Mapping invasive species in Highland

A Report for Highland LBAP Invasives Sub-Group

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1 Introduction

The threat posed to biodiversity and rural economies by invasive non-native species (INNS) is becoming increasingly recognised.

Compared to other areas in UK, populations of INNS in Highland are still relatively low, and with concerted action, it should be possible to bring them under control.

Compared to south and central Scotland the Highlands have a more limited distribution of non-native species. This is due partly to the larger extent of remote uplands and freshwater habitat (Welch *et al.* 2001).

In Highland, the habitat most affected by non-native plants is woodland. Woodland habitat has shown the greatest increase in non-native plants, a trend best exemplified by the spread of *Rhododendron ponticum* (Welch *et al.* 2001).

In 2008, the Highland Invasive Species Forum prioritised five species for action:

American mink	*Mustela vison*
Rhododendron	*Rhododendron ponticum*
Japanese knotweed	*Fallopia japonica*
Giant hogweed	*Heracleum mantegazzianum*
Himalayan balsam	*Impatiens glandulifera*

The purpose of this report is to identify and collate all the distribution data available for these five species for the Highland LBAP area.

2 The priority species

2.1 American mink

American mink *Mustela vison* was first introduced into Britain during the 1920s for the fur trade industry. Subsequent escapes and deliberate releases into the wild from fur farms resulted in their spread throughout the country. Mink pose a significant threat to many native species, in particular water voles and ground-nesting birds. In some offshore islands on the west of Scotland mink predation on chicks and eggs has resulted in whole colony breeding failures of several species of seabird (Craik, 2007).

The first Scottish fur farm opened in 1938 and the first mink escaped that same year (SNH, 2004). Most early escapees may have died as the first record of breeding in the wild in Scotland was in 1962 in Aberdeenshire (Jefferies, 2003). There was a rapid spread of wild mink between 1962 and 1974 mainly dispersing out from the fur farm areas in the Firth of Forth and the Grampian areas (Harrington *et al*, 2008). During this period mink were absent to the north of the Great Glen, except for a small population on the Black Isle, first recorded around 1965 (Jefferies, 2003). However, water vole and otter surveys conducted in the 1980s recorded mink in a significant number of the hectads north of the Great Glen. The Mink (Keeping) Order of 1987 prohibited the establishment of mink farms in Caithness & Sutherland and this may have helped to slow down expansion to the northern counties.

Results from the four national otter surveys indicated an increase in the spread of mink between the surveys of 1979 and the early 1990s but a possible decrease between 1994 and 2004. The decline in water vole populations, a principal prey species on inland waterways, and an increase in the otter population may be linked to changes in mink distribution.

However, although mink may be uncommon or transient in the northern districts they remain common elsewhere, particularly on coastal sites where there is a range of prey items. They are also known to disperse very large distances; up to 100 km has been recorded in Aberdeenshire (Cairngorms & North-east water vole conservation project, 2008). This suggests that movement and re-colonisation into mink-free habitat could occur rapidly.

Trapping results from the Sunart Mink control project indicated an increase in captures between 2006 and 2008, although this may be partly a result of increased trapping effort. At the present time it is unclear whether mink are increasing, decreasing or have a stable population in the southern half of the Highland LBAP area. The current mink population in Scotland was estimated to be 52,000 in 1995 (Harris *et al.* 1995) but due to potential under-recording and a patchy distribution this figure could vary by up to 50%.

2.2 Rhododendron

Rhododendron ponticum is an evergreen shrub that is native to parts of the Iberian peninsula, eastern Europe and west Asia. Spain and Portugal are thought to be the source of most of the *Rhododendron ponticum* established in the UK (Milne & Abbott, 2000).

First introduced to England in 1763 (Elton, 1958) it became popular in the policy woods around estate houses during the Victorian period. It was widely planted as a garden ornamental, as a shelterbelt, as cover for game and as root-stock for the many hybrid varieties of Rhododendron. Rhododendron was often planted on old woodland sites for ornamental purposes, for example in the pinewoods at Achnacarry on Loch Arkaig (Smout *et al*., 2005). There were few recorded escapes from gardens in the 19th century (Welch *et al*, 2001). The first record for Scotland is unknown but is likely to have been sometime in the early 19th century as there is a record of a *ponticum* hybrid at the Royal Botanic Gardens in Edinburgh in 1819 (Brown, 2004).

The decline in the management of policy woods and ornamental gardens along with the expansion of plantation forestry and the overgrazing of semi-natural woods and moorland created suitable conditions for Rhododendron germination. This led to a significant expansion of Rhododendron into the wild during the 20th century. The spread of this invasive shrub into semi-natural habitats has been particularly rapid and extensive in the west Highlands over the past 50 years. Welch *et al.* (2001) document an increase in the presence of Rhododendron in Scotland from 39 hectads in the 1950s to 55 hectads in 1988.

Rhododendron has a competitive and toxic nature, rapid growth and ability to sucker through its low branching habit. Along with a high seed output and efficient wind-dispersal, this ensures successful spread and colonisation onto new ground. It is tolerant of deep shade and can thrive in woodland, out-competing nearly all native trees and shrubs. Once established, it casts a dense shade that eliminates all ground flora. It will also colonise open ground habitats and will spread onto moorland and several types of bog and mire.

It is particularly prolific in the milder and wetter west coast climate where it thrives on the acid and peaty soils and, although also found throughout the eastern Highlands here it tends to have a less vigorous growth habit. However, the possibility of warmer and wetter winters in the east as a result of climate change may alter this pattern.

2.3 Japanese knotweed

Japanese knotweed *Fallopia japonica* is a rhizomatous perennial introduced into the UK from Japan in 1825 as an ornamental garden plant and as cattle fodder. It was recorded as a garden escape in the late 19th century and as naturalised populations in the early 20th century. Knotweed does not set seed in UK, but spreads readily by vegetative means.

It appears to have been first recorded in Highland in 1926, when it was noted in Wick Water (BSBI Vascular Plant Database).

2.4 Giant hogweed

Giant Hogweed *Heracleum mantegazzianum* was introduced into Britain in 1893 as an ornamental plant. It escaped from gardens and is colonising many areas of waste land and river banks. It can grow to 5m high and has a large umbel of white flowers from which it produces up to 50,000 viable seeds per year. When these seeds fall into water they are dispersed downstream and settle on riverbanks, often on scoured bare sediment, allowing the plant to spread rapidly along watercourses.

It appears to have been first recorded in Highland in 1890, when it was noted in Glenferness (BSBI Vascular Plant Database).

2.5 Himalayan balsam

Himalayan balsam *Impatiens glandulifera* (also known as Indian balsam) is a native of the Western Himalaya, introduced into UK in 1839. It is now recorded throughout Britain. It can grow over 2.5m in height and is reputed to be the tallest annual plant found in the UK. It can form dense stands and seeds prolifically; Weber (2003) reports up to 30,000 seeds/m^2 in some stands. Balsam can spread very rapidly, especially along watercourses.

It appears to have been first recorded in Highland in 1906, when it was noted in Cawdor village (BSBI Vascular Plant Database).

3 Sources of data

Datasets were provided by a wide range of correspondents, including agencies, NGOs and land-managers. These data were originally collected for a variety of purposes, principally:

- botanical recording to map distribution (*e.g.* BSBI Vascular Plant Database)
- environmental monitoring (*e.g.* Environment Agency's River Habitat Survey)

- surveys undertaken in preparation for control programmes (*e.g.* Cromarty Firth Fishery Trust survey).

The geographical coverage, resolution, comprehensiveness and quality of data also vary greatly, depending to a great extent on the purpose of collection.

For the purpose of description, the sources of data are broken down into those which yield data on more than one species (Section 4), and single species data sources (Section 5).

Details are also given of other organisations and datasets which were interrogated but which yielded no relevant data.

4 Data sources covering more than one species

4.1 Botanical recording

Botanists have long collected records of plant distribution. Many of these are unpublished, while some records are dispersed in 'grey literature', such as surveys and reports of field trips.

A great deal of information on plant distribution in Highland is to be found in various county floras (*e.g.* Duncan 1980, Evans 2002, Pearman & Preston 2000, Webster 1978). Some recent local floras (*e.g.* Bungard) are available on the internet.

For scarce or local species, place names are often given, though it is not always easy to identify these locations accurately, *e.g.* a record of Japanese knotweed in "various waste places, Strathpeffer" (Duncan 1980). Floras commonly use Ordnance Survey (OS) grid squares to describe locations, but usually only at low resolution (such as 10km squares).

Published and unpublished plant records have been gathered by Vice County (VC) Botanical Recorders working (as volunteers) under the *aegis* of the Botanical Society of the British Isles (BSBI). A major data-gathering exercise was undertaken in the late 1990s prior to the compilation of the New Atlas (Preston *et al.* 2002).

The Highland vice-counties are detailed in Appendix 1. Most of the botanical records for these vice-counties have been entered into a digital database, though some data have yet to be digitised. This project is ongoing, and due for completion in 2011 (J. McIntosh *pers. comm.*).

Three BSBI digitised datasets include data for Highland:

- The dataset "Vascular Plant Database" (VPD)1 holds 9.8 million records which detail the known distributions of 6669 taxa of flowering plants and ferns. Most of these records were collected by volunteer members of the BSBI and include those gathered for the Atlas of the British Flora (Perring & Walters, 1962) and the New Atlas of the British and Irish flora (Preston *et al.* 2002).
- The dataset "Vascular Plants Database additions since 2000" lists 1.3 million recent records.

- The dataset "Vascular plant data for Scottish Vice-counties 80, 84, 95, 96, 97, 103, 104 & 106" lists 243,000 records from eight Scottish vice-counties and computerised over the period 2005/7.

Following discussion with BSBI, we were granted full access to these datasets. Data for each plant species (Rhododendron, Japanese knotweed, Giant hogweed, Himalayan balsam) were downloaded from the National Biodiversity Network (NBN) website. For each species, the three digitised datasets were amalgamated. Records from the Highland LBAP area were extracted and mapped as described in Appendix 2. This dataset is referred to in this report as "VPD".

Many VPD records simply record presence of a species in a 10km square (or "hectad"), the unit commonly used to compile the earlier atlas distribution maps. More recently, records have been gathered for 2km squares (or "tetrads"). Some records are more accurate still, *e.g.* 1km squares or six-figure OS grid references, but these are relatively few.

For mapping purposes, the VPD data were imported into GIS (see Appendix 2), with hectad and tetrad data being assigned different symbols to distinguish them from higher resolution data.

The Highland VC recorders were also contacted with a request to provide any additional data; some data were received from VC 104, 106 and 108. These data were treated as "Miscellaneous data" (see Section 4.9), and mapped separately from the VPD.

For the purposes of the current exercise, the VPD data for Highland are valuable in the following respects:

- records are collected by competent field botanists, and verified by the VC recorders
- although coverage is uneven, it is Highland-wide, with botanists making an effort to visit all hectads.

However, they have certain deficiencies:

- records are often at a very low resolution, with many only at hectad level
- records only indicate the presence of a species; they provide no indication of abundance or extent (one isolated Himalayan balsam plant or a five hectare stand can result in the same hectad record)
- given the sparsity of field botanists in Highland, many species are under-recorded
- the record is probably rather less complete for non-native plants than native species; historically, some botanists failed to record 'alien' species (although this is changing, as BSBI now encourages the recording of non-native plants).

4.2 Scottish Wildlife Trust Phase 1 Habitat Surveys

Phase 1 habitat surveys were carried out between 1992 and 2000 for all lowland areas in the districts of Inverness, Easter Ross and Nairn. All broad vegetation types were drawn onto Ordnance Survey base maps and colour coded according to some 90 specified habitat types (NCC, 1990). Although the survey is based on

a relatively rapid visual assessment it includes codes for dominant species and descriptive target notes for particular areas of interest. It is the target notes that contained information, including a six-figure grid reference, for named non-native invasive plant species. A search of the target notes revealed 50 sites containing Rhododendron, one site with Himalayan Balsam, five sites with Giant Hogweed and six sites with Japanese Knotweed. Some information was also occasionally given on the extent of the non-native species at each location.

All grid-referenced sites have been loaded onto GIS and plotted as point data on the maps (Appendix 6).

4.3 Fishery Boards and Trusts

Many Fishery Boards and Trusts in Highland have taken an interest in INNS. Under the direction of the Rivers and Fisheries Trusts of Scotland (RAFTS), all Trusts will be preparing Biosecurity Plans. These will take account of the INNS which might threaten fisheries.

In Highland, Cromarty Firth Fisheries Trust (CFFT) has been especially proactive, and has conducted a comprehensive survey of INNPS in the riparian zone as part of a river habitat survey. The survey recorded Rhododendron, Japanese knotweed, Himalayan balsam, Giant hogweed, Sycamore, Sitka spruce, Larch and Beech. Other unidentified exotic species were photographed and GPSd.

The Trust is actively engaged in INNPS control. It has almost eradicated Himalayan balsam on the lower Conon, and is currently removing Rhododendron on the Orrin.

The Trust kindly supplied survey data in Excel format and as maps for each species. As an example, the map for Himalayan balsam is shown in Appendix 3. For our mapping, point data for Rhododendron, Japanese knotweed, Giant hogweed and Himalayan balsam were transferred manually from the CFFT maps, and shown in the maps (Appendix 6).

The quality of the CFFT dataset is high and will provide a sound basis for control programmes in the riparian zones. It must however be borne in mind that the CFFT has not conducted systematic surveys outwith the riparian zone. Whilst the great majority of Japanese knotweed, Giant hogweed and Himalayan balsam may have been identified in the CFFT catchment area, a significant proportion of the *Rhododendron ponticum* present will exist outside river corridors.

4.4 Surveys in Glenurquhart

Until recently, Urquhart Bay Woods SSSI / SAC had some of the most extensive and well-established populations of INNPS in Highland (including >4ha of Japanese knotweed and >20ha of Himalayan balsam).

Over the years, several surveys have been undertaken in the SSSI (*e.g.* MacKenzie 1989, James 2004). In 2004, Una Urquhart undertook a vegetation survey of Glenurquhart for the SAFER project. She recorded occurrences of non-native plants as point data using the DAFOR scale (Urquhart 2004).

In 2007, under commission from Scottish Natural Heritage (SNH), Scottish Native Woods collated all existing data and conducted a field survey of invasive non-

native plant species (INNPS) in Glenurquhart (Parrott 2008). Since then, Scottish Native Woods has been managing an ongoing control programme, also funded by SNH. The work is focussing principally on Japanese knotweed, Himalayan balsam, Sycamore and White Butterbur.

GIS data (polygons and points) for Japanese knotweed and Himalayan balsam from the 2007 survey are included in the maps in Appendix 6.

4.5 Scottish Environment Protection Agency

SEPA collect data on INNPS through surveys of river habitat. During 1994 – 1997, the Environment Agency (EA) coordinated a UK-wide survey of river habitats. Sites in every 10km square of England, Wales, Scotland, Northern Ireland and the Isle of Man were randomly selected and surveyed by accredited surveyors. The 5740 sites formed a baseline network, which provided a representative picture of physical river habitat quality and modification across the UK. The River Habitat Survey (RHS) is a standard field survey of a 500m stretch of river where data are collected in a replicable manner. Features and modifications, included invasive species are recorded as absent, present (up to 33% of the site) or extensive (>33%). Further details of the survey protocol are given in Appendix 3.

in 2009, SEPA started recording the presence of Japanese knotweed, Giant hogweed, Himalayan balsam and Rhododendron at all river and freshwater loch sites visited for ecological surveys. For rivers, the assessment is carried out over approximately 100m along the banks, and for lochs 200m along the shore. These routine surveys will only give a local snapshot, and will not provide catchment-wide data. The information will be used for the Water Framework Directive classification for alien species, which will highlight areas where there is a significant impact, and indicate areas for further investigation.

Data from the 1994-1997 survey, and subsequent survey data from 2005 and 2009 were supplied by EA as Excel files. Positive observations of Japanese knotweed, Giant hogweed and Himalayan balsam in Highland are included in the maps (Appendix 6). Some records of Rhododendron were also collected but as this species was not one of the main target species in the RHS the information will be an under-representation. The sites surveyed are shown on the map in Appendix 5.

The RHS dataset differs from most others in that it includes negative records. However some surveys were conducted outside the growing season, and it is possible that some INNPS were overlooked. Furthermore, some of the records are over 15 years old, during which time any of the species' status may have changed through colonisation or control operations.

SEPA and SNH compiled some information on INNS in preparation for compliance with the Water Framework Directive (WFD). However, the original list of species agreed by the WFD UK Technical Advisory Group did not include riparian plants.

4.6 Infrastructure managers

Many invasive species can readily spread along road, rail and canal networks. Their dispersal may be assisted by vehicle movements, management operations and fly-tipping (Booy *et al.* 2008).

Most infrastucture managers appear to have policies regarding the control of INNS, but identification and recording skills, and protocols for implementation appear to vary widely between organisations. Like any land owner / manager, they all have legal obligations under the Wildlife and Countryside Act 1981 not to allow the spread of Japanese knotweed onto neighbouring land. However, none of them appear to keep a centralised digitised record of INNPS.

The following managers were contacted:

The Highland Council Roads Department do not keep systematic records of INNPS centrally, although some operational depots may have information. The Council is planning to include the location of INNPS in their new GIS-linked asset management system (J. Saxby *pers. comm*.).

Scotland TranServ keep records of Japanese knotweed and Giant hogweed for trunk roads, but locations are not grid-referenced or held on GIS (J. Bowen *pers. comm.*). They provided some named locations for Japanese knotweed, but no OSGRs.

British Waterways do not keep systematic GIS records of INNPS. They provided one known location for Himalayan balsam, but no OSGR (O. Lassiere).

Network Rail do not keep records of INNPS, although they undertake control as and when necessary.

4.7 Other miscellaneous data

Data on INNPS were solicited or received from a variety of other sources, including agencies, NGOs, countryside rangers, environmental and community groups, utilities companies and individuals.

4.7.1 SNH Site Condition Monitoring

All SSSIs and SACs were visited between 1999 and 2005 as part of Scottish Natural Heritage's cycle 1 site condition monitoring programme. Brief site notes were compiled and the presence of non-native invasive plant species, if present, were identified and recorded as part of the target reporting procedure. The cycle 2 programme began in 2005 but will not be completed until 2012. Rhododendron was recorded in 42 designated SSSIs/SACs in the Highland area, Japanese knotweed in four designated sites and Himalayan Balsam in two designated sites. Giant Hogweed was not recorded in any SSSI/SAC.

All grid-referenced sites containing a recorded presence of the three non-native invasive plant species have been loaded onto a GIS and plotted as point data in the maps (Appendix 6).

4.7.2 LIFE Projects Woodland habitat restoration

The LIFE Projects Core Sites for a Forest Habitat Network Progress report 2004 (Caledonian Partnership, Munlochy) details two instances of INNPS:

- clearance of Rhododendron around Borrodale, Rahoy and Glen Cripesdale in Sunart, and Slattadale –Talladale (Loch Maree).
- clearance of Japanese knotweed at Borrodale.

4.7.3 Scottish Wildlife Trust Reserves

Invasive non-native species are recorded on reserves. Rhododendron was recorded at only one reserve - Doire Donn. Mink was recorded at Loch Fleet and Rahoy Hills.

4.7.4 Other sources

The following seven LBAP local groups were contacted and asked to supply any relevant data: Caithness, Sutherland, Easter Ross, Wester Ross, Inverness & Nairn, Skye & Lochalsh and Lochaber. A response was received from Caithness Biodiversity Group, who supplied several locations for Rhododendron, Japanese knotweed, Giant hogweed and Himalayan balsam, most with six-figure OSGRs. A response was also received from Skye & Lochalsh Environment Forum who supplied details of mink records from that area.

Data from all the above sources were entered into a spreadsheet and mapped together as “Miscellaneous data”.

5 Single-species data sources

These datasets are typically generated by projects aimed at controlling INNS.

5.1 American mink

There had been no dedicated survey specifically targeting mink in Scotland until the WILDCRU survey in 2008 which focused on an area known to have very few records of mink. Most records are incidental, either from general biological recording or from surveys targeting other species. The methodology involved in some of the otter surveys for example meant that as soon as otter signs are detected in a given survey area the search for mink signs ends. The water vole survey is mainly concerned with the conservation of water voles and therefore survey effort will be concentrated on inland waterways and habitats likely to hold water vole populations. In both these cases mink are likely to be under-recorded.

5.1.1 North-west Highlands Mink Control Project

This project was set up in 2009 as part of a wider collaborative strategy involving NE Scotland and the Cairngorms, where there are other mink control initiatives (see www.watervolescotland.org). The primary objective of the NW Highlands project is to prevent mink colonising Caithness and Sutherland through the creation of a ‘cordon sanitaire’ between Loch Broom and the Dornoch Firth. Mink monitoring rafts and trapping is being established in this zone (Rivers Carron, Kyle of Sutherland, Fleet, Oykel, Runie, Ullapool and Kanaird) as well as to the south, in the catchments of the Conon, Beauly and Ness. In the future the project may expand into Wester Ross, Skye and Lochalsh. In the cordon sanitaire rafts are placed every 5 km in freshwaters and every 1 km on accessible coastal areas.

Results from the rafts in the cordon sanitaire during the past six months revealed no evidence of mink although one mink was trapped on a fish farm to the north of Ullapool in November 2009 and another near Bonar Bridge in December 2009 – both on the northern edge of the cordon sanitaire (Lois Canham, pers. comm.). There are also results from monitoring rafts and traps set during 2008 and 2009 in the catchment of the Rivers Ness, Moriston and Conon. These data are available on a spreadsheet with grid references, site name and brief comments. Data were placed on Appendix 6 as point data.

5.1.2 Sunart Mink Control Project

This project was set up through the Sunart Oakwood Initiative with the primary aim of improving the breeding success of seabird colonies and other ground nesting birds in the Sunart area. This aim was to be achieved by trapping and removing mink from the vicinity of all known breeding colonies of seabirds. The project began in 2006 and continued until 2008, covering 3 breeding seasons. The targeted mink control areas included Loch Sunart, Loch Moidart, Loch Teacuis, and Loch Ailort, including offshore islands as well as some inland waterways around Loch Shiel, Loch Doire na Mairst, Loch Arienas and the River Aline.

Three annual reports were produced by the project (Wilson, 2006, 2007 and 2009). The success of the control scheme was measured by the breeding results of nesting birds with number of nesting pairs and numbers of young fledged for each species given for each location. The total number of mink caught was 23 in 2006, 80 in 2007 and 114 in 2008. There was no information or grid references in the reports on the precise locations of mink observed or captured or results from the mink monitoring rafts. Consequently, it was not possible to assess trends in the local mink population as the increase in captured mink could have been due to increased or better targeted trapping effort. However, the project was deemed to be successful as mink predation on ground-nesting birds was prevented at all the trapped sites. There was also an increase in the numbers of most ground-nesting birds successfully rearing chicks (Wilson, 2009).

Grid references were available for most of the seabird colonies and for some of the general locations where trapping was undertaken and these locations were converted to point data and plotted on the map (Appendix 6). However, this will be an underestimate of the distribution of mink in the Sunart area.

5.1.3 Vincent Wildlife Trust survey of Water Vole and Mink

This was a national survey of Britain that was first undertaken in 1989-1990 and subsequently repeated in 1996-1998 (Jefferies, 2003). The field survey examined 608 sites from a grid of 10 km squares in Scotland for signs of water vole and mink. The survey concentrated mainly on a 600 metre transect of waterways within each square. The results showed that mink had declined in Scotland by 59% between 1989/90 and the second survey in 1996-98. In 1989/90 there were 158 sites indicating a presence of mink while in 1996/98 this had dropped to 65.

In the Highland LBAP area positive mink sightings were recorded in eight hectads and these have been plotted on the map. These data are also listed in the NBN. Precise grid references were not available in the report.

5.1.4 WILDCRU survey

This project aimed to establish whether mink were present in the north of Scotland and to assess the feasibility of a control line between the west and the east of the Highlands. This 'cordon sanitaire' would prevent future incursions of mink dispersing northwards into Caithness and Sutherland (Harrington *et al*, 2008). In 2008 field surveys based on a 2 km sample unit at 164 pre-selected sites looked for mink signs along the north, west and east coasts and along inland waterways in Sutherland and Caithness to the north of a line between Ullapool and Ardgay. The findings indicated that there were no, or only a few transient, mink north of the proposed 'cordon sanitaire' and that a monitoring and control programme along this corridor would help to maintain the north of Scotland as a mink-free zone.

5.1.5 Otter survey of Scotland 1991-1994

The Natural Heritage trends paper on mink (SNH, 2004) summarised the distribution data from the three otter surveys of Scotland that were undertaken between 1979 and 1994 (see Green & Green, 1980, 1987 & 1997) supplemented by additional data from 1994 to 2000 from several other sources. The supplemental data, for example from the Highland Biological Records Centre, added new mink records to the west of Scotland, including Skye and Lochalsh, Loch Broom, Loch Shin and the north coast. Fifty hectads within the Highland LBAP area had a recorded mink presence from the 1991-1994 survey and a further 15 hectads were added to the mink distribution map between 1994 and 2000. These hectad grid references are included in the map (Appendix 6). Higher resolution grid references were not available.

5.1.6 National Survey of Otter distribution in Scotland 2003 -2004

This fourth national survey of otters was undertaken by SNH between 2003 and 2004 (Strachan, 2004). A total of 1376 survey sites within 574 different 10 km squares throughout Scotland were visited. The presence of mink was also recorded at a number of the survey squares. The hectad map of positive squares for mink shows the distribution of mink recorded in the 1994 survey (Green & Green, 1997) and additional records from the 2004 survey. The additional records are on the north-east margins of the mink range – the Moray Firth and Dornoch Firth area. Elsewhere in the north mink would appear to have declined since the time of the earlier surveys as there no records from the north coast or north-west Highlands. However, these data are certainly an underestimate as the full survey transect was not completed if otter signs were found first (Jefferies, 2003).

These hectad grid references were plotted on the map (Appendix 6). The data are also listed on the NBN. Higher resolution grid references were not available.

5.1.7 Miscellaneous data

Additional data were gathered from the following sources:

- **Skye and Lochalsh Environmental Forum**. Mainly records (24) of mink in a spreadsheet collected by Roger Cottis and others between 2002 and 2009 in the Skye and Lochalsh area. Contains grid references, site name and some notes on abundance etc. Some records were of scats and some were observed live animals or dead specimens found on the public road.

- **Scottish Natural Heritage staff, Kinlochewe**. 14 mink records collated by Nicola Tallach from local sources. Data in spreadsheet with dates (2002 – 2008), site name and comments on sighting. Several records refer to mink captured in live traps.
- **Clive Craik.** These seven Lochaber records from 1996 were all observed or trapped mink. Grid references and site names were published in Craik (1997).
- **British Trust for Ornithology (BTO) Waterways Breeding Bird Survey**. Seven records were collected between 1999 and 2007 from the Rivers Nairn, Findhorn and Spean areas as part of the bird survey. Data on spreadsheet with grid references, site name, date and a few comments.
- **BTO – Breeding bird Survey**. No records have been collected in recent years from the Highland LBAP area.
- **BTO - Garden Birdwatch**. No records have been collected in recent years from the Highland LBAP area.
- **Scottish Wildlife Trust Reserves at Loch Fleet and Rahoy** – mink recorded at both sites; not recorded at other SWT reserves.
- **Various sources.** Records with grid reference, site name and date from Ratcliffe *et al* (2008), MacKenzie (1993 & 2006, personal observation), Anderson, National Trust for Scotland from 2009 prints on monitoring raft, and Strachan (2004) from a 10 km square record not listed in the NBN.

5.2 Rhododendron

There have been several detailed field surveys of Rhododendron in the west Highlands, where plants and stands have been mapped according to several density classes. Some of these are available in digital format as georeferenced polygons or point data and some are available as colour-coded areas or points on paper maps. In order to present the data in a compatible and standardised format for the scale of maps in this report most of the sourced data had to be converted to point data in a GIS.

5.2.1 Rhododendron survey of Wester Ross

A survey of all the main areas of Rhododendron in Wester Ross was commissioned by SNH in 1996 in order to identify priority areas for control purposes. The resultant report included paper maps at a scale of 1:10,000 with the Rhododendron areas on the maps classified into three density categories (Robertson, 1996). Brief target notes with grid references, areas and number and density of bushes are also contained within the report. A total of 800 ha of Rhododendron affected ground was surveyed along with numerous small stands and isolated bushes too small to measure. At some of these sites there is an ongoing control scheme in place but Rhododendron frequently returns via re-growth or re-seeding, including on well controlled sites such as the Loch Maree Islands. Rhododendrons within garden ground, often the main seed source, were usually excluded from the survey as owners generally did not wish the plants removed.

In order to convert the mapped areas of Rhododendron from the paper maps into a digitised georeferenced format the scanned images were used as a locational

backdrop to create points on a GIS. Points were created for each stand of Rhododendron irrespective of area or density class. Larger stands that extended across more than 1 kilometre square were allocated additional points. This method provided a quick and easy solution for the digitisation of Rhododendron areas with centre point grid references on a map at a scale suitable for strategic planning. Full digitisation of all the paper map polygons and points would have been time consuming and beyond the scope of this project.

Ninety nine points indicating a Rhododendron site were obtained from the paper maps and these are plotted on the map in Appendix 6.

5.2.2 Rhododendron survey of Sunart Oakwoods

A survey of the Sunart Oakwoods Initiative area (Morven, Sunart, Moidart and Ardnamurchan) was commissioned by Forestry Commission Scotland and completed in 2008. This is one of the most comprehensive surveys available as it updated existing surveys and added new information, often from remote parts of the region (Kennedy, 2008). All sites were investigated and transposed onto 1:25,000 scale paper maps through a combination of roadside survey, local information and walkover field survey. Rhododendron sites, including garden and individual plants, were classified into three density categories. The report also describes the distribution and status of the Rhododendron in each mapped area and includes recommendations for control and estimated costs, particularly at priority sites. A total of 3,314 ha within the Sunart Oakwoods Initiative Area are currently affected by *Rhododendron ponticum*. Many of the sites are SSSIs or SACs and, although Rhododendron control schemes are in place across 1,725 ha of the total area, almost all of them still contain Rhododendron and require further follow-up work.

In order to convert the mapped areas of Rhododendron into the GIS format standardised for this report the same procedure as described for the Wester Ross survey was used.

One hundred and seventy six points indicating a Rhododendron site were obtained from the paper maps and these are plotted on the map in Appendix 6.

5.2.3 Survey of key areas of woodland within Lochaber

This survey was commissioned by SNH and carried out in 1997. The survey concentrated on a limited number of woodland sites in the Lochaber area that had a high conservation interest and were mainly SSSIs (Buist, 1997). Rhododendron was mapped at 1:10,000 scale and classified into three density categories on paper maps. A total of 584 ha were surveyed. The survey included a number of sites that were more recently mapped for the Kennedy (2008) survey but also included sites outside that survey area, mainly in the Loch Leven area. It is these latter eleven sites that were incorporated into the maps for this report using the same standardised method as for Wester Ross.

5.2.4 Survey of Glen Garry (Lochaber)

This survey was commissioned by Scottish Native Woods and undertaken in 2004. It was a rapid field survey of private land in the Glen Garry catchment and was based on roadside observation and binoculars along with some walkover field checking (MacKenzie, 2004). The survey excluded land belonging to the Forestry Commission which was conducting its own assessment. All surveyed areas were

digitised as polygons onto 1:10,000 scale maps using GIS software. The mapped polygons were divided into five broad density classes. A total area of 160 ha of Rhododendron was surveyed. None of the areas were under a Rhododendron control scheme at the time of the survey.

Although this survey is available in a fully digitised GIS format the polygons were converted to seventeen points in order to make the data compatible with the data created from the paper maps.

5.2.5 Survey of NTS Balmacara Estate

National Trust for Scotland (NTS) have carried out a detailed Rhododendron survey of their Balmacara Estate. The first field survey was undertaken in 1999 and was updated during 2008 and 2009. This was a comprehensive survey and each Rhododendron plant or stand was recorded with location, area, site class and other data on a dataset. Boundaries were recorded with a GPS and transferred to a GIS as polygon and point data. A total of 226 points indicating the distribution of Rhododendron in the survey area was transferred to the map in Appendix 6.

5.2.6 Survey of NTS Torridon and Inverewe Estates

There are no comprehensive mapping data available at present but there are details on a spreadsheet and some maps of selected sites at Torridon where Rhododendron has been controlled and sites where a control scheme is planned. The details of 49 sites at Torridon and Inverewe include grid reference, site description, broad habitat type, area or abundance of bushes (DAFOR scale) and method of control (previous and planned work). These locations were added as point data to the map (Appendix 6).

5.2.7 Forestry Commission Scotland – Grant Schemes

The Forestry Commission has funded a large number of Rhododendron control programmes throughout the Highland area over the past 10-15 years. The Woodland Grant Scheme (WGS) paper files (mainly between 1995 and 2003) contain information on the location and density of Rhododendron as well as compartment maps of the areas brought under control. However, these data are not digitised and the identification of WGS sites could only be ascertained from location information supplied by the Woodland Officers. Plan identification numbers were then obtained from the Land Information Service on the FCS website in order to locate the paper files in FCS's Dingwall office. This was a relatively time consuming process which was not very comprehensive as out of date contracts had sometimes been destroyed.

The Scottish Forestry Grant Scheme (SFGS) covered the period 2003 until 2008 and all schemes were listed on a species searchable dataset. A keyword search revealed the location, grid reference, area, control method and GIS map of every grant-aided SFGS in Highland Conservancy. In some cases the polygons on the GIS were an accurate map of the extent of Rhododendron but at some sites the Rhododendron may have been a component of a larger mapped area.

The current grant scheme, the SRDP, also funds Rhododendron control programmes, but at present only two schemes are found in Highland Conservancy, although several more are in preparation (Ian Collier, *pers. comm.*).

The grid references of the WGS and the polygons of the SFGS/SRDP were entered into the Invasive Non-native Species dataset as points in order to be compatible with the data presented in the map (Appendix 6). The FCS grant schemes provided a total of 120 points in the Highland area and their distribution and overlap with other data sources are an indication of where the main control schemes are located.

5.2.8 Forestry Commission National Inventory of Woodland and Trees

The Forestry Commission carries out a national survey of all woodlands every 15 – 20 years. The most recent survey was undertaken between 1994 and 2000 to provide a digital map showing all woodlands over 2 ha (FC, 2001). The map illustrates broad forest types that were initially created from an updated version of the woodland components of the Land Cover of Scotland 1988 project (MLURI, 1993). Ground sampling was also undertaken to obtain information on tree and shrub species, age and stocking density. Sampling was based on 1 hectare square plots in selected woodlands in order to achieve a 1% sample of the woodland in each of three size categories. Rhododendron was included in the sample survey and the digital dataset can be interrogated at a 1 km square resolution to provide point data. These are included in the map (Appendix 6). More precise data at the 1 hectare scale are not available because of owner confidentiality. 65 of the surveyed sample plots within the Highland LBAP area were recorded with Rhododendron.

5.2.9 Other miscellaneous data

- FCS Woodland Officers marked areas of known Rhododendron sites on a map of the Highland LBAP area. These 20 sites were additional to the grant aided schemes described above. The sites were converted to grid references and added to the map as point data.
- Plantlife Scotland carried out a survey of seven key woodland sites in the west of Scotland with Rhododendron infestation in order to determine the impact of Rhododendron and Rhododendron control work on important bryophyte and lichen species (Long and Williams, 2007). Sites listed in the report were added to the map as point data.
- Some VC recorders provided additional details of Rhododendron sites that included grid references of variable resolution as well as site names. A total of 130 sites were provided. If the grid reference was only 10 kilometer square resolution but a precise location name was given then this was converted to a 1 kilometer square resolution and added to the map as point data.

5.3 Japanese knotweed

5.3.1 Control programmes

The Skye and Lochalsh Environment Forum (SLEF) Japanese knotweed Project has been surveying and controlling knotweed in Skye & Lochalsh since 2008. The project is funded under the Communities Projects for Highland Biodiversity programme.

Data were gathered from a variety of sources, including earlier surveys, local knowledge and reports from the public and agency staff. Data were compiled and verified by project staff through the National Trust for Scotland (NTS) office at Balmacara. This project will close in May 2010 although new records are still being added to the database. The database includes detailed information on location, extent, access and control measures undertaken.

Point data indicating the location of 143 stands were supplied by the project in Excel and mapped, together with the area being surveyed (map, Appendix 6).

5.3.2 Licences and legal infringements

Japanese knotweed is specifically mentioned in two pieces of UK legislation.

It is an offence under section 14(2) of the Wildlife and Countryside Act 1981 to "plant or otherwise cause to grow in the wild" any plant listed in Schedule 9, Part II to the Act (which includes Japanese knotweed). Infringements are handled by the Wildlife Crime Unit. Contact was made with WCU but no response was received.

Any Japanese knotweed-contaminated soil or plant material that owners or developers intend to dispose of is likely to be classed as 'controlled waste' under the Environmental Protection Act 1990 and has to be accompanied by appropriate Waste Transfer documentation.

Licences for the movement of controlled waste are handled by SEPA. Equally, infringements are reportable to SEPA. Whilst SEPA maintain a database of waste movements and complaints, it cannot be searched for information relating to knotweed (P. Watson *pers. comm.*).

5.4 Giant hogweed

A control programme for Giant hogweed was started in 2006 along a few kilometres of the Auldearn Burn (Nairn), and coordinated by Bowlts; spraying was repeated in 2007 and 2008, but not in 2009. No maps or GPS data appear to have been generated by this exercise, but there are proposals to progress the spraying in 2010 (C. Forster, J. Willet *pers. comm.*).

5.5 Himalayan balsam

NTS have mapped Himalayan balsam at Balmacara and have been working to control it. Several small areas at Reraig are included as “Miscellaneous data”.

6 Discussion

The data used to build up a picture of INNS distribution come from a wide variety of sources. Some have been expressly gathered in order to plan a programme of control. For plant species, such surveys typically focus on a relatively small area (a single land-holding or a river catchment, for instance). They aim to search the area systematically and pick up a very high proportion of plants. They usually include accurate information on the location, extent and densities of stands, often mapped as polygons using GPS. At the other extreme, some datasets simply comprise a collection of incidental observations.

Combining such disparate datasets is naturally fraught with difficulties when it comes to interpretation. The maps generated from such an exercise are likely to reflect observer effort as much as actual species distribution. The maps generated should therefore be treated with caution.

6.1 Trends and impacts

It is self-evident that the status of all the five species investigated has changed over time. By their very nature, INNS can quite quickly increase their range. Equally, where attempts have been made to control INNS, there is potential for range contraction.

However, the data for most species are too sparse to allow any assessment of any trend in changing distribution or status. No attempt has been made to sort data according to the date of recording.

Data collected for this project suggest that all the four plant species continue to have a significant negative impact on biodiversity and appear to be spreading. An audit of alien species in Scotland undertaken a few years ago (Welch *et al*., 2001) concluded that the present and future impact was either moderate or significant and that the current trends in status of the four plant species were for a significant increase. Despite a number of projects to control all five species, it is doubtful whether any control programme for any of these five species in Highland has yet resulted in complete eradication from any site.

In relation to American mink, Welch *et al.* (2001) concluded that the species had a highly significant present and predicted future impact on small mammals and ground nesting birds, especially associated with aquatic habitats. They determined that the current trend in status of mink was a small increase but there was limited information on the pattern of its spread and there were insufficient records in some areas. The map in Welch *et al.* (2001) indicated very few records north of the Great Glen but recent distribution data collected by the mink control projects and local recorders suggest that mink may be increasing in the west of Scotland.

Scottish Natural Heritage are currently updating their trend notes on non-native species and these will become available on a new SNH website that is due to be launched in the spring of 2010.

6.2 American mink

Most of the higher resolution mink records shown in the map were collected over the past ten years while the hectad records tend to be from 1979 to early 1990s. There is a clear pattern of mink distribution in the coastal areas of Sunart, Skye & Lochalsh, river systems entering the Dornoch and Beauly Firths and along the Great Glen. There is also a scattering of records from Wester Ross. Elsewhere, and particularly the north, the records may be over 25 years old. However, many of the recent records reflect the enthusiastic collecting of data by local recorders (*e.g.* Skye) and the efforts of the mink control projects (*e.g* Sunart) and mink may be under-recorded elsewhere – Wester Ross for example. The conclusions from rapid, one-off surveys, such as the WILDCRU sampling of Caithness & Sutherland, should also be treated with some caution. Additional survey effort should probably be undertaken in many of the remote coastline habitats north of Ullapool. Surveys in the more outlying Inner Hebridean islands of Rum, Eigg, Muck and Canna, have concluded that mink are absent from these locations (Craik, 1997). But islands closer to the mainland and within the two mile (3.2km) swimming range of mink, such as Soay, Rona and Scalpay do hold mink populations. One interesting location is the record of mink on Priest Island some five kilometers from the nearest point of the mainland (Ratcliffe, 2008). The ability of mink to travel and to swim great distances should not be underestimated.

6.3 Rhododendron

Rhododendron ponticum is a ubiquitous species throughout the Highlands. It achieves its greatest density and impact on natural habitats in the west but also thrives at localised hotspots in the east and central Highlands. It is only in the north where records are sparse. There are very few hectads in the west without Rhododendron and it also grows in many of the islands such as Rum, Eigg, Canna, Raasay and Soay. Recent surveys in the west have shown the pattern of spread in native woodlands, neglected plantations and adjacent moorland. The higher resolution data on the map give a much more accurate indication of density and distribution in these areas but a better overall picture of the Highlands could be obtained with more precise survey coverage in the areas where there are only hectad data.

Rhododendron control has been ongoing in some areas for many years. Annual clearance programmes have resulted in a significant reduction of plants in many areas but have rarely resulted in complete eradication. Control of Rhododendron in the Coulin native pinewood in Wester Ross has been ongoing for 30 years but seedlings are still successfully regenerating in the woodland (MacKenzie, 2007). Despite regular removal of bushes the Loch Maree Islands continue to be colonised by Rhododendron from seed sources on the mainland. LIFE control programmes in the Loch Maree - Talladale area eradicated all the main bushes but a lack of follow up work has resulted in re-growth and re-colonisation.

The distribution of Forestry Commission grant-aided control schemes on the map (Appendix 6) indicates those areas where there has been control but most areas still contain Rhododendron. There has been no regional survey to establish the degree of success of grant-aided control schemes.

6.4 Japanese knotweed

Japanese knotweed is widely distributed in Highland, although stands are rarely large. It is particularly associated with Estate policies, dwellings, watercourses, waste ground and roadsides. In addition to deliberate translocation (mainly historical), movements of contaminated material by contractors involved in construction and road maintenance appear to be an important factor in its spread.

Some correspondents volunteered additional data on other knotweed species, all members of the family Polygonaceae:

Giant knotweed	*Fallopia sachalinensis*
Hybrid knotweed	*Fallopia x bohemica*
Himalayan knotweed	*Persicaria wallichii*

All are invasive, and should probably be considered alongside *Fallopia japonica* for the purposes of future survey and control.

6.5 Giant hogweed

The distribution of Giant hogweed in Highland is strongly focussed on the Moray Firth, with a hotspot around Nairn. It is much more frequent in neighbouring Moray and Grampian. This underlines the need to take account of a species' status in adjacent areas when planning a control strategy for Highland.

There is anecdotal evidence that some owners have undertaken control of Giant hogweed on their own holdings. This may partly explain its relatively restricted distribution.

6.6 Himalayan balsam

Like Giant hogweed, Himalayan balsam is most frequent in the Moray Firth. It is has a reputation for rapid spread, especially along watercourses. The population in Glenurquhart appears to have started in a garden by Loch Meikle in the 1980s; by 2007, it dominated the field layer over *c.* 20 hectares of Urquhart Bay Woods, about 10 kms downstream.

Balsam thrives best on nutrient-rich soils and in areas free of domestic grazing. Its spread in Highland may have been hampered by the fragmented nature of suitable habitat.

7 Principal recommendations

7.1.1 Gathering more data

Gathering accurate and up-to-date information on the distribution and status of any invasive non-native species is an essential stage in the planning and implementation of an INNS control programme (Grice 2009).

Some of the data sources queried for this report were deficient in certain respects. For instance, some data were low resolution, while others were not

digitised or georeferenced. Some areas were under-recorded (*e.g.* Rhododendron in the Great Glen, Mink in the far North). Some mink control schemes did not adequately report trapping and monitoring raft results (OSGRs, site names and numbers of animals). There is a need to encourage observers to adopt more comprehensive data collection protocols.

Our enquiries identified some data sources which should yield useful additional data to our draft maps in the near future. These are from surveys or data-gathering exercises which are still ongoing. They include:

- a survey of Rhododendron on the Forestry Commission estate - likely to become available late 2010
- complete digitisation of Vascular Plant Database (VPD) by VC recorders – to be completed 2011
- Native Woodland Survey of Scotland (NWSS) - data for Highland should be published 2012

It is also likely that the publication of this report will prompt the offer of additional data from various quarters. With the help of BSBI and vice-county recorders, there may be scope for presenting VPD data at a higher resolution. With access to the full dataset, including recording dates, it may be possible to track changes in distribution over time.

> Set up a system for collecting data on priority INNS, following a standard protocol

7.1.2 Engaging the public

Many of the data used in this report have been gathered by amateur botanists, volunteers and members of the public. Further public participation could yield much more data, as has been demonstrated in other INNS initiatives (*e.g.* Cornwall Knotweed Forum, Harlequin Ladybird Project).

Involving the public in the early stages of a control programme is also likely to lead to better cooperation in the longer term. Reporting sightings, ongoing monitoring, liaising with landowners and certain control operations could all be greatly facilitated by local communities.

> investigate options for greater public participation in INNS reporting, monitoring and control

7.1.3 Developing strategies for INNS control

Many past efforts at INNS control have made encouraging initial progress, only to falter at a later date. The reasons for this vary. Many control programmes have only operated on individual holdings, and have been compromised by recolonisation from sources on neighbouring land or upstream. Other schemes have simply failed to sustain control operations and ongoing monitoring over a sufficiently long period.

In particular, rhododendron control has often been undertaken on single holdings and eradication has rarely been achieved.

> Review the effectiveness of past and current control programmes

The most appropriate control strategies should be assessed for each of the five priority species. These strategies should set out objectives, timescales and geographical scales. These will be determined by each species' current distribution and status, its dispersal ability, control methods and available resources.

For example, in certain areas, containment may be an objective for rhododendron. For less well-established species, eradication may be a desirable and achievable objective. It may appropriate to initially focus limited resources on control in peripheral areas where there are only a few records.

> Draw up a control strategy for each of the five priority species

8 The next steps

An interactive web-based facility to input records would help address many of the above objectives.

It would facilitate the maintenance of an up-to-date database on INNS distribution in a standard format, and minimise the labour involved in data management. A website would allow data to be viewed, updated and shared by any party with access to the internet, including agencies, NGOs and individuals.

The interactive maps would also allow the progress of control projects to be monitored over time. The inclusiveness and transparency offered by a public-viewable platform will assist with fund-raising efforts.

The website would provide a forum for exchanging a wide range of information on invasive species, control techniques and news on ongoing projects.

Because Highland is fortunate to host relatively few INNS, it would be an ideal area to trial an innovative approach to controlling and monitoring invasive non-native species.

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11 Appendices

Appendices 1- 5 (A4 – appended below)

Botanical records in Highland vice-counties

Importing data

CFFT data (Himalayan balsam)

River Habitat Survey protocol

RHS survey sites

Appendix 6 (A3 format – as separate files)

Metadata (.xls) for each species:

- American mink
- Rhododendron
- Japanese knotweed
- Giant hogweed
- Himalayan balsam

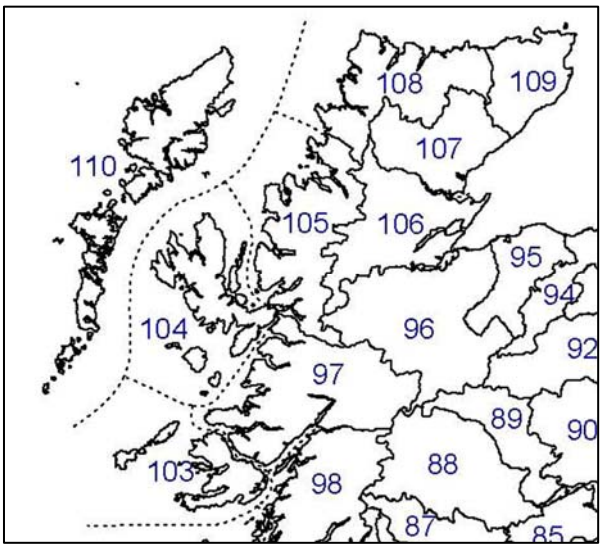
Maps (.jpg) for each species:

- American mink
- Rhododendron
- Japanese knotweed
- Giant hogweed
- Himalayan balsam

Appendix 1: Botanical records in Highland vice-counties

For the purposes of botanical recording, H. C. Watson split Great Britain into "vice-counties" in the mid-nineteenth century. The collection of vascular plant records is coordinated by the Botanical Society of the British Isles (BSBI). The Society appoints a Recorder for each Vice-county, and it is the Recorder's role to catalogue and verify records of plants in that county.

There are 112 Watsonian vice-counties in Great Britain. Although the vice-county boundaries often follow those of present-day administrative counties, they are fixed. The counties have a roughly similar size and these units are widely used for biological recording purposes.



The Highland LBAP area includes the following vice counties:

96	Easterness	(East Inverness-shire with Nairn)
97	Westerness	(West Inverness-shire)
104	North Ebudes	(Skye and the Inner Hebrides)
105	Wester Ross	
106	East Ross	
107	East Sutherland	
108	West Sutherland	
109	Caithness	

and part of the following two vice-counties:

95	Moray	Moray
98	Argyll Main	

Records in the Vascular Plant Database (VPD) appear at different levels of resolution, this being indicated by the format of Ordnance Survey grid references (OSGR), as shown in Appendix 2.

Appendix 2: Protocols for importing, presenting and collating data

Data importation

Data were received in several different formats. Apart from the data for Mink, data with location names only (i.e. without OSGRs) were not generally imported into GIS.

GIS files and other geo-referenced data (*i.e.* maps and data with Ordnance Survey grid references) were imported into the maps as described below.

method/protocol	*file format*	*import stages*
1	GIS files (e.g. SHP, DRA)	direct to GIS
2	tabulated data files (e.g. TAB, DOC, XLS) with OSGRs	convert to DBF and import to GIS (see protocol below)
3	maps as graphics files	calibrate and manually digitise points (estimated centre points for polygons)
4	hardcopy maps	scan, calibrate and manually digitise points (estimated centre points for polygons)

For the purposes of importing into GIS, OSGRs were converted to all-numeric coordinates in 2 columns, as shown in the example below.

OS grid ref format	**X (easting)**	**Y (northing)**	**resolution (m)**	
NH16	210000	860000	10000	hectad
NH16A	211000	861000	4000	tetrad
NH1060	210000	860000	1000	
NH100600	210000	860000	100	
NH10006000	210000	860000	10	
NH1000060000	210000	860000	1	

A standard procedure was adopted to import tabulated data into GIS. For mapping purposes, hectad and tetrad records were assigned different symbols to distinguish them from higher resolution records. VPD points were offset, rather than centred, so that the larger square symbols (for hectads and tetrads) correctly defined the area indicated by the OSGR.

As an example, the protocol used for mapping the VPD data is detailed overleaf.

Importing Vascular Plant Database datasets to GIS

For each species (sp):	*file name*
download TAB data for: Vascular Plants Database	
Vascular Plants Database additions since 2000	
Vascular plant data for Scottish Vice-counties 80, 84, 95, 96, 97, 103, 104 & 106	
amalgamate datasets in Excel	*NBN sp ALL.xls*
remove data for Northern Ireland (OSNI), retaining all OSGB data	*NBN sp OSGB.xls*
select data for grid squares NB NC ND NG NH NJ NM NN NO	*NBN sp NBNO.xls*
sort by resolution (10000, 4000, 1000, 100)	
move tetrad data (4000m res) into a new worksheet	
convert alpha-numeric OS GRs to all-numeric X and Y for both worksheets	*NBN sp grcon.xls*
select data in each worksheet and save each as a DBF	*NBN sp hectads+.dbf*
	NBN sp tetrads+.dbf
import each DBF dataset into Mapmaker	*NBN sp hectads+.dra*
	NBN sp tetrads+.dra
in Mapmaker, load both DRA files into live layer with DBF data	
save live layer (all data for North Scotland, NB - NO)	*NBN sp NSCOT.dra*
load NBN sp NSCOT into live layer with DBF data	
clip with HIGHLAND LBAP area polygon	
save selected data	*NBN sp Highland.dra*
	NBN sp Highland.dbf
separate data according to styles (resolution) for clarity of mapping	*VPD sp hectads*
	VPD sp tetrads
	VPD sp higher res

Data presentation

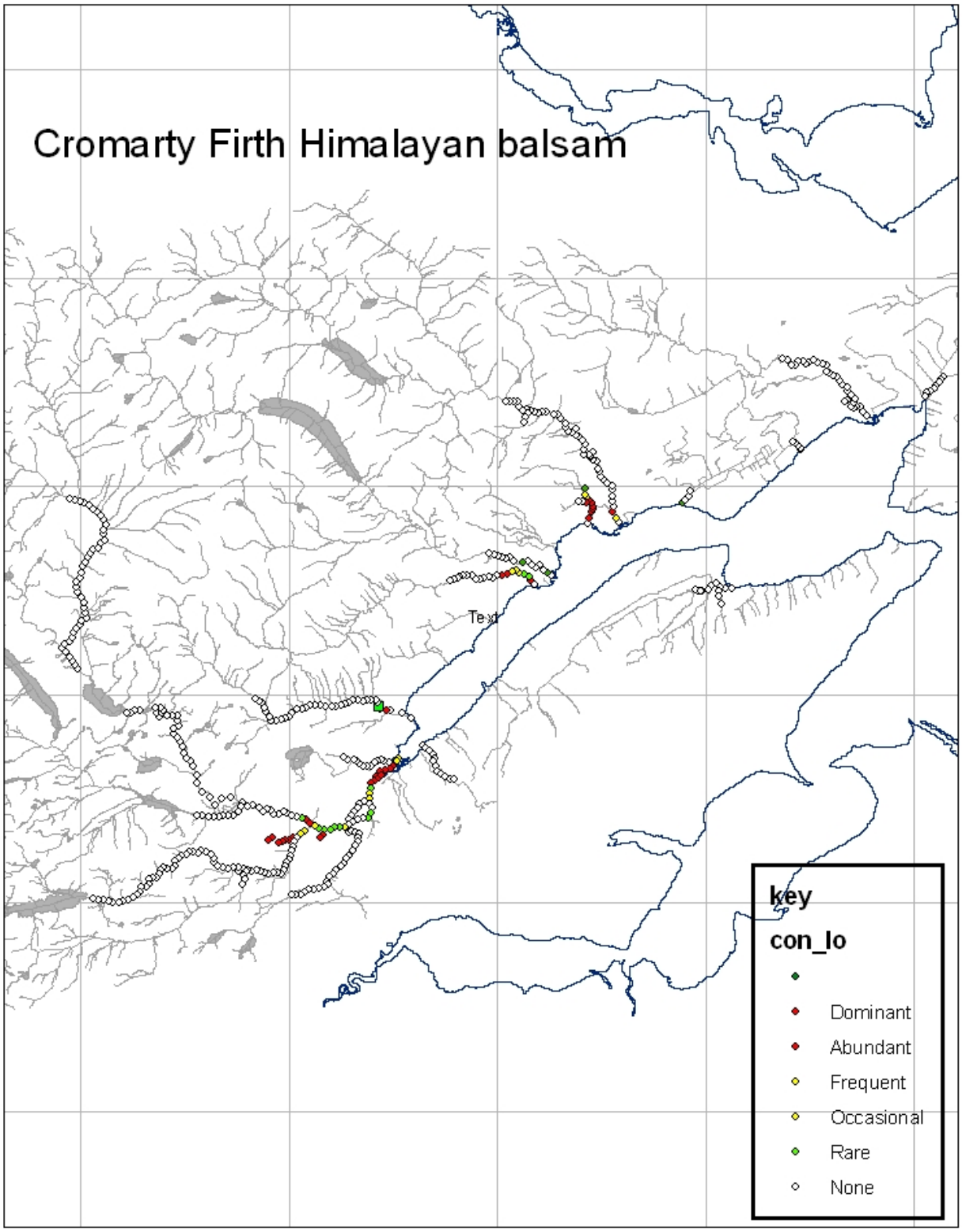
Metadata for each species are summarised in Appendix 6.

Data for each species are mapped at a scale of 1 : 1 000 000 (Appendix 6).

All digital data collected are saved to the appended CD.

Appendix 3: CFFT data

Cromarty Firth Fisheries Trust (CFFT) has carried out comprehensive surveys of INNPS in the riparian zone. As an example, the data for Himalayan balsam are shown below.



Appendix 4: River Habitat Survey 1994 – 1997

The RHS survey protocol allows the recording of "Notable Nuisance Plant Species" as shown in Section O of the form:

O NOTABLE NUISANCE PLANT SPECIES Use ✓ or E (≥ 33% length) *record even if <1%

		bankface	banktop to 50m		bankface	banktop to 50m
None ☐	*Giant hogweed	☐	☐	*Himalayan balsam	☐	☐
	*Japanese knotweed	☐	☐	*Other (state).....	☐	☐

and the following notes from the Field Survey Guidance Manual:

SECTION O. NOTABLE NUISANCE PLANT SPECIES

Indicate the absence or presence (including extent) of those alien plant species listed on the form by ticking appropriate boxes.

Estimate abundance within the site as a whole by using a '✓' when present along <33% of the bank-length or 'E', when present along ⩾33% of total bank-length. Separate records are made for the bankface, and the river corridor up to 50m from the banktop. **Include plants growing on mid-channel bars in the 'bankface' category.**

The main introduced nuisance species associated with rivers in Britain and Ireland are:

* giant hogweed (*Heracleum mantegazzianum*) O1a;

* Himalayan (Indian) balsam (*Impatiens glandulifera*) O2a;

* Japanese knotweed (*Fallopia japponica*) O3a.

If you know that other alien species are present, list these in the space provided. A common example in some upland locations is Rhododendron. O4a.

Species are shown on the form prefixed by an *asterisk, so the presence of a single plant should be recorded. It is important to report even an isolated occurrence, since control measures may be able to be taken.

Appendix 5: RHS survey sites