# *Rhododendron ponticum* in Britain and Ireland: Social, Economic and Ecological Factors in its Successful Invasion

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## ABSTRACT

*Rhododendron ponticum* is the most expensive alien plant conservation problem in Britain and Ireland. It was introduced in the eighteenth century, probably in 1763 from Spain, and was then described as a not fully hardy plant. It was expensive to buy. It was made hardier by artificial and natural selection and by hybridisation with Appalachian and other *Rhododendron* species. It is easy to propagate and became cheap and popular in the mid and late nineteenth century as an ornamental, for game cover and as a root stock for other ornamental rhododendrons. The lowest price was in about 1880 by which time it had escaped widely. The escapes were ignored by botanical recorders for over 50 years. It was scarcely recognised as a problem until between the two world wars. Major control projects date from the second half of the twentieth century.

## KEYWORDS

*Rhododendron ponticum*, Britain and Ireland, history, biological invasions, plant prices

## 1. INTRODUCTION

There has been a 'rising tide' both of invasions and of books about invasions, building on the well known works of Elton, Williamson and various international programmes.[1] With this, there has been a rising interest in risk analysis

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with a view to predicting troublesome invaders.[2] But, while it is often possible to explain invasions, 'explanation is not prediction'. [3] There is also a growing awareness of the importance of human effects on biological invasions after the introduction stage, making it more and more evident that invasive species are an interdisciplinary problem requiring a combination of insights from biological and social-economic science and history. [4]

One of the key variables explaining biological invasions seems to be propagule pressure, which comes from the number of introductions and the number of propagules in each introduction. With increasing propagule pressure there is an increasing probability of species establishing.[5] Propagule pressure depends generally on human activity and so is a socio-economic and historical variable. Williamson noted that propagule pressure and previous success were the most useful factors in explaining invasions and were historical rather than biological.[6] Even so, there is rather little research that tries to relate invasion processes to underlying socio-economic factors. For plants, deliberate introduction for horticulture is the main pathway for aliens in many countries (see Groves for Australia, Mack and Erneberg for the USA, and Kühn and Klotz for Germany).[7] Socio-economic factors, like gardening fashions or the structure of the horticultural market, affect the extent to which a species is distributed and planted and so influence the pattern and extent of propagule pressure.

Time lags between the introduction of many species, their naturalisation and the occurrence of recognised damage make it necessary to take into account historical processes that may have favoured their invasion success. For example, many of the species problematic in Britain today are introductions from the eighteenth/nineteenth centuries, the 'Age of the exotic specimen'.[8] *Fallopia japonica, Heracleum mantegazzianum* and *Impatiens glandulifera* were all introduced as ornamentals in the first half of the nineteenth century. Furthermore, of 348 plants listed as garden escapes 97 per cent were introduced before 1900.[9] Their use and promotion soon after their introduction into a new area may be the key to understanding their invasion processes and their distribution today. Although the way a plant is perceived does not influence the invasion process directly, it is the underlying rationale for planting it and controlling it. Differing views on how to value and classify the impact of invasive species are common even within groups of different scholars and have implications for policy.[10] Plants introduced as ornamentals are especially the subject of different views in society as they may be regarded particularly favourably. This may change for ornamentals that become invasive resulting in parts of society seeing the species as a pest and others still valuing it as an ornamental. This change from 'prize-winners to pariahs' has been documented for *Fallopia japonica* in Britain and *Prunus serotina* in central Europe.[11]

In this paper, we consider *Rhododendron ponticum* in Britain and Ireland so as to analyse the interplay of social, economic and ecological factors in its invasion process. *R. ponticum* has been present in Britain for more than 240

years and is today the most damaging alien plant in semi-natural habitats, with high control and restoration costs.[12] These populations are genetically, ecologically and generally morphologically distinct from other populations.[13] Their main ancestor is the population of *R. ponticum* from the southernmost tip of Spain and their minor ancestors are *R. catawbiense* and *R. maximum* from the Appalachian mountains in USA and other *Rhododendron* spp. The Black Sea populations of *R. ponticum*, which are mainly in Turkey, including Pontus, but also in Bulgaria, Georgia and the Russian Caucasus, seem not to have been involved.[14] The Iberian populations are relic and vulnerable, even endangered.[15] How and why did this scarce, not fully hardy (by English standards) plant become a troublesome problem?

Ecologists have attributed its success as an invasive species mainly to its biological-ecological characteristics: the species produces great quantities of small wind-dispersed seeds, it is shade tolerant and out-competes other plants through its dense canopy.[16] The establishment of seedlings seem to be the critical stage in the life cycle of *R. ponticum* as it depends on the presence of damp and partly shady sites with seedlings likely not to survive any droughts.[17] Fallen logs or tree stumps, newly colonised by moss, were identified as the most favourable habitat type for seedling establishment in woodlands.[18] The possession of ericaceous mycorrhizas enables *R. ponticum* to colonise and perform well on sites low in nutrients.[19] The leaves contain andromedo-toxin which is highly toxic if ingested and causes grazing animals to avoid the plant.[20] The impacts of the species are seen as negative because it overgrows and out-competes native plant communities, in particular woodland and heathland on acid soils. The control of the species is difficult as it is able to resprout readily when it is cut back and re-colonises cleared areas quickly if any seed-sources are left. Similarly, fire will destroy seedlings and shoots but re-sprouting will occur from underground buds.[21] However, many of these characteristics describe the genus Rhododendron in general and are not in particular specific for *R. ponticum*. For example, in the southern Appalachian mountains *R. maximum* is causing similar problems, but has not ever been recorded even as a casual in Britain.[22]

In view of the four or five hundred Rhododendron species and many cultivars and hybrids grown as ornamentals in Britain it is remarkable that *R. luteum* is the only other widely naturalised rhododendron in Britain (but has not to our knowledge yet become a conservation problem), and only five other species have been seen growing as casual (temporary) plants.[23] In this paper, we therefore focus on the human mediated factors in the invasion process of *R. ponticum* which may distinguish this species from all the other Rhododendrons used as ornamentals in Britain. We trace its history from an expensive, not fully hardy plant, through selection and hybridisation for hardiness to mass planting and to the recognition of the damage it does to forests and moorlands. We hope that these considerations will bear on other cases and may even be a step towards reliable prediction.

## 2. METHODS

Our analysis of the historical reasons for planting the species is mainly based on the gardening literature of the nineteenth and early twentieth centuries. Magazines like *Gardeners' Chronicle*, *Gardener's Magazine* and *The Garden* provide, especially in the small contributions of local correspondents, an insight into the importance and handling of the species. Data on the prices paid for the species were obtained from nursery catalogues which also gave recommendations for use and on the habitats regarded as suitable. As there are only a few nursery catalogues preserved from before 1840, which at that time seldom included prices, we have unfortunately only been able to get four prices for this period.[24] Further price information for later years came from commercial advertisements in those gardening magazines. We always used the lowest price for which a plant was available, regardless of the size of the plant or the volume of sales. Historical prices were converted to 2002 pounds, using the online calculator provided by Economic History Services.[25] The calculator uses a retail price index and allows a value in pounds sterling for any year from 1264 to 2002 to be adjusted for inflation and restated at its 2002 equivalent.

First records of *R. ponticum* in the wild were obtained by writing to all 142 vice-county recorders of the Botanical Society of the British Isles (BSBI) who keep records on plants and their locations within their vice-county. (Vice-counties are the approximately equal area sub-divisions of the historical counties devised by H.C. Watson, a friend of Darwin, in 1852).[26] We received 83 answers (a 58 per cent rate of return) and 50 provided the date of the first record in their vice-county.

We also had data on the first occurrence of *R. ponticum* from two surveys run in 1985 and 2002.[27] Both surveys asked managers of nature reserves, private estates and forests to give the date of the first self-sown *R. ponticum* on their sites. In both cases we used the original completed questionnaire forms; the data have not been published. There were 74 responses from the 1985 survey, 88 from 2002. Several respondents in both surveys said their answer was an estimate and also gave the date *R. ponticum* was first planted. The vice-county of sites in both surveys was used for comparison with the BSBI survey.

## 3. RESULTS AND DISCUSSION

### *3.1. Introduction of* R. ponticum *in Britain and Ireland*

1763 is usually given as the date of introduction of *R. ponticum* to England. The earliest mention of the species in Britain is in Hill's 1768 list of species cultivated then at Kew.[28] It was William Aiton in 1789 who gave 1763 as the date of introduction and describes the 'Purple Rhododendron' as a native of 'Levant and Gibraltar'.[29] Unlike his entries for other species, he says nothing

of who introduced the plant nor is that information in the second edition of *Hortus Kewensis* by his son William Townsend Aiton.[30] So we do not know the source of Loudon's report from 1838, referring to *Hortus Kewensis*, that it was introduced in 1763 by Conrad Loddiges 'who sold the first plant to the Marquess of Rockingham, a noble encourager of botany and gardening'.[31] In 1803, Curtis gave the first detailed description of the plant with an excellent drawing (Figure 1). Although he is unsure whether the plants grown in England originated from Gibraltar or the Black Sea area, he says they resembled precisely the description of the Iberian variety.[32]

FIGURE 1. *Rhododendron Ponticum* from *Curtis's Botanical Magazine*, 1803.

For Ireland, Loudon describes a plant in Dublin '60 years planted' which in 1834 was 16 ft high, implying that *R. ponticum* was introduced into Ireland shortly after its introduction to England.[33] Rhododendrons of large size were also described from Derrycunihy Wood, Killarney by Hall & Hall in 1843 .[34]

### *3.2 Biological characteristics*

#### *3.2.1 Hardiness*

*R. ponticum* was described by Curtis as 'a hardy evergreen, but apt to be injured by late frosts'. He also says that the species was brought to the London markets in great numbers 'to ornament our houses in the Spring' probably implying that the plants were kept inside houses.[35] His description of a *R. ponticum* flower producing nectar also refers to a plant kept inside: 'standing in a very light airy bow-window facing the North'. There is no further reference to this practice later. Nowadays such a plant would be called 'not fully hardy'.

Throughout the nineteenth century there were years with severe frosts when *R. ponticum* was badly damaged. 1859 saw debilitating autumn frosts which were seen as a good test of hardiness, much discussed in the press of 1860.[36] Another exceptionally cold winter in 1894/1895 seemed to have had similar effect in parts of the country and resulted in a call to nurserymen 'to get us substitutes for this tender ponticum, which is wrongly used to such a vast extent. They might propagate catawbiense and other hardy forms to take the place of the tender ponticum … Ponticum, as we have seen, is not hardy on its own … '.[37] We have not noted any further reports of appreciable frost damage. By the twentieth century, late frosts could affect the flowers or autumn frosts the tips as reported for Somerley Park, Ringwood in 1952 but there seem to have been no serious dieback of plants, even in very severe winters such as 1963.[38]

It would seem that the stock has been changed by both natural and artificial selection and by hybridisation so that it has become better adapted to the climate in Britain.[39] Evidence for this comes from the gardening literature. In 1899, Gertrude Jekyll described her rhododendrons planted nine years before and stressed the details by which she could still recognise the original parents *R. ponticum* and *R. catawbiense:* 'these, being two of the hardiest kinds, were the ones first chosen by hybridisers, and to these kinds we owe nearly all of the large numbers of beautiful garden Rhododendrons now in cultivation'.[40] Osborn reported in 1933 that *R. ponticum* 'has been very largely used in breeding the hardy race of large-leaved rhododendrons and it is unsurpassed as a stock for grafting'.[41] Breeding practices were designed to select hardier rhododendron varieties. In his history of rhododendrons in British gardens Elliott describes the 1820s–1850s as the period which was marked by experiments in hardiness where there were systematic programmes for testing hardiness for instance by planting seedlings in the open.[42]

Indirect evidence for the selection of more hardy plants comes from the fact that *R. catawbiense,* which was usually offered as the hardy alternative to *R. ponticum,* was less frequently included in twentieth-century catalogues than in the nineteenth-century ones. A reason for this might be that it was no longer necessary to offer a hardy alternative because the hardiness of *R. ponticum* had improved.

A genetic analysis of *R. ponticum* material from many places in Scotland, England, Wales and Ireland found much hybridisation with several species of *Rhododendron* and that plants with evidence of introgression from *R. catawbiense* were significantly more abundant in Britain's coldest winter region, eastern Scotland, than elsewhere.[43] Altogether there seems little doubt that *R. ponticum* became hardier through selection and hybridisation and that this process went on for much of the nineteenth century.

*3.2.2 Ease of propagation*

Curtis gives the earliest advice: 'May be propagated by layers … , but can be easily raised by seeds'.[44] Loudon gives detailed instructions on propagation by cuttings and layers, 'a common mode with sorts which do not seed freely', but points out 'by far the most general method practised in gardens is by seeds. These are produced in abundance in this country'.[45] Although he does not name *R. ponticum,* we can safely assume that he includes it here because he gives this general information on the propagation of rhododendrons in the paragraph where he describes *R. ponticum*. He also depicts its seeds.

From an ecological point of view, the first description of self-sown plants is of particular interest as it is an essential stage on the way to full naturalisation.[46] The first hint was given in 1829 in an article in the *Gardener's Magazine*, where self sown rhododendrons are described, although no particular species is named.[47] The first reference to *R. ponticum* appears in the *Gardeners' Chronicle* in 1841 where Philip Frost, Dropmore, says: 'In the woods here we have by a little attention, thousands of self-sown seedling *Rhododendron ponticum*'.[48] Joseph Hooker in his famous description of the rhododendron species of the Sikkim-Himalaya in 1849 includes a footnote on *R. ponticum* and its self-sowing ability in Britain.[49] He quotes letters: from Embley near Romsey, Hants, Miss Nightingale reports 'the *Ponticum* and var. *roseum* seed themselves to a great extent' and from Penllergare, Glamorgan, Dillwyn Llewllyn writes: 'the seedlings of the common *Rhododendron Ponticum*, … appear in thousands throughout our woods'. In both places the landowners confirm that *R. ponticum* is still present today.

Setting viable seed and so being easy to propagate allowed extensive plantings, as the landowners could propagate and spread the plants themselves. In 1841, Philip Frost said: 'It is very easy to fill woods with them, by sowing the seeds broad-cast … . A man and boy can collect enough [seeds] to sow acres in a few hours'.[50] More importantly, ease of propagation made *R. ponticum* an

ideal product for the nursery industry that could be offered in large quantities at low prices.

### *3.3 Reasons for planting*

The extensive planting of *R. ponticum,* particularly in the nineteenth century, is seen as one of the major reasons for the success of the species in the British Isles. We consider five aspects.

#### *3.3.1 Gardening fashions*

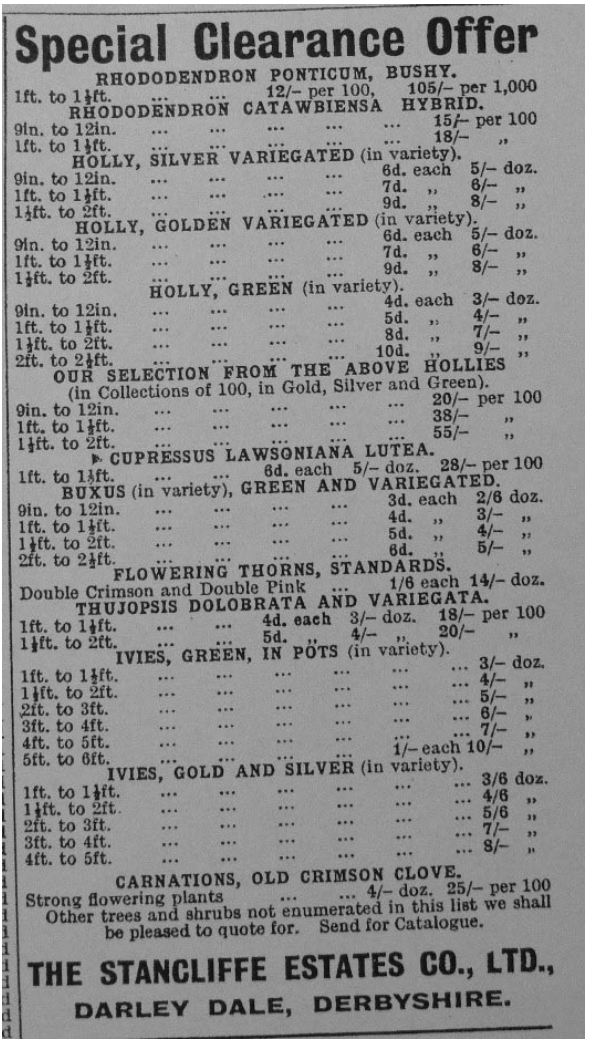
Changing gardening fashions in the nineteenth century suited *R. ponticum* perfectly. In the eighteenth century, the taste for formal gardens changed to a more naturalistic style to include the surrounding landscape. The nineteenth century saw the enrichment of these landscape gardens by adding more colour, which was provided by an increasing number of newly introduced exotic species. In addition, there was great enthusiasm for introduced species in general and rhododendron species in particular. In 1870, William Robinson published the first edition of his influential book *The Wild Garden* which promoted 'the placing of perfectly hardy exotic plants under conditions where they will thrive without further care'.[51] Woodland gardens created in the nineteenth century and the beginning of the twentieth century offered ideal conditions for rhododendron collections and they gradually became the dominant species in those gardens.[52]

#### *3.3.2 Prices*

As early as 1783 *R. ponticum* was on offer commercially in the nursery catalogue of Gordon, Dermer and Thomson, Mile End, London, but the catalogue did not give a price for the plant. The first priced entries in nursery catalogues appeared in 1793 in those from John and Grosvenor Perfect, Pontefract, Yorkshire and John and George Telford in Tanner-Row, York. Both offered 'Rhododendron the Purple or Ponticum' for the price of 7 shillings and 6 pence. The only other rhododendron species on offer in their catalogues was *R. maximum,* at 15s. twice as expensive. The ease of propagation soon made it possible to offer the plant at very low prices. *R. ponticum* was sold per dozen, per hundred and per thousand. In 1833, in F. Mackie's Norwich nursery catalogue, *R. ponticum* is again the cheapest of the 14 species on offer and together with *R. ferrugineum* the only one sold per dozen.[53] By 1838 the prices given by Loudon are per hundred and continue to appear like that throughout the nineteenth century in nearly all the catalogues analysed.[54] The only other rhododendron species offered in such quantities was *R. catawbiense*. Together they were often offered apart from the other rhododendrons in special categories like 'Rhododendrons at low prices' or 'Cheap Rhododendrons, for general planting'. For instance, in 1868 Charles Noble's nurseries, a specialised supplier of rhododendron species and hybrids, introduced this category for the first time offering *R. catawbiense* and including *R. ponticum* only two years later. Apart from the nursery trade, estates were

trading the plant among themselves using the natural supply of their woodlands thus allowing for even lower prices.[55]

After the Second World War the interest in *R. ponticum* as an ornamental, apart from its use as grafting stock, decreased rapidly. The Sunningdale Nurseries, the successor of Charles Noble's nursery, no longer offered the plant



**Special Clearance Offer**

RHODODENDRON PONTICUM, BUSHY.
1ft. to 1½ft. ... ... 12/- per 100, 105/- per 1,000

RHODODENDRON CATAWBIENSA HYBRID.
9in. to 12in. ... ... ... ... ... 15/- per 100
1ft. to 1½ft. ... ... ... ... ... 18/- ,,

HOLLY, SILVER VARIEGATED (in variety).
9in. to 12in. ... ... ... ... 6d. each 5/- doz.
1ft. to 1½ft. ... ... ... ... 7d. ,, 6/- ,,
1½ft. to 2ft. ... ... ... ... 9d. ,, 8/- ,,

HOLLY, GOLDEN VARIEGATED (in variety).
9in. to 12in. ... ... ... ... 6d. each 5/- doz.
1ft. to 1½ft. ... ... ... ... 7d. ,, 6/- ,,
1½ft. to 2ft. ... ... ... ... 9d. ,, 8/- ,,

HOLLY, GREEN (in variety).
9in. to 12in. ... ... ... ... 4d. each 3/- doz.
1ft. to 1½ft. ... ... ... ... 5d. ,, 4/- ,,
1½ft. to 2ft. ... ... ... ... 8d. ,, 7/- ,,
2ft. to 2½ft. ... ... ... ... 10d. ,, 9/- ,,

OUR SELECTION FROM THE ABOVE HOLLIES
(in Collections of 100, in Gold, Silver and Green).
9in. to 12in. ... ... ... ... ... 20/- per 100
1ft. to 1½ft. ... ... ... ... ... 38/- ,,
1½ft. to 2ft. ... ... ... ... ... 55/- ,,

CUPRESSUS LAWSONIANA LUTEA.
1ft. to 1½ft. ... ... 6d. each 5/- doz. 28/- per 100

BUXUS (in variety), GREEN AND VARIEGATED.
9in. to 12in. ... ... ... ... 3d. each 2/6 doz.
1ft. to 1½ft. ... ... ... ... 4d. ,, 3/- ,,
1½ft. to 2ft. ... ... ... ... 5d. ,, 4/- ,,
2ft. to 2½ft. ... ... ... ... 6d. ,, 5/- ,,

FLOWERING THORNS, STANDARDS.
Double Crimson and Double Pink ... 1/6 each 14/- doz.

THUJOPSIS DOLOBRATA AND VARIEGATA.
1ft. to 1½ft. ... ... 4d. each 3/- doz. 18/- per 100
1½ft. to 2ft. ... ... 5d. ,, 4/- ,, 20/- ,,

IVIES, GREEN, IN POTS (in variety).
1ft. to 1½ft. ... ... ... ... ... ... 3/- doz.
1½ft. to 2ft. ... ... ... ... ... ... 4/- ,,
2ft. to 3ft. ... ... ... ... ... ... 5/- ,,
3ft. to 4ft. ... ... ... ... ... ... 6/- ,,
4ft. to 5ft. ... ... ... ... ... ... 7/- ,,
5ft. to 6ft. ... ... ... ... ... 1/- each 10/- ,,

IVIES, GOLD AND SILVER (in variety).
1ft. to 1½ft. ... ... ... ... ... ... 3/6 doz.
1½ft. to 2ft. ... ... ... ... ... ... 4/6 ,,
2ft. to 3ft. ... ... ... ... ... ... 5/6 ,,
3ft. to 4ft. ... ... ... ... ... ... 7/- ,,
4ft. to 5ft. ... ... ... ... ... ... 8/- ,,

CARNATIONS, OLD CRIMSON CLOVE.
Strong flowering plants ... ... 4/- doz. 25/- per 100

Other trees and shrubs not enumerated in this list we shall be pleased to quote for. Send for Catalogue.

**THE STANCLIFFE ESTATES CO., LTD.,**
**DARLEY DALE, DERBYSHIRE.**

FIGURE 2. Advertisement in *The Garden*, 1912, offering *Rhododendron ponticum* at 105/- per 1000

per hundred, the price increased, and by 1955 that catalogue did not include *R. ponticum* (or *R. catawbiense*) at all. The species was also not on offer in the 1953 catalogue of the Knapp Hill Nursery. However, both nurseries later included it in their catalogues again, separately from other rhododendrons, as hedge plants. Today, *R. ponticum* is still available from a few nurseries; the 'Plant-Finder' lists 12 nurseries in the 2003/2004 edition.[56] It is offered as 'good for naturalising' or 'infilling and for woodland planting'.[57] During the whole period *R. ponticum,* sometimes together with *R. catawbiense,* was always the cheapest Rhododendron on offer.

The changes in the market in *R. ponticum* are shown quantitatively in Figure 3 from the first documented prices, 1793, to today by expressing the prices in the catalogues as 2002 pounds. The first pair of prices for *R. ponticum* of 7s. 6d. corresponds to £25.60 in 2002. This was the highest in all the catalogues analysed. There is a gap of 27 years until the next price available, 1820, when it had fallen by nearly 90 per cent to £2.76. The steady decline of the price continues to the 1870s from where it starts to go up again. From 1838 to about 1919 the price remains under £1 in nearly all catalogues, with the lowest at 20s. (one pound) per 1000 plants (£0.07 per plant in 2002 pounds) in 1886, reported for

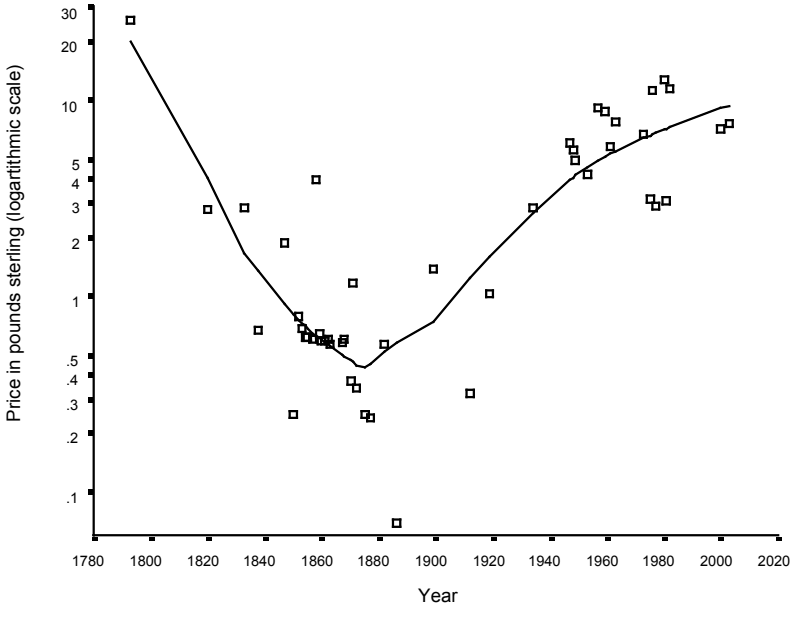



FIGURE 3. Price for one *R. ponticum* plant from 1793 to today. The prices are in 2002 pounds. The line of best fit is from a Lowess regression with a span of 0.5 (3 iterations).

a trade between estates.[58] The rise in the second half of the twentieth century is probably caused by decreasing demand and lower competition among nurseries. Most nurseries now no longer sold the plant with a quantity discount, but Exbury Garden Ltd. was still offering it per hundred. The three rather low prices in the 1970/80s (Figure 3) came from that nursery.

As the marked down-and-up trend in Figure 3 might correspond to a general trend for gardening plants, we got similar data for other ornamentals (Figure 4). In rhododendrons there are few species or hybrids as continuously on sale as *R. ponticum*. We chose *R.* x *nobleanum,* one of the oldest hybrids (*R. arboreum x caucasicum*) created in 1835 and still on sale today.[59] This species represents the large group of hybrid rhododendrons dominating rhododendron catalogues. We also used price data on two other ornamental flowering woody species that have been on sale over the same period: *Magnolia grandiflora*, an evergreen Magnolia species from North America introduced in 1734, and the deciduous *Buddleja globosa* from South America introduced in 1774. In Figure 4 the price for these three is expressed as the ratio, on a logarithmic scale, of the *R. ponticum* price in a particular year. This shows that *R. ponticum* was relatively cheap during the second half of the nineteenth century; e.g. in 1863, the price

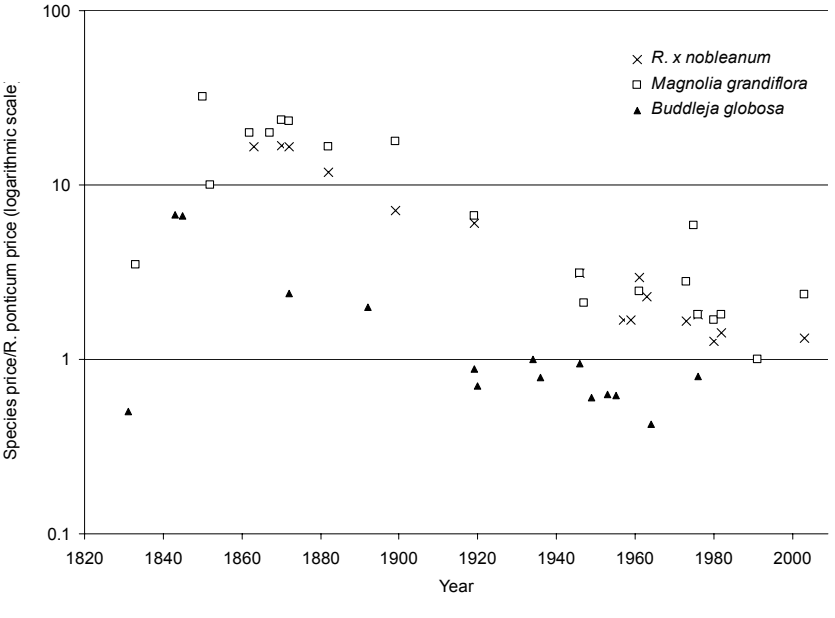



FIGURE 4. The ratio of the price of other ornamental garden plants to the price of *R. ponticum* calculated for every year for which price information for both species was available. Note the logarithmic ordinate.

of one *R. x nobleanum* was that of 16 *R. ponticum* plants whereas today it is only 1.3 plants.

*3.3.3 Game cover*

Shooting game in England increased in popularity from the beginning of the nineteenth century.[60] In 1866, the Government removed the duty on imported timber resulting in falling timber prices which made the management of woodlands for hunting for sport more attractive.[61] In these woodlands, the primary goal was to create a suitable environment to keep high densities of game animals and the production of timber was only second: 'As the new methods of shooting were widely adopted so the woodlands came to be regarded simply as pheasant coverts in the management of which the keeper took precedence over the forester. It was now the head keeper who decided which areas should be felled and which should be retained and the quality of the crop or the replacement of deteriorating stands by young plantations which could provide timber for the future, was not considered.'[62] Improvements in guns and ammunition made it possible to shoot more accurately, at a faster rate and a longer range, resulting in a high demand for game birds, particularly pheasants *Phasianus colchicus*.[63] Woodlands started to be managed intensively for high pheasant densities and partly this was by providing cover for the birds by planting shrubs.[64] Loudon describes such use of *R. ponticum*: 'In Britain, it is planted as an ornamental shrub, not only in open situations, but, on a large scale, in woods, to serve as undergrowth, and as a shelter for the game'.[65] Nursery catalogues and magazines describe the advantages which *R. ponticum* was believed to have for game cover. These were its ease of culture in almost any lime free soil and even in shady situations under dense canopies, its hardiness and immunity against game bite and rabbits and its low price.[66] The flowers in early summer and the evergreen underwood were seen as additional aesthetic benefits.

Its benefits as game shelter were questioned early. The main concern raised was that the bushes were 'such a tangled mass of branches that it is anything but pleasant quarters for game'.[67] The proponents argued: 'the mere fact of his lordship having killed 1367 pheasants, 500 hares, besides rabbits, in one day, in covers abounding in Rhododendrons, is evidence that Rhododendrons are not disliked by pheasants and hares'.[68] *R. ponticum* was sold widely for game cover up to the start of the twentieth century. The last mention we have found in a nursery catalogue was in the 1936 edition of Sunningdale Nurseries.

*3.3.4 Grafting stock*

From the 1830s onwards newly introduced rhododendron species and hybrid rhododendrons were grafted on stocks of *R. ponticum*.[69] The supply came from the estates as well as nurseries: ' … they grow and increase very rapidly, hundreds of thousands of seedlings being sold to nurserymen, who buy them principally for grafting purposes'.[70] Bean writes 'hundreds of thousands of young plants are used every year as stocks'.[71] *R. ponticum* was the most common grafting

stock far into the twentieth century, and it is still used today by a few nurseries.[72] However, the species was not the ideal grafting stock: 'For when planted out and left unwatched the stock frequently sends up sucker-growth, and it then becomes only a matter of time before the finer bred and less assertive scion is overwhelmed'.[73] Bean assumed that the occurrence of *R. ponticum* in many gardens resulted from its use as grafting stock.[74] It could overwhelm what it was supposed to nurture: 'We know an area of about ten acres of *R. ponticum* where a bulldozer would be necessary to clear a path: yet we remember our father and grandfather respectively, telling us that in the early eighties this used to be a thin and pleasant woodland, with glades lined with what was then an excellent collection of new hybrid rhododendrons. Today not one remains, but mounds of *R. ponticum* … And that is no solitary case'[75]. With *R. ponticum* today it is not possible to tell if they result from planting the plant itself or from its use as grafting stock.

*3.3.5 Perception*

The literature on *R. ponticum* in the nineteenth century is dominated by technical advice on the use of the plant and how to propagate and plant it, but there are scarcely any enthusiastic descriptions of the plant itself. This may be because it became very common soon after its introduction and from the 1850s many newly introduced rhododendron species and hybrids attracted more attention. Probably one of the last enthusiastic descriptions of *R. ponticum* was published in 1910/11: 'We have no shrub to equal it … [it] is, when in flower, the most effective of all Rhododendrons. There is a softness in the shade of purple, an elegance in the form and pose of its flower-heads, which are not easily equalled'.[76]

After the Second World War the gardening literature ignored the species or only mentioned its use as grafting stock. This lack of interest is shown by its not being offered by the nursery industry for some years (see the section on prices, above).

*3.4 The growth of the conservation problem*

*3.4.1 Spread*

Curtis says *R. ponticum* is 'extremely common'.[77] Loudon implies that by 1838 *R. ponticum* has been distributed over all Britain: ' … it has since spread through the country with such an extraordinary degree of rapidity; that there is now scarcely a shrubbery or pleasure-ground in Britain without it … '[78]

Unfortunately, there are very few data with both the date and site of the original planting and when it started to spread to unintended habitats. This is partly because botanical recording ignored the species for a long time, as an ornamental. For the same reason, herbarium specimens are of no help.[79] This recording problem is shown by comparing our survey of the Vice County recorders of the Botanical Society of the British Isles (BSBI) with the 1985/2002 surveys (Figure 5); they are not in agreement on the timing of the spread. The timings

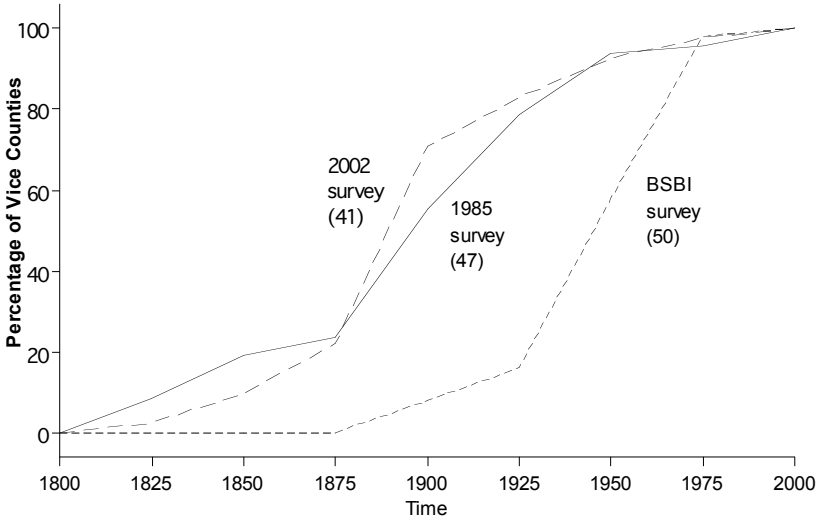



FIGURE 5. Cumulative records of *R. ponticum* in Vice Counties from the 1987 and 2002 surveys of land managers and the 2003 survey of recorders of the Botanical Society of the British Isles. The results are percentages of the total number of Vice Counties surveyed (Number of Vice Counties included in brackets).

of the 1985 and 2002 surveys are not significantly different but the BSBI timings are significantly later (t tests, $p < 0.001$). For instance, of 27 Vice Counties included in both the BSBI and 1985/2002 surveys, by 1900 *R. ponticum* was present in 16 but had been recorded in just three. The 2002 survey also provides some information on whether the sites were affected because *R. ponticum* had been planted or if it had invaded from outside. For 67 sites respondents gave information on the source of infestation. For sites known to be affected before 1900 planting was seen as the main reason for the establishment in 80 per cent of the cases, whereas at sites affected later the source of infestation was more likely to be spontaneous with increasing time.[80]

Why was recording delayed? One reason was certainly the lack of awareness of the naturalisation of ornamental plants in general. In many cases it was not recorded before the 1950s or later (see the section on perception below). That was partly because it was spreading faster and more conspicuously by then. During and after the Second World War many of the great rhododendron gardens suffered, becoming neglected and overgrown. One of the major problems in their renovation was the need to cut back *R. ponticum*.[81] Less intensive management of gardens and woodlands may have favoured the spread of *R. ponticum*. Other reasons for an increased rate of spread then, discussed in the literature, are land use changes, particularly overgrazing and the sudden decline of rabbits, which fed on seedlings, following the outbreak of myxomatosis in

1954.[82] Aerial photographs from the 1950/60s to 1970/80s show the increase in the Snowdonia National Park and on the Norfolk coast.[83]

Perring and Walters, in the first British hectad atlas, show *R. ponticum* in 993 out of 3614 10-km$^2$ grid cells.[84] In the second plant atlas *R. ponticum* is present in 2238 out of 3844 grid cells, implying that it more than doubled its distribution in 40 years.[85] But the 1962 Atlas did not give the full distribution at that time and so doubling is an overestimate. Perring and Walters say 'The maps of a few conspicuous aliens ... are inadequate because some recorders ignored them.'[86] So the species is one of those not used by Williamson *et al*..[87] But that there has been a considerable spread is not in doubt.

*3.4.2 Recognition of the problems*

There was criticism of the massive plantings of *R. ponticum* in the nineteenth century. In 1872, Salmoniceps said: 'We are threatened with the marring of some of our best home landscapes by the ill-judged planting of the common Rhododendron ponticum'.[88] There seems to be no description of the problems caused by the vigorous growth of the plant before early in the twentieth century: 'It must be said, indeed, that in spite of its great beauty the Pontic rhododendron needs occasionally the curb of a strong hand. I know more than one demesne in the south of England which is overrun with the shrub to such an extent as to have become monotonous.'[89]

The Stapleford Wood Working Plan (see Acknowledgements) dated 1930 shows the problems in woodland in Lincolnshire. The description of the different compartments contains several entries like 'Rhododendrons bad' or 'impossible to remove culls without cutting rhododendrons' and the first evidence on control actions in an handwritten comment added later ('cleared of rhodos in winter 1935'). In addition, problems were caused by visitors coming during flowering time to the wood making it necessary to have constant patrols by the police and private woodland staff. There were also notes on the 'costly operation' essential to maintain rides free of *R. ponticum*, the negative effect on shooting rights and an increased risk of fire caused by the numerous visitors. This was not an isolated case and the Forestry Commission started trials on best control management for *R. ponticum* in 1949.[90]

Botanists and ecologists started to notice the plant and its impact during the twentieth century. The species was 'occasionally planted among indigenous vegetation' in the *Alien Flora of Britain* from 1905 but unlike other species in that flora, naturalisation was not mentioned.[91] This may well reflect the perception of most ornamental plants at that time and the underlying assumption that they had to have been planted wherever they occurred. So it is not surprising that by 1953 *R. ponticum* was included in only one (Sussex) out of 12 county floras and there with the somewhat apologetic remark 'though not usually recorded in county floras, the Rhododendron is … completely naturalised'.[92] For an ecologist today, maybe equally surprisingly, Benson and Blackwell in 1926 described in detail the succession of vegetation on a clear felled area in Surrey

including the occurrence of *R ponticum* seedlings and plants but they did not even mention that it is non-native.[93]

The first description of the ecological impact of *R. ponticum* on native vegetation comes from the Killarney oakwoods in SW Ireland. An international team of experts, the 'International Phytogeographical Excursion', visited the woods in August 1911. They acknowledged the 'luxuriance' of *R. ponticum,* and noted that 'it is not native, but … evidently feels quite at home here', though did not say anything about its impact on native vegetation.[94] Not until 1939 did Turner and Watt publish a detailed phytosociological account of the oakwoods including a description of the naturalisation and competitiveness of *R. ponticum* which replaced *Ilex aquifolium* and had 'changed [the woodland] markedly in appearance.'[95] Later, Warburg described it as a 'menace' for native vegetation and complained about the insufficient data on its occurrences and spread.[96] In 1958, Elton drew the attention of a wider audience to the problems.[97] Today the problems caused by *R. ponticum*, especially in its impacts on native biodiversity and forestry are widely accepted among ecologists, foresters and conservationists.[98]

The British and Irish lines are also a problem in New Zealand, where they have been found free living since 1958, and may be becoming so in Belgium, the Netherlands and parts of Germany.[99] In logged riparian forest in the southern Appalachian mountains, *R. maximum* may have to be managed to ensure adequate regeneration of trees other than hemlock, *Tsuga canadensis* while in Turkey both *R. ponticum* and *R. flavum* (usually called *R. luteum*) suppress regeneration of the native beech *Fagus orientalis*, again particularly after logging though in neither case does the problem seem nearly as severe as in Britain and Ireland.[100]

*3.4.3 The pest species*

The growing awareness of the problems caused by *R. ponticum* produced increasing control effort by forestry, nature conservation and private landowners. The first publicly documented control work was undertaken by the Forestry Commission in the 1930s (and see the Stapleford Plan above). Systematic trials on best eradication techniques started in 1949.[101] Private landowners in Scotland started control in 1950 (Argyll Estates, personal communication) and nature conservationists in the 1960s (Scottish Natural Heritage, Royal Society for the Protection of Birds, Dorset Wildlife Trust, all personal communications). Systematic eradication trials in nature conservation were carried out in the early 1970s in the Coedydd Maentwrog and Coed Camlyn National Nature Reserves in Wales.[102] In 1981 the first work camps for volunteers took place in the Killarney National Park in Ireland and they have continued since then every year.[103] Rhododendron control and eradication work has since become one of the major activities of work camps and working holidays in the British Isles attracting an international spectrum of participants every year, raising awareness of the species in the general public. A journalist taking part in one of these working holidays was titled a 'National hero'.[104]

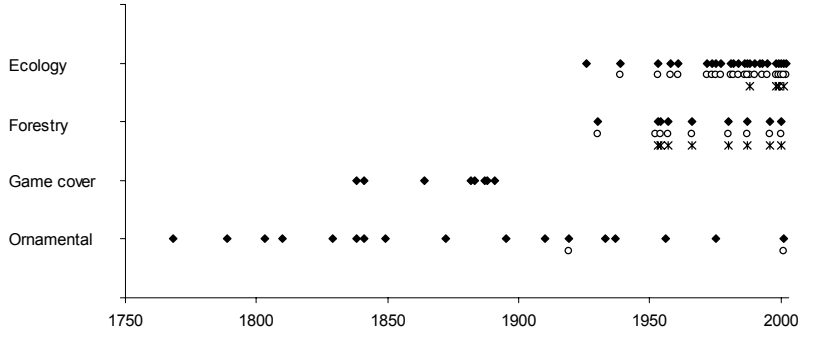



FIGURE 6. Publication of articles related to *R. ponticum* by thematic categories and date. Each black diamond represents at least one publication in a year. Open circles represent years with articles including descriptions of problems caused by the species whereas the star symbol indicates years with publications related to control methods.

Attitudes towards *R. ponticum* have changed considerably in Britain over the past 200 years. Starting from probably just an item for a botanical collector, through a period of enthusiastic planting, to a growing awareness of problematic impacts *R. ponticum* is today one of the most disliked non-native plants in Britain. Figure 6 summarises the changing perception of the species as reflected in the topics of publications relating to the species.

Public opinion has a wide spectrum from a hated weed to a countryside attraction especially when flowering. One extreme is Campbell-Culver: ' … it gradually revealed its true character – that of a killer, a smotherer, a choker-to-death of native woodland species and no plant for polite society. In its search for new victims it also spread along railway embankments, where its only merit is that one can sometimes see the wide variation of colour, from wishy-washy mauve to wishy-washy pink.'[105] The other extreme is the violence reported when *R. ponticum* control work was undertaken on farmland near Huddersfield in Yorkshire. An 'action group' supported by the local press tried to stop the machines and threw stones at the drivers (Elizabeth Elliott, personal communication 2002). Residents expressed their appreciation of *R. ponticum* in a letter to the editor of the local newspaper: the estate owners 'may class rhododendrons as an invasive weed but the floral display was spectacular. Millions travel miles to see such displays in parks all over the UK. Garden centres don't advertise them as weeds'.[106] Also, the two local MPs were 'calling for a change in the law to prevent landowners ploughing up popular beauty spots'.[107]

Nevertheless, professionals regard *R. ponticum* as one of the most harmful introduced plants in Britain. In one audit there are 627 species of vascular plant alien to Scotland listed but only two of them, *Heracleum mantegazzianum* and *R. ponticum*, are said to have an impact of high present significance while

another audit includes only six out of 680 flowering plant species as aliens in England 'with demonstrated negative environmental effects', one of them *R. ponticum*.[108] Harmful aliens are a small minority of all aliens but the harm they can do can be great.

## 4. CONCLUSIONS

*Rhododendron ponticum* in Britain and Ireland went from an expensive, not fully hardy, plant to a widely planted woodland shrub to a pest of many woodlands and moorlands almost entirely because of human action. It was selected and hybridised for hardiness. Its spread and increase was from propagation by nurseries and estates. It was distributed over distances far greater than its seeds could travel naturally. It was brought directly to habitats offering the most suitable conditions for its survival. Without all this the plant might perhaps still exist in the British Isles today just as specimens in botanical and horticultural collections like thousands of other introduced plants. The biological characteristics of the plant, especially its ease of propagation, matched both the needs for a successful product in the horticultural market and for a successful biological invader.

*Rhododendron ponticum* shows clearly that British and Irish botanists and ecologists used not to be aware of the naturalisation of ornamental plants. Whereas non-native plants unintentionally introduced with wool in the nineteenth and the early twentieth centuries were precisely recorded in local floras, the same botanists did not include far commoner species like *R. ponticum* in their lists. This lack of data makes it difficult to reconstruct accurately the geographical spread of alien plants originally introduced as ornamentals.

The changing perception of the plant by the general public did not result in a consensus on how to deal with the species. *R. ponticum* in Britain today may still be planted in gardens and woodlands by some people whereas in neighbouring places others try to get rid of it.

Our results offer some insights into factors that promote the establishment and spread of plants introduced for horticultural reasons. It seems that economic and market factors largely determine whether a species with the right potential to become problematic does so. We show elsewhere for a random sample of more than 500 ornamental species that the frequency with which these species appear in the market in the nineteenth century and today are good explanatory variables distinguishing species which escape from gardens from those species which do not.[109] Today, the distribution of ornamental plants by the horticultural trade is much more effective and operating globally. There are more than 73,000 species and cultivars on sale in Britain and the spread of non-native plants from gardens is seen as one of the major causes of changes in the UK flora.[110] It took more than 150 years to recognise that *R. ponticum* was a problem species and even more time to realise its ecological impact.

## NOTES

We are very grateful to all the BSBI Vice County recorders who participated in the survey. We particularly thank the BSBI's volunteer officer, the late Pete Selby, who helped to distribute the questionnaire and Irene Weston and Paul Barwick who made the 'Stapleford Wood Working Plan' available. Elizabeth Elliott provided us with information and newspaper articles about the *R. ponticum* control work on her estate in Yorkshire. Jenny Wong and Pat Denne made it possible for us to use the data of the 1985 *R. ponticum* survey. Liz Gilbert of the Royal Horticultural Society's Lindley Library has been very helpful in finding the appropriate nursery catalogues. Charles Perrings and two anonymous referees made valuable comments on the manuscript. KDS had been supported by a fellowship of the Deutsche Forschungsgemeinschaft and a Leverhulme Trust grant to the University of York.

[1] Simberloff 2004; Elton 1958; Williamson 1996; Mooney et al. 2005.

[2] Andersen et al. 2004.

[3] Pyšek et al. 2004; Williamson 1999; Ruiz and Carlton 2003.

[4] Mooney et al. 2005; Beinart and Middleton 2004, Perrings et al. 2000; McNeely 2001.

[5] Lockwood et al. 2005; Williamson 1996,1999.

[6] Williamson 1999.

[7] Groves 1998; Mack and Erneberg 2002; Kühn and Klotz 2002.

[8] Elliott 1996.

[9] Clement and Foster 1994; Ryves et al. 1996.

[10] Beinart and Middleton 2004; Perrins et al. 1992; Perrings et al. 2005.

[11] Bailey and Conolly 2000; Starfinger et al. 2003.

[12] Dehnen-Schmutz et al. 2004; Williamson 2002.

[13] Milne and Abbott 2000; Erfmeier and Bruelheide 2004, 2005.

[14] Cain 1944; Erfmeier and Bruelheide 2004; Milne and Abbott 2000.

[15] Mejías et al. 2002.

[16] Cross 1975; Shaw 1984.

[17] Cross 1975.

[18] Stephenson et al. 2006.

[19] Rotherham and Read 1988.

[20] Cross 1975.

[21] Ibid.

[22] Baker and Van Lear 1998; Vandermast and Van Lear 2002; Clinton and Vose 1996; Clement and Foster 1995.

[23] Clement and Foster 1995; Preston, Pearman and Dines 2002.

[24] Harvey 1972.

[25] McCusker 2003.

[26] Dandy 1969.

[27] Denne 1987; Dehnen-Schmutz et al. 2004.
[28] Hill 1768.
[29] Aiton 1789.
[30] Aiton 1810.
[31] Loudon 1838
[32] Curtis 1803.
[33] Loudon 1838
[34] Cited in Cross 1975.
[35] Curtis 1803.
[36] Elliott 1996
[37] Field 1895.
[38] Brown 1953.
[39] Shaw 1984
[40] Jekyll 1899.
[41] Osborn 1933
[42] Elliott 1996; Waston 1910/11.
[43] Milne and Abbott 2000.
[44] Curtis 1803
[45] Loudon 1838
[46] *Sensu* Richardson et al. 2000.
[47] Rinz 1829.
[48] Frost 1841.
[49] Hooker 1849.
[50] Frost 1841
[51] Robinson 1895.
[52] Elliott 1996.
[53] Harvey 1972
[54] Loudon 1838.
[55] 'J.S.W.' 1886.
[56] Royal Horticultural Society 2003.
[57] Goscote Nurseries Ltd 2003; Weasdale Nurseries Ltd. 2003.
[58] 'J.S.W.' 1886.
[59] Mills 1979.
[60] James 1981.
[61] Dunlop 1997.
[62] James 1981.
[63] Ibid.
[64] Robertson 1992.
[65] Loudon 1838
[66] Wythes 1891; Webster 1883; Goldring 1888.
[67] Webster 1883

[68] Craw 1864.
[69] Elliott 1996.
[70] Anonymous 1887.
[71] Bean 1919.
[72] Cox 1998.
[73] Bean 1919.
[74] Ibid.
[75] Cox and Cox 1956.
[76] Waston 1910/11.
[77] Curtis 1803.
[78] Loudon 1838.
[79] C. Preston in Usher 1986.
[80] Dehnen-Schmutz et al. 2004.
[81] Elliott 1996.
[82] Cross 1981; Shaw 1984; Fuller and Boorman 1977.
[83] Shaw 1984; Fuller and Boorman 1977; Thomson et al. 1993.
[84] Perring and Walters 1962.
[85] Preston, Pearman and Dines 2002.
[86] Perring and Walters 1962.
[87] Williamson et al. 2003.
[88] Salmoniceps 1872.
[89] Bean 1919.
[90] Holmes 1957.
[91] Dunn 1905.
[92] Warburg 1953.
[93] Benson and Blackwell 1926.
[94] Rübel 1912.
[95] Turner and Watt 1939.
[96] Warburg 1953.
[97] Elton 1958.
[98] Compton et al. 2002; Cross 1975, 2002; Shaw 1984; Usher 1986; Manchester and Bullock 2000; Simons 1988; Tabbush and Williamson 1987.
[99] Williams et al. 2000; Erfmeier and Bruelheide 2004.
[100] Eşen and Zedaker 2004; Vandermast and Van Lear 2002.
[101] Holmes 1957.
[102] Jones 1974.
[103] Barron 2000.
[104] *The Guardian* 'Labour of love' 03.11.2001.
[105] Campbell-Culver 2001.
[106] *Huddersfield District Chronicle* 'Whitley Park', 18.04.1997
[107] *Yorkshire Post* 'Secret weapon in park battle', 15.04.1997.

[108] Welch et al. 2000; Hill et al. 2005.

[109] Dehnen-Schmutz et al. in press.

[110] Royal Horticultural Society 2004; Preston, Telfer et al. 2002.

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