# 12b. Genetic resources for food and agriculture: plant genetic resources

**Type:** State / Benefits Indicator

## Indicator Description

Seed banks provide an insurance policy against the extinction of plants in the wild. They complement *in situ* conservation methods, which conserve plants and animals directly in the wild.

The indicator is based on an enrichment Index developed by the United Nations Food and Agriculture Organisation (FAO, 2010a&b) to assess the genetic diversity held in gene banks. The method factors in duplication and similarity to existing accessions. An upward trending line indicates diversity is being added to collections – the steeper the line, the greater the diversity being incorporated. An accession is a collection of plant material from a particular location at a point in time.

No update since previous publication.

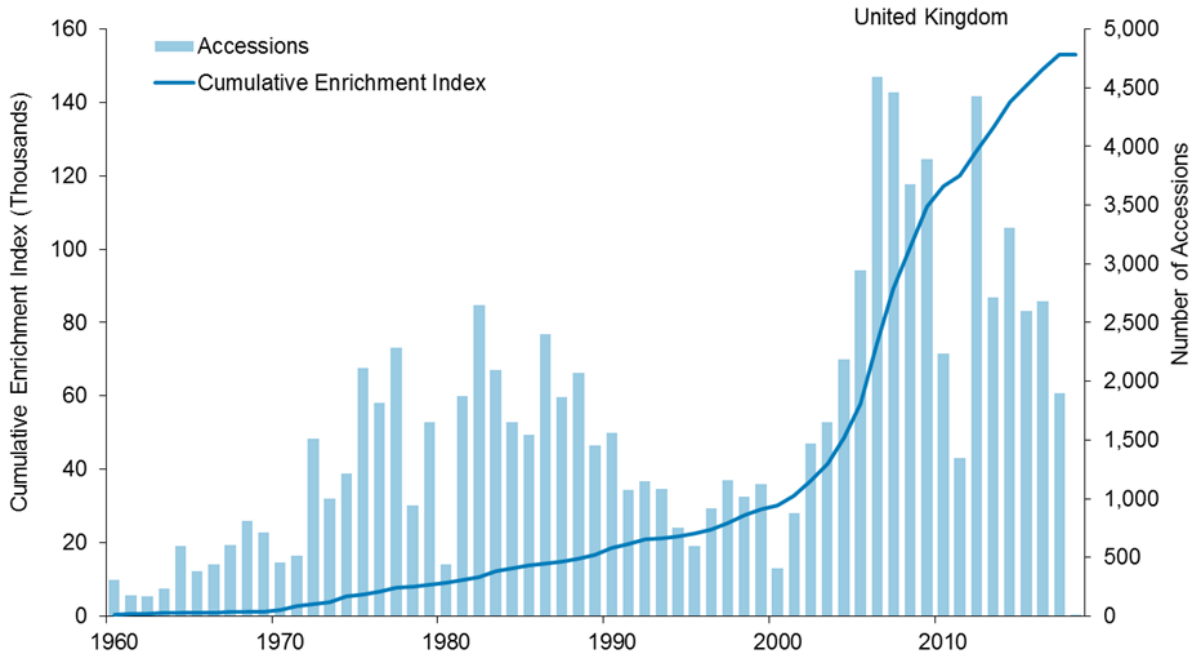
As a result of discussions in the UK Plant Genetic Resources Group, a revised indicator is being considered; whilst development is underway it is not ready for publication.

## UK Enrichment Index

There was a 15% increase in the Enrichment Index between 2013 and 2018. A rapid rise in the Enrichment Index since 2000 can be attributed to a concerted collection effort by the Millennium Seed Bank.

There is considerable annual variability in the number of new accessions into UK germplasm collections. The total number of accessions has risen since 1960, totalling 93,786 accessions by June 2018.

**Figure 12b.1: Cumulative Enrichment Index of plant genetic resource collections held in the UK and annual number of accessions into UK germplasm collections, 1960 to 2018**



**Notes:**

1. Data was obtained from EURISCO, which collates information across Europe from national germplasm collections, including the UK National Inventory of Plant Genetic Resources. The UK National Inventory includes food crop genetic resources such as crops, forages, wild and weedy species (including crop wild relatives), medicinal and ornamental plants, but does not include forest genetic resources.
2. The UK 2018 update of EURISCO includes information which had previously not been submitted as a result of improvements within the holding institutes to catalogue their holdings. The indicator is therefore not directly comparable with the versions previously published.

**Source:** EURISCO Catalogue http://eurisco.ipk-gatersleben.de/apex/f?p=103:1; date of data download 7 June 2018; based on UK contributions from: Genetic Resources Unit, Aberystwyth; Heritage Seed Library, Garden Organic; Commonwealth Potato Collection, The James Hutton Institute; Germplasm Resources Unit, John Innes Centre; Nottingham Arabidopsis Stock Centre; Millennium Seed Bank Partnership; Science and Advice for Scottish Agriculture, Scottish Government; Warwick Crop Centre, Genetic Resources Unit.

## Indicator assessment

### Assessment of change in status of ex situ conservation of cultivated plants and their wild relatives in the UK

### Cumulative Enrichment Index: Long term (1960 to 2018): Improving; Short term (2013 to 2018): Improving; Latest year (2018): No change.

**Note:** Long and short-term assessments are based on a 3% rule of thumb. The base years for these assessments use a 3-year average. See Assessing Indicators.

## Indicator description

- Genetic diversity is an important component of biological diversity. The genetic diversity of UK plant resources includes domesticated plants and their wild relatives, as well as socio-economically and culturally valuable plant species. These encompass plants grown in a farming or horticultural setting, or both, as well as commercial cultivars, landraces and traditional varieties and their wild relatives.

- *Ex situ* conservation of cultivated plants and their wild relatives is one method used to preserve genetic diversity. In the context of this indicator, the term *ex situ* means off-site conservation of genetic material.

- The Enrichment Index is a proxy measure of genetic diversity based upon the assumption that genetic diversity increases (to a greater or lesser extent) with originality of accessions, which is estimated based on: the number of species collected; the number of accessions collected; the number of countries collected from; and the area from which collection took place.

- As a result of discussions in the UK Plant Genetic Resources Group, a revised indicator is being considered; this was not available for 2018 or the 2019 publication, but it is hoped that a new indicator will be available for the 2020 publication.

The indicator presents the genetic diversity of cultivated plants and their wild relatives in the UK, including other socio-economically and culturally valuable plant species, by assessing the genetic diversity of target plants held in UK germplasm collections. Effectively, it is a measure of the status of *ex situ* conservation of cultivated plants and their wild relatives in the UK. Any plant which grows in or is cultivated in the UK, or has been grown in or has been cultivated in the UK, could be included in the indicator.

The indicator is based on an Enrichment Index developed by the United Nations Food and Agriculture Organisation (FAO, 2010a&b) to describe the enhancement of *ex situ* plant germplasm collections. The method factors in duplication and similarity to existing accessions. An upward trending line indicates diversity is being added to collections – the steeper the line, the greater the diversity being incorporated. A horizontal line indicates no accessions, and hence no diversity,

being added, and a downward trending line indicates diversity is being lost from collections. The total number of accessions illustrates the yearly collection effort added to the genetic resources institutes, without taking into account genetic diversity within those collections[1] (**Footnote:** Not all accessions of target species are included in the Enrichment Index, as some were excluded due to poor or insufficient data. Full calculation procedures are provided in the technical background paper).

Data were obtained from EURISCO, which collates information across Europe from national germplasm collections, including the UK National Inventory of Plant Genetic Resources. The UK National Inventory includes food crop genetic resources such as crops, forages, wild and weedy species (including crop wild relatives), medicinal and ornamental plants, but does not include forest genetic resources. Cultivars, landraces, farmers' varieties, breeding lines, genetic stocks and research material are also included (EURISCO 2013). The method of calculating the Enrichment Index almost exclusively tracks the content of the Millennium Seed Bank (MSB) figures as that is where the highest additions to taxon diversity are coming from.

EURISCO data (http://eurisco.ipk-gatersleben.de/apex/f?p=103:1:) is freely accessible, and provides accession-level information on germplasm maintained in *ex situ* plant collections in Europe. The last UK update to EURISCO was on 5 June 2018. The EURISCO database only displays current holdings of collections, so is a snapshot in time. Any accessions which are removed from collections, for example as a result of reduced viability, will therefore not show after an update of EURISCO has taken place, and therefore will not be included in a future download of data. The UK 2018 update of EURISCO included information which had previously not been submitted as a result of improvements within the holding institutes to catalogue their holdings. The indicator is therefore not directly comparable with the versions previously published.

The arithmetic mean of the first 3 years of the data series was compared with the most recent data point to determine the assessment for the long-term trend, and the arithmetic mean of the data 5 years back in the time series and the year to either side was compared with the most recent data point in order to assess the short-term trend.

## Relevance

The UK is relatively rich in wild relatives of crops, landraces of cereal, vegetable and fruit crops, and traditional orchard trees. Maintaining genetic diversity of UK plants is important for conservation of biological diversity, as well as for economic and cultural reasons. The UK is a Party to the International Treaty on Plant Genetic Resources for Food and Agriculture, and has also committed to a five-point action plan in response to the Foresight (2011) report on the future of food and farming (Environmental Audit Committee 2011) which includes actions on conserving plant genetic resources.

The indicator is also relevant to outcome 3 in *Biodiversity 2020: A strategy for England's wildlife and ecosystem services* and a number of international targets (see Annex A and B of the aforementioned publication).

## Background

Defra funds a number of plant genebanks which conserve and provide access to a variety of plant genetic material, and aims to further increase the accessibility to and utilisation of these genebanks in the future, as well as making use of new genomic technologies. Supporting genebanks helps ensure the UK meets its international agreements to protect important crops and safeguard global food security.

The National Fruit Collection at Brogdale in Kent is curated and maintained by the University of Reading. It is one of the largest fruit collections in the world with over 3,500 varieties of named apple, pear, plum, cherry, bush fruit, vine and cob nut cultivars. Unlike other genebanks where plant genetic material is stored as seeds, the National Fruit Collection is a live collection of plants open to the public as a visitor attraction.

[1] Not all accessions of target species are included in the Enrichment Index, as some were excluded due to poor or insufficient data. Full calculation procedures are provided in the technical background paper.

The UK Vegetable Genebank is held at the University of Warwick. It manages a collection of around 14,000 samples of vegetable crops, stored as frozen seeds. The genebank supplies materials to plant breeders, researchers and growers, as well as Genetic Improvement Networks (supported by Defra) which facilitate the transfer of genetic variations from collections of plant genetic resources into new varieties.

The pea collection at the John Innes Centre comprises over 3,500 accessions of wild and semi-cultivated material.

EURISCO means 'I find' in ancient Greek. It was developed as a catalogue of information on plant genetic resources maintained *ex situ* in Europe through a European Union Fifth Framework Programme project. EURISCO was publicly launched in September 2003. It is intended to be regularly updated from National Inventories of plant genetic resources and to be easily accessible via the internet.

The number of accessions (germplasm samples) per taxon is often used as a proxy for the level of genetic diversity in *ex situ* germplasm collections taking into account the threat of losing reference material through reduced seed viability. However, the Enrichment Index provides a better reflection of genetic diversity held in gene banks than the number of accessions as reduced weight is given to samples of taxa already present in the collection, particularly those originating from the same country.

It is assumed that there are positive relationships between the level of genetic diversity and the:

- number of accessions held;
- number of taxa held; and
- geographical distribution of collection sites.

The Enrichment Index first identifies duplicate accessions, i.e. samples belonging to the same taxon with the same collection date and country of origin. Each subsequent duplication is given a reduced weight. For each taxon present, the number of samples is weighted, with accessions from the same country of origin being given a reduced weight depending on the land area of the country of origin (duplicates from smaller countries of origin are given less weight than those from larger countries of origin). The weights of the accessions are compared with those of preceding years and summed to produce an assessment of the genetic diversity present in the collections each year.

The Index is a valuable method for assessing the efforts made to conserve genetic diversity of target plants through *ex situ* storage. However, the following points should be taken into consideration when interpreting it:

- The indicator does not assess the effectiveness of conservation in the field and therefore overlooks the importance of *in situ* conservation (i.e. conserving genetic diversity in the wild), which not only includes species but also the habitats in which they live.
- The indicator makes the assumption that the number of accessions per taxon is positively related to the level of genetic diversity stored *ex situ*. However, this relationship may not always exist, particularly for commercial cultivars, since many cultivars are bred for the same market and hence are phenotypically and probably genetically very similar. Crop wild relative populations are considered to contain far more genetic diversity than crops themselves (Hopkins and Maxted, 2010). Without detailed investigation it is difficult to assess how much genetic variation is present in a collection.
- The indicator focuses on *ex situ* conservation in germplasm collections, which will represent only a small proportion of the total genetic diversity of UK crops and their wild relatives. The EURISCO catalogue is the most comprehensive database available, containing more than half of the *ex situ* accessions maintained in Europe (EURISCO 2012). However, it is not a comprehensive data set for the UK.
- Not all genetic resource collections are stored as seed. For example, the National Fruit Collection (NFC) of more than 3,900 named apple, pear, plum, cherry, bush fruit, vine and cob nut cultivars owned by Defra is kept as a field collection. Consequently, a value for country of

origin is often not available and, due to a requirement for this by the Enrichment Index in use these are underrepresented.

- The genetic diversity of crop wild relatives is expected to be higher than for cultivated plants. Ideally a separate enrichment index would be produced separately for cultivated plants and crop wild relatives. However, it is not possible to determine in every case whether an accession is wild sourced or from a cultivated stock, so the indicator currently considers them together. A consequence of this is that the indicator potentially underrepresents the crop based genetic resource collections.
- Wild relatives of cultivated plants are those falling within taxon groups 1 to 3 as defined in the taxon group concept (Maxted *et al.,* 2006). In this indicator a slightly broader scope based on genus of the taxa is used, as within the taxon group concept, groups 1 to 3 goes to subgenus (which would add to the complexity of filtering the results downloaded from EURISCO).

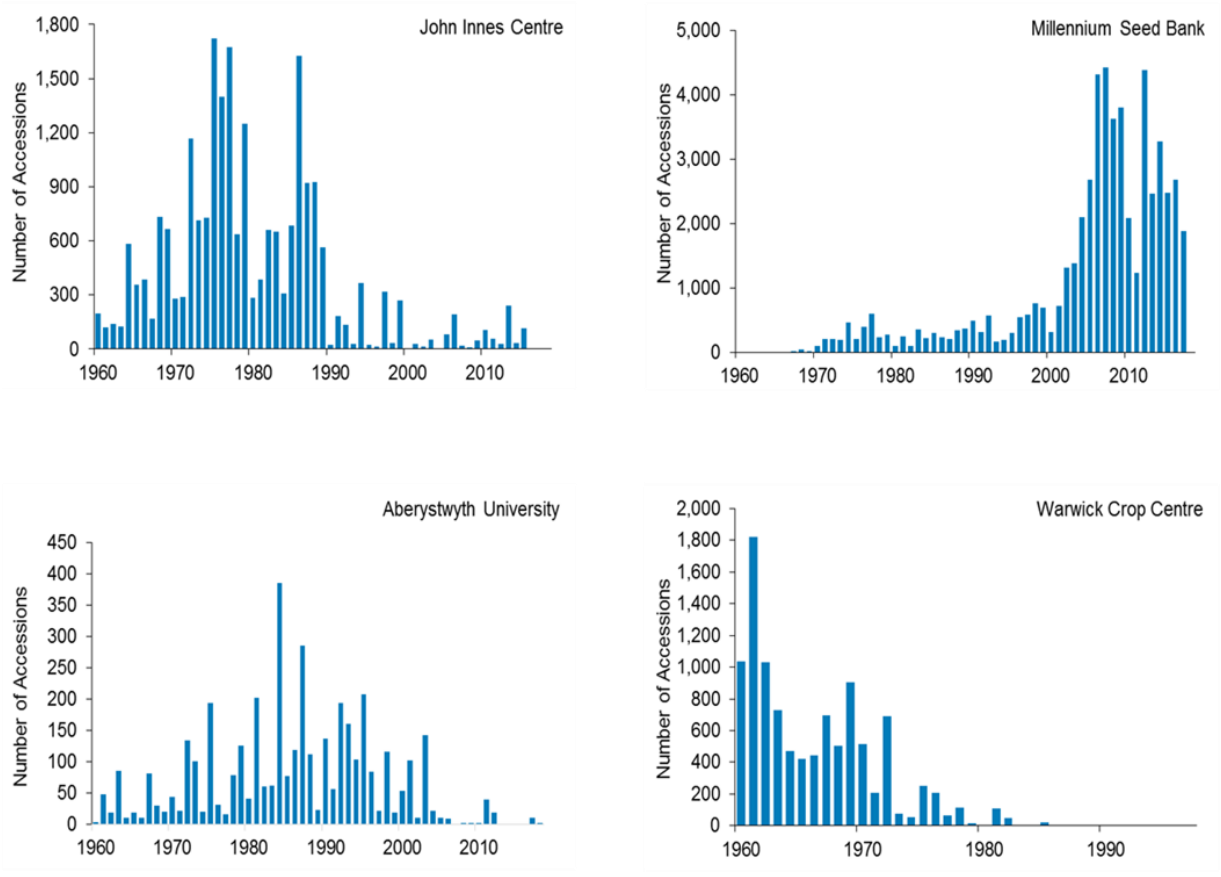
Plant Heritage's National Plant Collections contain, among other internationally significant socio-economically and culturally valuable resource, 2,395 taxa in 7 Annex 1 genera across 14 locations (Plant Heritage 2018). In the past year these increased by 512 taxa at 3 locations newly registered within the scheme.

Unpublished data (2011 to 2018) held within Plant Heritage's Threatened Plants Project (Seymour 2012) and publicly available data[2] (**Footnote:** http://rbg-web2.rbge.org.uk/multisite/multisite3.php accessed 28 June 2018), additionally shows that 9,000 relevant taxa in 54 genera are held across 185 other locations throughout the UK, including significant holdings by the National Trust and National Trust for Scotland, the Royal Horticultural Society, national, university and other botanic gardens and arboreta, the Sir Harold Hillier Gardens and the Eden Project.

Figure 12b.2 shows the number of accessions per year contributing to the Enrichment Index by a number of UK holding institutes. Note that accessions which do not have full information available (see technical document for details) for calculation of the Enrichment Index have been filtered out in advance of production of these figures.

[2] http://rbg-web2.rbge.org.uk/multisite/multisite3.php accessed 28 June 2018

## Figure 12b.2: Number of accessions added per year at selected UK holding institutes, 1960 to 2018




**Source:** EURISCO Catalogue http://eurisco.ipk-gatersleben.de/apex/f?p=103:1; date of data download 7 June 2018; based on UK contributions from: Genetic Resources Unit, Aberystwyth; Heritage Seed Library, Garden Organic; Commonwealth Potato Collection, The James Hutton Institute; Germplasm Resources Unit, John Innes Centre; Nottingham Arabidopsis Stock Centre; Millennium Seed Bank Partnership; Science and Advice for Scottish Agriculture, Scottish Government; Warwick Crop Centre, Genetic Resources Unit.

There are 2 significant developments captured in Figure 12b.2. Chronologically, the first is the development of the collections represented by the Department of Applied Genetics, John Innes Centre. This represents amalgamation of older working collections from a wide range of institutes and industry into the first custom built seed store facility based formerly at the Plant Breeding Institute in 1978 and their move to a newer facility at the John Innes Centre in 1990. The rate of accessions added since 1990 has been consistently at a lower level. The second relates to the development of the Millennium Seed Bank (MSB), which now holds samples of nearly all UK seed-bearing plants. Non MSB institutes are less likely to contribute significantly to the Enrichment Index as these institutes are more focused on diversity within a taxon; which the index is weighted against.

### Supplementary data on the Millennium Seed Bank

This section provides supplementary information of the conservation of plant resources in the Millennium Seed Bank project managed by the Royal Botanic Gardens, Kew. The Millennium Seed Bank (MSB) is one of the largest *ex situ* conservation projects in the World. It aims to collect seeds, herbarium specimens and data from species worldwide, including the entire UK seed-bearing flora, and to conserve these collections to international standards. These include the rarest, most threatened and most useful species.

The MSB already holds seeds from species thought to be extinct in the wild. In addition, seed banks provide a controlled source of plant material for research, education and public awareness.

The MSB manages an active UK seed banking programme. The current strategy is to maintain, augment and improve the UK collections held in the MSB, to make them more genetically comprehensive and of sufficient number to be of use for UK science and conservation.

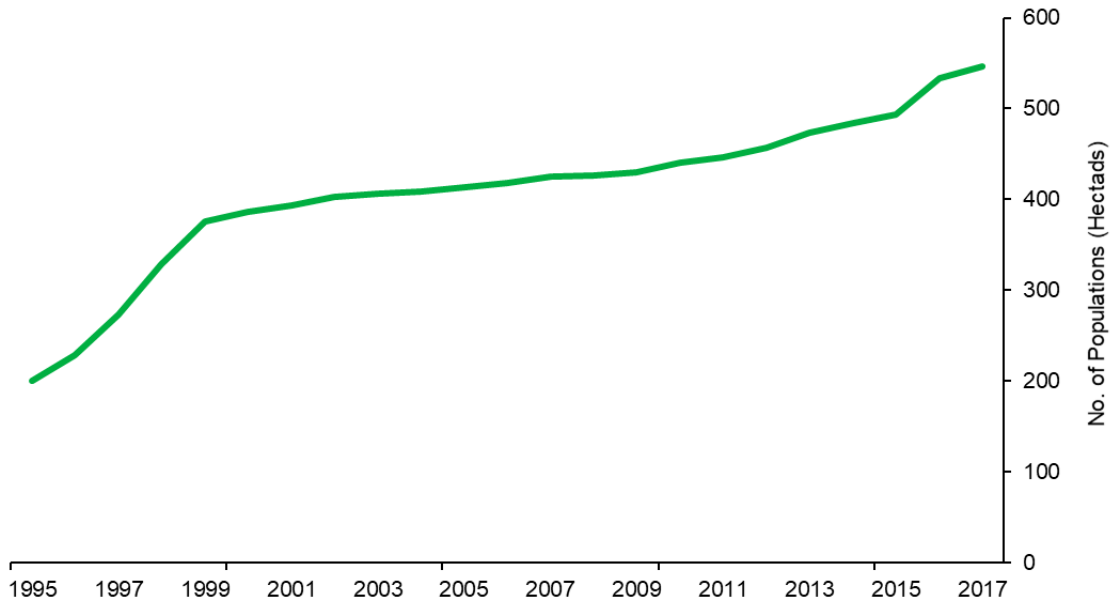
The UK Flora Project seeks to add to the MSB UK species which are currently missing, particularly targeting rare and threatened species which may be confined to just a handful of isolated locations. In addition, new provenance collections for species already banked at the MSB, for which better geographic coverage and hence genetic diversity are required are being sought.

The MSB is also leading a new initiative, the UK National Tree Seed Project, which undertakes in-depth sampling of the UK woody flora. For each target species multi- provenance seed collections are being made from right across its UK distribution. In many cases seeds from individual trees are being stored separately. These seeds will be available to research organisations working on solutions to the threats facing UK trees, such as the control of pests and diseases and to help foresters and conservationists develop woodland more resilient to environmental change.

Kew's UK Native Seed Hub aims to increase the quality, quantity and diversity of native plants and seeds available for conservation and habitat restoration by providing high quality UK native plant material. The initiative supplies seeds and plugs, with a focus on species which are not easily available through commercial native seed suppliers, and supports other UK native seed and plant producers and conservation organisations.

Figure 12b.3 shows the number of distinct geographic areas (hectads) from which collections of threatened seed-bearing plants have been made across the UK. A hectad is an area of 10km x 10km. Threatened seed-bearing plants are those listed as critically endangered, endangered or vulnerable in the Great Britain Vascular Plant Red List (PDF, 950kb). This is a measure of the conservation of genetic diversity of UK threatened species because the greater the number of hectads, the wider the sampling area and the more likely it is that the total sample contains greater genetic diversity. The number of sampled hectads almost doubled between 1995 and 2000 as a result of a lot of collecting effort in the run-up to the millennium, and has subsequently increased by 24% since 2010.

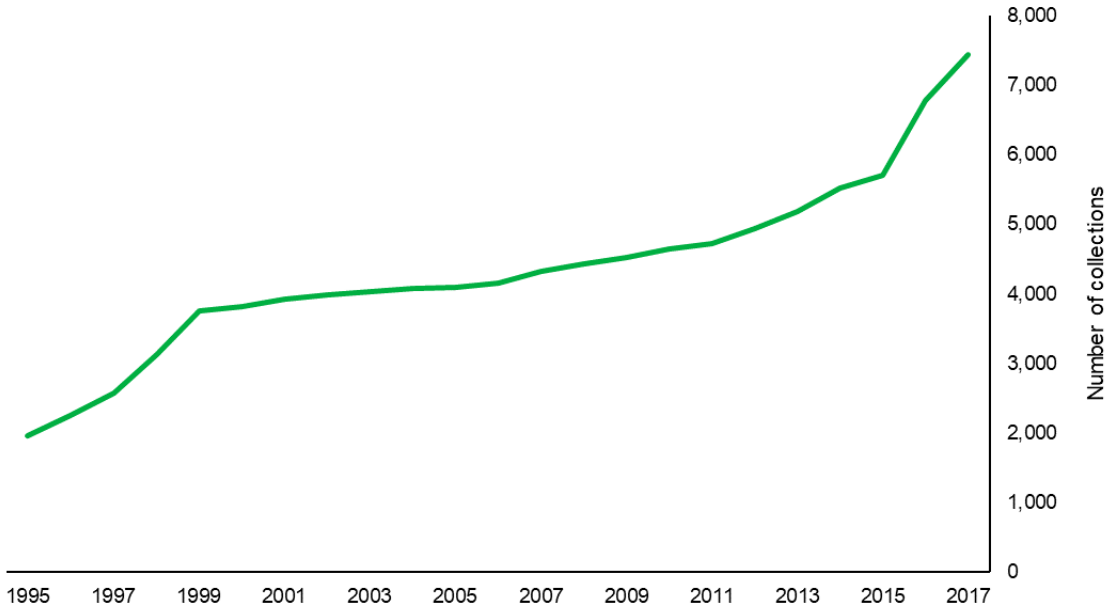
**Figure 12b.3: Number of species from around the world conserved in the Millennium Seed Bank, 2001 to 2017**




**Note:** Data up to 1 March 2018.

**Source:** Royal Botanic Gardens, Kew.

## Figure 12b.4: Number of UK Seed Collections in the Millennium Seed Bank, 1995 to 2017




**Note:** Data up to 1 March 2018.

**Source:** Royal Botanic Gardens, Kew.

Seed collections representing 96% of the UK's currently known circa 1,300 native, orthodox, seed-bearing species (excluding microspecies) are stored at the Millennium Seed Bank. The total number of UK seed collections in the Millennium Seed Bank is 7,434 collections, as shown in Figure 12b.4. Seeds are collected according to a written protocol that ensures a representative sample is taken from each site (see the Seed Collection Manual (PDF, 250kb)).

The UK native seed conservation network consists of a range of organisations and private individuals. Through this network, Kew is actively engaged in UK conservation activities. A tangible result is increased awareness of seed banking and use of high quality seed collections from priority species. Longstanding links exist with Natural England, the Botanical Society of Britain and Ireland, the Royal Botanic Garden Edinburgh, the Forestry Commission, Plantlife, the Wildlife Trusts, the National Trust and local authorities.

The MSB UK Programme makes a significant contribution to the achievement of Target 8 of the Global Strategy for Plant Conservation targets for the UK: *At least 75% of threatened plant species in ex-situ collections, preferably in the country of origin, and at least 20% available for recovery and restoration programmes.* 87% of UK threatened species, defined as critically endangered, endangered, or vulnerable flowering plant and conifer species as listed on the Great Britain Vascular Plant Red Data List (excluding hybrids and microspecies), are conserved as seed collections in the MSB with 44% available for use.

### Web links for further information

Aberystwyth University, Institute of Biological Environmental & Rural Sciences (Home page): https://www.aber.ac.uk/en/ibers/

Convention on Biological Diversity, Global strategy for plant conservation: https://www.cbd.int/gspc/

Defra, Technical Background Document: https://www.gov.uk/government/statistics/england-biodiversity-indicators

Defra, United Kingdom: Country Report on Plant Genetic Resources for Food and Agriculture (2010):

http://www.fao.org/fileadmin/templates/agphome/documents/PGR/SoW2/country_reports/europe/UK_genetic_resources_country_report.pdf (PDF, 430kb)

Defra, Vegetable landrace inventory of England and Wales (2009): http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=16377

EURISCO, Catalogue website: https://eurisco.ipk-gatersleben.de/apex/f?p=103:1:15384805561401:::::

Food and Agriculture Organisation of the United Nations, Commission on Genetic Resources for Food and Agriculture (2013): http://www.fao.org/docrep/meeting/027/mf804e.pdf (PDF, 931kb)

Garden Organic – the Organic Organisation, Heritage Seed Library (Home page): http://www.gardenorganic.org.uk/hsl/

John Innes Centre, Germplasm Resources Unit: Germplasm Resource Unit | John Innes Centre

Joint Nature Conservation Committee, Vascular plant red list: http://jncc.defra.gov.uk/PDF/pub05_speciesstatusvpredlist3_web.pdf (PDF, 950kb)

Nottingham Arabidopsis Stock Centre (Home page): http://arabidopsis.info/

Royal Botanic Gardens, Kew – Millennium Seed Bank Partnership: http://www.kew.org/wakehurst/attractions/millennium-seed-bank;

Royal Botanic Gardens, Kew – Seed Collection: http://www.kew.org/science/collections/seed-collection

Royal Botanic Gardens, Kew – Seed collection manual: http://brahmsonline.kew.org/Content/Projects/msbp/resources/Training/UK-Flora-Protocol-for-seed-collections.pdf (PDF, 250kb)

Royal Botanic Gardens, Kew – UK Native Seed Hub: http://www.kew.org/science/data-and-resources/seeds/kews-uk-native-seed-hub

Science and Advice for Scottish Agriculture (Home page): http://www.sasa.gov.uk/

The James Hutton Institute, Commonwealth Potato Collection (Home page): https://ics.hutton.ac.uk/germinate-cpc/#home

University of Reading, National Fruit Collection: http://www.nationalfruitcollection.org.uk/

Warwick Crop Centre, Genetic Resources Unit (Home page): http://www2.warwick.ac.uk/fac/sci/lifesci/wcc/gru

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**Last updated:** July 2018

**Latest data available:**

Enrichment Index – June 2018;

Millennium Seed Bank – December 2018