressed since companies such as E.W. King & Co. are key maintainers of UK landrace diversity. Furthermore, smaller seed companies are increasingly being taken over by larger international companies, which are more focused on supplying seed of varieties that are suitable for cultivation over a wider area, with the result that local varieties may become obsolete (Ford-Lloyd and Jackson, 1986).

Maintenance of vegetable landrace diversity by a number of NGOs and individuals (see section 3.4) is largely indicative of a resurgence in interest in growing traditional varieties that has been taking place since the 1970s when the Henry Doubleday Research Association (HDRA – now Garden Organic) started to campaign against the Plant Varieties and Seeds Act that led to the inception of the National Lists, and the Heritage Seed Library was conceived (Gear, 1998). In the wake of the pioneering work of HDRA, a number of NGOs were established that shared the same concerns and ideals, such that there are now many networks and groups in England and Wales organizing seed and plant swap events, educating growers about the value of traditional vegetable diversity and encouraging and supporting them to save their own seed.

Biodynamic farmers and gardeners are also notable as a key group maintaining vegetable landrace diversity as the use of hybrid seeds created using protoplast or cytoplast fusion techniques is disallowed and they therefore depend primarily on the use of traditional varieties, since these techniques are used for the production of many hybrids. The BDAA is also "working to develop a sustainable on farm plant breeding program, increase the availability of high quality seed varieties suited to organic growing conditions and encourage the establishment of a cooperative network of biodynamic seed producers"; further, "the breeding and development of appropriate site adapted varieties is of vital interest to biodynamic farmers" (http://www.biodynamic.org.uk/about-bdaa/aims-and-objectives.html). Two of the individual farmers identified in this project farm biodynamically and are involved in the development of varieties for biodynamic seed certification—two varieties that they have been improving are 'B' List varieties. One was historically used as a fodder crop (carrot 'James Scarlet Intermediate') but has now been improved for human

[43] While G. Lakin (Church of Bures, pers. comm., 2009) and G. Campbell (SASA, pers. comm., 2009) note that it is unlikely that one cycle of regeneration of seed in a different environment will have a marked effect on genetic variation within the varieties (although peas may be an exception – G. Lakin, Church of Bures, pers. comm., 2009), the seed that is sold each year will presumably have been affected to some degree by the environment in which it has been regenerated.

[44] This needs to be verified with those companies.

consumption. These improvements may have resulted in a significant change in the characteristics of the varieties, representing a shift away from the original material as maintained in the *ex situ* reference collections. Without assessment of these populations, it would not be possible to know whether these changes are within the accepted range of variation of the original varieties; nonetheless, collection of material from these populations for *ex situ* storage would be beneficial in order to ensure that any unique adaptations are captured.

Allotments are also likely storehouses of vegetable diversity since many have been established for several decades and there is a long-standing tradition of swapping and sharing seed amongst growers. The increase in uptake of allotments by the younger generation may be positive for vegetable landrace conservation as the traditional varieties grown by the older generation are more likely to be passed on to the next generation.

Other individual maintainers have also been identified who grow landrace vegetables for reasons of historical interest/tradition and/or because they recognize the value of the varieties for their own food security and biodiversity value. These include farmers, smallholders, market gardeners, allotment-holders and home gardeners.

4.6.2 Ex situ maintenance of UK vegetable landrace diversity

Results of this research indicate that four UK seedbanks are primarily responsible for the *ex situ* conservation of UK vegetable landrace diversity—the HSL, the JIC, SASA and WHRI—collectively, they hold at least 327 vegetable landrace/heritage varieties[45] of 24 crop species (Annex 10). However, we know that more landrace/heritage varieties are maintained in these collections and once they have been identified and coded as landraces and/or as material of UK origin, they can be included in the landrace inventory. The current analysis indicates that there is little duplication between collections, although this requires verification through further research, mainly because of missing data and a lack of standardization of data management between seedbanks. WHRI, SASA and HSL have already made progress by compiling a list of all accessions in their collections under the (unfunded) UK Vegetable Inventory Project (N. Green, SASA, pers. comm., 2009).

Although the current project is concerned primarily with creating an inventory of English and Welsh landraces, apart from the HSL, the seedbanks maintain varieties using ISO codes 'GBR'[46] or 'UK', with no indication of whether the material is from England, Wales, Scotland or Northern Ireland; therefore, it is not possible to identify the precise origin of varieties maintained by these seedbanks without further research, which will involve access to additional data where available. It is important to stress that the identification of vegetable landraces of UK origin is not 100% reliable and does not necessarily indicate that a variety was developed in the UK. This may be because the information was not available when material was donated to a seedbank or simply that the origin is unknown because movement of vegetable seeds around the world has led to a high degree of uncertainty as to the true origin of varieties. Nonetheless, in the absence of a clear history of a variety, it is often possible to make an educated guess.

One of the objectives of the current project was to initiate the process of obtaining seed samples of varieties not already conserved *ex situ*. Survey respondents were asked whether they would consider passing on seed of the varieties they grow to a seedbank and the majority of respondents that completed the survey answered 'yes'. It was recommended at the experts' meeting that for any new landrace material added to *ex situ* collections it should be made clear to the maintainer from the outset that once material is deposited in a seedbank it will be available for distribution and use. It was also agreed at the experts' meeting that if any respondents to the survey should ask for information about the potential use of the germplasm, they would be put in touch with the appropriate seedbank(s). This question did not arise; however, in one case a commercial company

[45] 'Heritage varieties' include some early hybrid material of peas and beans that have been included in the analysis from the JIC collection.

[46] 'GBR' is the standard country code used for the National Inventory, which feeds into EURISCO.

that was interviewed indicated that they believe *ex situ* conservation of landrace diversity in seedbanks to be of little value and that *in situ* grower-based breeding is the key to the maintenance, increase and continued availability of vegetable diversity, and to future food security. Presumably, their reason for stating this is because varieties maintained *in situ* are constantly changing and adapting to the local environment and to the needs of the grower and/or consumer; however, their reasoning was not clear and could have been based on a lack of confidence in seedbank management and/or that fact that seedbanks provide germplasm to the formal plant breeding sector and in their view this results in the production of more F1 hybrids and greater homogeneity of our crops.

4.6.3 Maintenance of 'B' List vegetable varieties

The UK National Lists of Varieties of Vegetable Plant Species 'B' List contains 345 varieties of 20 crop species of non-hybrid origin, including approved maintenances. Some of these varieties were introduced to the UK prior to 1973 when the 'B' List was published, but their continued maintenance in the UK for almost four decades is justification enough for their inclusion in the inventory. Collectively, these varieties are therefore an important component of UK PGRFA and those that remain commercially viable may be considered as the 'stalwarts' of the vegetable varieties grown in the UK prior to the inception of the 'B' List in 1973. While we do not have a consolidated list of all landrace/traditional vegetable varieties maintained in the UK prior to the 1970s, the 'B' List provides a useful benchmark for monitoring the continued maintenance of this subset of UK landrace diversity in future years. We already know that some of the current 'B' List varieties maintained by commercial companies are destined for the commercially obsolete list, partly due to a fading market, but also because of competition from overseas companies marketing seed in the UK.

The 'B' List varieties are officially maintained by 40 companies, 20 of which are based in the UK. SASA is the official maintainer of 42% of 'B' List varieties of non-hybrid origin[47] and a significant proportion (38%) is officially maintained by three commercial seed companies—E.W. King & Co. Ltd. (22%), A.L. Tozer Ltd. (12%) and W. Robinson & Son Ltd. (4%). The remaining 84 varieties (24%) are officially maintained by 27 companies, 12 of which officially maintain only one variety. [48] The dependency on only three commercial seed companies to officially maintain a significant proportion of 'B' List varieties could present a significant threat to UK vegetable landrace diversity because there is always a possibility that the companies may cease trading. W. Robinson & Sons stated in response to this survey that if they ceased trading they would pass on stock to a seedbank (M. and S. Robinson, W. Robinson & Son Ltd., pers. comm., 2009), while E.W. King & Co. Ltd., official maintainers of 22% of 'B' List varieties are aware of the conservation value of the varieties that they maintain and stated that they send seed samples of discontinued varieties to one of the UK's gene banks—usually Garden Organic's HSL (P. Miller, E.W. King & Co. Ltd., pers. comm., 2009). Both of these companies are well-established, having been in business for nearly 150 years and over 120 years, respectively; therefore, the chances of them failing in business might be considered low. However, the commercial seed market could potentially change rapidly—for example, as a result of climate change many varieties may no longer be suitable for cultivation and this in turn could impact on the commercial viability of smaller seed companies—unless seed is collected and maintained *ex situ*, this could result in a significant loss of crop genetic diversity when companies cease trading.

It is also important to stress that some official 'B' List variety maintainers also maintain other 'B' List varieties for which they are not listed as official maintainers; however, monitoring the

[47] A recent major review of the 'B' List revealed that some former maintainers had either gone out of business or no longer wanted to maintain the varieties. SASA took on maintenance of varieties of non-hybrid origin for which they had samples in the reference collection.

[48] Some varieties are maintained by more than one company.

continued maintenance of these varieties by these companies will be more difficult than those that are officially maintained because we first need commercial companies to be forthcoming with lists of landrace/traditional varieties that they maintain and once such a list is established, it will require periodic review and updating and this will again rely on voluntary compliance by the companies involved. The fact that only four of the 34 official 'B' List variety maintainers responded to the current survey illustrates how problematic monitoring the maintenance of 'B' List varieties maintained by commercial seed companies might be. However, it should be noted that this survey was carried out at a particularly busy time of the year for seed companies; therefore, given more time to follow up with the survey by contacting companies by telephone and email would undoubtedly result in a much higher response rate. Further, a semi-formal mechanism to periodically review the maintenance of landrace vegetables by commercial seed companies could be put in place and, once established, may help to overcome this challenge.

As already noted, during a recent major review of the 'B' List, a number of companies stated that they no longer wished to act as official maintainers of 'B' List varieties. The reasons for this may be because a) the varieties are no longer commercially viable, b) the company has gone out of business, or c) the individual maintainer has passed away (G. Campbell, SASA, pers. comm., 2009); however, this does not necessarily mean that the varieties are no longer maintained in the UK, either by another company or individual growers. For example, we know that around 1000 unregistered vegetable varieties are being sold by companies in the UK in small seed packets—much via the internet (J. Edgley, Fera, pers. comm., 2009). We do not know how many of these varieties are unique as some are likely being sold under synonyms in the marketplace; however, as a precautionary measure, it would be wise to secure samples of as many different named varieties as possible *ex situ*, with a view to carrying out characterization at a later date—otherwise, we could be overlooking the conservation of unique genetic diversity that is as yet unidentified[49]. Further, these unregistered varieties are of particular interest if they are being subjected to grower selection and seed saving in the UK—especially those that have been maintained here for a significant period.

5. Forage Inventory

5.1 Background

Wild white and red clover, perennial ryegrass and timothy are native to the UK and almost ubiquitous. From this genetic source, several landraces have been developed by local seed growers, especially in South-East England which proved to be very suitable for clover seed production (Haggar and Holmes, 1963). North-Western Europe is considered a centre of diversity for grasses (Zeven and Zhukovsky, 1975). Grasses are one of the few landraces that can hybridise with native wild relatives in the UK, this is especially important as temperate forage grasses are outbreeders. Cultivated forms will actively introgress with wild forms leading to a gradual transition from the wild relatives of grasses through natural and semi-natural grasslands to sown grassland (Tyler, 1978). For this reason, no clear-cut division between ecotypes and landraces is possible.

Domestication of forages in Europe has an extensive history: (Dutch) white clover seed was traded from the end of the 16th century (Zeven, 1991) and was introduced into the UK at the end of the 17th century. Considerable quantities of clover seed were grown by local farmers in Southern England. Many local varieties were produced by natural selection as a result of continuous growing on the same farm year after year. These became stabilised into valuable commercially, distinctive forms

[49] Such as approach could be costly and time consuming; therefore, initial research to compare the genetic diversity between available varieties for a selection of crops from each of the major groups (roots, leafy vegetables, legumes etc.) would be a beneficial first step.

(Sneddon, 1980). However, before the 1900s little grass seed was grown in England, at that time Cambridgeshire was the most important county for the production of ryegrass (Sneddon, 1980).

The early 20th century saw a wide diversity of local commercial forage landraces, as documented by local seed catalogues. For example, Townsend's seed catalogue from 1936 lists the following local varieties: two red clovers, two cowgrasses, three wild white clovers, one sainfoin and one English trefoil, while Williams (1945) lists six clover landraces commercially available. In 1961 eight British sainfoin varieties were on trial at the Welsh Plant Breeding Station, these included five of the common type: Vale of Glamorgan, Cotswold, Hampshire, English and Eastern Counties, and three of the Giant type: English I, English II and Woodford (Evans, 1961).

Forage landraces were closely connected with local seed growers, for example in 1943 there was a Cornish Marl Clover Growers Association; Devon Seed Growers Association; South Western Seed Growers Association; Montgomeryshire Late Flowering Red Clover Association; Vale of Clwyd Seed Growers Association; South Western, Cambridgeshire and Cotswold Seed Growers Association and the Essex, South Western, Cambridgeshire, East Suffolk and Cotswold Seed Growers Association (Sneddon, 1980). Therefore there was a close link between seed supply specifically for the local market. In 1955 there were 830 herbage seed growers with a total of 26,000 acres under cultivation. This was the first year of the National Certifying Authority and 90% of eligible crops were entered in the certifying scheme.

Seed certification in its early days facilitated the retention of local seed origin and thus maintenance of the character of these landraces. The principle adopted at this time was that morphological criteria alone were not the only base for certification (Sneddon, 1980), historical evidence and details relating to origin were also relevant "because they depended on adaptation to a particular environment, seed production should be confined entirely to a defined area and be subject to traditional management to ensure maintenance of the type" (Sneddon, 1980).

The inclusion of ecotypes and local varieties or landraces is visible in the earliest formal breeding programs. Formal breeding of forage grasses in the United Kingdom started in the 1920's with selections based on indigenous pastures (Tyler, 1978). An example of an early WPBS cultivar is S.23, a cultivar consisting of several indigenous perennial ryegrasses populations, which so variable that the variety proved to be highly unstable (Humphrey, pers. comm).

In the 1960's exotic material was introduced into the breeding programs at Aberystwyth. Targeted collection missions commenced in 1963 with the establishment of the Plant Introduction Unit. In these missions both foreign primitive cultivars and wild relatives were collected in order to capture a wider range of climatic ecotypes for the breeding program (Tyler, 1978). An overview of the IGER collection missions is given by Humphreys (2003). In the 1970, highly bred synthetic clover cultivars started to replace local varieties or ecotypes (Woodfield and Caradus, 1994). This trend is reflected in forage seed imports compared to home grown seeds shown in Table 8; the vast majority of varieties are now imported cultivars, with the exception of perennial ryegrass.

Table 8. UK grown versus foreign forage seed sown in 2002 (Data source: DEFRA, 2003).

Species	UK grown seed (tonnes)	Imported seed (tonnes)
Timothy	30	467
Perennial ryegrass	5077	8433
Red clover	15	126
White clover	9	338

Associated with this movement away from UK forage seed production and replacement of native with exotic varieties is the genetic erosion in grasslands in the UK in the form of the continuing loss of traditional permanent grassland or landraces (Sackville Hamilton, 1999). Management practices

have changed to high input-high output agricultural systems with new cultivars, new machinery and practices as constant ploughing and reseeding for improving production (Chorlton pers. comm. quoted in Camacho Villa, 2003).

The five forage landraces found in this assessment are each at least 80 years old and have been developed by local seed growers without intervention of formal breeding programmes. These forages have a distinct local area of origin although current actual seed production may be wider. Their survival on the UK National List is remarkable in comparison with for example The Netherlands where Fries-Groninger clover, the last Dutch landrace, was removed from the Dutch National List in 1979 (Zeven, 1991).

5.2 Results

Kent Wild White Clover: is probably the widest known English landrace. It was first certified in 1930 (Caradus, 1986). Kent Indigenous, a perennial rye grass was developed in the same area. Kent White Wild Clover is one of the oldest UK indigenous forages on the National List. In 1940 the Kent Wild White Clover Perennial Grass Committee was formed. It was a model for herbage seed certification (the so called Kent Scheme), and has been used as control variety for VCU herbage trials and as control in scientific trials (Sackville Hamilton *et al.*, 1978). Between 1943 and 1960 between 1000 and 3000 acres of Kent Wild White Clover were seed harvested with an estimated total yield ranging from 14 to 105 tonnes per year (Haggar and Holmes, 1963). Currently seed production is restricted to four or five growers on Romney Marsh and seed production in 2003 was 0.5 tonnes (Holiwell, pers. comm.). Kent Wild White was on the DARD Recommended List for 2002-2003.

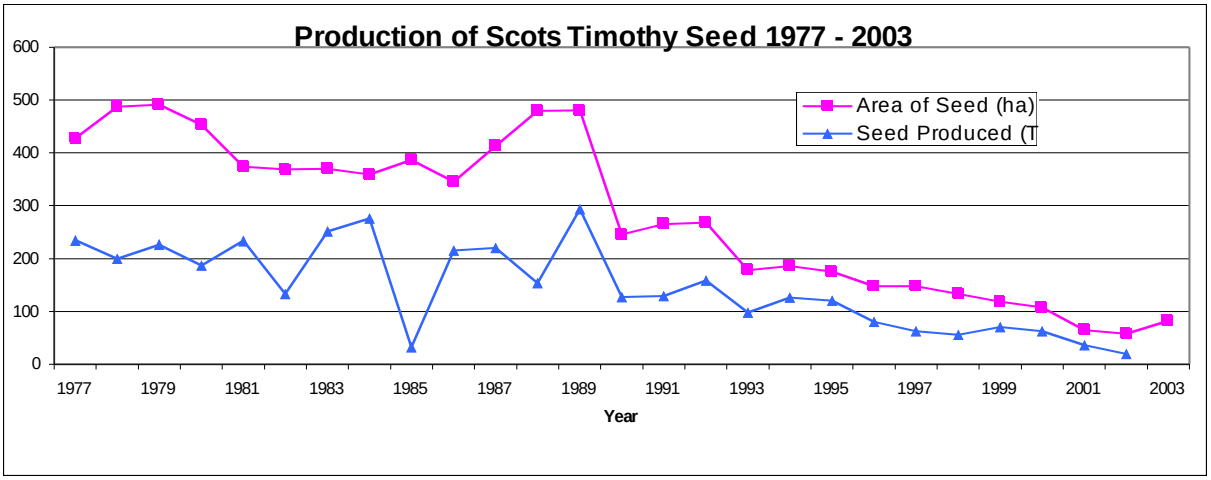
Kersey white clover: was resurrected from 17 kilos of seed that remained after a period of no production (T. Church, pers. comm.). It is currently maintained by the seed company Church of Bures. It was first developed in 1924 from a single plant in a Lucerne field near Bury St. Edmunds by Mr. E. Partridge (Hawkins, 1967). In 1946 Mr. Partridge's son gave it to the West Suffolk Seed Growers Association. In 1951 NIAB approved of filed inspection of Kersey and in 1956 Kersey White Clover was admitted as eligible for the production of British Certified Seed. In 1963 the Eastern Region Clover committee was formed which recognized that seed for Kersey can be multiplied anywhere east of a line along the Thames, the Great North Road and the river Ouse from St. Neots (Hawkins, 1967). At the time Hawkins was writing, about 1000 acres of it were grown annually. Seed production of Kersey was 0.9 tonnes in 2003.

Essex Broad Leaved Clover is another old local variety maintained by Church in Bures and traded over more than 70 years (Church, pers. comm.). It is the only surviving type of the English Broad Leaved clovers. There was no seed production in 2003.

Scots Timothy was in danger of being lost after the Second World War due to the widespread introduction of exotic stocks. At that time, public breeding efforts were geared towards upgrading Scotland's marginal arable and rough grazing land. The Scottish Plant Breeding Station grass' program was "predominantly directed towards selection of land races that were judged to be most suitable for growing in Scotland' (Gregor 1971). A certification schedule was set up in co-operation with the West of Scotland Agricultural College and James Gray & Coy Ltd. and a regional race of timothy was marketed as 'Scots' timothy (Gregor, 1971). Scots is currently produced by a small grower's co-operative, the Scots Timothy Seed Growers Association (STSGA). In 2003 it was still on the National List and on the SAC Recommended List for Scotland. Almost 20 tonnes of seed were produced in 2003 but production has been in steady decline since the early 1990s as can be seen from Figure 14.

Kent Indigenous perennial ryegrass: is still a higher seed production ley grass which might reflect the stronger position of home grown perennial ryegrass compared to clovers (as can be seen from Table 2).

Figure 14. Production of Scots Timothy Seed 1977 – 2003 (Scots Timothy Growers Association, 2003).



Sainfoin landraces

Sainfoin has been cultivated in the UK since the 18th century and was used as a source of high quality hay (Koivisto and Lane, 2001). There have been several historical landraces of sainfoin in two basic forms: 'common' types such as Cotswold Common, Hampshire Common, Essex Common, Cambridge Common, and Vale of Clamorgan Common, and the taller 'giant' type, such as Hampshire Giant and English Giant (Koivisto and Lane 2001). In the current assessment, Cotswold Common and Hampshire Common were found in cultivation. The Cambridge Common landrace has been observed for many years in weedy form in Cambridge (Edmunds, pers. comm.). There is also anecdotal evidence that one of the Giant landraces may still be grown. Neither the Hampshire nor Cotswold Common are currently certified but both have been in the past. Both were tested for agronomic performance in Aberystwyth in 1961 (Evans, 1961).

Hampshire Common is currently grown on the Cholderton Estate in Hampshire (www.cholderton-sustainable.com), where it has been cultivated and seed saved since 1720. Currently on the estate 440 hectares are cultivated in a legume/ grass ley – cereals rotation. Four to five tonnes of seed are produced on average per year, the seed being harvested with combine and cleaned off-farm then planted in the following year. The delisting of Hampshire Common in the 1980's illustrates the difficulties of local landraces in the National List system. In the early eighties only one maintainer and one grower for Hampshire common was left and he contacted NIAB concerning the certification fees:

> *I have come up with a considerable problem because the costs of certification are so enormous that it makes it quite uneconomic for me to certify a field each year. I believe that it is in the National Interest that Hampshire Common Sainfoin is kept on the lists. Do you think the N.I.A.B. could assist me in some way? It seems grossly unfair to me that I, as a dedicated grower, should be expected to pay the same charges as a commercial seedsman. (15th March 1978).*

NIAB was unable to offer assistance and in 1984 Hampshire Common was delisted and so made unavailable to other potential maintainers / users.

Cotswold Common is currently used in Conservation Mixtures and seed is produced on 8 hectares with a seed production of 250 kg per year and marketed as part of a conservation mixture

(www.cotswoldseeds.com). Without probably realising it, some 140 UK farmers are growing landraces as part of their Countryside Stewardship Scheme (Hill, pers. comm.). As with Hampshire Common, the survival of Cotswold Common is entirely ascribed to a single grower's enthusiasm for the landrace.

Research into sainfoin cultivars is currently undertaken by Forages Legume group of the British Grassland Society in a variety trial (Koivisto and Lane, 2001). Only one UK sainfoin landrace has been conserved *ex situ*, the EURISCO database shows two accessions of Cotswold Common are conserved *ex situ* but neither of these is in the UK. Both landraces are, however, conserved in the statutory reference collection of DARD at Crossnacreevy. These statutory collections are not accessible as the legal position of their collections is unclear. However, seed from the Cholderton Estate was sent to the Millennium Seed Bank for conservation in 2000.

Since the start of clover breeding in the 1930's, more than 250 synthetic cultivars and 'ecotypes' of white clover alone have been released, with a sharp increase since 1970 (Woodfield and Caradus, 1994). During this time the older selections and ecotypes have been superseded by cultivars (Woodfield and Caradus, 1994). The long-term future of the five currently commercially available landraces is uncertain to doubtful, see Table 9. For Kent White Wild Clover, Kent Indigenous and Scots Timothy hard decisions are currently being taken about their maintenance on the National List (Holliwell pers. comm; Muirhead, pers. comm).

Table 9. Overview of forage landraces seed production (DEFRA, 2003).

Landrace Name	Tonnes/Year 2003	Number Of Growers	Trend
Kent wild white clover	0.5	4-5	Decline
Kersey clover	0.9		Unknown
Essex broad Leaved Clover	2049 (2002)		Variable
Kent Indigenous perennial ryegrass	10-15	7-8	Decline
Scots Timothy	19.8 (2002)	9	Decline
Hampshire Common	4 - 5	1	Not marketed
Cotswold Common	0.25	1 – 2	Increasing

For the former two, a complex of factors was mentioned to describe their decline[50]. The clover needs heavy grazing by sheep, hence its survival is dependent on sheep and declining sheep production is one factor. Along with changing agricultural practices; contemporary farmers are less willing to undertake herbage seed production in general, so that when it comes to generation change on a farm, the younger generation stops the seed production. Seed of Kent White Wild Clover is relatively expensive to produce and has to compete with cheaper seed from abroad. The unpredictability of British weather and hence British seed production was also cited as a reason for decline, lack of pollination is thought to be a limiting factor. The latter two factors are also believed to impact on Scots Timothy: competition with cheaper foreign seed and the unpredictability of British weather making yields haphazard. Two problems, mentioned by more than one forage seed producer was scale of production and the UK weather, both do not favour UK forage seed growers as foreign seeds are grown on larger scale and under more reliable weather conditions. Another factor influencing future seed production of all of these landraces is the current CAP reform. The replacement of the Seed Production Aid subsidies (see Table 10) by the Single Payment planned for 2005 may be considered by many farmers to present another disincentive for seed production.

[50] Kindly listed by Mr. Allan Holliwell, The Holliwell Seed and Grain Co Ltd.

However, inclusion of landraces in Countryside Stewardship Scheme has been suggested as a new marketing opportunity.

Table 10. Overview of current aid rate £ (pounds) per tonne (DEFRA, 2003).

Crop	£ aid per tonne
Sainfoin	139.52
Red clover	372.40
White clover	522.92
Perennial ryegrass	215.75
Timothy	581.74

6. Accessing landrace information: challenges and successes

The results of this project can be used to inform future research into UK landraces and the continued development of the PGRFA inventory. Importantly, some key lessons have been learned about gaining access to landrace information, as outlined below.

Different people have different definitions of 'landrace'

Undoubtedly the first question that arises when making contact with individuals to gather information about landraces is 'how do you define a landrace?' While it is both interesting and important to discuss different definitions of 'landrace', the decision was made at the experts' meeting to keep an open definition from the outset of the project in order to capture as wide a range of genetic diversity in the inventory as possible. A range of terms may be used for varieties that come under the general umbrella of the material that we are interested in conserving; such as 'traditional', 'heritage', 'heirloom' or 'old' varieties, and these may include a few very early hybrid varieties (such as those identified in the JIC collections – see section 4.2, Box 5), as well as open-pollinated varieties that may not necessarily have been grown and developed in the same place for several generations, but are nonetheless varieties that are likely to contain a broad range of genetic diversity and are therefore of interest to UK agriculture and horticulture. Therefore, the precise definition of 'landrace' is not an essential prerequisite to the conservation of PGRFA genetic diversity, but what is important is to ensure that the individuals contacted and involved in the research are clear about the meaning of 'landrace' by giving a clear explanation of the scope of the inventory in printed materials, in email correspondence and when speaking to individuals by telephone. The definition of 'landrace' is also discussed in section 2.2.

Landrace identification in UK seedbanks

The issue of identification of landrace material in UK seedbank collections has already been highlighted and it important to reiterate that the results of analysis of seedbank data presented in this report do not fully reflect the landrace diversity extant in the collections. There is more work to do in this area and while some steps are being taken to identify further landrace material of UK origin, a greater injection of resources may be needed to achieve this goal for all the major seedbanks holding significant collections of diversity. It is also worth noting that while it has always been fairly simple to distinguish commercial cultivars from landrace material in the WHRI collections, this will not be so simple in the future because the unregistered varieties that are available in the UK market mean that we have no benchmark description against which we can reference the material—presumably, most of these are old varieties, so there will be descriptions available, but we will not know what has happened to them in terms of seed production and quality control.

Access to landrace data is also hindered by differences in information management standards between seedbanks, and while these were relatively easy to overcome in the context of this project, greater standardization of the seedbank data management systems would undoubtedly help with the PGRFA inventorying process, as well as in its continued management.

Country of origin does not necessarily mean a landrace was developed in the UK

The issue of how to delineate between UK and imported varieties for the purposes of the UK PGR inventory was discussed at the experts' meeting where it was concluded that if a variety is grown in the UK it should be included in the inventory, regardless of its origin (see section 2.2). However, we have aimed to limit the analysis of seedbank holdings of landraces to varieties of UK origin as far as possible, since seedbank collections are not a direct reflection of the diversity maintained *in situ* in the UK, but repositories of germplasm from a wide range of countries worldwide. In the context of seedbank data management, the issue of knowing the actual origin of varieties has already been highlighted in section 4.2. The fact that some varieties were not originally developed in the UK is not critical because any varieties, whether imported or not have relevance as UK PGRFA and value to UK agriculture and horticulture, particularly those that have been subjected to repeated cycles of selection and seed-saving over a number of years and have become reasonably well established on UK soil. This point is particularly relevant with regard to the many exotic varieties that have been introduced and are being grown by people of the wide range of different ethnic origins that have settled in the UK.

Crop variety name is not a reliable indicator of its source

Some landraces have traditionally been named after the place in which they were developed (e.g., onion 'Bedfordshire Champion', white cabbage 'Cotswold Queen' and 'Durham Early', runner bean 'Droitwich Champion' and Brussels sprout 'Evesham Special'). The variety name can thus sometimes be used as an indicator of its source, but this is not a reliable method of identification of landrace material because names can be misleading. For example, many varieties are also named after the grower that developed them; for example, runner bean 'Melbourne Mini', which is not from Melbourne, Australia as might be expected, but was developed by an English man called Syd Melbourne in Sussex (see section 4.4, Box 7). Further, the fact that F1 hybrids have occasionally been given names that misleadingly associate them with a particular place, coupled with the fact that anyone marketing seed can sell it under any name they choose, albeit illegally, means that it is not possible to trawl seed catalogues with the aim of pulling out landrace varieties based on their names. The only way that landraces or heritage varieties can be identified is by asking the company marketing the seed to identify them and this in itself presents it own challenge, as discussed below.

Commercial sensitivity, and time/resource limiting factors

While the majority of individuals contacted who maintain landraces for business purposes were interested in the project and were supportive of its aims, issues of commercial sensitivity were evident, and the few cases in which such issues were encountered during this research are probably indicative of a larger group of concerned businesses, although this cannot be verified. A reluctance by businesses to provide information about the varieties they maintain may be founded on concerns about potential legal repercussions regarding unregistered varieties, that they may be inundated with requests for material of the varieties they maintain, or simply that due to company confidentiality and policy, they are bound to conceal certain information about their activities. Although requests for information were accompanied by a clear statement that no personal data or contact details would be made available in the public domain and that the survey conformed to the Data Protection Act 1998, a more concerted effort to alleviate such fears may be needed in a continuation project.

A second major limiting factor in obtaining information from businesses is simply due to a lack of time and resources available to the companies. Several companies showed a keen interest in participating in the survey, but were unable to respond within the given time frame due to a lack of time and adequate staffing. Some companies stated that they intended to respond to the survey,

but information was not always forthcoming. As already noted, the first quarter of the year is a particularly busy time for seed companies and two companies noted that a face to face meeting would not be possible until the summer. Therefore, this hurdle could probably be largely overcome given more time and the opportunity to follow up on correspondence with telephone calls.

Modes of access to novel data

The means of accessing novel landrace information are described in section 2.4.2. Modes used were media releases, advertisements, a questionnaire (or survey), internets searches, and communication with individuals and businesses by email, telephone and face to face meetings. Within the short time-frame of this project, it has been difficult to fully assess the effectiveness of the media releases, advertisements and the questionnaire; however, based on the responses received, it is likely that collectively, a combination of all of these approaches is an effective means of accessing information.

Questionnaires are notorious for having low response rates, especially those that are aimed at a very broad respondent base, as opposed to those that are targeted to a particular interest group. It is not possible to provide an accurate response rate as the precise number of questionnaire recipients is unknown. However, very few responses were received (48 online and 6 by post), considering the wide sweep of the targeted groups and individuals (see Annex 6). Interestingly, a significant proportion of respondents that started to complete the online survey, did not complete it and in most cases the information they provided was therefore of little use. A number of people got as far as reading the introduction to the survey but did not provide any responses to the questions. A few provided some useful information, but sometimes this was compromised by, for example not providing contact details, despite agreeing that they may be contacted for further information. It is likely that these issues are endemic to surveys and are therefore to be expected, but it would be beneficial in a continuation project to obtain expert advice on the survey design and ensure that a pilot survey is carried out. A pilot survey was not carried out in this project due to time restrictions; however, a number of individual experts were asked to comment on the suitability of the survey before it was widely circulated. A positive outcome of the survey was that when completed, it did provide a solid basis for the inventory by requesting information to meet minimum descriptor requirements (see Annex 5).

Use of the internet, and communication by email and telephone were fundamental to this research. The internet is a prime vehicle for accessing baseline information and contact details as leads for obtaining further information. Most commercial organizations have websites providing basic information about their activities and usually including catalogues listing the varieties that they sell. Likewise, NGOs, large and small usually have websites from which useful information can be obtained. Internet searches can then be followed up with emails and telephone calls. In particular, telephone contact was found to be a very productive means of accessing information, both when contact was made from researcher to participant and vice versa. In general, most individuals contacted were friendly and willing to help with the research.

Seed swap events are also a useful way of gaining information about landraces. One small-scale seed swap event was attended during this project and this resulted in useful information gained through impromptu interviews with small-scale businesses selling seed on stalls at the event. For example, a small company selling seed potatoes informed us of an elderly farmer who maintains “around 400 potato varieties in Gloucestershire”. It was not possible to validate this assertion by making contact with this farmer during this project, but given more time, this is exactly the type of lead that is likely to reveal important information about *in situ* landrace maintenance.

The media releases did result in some responses, both to the online survey and via contact made with the researcher by email or telephone; therefore, this is a worthwhile means of gathering information. However, the lack of control over the exact wording used by journalists that pick up releases can be more of a hindrance than a help. For example, the headlines ‘Wanted: traditional vegetable growers to help conservation’ and ‘Turn Back the Crops: Growers Needed to Help Stop

Plants Going to Seed' were used for two media releases from WHRI and the University of Birmingham, respectively. This was translated into 'Growers needed to help preserve traditional vegetable varieties' in the editorial included in a number of newsletters and periodicals. It is easy to see in hindsight that the original headlines were misleading, but until the researcher received several communications from interested individuals wanting to help by growing traditional vegetable varieties, this unintentional error went unnoticed. Importantly, use of the media is also a useful way of adding kudos to research of this kind; for example, the project was publicized on BBC Radio 4's Farming Today by way of an interview with the senior researcher responsible for its implementation.

Advertisements placed in key periodicals, such as Farmers' Weekly, The Vegetable Farmer and The Grower circumvent the problem of the potential for artistic license leading to misleading statements in editorials, as well as the uncertainty of not knowing when and where the media release will be picked up. The downside of advertising is that it is costly, although some periodicals are able to offer a discounted rate to research institutes and we also found them to be very helpful in terms of assisting with artwork, as well as taking a keen interest in the project and offering to include editorial coverage of the project in the periodical in addition to the advertisement.

7. Conclusions and Recommendations

The purpose of this project was to instigate the establishment of a UK national inventory of landraces to provide the baseline data needed to a) identify conservation needs, b) enact the systematic conservation of landraces *in situ* and *ex situ*, c) monitor change (including the assessment of genetic erosion), and d) enhance their use in meeting changing market demands and in promoting UK food security. Within this four month project we have created an inventory of 569 English and Welsh vegetable landrace populations representing 470 named varieties. A detailed set of landrace descriptors and a database for information management have also been created and provide the basis for further data collation. We have synthesized data from the main UK seedbanks with vegetable holdings and 'B' List vegetable varieties of non-hybrid origin, and identified some of the key groups of growers (both commercial and non-commercial) who maintain vegetable landrace diversity. We have also identified the socio-economic reasons underlying the loss of landrace diversity and conversely, the reasons for their continued maintenance. Collectively, these project outputs are a significant contribution to the necessary baseline information needed to meet the long-term aim of conserving our vegetable landrace resources. This study also provides a methodology and framework for the continuation of the establishment of the UK landrace inventory and the lessons learned from this pilot project are also important to guide future research.

We are already armed with the knowledge that many old landrace varieties have been lost—mainly due to replacement with modern, high-yielding varieties—and although it is not known exactly how many because there is no consolidated historical list, it should be possible to estimate this loss for specific crop groups through further research. While the loss of a named variety does not necessarily imply an associated loss of genetic diversity (due to potential synonymy), in the absence of solid evidence (i.e., results of genetic diversity analyses to compare genetic diversity between varieties), we have to assume that to some degree, loss of named varieties will equate to some loss of genetic diversity. This is essentially the catalyst for the landrace inventory because unless we create an inventory of the diversity extant in England and Wales and across the whole of the UK now, we will not be able to monitor their continued maintenance to ensure that no further diversity is lost. This research has revealed that commercial varieties are still being discontinued; for example, E.W. King & Co. Ltd. have discontinued the sale of around 20 traditional vegetable varieties in recent years, largely because of overseas companies selling seed in the UK at a more competitive price, but also due to a fading market (P. Miller, E.W. King & Co. Ltd., pers. comm., 2009). Fortunately, companies such as E.W. King & Co. Ltd. are aware of the biodiversity value of

the varieties that they maintain and are active in donating samples of discontinued varieties to one of the UK's seedbanks, as well as continuing to maintain some varieties that are no longer commercially viable. However, this is not necessarily the case for all businesses and those that are responsible for maintaining a large number of landraces present a potential threat to landrace diversity in that there is no certainty that their business will survive. Even for a company like E.W. King & Co., which is one of the UK's largest seed companies and a key maintainer of UK landrace diversity, the competition that they face from overseas companies marketing seed in the UK at a more competitive price is gradually eroding the number of landrace varieties in their seed catalogue. Opening and maintaining communication channels with these businesses will be critical to the expansion, consolidation and ongoing management of the UK landrace inventory. This should include all commercial seed companies involved in UK landrace maintenance, whether large or small and whether official maintainers of 'B' List varieties or not. The hurdles faced by issues of commercial sensitivity require further discussion, but it is clear that a carefully considered approach and appropriate mediation will be necessary. Furthermore, companies such as E.W. King & Co. deserve and require support if they are to continue to maintain UK landraces on UK soil.

The known loss of landrace diversity in the past and knowledge that varieties continue to be added to the obsolete list at the present time are stark reminders that action is required now (most immediately, *ex situ* back-up in seedbanks) to secure as much remaining diversity as possible. However, while we look to what we have irreplaceably lost in the past, we also need to pay attention to the current movement in the UK that strongly opposes the replacement of traditional varieties with F1 hybrids and is actively engaging not only in the maintenance of vegetable landraces, but also in their development and improvement. This resurgence in interest in growing traditional varieties and in grower-based breeding is taking place amongst both amateur and professional growers. Again, it is critical that communication channels are opened and a dialogue maintained with these groups and individuals, assuring them that the aims of the PGRFA conservation community work in harmony with their own philosophies and goals. We are likely to be in the midst of a new wave of landrace diversity production through grower-based selection, seed-saving and breeding. The custodians of this diversity need to be facilitated and encouraged to help ensure the continued *in situ* maintenance of landrace diversity, and importantly, new diversity created and maintained *in situ* needs to be backed up in *ex situ* collections. An opening gambit is the publication of a short information bulletin summarizing the main findings of the current project in an accessible format for those who participated in the project and associated interest groups. The continued publication and circulation of such a bulletin on a regular basis may help to bridge the gap between the formal PGRFA conservation community and the vital custodians of *in situ* landrace diversity—the farmers, smallholders, market gardeners, allotment-holders, home gardeners and seed companies. The link between people and the crop varieties that they choose to grow, whether they are local or imported varieties is a critical component of PGRFA conservation activities.

To conclude, we propose the following specific recommended actions that will be necessary to secure the diversity of UK landraces as an agrobiodiversity resource critical for future food security, as well as a vital component of our biodiversity and cultural heritage.

Establish and maintain a comprehensive inventory of UK landraces

The establishment and ongoing maintenance of a comprehensive landrace inventory is critical to provide the baseline data needed to initiate appropriate conservation actions, to monitor change and to assess genetic erosion. Critically, the inventory must include the contact details of a named person or organization responsible for the maintenance of the varieties. Although this information would not be published in the public domain, it is vital that the link between the varieties being maintained and the person or people responsible for maintaining them is made as these are the people who will ultimately be responsible for their conservation and upon who the PGRFA

conservation community will rely. Further, the collation of local indigenous knowledge associated with landrace diversity will be a key part of the inventorying process.

Part of the inventorying process involves the collation of records of landraces maintained *ex situ* in the UK's seedbanks. Resources are needed to process, digitize and record details of landrace accessions maintained in seedbanks where the data are not already digitized. For example, at SASA, relevant data are stored in a variety of forms, including paper records which require digitization. Records of UK landrace material may also be stored in overseas seedbanks—collation of data from these sources requires further investigation.

Improve and standardize the management of landrace data

The inventory should include a minimum set of landrace descriptors for each variety listed as this information is necessary to make informed decisions and to assess change. As an output of this project, a comprehensive set of descriptors has been proposed for discussion and further refinement (see section 2.3 and Annex 1)[51]. The database created for management of novel data collated in this project (Annex 2) also requires further refinement and development for use in future projects. Standardization of information management for landrace accessions across seedbanks would also be beneficial[52]; however, this is likely to require an additional injection of resources.

Establish and maintain a list of landrace maintainers and key contacts

As PGRFA conservationists, we are interested in maximizing the conservation of genetic diversity that is critical for the health of agriculture and horticulture and for future food security. This means that we traditionally focus on the taxon as our conservation target because it is the diversity within and between taxa that we wish to conserve. However, in the case of landraces, it would be wise to think about conserving diversity in broader terms. Landrace diversity does not exist without the people who are responsible for their maintenance through regular, repeated cycles of cultivation and seed selection, and if we are interested in conserving diversity, we need to work with the people responsible for its creation and maintenance. This seems an obvious point to make, but is perhaps an aspect of PGRFA conservation that has historically been given less attention than it deserves. Therefore, we conclude that knowing who is maintaining landraces is probably as important as inventorying the crop varieties themselves. This study has highlighted some of the key organizations and individuals involved in landrace maintenance—further research will undoubtedly reveal many more. A database of these contacts should be maintained.

Open and maintain dialogue with key groups and individuals

Opening and sustaining a dialogue with landrace maintainers, including the key interest groups will be critical for the effective, long-term conservation of landrace diversity. This dialogue is necessary on a number of levels; including:

- Informing current and prospective landrace maintainers of the goals of the formal conservation community and engendering good relations and trust;
- Enabling access to maintainers' landrace material to ensure that sufficient samples are collected and maintained *ex situ* and available for genetic diversity analyses;
- Gaining an understanding of maintainers' motivation for cultivating landraces;
- Acquiring knowledge of landrace maintainers' management practices—critically, knowing what criteria they use to select and save seed for subsequent growing cycles and whether they exchange seed with other growers;

[51] In the light of the preliminary analysis presented in section 3.5, it may be beneficial to review the descriptors for crop variety qualities to include further descriptors. Also, as 'strong market demand' is only applicable to commercial growers and may be due to a number of other reasons, it may be appropriate to exclude this descriptor from future analyses.

[52] Using the FAO/IPGRI Multi-crop Passport Descriptors (MCPD) as a minimum standard (see http://www.bioversityinternational.org/Publications/pubfile.asp?ID_PUB=124)

- Recording data on the environmental conditions in which the landraces are grown;
- Informing landrace maintainers of the results of genetic diversity and/or other landrace studies involving their participation and/or their landrace material;
- Being informed when a maintainer ceases to cultivate a landrace so that measures can be put in place to ensure it is adequately conserved *ex situ* and preferably also transferred for continued cultivation by another maintainer;
- Encouraging additional growers to cultivate and maintain landraces.

This dialogue needs to include the full range of landrace maintainers, including those that traditionally may not have been approached by the UK's formal conservation sector—such as biodynamic farmers, small-scale seed companies and allotment-holders. We found that most growers of landraces are interested in their long-term conservation and keen to be involved in this research—this interest needs to be encouraged and nurtured. Means of communication could include the establishment of an emailing list and/or online discussion group and a simple annual bulletin providing information about UK PGRFA conservation activities, providing the opportunity for landrace maintainers to contribute. Seedbank open days (such as those already organized and hosted by the JIC and which have proved very popular and successful), to which landrace maintainers could be invited, would be a good way of linking the formal and informal sectors[53] and of encouraging and maintaining a dialogue. The establishment of regional networks of local vegetable and fruit landrace resources would also be beneficial.

The need for provision of support to UK-based seed companies that are important for the continued maintenance of landrace diversity requires discussion. If the issue of competition faced by UK companies from overseas companies is not addressed, we may lose critical landrace diversity that has been maintained by these companies for more than 100 years.

Initiate a landrace protection scheme in England and Wales

The initiation and implementation of a landrace protection scheme in England and Wales, possibly following the model used in Scotland (the Scottish Landrace Protection Scheme (SLPS) – see section 1.4.2), would help to maintain dialogue between growers and seedbanks, and ultimately in the conservation of landrace diversity. The SLPS was initiated by SASA; the scheme provides *ex situ* back-up of seed that can be made available to the grower in the event of crop failure or loss of stock seed. The seed is also available for distribution and use if the consent of the donor is given. Given sufficient resources, a similar scheme could be initiated in other UK seedbanks, starting with one or two landrace maintainers as a means of testing the scheme. A specific example of a case where a landrace was almost lost through the loss of stock seed was 'Throws' winter field beans maintained by F. Watkin & Son in Sussex. Recently, the farmer nearly lost the landrace after not cultivating it for three years and almost losing his supply of stock seed. However, he managed to save it by planting all his remaining seed to bulk it up. Had he lost the seed completely, the proposed English landrace protection scheme would have acted as a back-up and the material could have been reintroduced from the seedbank to the farm.

Enhance ex situ landrace collections

Identification of landrace material in *ex situ* collections is ongoing in UK seedbanks; however, additional resources are needed to expedite this process and ensure that all landrace material maintained *ex situ* is included in the UK landrace inventory as soon as possible. A review of the collections to ensure that there is adequate back-up of UK landrace material conserved and that representative samples are maintained is also needed. Fresh samples of existing varieties should be collected where possible in order to capture any potential genetic adaptation and any new varieties found should be sampled and stored. While there is no certainty that fresh samples will

[53] The formal sector being UK seedbanks and plant breeders and the informal sector being farmers and other landrace maintainers.

capture new genetic diversity, this precautionary approach is necessary in the absence of prior genetic diversity analyses to compare populations with existing accessions. In tandem with this approach, resources are needed to undertake genetic diversity analyses to compare existing samples maintained *ex situ* with new samples in order to maximize resource use in the future. As already suggested, these studies could initially be carried out for a selection of crops from each of the major groups (roots, leafy vegetables, legumes etc.), comparing diversity within and between existing varieties with fresh samples of the same varieties or with samples of varieties with different names.

Stimulate landrace use by plant breeders

One of the primary reasons for conserving landrace diversity *ex situ* is to make it available to plant breeders for crop improvement. At present, not all landrace material is available for use, but there are moves within UK seedbanks to try to improve this situation. As described above, a landrace protection scheme involving a written agreement between the donor and seedbank may go a long way towards helping to improve access to germplasm samples. However, germplasm also needs to be characterized in order for it to be of interest and use to breeders. To this end, landraces would be a good target for the application of novel genomic and transcriptomic approaches to characterization. However, in the absence of genetic characterization data, passport data can provide a proxy means of assessing the potential use value of samples when detailed information about the collection site is available. The promotion of landrace diversity use by seedbanks, as well as periodic reviews of how it is being used will be important to maintain the momentum for landrace diversity conservation. Opening a dialogue with the British Society of Plant Breeders (BSPB – http://www.bspb.co.uk/index.asp) on the use of landrace material in breeding programmes could be beneficial in order to stimulate greater interest from the plant breeding sector. Further, landrace improvement through participatory plant breeding (PPB) should also be explored (Veteläinen *et al.*, 2009).

Carry out research into landrace diversity in the context of climate change

Knowledge of the effect of climate change on agrobiodiversity in the UK is currently limited. We need to understand both the potential impact of climate change on landrace diversity and how landraces might be managed to improve their resilience in the face of the potential impacts of climate change (Veteläinen *et al.*, 2009). Part of this research will involve population dynamics and genetic diversity studies to understand how landrace populations change in response to human and environmental selection pressures. The role and increased utilization of landraces in sustainable agricultural systems also requires further investigation.

Educate and raise public awareness of local landrace diversity

The resurgence in interest in growing traditional varieties and in buying local produce is positive for landrace conservation. However, more could be done to increase awareness of the importance of landrace diversity amongst the public. Many schools now have their own gardens in which children are encouraged to grow their own vegetables. Providing information to schools to encourage them to work with children to grow local traditional varieties, selecting and saving the seed for the next growing cycle, would be highly beneficial as a means of instilling an appreciation of the importance of landrace diversity and maintenance in the population at an early age. Shops (including supermarkets) should also be educated about the importance of supporting growers maintaining landraces. Marketing landrace produce by highlighting its special qualities, such as taste, variety of culinary uses and unusual colours and textures may encourage consumers to choose landrace varieties over their more uniform counterparts. Establishing a broader market for landraces, both at local and national level will be important for their continued *in situ* maintenance. To achieve this, the PGRFA conservation community needs to work together with existing national organizations promoting sustainable local food production, such as Sustain (http://www.sustain.co.uk), Slow Food UK (http://www.slowfood.org.uk/Cms/Page/home), The Soil Association (http://www.soilassociation.org/), Campaign to Protect Rural England (CPRE –

http://www.cpre.org.uk/home), the National Farmers' Retail and Markets Association (FARMA – http://www.farma.org.uk/) as well as the many regional initiatives around the country (see Soil Association Local Food Links – http://www.soilassociation.org/localfood and http://www.soilassociation.org/Web/SA/SAWeb.nsf/localfoodworks_networks.htm). Further, the use of product labeling systems such as the EU Protected Food Names Scheme (PDO – Protected Designation of Origin, PGI – Protected Geographical Indication and TSG – Traditional Speciality Guaranteed[54]) could be explored as marketing tools to help underpin niche markets, enhance income generation and encourage landrace production in a rural development context (Veteläinen *et al.*, 2009). In light of the Policy Commission on the Future of Farming and Food's report, which highlighted the growing enthusiasm among consumers for high quality food with a clear regional identity and recommended that the industry do more to ensure that producers take part in the protected food names schemes, Defra is actively seeking to raise awareness about the scheme and encourage more UK applications (http://www.defra.gov.uk/foodrin/industry/regional/foodname/index.htm). This could be a good opportunity to raise the profile of landraces and provide security to maintainers for their continued cultivation. However, the legislative aspects relating to variety registration would have to be considered in tandem with this scheme.

Opportunities for supporting landrace cultivation through policy and legislative instruments

There are a number of ways in which landrace maintenance could be facilitated through their positive recognition in national and European policy and legislative instruments. For example, the promotion of landrace cultivation in agro-environment schemes would help to support their continued maintenance. Government funds are currently available in the UK to promote the use of traditional animal breeds in environmentally sensitive areas—a similar scheme to promote the cultivation of landraces should be considered. The recent inception of Commission Directive 2008/62/EC requiring European member states to provide a framework for national listing and marketing of conservation varieties of agricultural plant species threatened with genetic erosion has been widely criticized because many believe that although it was instigated to maintain landrace diversity, it may not have this effect because it's prime focus is on seed marketing and because it allows a very wide range of interpretation and subsequent legislative implementation in each member state (Veteläinen *et al.*, 2009). While we are aware that this legislative instrument has already been under some scrutiny at UK governmental level and a discussion has been undertaken with key UK stakeholders, it is worth highlighting the importance of the need for a continuous review of the effect of the implementation of this legislation. Legislative models based on the preservation of plant genetic resources (instead of on commercializing them) exists (e.g., see Lorenzetti *et al.*, 2009) and their wider implementation would be more appropriate to guarantee future food security at local, national and regional levels (Veteläinen *et al.*, 2009).

[54] PDO is open to products which are produced, processed and prepared within a particular geographical area and with features and characteristics which must be due to the geographical area. PGI is open to products which must be produced or processed or prepared within the geographical area and have a reputation, features or certain qualities attributable to that area. TSG is open to products which are traditional or have customary names and have a set of features which distinguish them from other similar products—these features must not be due to the geographical area the product is produced in nor entirely based on technical advances in the method of production (http://www.defra.gov.uk/foodrin/industry/regional/foodname/index.htm).

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