# The economic cost of invasive and non-native species in

*Ireland and Northern Ireland*

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**28 March 2013**

**Version: Final**

Prepared for:
**The Northern Ireland Environment Agency and the National Parks and Wildlife Service**

As part of:
**Invasive Species Ireland**

invasivespecies Ireland
www.invasivespeciesireland.com

**Acknowledgements**:

The authors would like to acknowledge the support and input of all those contacted during the course of developing this report. There are literally too many to mention. We would particularly like to acknowledge the input of the Invasive Species Ireland Steering Group and the client officers from NIEA and NPWS.

The Client Officers for the Invasive Species Ireland contract are John Early (NIEA) and Gerry Leckey (NPWS).

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**Recommended citation:** Kelly, J., Tosh, D., Dale, K., and Jackson, A., 2013. The economic cost of invasive and non-native species in *Ireland and Northern Ireland*. A report prepared for the Northern Ireland Environment Agency and National Parks and Wildlife Service as part of Invasive Species Ireland.

NIEA Northern Ireland Environment Agency
www.ni-environment.gov.uk

An Agency within the Department of the Environment
www.doeni.gov.uk

An Roinn Ealaíon, Oidhreachta agus Gaeltachta
Department of Arts, Heritage and the Gaeltacht

# EXECUTIVE SUMMARY

The impact of invasive species is not just an issue for biodiversity. Invasive species are known to affect key economic sectors such as agriculture, tourism and the construction sectors. However, these economic impacts are often overlooked or under-reported. There are also inherent difficulties in making cost estimates of economic impacts on which to base decisions on management and control.

While a number of studies exist on the economic impact of invasive species in other countries and regions with examples from Europe, the United States and Australia, there have been no previous attempts to estimate the costs for Ireland and Northern Ireland. This study represents the first attempt to review the economic impact of invasive species in both Ireland and Northern Ireland and the island as a whole, with the primary aim of providing an annual cost. It should be noted that only the negative impacts of invasive species are included; this report makes no attempt to elucidate any positive contributions of invasive species to the economy.

The methods used in this study were based on that of the similar study in Great Britain (Williams, 2010). The intention was to allow the results for Ireland to be comparable with the UK and to ensure the results for Northern Ireland were based on a similar approach to that for the rest of the UK. The methods included a questionnaire sent to stakeholders, however, as this exercise yielded limited useful data, projections from the GB study were made on a per capita basis, with ground-truthing using Irish and Northern Irish data. Eight case studies are also included to help demonstrate the costs incurred at different stages in the management process.

The estimated annual cost of invasive species to the economies of Ireland and Northern Ireland is £161,027,307 (€202,894,406) and £46,526,218 (€58,623,034) respectively. The combined estimated annual cost of invasive species on both economies is £207,553,528 (€261,517,445). Correcting the estimate for GB for inflation, the current estimate of the annual cost of invasive species to the UK economy is £1.8 billion (€2.3 billion). The current estimate of the annual combined UK and Ireland cost is £2 billion (€2.5 billion).

This report primarily focuses on direct costs to the economies of Ireland and Northern Ireland. An attempt was made to assess the indirect costs, however, there is limited data available at this time and, as the ecosystem services subject area is still developing, a significant amount of research would be required to provide an estimate of the economic impacts on these services. As the GB study pointed out, invasive species can have significant indirect costs, which are likely to far outweigh the direct costs.

The costs of invasive species are likely to rise as more species arrive each year and species that are already present become invasive or more widespread. Investment in biosecurity measures to prevent new invasive species arriving on the island of Ireland is paramount. It is also obvious from the case studies that controlling invasive species early in the invasion process will reduce the impact that they will have on the island of Ireland’s biodiversity, whilst reducing the costs associated with their long term control or management.

**Conversions**

€1 = GB £0.787564
GB £1 = €1.269738
€1 = IR £0.787564

1 Hectare = 2.471 Acres
1 Acre = 0.404 Hectare

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# 1. INTRODUCTION

The introduction of non-native species by human action to naïve environments is not a new phenomenon. Many of these non-native species do not have a significant impact on native species or habitats but some can and do negatively impact on the ecology of their new environment. These latter species are known as invasive species, although the term 'invasive species' is not defined in law in Ireland or Northern Ireland. Invasive Species Ireland (ISI) therefore uses the definitions laid down by the Convention on Biological Diversity for invasive species:

An invasive species is defined as: *"A non-native (aka alien) species whose introduction and/or spread threaten biological diversity*".

Invasive species have been transported deliberately and accidentally by humans for millennia. However, the improvement of transport and trade links, via globalisation, has undoubtedly facilitated the introduction and spread of invasive species across the world. Mammal, invertebrate and plant introductions to Europe increased from the 19$^{th}$ century to the 20$^{th}$ century, arguably as a result of this (Genovesi *et al*., 2012; Hulme *et al.*, 2009). Consequently, increased transfer of non-native species and higher rates of successful introductions has led to invasive species being classed as one of the greatest threats to global biodiversity (Secretariat of the Convention on Biological Diversity, 2006). Invasive species can ultimately lead to the extinction of native flora and fauna as in the United States of America (USA) where 40% of floral and faunal extinctions are linked to invasive species (Pimental *et al.*, 2005).

The history of Ireland's flora and fauna is inextricably linked to introductions of non-native and invasive species by man. Arguably, 14 (58%) of Ireland's 24 species of terrestrial mammals and 1,108 (57%) of Ireland's 1923 seeding plants have been introduced by man (Scannel and Synnot, 1987; Reynolds, 2002). The impacts they have on Ireland's native flora and fauna include: competition, herbivory, predation, introduction of parasites or pathogens, alteration of habitats, and genetic hybridisation (Stokes *et al.*, 2006). In addition to affecting biodiversity, invasive species also impact the 'ecosystem services' that biodiversity provides.

Ecosystem services are the benefits provided by ecosystems that contribute to making human life both possible and worth living. Examples of ecosystem services include products such as food and water, regulation of floods, soil erosion and disease outbreaks, and non-material benefits such as recreational and spiritual benefits in natural areas. The term 'services' is usually used to encompass the tangible and intangible benefits that humans obtain from ecosystems, which are sometimes separated into 'goods' and 'services' (UK National Ecosystem Assessment, 2011).

Ecosystem services can be divided into four categories (Millennium Ecosystem Assessment, 2000):

- *supporting services* e.g. nutrient cycling;
- *provisioning services* e.g. food, fibre;
- *regulating services* e.g. carbon sequestration; and

- *cultural services* e.g. recreation, tourism.

The impacts of invasive species are not only an environmental problem but also an economic one. The economic impacts of invasive species are often overlooked or under-reported; leading to a lack of understanding of the true impact an invasive species can have and making it difficult to justify expenditure on management and control. Therefore, if invasive species are to be managed effectively and efficiently their impact has to be quantified economically as well as understood biologically.

In response to the issues described above, this study represents the first attempt to review the economic impact of invasive species in both Ireland and Northern Ireland and the island as a whole. The primary aim of the study is to provide an estimate of the economic costs associated with invasive species to these economies on an annual basis. In addition, a review of the literature on the application of economic valuation techniques will explore the options available to policy-makers where the full monetary benefits of the sustainable management of biodiversity remain open to debate.

# 2. VALUING BIODIVERSITY

## 2.1 Background

Biodiversity encompasses the number, abundance and distribution of all species of life on earth. It includes the diversity of individual species, the genetic diversity within species and the range of habitats that support them. Biodiversity also includes humans and human interactions with the environment. The natural environment provides us with a range of benefits – ecosystem services – including food, water, materials, flood defences and carbon sequestration, and biodiversity underpins most, if not all, of them (CIRIA, 2011).

Values need to be ascribed to the stock of biodiversity in a country before the impacts on it can be assessed. For example, this is done on a local scale through the Environmental Impact Assessment (EIA) process, which specifically looks at the effects of a development proposal on the environment. Although these effects are not monetised, they are ascribed a geographical level of significance.

The Economics of Ecosystems and Biodiversity study (TEEB) was a major international initiative set up in 2007 to analyse the global economic benefit of biodiversity, the costs of the loss of biodiversity and the failure to take protective measures versus the costs of effective conservation. Ideally TEEB will act as a catalyst to help accelerate the development of a new economy: one in which the values of natural capital, and the ecosystem services that this capital supplies, are fully reflected in the mainstream of public and private decision-making (Sukhdev *et al*, 2010).

The UK National Ecosystem Assessment (NEA) is the first analysis of the UK's natural environment in terms of the benefits it provides to society and continuing economic prosperity. The assessment outlines how the natural world and its ecosystems are undervalued through conventional economic analyses. As a nation and individually there is a heavy dependence on the environment and therefore the need to value it to enable better decision-making, more certain human investment and greater human well-being.

More specific valuations of the benefits derived from ecosystem services, and the cost of their loss, already provide a compelling case for the conservation of the natural heritage in Ireland. The Economic and Social Aspects of Biodiversity - Benefits and Costs of Biodiversity in Ireland report by Bullock *et al*, 2008, presents an assessment of the benefits of selected ecosystem services in the principal social and economic sectors. Although only a preliminary estimate is proffered, the current marginal value[1] of ecosystems services in Ireland in terms of their contribution to productive output and human utility is estimated at over €2.6 billion per annum.

[1] A marginal value allows us to begin to determine how much we should be spending on biodiversity protection. If we have an angle on the benefits, then we can assess how far these benefits exceed the amounts that are currently being spent on relevant policies, or vice-versa. Naturally, we also need to know how effective those policies are. Typically, such policies benefit not only biodiversity, but have other purposes such as providing for recreation or protection of the landscape (Bullock *et al*, 2008).

## 2.2 Implications for assessing the economic impact of invasive species

To value biodiversity and hence evaluate the impact of invasive species, all goods and services provided by a particular ecosystem are categorised within a framework of Total Economic Value (TEV) and subsequently assigned a monetary value (Charles and Dukes, 2007) (Figure 1). TEV is comprised of use (direct, indirect) values and non-use (existence, option and bequest) values (see Williams *et al.,* 2010, Charles and Dukes, 2007; Defra, 2007 for further explanation).

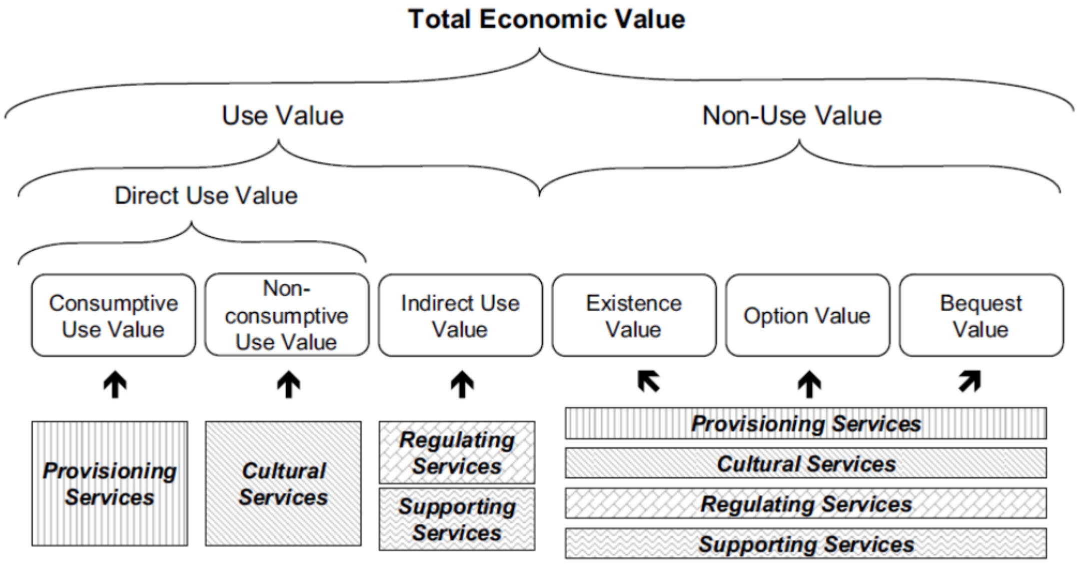


**Figure 1:** Framework for economic valuation of ecosystem services (Charles & Dukes, 2007)

- **Direct use** costs are those costs that invasive species have on the use of an ecosystem service in terms of extraction of resources from the ecosystem (e.g. food production, timber extraction) or the use of the ecosystem for recreation, even though this is a non-marketable product. A reduction in production, or an increase in expenditure to maintain production caused by the presence of an invasive species, is an economic cost.
- **Indirect use** costs are due to the effects of invasive species on the ecological functions that support life. These costs could include the effects on nutrient cycling, pollination and flood attenuation. Any reduction in the functioning of these ecosystem services due to the presence of invasive species will be a cost to the economy.
- **Existence values** are the values that people place on an ecosystem, such as a forest, or a charismatic species. If the existence of these values is threatened by the presence of an invasive species, then the reduction in value that people place on the affected forest is a cost attributable to the invasive species.
- **Option values** cover several aspects of the impact of invasive species. They include the reduction in the potential of an ecosystem to provide resources for the future, which could cover new pharmaceutical discoveries, new agricultural opportunities from native species, or tourism developments. In addition, people place values on ensuring that an ecosystem or charismatic species are available for others to enjoy. If invasive species affect the ecosystem in such a way that these services are no longer available, or the ecosystem is not perceived as being as valuable as it was to others to use, then these are costs of invasive species to the economy.

- **Bequest values** are those values that people place on ensuring that an ecosystem is still present for future generations. If the ecosystem is damaged by an invasive species and the value that is placed on ensuring it is available in the future is reduced, this reduction in value is a cost caused by invasive species (CABI, 2012).

Direct and indirect use costs associated with invasive species can be measured using market prices, for example, the loss of output by agricultural, forestry and fisheries enterprises; the loss of custom or revenue from tourism or recreational attractions; the increased maintenance outlays on assets (and thus running costs) in the transport infrastructure and utilities sectors; the funding of quarantine, inspection and regulation of vectors; expenditure on control and eradication; and ongoing basic research to identify and anticipate risks. It is important to note that the inclusion of quarantine and surveillance outlays as a direct user cost of invasive species is open to question. These elements should really be regarded as precautionary investments in biosecurity that limit the direct user cost impacts of invasive species. There is a trade-off between the amounts devoted to quarantine and surveillance and the likelihood of damage caused by invasive species, as the recent example of infected ash trees in Great Britain and Ireland demonstrates. If quarantine and surveillance outlays are reduced, this can trigger much higher direct user costs down the line (Figure 2).

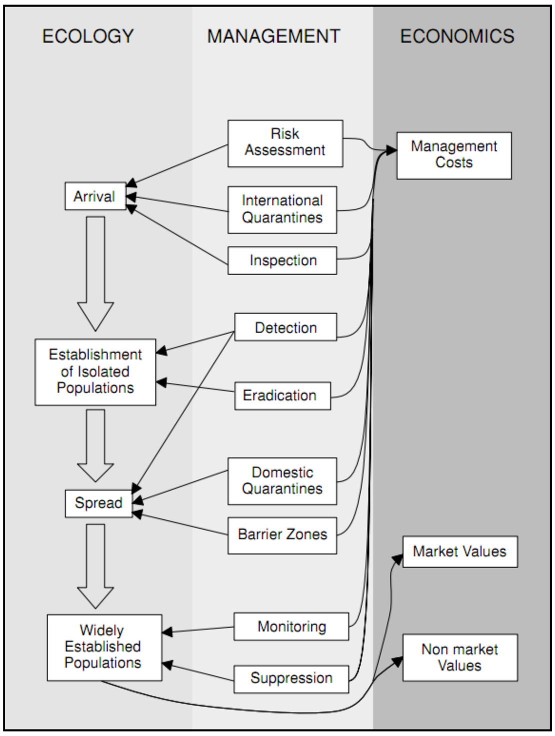


**Figure 2:** The stages of a biological invasion are linked to management actions that can be applied at each stage; each of these management actions has economic implications (Holmes et al., 2009).

Non-use costs associated with invasive species reflect the range of existence, option or bequest values that society places on ecosystem services and the actual or potential threats that invasive species are deemed to pose to these. These costs are much more difficult to estimate as there are no market prices for them. The stated preference approach is often used, based on the willingness of individuals to pay for the goods and services provided by the earth's ecosystems, or to pay for the preservation of these goods and services so that present and future generations are able to benefit both from their existence and their use. This approach has many difficulties and has been questioned by ecologists and economists for a number of reasons. Therefore, instead of attempting to assign non-use values to biodiversity, the NEA examines the cost-effectiveness of adopting different strategies towards the conservation of biodiversity in the UK. Biodiversity assessment models (using bird populations as a proxy):

> "are applied to a number of different scenarios for the future of Great Britain. A range of economic values are also assessed for each of these scenarios. By contrasting these values with the biodiversity implications of each scenario, the decision maker can observe the costs of obtaining different levels of biodiversity. This cost-effectiveness approach provides a useful guide for decision making in situations where the full monetary benefits of a value stream (here biodiversity) cannot be established".

This approach is also referred to as (Benefit) Value Transfer by Defra (Defra, 2010), which provides an official sanction for this approach and incorporates it into the Treasury Green Book.

To date, the majority of studies on the economic impacts of invasive species focus on their impacts on the direct use values provided by provisioning ecosystem services e.g. timber and food production, due to the greater ease in which economic effects can be calculated. Direct use of an ecosystem service involves actual or planned uses, which can be further subdivided into consumptive (items that have a marketable value and can be traded on a market) or non-consumptive (that are non-marketable and there is no formal market) use values (Defra, 2007 and Figure 1). Consumptive use values are typically studied due to the availability of quantifiable market values for many direct value provisioning services but non-consumptive prices can be determined via alternative methods e.g. willingness to pay studies, although these methods are questionable, as stated above.

Whatever the approach taken or ecosystem service studied, the general consensus is that invasive species have a large, negative impact on biodiversity. An assessment of the economic damage caused by introduced pests to crops, pastures, and forests (provisioning ecosystem services) in the USA, United Kingdom (UK), Australia, South Africa, India, and Brazil estimated the cost at nearly US$230 billion per annum (Pimental *et al.*, 2001). Associated annual environmental losses caused by invasive species in the same study was US$100 billion. The calculated cost per capita for the losses incurred in the six nations investigated was approximately US$240 per year. Assuming similar costs worldwide, damage from invasive species would be more than US$1.4 trillion per year, representing nearly 5% of the world's economy (Pimental *et al*, 2001). Similarly, Kettunen *et al.*, (2009) estimate the total documented monetary impacts of invasive species in Europe to amount to €12 billion per annum over the last 20 years[2]. Most of this total (i.e. €9.6 billion) can be attributed to the costs of damage associated with invasive species (e.g. to the agriculture, fisheries and aquaculture, forestry and health

[2] These total costs include costs of damage and costs of control/management/restoration. This estimate of the costs of invasive species impacts in Europe was developed based on available/documented costs of invasive species to date. The majority of these costs have been incurred during the past 20 years.

sectors). However, this estimate is generally considered an underestimate of the real cost; in reality a far greater number of invasive species cause negative socio-economic effects than are documented in monetary terms. In addition, there are less tangible impacts involving loss of amenity brought about by damage to cultural ecosystem services.

In the absence of detrimental impacts caused by invasive species, the costs of production would be lower and productivity would be higher for economic activities dependent on provisioning ecosystem services, the quality of our natural heritage would be higher in terms of the cultural ecosystem services and the regulating and supporting ecosystem services offered through biodiversity would prove to be more resilient and effective.

# 3. METHODS ADOPTED

## 3.1 Estimation of economic impacts on the use values of ecosystem services

### 3.1.1 Approach

Within Europe, we have identified two areas, Great Britain (Williams *et al.,* 2010) and Germany (Reinhardt, 2003) that have attempted to assess the economic impact of invasive species. The approach of Williams *et al.* (2010) provides a method on which to base the assessment for Ireland and Northern Ireland. This reflects the close links between the economies of Ireland to the rest of the UK and will help ensure that the assessment for Northern Ireland is directly comparable with the rest of the UK.

To calculate the economic costs associated with invasive species in the different economic sectors within Ireland and Northern Ireland we used projected costs based on the CABI data from Great Britain (GB) (Williams *et al.,* 2010), converted to per capita costs. The conversion factors used are as follows:

- Ireland and Northern Ireland combined as a percentage of the GB population: 10.560
- Ireland as a percentage of the GB population: 7.582
- Northern Ireland as a percentage of the GB population: 2.978

In addition, information was collected to inform the impact assessments for the different economic sectors. This was done in three ways:

1. **On-line-questionnaire:** In order to quantify the costs associated with the monetised impacts of invasive species we created a questionnaire on www.surveymonkey.com and approached all email contacts (n=411) on the Invasive Species Ireland database. Recipients of the email were also asked to forward the email to relevant contacts and the questionnaire was advertised on www.invasivespeciesireland.com. Therefore, an unknown number of people received the survey. Our approach was intended to solicit information from people directly involved in the management of, or directly affected by, invasive species. The questionnaire (Appendix 1) consisted of 49 closed format questions and followed that used by Williams *et al*., (2010). The survey was open for responses during the month of March 2012. Unfortunately the response was low (12.1% of directly contacted individuals) and none of the respondents answered the survey in its entirety. Therefore, its contribution to the economic assessment is limited.

2. **Direct contact with businesses:** Additional information relating to the costs associated with the management of specific invasive species was solicited via direct email and telephone approaches to businesses not contacted in relation to the questionnaire.

3. **Literature review:** Similar to the Williams *et al*. (2010) study, further information on invasive species and market costs was gathered through searches of standard

internet search engines, CABI's invasive species compendium, NOBANIS, DAISIE, and Web of Science and Science Direct. Data on the distribution of invasive species was obtained from the National Biodiversity Data Centre.

It is recognised that this approach is not perfect as it makes a number of assumptions, such as: the patterns of crop and livestock production per capita and the impacts of invasive species on the island of Ireland and GB are identical. Clearly some of the assumptions made for GB are not applicable to Northern Ireland and Ireland, but the aim was to derive, where datasets allowed, estimates for Ireland and Northern Ireland for comparison with GB. Where manipulation of datasets was not possible, costs per annum were accepted based on the review of available datasets. However, where projections were likely to be an overestimate of economic impact, the calculated costs were not always used in the final assessment. Where this has occurred, it has been stated.

Although there is a growing body of research into the economic impacts of invasive species, there remains a limited number of studies to call upon for reference, and the number of studies originating from Ireland and Northern Ireland is limited even more. Therefore, where the quality of the source data is questionable and where no direct studies exist, we either present a conservative assessment or do not present an economic cost.

While every effort has been taken to avoid errors in the conversion of British pounds to euros, or vice versa, it is inevitable that some very small degree of error has entered into our calculations due to the rounding up/down function of Microsoft Excel. These are minor errors and will only represent 10's of pounds or euros.

### 3.1.2 Invasive species case studies

In addition to assessing the costs of invasive species to the different economic sectors in Ireland and Northern Ireland, case studies were conducted on a variety of terrestrial, freshwater and marine invasive species. These case studies illustrate the costs associated with the species at different stages in the invasion process (early or late stage invasion). Non-native species bring both costs and benefits, which may accrue to different sectors of society (Callaghan, 2003) but these case studies are not intended to act as cost-benefit analyses. It is the sole intention of this element of the study to provide accessible information for decision makers, stakeholders and the general public. The information collected via the on-line questionnaires, contact with businesses and literature review relating to market values of commodities or management services were used to calculate the direct use values reported in each case study.

### 3.1.3 Limitations

The information collected during this element of the study was used only to quantify the economic impacts on direct use values of provisioning ecosystem services (consumptive use value). We have made no attempt to value the direct non-consumptive use value of cultural ecosystem services or the regulating and supporting indirect use values where non-market value costs would have to be estimated. The reasons for this have been in part explained in the section 2 but simply put they require information and research that does not currently exist or methods and approaches beyond the scope of this study. Consequently, the economic costs on the economic sectors and those presented in the case studies are likely to be an underestimate of the direct use economic costs of invasive species.

## 3.2 Estimation of economic impacts on the non-use values of ecosystem services

Our approach to this element of the economic impact assessment was to investigate the applicability of using the NEA cost-effectiveness method in Ireland to conserve biodiversity by managing invasive species, on a per capita basis. We were not convinced by this approach, therefore our methods are not provided in detail here and the results are not presented in this report. We consider that the key to evaluating the impact of invasive species on assets such as biodiversity is to consider the marginal impact of a change in the status of invasive species on the stock of biodiversity, not the impact of invasive species in undermining biodiversity as a whole. Bullock *et al* (2008) have calculated a figure in excess of £2,010m for the overall annual marginal value of ecosystem services in the Republic of Ireland. If additional primary research work was carried out (beyond the scope of this study) the figures derived from different approaches to estimate non-use values could be validated and applied to Ireland, Northern Ireland and the island as a whole. It would then be possible to combine these with the estimates for damage caused by invasive species to the use values of ecosystem services, derived on the same basis from the CABI report for Great Britain, to provide some overall estimates for invasive species damage in Ireland.

# 4. ESTIMATION OF ECONOMIC IMPACTS ON THE USE VALUES OF ECOSYSTEM SERVICES

The results of the projections made of the impact of invasive species in GB have been reproduced in Table 1 and 2. The table provides an indication of equivalent outlays for Ireland, based simply on adjusting for relative populations and ignoring variations that might be caused by differences in economic structure, ecosystems and policy measures.

**Table 1:** Projected economic impact of invasive species for Ireland and Northern Ireland based on Great Britain (£). Figures exclude biodiversity and conservation estimates. Corrected for inflation.

| Sector | Projected Ireland and Northern Ireland combined | Projected Ireland | Projected Northern Ireland |
|---|---|---|---|
| Agriculture | £118,845,377.94 | £85,330,081.02 | £33,515,296.92 |
| Forestry | £12,163,717.32 | £8,733,456.88 | £3,430,260.43 |
| Quarantine and surveillance | £1,979,922.32 | £1,421,569.23 | £558,353.09 |
| Aquaculture | £796,270.69 | £571,716.32 | £224,554.37 |
| Tourism and recreation | £10,892,358.89 | £7,820,631.16 | £3,071,727.72 |
| Construction | £23,653,418.53 | £16,982,975.31 | £6,670,443.22 |
| Transport | £9,058,540.26 | £6,503,963.28 | £2,554,576.98 |
| Utilities | £1,127,483.63 | £809,524.70 | £317,958.92 |
| Human health | £5,363,821.99 | £3,851,183.55 | £1,512,638.44 |
| **Sub totals** | **£183,880,911.55** | **£132,025,101.46** | **£51,855,810.09** |
| Double count | -£3,331,966.54 | -£2,392,326.74 | -£939,639.81 |
| **Totals** | **£180,548,945.01** | **£129,632,774.72** | **£50,916,170.29** |

**Table 2:** Projected economic impact of invasive species for Ireland and Northern Ireland based on Great Britain (€). Figures exclude biodiversity and conservation estimates. Corrected for inflation.

| Sector | Projected Ireland and Northern Ireland combined | Projected Ireland | Projected Northern Ireland |
|---|---|---|---|
| Agriculture | €149,745,176 | €107,515,902 | €42,229,274 |
| Forestry | €15,326,284 | €11,004,156 | €4,322,128 |
| Quarantine and surveillance | €2,494,702 | €1,791,177 | €703,525 |
| Aquaculture | €1,003,301 | €720,363 | €282,939 |
| Tourism and recreation | €13,724,372 | €9,853,995 | €3,870,377 |
| Construction | €29,803,307 | €21,398,549 | €8,404,758 |
| Transport | €11,413,761 | €8,194,994 | €3,218,767 |
| Utilities | €1,420,629 | €1,020,001 | €400,628 |
| Human health | €6,758,416 | €4,852,491 | €1,905,924 |
| **Sub totals** | **€231,689,949** | **€166,351,628** | **€65,338,321** |
| Double count | -€4,198,278 | -€3,014,332 | -€1,183,946 |
| **Totals** | **€227,491,671** | **€163,337,296** | **€64,154,375** |

**NOTE:** These figures should not be referenced as the economic impact of invasive species for Ireland and Northern Ireland.

## 4.1 Agriculture and horticulture

The agri-food sector is one of Ireland's most important indigenous manufacturing sectors, employing around 150,000 people. It includes approximately 600 food and drinks firms throughout the country that export 85% of our food and seafood to more than 160 countries worldwide. Data from the Central Statistics Office indicates that the agri-food sector (including agriculture, food, drinks and tobacco) accounts for around 7% of GDP with primary agriculture accounting for around 2.5% of GDP. The 2010 National Farm Survey (NFS) from Teagasc estimates that average farm income (excluding off-farm income) increased by 46% in 2010 to €17,771. Full-time farms, as defined by Teagasc, had an average farm income of €41,624, while the part-time equivalent was €7,554. Special analysis of EU-SILC 2008 data showed that farm households have an average total income of €61,053 or €53,484 (depending on whether a broad or narrow definition of "farm household" is utilised). These compare with a state average of €60,579[3]. Total income from farming (TIFF) - which measures the return to farmers, partners and directors, their spouses and other family workers for their labour, management input and own capital invested – increased by 21% (15% per cent in real terms) to £308 million, from £255 million in 2010[4]. Invasive and non-native species that affect agriculture in Ireland and Northern Ireland cross taxonomic groups. This is similar to the situation in GB and the rest of the EU.

### 4.1.1 Projected costs of invasive species on agriculture and horticulture

Estimates from the Great Britain report set out in Table 2 indicate that the main losses from invasive species are associated with plant pathogens and animal pests, which together account for some £620 million in annual losses to a range of crops. Weeds and invertebrates account for a further £350 million in losses, split between actual reductions in yield and additional outlays on herbicides and pesticides to prevent further losses. Projected figures for Ireland and Northern Ireland are calculated on a simple per capita basis. To the extent that the pattern of output here varies, leaving agricultural production vulnerable to different invasive species or requiring different forms of treatment, actual costs will differ. The extent of commercial horticultural and ornamental cultivation is also likely to vary from the pattern in GB.

[3] http://www.agriculture.gov.ie/media/migration/publications/2012/FactsheetonIrishAgricultureApr12.pdf
[4] http://www.dardni.gov.uk/the_statistical_review_of_northern_ireland_agriculture_2011.pdf

**Table 3:** Projected annual costs of invasive species to agriculture and horticulture in Ireland and Northern Ireland based on estimates for GB (£). Source: Table 5.14, Williams et al, 2010.

| | **Great Britain** | **Great Britain corrected for inflation at 2.73% per annum** | **Projected Ireland and Northern Ireland combined** | **Projected Ireland** | **Projected Northern Ireland** |
|---|---|---|---|---|---|
| Herbicides | £90,654,000 | £95,671,272 | £10,102,886 | £7,253,796 | £2,849,090 |
| Yield loss: weeds | £104,717,000 | £110,512,593 | £11,670,130 | £8,379,065 | £3,291,065 |
| Pesticides | £26,040,000 | £27,481,191 | £2,902,014 | £2,083,624 | £818,390 |
| Yield loss: invertebrates | £129,341,000 | £136,499,415 | £14,414,338 | £10,349,386 | £4,064,953 |
| Sprayer water | £758,000 | £799,952 | £84,475 | £60,652 | £23,823 |
| Storage pests | £17,643,000 | £18,619,457 | £1,966,215 | £1,411,727 | £554,487 |
| Nematodes | £50,000,000 | £52,767,265 | £5,572,223 | £4,000,814 | £1,571,409 |
| Varroa mite | £27,119,000 | £28,619,909 | £3,022,262 | £2,169,961 | £852,301 |
| Plant pathogens | £401,707,000 | £423,939,590 | £44,768,021 | £32,143,100 | £12,624,921 |
| Deer | £7,262,000 | £7,663,917 | £809,310 | £581,078 | £228,231 |
| Rabbit | £187,621,000 | £198,004,939 | £20,909,322 | £15,012,734 | £5,896,587 |
| Rats | £21,830,000 | £23,038,188 | £2,432,833 | £1,746,755 | £686,077 |
| Mink | £214,000 | £225,844 | £23,849 | £17,123 | £6,726 |
| Geese & Swans | £1,503,000 | £1,586,184 | £167,501 | £120,264 | £47,237 |
| **Total** | **£1,066,409,000** | **£1,125,429,715** | **£118,845,378** | **£85,330,081** | **£33,515,297** |

**Table 4:** Projected annual costs of invasive species to agriculture and horticulture in Ireland and Northern Ireland based on estimates for GB (£). Source: Table 5.14, Williams et al, 2010.

| | **Great Britain** | **Great Britain corrected for inflation at 2.73% per annum** | **Projected Ireland and Northern Ireland combined** | **Projected Ireland** | **Projected Northern Ireland** |
|---|---|---|---|---|---|
| Herbicides | €114,224,040 | €120,545,803 | €12,729,636 | €9,139,783 | €3,589,853 |
| Yield loss: weeds | €131,943,420 | €139,245,867 | €14,704,364 | €10,557,622 | €4,146,742 |
| Pesticides | €32,810,400 | €34,626,301 | €3,656,538 | €2,625,366 | €1,031,171 |
| Yield loss: invertebrates | €162,969,660 | €171,989,263 | €18,162,066 | €13,040,226 | €5,121,841 |
| Sprayer water | €955,080 | €1,007,940 | €106,439 | €76,422 | €30,017 |
| Storage pests | €22,230,180 | €23,460,516 | €2,477,431 | €1,778,776 | €698,654 |
| Nematodes | €63,000,000 | €66,486,754 | €7,021,001 | €5,041,026 | €1,979,975 |
| Varroa mite | €34,169,940 | €36,061,085 | €3,808,050 | €2,734,151 | €1,073,899 |
| Plant pathogens | €506,150,820 | €534,163,883 | €56,407,706 | €40,500,306 | €15,907,400 |
| Deer | €9,150,120 | €9,656,535 | €1,019,731 | €732,158 | €287,571 |
| Rabbit | €236,402,460 | €249,486,223 | €26,345,746 | €18,916,045 | €7,429,700 |
| Rats | €27,505,800 | €29,028,117 | €3,065,370 | €2,200,911 | €864,457 |
| Mink | €269,640 | €284,563 | €30,050 | €21,575 | €8,475 |
| Geese & Swans | **€1,893,780** | **€1,998,592** | **€211,051** | **€151,533** | **€59,519** |
| **Total** | **€1,343,675,340** | **€1,418,041,441** | **€149,745,176** | **€107,515,902** | **€42,229,274** |

**NOTE:** Projected figures should not be referenced as the economic impact of invasive species for Ireland and Northern Ireland. Please refer to individual sections or the summaries of each economic sector for estimates.

### 4.1.2 Control of invasive species in agriculture and horticulture

The economic impacts associated with control of invasive weeds and invertebrates have been calculated and also the loss in yields due to weeds that survive control efforts and reduce yields through competition. This is similar to the approach taken for GB but utilising datasets for Ireland and Northern Ireland on pesticide usage statistics. The assumptions made for GB (Section 5.1 page 50-53) have been applied to this study. The results of the calculations are presented in Tables 3 and 4 below. The estimated total cost associated with control of invasive species in agriculture is €33,498,097 (£26,128,515) in Ireland and £5,684,461 (€7,162,420) in Northern Ireland. Available datasets did not allow us to estimate the cost associated with biological control.

***Identified invasive species:*** Brome species (*Bromus* spp.), sterile or barren brome (*B. sterillis*), wild oat (*Avena fatua*), Italian ryegrass (*Lolium perenne*), and common field-speedwell (*Veronica persica*).

**Table 5:** Estimated pesticide targeting invasive and non-native species impacting crops in Ireland.

| Crop | Fungicides | Herbicides | Insecticides | Seed treatments: Insecticides and fungicides | Molluscicides |
|---|---|---|---|---|---|
| **Spring barley** | €5,953,536.00 | €3,198,720.00 | €2,407,200.00 | €3,060,188.40 | €0.00 |
| **Winter barley** | €747,840.00 | €401,800.00 | €302,375.00 | €389,116.80 | €19,586.82 |
| **Spring wheat** | €1,138,176.00 | €611,520.00 | €460,200.00 | €606,048.00 | €0.00 |
| **Winter wheat** | €2,608,320.00 | €1,401,400.00 | €1,054,625.00 | €1,493,844.60 | €61,758.84 |
| **Spring oats** | €255,360.00 | €137,200.00 | €103,250.00 | €106,943.40 | €0.00 |
| **Winter oats** | €470,592.00 | €252,840.00 | €190,275.00 | €228,330.00 | €0.00 |
| **Oilseed rape** | €65,372.16 | €35,123.20 | €26,432.00 | €53,223.90 | €10,241.22 |
| **Peas** | €11,673.60 | €6,272.00 | €4,720.00 | €5,664.00 | €0.00 |
| **Beans** | €96,963.84 | €52,096.80 | €39,205.50 | €47,046.60 | €0.00 |
| **Linseed** | €0.00 | €6,526.80 | €0.00 | €7,628.70 | €0.00 |
| **Set-aside** | €0.00 | €610,246.00 | €0.00 | €0.00 | €0.00 |
| **Non-food** | €14,737.92 | €7,918.40 | €5,959.00 | €8,053.50 | €0.00 |
| **Lupins** | €2,444.16 | €1,313.20 | €988.25 | €1,185.90 | €0.00 |
| **Sugar beet** | €1,134,528.00 | €609,560.00 | €458,725.00 | €1,851,844.80 | €661,356.96 |
| **Potatoes** | €5,554,080.00 | €259,190.40 | €122,322.00 | €205,196.10 | €650,072.28 |
| **Total €** | **€12,499,543.68** | **€7,332,536.40** | **€5,053,954.75** | **€7,859,118.60** | **€752,943.84** |
| **Total €** | **£9,749,644.07** | **£5,719,378.39** | **£3,942,084.71** | **£6,130,112.51** | **£587,296.20** |

**Table 6:** Estimated pesticide targeting invasive and non-native species impacting crops in Northern Ireland.

| Crop | Fungicides | Herbicides | Insecticides | Seed treatments: Insecticides and fungicides | Molluscicides |
|---|---|---|---|---|---|
| **Spring barley** | £515,796.80 | £904,847.60 | £147,588.50 | £218,754.30 | £0.00 |
| **Undersown barley** | £17,966.40 | £17,912.40 | £2,301.00 | £8,867.70 | £0.00 |
| **Winter barley** | £205,716.80 | £382,910.00 | £88,927.75 | £110,217.90 | £2,608.98 |
| **Spring wheat** | £51,254.40 | £75,378.40 | £11,387.00 | £25,116.30 | £0.00 |
| **Winter wheat** | £278,190.40 | £504,568.00 | £128,664.25 | £167,990.70 | £10,007.58 |
| **Undersown wheat** | £1,763.20 | £3,304.00 | £309.75 | £1,026.60 | £0.00 |
| **Spring oats** | £43,806.40 | £30,868.80 | £2,728.75 | £11,841.30 | £0.00 |
| **Undersown oats** | £0.00 | £0.00 | £0.00 | £672.60 | £0.00 |
| **Winter oats** | £25,566.40 | £45,335.60 | £3,540.00 | £14,337.00 | £0.00 |
| **Oilseed rape** | £13,558.40 | £24,874.40 | £5,324.75 | £7,487.10 | £0.00 |
| **Peas & beans** | £2,584.00 | £3,233.20 | £1,460.25 | £1,274.40 | £0.00 |
| **Triticale** | £152.00 | £0.00 | £73.75 | £0.00 | £0.00 |
| **Seed potatoes** | £21,492.80 | £52,864.00 | £4,144.75 | £4,212.60 | £3,348.84 |
| **Early potatoes** | £14,516.00 | £11,422.40 | £545.75 | £1,203.60 | £778.80 |
| **Maincrop potatoes** | £1,030,455.00 | £354,684.40 | £15,649.75 | £32,054.70 | £14,991.90 |
| **Total GB £** | **£2,222,819.00** | **£2,412,203.20** | **£412,646.00** | **£605,056.80** | **£31,736.10** |
| **Total €** | **€2,800,751.94** | **€3,039,376.03** | **€519,933.96** | **€762,371.57** | **€39,987.49** |

### 4.1.3 Agricultural and horticultural weeds

Despite the efforts to control the species, control measures are not 100% effective in all instances. There is still a loss due to competition from weeds that survive control methods. We apply the assumptions made for Britain for the assessment of losses due to weeds that survive control. A 5% yield loss is assumed for relevant crops. Data on productivity has been obtained from the CSO (2004)[5] for Ireland and DARD (2010)[6] for Northern Ireland.

**Table 7:** Estimated economic cost of yield losses due to invasive and non-native species on crops in Ireland.

| Crop | GB £ | Euro |
|---|---|---|
| Barley | £5,225,714.29 | €6,584,400.00 |
| Wheat | £3,127,857.14 | €3,941,100.00 |
| Oats | £431,071.43 | €543,150.00 |
| Potatoes | £4,715,714.29 | €5,941,800.00 |
| Sugar beet | £2,185,714.29 | €2,754,000.00 |
| Other fresh vegetables | £3,205,357.14 | €4,038,750.00 |
| **Total yield losses** | **£18,891,428.57** | **€23,803,200.00** |

**Table 8:** Estimated economic cost of yield losses due to invasive and non-native species on crops in Northern Ireland.

| Crop | GB £ | Euro |
|---|---|---|
| Barley | £881,587.58 | €1,110,800.34 |
| Fruit | £401,553.95 | €505,957.98 |
| Mushrooms | £1,024,202.50 | €1,290,495.15 |
| Oats | £80,770.90 | €101,771.33 |
| Ornamental and hardy nursery stock | £538,126.58 | €678,039.48 |
| Other crops | £611,751.81 | €770,807.28 |
| Potatoes | £1,079,309.97 | €1,359,930.56 |
| Vegetables | £802,431.23 | €1,011,063.35 |
| Wheat | £583,915.22 | €735,733.17 |
| **Total yield losses** | **£6,003,649.73** | **€7,564,598.65** |

### 4.1.4 Crop disease

The potato industry makes an important contribution to the agricultural economies of both Ireland and Northern Ireland. The CSO estimated the value of potatoes at €74.4m in 2008, while in Northern Ireland the total farm gate value for the local potato industry in 2010 was approximately £22.8million with some 187,000t of potatoes produced[7].

Heavy losses in potatoes can arise from tuber diseases and tuber damage. The principal diseases of tubers are Potato Blight, Common Scab, Powdery Scab, Skin Spot, Black Scurf, Silver Scurf, Black Leg, Soft Rot, Dry Rot and Gangrene. Some of these develop while

[5] http://www.cso.ie/en/media/csoie/releasespublications/documents/agriculture/2003/oiifin_2003.pdf
[6] http://www.cso.ie/en/media/csoie/releasespublications/documents/agriculture/2003/oiifin_2003.pdf
[7] http://www.northernireland.gov.uk/index/media-centre/news-departments/news-dard/news-dard-240811-business-growth-in.htm

tubers are still in the soil and may continue to develop after lifting. Dry Rot and Gangrene develop during storage from infection picked up in the soil during harvesting, during subsequent handling and in stores. Tuber damage may render the tubers unsaleable and increase the risk of infection.

Datasets to estimate the losses associated with all potato diseases were not identified in time for this study. Kavanagh (1992) assessed the impact of potato blight and potato cist nematode (PCN) on potato production in Ireland. This dataset identified the cost of controlling potato blight as *IR £*4,320,000 per annum and the cost of the loss of yield and post-harvest rotting at *IR £*2,700,000 (total of *IR£*7,020,000 at 1988 prices; equivalent to €8,913,561; or €16,450,210 at today's prices after accounting for inflation). The Expenditure Review of Programmes in the Potato Sector indicates that the potato sector has undergone significant changes since the time of Kavanagh, therefore, these figures are considered to be out-of-date and require updating. No similar study was identified for Northern Ireland when undertaking this review.

The cost of potato blight has been calculated based on the reported value of the potato crop to the economies of Ireland and Northern Ireland. An extrapolated cost of potato blight without control has also been calculated, assuming a 50% loss of marketable potatoes. This is only for illustrative purposes as, if this situation occurred, market forces would impact on the sector in an unpredictable manner, resulting in a very different economic impact. The results merely serve to highlight the value of current control efforts.

**Table 9:** Estimated economic costs of yield loss due potato blight in Ireland and Northern Ireland with treatment and illustrative cost of yield loss without treatment.

| Crop | Ireland € | Northern Ireland € | Ireland GB £ | Northern Ireland GB £ |
|---|---|---|---|---|
| **Potato with treatment 5.00% yield loss** | €3,720,000 | €1,460,500 | £2,901,600.00 | £1,150,000.00 |
| **Potato without treatment 50.00% yield loss** | €37,200,000 | €14,605,000 | £29,016,000.00 | £11,500,000.00 |

### 4.1.5 Damage to bee pollinators by varroa mite

Bees play an essential role worldwide by pollinating many of our commercial food crops. They also maintain biodiversity in the wild by pollinating wild plants, which then provide shelter and food for a wide range of insects and animals. The honey bee is by far the most important insect pollinator in the world. *Varroa destructor*, originally classified as *Varroa jacobsoni*, and commonly referred to as 'varroa' is a highly destructive pest that can severely reduce honey production. Varroa is a small mite that causes precocious reduction in foraging, increased drifting and high mortality during the winter[8]. The varroa mite is the most devastating pest affecting honey bees in Europe. Since its introduction into Ireland in 1998 it has become endemic and is now a major problem for Irish beekeepers.

[8] http://www.agriculture.gov.ie/media/migration/farmingsectors/beekeepingandhoney/HoneybeePublication.pdf

The national apiculture programme on bee pathogen research is being carried out by the University of Limerick in conjunction with Teagasc. This three year research programme, running to August 2013, has a budget of €300,000 and is jointly funded by the Department of Agriculture, Fisheries and Food and the EU[9]. There are approximately 2,200 beekeepers in Ireland who maintain an estimated 20,000-22,000 hives[10]. There are thought to be around some 800 beekeepers in Northern Ireland, who maintain about 4,000 colonies of honey bees. These are mainly small-scale beekeepers with less than 40 hives – with the typical number of hives being between three and five[11].

Williams (2010) has estimated that hives in GB are valued at £856 each, which includes the value of honey production and also the value of pollination of crops. This figure is used for the current calculations for Ireland. Williams also calculated that the cost of varroa mite for the entire UK is £15,839,424, with £791,971 attributed to Northern Ireland. This figure is accepted for the current study. In Ireland, an average of 21,000 hives is used and the same assumptions applied for GB are applied here i.e. 90% of the estimated average winter loss of 8% of hives is attributed to varroa mite. This leaves the economic cost of varroa mite at €1,630,783 (£1,294,272) per annum for Ireland.

### 4.1.6 Damage to agriculture and horticulture from deer

All species of deer in Ireland owe their introduction to human action. The red deer has perhaps the most complex history (see Carden 2012 for details) with calls for special protection of the Kerry population due to its ancient lineage. Sika deer were introduced into Ireland in 1860 by Viscount Lord Powerscourt of Co. Wicklow. Fallow deer were possibly introduced to Ireland by the Anglo-Normans during the medieval period (late 1100's/1200's). Muntjac deer are a recent arrival to Ireland with the first verified record from the wild dating to 2006, although this species is not at sufficient numbers to cause any economic impact and is therefore not considered here.

Deer can impact agriculture by grazing and flattening (trampling, rolling or lying) crops, by causing damage to field boundaries (fences and hedgerows) and by stripping bark from trees (Gill *et al.*, 2000; Scott and Palmer, 2000). Most studies on deer impacts in agriculture have focused on their effects on crops, with damage recorded for cereals, pasture, silage and root crops (e.g. beet). Factors affecting the occurrence of damage include distance from cover (e.g. woodland), deer density and the species of deer. Damage decreases with distance from cover, occurring primarily along field boundaries, and increases above certain deer densities (Scott and Palmer, 2000; White *et al.*, 2004). Additionally, red (*Cervus elaphus*), fallow (*Dama dama*) and roe (*Capreolus capreolus*) deer are considered the species most likely to cause damage, whilst sika (*Cervus nippon*) and muntjac (*Muntiacus reevesi*) are considered the lowest risk (Putman and Moore, 1998). The occurrence and extent of damage is also temporally variable with winter cereals at greatest risk in spring (when there is less suitable forage elsewhere) and peas and beet in summer (Scott and Palmer, 2000; Pursar 2009).

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[9] http://debates.oireachtas.ie/dail/2011/06/29/00017.asp
[10] http://www.agriculture.gov.ie/media/migration/farmingsectors/beekeepingandhoney/NationalApicultureProgramme20102013.pdf
[11] http://www.dardni.gov.uk/strategy-for-the-sustainability-of-the-honey-bee.pdf.

The effect of deer damage on crop yields is difficult to quantify, as many factors affect yields (Anon, 2003). However, in GB, the economic impact is considered to be less than that from rabbits and in England it is considered to be no more than £500 per annum per farmer (Doney and Parker, 1998; White *et al.*, 2004). The few studies that exist from GB where economic impacts have been estimated have used estimates of deer populations to calculate costs (Scott and Palmer, 2000; White *et al.*, 2004). We are unable to follow a similar methodology as no similarly robust estimates of deer populations have been made Ireland or Northern Ireland. Therefore we are reluctant to make similar assumptions for Northern Ireland and Ireland without this basic information. A project is underway at University College Cork that will allow for some of these assumptions to be made but this would only represent a starting point for the assessment of economic impact. The projected figures from the GB assessment are accepted for the purpose of estimating the economic impact of deer on agriculture in Ireland and Northern Ireland. These figures are likely to be on the conservative side but are included in our calculations.

**Table 10:** Estimated economic impact of deer on agriculture in Ireland and Northern Ireland.

| | **Ireland** | **Northern Ireland** | **Ireland and Northern Ireland combined** |
|---|---|---|---|
| Deer GB £ | £581,078 | £228,231 | £809,310 |
| Deer € | €737,969 | €289,853 | €1,027,823 |

### 4.1.7 Damage to agriculture and horticulture from rabbits

The European rabbit (*Oryctolagus cuniculus*) was introduced to Ireland at some point during the 12th or 13th century (see Lever 2009 for details of recorded history). There are currently no estimates of rabbit numbers in Ireland or Northern Ireland. Additionally, no references could be located that describe the rabbit population in Ireland or Northern Ireland prior to the introduction of myxomatosis (1950's) and viral haemorrhagic disease (1990's).

Before beginning to estimate the impact of rabbits on the economies of Ireland and Northern Ireland, we need an estimate of the number of rabbits present. The hare survey of Ireland[12] does collate some data on rabbits but this has not been extrapolated to allow a population estimate. Therefore, the approach taken is to extrapolate the British population estimates to Ireland and Northern Ireland based on land mass area. Harris and Yalden (2008) quote a figure for the population of GB (area = 22,984,800ha) during the post-myxomatosis period in the 1990s as 37 million rabbits. Given that Ireland is about 36% of the size of GB if we adjust this figure we get a population of 13 million rabbits. Tables 9 and 10 show the estimated impact of rabbits on agriculture following the same assumptions made in Williams (2010).

[12] http://www.npws.ie/media/npws/publications/irishwildlifemanuals/media,5119,en.pdf

**Table 11:** Estimated impact of rabbits on crops in Ireland.

| Crop | GB £ | € Euro |
|---|---|---|
| **Spring barley** | £821,085.34 | €1,034,567.53 |
| **Winter barley** | £103,138.78 | €129,954.87 |
| **Spring wheat** | £590,377.05 | €743,875.09 |
| **Winter wheat** | £1,352,947.41 | €1,704,713.74 |
| **Spring oats** | £132,456.39 | €166,895.05 |
| **Winter oats** | £244,098.20 | €307,563.74 |
| **Oilseed rape** | £15,744.57 | €19,838.16 |
| **Peas** | £3,243.62 | €4,086.96 |
| **Beans** | £26,942.31 | €33,947.31 |
| **Linseed** | £2,925.75 | €3,686.44 |
| **Potatoes** | £134,042.54 | €168,893.60 |
| **Set-aside** | £273,553.15 | €344,676.97 |
| **Non-food** | £3,549.56 | €4,472.44 |
| **Lupins** | £588.66 | €741.72 |
| **Sugar beet** | £273,245.64 | €344,289.51 |
| **Grass silage** | £8,617,252.78 | €10,857,738.50 |
| **Hay (excluding silage)** | £2,466,163.74 | €3,107,366.31 |
| **Pasture** | £21,879,220.85 | €27,567,818.27 |
| **Rough Grazing** | £4,348,476.14 | €5,479,079.94 |
| **Total** | **£36,940,576.35** | **€46,545,126.21** |

**Table 12:** Estimated impact of rabbits on crops in Northern Ireland.

| Crop | GB £ | € Euro |
|---|---|---|
| **Spring barley** | £85,363.69 | €107,558.26 |
| **Undersown barley** | £2,973.42 | €3,746.50 |
| **Winter barley** | £128,047.48 | €161,339.83 |
| **Spring wheat** | £31,903.07 | €40,197.87 |
| **Winter wheat** | £173,158.35 | €218,179.52 |
| **Undersown wheat** | £1,097.50 | €1,382.84 |
| **Spring oats** | £27,267.09 | €34,356.54 |
| **Undersown oats** | £927.19 | €1,168.27 |
| **Winter oats** | £15,913.69 | €20,051.25 |
| **Oilseed rape** | £3,918.57 | €4,937.40 |
| **Peas & beans** | £861.59 | €1,085.60 |
| **Triticale** | £50.68 | €63.86 |
| **Seed potatoes** | £6,211.73 | €7,826.77 |
| **Early potatoes** | £1,936.03 | €2,439.40 |
| **Maincrop potatoes** | £35,504.36 | €44,735.49 |
| **Grass** | £6,827,319.05 | €8,602,422.00 |
| **Total** | **£7,342,453.49** | **€9,251,491.40** |

### 4.1.8 Damage to agriculture and horticulture from geese and swans

Geese and swans are known to cause damage to crops (cereals and root crops) and pasture via grazing (Vickery *et al.*, 1994; MacMillan *et al.*, 2004). In Ireland, two species of Anatidae are considered resident and non-native, the mute swan (*Cygnus olor*) and the Canada goose (*Branta canadensis*). Barnacle geese (*Branta leucopsis*), light bellied brent geese (*Branta bernicla hrota*), greylag geese (*Anser anser*), Greenland white-fronted geese (*Anser albifroms flavirostris*) and Whooper swans (*Cygnus cygnus*) overwinter in Britain and Ireland and are not considered resident (Boland and Crowe, 2012), therefore they are not included in the analysis. Populations of feral Canada geese are small and localised, with around 200 birds across Ireland and Northern Ireland (Crowe *et al.*, 2008). In contrast, mute swans are widespread across Ireland and Northern Ireland with numbers in 2003/04 estimated at 11,400 birds (Crowe *et al.*, 2008). The MacMillan (2004) study of the economic damage from geese on farms in Scotland estimated an average cost per goose of £16.74 (adjusted to 2012 prices). This cost included; loss of winter grazing, loss of silage, extra fertilizers, extra reseeding, crop losses and halting the growing of winter barley. Applying the estimated damage per goose (£16.74) to the total non-native geese population in Ireland and Northern Ireland (11,600), the total cost of geese and swan damage to agriculture is £190,588 (€240,140**)** per annum. On a per capita basis, this results in a cost for Ireland as €172,150 (£136,627.20) and £53,960 (€67,990) for Northern Ireland.

### 4.1.9 Summary of ground-truthed costs for agriculture and horticulture

**Table 13:** Summary of estimated costs of invasive and non-native species on the agricultural sectors in Ireland and Northern Ireland GB £.

| Agricultural and horticultural costs | Ireland | Northern Ireland | Ireland and Northern Ireland combined |
|---|---|---|---|
| Herbicides and pesticides | £26,128,515.88 | £5,684,461.10 | £31,812,976.98 |
| Yield loss: weeds | £18,891,428.57 | £6,003,649.73 | £24,895,078.30 |
| Yield loss: invertebrates | Insufficient data | Insufficient data | Insufficient data |
| Sprayer water | £60,652 | £23,823 | £84,475 |
| Storage pests | Insufficient data | Insufficient data | Insufficient data |
| Nematodes | Insufficient data | Insufficient data | Insufficient data |
| Varroa mite | £1,294,272 | £791,971 | £2,086,243.00 |
| Plant pathogens | £2,901,600 | £1,150,000 | £4,051,600.00 |
| Deer | £581,078 | £228,231 | £809,310 |
| Rabbit | £36,940,576 | £7,342,4539 | £44,283,029.84 |
| Rat control | £5,426,566 | £1,083,901 | £6,510,467.00 |
| Rat control - contractor | £1,591,680 | £317,952 | £1,909,632.00 |
| Rat - fire | £4,550,686 | £1,797,290 | £6,347,976 |
| Yield loss rat | £1,320,554 | £118,818 | £1,439,372 |
| Mink | Insufficient data (see case study from more detail) | Insufficient data (see case study from more detail) | Insufficient data (see case study from more detail) |
| Geese & Swans | £136,627.20 | £53,960 | £190,588 |
| **Total** | **£99,824,236** | **£24,596,510** | **£124,420,748** |

**Table 14:** Summary of estimated costs of invasive and non-native species on the agricultural sectors in Ireland and Northern Ireland €.

| **Agricultural and horticultural costs** | **Ireland** | **Northern Ireland** | **Ireland and Northern Ireland combined** |
|---|---|---|---|
| Herbicides and pesticides | €32,921,930 | €7,162,421 | €40,084,351 |
| Yield loss: weeds | €23,803,200 | €7,564,599 | €31,367,799 |
| Yield loss: invertebrates | Insufficient data | Insufficient data | Insufficient data |
| Sprayer water | €76,422 | €30,017 | €106,439 |
| Storage pests | Insufficient data | Insufficient data | Insufficient data |
| Nematodes | Insufficient data | Insufficient data | Insufficient data |
| Varroa mite | €1,630,783 | €997,883 | €2,628,666 |
| Plant pathogens | €3,656,016 | €1,449,000 | €5,105,016 |
| Deer | €732,158 | €287,571 | €1,019,731 |
| Rabbit | €46,545,126 | €92,514,919 | €55,796,618 |
| Rat control | €6,837,473 | €1,365,715 | €8,203,188 |
| Rat control - contractor | €2,005,517 | €400,620 | €2,406,136 |
| Rat - fire | €5,733,864 | €2,264,585 | €7,998,450 |
| Yield loss rat | €1,663,898 | €149,711 | €1,813,609 |
| Mink | Insufficient data (see case study from more detail) | Insufficient data (see case study from more detail) | Insufficient data (see case study from more detail) |
| Geese & Swans | €172,150 | €67,990 | €240,141 |
| **Total** | **€125,778,537** | **€30,991,603** | **€156,770,142** |

## 4.2 Forestry

At the end of the 19th century the area of woodland and forest cover in Ireland was estimated to be approximately 69,000 hectares, or 1% of the national land area. During the first 75 years of the 20th century forestry in Ireland was almost exclusively carried out by the State and by 1985 forest and woodland cover had increased to approximately 420,000 hectares. The mid 1980s saw a significant increase in private forest development, with the introduction of EU funded grant schemes aimed at encouraging private land owners, mainly farmers, to become involved in forestry. As a result, the area of national forest estate in Ireland has now increased to approximately 700,000 hectares, or 10% of the national land area. Of this, approximately 45% is in private ownership and 55% is in the ownership of Coillte Teoranta (The Irish Forestry Board).

### 4.2.1 Projected costs of invasive species on forestry

Table 12 reproduces the estimates for losses to forestry from invasive species in GB. The main losses are attributable to the management of two species: deer and rabbit. A large proportion of the costs reflect the use of fencing to minimise the loss from browsing and bark stripping. Other costs are associated with deer culling. Again the estimates for Ireland will vary not just according to the differences in forestry cover but also to the extent that plantation practices differ. Conifer plantations are susceptible to serious insect infestation and evidence from British Columbia, where many exotic species originate, points to the growing hazards from monoculture of pine trees in the face of climate change.

**Table 15:** Projected annual costs of invasive species to Irish forestry based on estimates for GB (£)
Source: Table 6.4. Williams et al, 2010.

| Forestry costs | Great Britain | Great Britain corrected for inflation at 2.73% per annum | Projected Ireland and Northern Ireland combined | Projected Ireland | Projected Northern Ireland |
|---|---|---|---|---|---|
| Rabbit | £70,017,000 | £73,892,111 | £7,803,007 | £5,602,500 | £2,200,507 |
| Deer | £17,378,000 | £18,339,790 | £1,936,682 | £1,390,523 | £546,159 |
| Edible Dormouse | £250,000 | £263,836 | n/a | n/a | n/a |
| Grey Squirrel | £6,097,000 | £6,434,440 | £679,477 | £487,859 | £191,618 |
| Rhododendron | £8,621,000 | £9,098,132 | £960,763 | £689,820 | £270,942 |
| Insects | £3,732,000 | £3,938,549 | £415,911 | £298,621 | £117,290 |
| Plant Pathogens | £1,356,000 | £1,431,048 | £151,119 | £108,502 | £42,617 |
| Quarantine and research | £1,945,000 | £2,052,647 | £216,759 | £155,632 | £61,128 |
| **Totals** | **£109,396,000** | **£115,450,553** | **£12,163,717** | **£8,733,457** | **£3,430,260** |

**Table 16:** Projected annual costs of invasive species to Irish forestry based on estimates for GB (€)
Source: Table 6.4. Williams et al, 2010.

| Forestry costs | Great Britain | Great Britain corrected for inflation at 2.73% per annum | Projected Ireland and Northern Ireland combined | Projected Ireland | Projected Northern Ireland |
|---|---|---|---|---|---|
| Rabbit | €88,221,420 | €93,104,060 | €9,831,789 | €7,059,150 | €2,772,639 |
| Deer | €21,896,280 | €23,108,135 | €2,440,219 | €1,752,059 | €688,160 |
| Edible Dormouse | €315,000 | €332,433 | n/a | n/a | n/a |
| Grey Squirrel | €7,682,220 | €8,107,394 | €856,141 | €614,702 | €241,439 |
| Rhododendron | €10,862,460 | €11,463,646 | €1,210,561 | €869,173 | €341,387 |
| Insects | €4,702,320 | €4,962,572 | €524,048 | €376,262 | €147,785 |
| Plant Pathogens | €1,708,560 | €1,803,120 | €190,410 | €136,713 | €53,697 |
| Quarantine and research | €2,450,700 | €2,586,335 | €273,116 | €196,096 | €77,021 |
| **Totals** | **€137,838,960** | **€145,467,697** | **€15,326,283** | **€11,004,156** | **€4,322,128** |

### 4.2.2 Management to prevent damage to forestry from rabbits

Rabbits can damage or kill planted nursery stock and young trees of many species. Damage to the bark of large trees can also be serious and semi-mature hedgerows may also be vulnerable. In extreme circumstances, rabbits may prevent natural regeneration in woodlands. Damage ranges from the eating of young seedlings to the destruction of leading shoots, the browsing of branches and the removal of bark. The burrowing activities of rabbits can also undermine root systems.

In Britain, the total winter population of rabbits is estimated to be at 35% to 40% of the pre-myxomatosis level (circa 1952) and is increasing by about 2% annually. This is due primarily to the reduced effect of myxomatosis, resulting from increased levels of genetic resistance. Harris and Yalden (2008) quote an estimate for the population of GB (area = 22,984,800ha) during the post-myxomatosis period in the 1990s as 37 million rabbits. Given that Ireland is about 36% of the size of GB if we adjust this figure we get a population of 13 million rabbits.

Given the problems associated with rabbits, this increase in numbers is likely to be accompanied by a corresponding rise in the amount of serious crop damage. It is essential, therefore, that effective control strategies are available to ensure that crops vulnerable to rabbit damage are adequately protected. This will serve to benefit landowners and occupiers who have a statutory responsibility to manage rabbit infestations on their land and to prevent them causing damage to neighbouring properties. However, similar to the situation in Britain, there is limited data to indicate the reduction in value of timber due to rabbit damage. No data could be found to suggest what acreage of forests was damaged by rabbits in Ireland or Northern Ireland. Additionally, no data were found on what expenditure takes place on controlling rabbits in forestry in Ireland and Northern Ireland.

There is a paucity of data on which to confidently base the assessment of rabbit impact on forestry in both Ireland and Northern Ireland. The assumptions made for GB cannot be applied here as the baseline data on the rabbit population specific to the forestry environment does not exist. Additionally, the crop area at risk from rabbits is not known at the time of this assessment. While considering these problems, we recognise the level of impact rabbits are estimated to have in GB on forestry and it is important to include some level of economic damage in our assessment. Therefore, we accept the projections made for Ireland and Northern Ireland for the purposes of this report (Table 13).

**Table 17:** Estimated economic impact of rabbits on forestry in Ireland and Northern Ireland.

| Forestry costs | Ireland | Northern Ireland | Ireland and Northern Ireland combined |
|---|---|---|---|
| Rabbit GB £ | £5,602,500 | £2,200,507 | £7,803,007 |
| Rabbit € | €7,059,150 | €2,772,639 | €9,831,789 |

### 4.2.3 Management to prevent damage to forestry from deer

All species of deer in Ireland owe their introduction to human action. The red deer has perhaps the most complex history (see Carden 2012 for details) with calls for special protection of the Kerry population due to its ancient lineage. Sika deer were introduced into Ireland in 1860 by Viscount Lord Powerscourt of Co. Wicklow. Fallow deer were possibly introduced to Ireland by the Anglo-Normans during the medieval period (late 1100’s/1200’s). Muntjac deer are a recent arrival to Ireland with the first verified record from the wild dating to 2006, although this species is not at sufficient numbers to cause any economic impact and is therefore not considered here.

Wild deer can cause potentially serious financial losses in commercial forests through their habits of browsing the leading shoots of young conifer trees in the first few years after planting and stripping the bark from such trees in the first 25 years or so (Anon, 2009 cited in Pursar 2009). These lead on to prevention and mitigation measures such as erecting fences or culling. Economic impacts are also spread across broadleaf forests.

Browsing in natural forests restricts regeneration whilst in commercial plantations browsing reduces growth rates, and consequently log size, which leads to yield losses (Gill *et al.*, 2000). Similarly, bark stripping reduces economic yields by reducing the value of timber by providing an entry point for fungi that can stain wood (Gill *et al.*, 2000).

#### *4.2.3.1 Broadleaf plantations*

Purser (2009) described that broadleaved woodland currently makes up nearly 25% of total forest cover in Ireland. This predominantly (92%) consists of native species either growing as native woodland or in established plantations. Broadleaf plantations have been extensively established in the last 10 years and during this time their contribution to the annual afforestation programme has risen to 31%. Fifteen per cent of all broadleaved woodlands are now under 10 years of age. While there are many other issues affecting timber quality, particularly with broadleaves, deer now pose a significant risk to the quality of timber in Ireland's new broadleaf woodlands. In the absence of proper deer distribution and density data it is not possible to quantify this risk, or to effectively plan to mitigate it. However, given that:

a) deer populations are expanding rapidly,
b) much of Ireland's forest estate is categorised as young woodland,
c) young woodlands are susceptible to deer damage, and
d) woodlands are favoured habitats of most deer species,

it is clear that significant problems lie ahead.

Ireland is described as being relatively unique when it comes to broadleaf plantations. It has young broadleaf plantations established on green-field sites, whereas most literature on economic loss resulting from deer damage in forests relates to regeneration in mature forests or damage in young conifer plantations.

A model developed by Pursar (2009) showed that, all other things being equal, a potential loss of 62% (€34,000,000) of revenue value will occur in the worst case scenario, but more realistically a potential loss of 32% (€18,000,000 or £14,040,000) attributable to damage caused by deer is more likely.

The Forest Service introduced a deer fencing grant in 2007 for the "retro-erection" of deer fencing around plantations where no deer problem had been envisaged at establishment but which had subsequently experienced significant damage. So far under this scheme 73.5 km of deer fence have been erected at a cost to the State of €662,158. Many of these plantations also required filling in (replanting trees that were lost to deer damage) at considerable cost to the taxpayer under the reconstitution grant scheme.

*4.2.3.2 Conifer crops*

***Bark stripping***

The susceptibility of a tree to bark stripping depends on a number of factors that include species, age, size and time of year (Gill *et al.*, 2000). Bark stripping occurs throughout the year but peaks in the winter months. The extent and occurrence of damage varies between stand age and species type, with Norway spruce (*Picea abies*) the most susceptible to damage and Sitka spruce (*Picea sitchensis*) the least (Gill *et al.*, 2000). Cumulative levels of bark stripping damage during crop rotations can vary between 0.7% and 27% for Sitka spruce and 4.7% and 11.4% for Norway spruce (Gill *et al.*, 2000; Kiffner *et al.*, 2008; Scott and Palmer, 2000). The species of deer also has an effect on the occurrence of bark stripping, with only the large species, fallow (*Dama dama*), sika (*Cervus nippon*) and red (*Cervus elaphus*) (all present in Ireland) considered to be the perpetrators of the greatest damage.

Using an economic yield loss of 3%, as derived by Scott and Palmer (2000), we can estimate the potential losses to state owned forestry in Ireland and Northern Ireland from bark stripping. It is assumed that all harvested forests contain deer and bark stripping has occurred throughout the rotation (life time of timber) to the levels recorded as causing damage elsewhere.

**Northern Ireland:** The majority of timber sold in NI during 2011 was spruce (99.3% or 392,203$m^3$) which is equivalent to £6,706,671 standing value (£17.10 per $m^3$) or £10,605,653 roadside value (£26.23 per $m^3$). If we assume these values equate to 97% of the potential economic value of the timber (as 3% is lost due to deer bark stripping) the loss to standing and roadside timber incomes from deer bark stripping is potentially between £207,422 and £318,169 respectively in Northern Ireland. This gives an average cost of £262,795.

**Ireland:** In 2010, 1,921,000 $m^3$ (82%) of timber sold by Coillte was spruce (Norway or sitka) (Marie Roche, Coillte, pers. comm.). Average 2011/2012 Teagasc timber prices (standing (€47.84) and roadside (€61)) give this a value of between €91,900,640 and €117,181,000. Again, assuming these values equate to 97% of the potential economic value of timber in Ireland, the loss to Ireland's forestry sector from deer bark stripping is potentially between €2,842,287 and €3,624,154 depending on standing or roadside timber values. This gives an average cost of €3,233,220.

### 4.2.4 Impact to forestry from grey squirrel

Damage by grey squirrel is discussed in the relevant case study. The costs are duplicated in the summary section (section 4.2.6) for ease of reference.

### 4.2.5 Impact to forestry from rhododendron

Insufficient data supplied to estimate costs to the economy.

### 4.2.6 Summary of ground-truthed costs for forestry

**Table 18:** Summary of estimated costs of invasive and non-native species on the agricultural sectors in Ireland and Northern Ireland GB £.

| Forestry costs | Ireland | Northern Ireland | Ireland and Northern |
|---|---|---|---|

| | | | Ireland combined |
|---|---|---|---|
| Rabbit | £5,602,500 | £2,200,507 | £7,803,007 |
| Deer | £4,488,084 | £262,795 | £4,750,879 |
| Grey squirrel | £3,295,218 | £340,352 | £3,635,570 |
| Rhododendron | Limited datasets | Limited datasets | Limited datasets |
| Insects | Insufficient data | Insufficient data | Insufficient data |
| Plant pathogens | Insufficient data | Insufficient data | Insufficient data |
| Quarantine and research | Insufficient data | Insufficient data | Insufficient data |
| **Totals** | **£13,385,802** | **£2,803,654** | **£16,189,456** |

**Table 19:** Summary of estimated costs of invasive and non-native species on the agricultural sectors in Ireland and Northern Ireland €.

| **Forestry costs** | **Ireland** | **Northern Ireland** | **Ireland and Northern Ireland combined** |
|---|---|---|---|
| Rabbit | €7,059,150 | €2,772,639 | €9,831,789 |
| Deer | €5,654,986 | €331,122 | €5,986,108 |
| Grey squirrel | €4,151,975 | €428,844 | €4,580,818 |
| Rhododendron | Limited datasets | Limited datasets | Limited datasets |
| Insects | Insufficient data | Insufficient data | Insufficient data |
| Plant pathogens | Insufficient data | Insufficient data | Insufficient data |
| Quarantine and research | Insufficient data | Insufficient data | Insufficient data |
| **Totals** | **€16,866,111** | **€3,532,604** | **€20,398,715** |

## 4.3 Aquaculture

Modern aquaculture in Ireland and Northern Ireland began its development in the early 1970's and has become an important contributor to rural economies, generating incomes in many areas where there are few other job opportunities. In 2006, total aquaculture production in Ireland and Northern Ireland was 68,523 tonnes, valued in excess of €136 million, supporting 2,275 jobs in coastal and rural area[13]. There has been a steady and, in some cases, exponential increase in both output and value, in job creation, and in the diversity of sites used and species farmed.

Mussels, Pacific oysters, native oysters, clams and scallops are the main shellfish species being produced in Ireland at present. Salmon and rainbow trout are the two principal finfish species farmed at sea. Salmon consistently account for 85-95% by volume of annual finfish production. New species have entered the sector since the 1970s and among their number include cod, scallops, abalone, clams, charr, and perch.

### 4.3.1 Projected costs of invasive species on aquaculture

As Table 15 indicates, the projected costs on the aquaculture sector from the cost estimates for GB are relatively modest compared with agriculture/horticulture and forestry. This is consistent with our expectations, as some invasive species, such as the slipper limpet and topmouth

[13] http://www.aquacultureinitiative.eu/Aqua_Report_1.pdf

gudgeon, which are found in GB, are not present in Ireland or are only here in low numbers (omitted from this study).

**Table 20:** Projected annual costs of invasive species to aquaculture based on estimates for GB (£) Source: Table 8.1. Williams et al, 2010.

| | **Great Britain** | **Great Britain corrected for inflation at 2.73% per annum** | **Projected Ireland and Northern Ireland combined** | **Projected Ireland** | **Projected Northern Ireland** |
|---|---|---|---|---|---|
| Hull fouling | £721,000 | £760,904 | £80,351 | £57,692 | £22,660 |
| Fouling (shellfish) | £864,000 | £911,818 | £96,288 | £69,134 | £27,154 |
| Slipper limpet (oysters) | £1,430,000 | £1,509,144 | Not calculated | Not calculated | Not calculated |
| Slipper limpet (scallops) | £3,530,000 | £3,725,369 | Not calculated | Not calculated | Not calculated |
| Slipper limpet (mussels) | £550,000 | £580,440 | Not calculated | Not calculated | Not calculated |
| Topmouth gudgeon | £50,000 | £52,767 | n/a | n/a | n/a |
| **Total** | **£7,145,000** | **£7,540,442** | **£176,639** | **£126,826** | **£49,814** |

**Table 21:** Projected annual costs of invasive species to aquaculture based on estimates for GB (€) Source: Table 8.1. Williams et al, 2010.

| | **Great Britain** | **Great Britain corrected for inflation at 2.73% per annum** | **Projected Ireland and Northern Ireland combined** | **Projected Ireland** | **Projected Northern Ireland** |
|---|---|---|---|---|---|
| Hull fouling | €908,460 | €958,739 | €101,242 | €72,692 | €28,552 |
| Fouling (shellfish) | €1,088,640 | €1,148,891 | €121,323 | €87,109 | €34,214 |
| Slipper limpet (oysters) | €1,801,800 | €1,901,521 | Not calculated | Not calculated | Not calculated |
| Slipper limpet (scallops) | €4,447,800 | €4,693,965 | Not calculated | Not calculated | Not calculated |
| Slipper limpet (mussels) | €693,000 | €731,354 | Not calculated | Not calculated | Not calculated |
| Topmouth gudgeon | €63,000 | €66,486 | n/a | n/a | n/a |
| **Total** | **€9,002,700** | **€9,500,957** | **€222,565** | **€159,801** | **€62,766** |

### 4.3.2 Management to prevent damage to aquaculture from hull fouling

Surfaces immersed in the aquatic environment become bio-fouled when unwanted aquatic organisms such as barnacles, tubeworms and seaweed settle and grow on them. Uncontrolled bio-fouling leads to significantly increased maintenance costs and production losses (low growth/poorer quality of stock). It is well established that bio-fouling on ships increases the surface roughness of the hull which, in turn, causes increased frictional resistance and fuel consumption and decreased top speed and range. In order to control the problem of fouling, antifouling coatings are used. Most of these coatings incorporate biocides that are toxic to marine organisms and may impact non-target species (Schultz, 2010).

Within hours of a clean hull being submerged in the sea, bacteria begin to accumulate on it, whether or not it is coated with anti-foulants or silicone or other foul-release coatings or anything else. In its early stages, this slime is hardly visible, yet even a light slime has been shown to increase fuel consumption by 8% or more and a heavy slime can result in fuel consumption increases of 18% or more[14].

Three hundred and forty-six vessels with an average length of 12.08m are recorded in the December 2012 UK Vessels list of the Marine Management Organisation (MMO) databases[15]. 2,217 vessels with an average length of 9.58m are recorded in the Sea Fishing Fleet Register of the Department of Agriculture Food and the Marine database (accessed 08/01/2012). Williams reported the cost of hull cleaning through pressure washing is estimated at £25m$^{-1}$ vessel length (based on pricing information provided by Milford Haven Ship Repairers). Treatment with anti-fouling paint costs approximately five times as much, and is therefore estimated at £125m$^{-1}$. The advice for boat owners is to clean the hull once a year, but treatment with antifouling paint is required less frequently, generally once every five years. Based on these assumptions and the size of the fishing fleets in Ireland and Northern Ireland, the cost of removing fouling is estimated at €669,024 (£530,971) in Ireland and £104,492 (€131,660) in Northern Ireland. The annual cost of treating 20% of both fleets in one year is estimated at €669,024 (£530,971) in Ireland and £104,492 (€131,660) in Northern Ireland. The total cost for treating hull fouling in both Ireland and Northern Ireland is £1,270,927 (€1,601,368.02). Williams assumed that 25% of these costs are attributable to preventing damage from non-native and invasive species. There are no datasets for Ireland or Northern Ireland to alter this assumption and therefore it is accepted for the purposes of this study. Table 16 summarises the total cost of management to prevent damage to aquaculture from hull fouling in both jurisdictions.

**Table 22:** Estimated cost of controlling invasive and non-native species fouling aquaculture.

| | **Estimate in GB £** | **Estimate in €** |
|---|---|---|
| Ireland | £265,485 | €334,512 |
| Northern Ireland | £52,246 | €65,829 |
| **Total** | **£317,731** | **€400,342** |

### 4.3.3 Damage to aquaculture from fouling on farmed fish and shellfish

Current estimates based on figures from the industry and the FAO suggest that the management of fouling on fish cages and shellfish costs the European aquaculture industry between 5% and 10% of the industry value (up to €260 million/year). For example, the cost of changing nets on medium-sized salmon farms is €60,000/year. Fouling reduces product value; currently tubeworm fouling of mussels downgrades them from Class A (€1,300 per tonne) to Class B (€570 per tonne). At a local level, periodic heavy fouling can be catastrophic, reducing the saleable product by 60-90%[16]. While fouling may be an issue for certain aquaculture activities, it must be recognised that not all fouling will be of non-native and invasive species, which is the primary focus of this study

[14] http://www.shiphullperformance.org/upload/previewpapers/pdfs/Hydrex_White_Paper_2-Intro.pdf
[15] http://www.marinemanagement.org.uk/fisheries/statistics/vessel_archive.htm
[16] http://www.crabproject.com/

Williams (2010) reported that fouling can cause additional costs and it is estimated that the European shellfish industry experiences a loss of 5-10% (FAO) due to the cost of labour to clean fouled produce. The time and cost spent in cleaning shellfish can be 20% of the market price (GISP 2008). Therefore, based on the market value of the shellfish industry in Ireland in 2007 (€47,291,000) and Northern Ireland (£6,290,000), the annual cost of removing all fouling from shellfish in Ireland is €9,458,200 and £1,258,000 in Northern Ireland. Williams (2010) assumed that non-native species make up a maximum of 20% of fouling species. However, there is no data on the speciation of fouling communities of shellfish in Ireland and Northern Ireland. Following the approach of Williams, the estimated cost of non-native fouling on the aquaculture sector in Ireland is €1,891,640 (£1,475,479) and in Northern Ireland is £251,600 (€317,016).

### 4.3.4 Summary of ground-truthed costs for aquaculture

**Table 23:** Summary of estimated costs of invasive and non-native species on the aquaculture sector £.

| Annual costs to marine aquaculture and fisheries | Ireland | Northern Ireland | Ireland and Northern Ireland combined |
|---|---|---|---|
| Hull fouling | £265,485 | £52,246 | £317,731 |
| Fouling (shellfish) | £1,475,479 | £251,600 | £1,727,079 |
| **Total** | **£1,740,964** | **£303,846** | **£2,044,810** |

**Table 24:** Summary of estimated costs of invasive and non-native species on the aquaculture sector €.

| Annual costs to marine aquaculture and fisheries | Ireland | Northern Ireland | Ireland and Northern Ireland combined |
|---|---|---|---|
| Hull fouling | €334,511 | €65,830 | €400,341 |
| Fouling (shellfish) | €1,859,104 | €317,016 | €2,176,120 |
| **Total** | **€2,193,615** | **€382,846** | **€2,576,461** |

## 4.4 Tourism and recreation

Tourism is an important driver of economic activity for both Ireland and Northern Ireland. It directly and indirectly supports employment across both regions for a range of skill levels, often in areas where the scope to develop other export-focused sectors is constrained.

The tourism and hospitality industry in Ireland employs approximately 180,000 people and generates an estimated €5 billion a year in revenue from home and abroad, which is equivalent to over 3% of GDP or almost 4% of GNP [at constant (2009) prices].

### 4.4.1 Projected costs of invasive species on tourism and recreation

In GB, as Table 18 indicates, the main tourism and recreational costs associated with invasive species relate to recreation boating, the maintenance of boats and waterway management costs. Other significant costs are met by golf clubs, inland angling, shooting, and efforts to eradicate

Japanese knotweed from riparian habitats. The actual Irish outlays in these sectors of activity will clearly be influenced by differences in the availability of certain types of recreational pursuit, such as managed waterways.

**Table 25:** Projected annual costs of invasive species to tourism and recreation in Ireland and Northern Ireland based on estimates for GB (£). Source: Table 9.6. Williams et al, 2010.

| | **Great Britain** | **Great Britain corrected for inflation at 2.73% per annum** | **Projected Ireland and Northern Ireland combined** | **Projected Ireland** | **Projected Northern Ireland** |
|---|---|---|---|---|---|
| Coastal tourism | £15,000 | £15,830 | £1,672 | £1,200 | £471 |
| Golf | £8,411,000 | £8,876,509 | £937,359 | £673,017 | £264,342 |
| Angling (inland) | £4,894,000 | £5,164,860 | £545,409 | £391,600 | £153,810 |
| Recreational boating | £30,451,000 | £32,136,319 | £3,393,595 | £2,436,576 | £957,020 |
| Waterway management costs | £21,860,000 | £23,069,848 | £2,436,176 | £1,749,156 | £687,020 |
| Giant hogweed | £965,000 | £1,018,408 | £107,544 | £77,216 | £30,328 |
| Japanese knotweed | £5,637,000 | £5,948,981 | £628,212 | £451,052 | £177,161 |
| Hull fouling of recreational boats | £21,368,000 | £22,550,618 | £2,381,345 | £1,709,788 | £671,557 |
| Shooting | £4,137,000 | £4,365,963 | £461,046 | £331,027 | £130,018 |
| **Total** | **£97,738,000** | **£103,147,338** | **£10,892,359** | **£7,820,631** | **£3,071,728** |

**Table 26:** Projected annual costs of invasive species to tourism and recreation in Ireland and Northern Ireland based on estimates for GB (€). Source: Table 9.6. Williams et al, 2010.

| | **Great Britain** | **Great Britain corrected for inflation at 2.73% per annum** | **Projected Ireland and Northern Ireland combined** | **Projected Ireland** | **Projected Northern Ireland** |
|---|---|---|---|---|---|
| Coastal tourism | €18,900 | €19,946 | €2,107 | €1,512 | €593 |
| Golf | €10,597,860 | €11,184,401 | €1,181,072 | €848,001 | €333,071 |
| Angling (inland) | €6,166,440 | €6,507,724 | €687,215 | €493,416 | €193,801 |
| Recreational boating | €38,368,260 | €40,491,762 | €4,275,930 | €3,070,086 | €1,205,845 |
| Waterway management costs | €27,543,600 | €29,068,008 | €3,069,582 | €2,203,937 | €865,645 |
| Giant hogweed | €1,215,900 | €1,283,194 | €135,505 | €97,292 | €38,213 |
| Japanese knotweed | €7,102,620 | €7,495,716 | €791,547 | €568,326 | €223,223 |
| Hull fouling of recreational boats | €26,923,680 | €28,413,779 | €3,000,495 | €2,154,333 | €846,162 |
| Shooting | €5,212,620 | €5,501,113 | €580,918 | €417,094 | €163,823 |
| **Total** | **€123,149,880** | **€129,965,646** | **€13,724,372** | **€9,853,995** | **€3,870,377** |

### 4.4.2 Damage to coastal tourism

No species have been identified that are reported to have a significant impact on coastal tourism in Ireland and Northern Ireland. *Sargassum muticum* is reported to be able to impede boat traffic and swimmers (Guiry, 2012) but there are no records of this occurring in Ireland or Northern Ireland in the public domain. *Didemnum vexillum* would be expected to have the potential to increase costs associated with removing fouling organisms but this species is highly localised in Ireland and Northern Ireland and therefore no cost estimates are available.

### 4.4.3 Management to prevent damage to golf courses

In Europe one out of every 150 citizens is a golfer. GB and Ireland comprise by far the largest golf market in Europe, with approximately 3,000 regular courses and around 1.5 million affiliated players. In GB and Ireland alone, golf accounts for about 14% of all the sporting facilities, and golf courses contribute about 13% to this region's total GDP from sport[17].

The only non-native species with population levels that could impact on the golfing sector in Ireland and Northern Ireland is the rabbit. The population of non-native geese is not known to be at high enough levels to impact on golf courses. Williams (2010) estimated that each golf club in GB spends £2,000 a year on rabbit control. Other expenditure is on species not present or at low numbers in Ireland and Northern Ireland and therefore not considered in this study. The A-Z of golf courses listed on www.irishgolfcourses.co.uk lists 84 golf courses in Northern Ireland and a further 357 in Ireland. Following the assumptions made by Williams that rabbit control costs each golf course £2,000 a year, then the cost of non-native species to golf in Ireland is €899,640 (£714,000) and £168,000 (€211,680) in Northern Ireland, giving a total cost of £882,000 (€1,111,320).

### 4.4.4 Management to prevent damage to inland waterways

The key invasive plants in Ireland and Northern Ireland are the invasive aquatic plants: curly leaved waterweed, and Canadian and Nuttall's pondweed (*Elodea canadensis* and *E. nuttallii*). Other invasive aquatic plants have a more restricted distribution: parrot's feather (*Myriophyllum aquaticum*), fringed water lily (*Nymphoides peltata*) and floating pennywort (*Hydrocotyle ranunculoides*). The key riparian invasive plant species that can impact on angling by obstructing access or by altering ecosystems are Japanese knotweed (*Fallopia japonica*), giant hogweed (*Heracleum mantegazzianum*) and Himalayan balsam (*Impatiens glandulifera*).

The baseline data on species distribution and density in the Irish environment are not available to allow us to make estimates with a sufficient degree of confidence at this time. We have therefore accepted the projected costs from the GB study. The results of this are given in Table 19 below, although they are likely to represent an underestimate of the true economic impact. In support of this assertion, we point to the experience of Waterways Ireland and Inland Fisheries Ireland when attempting to eliminate *Crassula helmsii* from approximately 2.2km of the Grand Canal during winter/spring 2011-12. This work cost approximately €230,000 using a variety of control measures. Waterways Ireland have also been involved in a programme to control invasive weed growth in Upper Lough Erne for several years. In 2010 *Elodea nuttalii* was removed from the navigation channel in Upper Lough Erne at a cost of approximately £91,000.

[17] http://www.egcoa.eu/bestanden/pics/The%20Economic%20Value%20of%20Golf%20to%20Europe_28082009%20(2).pdf

**Table 27:** Estimated economic impact of invasive species on inland waterways £.

| | Ireland and Northern Ireland combined | Ireland | Northern Ireland |
|---|---|---|---|
| Angling (inland) | £545,409 | £391,600 | £153,810 |
| Giant hogweed | £107,544 | £77,216 | £30,328 |
| Japanese knotweed | £628,212 | £451,052 | £177,161 |
| **Total** | **£1,281,165** | **£919,868** | **£361,299** |

**Table 28:** Estimated economic impact of invasive species on inland waterways €.

| | Ireland and Northern Ireland combined | Ireland | Northern Ireland |
|---|---|---|---|
| Angling (inland) | €687,215 | €493,416 | €193,800 |
| Giant hogweed | €135,505 | €97,292 | €38,213 |
| Japanese knotweed | €791,547 | €568,325 | €223,222 |
| **Total** | **€1,614,268** | **€1,159,033** | **€455,236** |

### 4.4.5 Damage to recreational boating

Insufficient data available.

### 4.4.6 Damage to shooting

Gamekeepers (usually on estates) manage areas for shooting, called beats. They make sure that there is enough game in their beats for shooting. Game includes deer, and birds such as grouse, partridge and pheasant (Lantra, 2012). Due to the lack of data available on pest control effort exerted in Ireland, we are unable to estimate the costs associated with controlling mink for game purposes. We are also unable to accept the projected costs from Table 18, as our understanding of the industry suggests it operates differently in Ireland compared to GB and it is therefore not comparable.

During our development of the mink case study, we were able to estimate the impact associated with mink taking pheasants. The relevant text is duplicated here: 'A total of 40% of gun clubs surveyed in the island of Ireland reported economic losses associated with mink (Hawkins, 2010). This equates to 370 of the 926 gun clubs in Ireland (www.nargc.ie) suffering economic losses. The mean number of pheasant poults or birds lost to mink each year is estimated at an average of 28 per year per club. A pheasant poult costs approximately €4.20 to purchase at 6/7 weeks old (Robert Crofts, pers. comm.). Therefore, if each club loses an average of 28 birds per year at a cost of €4.20 each, that would equate to 10,360 birds lost a year at a cost of €43,512.

### 4.4.7 Summary of ground-truthed costs for tourism and recreation

**Table 29:** Estimated impact of invasive and non-native species on tourism and recreation £.

| | **Ireland** | **Northern Ireland** | **Ireland and Northern Ireland combined** |
|---|---|---|---|
| Coastal tourism | No estimate made | No estimate made | No estimate made |
| Golf | £714,000 | £168,000 | £882,000 |
| Angling (inland) | £391,600 | £153,810 | £545,409 |
| Recreational boating | Insufficient data | Insufficient data | Insufficient data |
| Waterway management costs | Insufficient data | Insufficient data | Insufficient data |
| Giant hogweed | £77,216 | £30,328 | £107,544 |
| Japanese knotweed | £451,052 | £177,161 | £628,212 |
| Hull fouling of recreational boats | Insufficient data | Insufficient data | Insufficient data |
| Shooting | Insufficient data | £97,383 | Not calculated |
| **Total** | **£1,633,868.00** | **£626,682.00** | **£2,163,165.00** |

**Table 30:** Estimated impact of invasive and non-native species on tourism and recreation €.

| | **Ireland** | **Northern Ireland** | **Ireland and Northern Ireland combined** |
|---|---|---|---|
| Coastal tourism | No estimate made | No estimate made | No estimate made |
| Golf | €899,640 | €211,680 | €1,111,320 |
| Angling (inland) | €493,416 | €193,801 | €687,215 |
| Recreational boating | Insufficient data | Insufficient data | Insufficient data |
| Waterway management costs | Insufficient data | Insufficient data | Insufficient data |
| Giant hogweed | €97,292 | €38,213 | €135,505 |
| Japanese knotweed | €568,326 | €223,223 | €791,547 |
| Hull fouling of recreational boats | Insufficient data | Insufficient data | Insufficient data |
| Shooting | Insufficient data | €122,703 | Not calculated |
| **Total** | **€2,058,674** | **€789,619** | **€2,725,588** |

## 4.5 Construction, development and infrastructure

The construction industry in both Ireland and Northern Ireland is an important sector, offering employment and making significant contributions to both economies. In Ireland, the construction industry peaked at close to €39 billion or almost 25% of GNP in 2006 but this was followed by a loss of output to €8.7 billion in 2011, or 7% of GNP. In 2012, the output of the construction industry was predicted to decline again to an estimated €7.5 billion. While the construction industry in Ireland is undergoing a protraction, it still represents a significant percentage of GNP at 6% (see http://www.scsi.ie/constr2012 for details of the sector). Northern Ireland has strong links with Ireland, and this accounted for almost a quarter of construction output at the peak of the economic boom in 2007 (HM Treasury, 2011)[18].

[18] http://www.hm-treasury.gov.uk/d/rebalancing_the_northern_ireland_economy_consultation.pdf

### 4.5.1 Projected costs of invasive species on construction, development and infrastructure

We have reproduced the main costs associated with invasive species for the construction, development and infrastructure sectors from GB and projected equivalent costs for Ireland (Table 21).

**Table 31:** Projected annual costs of invasive species to Irish construction, development and infrastructure based on estimates for GB (£). Source: Table 10.2. Williams et al, 2010.

| | **Great Britain** | **Great Britain corrected for inflation at 2.73% per annum** | **Projected Ireland and Northern Ireland combined** | **Projected Ireland** | **Projected Northern Ireland** |
|---|---|---|---|---|---|
| Japanese knotweed - construction | £150,510,000 | £158,840,020 | £16,773,506 | £12,043,250 | £4,730,256 |
| Japanese knotweed – housing devaluation | £1,116,000 | £1,177,765 | £124,372 | £89,298 | £35,074 |
| Japanese knotweed - households | £448,000 | £472,795 | £49,927 | £35,847 | £14,080 |
| Japanese knotweed – local authority management | £432,000 | £455,909 | £48,144 | £34,567 | £13,577 |
| Other plants - construction | £1,397,000 | £1,474,317 | £155,688 | £111,783 | £43,905 |
| Brown rat - control | £31,550,000 | £33,296,144 | £3,516,073 | £2,524,514 | £991,559 |
| Brown rat – surface control | £371,000 | £391,533 | £41,346 | £29,686 | £11,660 |
| House mouse-control | £17,876,000 | £18,865,352 | £1,992,181 | £1,430,371 | £561,810 |
| Edible dormouse | £114,000 | £120,309 | n/a – species absent | n/a – species absent | n/a – species absent |
| Grey squirrel - damage | £5,128,000 | £5,411,811 | £571,487 | £410,323 | £161,164 |
| Grey squirrel - control | £1,915,000 | £2,020,986 | £213,416 | £153,231 | £60,185 |
| Parakeets | £10,000 | £10,553 | n/a – species absent | n/a – species absent | n/a – species absent |
| River/ Canal bank/lock infrastructure repairs | £350,000 | £369,371 | n/a – species discussed in GB report is absent | n/a – species discussed in GB report is absent | n/a – species discussed in GB report is absent |
| Buddleia - disrepair control | £349,000 | £368,316 | £38,894 | £27,926 | £10,968 |
| Buddleia- listed buildings | £612,000 | £645,871 | £68,204 | £48,970 | £19,234 |
| Termites | £190,000 | £200,516 | n/a – no data found to suggest relevant to current study | n/a – no data found to suggest relevant to current study | n/a – no data found to suggest relevant to current study |
| **Total** | **£212,368,000** | **£224,121,569** | **£23,593,238** | **£16,939,766** | **£6,653,472** |

**Table 32:** Projected annual costs of invasive species to Irish construction, development and infrastructure based on estimates for GB (€). Source: Table 10.2. Williams et al, 2010.

| | **Great Britain** | **Great Britain corrected for inflation at 2.73% per annum** | **Projected Ireland and Northern Ireland combined** | **Projected Ireland** | **Projected Northern Ireland** |
|---|---|---|---|---|---|
| Japanese knotweed - construction | €189,642,600 | €200,138,425 | €21,134,618 | €15,174,495 | €5,960,123 |
| Japanese knotweed – housing devaluation | €1,406,160 | €1,483,984 | €156,709 | €112,515 | €44,193 |
| Japanese knotweed - households | €564,480 | €595,722 | €62,908 | €45,167 | €17,741 |
| Japanese knotweed – local authority management | €544,320 | €574,445 | €60,661 | €43,554 | €17,107 |
| Other plants - construction | €1,760,220 | €1,857,639 | €196,167 | €140,847 | €55,320 |
| Brown rat - control | €39,753,000 | €41,953,141 | €4,430,252 | €3,180,888 | €1,249,364 |
| Brown rat – surface control | €467,460 | €493,332 | €52,096 | €37,404 | €14,692 |
| House mouse-control | €22,523,760 | €23,770,344 | €2,510,148 | €1,802,267 | €707,881 |
| Edible dormouse | €143,640 | €151,589 | n/a – species absent | n/a – species absent | n/a – species absent |
| Grey squirrel - damage | €6,461,280 | €6,818,882 | €720,074 | €517,007 | €203,067 |
| Grey squirrel - control | €2,412,900 | €2,546,442 | €268,904 | €193,071 | €75,833 |
| Parakeets | €12,600 | €13,297 | n/a – species absent | n/a – species absent | n/a – species absent |
| River/ Canal bank/lock infrastructure repairs | €441,000 | €465,407 | n/a | n/a | n/a |
| Buddleia - disrepair control | €439,740 | €464,078 | €49,006 | €35,187 | €13,820 |
| Buddleia- listed buildings | €771,120 | €813,797 | €85,937 | €61,702 | €24,235 |
| Termites | €239,400 | €252,650 | n/a | n/a | n/a |
| **Total** | **€267,583,680** | **€282,393,177** | **€29,727,480** | **€21,344,105** | **€8,383,375** |

### 4.5.2 Damage and treatment costs of Japanese knotweed and other plants

The damage and treatment costs relating to Japanese knotweed form by far the largest proportion of economic costs to this sector in GB. To date, there have been limited formal reports of invasive species impacting on the construction sector in Ireland and Northern Ireland. However, in recent years, there have been a number of developments in environmental legislation and policy that will require the construction industry and developers to pay more attention to invasive species such as Japanese knotweed and giant hogweed. As the new pieces of legislation bed in, we are expecting that the economic impact will become more apparent. We are also aware that there are a number of live cases that have to consider Japanese knotweed and/or giant hogweed but we cannot report on them at this time (John Early, pers. comm.). As such, the projections for Japanese knotweed and other plants impacting on this sector cannot be accepted. However, we contend that they should be used as a guide to the economic impacts that may be realised as new legislation achieves greater compliance.

There are a growing number of reports of mortgage providers refusing to offer mortgages in Northern Ireland. The members of the Council of Mortgage Lenders (CML) and the Building Societies Association (BSA) account for the majority of UK residential mortgage lending. Both represent the views of their members but neither can impose policies. When the Japanese knotweed problem became apparent, the CML consulted its members. It did not publish a formal policy, but it was clear that there was a general reluctance to lend on knotweed-affected properties. However, some individual lenders are willing to consider applications on a case-by-case basis once remediation works have been implemented (RICS, 2011). Through direct communication with the public, the authors have been made aware of at least five cases in the last three years where applicants have faced unexpected difficulties due to Japanese knotweed in Northern Ireland. The outcome of the individual cases is unknown (J. Kelly, unpublished data). We are not aware of any similar cases in Ireland.

### 4.5.3 Damage from grey squirrels

Williams (2010) has described and estimated the impact grey squirrels have to lofts of dwellings. However we are not aware of a similar problem associated with grey squirrels in Ireland and Northern Ireland. No reports have been identified and no members of the public have contacted Invasive Species Ireland seeking advice on this subject. We are therefore unable to provide an estimate of damage done by grey squirrels and suggest that the level is currently low or non-existent at present.

### 4.5.4 Control of damage from rats and mice

The impact of rats on the construction sector has been examined in the relevant case study. For ease of reference, these estimates are reproduced in the summary section.

Assuming 1.83% of households have mice infestations (Langton et al., 2001) then 12,603 homes in NI and 26,892 homes in Ireland have mice. If 25% of homeowners don’t treat for mice and 10% carry out control themselves, then 65% potentially use pest controllers to treat mouse infestations (Richards, 1989). This equates to 25,670 homes across Ireland (8,191 in NI and 17,479 in Ireland) that potentially use pest controllers. Assuming treatment costs for mice are the same as for rats (£192) then total annual spend is potentially €4,928,832 per annum (£3,355,968 in Ireland and £1,572,672 in Northern Ireland).

### 4.5.5 Damage from buddleia

The impact of Buddleia (*Buddleia davidii*) in Ireland and Northern Ireland is undocumented and unreported. Casual observations by the authors note that Buddleia can and does grow out of buildings and walls, causing damage to the structure of the building or asset in question. This is consistent with the experience in GB as reported by Booy (2008) and Williams (2010). This plant therefore has an economic impact but, in the absence of suitable datasets on which to base assumptions on for Ireland and Northern Ireland, we are unable to put a cost estimate on this impact. We therefore accept the projected costs for this species for the purpose of this study but they are likely to represent a conservative estimate.

### 4.5.6 Summary of ground-truthed costs for construction, development and infrastructure

**Table 33:** Estimated economic impact of invasive species for construction, development and infrastructure.

| | **Ireland** | **Northern Ireland** | **Ireland and Northern Ireland combined** |
|---|---|---|---|
| Japanese knotweed – construction | Insufficient data | Insufficient data | Insufficient data |
| Japanese knotweed – housing devaluation | Insufficient data | Insufficient data | Insufficient data |
| Japanese knotweed – households | Insufficient data | Insufficient data | Insufficient data |
| Japanese knotweed – local authority management | Insufficient data | Insufficient data | Insufficient data |
| Other plants - construction | Insufficient data | Insufficient data | Insufficient data |
| Brown rat – control | £3,356,160 | £1,602,816 | £4,958,976 |
| House mouse-control | £3,355,968 | £1,572,672 | £4,928,640 |
| Grey squirrel – damage | None identified | None identified | None identified |
| Grey squirrel – control | None identified | None identified | None identified |
| Buddleia - disrepair | £27,926 | £10,968 | £38,894 |
| Buddleia- listed buildings | £48,970 | £19,234 | £68,204 |
| **Total** | **£6,789,024.00** | **£3,205,690.00** | **£9,994,714.00** |

**Table 34:** Estimated economic impact of invasive species for construction, development and infrastructure.

| | **Ireland** | **Northern Ireland** | **Ireland and Northern Ireland combined** |
|---|---|---|---|
| Japanese knotweed – construction | Insufficient data | Insufficient data | Insufficient data |
| Japanese knotweed – housing devaluation | Insufficient data | Insufficient data | Insufficient data |
| Japanese knotweed – households | Insufficient data | Insufficient data | Insufficient data |
| Japanese knotweed – local authority management | Insufficient data | Insufficient data | Insufficient data |

| | | | |
|---|---|---|---|
| Other plants - construction | Insufficient data | Insufficient data | Insufficient data |
| Brown rat – control | €4,228,762 | €2,019,548 | €6,248,310 |
| House mouse-control | €4,228,520 | €1,981,567 | €6,210,086 |
| Grey squirrel – damage | None identified | None identified | None identified |
| Grey squirrel – control | None identified | None identified | None identified |
| Buddleia - disrepair | €35,187 | €13,820 | €49,006 |
| Buddleia- listed buildings | €61,702 | €24,235 | €85,937 |
| **Total** | **€8,554,170** | **€4,039,169** | **€12,593,340** |

## 4.6 Transport

Japanese knotweed accounts for most of the spending on roads in GB, with some outlays associated with attempts to reduce the risk of collisions with deer. A range of non-native plants and trees require annual management along railway tracks. Efforts to minimise bird strikes at airports absorb most of the outlays identified as attributable to invasive species for aviation. Ballast water management is the prime cost associated with invasive species for shipping, with added expenses incurred in hull cleaning.

### 4.6.1 Projected costs of invasive species on transport

We have reproduced the main costs associated with invasive species for the transport sector from GB and projected equivalent costs for Ireland (Table 23).

**Table 35:** Projected annual costs of invasive species to Irish transport based on estimates for GB (£) Source: Table 11.6. Williams et al, 2010.

| | **Great Britain** | **Great Britain corrected for inflation at 2.73% per annum** | **Projected Ireland and Northern Ireland combined** | **Projected Ireland** | **Projected Northern Ireland** |
|---|---|---|---|---|---|
| Roads | £17,133,000 | £18,081,231 | £1,909,378 | £1,370,919 | £538,459 |
| Railway | £30,460,000 | £32,145,818 | £3,394,598 | £2,437,296 | £957,302 |
| Aviation | £940,000 | £992,025 | £104,758 | £75,215 | £29,542 |
| Shipping | £32,750,000 | £34,562,558 | £3,649,806 | £2,620,533 | £1,029,273 |
| **Total** | **£81,283,000** | **£85,781,631** | **£9,058,540** | **£6,503,963** | **£2,554,577** |

**Table 36:** Projected annual costs of invasive species to Irish transport based on estimates for GB (€) Source: Table 11.6. Williams et al, 2010.

| | Great Britain | Great Britain corrected for inflation at 2.73% per annum | Projected Ireland and Northern Ireland combined | Projected Ireland | Projected Northern Ireland |
|---|---|---|---|---|---|
| Roads | €21,587,580 | €22,782,351 | €2,405,816 | €1,727,358 | €678,458 |
| Railway | €38,379,600 | €40,503,731 | €4,277,193 | €3,070,993 | €1,206,201 |
| Aviation | €1,184,400 | €1,249,952 | €131,995 | €94,771 | €37,223 |
| Shipping | €41,265,000 | €43,548,823 | €4,598,756 | €3,301,872 | €1,296,884 |
| **Total** | **€102,416,580** | **€108,084,855** | **€11,413,760** | **€8,194,993** | **€3,218,767** |

### 4.6.2 Damage to the road and railway network

No data identified in time for study.

### 4.6.3 Damage to aviation

No economic impacts from invasive species in the aviation industry were identified. According to the website of the Air Accident Investigation Unit of Ireland (www.aiu.ie) there have been four reported bird strikes since 1998. However, in the two cases where the species were known (lapwing, pigeon), none involved invasive geese. Additionally, the website of the Air Accidents Investigation Branch from the United Kingdom does not list any bird strikes as having occurred in Northern Ireland (www.aaib.gov.uk).

### 4.6.4 The cost of deer vehicle collisions

According to Langbein (2011), the average number of recorded Deer Vehicle Collisions (DVCs) each year in GB is approximately 7,300. Langbein (2011) assumes that the number of DVCs is underestimated and those recorded are approximately 30% of all likely DVCs. This is based on Department of Transport statistics that indicate that only 26% to 32% of injury road accidents are logged by the police (Anon, 2011a). Applying this to DVCs there are approximately 24,333 DVCs in GB each year. DVCs are not distributed evenly as they reflect deer densities and the amount of road traffic (Langbein, 2011).

The current distribution and density of the three species of deer (red, fallow and sika) with known breeding populations in Ireland is poorly understood. Therefore, we cannot assess how deer density affects the risk of DVCs occurring. However, we do know the average distance travelled by car each year by people resident in Ireland and Northern Ireland. Therefore, we have compared the number of DVCs in GB per mile travelled by car to that for Ireland and Northern Ireland to derive estimates for the number of DVCs in Ireland and Northern Ireland.

The current population of GB is 60,852,000 (World Bank, 2011) and the average distance travelled per person by car each year is 5,246 miles (Anon, 2010). Therefore, there is approximately 1 DVC for every 13 million miles travelled in GB. The combined population of

Ireland (4,487,000, World Bank, 2011) and Northern Ireland (1,789,000 World Bank, 2011) is 6,256,000. The average distance travelled per person by car each year is 5,242 miles and 4,840 miles in Ireland and Northern Ireland respectively (Anon, 2011b; 2012). Applying the same methods as above, there are approximately 7,560 DVCs in Ireland and Northern Ireland each year, which is equivalent to 1 DVC per 4.2 million miles travelled by car.

To assess the cost associated with DVCs we have used the data from GB as the basis of our assessment for Ireland and Northern Ireland. Approximately 1,280 DVCs in England (where 80% of DVCs occurred) resulted in Personal Injury Accidents (PIA) (Langbein, 2011). Therefore, 497 PIA's would occur on average in Ireland and Northern Ireland combined if 7,566 DVCs occurred. Applying the average value for preventing a road accident from GB (£68,320), the cost of PIA to the economies of Ireland and Northern Ireland is £33,989,708 each year (Anon, 2011c). The additional 7,069 DVCs in Ireland and Northern Ireland can be classed as road accidents, which cost on average £1,880 each (Anon, 2011c). Therefore, the additional cost of accidents that do not result in injury is £13,289,720 each year. The total cost arising from DVCs, per annum, to the economies of Ireland and Northern Ireland is £47,279,428. These estimates are accepted for the current study but the authors recognise that there is a need for a more robust estimate of the number of DVC's in Ireland and Northern Ireland. Additionally, the authors note that there have been no serious or fatal DVCs recorded by the police in Northern Ireland in the five years prior to and including 2011 (Anon, 2011d). The estimates are divided on a per capita basis for Ireland and Northern Ireland in Table 37.

### 4.6.5 Damage to shipping

No data available during study.

### 4.6.6 Summary of ground-truthed costs for transport

**Table 37:** Economic impact of invasive and non-native species on transport sector.

| | **Ireland** | **Northern Ireland** | **Ireland and Northern Ireland combined** |
|---|---|---|---|
| Roads | Insufficient data | Insufficient data | Insufficient data |
| DVC's | £33,802,230 | £13,477,198 | £47,279,428 |
| Railway | Insufficient data | Insufficient data | Insufficient data |
| Aviation | No impact identified | No impact identified | No impact identified |
| Shipping | Insufficient data | Insufficient data | Insufficient data |
| **Total** | £33,802,230 | £13,477,198 | £47,279,428 |

**Table 38:** Economic impact of invasive and non-native species on transport sector.

| | **Ireland** | **Northern Ireland** | **Ireland and Northern Ireland combined** |
|---|---|---|---|
| Roads | Insufficient data | Insufficient data | Insufficient data |
| DVC's | €42,590,809 | €16,981,270 | €59,572,079 |
| Railway | Insufficient data | Insufficient data | Insufficient data |
| Aviation | No impact identified | No impact identified | No impact identified |
| Shipping | Insufficient data | Insufficient data | Insufficient data |
| **Total** | **€42,590,809** | **€16,981,270** | **€59,572,079** |

## 4.7 Utilities

The utility sector facilitates modern living and is vital to the functioning of society and the economy. Invasive species can impact on the utility sector by, for example, blocking water supplies, impacting on flood protection, and blocking intake and outflow pipes from electricity power plants. In some cases, these impacts can increase maintenance costs, which can be passed on to the end user by the provider of the utility.

### 4.7.1 Projected costs of invasive species on utilities

**Table 39:** Projected annual costs of invasive species to utilities in Ireland and Northern Ireland based on estimates for GB (£) Source: Table 12.1. Williams et al, 2010.

| Utility costs associated with invasive species | Great Britain | Great Britain corrected for inflation at 2.73% per annum | Projected Ireland and Northern Ireland combined | Projected Ireland | Projected Northern Ireland |
|---|---|---|---|---|---|
| Water companies | £4,687,000 | £4,946,403 | £522,340 | £375,036 | £147,304 |
| Power stations | £5,230,000 | £5,519,456 | £582,855 | £418,485 | £164,369 |
| Railway power lines | £200,000 | £211,069 | £22,289 | £16,003 | £6,286 |
| **Total** | £10,117,000 | £10,676,928 | £1,127,484 | £809,525 | £317,959 |

**Table 40:** Projected annual costs of invasive species to utilities in Ireland and Northern Ireland based on estimates for GB (€) Source: Table 12.1. Williams et al, 2010.

| Utility costs associated with invasive species | Great Britain | Great Britain corrected for inflation at 2.73% per annum | Projected Ireland and Northern Ireland combined | Projected Ireland | Projected Northern Ireland |
|---|---|---|---|---|---|
| Water companies | €5,905,620 | €6,232,468 | €658,148 | €472,545 | €185,603 |
| Power stations | €6,589,800 | €6,954,515 | €734,397 | €527,291 | €207,105 |
| Railway power lines | €252,000 | €265,947 | €28,084 | €20,164 | €7,920 |
| **Total** | **€12,747,420** | **€13,452,929** | **€1,420,630** | **€1,020,002** | **€400,628** |

### 4.7.2 Management to prevent damage to the water industry

Across Ireland, 34 Local Authorities are responsible for the management and strategic planning of water and sewerage services. The water industry in Ireland is highly fragmented with five distinct categories of water supply. One in five households is not connected to the public mains supply. Presently there are over 5,500 group water schemes in existence serving 10% of the population (Brady 2010). In Northern Ireland, water and sewerage services are run by Water NI, a Government Owned Company (GoCo) (a statutory trading body owned by central government but operating under company legislation, with substantial independence from government).

The primary invasive species affecting water supply is the zebra mussel. Treatment for zebra mussels is the main expenditure on invasive species for water utilities in GB and the annual cost of zebra mussels to the industry in North America is estimated to be *circa* $5 billion (Williams, 2010). In Northern Ireland, Maguire (2004) reported that a water abstraction plant in Killyhelvin required an upgrade to prevent damage by zebra mussels, costing £120,000. As discussed in the zebra mussel case study, a domestic dwelling in County Galway reported that their water supply was cut off due to zebra mussels blocking the pipes and the pump. Despite these two identified case studies, the predicted impacts have largely not been documented or reported in the literature searched during this report. Therefore, there is no data available on which to base the economic impact of zebra mussels on the water industry. The assumptions made for GB cannot confidently be applied to Ireland and Northern Ireland as the evidence that water supply is severely affected is not reported here or possibly not collected.

### 4.7.3 Damage to power supplies

Invasive species can affect power supplies in a number of ways. Non-native trees are known to fall on power lines disrupting supply, rats and mice can chew through cables and damage equipment and the zebra mussel can clog the pipes in hydroelectric power stations or the outflow pipes from other power stations. It was not possible to access data on these impacts in Ireland or Northern Ireland during this study and, in the absence of data supporting the assumptions made for GB in Ireland and Northern Ireland, we have not attempted to estimate the impact of invasive species on power supplies.

### 4.7.4 Summary of ground-truthed costs for utilities

The annual economic impact of invasive species on the utility sector cannot be calculated due to the lack of data at this time. While there may be some case studies, these data cannot be transformed into an annual cost. A more in-depth study of the utility sector would be required to inform a reliable assessment.

## 4.8 Human health

As should be apparent to the reader, invasive species are not just a concern of conservation organisations. Some invasive species impact on key areas of our economies. In addition, some invasive species are known to impact on human health. Key examples are giant hogweed; rats and mice; and cockroaches. In addition to these species, which are known to be present in Ireland and Northern Ireland, there are some species that are implicated in causing hay fever, such as the common ragweed (*Ambrosia artemisiifolia*), which is described by DAISIE as ‘highly allergenic and the prime cause of hay fever. During the pollen release period, it causes rhino-conjunctivitis, asthma and, more rarely, contact dermatitis and urticaria. In colonised areas, ragweed rapidly becomes the main allergenic species’. This species is recorded in Ireland (not Northern Ireland) but is not widely distributed.

**Table 41:** Estimated impact of invasive species on human health interests in Ireland and Northern

Ireland £.

| Impact | Ireland GB £ | Northern Ireland GB £ | Ireland and Northern Ireland combined GB £ |
|---|---|---|---|
| Cockroach | £3,805,334 | £1,494,630 | £5,299,964 |
| Weil's Disease | £800 | £314 | £1,114 |
| Lyme Disease | £45,049 | £17,694 | £62,743 |
| **Total** | **£3,851,184** | **£1,512,638** | **£5,363,822** |

**Table 42:** Estimated impact of invasive species on human health interests in Ireland and Northern Ireland €.

| Impact | Ireland GB £ | Northern Ireland GB £ | Ireland and Northern Ireland combined GB £ |
|---|---|---|---|
| Cockroach | €4,794,721 | €1,883,234 | €6,677,955 |
| Weil's Disease | €1,008 | €396 | €1,404 |
| Lyme Disease | €56,762 | €22,294 | €79,056 |
| **Total** | **€4,852,492** | **€1,905,924** | **€6,758,416** |

### 4.8.1 Giant hogweed treatment costs

There is no obligatory reporting procedure for people exposed to giant hogweed in Ireland but the National Poisons Information Centre occasionally receives enquiries from both healthcare professionals and members of the public if symptoms have developed. The number of calls is quite low but it is difficult to know whether this is indicative of a low rate of exposure or because medical staff have prior knowledge of treatment options. There may also be a proportion of cases that are not reported because people are not aware that exposure to the plant has occurred, consequently the skin eruptions are treated 'symptomatically'. Between January 2004 and November 2012 the National Poisons Information Centre was contacted about 23 cases, the majority of which involved adults, with only five involving children under 12 years. Blistering and rash were the most common symptoms reported (Elaine Donohoe, National Poisons Information Centre).

We were not able to identify comparable datasets for Northern Ireland in time for this study. Despite having access to data on the number of cases in Ireland, we are not able to attribute an economic cost to these as the treatment costs are not accessible and we cannot access data on the impact to the individual affected.

### 4.8.2 Other human health impacts

The GB assessment (Williams, 2010) discusses the impact of cockroaches, food poisoning, rat transmitted diseases and Lyme's disease. At the time of reporting, we were unable to identify suitable datasets and statistics for Ireland and Northern Ireland to make a complete assessment of these impacts on their economies. A detailed study of the human health impacts would ideally be required but, for the purposes of this study, we have accepted the projections made from the GB assessment to highlight the importance of these issues (Table 26).

# 5. CASE STUDIES

## 5.1 Introduction

The literature indicates that early action programmes that succeed in preventing or eradicating new invasive species offer attractive benefit-cost ratios (see, for example, Hill & Greathead, 2000). A technical report underpinning the current European Union (EU) strategy on invasive species states that 'data obtained highlight the potentially huge costs of control across all taxonomic groups and thus confirm the case for prevention/rapid eradication compared to long-term control or containment' (Shine *et al*, 2009: 41).

This section provides a number of case studies of invasive species under the following headings:

- Early stage management; and
- Widely established species.

## 5.2 Early stage management

### 5.2.1 Chub

***Scientific name:*** *Squalius cephalus* (Linnaeus, 1758).

***Origin***

North, Baltic, northern Black, White, Barents and Caspian Sea basins, Atlantic basin southward to Adour drainage (France), GB north to 56°N, Scandinavia: southern Finland, Sweden north to about Stockholm. Mediterranean basin from Var to Hérault (possibly Aude) (France) drainages. Introduced elsewhere. Naturally absent from Italy and Adriatic basin.

Chub is a cyprinid fish that is widespread throughout central and southern Europe. It is native to England but, until 2004, had not been formally recorded in Ireland. It is a species that inhabits rivers with a moderate flow, but can also be found in lakes. It was probably intentionally introduced to Ireland by anglers. Chub feed on aquatic plants and invertebrates when young but, as they mature, they feed more selectively on larger prey items, including young fish. They could result in an imbalance among our native fish communities if they establish large populations (http://www.fisheriesireland.ie/Invasive-species-list/chub.html).

***Distribution***

The chub is a European freshwater cyprinid that has been reported as an invasive species in Italy and targeted for removal from a river system where introduced in Ireland. It is a long- lived fish and has high mobility due to its pelagic condition. Humans may also facilitate its spread due to its value as a game or bait species in recreational fishing.

***Ecological impact***

*S. cephalus* has ecological characteristics associated with invasiveness. It is omnivorous, and its food sources range from small (i.e. detritus, plants, invertebrates) to large (i.e. tadpoles, small fish) items. In addition it has high fecundity, a fast growth rate, and is considered to be tolerant of anthropogenic pressures. However, there are few reports of impacts in its introduced range and the changes in the taxonomic status of the species make it difficult to identify introduced populations.

The introduction of exotic species may cause hybridisation with native species, predation, resource competition and aggressive behaviour with native species and/or the introduction of diseases. Chub does not represent a risk to humans but it may cause changes to ecosystems (i.e. altering food web structures) and it may predate on native species.


**Figure 3:** Distribution of chub as recorded by the National Biodiversity Data Centre, 2013. www.biodiversityireland.com Date accessed: 7th January 2013.

***Direct and indirect economic costs***

There have been no economic impacts associated with this species in Ireland to date.

***Costs for control***

At the time of writing, Inland Fisheries Ireland has conducted 5 full electrofishing operations in the River Inny. The estimated costs for research staff per week to undertake this work is approximately €2,300. There exists no modelling exercise to indicate the possible distribution of Chub in available habitat in Ireland or Northern Ireland. Therefore, we compare the cost of this current operation with similar work in GB as reported by Britton *et al.* (2010) to highlight the overall value for money of IFI's work to control chub before it becomes more widespread. Current efforts to control topmouth gudgeon in GB amount to £190,000 over 4 years.

### 5.2.2 Water primrose

***Scientific name:*** *Ludwigia grandiflora* (Michaux).

***Origin***

Water primrose *Ludwigia grandiflora* is native to South America. There are no native members of the *Ludwigia* genus in Ireland or Northern Ireland. Nehring (2011) has reported that the plant was intentionally released in 1830 in southern France but remained restricted to the area from the Camargue to Aquitaine during a long period until the middle of the twentieth century. However, the spread of *L. grandiflora* has been substantial during the past four decades in France, where the species is now already present in half of the country.

***Distribution and mode of introduction***

This species has been recorded growing in artificial ponds and not in the wild.

*Ludwigia* spp. are likely to spread in Ireland if the current populations are not controlled or the species escapes from a garden pond. The modelling exercise prepared by Brunel (2009) (Figure 4), shows Ireland has large areas of suitable wetland environments.

***Ecological impact***

The dominance of *Ludwigia* spp. leads to local loss of floral biodiversity, as well as faunal biodiversity (for macro-invertebrates and fishes) (Dandelot, 2004).

An analysis of the distribution of *Ludwigia* spp. in France shows that habitats under threat by this species include at least 12 habitats of interest for the European Commission (Habitat Directive 92/43/EEC), and three types of wet habitats (aquatic vegetation of the *Nymphaeion albae,* swamp vegetation with tall helophytes, prairial vegetation and flooded forests (Dutartre *et al.,* 2007)).

**Figure 4:** Distribution of Ludwigia as recorded by the National Biodiversity Data Centre, 2013. www.biodiversityireland.com. Date accessed: 7th January 2013.

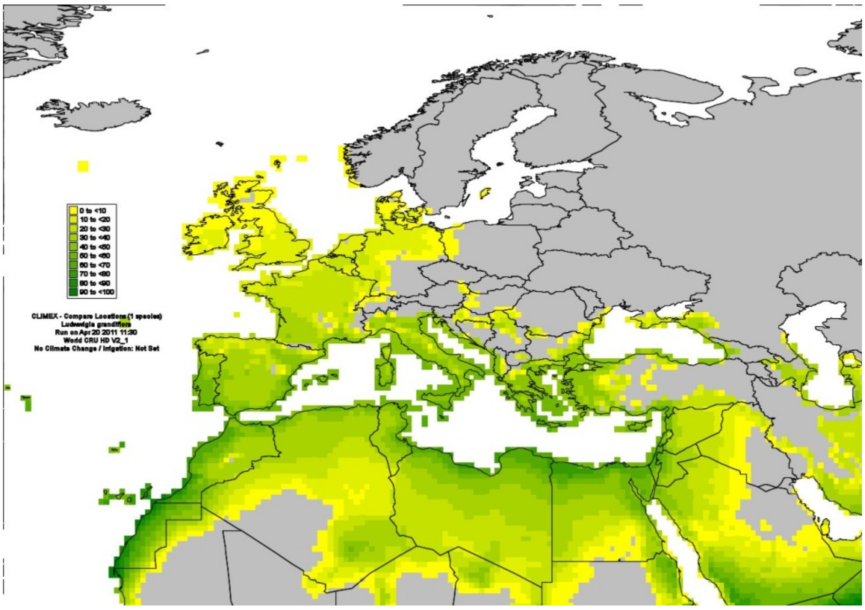


**Figure 5:** Climex map for L. grandiflora for the EPPO region (EPPO, 2012),

*Ludwigia* spp. cause significant changes of ecological processes and structures in the following ways:

- the high biomass production leads to the slowing of water flow (Dutartre, 1988) in channels, ditches and shallow rivers, causing increased sedimentation, which may lead to increased flood risk by reduction of channel carrying capacity, particularly in autumn. This may lead to modifications of flora and fauna communities, fish disappearing in dense beds, etc. In static open waters, the slow rate of litter decomposition can lead to shallowing of the water body and succession to swamp and marsh type vegetation.
- reduction in oxygen concentrations: in static waters, dense stands prevent the transfer of oxygen between water and the atmosphere, the reduction in light availability for submerged plants reduces photosynthetic oxygen production, and consumption of oxygen by *Ludwigia* spp. root respiration results in severe deoxygenation, which is harmful to aquatic fauna. Concentrations of oxygen <1mg/l have been recorded in waters where *Ludwigia* spp. are present (Dandelot *et al*., 2005a).
- decreases in pH are common due to the suppression of submerged aquatic photosynthetic processes (Dandelot *et al*., 2005b).
- change in hydrological regimes of water bodies (Dandelot, 2005b).

***Direct and indirect economic costs***

*L. grandiflora* interferes with agricultural production, ecosystem services and human use of water bodies (e.g. deterioration of dams and infrastructures, loss of recreation areas, increase in flood risk, etc.).

***Costs for control***

In the west of France, for the period 1990-2003, the cost ranges of pulling techniques, expressed in tonnes of fresh biomass (Million, 2004), were as follows for both *L. grandiflora* and *L. peploides*:

- Mechanical removal: €51 to €64 for highly invaded sites with very dense biomass.

- Manual removal: €1,100 to €1,330 for new infestations, and for removal of small isolated patches over larger areas after initial mechanical extraction.

In Belgium sums of €140,000 and €126,000 were respectively spent in 2005 and 2006 to clear 25ha invaded with *L. grandiflora* (De Bruyn et al., 2007).

The cost of control in the UK between 1998 and June 2010 for a total of 2.38ha was £27,320, including method development costs, which is equivalent to £11,467 per hectare (Renals, 2010). These costs are ongoing until eradication is achieved.

Schleupner[19] showed that Ireland has potential existing wetlands of about 19% of the landmass. Assuming that *Ludwigia* could potentially colonise 10% of this area, the potential annual cost of *Ludwigia* control in wetlands in Ireland and Northern Ireland is: £3,207,960 (€4,042,029) and £525,920 (€662,650) respectively. According to the Characterisation and Analysis of Ireland's River Basin Districts there is a total of 24,970km of rivers in Ireland and Northern Ireland. Assuming a 10% infestation rate and a cost of £2,000 per kilometre (see Williams, 2010), this results in an annual control cost of £4,994,000 (€6,292,440). Based on river, stream and lake data from the FAO, we are able to disaggregate this figure to Ireland and Northern Ireland, giving an estimated value of control for Ireland at £2,951,000 (€3,718,260) per annum and £1,754,000 (€2,210,040) per annum for Northern Ireland. Data on the Royal Canal, Grand Canal and the Shannon-Erne Waterway found on www.waterwaysireland.org indicate that there are 341km in these canals. If *Ludwigia* was to infest 10% of this area it is estimated that the annual control cost would be £68,200 (€85,932).

Combining these values gives a total estimated annual cost of control at £8,796,080 (€11,083,060) for both Ireland and Northern Ireland.

The costs depicted above are our estimate of annual control costs based on an optimal control strategy, where all sites are identified and managed to minimise impacts associated with *Ludwigia* should the species become widespread. If the goal is eradication, i.e. the complete removal of the plant from the wild, then the costs would increase. We estimate that this would at least double the outlays required to achieve the management goal. The estimate for eradication is £17,592,160.00 or €22,166,121.60.

### 5.2.3 New Zealand pigmyweed

***Scientific name:*** *Crassula helmsii* (T. Kirk) Cockayne.

**Origin**

A small flowering perennial plant, this species originates from the coastal regions of Australia, Tasmania and New Zealand and is believed to have been brought to GB from Tasmania in 1911 (Minchin, 2009). It is now found across Europe, Russia and the south east USA but is not considered invasive in all European countries due to its localised distribution (CABI, 2013).

[19] http://www.fnu.zmaw.de/fileadmin/fnu-files/publication/working-papers/Wetland_I_schleupner.pdf

**Distribution**

At present the National Biodiversity Data Centre holds 34 records of this species from the wild in Ireland. These records are present in 14 (1.4%) of Ireland's 10 kilometre squares. The earliest record originates from 1984 at Gosford Park in Co. Armagh (NBDC, 2013). Reynolds (2002) considers it a rare escape from cultivation with a localised distribution at present, which is likely to increase without management.

**Figure 6:** Distribution of New Zealand pigmyweed as recorded by the National Biodiversity Data Centre, 2013. www.biodiversityireland.com. Date accessed: 7th January 2013.

**Ecological Impact**

This species forms dense floating or submerged mats that extend from the margins of sheltered freshwater habitats (ponds, lakes, canals) (Minchin, 2009). It has a fast growth rate that is year round (no winter dieback) and can completely cover the water surface with tangles of stems and roots. This results in pigmyweed outcompeting native plant species that dieback in winter by shading them out, which, in turn, results in oxygen depletion arising from limited water circulation and decomposition of out-shaded dead native plants (CABI, 2013). It also suppresses the germination of native plant species and is thought to result in the decline of invertebrate communities, frogs, fish and newts, although the latter is still debated (Langdon *et al.*, 2004).

***Direct and indirect economic costs***

The loss of recreational and aesthetic value associated with *C. helmsii* can also cause a decline in waterfront property values, as well as possible declines in tourism-related revenue for communities. One recent estimate puts control costs of *C. helmsii* between €1.45 and €3 million (US $2.1-4.4 million) to manage 500 sites over 2-3 years (Leach and Dawson, 1999).

***Costs for control***

Waterways Ireland initiated an eradication programme in conjunction with Inland Fisheries Ireland from the Grand Canal (www.caisie.ie).

### 5.2.4 Hottentot fig

***Scientific name:*** *Carpobrotus edulis* (L.) N.E. Br..

***Origin***

The hottentot fig comes from the Cape region of South Africa. Reynolds (2002) suggests that the species is a rare garden escape or discard. Records in Ireland began in 1915 while the first record from GB is from 1886 (NNSS, 2013).

***Distribution***

At present, NBDC holds 16 records from across Ireland that show that the species is presently restricted to the eastern and south east coasts. These records are found in 13 (1.3%) of Ireland's 10 kilometre squares. At present it is locally naturalised and often abundant in coastal areas (Reynolds, 2002).


**Figure 7:** Distribution of hottentot fig as recorded by the National Biodiversity Data Centre, 2013. www.biodiversityireland.com. Date accessed: 7th January 2013.

***Ecological impacts***

The hottentot fig is a trailing perennial that forms extensive dense (up to 50cm) vegetative mats that can displace native beach vegetation and prevent the establishment of native species (Conser and Connor, 2009). It rapidly produces a monoculture and once established is not affected by herbivory or competition with other native species (Delipetrou, 2009). It also acidifies underlying soils and can destabilise sand dunes (NNSS, 2013).

***Direct and indirect economic costs***

***Costs for control***

In 2007 the National Botanic Gardens of Ireland started a project to remove the species from Howth, Dublin, which was supported by the Heritage Council of Ireland[20]. This project has been regarded as a success due to the 97% reduction in its presence in Howth and the recovery of native flora. The National Botanic Gardens is endeavouring to eradicate this species from the wild in Ireland in order to protect biodiversity and prevent any issues from escalating. The National Botanic Gardens, Glasnevin received a grant from the Heritage Council of €25,000 to initiate control of this species at sites in Ireland (Noeleem Smyth, pers. comm.). This capital investment represents excellent value for money in terms of protecting native biodiversity and reducing the need for more widespread control of this species.

## 5.3 Widely established species

### 5.3.1 Zebra mussel

***Scientific name:*** *Dreissena polymorpha* (Pallas, 1771).

***Origin***

Native to the drainage basins of the Black, Caspian and Aral Seas. Introduced to north-west Russia, central and western Europe, Scandinavia, Britain, Ireland and North America (DAISIE, 2012).

[20] www.botanicgardens.ie/news/20110915.htm

### *Distribution and mode of introduction*

Zebra mussels were first recorded in Britain in Surrey docks (London) and at Wisbech, Cambridgeshire in 1824. After establishment in Britain, the zebra mussel did not arrive in Ireland for another 170 years.

The zebra mussel was reported for the first time in Ireland during 1997. It may have been introduced during or before 1994. Information, based on eye-witness accounts from 1995 and the age structure of zebra mussels sampled during October and November 1997, suggests that they first became established in the region between southern Lough Derg and Limerick Docks.

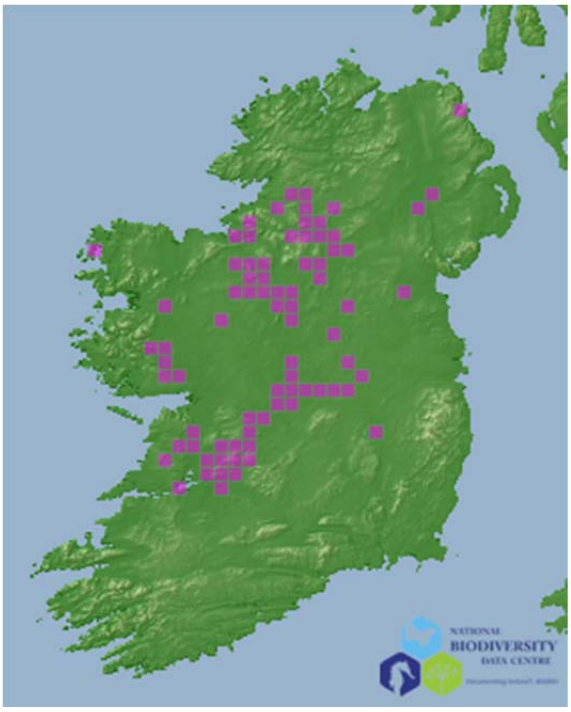

**Figure 8:** Distribution of zebra mussels as recorded by the National Biodiversity Data Centre, 2013. www.biodiversityireland.com. Date accessed: 7th January 2013.

Several events in 1993 may have created an ‘invasion window’, facilitating the spread of the zebra mussel. The introduction of the European Free Trade Agreement permitted the tax-free importation of used watercraft to Ireland from January onwards. In England, it became necessary to have a certificate of competence for second-hand boats. Combined with a favourable exchange rate these events resulted in increased sales of second-hand boats from England to Ireland, some of which had hulls fouled with zebra mussels (Minchin & Moriarty, 1998; Minchin *et al.*, 2003).

### *Ecological impact*

The zebra mussel fouls all available hard surfaces in mass numbers. It causes severe fouling problems on infrastructure and vessels and blocks water intake pipes, sluices and irrigation ditches (IMO, 2012).

Zebra mussels displace native aquatic life and alter habitats, ecosystems and food webs by competing for space and food with native mussels and other filter-feeding organisms. The zebra mussel’s high consumption of phytoplankton results in increased water clarity and it causes severe habitat alterations. It is a food source for birds and benthophagous demersal fish. It also bio-accumulates pollutants.

### *Direct and indirect economic costs*

The invasion of the zebra mussel to North America is causing annual multi-million dollar losses to the economy. The economic costs to the USA alone were around US$750 million to US$1 billion between 1989 and 2000 (IMO, 2012).

The zebra mussel causes multiple economic impacts on the following sectors: fisheries (interference with fishing gear, prey for commercial fish, alteration of fish communities); aquaculture (fouling of cages); water abstractions (clogging of water intake pipes); and aquatic transport (fouling of ship hulls and navigational constructions). All these impacts have been reported in the literature for outside of Ireland and Northern Ireland.

When the zebra mussel first invaded waterbodies in Ireland, there were predictions of impacts on water abstraction and hydroelectric power generation (Minchin & Moriarty, 1998). There are a number of *ad hoc* references reported in the media and reports but there is no system in place to regularly collate data on any impacts on economic sectors. One waste water treatment works at Killyhevlin, County Fermanagh, underwent a £120,000 upgrade to allow continuation of their activities. A domestic dwelling in County Galway reported that their water supply was cut off due to zebra mussels blocking the pipes and the pump. Despite these two identified case studies, the predicted impacts have largely not been documented or reported in the literature searched during this study. Therefore, there is no data available on which to base the economic impact of zebra mussels.

Some recreational water users have reported that the bathing waters in lakes are unsuitable for children due to the sharp shells that can cause injury, and some anglers have reported that the shells can also cut lines. However, these are purely anecdotal reports and there have been no efforts to assess the nature of these impacts or quantify their effects on the economy.

***Costs for control***

Currently, there are no effective control programmes that can be applied to zebra mussels once they are present in a waterbody. Preventing spread from one waterbody to another is the only avenue open to managers and policy makers.

### 5.3.2 American mink

***Scientific name:*** *Neovison vison* (Schreber, 1777)

The American mink is listed as one of the world's worst 100 invasive species by the IUCN's Invasive Species Specialist Group (www.issg.org). At present, there is no Ireland-wide management strategy for this species, with control undertaken purely at a localised level by businesses or individuals (gun clubs, farmers, anglers, aquaculturists) who perceive the species to be a pest (Hawkins, 2010). The Northern Ireland Rivers Agency does not undertake control (Johnathan McCormack, pers. comm.) and neither does Waterways Ireland (Jenny McTague, pers. comm.) or Inland Fisheries Ireland (Joe Caffey, pers. comm.).

***Origin***

Although native to North America (USA and Canada), the American mink has been transported across the world for the purpose of fur farming (Harris and Yalden, 2008). Escapes and deliberate releases have resulted in the establishment of feral mink populations in many locations where the species is, currently or historically, farmed (Harris and Yalden, 2008). Similarly, the feral mink population of Ireland is also likely to be a consequence of escapes and deliberate releases (Smal, 1988). The first mink farm was established in County Donegal in 1951 and, at its peak, the Irish mink industry consisted of no more than 40 breeders (Smal, 1988). Escapes were acknowledged by the industry during the 1960s whilst the earliest recorded malicious release occurred in Co. Dublin in 1964 (Deane & O'Gorman, 1969). Mink were first recorded in the wild during 1961 and by the late 1980s the feral mink population of Ireland was considered to be self-perpetuating (Smal, 1988). Fur farming is currently banned in the UK and is regulated in Ireland where five farms still operate (Stokes *et al.*, 2004; Anon, 2012).

***Distribution***

The National Biodiversity Data Centre has records of mink from 411 (41.9%) of the 979 10 kilometre squares in Ireland whilst Roy *et al.*, 2009 reported mink present in 430 (43.9%) 10 kilometre squares (NBDC, 2012).

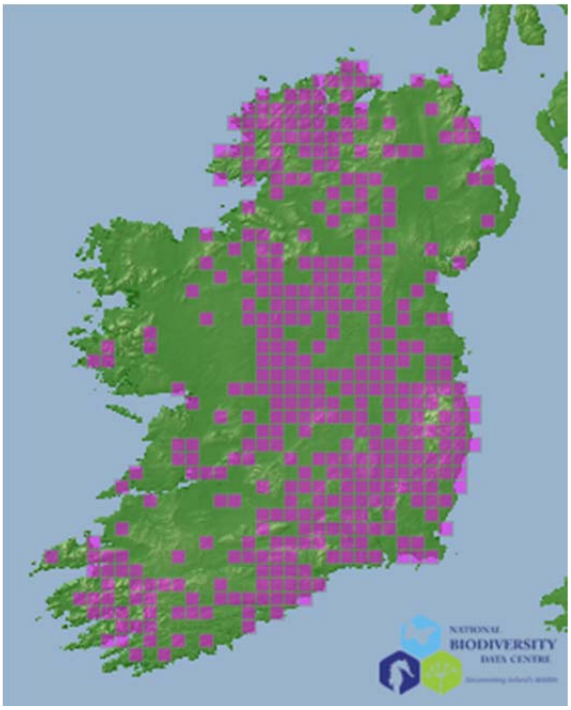

**Figure 9:** Distribution of American mink as recorded by the National Biodiversity Data Centre, 2013. www.biodiversityireland.com. Date accessed: 7th January 2013.

***Ecological impact***

In Great Britain and continental Europe feral populations of American mink are associated with the decline of water voles (*Arvicola amphibius*) via predation (Aars *et al.*, 2001; Halliwell and Macdonald, 1996) and European mink (*Mustela lutreola*) via competition (Lode *et al.*, 2001). The poor breeding success of birds on offshore islands (tern species (*Sterna* spp.)) and rivers (coot (*Fulica atra*) and moorhen (*Gallinula chloropus*)) is linked to predation by introduced mink populations (Ferreras and

Macdonald, 1999; Craik, 1997). At present, its impact in Ireland is poorly understood but similar declines in breeding gulls around Loughs Corrib, Conn, Mask, Carra and Cullin since the 1970s, are believed to be a result of mink predation (Hawkins, 2010).

***Direct economic costs***

Mink are perceived as a pest by farmers, anglers, fish farmers, gun clubs and poultry producers due, primarily, to predation of livestock i.e. poultry, wildfowl, poults or farmed fish (Harris and Symes, 1989; Whitby *et al.*, 2009; Hawkins, 2010). To date, few studies have attempted to estimate the economic impact of established feral mink populations with finfish (trout and salmon) farmers in the aquaculture industry the focus of much of the limited number of studies conducted. In the 1980s, 16% of English and Welsh trout farmers considered mink a serious economic problem, whilst in a more recent survey from Wales, 35% of fish farms perceived mink to have a detrimental impact on their business (Harris and Symes, 1989; Whitby *et al.*, 2009). In the only study from Ireland, over 70% of finfish farmers considered mink a pest and 60% reported suffering economic losses to the species (Hawkins, 2010). This same report attempted to estimate the economic impact of mink in Ireland on anglers, farmers, poultry keepers, gun-clubs and finfish farmers. Due to the lack of any other assessment, we shall use Hawkins (2010) to inform our estimation of the economic impact of mink to Ireland. However, this has its limitations, due to the following reasons:

i) A total of 8,526 farms in Ireland are recorded as keeping poultry but the 2010 agricultural census of Ireland does not differentiate between small and large scale production (Anon, 2012). Therefore, we can't confidently apply losses derived from Hawkins (2010) to create an accurate estimate of losses due to mink in either the poultry industry or small scale poultry keeping.

ii) We are unable to confidently determine the number of angling clubs in Ireland or Northern Ireland. Therefore, we have not been able to estimate the costs associated with mink control for this sector.

iii) There are roughly 900 gun clubs in Ireland (Des Crofton, pers. comm.) and an undetermined number of game estates. However, we are unsure of the level of control or the damage incurred by these groups. We have not been able to determine the economic impact.

Due to the paucity of source material we shall only estimate the cost of mink to the aquaculture industry in Ireland. We shall focus on the finfish industry, as mink are not known to be a pest to shellfish production (Hawkins, 2010).

A total of 60% of aquaculturists in Ireland reported economic losses due to mink, which is equivalent to 56 out of the 94 trout and salmon farms in Ireland suffering losses due to mink (Hawkins, 2010). Mean yearly economic losses associated with mink on fish farms is estimated at €849.40 (range €40 - €22,400). Therefore, mean yearly losses to the entire finfish industry of Ireland and Northern Ireland as a result of mink is €47,566 (range €2,240 - €112,000). In 2006, the finfish industry contributed €61.4 million to the economy of Ireland and in Northern Ireland this sector generated £3.9 million in 2011 (Anon, 2007; www.dardni.gov.uk). Therefore, the economic losses as a result of mink predation equate to 0.07% of the income generated by finfish production in Ireland and Northern Ireland combined.

***Assessments of current costs of control***

In Hawkins' (2010) study, a proportion of all respondent groups (aquaculturalists, gun clubs, farmers, anglers, poultry keepers) reported controlling mink. However, Hawkins (2010) did not report the amount of time spent controlling mink by the individual respondent groups. Therefore, we will use the mean value (44 hours, range: 1-300 hours over 6 months) derived from the whole sample to calculate the cost incurred within each group of respondents.

An estimated 38% finfish farms in Ireland control mink. By our calculations, the 36 finfish farms that control mink each spend, on average, €761.20 a year (range €17.30 - €5,190). This equates to a mean total expenditure of €27,403.20 (range: €622.80 - €186,840) per year.

Birdwatch Ireland undertook a mink removal programme on Puffin Island, Co. Kerry in 2011 at a cost of €12,000. NPWS are reported to have or are currently controlling mink on the island of Great Blaskett, Co. Kerry, Lough Mask, Co. Mayo and common scoter (*Melanitta nigra*) and red-throated diver (*Gavia stellata*) sites (Stephen Newton, pers. comm.). However, attempts to obtain this information from NPWS have been not been forthcoming.

***Estimating costs of control programmes***

As part of their report for NPWS Roy *et al.* (2009) provided crude estimates of the cost of mink eradication within an 800km$^2$ catchment over a five year period using live-traps. Estimates were based on experience gained from the Hebridean mink project started in 2002, with the aim of reducing mink populations to improve the breeding success of seabirds (Anon. 2006). The estimated cost of achieving an annual population reduction of 75% over five years was €1,062,425 or roughly €1,000 to €1,328 per km$^2$ (Roy *et al.*, 2009). Therefore, the cost of eradicating the species based on its current distribution (410 10 kilometre squares) would be between €41.1 million and €53.6 million over five years. If eradication was left to the point when mink were present across the whole of Ireland, assuming the area of the island of Ireland is 84,043 km$^2$, we can estimate the cost of eradicating mink over a five year period as between €84,043,000 and €111,609,100. It should be noted that Roy *et al.*, 2009 suggest that the price should decrease over a larger area and that the prices they quote do not include overheads etc.

As a crude comparison, Zabala *et al.* (2010) estimated the cost of eradicating mink from Spain. They modelled costs based on experience gained from small scale eradication programmes. They estimated that the cost of removing mink from the five population centres covering 633 10 kilometre squares in Spain would cost between €3 and €13 million over a year (Zabala *et al.*, 2010). This estimate was solely based on the removal of the species from river systems (and not coastlines) using live-traps. In another study from Spain, the cost of eradicating the species from an area of 174km$^2$ was estimated to cost in the range of €58,300 to €172,500 (Zuberogoitia *et al*., 2010). Extrapolating these costs to the current Ireland distribution of mink, gives a control cost between €13.7 and €40.7 million over a year.

### 5.3.3 Grey squirrel

***Scientific name:*** *Sciurus carolinensis* Gmelin, 1788

***Origin***

The grey squirrel is native to north east America. The current Irish population is believed to be derived from six pairs that were introduced to Castle Forbes, Co. Longford in 1911 from a site in England (Moffat, 1938).

***Distribution***

At present, the National Biodiversity Data Centre has 1,126 records originating from 348 (35.5%) of the 10 kilometre squares in Ireland. Carey *et al's* (2007) squirrel distribution survey revealed grey squirrels to be present in all six counties of Northern Ireland and 20 counties of Ireland.

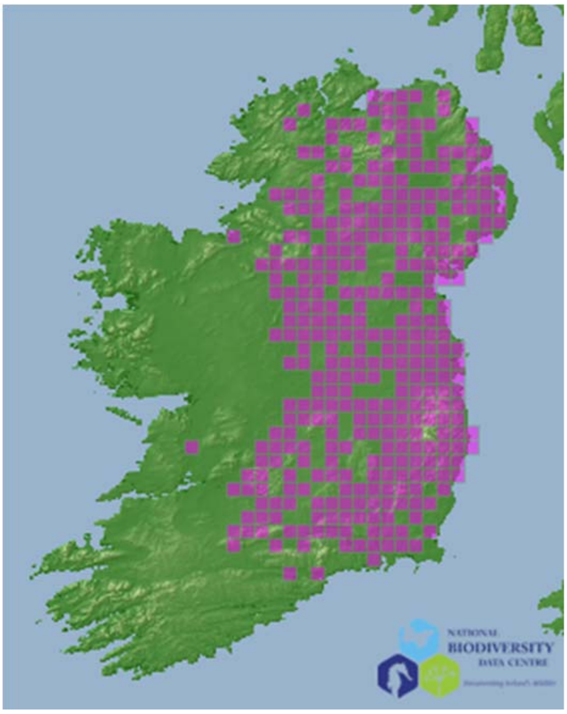

**Figure 10:** Distribution of grey squirrel as recorded by the National Biodiversity Data Centre, 2013. www.biodiversityireland.com. Date accessed: 7th January 2013.

***Ecological impact***

***Primary impact***

The expansion of the grey squirrel's range in Ireland has coincided with a decline in the range of Ireland's only native *Sciuridae*; the red squirrel (*Sciurus vulgaris*). Competition and the susceptibility of red squirrels to squirrel pox virus (SQPV), which grey squirrels carry antibodies to, appear to be the main reasons for the decline of the red squirrel in Great Britain (GB) and Ireland (Skelcher, 1997; Tompkins *et al.*, 2003).

***Secondary impacts***

The presence of grey squirrels can have a negative impact on woodlands and their associated flora and fauna (Huxley, 2003). Feeding on seeds and fruit can reduce the natural regeneration rates of woodlands whilst removal before ripening can lead to competition for food with other species (Huxley, 2003; Mayle, 2005). Bark stripping has influenced woodland management practices in England, where a shift away from trees susceptible to squirrel damage has been observed (Mayle, 2005). This in turn has implications for the flora and fauna associated with specific woodland types. Squirrels predate the eggs of birds and fledgling birds in woodlands but there is little evidence of any population declines in woodland bird species as a result (Amar *et al.*, 2006; Newson *et al*., 2010).

***Direct economic costs***

The greatest economic cost associated with the grey squirrel arises from damage caused to trees in the forestry sector by bark stripping. Its most extreme form, ring-barking, can lead to the death of the tree but it is thought to only result in fewer than 5% of trees actually dying (Mayle, 2010).

However, bark stripping increases the risk of fungal infections and invertebrate damage, which can lead to limb loss, the development of calluses and staining, all of which can reduce timber yield (Mayle, 2010). Tree species, age and time of year influence the risk of squirrel damage (Mayle et al., 2008). Beech (*Fagus sylvatica*) and sycamore (*Acer pseudoplatanus*) are at the greatest risk of damage but any thin-barked tree species between 10 and 40 years old is at risk e.g. oak (*Quercus* spp.), sweet chestnut (*Castanea sativa*), larch (*Larix* spp.) and Norway spruce (*Picea abies*) (Mayle, 2004). The extent and level of damage within a woodland varies from year to year but if damage does occur it is most likely to happen between April and July (Mayle, 2004). Mayle *et al.*, (2009) reported 2% -17% of trees ring barked and 9% -38% trees damaged in any one year over a six year period in an oak plantation, whilst Mayle (2010) reported that 4% of Norway spruce harvested was regarded as dead wood.

***Estimating direct economic costs***

The losses attributable to grey squirrels in the forestry sector are difficult to ascertain. No specific estimates have been published to date but in GB Gurnell and Mayle (2002) expected losses to exceed £1 million per year, while Broome and Johnson (2001) estimated maximum losses from damage to the three most susceptible species (beech, sycamore and ash) to be £10 million. At present there is no information on the extent and level of damage caused to forestry by grey squirrels in Northern Ireland or Ireland. Therefore, we have used information from GB to assess what the potential maximum economic losses to the forestry sectors in NI and Ireland might be. The following assumptions are made in assessing this cost:

i) We assume the worst case scenario: grey squirrels are present in every woodland, grey squirrels are causing damage to every harvested area and damage to spruce forests in Ireland is equal to that in GB i.e. 4% (Mayle, 2010).
ii) Losses are calculated against total timber production for Coillte and the Forest Service only. No assessment of losses to the private sector is made.
iii) Total timber sales for the FS and Coillte are based on 2011 and 2010 figures respectively.
iv) Standing (trees still in forest) and roadside (harvested trees) prices are given based on prices quoted by the FS and Coillte from 2011 and 2011/12 respectively. No single value has been used for timber sales in Ireland or Northern Ireland due to the difference in quoted figures.

**Northern Ireland:** In 2011, 438,927$m^3$ of timber was sold by the FS generating £8.34 million (FS, 2012). The majority of timber sold, 99.3% (392,203$m^3$), was spruce (sitka spruce and Norway spruce), whilst 316$m^3$ (0.07%) consisted of hardwood (FS, 2012). Using the assumptions above, a maximum of 15,688$m^3$ of spruce timber could be lost in NI each year. In monetary terms, using average 2011 standing (£17.10) or roadside (26.23) timber prices per $m^3$, the cost of damage caused by grey squirrels to the NI FS would be between £268,266 and £412,437 per year based on average 2011 timber prices (FS, 2012).

**Ireland:** In 2010, Coillte sold 2.34 million $m^3$ of roundwood (Marie Roche, Coillte, pers. comm.). A total of 1,921,000$m^3$ (82%) of timber sold was spruce (Norway or sitka), 250,000$m^3$ (10.6%) was pine and 173,000$m^3$ (7.3%) were ‘other’ trees (Marie Roche, Coillte, pers. comm.). Assuming a similar situation to Northern Ireland, where grey squirrels are present in all forests, all harvested areas and losses to spruce equate to 4% of harvested wood; a maximum of 76,840$m^3$ of spruce timber would be lost in Ireland each year. Using information on average 2011 and 2012 standing (€47.84) and roadside (€61) timber prices from Teagasc (www.teagasc.ie), the maximum potential losses to spruce production would be between €3,676,025 and €4,687,240 (average of €4,163,265 (£3,280,745)).

***Indirect economic costs***

As a consequence of the threat of the continued expansion of grey squirrels in Ireland, studies have been undertaken to examine the feasibility of translocation of red squirrels for their long-term survival. NUI Galway translocated red squirrels to commercial plantations previously unoccupied by squirrels and estimated the costs associated with such an exercise (Poole, 2007). Depending whether a part-time consultant or PhD student did the work, a 20 month project would cost between €93,290 and €118,372 respectively (Poole, 2007). This is comparable to the conclusions made by Shuttleworth (2005), who concluded that a similar cost (€86,313) would be involved in translocating red squirrels to the Isle of Mull, off the west coast of Scotland.

**Costs of control**

At present, there are few sources of information relating to the costs incurred by government or private organisations in Ireland or Northern Ireland for controlling grey squirrels. Therefore, we use the information that does exist, with costs derived from GB studies, to estimate what the cost of squirrel control in Ireland could amount to. Grey squirrel eradication is largely regarded as being an unrealistic aim, so the estimates of cost reported here relate to grey squirrel control.

Warfarin baits, live traps, fenn-traps and shooting have been used to control grey squirrels (Huxley, 2003). The cost of the different methods varies as does their suitability. Warfarin baits and fenn-traps are the cheapest forms of control but their use can lead to the exposure of non-target animals (domestic and wild) to anticoagulant baits and the trapping of red squirrels respectively (Harris *et al.*, 2006; Huxley, 2003). Therefore, the economic information presented here is derived by using an assessment of control costs associated with the use of live-traps only, a method that can be used anywhere and has little implication for non-target animals. The costs presented only include labour and are likely to be low end estimates of the potential maximum economic costs of controlling grey squirrels via the use of traps.

**Northern Ireland:** If we assume that grey squirrels are present in all areas of forest in Northern Ireland then control would be required in approximately 105,000ha of forest (39,000ha of broadleaved and 66,000ha of coniferous) (FS, 2012). Using the mean cost (£27.06) of controlling grey squirrels per annum per hectare of woodland from a number of sources (Tosh, 2012; Carey and Hamilton, 2008; Gurnell and Pepper, 1996; and Gurnell *et al*., 1997), without adjusting prices for changes in inflation, the average cost of controlling grey squirrels in Northern Ireland would be £2,841,300 per year.

**Ireland:** Making similar assumptions for the 602,968ha of woodland in Ireland (Department of Communications, Marine and Natural Resources), the average cost of control would be €19,579,576 per year.

**Concluding remarks**

The greatest economic cost associated with the presence of the grey squirrel in Ireland is likely to result from its control to prevent damage to forestry and biodiversity. The costs associated with control will vary depending on whether control is undertaken 'in-house' e.g. government employees or via competitive tender (a greater cost). The biggest impact to biodiversity will be the loss of the red squirrel from Ireland but we can't estimate the financial impact of this species loss without an assessment of the value of its contribution to the ecosystem services of Ireland and Northern Ireland. In order to improve any estimated impacts on Ireland's and Northern Ireland's forestry sectors, further work has to be done to determine the extent and level of damage in Irish forests.

### 5.3.4 Brown and black rat

***Scientific name:*** *Rattus norvegicus* (Berkenhout, 1769) and *Rattus rattus* (Linnaeus, 1758).

***Origin***

Movement of humans and trade is believed to have resulted in the arrival of the black rat and brown rat in Europe as the genus *Rattus* is considered an Asian genus. No research details the timing of either species arrival in Ireland but they are generally thought to have arrived at similar times as recorded for Great Britain. Originating from India, the black rat is thought to have arrived in GB with the Romans during the 3rd Century whilst the brown rat originates from Central Asia and did not arrive in GB until the 18th century via shipping from Russia. The arrival of the brown rat signalled the decline of the black rat in Europe with the former largely replacing the latter over much of its European range.

***Distribution***

The brown rat is found across the Palaearctic from Iceland to China and is considered widespread in Ireland (Yalden and Harris, 2008) but records from the National Biodiversity Data Centre do not reflect this (NBDC, 2012). However, this disparity may represent under-recording of the species. The current Irish black rat population is restricted to the island of Lambay off the coast of Co. Dublin (NBDC, 2012), although Harris and Yalden (2008) report the possibility of populations in counties Waterford and Wexford.

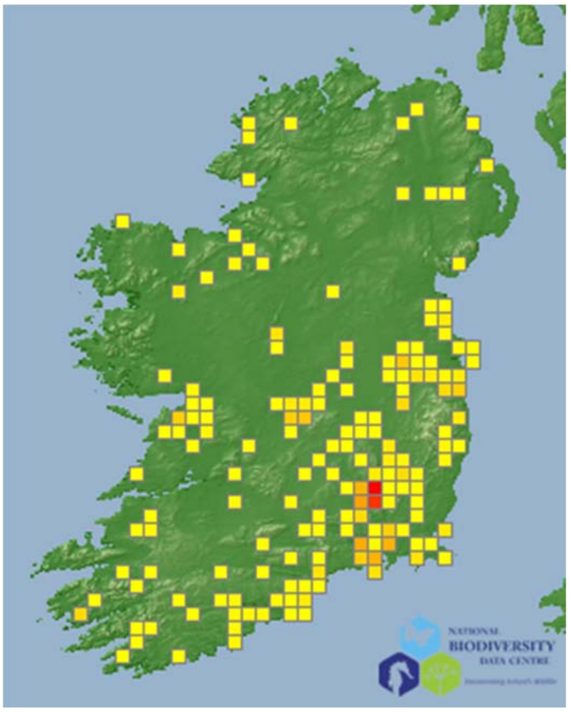

**Figure 11:** Distribution of Norway rat as recorded by the National Biodiversity Data Centre, 2013. www.biodiversityireland.com. Date accessed: 7th January 2013. Black rat not shown as only population known is on Lambay island.

***Ecological impact***

The greatest ecological impact that either rat species has is on the fauna and flora of offshore islands. Black and brown rats are two of three invasive rat species considered to pose the greatest threat to island fauna (Courchamp *et al.*, 2003; Jones *et al.*, 2008). These three rat species have been responsible for the extinction of at least 14 species of island birds (Courchamp *et al.*, 2003) and are known to predate reptiles and bats. The most widely documented impact on island fauna is the suppression of seabird numbers via the predation of chicks and eggs. In GB and Ireland the presence of rats on islands is thought to explain the poor breeding success of internationally important populations of the Manx shearwater (*Puffinus puffinus*), puffin (*Fratercula arctica*) and European storm petrel (*Hydrobates pelagicus*) (Appleton *et al.*, 2006; Stoneman and Zonfrillo, 2005; Zonfrillo, 2002). Removal of rats from the Scottish islands of Ailsa Craig and Handa and the island of Lundy off the coast of Wales has seen a recovery in some seabird numbers.

***Direct economic costs***

Rats are largely considered to be pests due to competition with man for resources (consumption of crops pre- and post-harvest), economic losses arising from their activity (lowering of crop yields and structural damage to property) and their ability to act as vectors for diseases of humans and livestock. However, there are few data that relate to the damage caused by rats and the subsequent economic impacts.

Our research has shown that few, if any, of the businesses approached that perceive a problem with rats can quantify the amount of damage attributable to this pest. The majority recognise the risk their presence poses and as a consequence bait using poisons to minimise any impact they may have. However, what can be agreed is that rats cause damage in the following areas:

**Domestic and farm fires:** Fires are caused by rodents chewing electrical cables (Stuart Formby, Burgoyne Fire Investigations, pers. comm.) but statistics relating to the number of fires caused by rodents are not available. Neither the British Association of Insurers (Daniel Edgar, pers. comm.) or the Irish Insurers Federation (Paul Holohan, pers. comm.) collate statistics on fires and their causes, while individual insurers will not release such information. Additionally, the British and Irish fire brigades do not record fires started by rodents in their annual statistics. Therefore, we are not able to assess the costs associated with fires caused by rats in domestic buildings or businesses. However, statistics do exist that relate to fires caused on farms by rodents in GB. During the 1980s, Richards (1989) suggested that 50% of fires on farms are caused by rodents chewing wires. Using this figure we can assume that 152 fires in Ireland (285) and Northern Ireland (19) on agricultural premises were the result of rats chewing electrical wires[21]. Applying estimates for the average cost of a fire in agricultural buildings from the UK (£35,200), the total cost of agricultural fires in Ireland and Northern Ireland, adjusting for inflation, is £6,347,976 or €7,617,571 per annum (Anon, 2006). This cost assessment includes human costs, property damage, lost business and response costs (Anon, 2006).

**Damage to transport networks:** Possible damage to rail networks can occur via the chewing of electrical wires, which can cause delays incurring fines (Battersby, 2004). However, contact with Irish Rail (Mark Neilan, pers. comm.) suggests that little damage attributable to rats is recorded on Ireland's rail network. We are currently awaiting a response from Northern Ireland Railways who

[21] www.fireinvestigation.ie/irish-fire-statistics

are in the process of reviewing the data they have on the subject.

**Pre-harvest consumption of crops:** The agricultural sector at greatest risk from rats in Ireland and Northern Ireland is the cereal (wheat, barley and oats) sector. In 2012, cereals contributed £44.3 million to the Northern Ireland economy (Anon, 2012) and €195 million to agricultural output in Ireland during 2008. Losses attributable to rats in this sector are most likely to occur pre-harvest and less likely to happen post-harvest. Once cut, 90% of cereal harvested in Ireland is taken directly to grain merchants (Tom Kelly, Cropsure Ltd, pers. comm.). The contamination of cereal by urine or faeces can render grain unsalable, therefore, most grain merchants adhere to strict rat control practices (Tom Kelly, pers. comm.). At present there are no reliable sources that relate pre-harvest consumption by rats to effects on yields. What information that does exist relates to post-harvest losses attributable to house mice (*Mus musculus*) or other rodents affecting crops not grown in Ireland. Low densities of house mice (<75 per ha) can reduce wheat yields by 5% (Brown and Singleton, 2000). Therefore, assuming 8.2% of farms growing cereal crops have rats outdoors (Langton et al., 2001), rats cause 5% pre-harvest damage to cereal (Brown and Singleton, 2000), and cereal prices are €197/tonne in Ireland[22] and £143.50/ tonne in Northern Ireland (Anon, 2010), we can calculate the following:

**Ireland:** A total of 12,300 farms grow cereals in Ireland producing on average 2 million tonnes a year (Anon, 2008). Therefore, on average, each farm produces 162 tonnes per annum. If 8.2% (1,008) of farms growing cereals have rats the amount of crop affected, if the maximum damage of 5% occurs on all farms with rats, is 163,296 tonnes. Assuming this value relates to 95% of the potential cereal harvested, 8,594 tonnes are lost to rats pre-harvest. This is equivalent to €1,693,018 or 0.86% of the total income generated from cereals in 2008 using 2012 prices.

**Northern Ireland:** In 2011, 2,485 farms in Northern Ireland were recorded as growing cereals, producing 192,000 tonnes of cereal a year (Anon, 2011; Anon, 2012). Making the same assumptions as above, 828 tonnes of cereal will be lost to rats pre-harvest. This is equivalent to £118,818 or 0.26% of 2012's cereal output.

**Damage to utilities:** To assess the cost of rat damage amongst utility companies in Ireland and Northern Ireland we contacted companies/organisations responsible for sewers and the supply of electricity, gas and telephone services. To date we have contacted Northern Ireland Water, County (27) and City (5) councils of Ireland and telephone (3) and electricity/gas (5) companies. However, we have only elicited responses from two city councils, seven county councils and Northern Ireland Water. No electric/gas or telephone companies have responded. None of the organisations contacted were able to quantify the damage to utilities from rats or thought that rats were not a problem, which mirrors the situation in GB (Battersby, 2004).

***Costs of control***

**Local councils:** According to the British Pest Control Association, 25% of local councils in Northern Ireland provide rat control services for local residents (BPCA, 2012). None of the city or

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[22] www.farmersjournal.ie/site/farming-Grain-report-13776.html

county councils contacted in Ireland provide a pest control service. Based on available information, the average cost to a householder of a council-provided treatment is £54.50 (n=2). In 2011, Northern Ireland councils conducted 2,551 treatments for rats, therefore, the annual cost of the rat control service provided by councils in Northern Ireland is £139,029 per annum (BPCA, 2012). This price does not take into consideration the expenditure of the councils in undertaking these subsidised treatments. In addition to providing pest control services, local councils also bait within council owned buildings. Two councils provided information on annual control costs, which on average are £1,150 per annum. Extrapolating this to the 28 local councils in Northern Ireland, and the 29 county councils and 5 city councils in Ireland, annual control costs are £71,300.

**Pest controllers/household costs:** According to Richards (1989), 25% of householders with rodents do not control infestations and a further 10% undertake control themselves. Furthermore, the England Household Survey in 1996 indicated that 0.23% of homes have rats indoors and 1.6% have rats outdoors (Langton et al., 2001). Applying figures for homes with rats we can assume that 10,951 homes in Northern Ireland and 26,891 homes in Ireland have rats (inside and out) (CSO, 2011, NISRA, 2008). Assuming 25% don't control (2,737 Northern Ireland and 6,722 Ireland) and 10% control themselves (958 Northern Ireland and 2,689 Ireland) then 8,348 households in Northern Ireland and 17,480 households in Ireland potentially use pest controllers (CSO, 2011, NISRA, 2008). Applying the average cost of rat control elicited from private pest control companies (£192, n=2) the potential total annual spend by householders on rat control in Northern Ireland is £1,602,816 and £3,356,160 in Ireland.

**Farmers:** According to Tosh *et al*. (2011), 74% of farmers in Northern Ireland used anticoagulant rodenticides themselves to control rodents. This equates to 20,424 of farms in Northern Ireland and 102,253 farms in Ireland where rodenticides are applied (Anon, 2010; 2011). Using unpublished data from Tosh *et al*'s (2011) study, the average amount of bait used by farmers in a year is 5.8kg ( n=26) and the average cost of 1kg of bait is £9.15 ( n=14, internet research), the average yearly spend by farmers on rodenticides is £53.07 a year. Therefore, the total annual spend by farmers in Northern Ireland that use baits themselves is £1,083,901 and in Ireland is £5,426,566. From the same study by Tosh *et al*. (2011), 6% of farmers surveyed reported using contractors to undertake rodent control. This equates to 1,656 and 8,290 farmers in Northern Ireland and Ireland respectively (Anon, 2010; 2011). If we assume that a rat treatment costs (at least) £192, then the costs incurred by farmers in Northern Ireland are £317,952 and £1,591,680 in Ireland per annum.

**Utilities and transport:** To date, we have only received replies from Northern Ireland Water and one section of Irish Rail in regard to control costs. Therefore, the figures we report here are an underestimate. Northern Ireland Water spent £30,000 between November 2011 and November 2012 on rat control in sewers (John Collins, pers. comm.) whilst the eastern section of Irish Rail will spend €10,560 in 2013 on contractors controlling rats in signal boxes (Mark Neilan, pers. comm.).

**Island conservation:** As far as we are aware, the only attempts to control rats in relation to conservation in Ireland and Northern Ireland have taken place on Lambay Island, off the coast of

Donegal, and Rams Island in Lough Neagh. Since 2005, BirdWatch Ireland have spent approximately €28,500 attempting to control rats on sections of Lambay that range from 5ha to 31ha in size (Stephen Newton, pers. comm.). These costs are estimated, as much of the work has been done voluntarily, either by students or as part of contracted positions within BirdWatch (Stephen Newton, pers. comm.). The Ulster Wildlife Trust were responsible for the control of rats on Rams Island but as yet they have not supplied any information relating to costs. Table 27 lists costs associated with the removal of rats from islands off the coast of Britain. Further examples of the costs associated with rat removal can be found in Martins *et al.*, (2006), which documents costs associated with the removal of rats from islands from across the world.

**Table 43:** Example of costs associated with the removal of rats from islands around Great Britain. Prices are adjusted for inflation.

| **Island** | **Year of control** | **Area (ha)** | **Cost** | **Notes** |
|---|---|---|---|---|
| Canna, Scotland | 2006 | 1130 | £777,566 | Control undertaken by specialist island management company |
| Handa, Scotland | 1997 | 309 | £2,718 | Labour was provided voluntarily |
| Ailsa Craig, Scotland | 1991 | 99 | £15,669 | Labour was provided voluntarily and transport (helicopter) provided by Navy |
| Lundy, England | 2004 | 485 | £90,806 | Labour provided in kind |
| Ramsey, Wales | 1999 | 281 | £37,810 | Labour was provided voluntarily |

# 6. DISCUSSION

## 6.1 User costs

In line with the majority of other economic studies, in this study we have focussed on deriving the impacts of invasive species on direct use values provided by provisioning ecosystem services, due to the greater ease in which economic effects can be calculated. We have been moderately successful in assessing the effects on consumptive use values (items that have a marketable value and can be traded on a market) but we have not attempted to assess the effects on non-consumptive use values (items that are non-marketable and there is no formal market). Similarly, we have not attempted to assess the effects on indirect use values. For ease of reference, Figure 1 is shown again below, which puts these use values into the context of Total Economic Value (TEV) and ecosystem services.

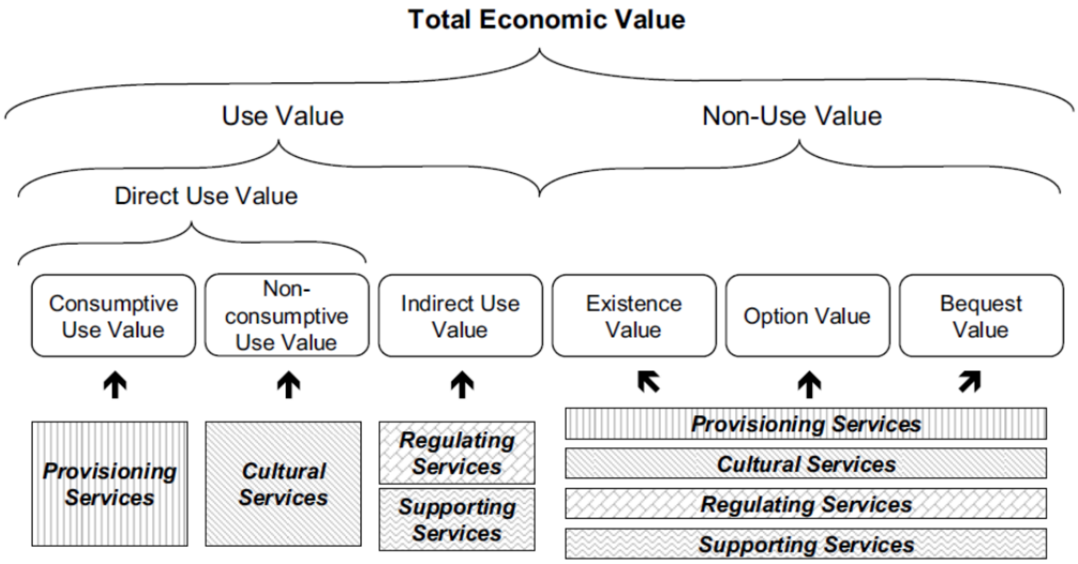


**Figure 1:** Framework for economic valuation of ecosystem services (Charles & Dukes, 2007).

### 6.1.1 Market costs

Within the assessment of consumptive use value, we have mainly been forced to concentrate on the expenditure on management and control, rather than the actual losses incurred to the product, which are currently poorly quantified for most sectors. However, it should be borne in mind that management and control are, of course, economic activities in their own right, and there is a market for invasive species work. Management and control also, if effective, prevent further losses, as do biosecurity measures, which we specifically regard here as investments in the future, even though these are all included in the cost estimates.

We have drawn heavily on the Williams (2010) report on The Economic Cost of Invasive Non-Native Species on Great Britain and have extrapolated figures for Ireland and Northern Ireland and the island as a whole from GB figures, employing a number of assumptions. We then ground-truthed these extrapolations as far as possible with the information available from our questionnaire and literature review. In some cases we accepted the GB extrapolation if few data were available. The final annual estimates for the cost of invasive species on each sector of the Irish economies are presented in Table 44 and  45 below.

**Table 44:** Summary in GB £ of the estimated impact of invasive and non-native species economic impact on sectors in Ireland and Northern Ireland.

| Sector | Ireland | Northern Ireland | Ireland and Northern Ireland combined |
|---|---|---|---|
| Agriculture | £99,824,236 | £24,596,510 | £124,420,748 |
| Forestry | £13,385,802 | £2,803,654 | £16,189,456 |
| Aquaculture and fisheries | £1,740,964 | £303,846 | £2,044,810 |
| Tourism | £1,633,868 | £626,682 | £2,260,550 |
| Construction | £6,789,024 | £3,205,690 | £9,994,714 |
| Transport | £33,802,229 | £13,477,198 | £47,279,428 |
| Human health | £3,851,184 | £1,512,638 | £5,363,822 |
| **Total estimate** | **£161,027,307** | **£46,526,218** | **£207,553,528** |

**Table 45:** Summary in Euro of the estimated impact of invasive and non-native species economic impact on sectors in Ireland and Northern Ireland.

| Sector | Ireland | Northern Ireland | Ireland and Northern Ireland combined |
|---|---|---|---|
| Agriculture | €125,778,537 | €30,991,603 | €156,770,142 |
| Forestry | €16,866,111 | €3,532,604 | €20,398,715 |
| Aquaculture and fisheries | €2,193,615 | €382,846 | €2,576,461 |
| Tourism | €2,058,674 | €789,619 | €2,725,588 |
| Construction | €8,554,170 | €4,039,169 | €12,593,340 |
| Transport | €42,590,809 | €16,981,269 | €59,572,079 |
| Human health | €4,852,492 | €1,905,924 | €6,758,416 |
| **Total estimate** | **€202,894,407** | **€58,623,034** | **€261,394,740** |

When comparing our estimates to the projected costs presented in Table 1 and 2, we can see the projections did provide a useful measure of the economic impact of invasive species. However, relying on the projections alone and not investigating data for Ireland and Northern Ireland would have resulted in an underestimation of the economic impact. Indeed, in light of the lack of available datasets for sectors in Ireland and Northern Ireland, our estimate is still considered an underestimation of the true economic impact.

As in the GB study, invasive species have by far the largest effect on agriculture and horticulture. This reflects the importance of the agricultural sector to both economies. This also highlights the need for increased engagement with the agricultural and horticultural sectors in terms of preventing invasive species issues in the first place. The argument that invasive species issues are merely an environmental consideration does not hold true when considering economic interests. It is also true that the economic impacts may not be immediately apparent to actors in these fields given that the activities to prevent economic loss will by and large be considered part of their everyday work.

Unfortunately, datasets to allow a full assessment of the impact of invasive species on the construction sector were not available. Our estimates for this sector are likely to be very conservative. While we have presented our estimate of the economic impact of invasive species on transport, this covers just one deer vehicle collisions alone and other impacts could not be estimated due to lack of workable datasets. Additionally, our estimate of deer vehicle collisions would be enhanced greatly by the establishment of a database which captures this information in partnership with insurance companies and members of the public.

In terms of split between Ireland and Northern Ireland, the estimates do appear to come in at good per capita split of cost with 76% and 24% respectively.

### 6.1.2 Confidence level of the estimates

During the course of this study we attempted to assess both the user and non-user costs associated with invasive and non-native species on the economies of Ireland and Northern Ireland. We were unable to identify any other estimates of the economic impact of invasive species in Ireland or Northern Ireland that we could compare our results with. Therefore, this report should set the benchmark for future work in this area.

The results of the assessment into user costs drew upon a wide range of data sources. The assessment was undertaken with limited availability of empirical evidence of economic impact associated with invasive and non-native species. Unfortunately, the survey conducted yielded limited results of value. Therefore, our approach was to rely more heavily on the results of the GB study than we had initially hoped. Williams (2010) had a high degree of confidence in their estimates and this detailed work was based on real data from GB. While this transfer of data from GB to Ireland and Northern Ireland will obviously bring in some degree of variation to our estimates, the similarities between the two regions should help maintain accuracy of our estimates but also ensure our estimates are better than educated guesses alone.

Our level of confidence on individual species economic impact varies greatly. In many cases, there are no estimates of population numbers across Ireland and Northern Ireland and additionally, no measure of impacts on economic sectors. For example, there is no peer reviewed estimate of rabbit or deer numbers in Ireland or within environments such as agricultural or forestry. Additionally, there are no monitoring programmes to assess the impact on economic sectors of these species. This impacts on our ability to fully estimate the impact on economic sectors.

Where assumptions of impact have been used, they are based on the data from Williams (2010) and also verified against pertinent data available from Ireland or Northern Ireland. Williams (2010) took a conservative approach to ensure that assumptions did not overestimate the economic impact of species. We also followed this approach to help ensure that we did not overestimate the economic impact of invasive and non-native species. Where data was not available or expert input suggested minimal impact in Ireland and Northern Ireland we did not include impact in this study.

### 6.1.3 Non-market costs

Non-market costs are notoriously difficult to estimate in any study, although they compose probably the largest part of the economic impact of invasive species (CABI, 2010). This study captured some non-market costs, such as the estimated costs to the native red squirrel due to the non-native grey squirrel, but a key issue is that no estimates have been made for the majority of non-market costs, which comprise cultural ecosystem services (direct use) and regulating and supporting services (indirect use), due to the lack of available data on which to base any calculations. It was beyond the scope of this project to carry out additional research to quantify the costs of invasive species to ecosystem services other than provisioning services.

## 6.2 Non-user costs

We attempted to address the non-user costs of invasive species (see Figure 1 above) by following the cost-effectiveness approach from the UK National Ecosystem Assessment (NEA), also referred to as (Benefit) Value Transfer by Defra, on a per capita basis. These estimates have not been presented in this report as they were not definitive, however, they fitted into the arguments set out by a range of authors, including those engaged in the NEA exercise and Bullock *et al* (2008), who calculated a figure for the overall annual marginal value of ecosystem services in the Republic of Ireland. This emphasises the weight that should be attached to the value of non-use ecosystem services underpinning biodiversity and the damage to these services wrought by invasive species.

## 6.3 Knowledge gaps

It is apparent from the literature search conducted during this study that there are gaps in our knowledge in a number of areas relating to invasive species and their economic impacts. We have divided knowledge gaps into four different areas:

1. ***Impact of invasive species in naïve environments***. It was evident from the literature searches conducted that there remains a lack of knowledge relating to the impacts of many invasive species in naïve environments. In Ireland particularly, but also elsewhere around the world, there is a dearth of knowledge on what impacts invasive species have. In many cases, anecdotal evidence is often given as a reason for a species' invasiveness (see CABI). This is even the case for species widely regarded as invasive e.g. Himalayan balsam where there is often conflicting or little knowledge of the negative impacts this species has**.** Therefore, if more informed estimates of economic and ecological damage caused by invasive species are to be made, further work is required to establish what the exact impacts actually are. This will then allow more accurate economic assessments to be made without the need for so many assumptions.

2. ***Distribution and density of invasive species in Ireland and Northern Ireland*.** Our inability to provide estimates of the economic costs associated with damage inflicted by invasive species was inhibited by poor information on distribution and density for many species. It should be noted though, that without the records held by the National Biodiversity Data Centre it is unlikely we would have been able to undertake many of the

assessments made in this report. Despite these records, our ability to estimate costs was undoubtedly limited by the lack of detailed information relating to the distribution of some species. For example, if information pertaining to the length of rivers with invasive plants e.g. giant hogweed was available then we could have estimated the costs of damage using information collected from organisations and individuals involved in their management. Therefore, in order for robust estimates of the direct costs associated with invasive species to be made in Ireland and Northern Ireland further work needs to be undertaken to determine a finer scale distribution of invasive species.

3. ***Costs associated with management programmes in Ireland and Northern Ireland***. Although management costs of some invasive species are well documented e.g. grey squirrels, data relating to many species does not exist or is not easily accessible. Therefore, if the cost of control or management is to be assessed, similar to impacts, further work needs to be done to assess these costs or share information where the data exists. In a Northern Ireland and Ireland context this would benefit greatly from such information being collated and supplied by governmental and non-governmental departments e.g. NPWS in relation to mink control.

4. ***Costs associated with non-provisioning ecosystem services***. Our ability to estimate the non-market costs of invasive species in Ireland and Northern Ireland is limited by the lack of studies. This undoubtedly arises from the inherent difficulty of assessing the value of ecosystem services via traditional monetary and market based models (Binimelis *et al.*, 2007). However, for a complete economic evaluation of the monetary costs of invasive species to be made for Ireland and Northern Ireland further research has to be done in this area.

## 6.4 Data gathering difficulties

Similar to many methods used to collect information to inform research e.g. questionnaires, we encountered problems in collecting data that would inform assessments of the economic costs of invasive species. We identified three areas that limited our ability to collect data:

1. ***Lack of response from people affected by invasive species***. This study has demonstrated the oft encountered difficulty in engaging people to respond to surveys. The response to the online questionnaire was very low and lower than the response rates observed for other collection methods e.g. telephone surveys and email communication. At present we are not able to identify the reasons for the low response but it is possible that the number of questions was a limiting factor, as few respondents actually completed the entire survey. Therefore, perhaps a shorter survey or one that had open questions specific for the sector of interest might have elicited a greater response rate. However, an approach such as this would have defeated the purpose of this element of the study, to compare our results to GB's. Whatever the reasons, a greater response would have better informed our assessments of the control costs of invasive species and the damage associated with invasive species.

2. ***Inability or unwillingness of people to attribute costs of invasive species***. Two additional problems encountered during the data gathering process related to the unwillingness of people or organisations to share data and the inability of people

affected by invasive species to attribute costs to them. Particular problems were encountered with obtaining information from insurance companies on fires associated with rodents. The insurance companies contacted said that they could not share this information due to the commercial nature of the data; a similar response was reported in the GB study (Williams *et al.*, 2010). Additionally, many businesses contacted in relation to the costs associated with invasive species damage were simply unable to attribute or quantify them. This was either a result of doubt that invasive species caused damage, or the inability to distinguish damage by invasive species from damage by other sources.

3. ***Lack of capacity for those involved in invasive species management***. Many government and non-governmental organisations and businesses involved in the management and control of invasive species were contacted in an effort to solicit information relating to the costs of control. However, response rates were low and despite promises of information we still await responses from a variety of organisations. This is likely a result of our information requests being in addition to the work requirements of individuals. Responses may be improved by undertaking Freedom of Information requests to various organisations. Low responses from businesses may be a result of fear of sharing commercially sensitive information. However, in order to inform the assessment of management costs this information is needed in order to ground truth any assessments made.

### 6.5 Investment in biosecurity measures

The costs of individual elements of any set of invasive species management interventions are not independently determined, since the extent to which later actions are required depends on the effectiveness of earlier ones. Effective biosecurity reduces subsequent damage to threatened ecosystems and expenditure on containment. Conversely, ineffective barriers allow greater damage and increase outlays on containment. Simply to aggregate all these outlays to calculate the overall burden on the economy created by invasive species produces misleading figures, because a reduction in the budget for biosecurity could be expected to trigger higher overall damage from invasive species. A more robust approach is to treat biosecurity as an investment, and calculate its returns in the form of avoided ecosystem damage and associated containment costs. Our difficulty in assessing the total investment in biosecurity measures in Ireland, Northern Ireland and the island as a whole was that data was not forthcoming. However, we have managed to include some data from forestry.

The literature indicates that early action programmes that succeed in preventing or eradicating new invasive species offer attractive benefit-cost ratios (see, for example, Hill and Greathead, 2000). A technical report underpinning the current European Union (EU) strategy on invasive species states that ‘data obtained highlight the potentially huge costs of control across all taxonomic groups and thus confirm the case for prevention/rapid eradication compared to long-term control or containment’ (Shine *et al*, 2009: 41). Section 5 of the same report identifies a range of prevention/rapid eradication programmes that enjoy benefit-cost ratios well in excess of ten.

Given the high returns apparently on offer, high-income nations should find further investment in biosecurity safeguards attractive, yet they still seem reconciled to meeting large and growing losses from invasive species. A small part of the explanation for this anomalous situation is that a learning curve is involved. A lagged policy response to invasive species problems that are only beginning to be fully appreciated is understandable, given the relative invisibility of much of the damage associated with non-marketed ecosystem services. A more substantial part relates to the uncertain nature of the risk involved and the possibility of failure in attempting to address it, which has to be factored into the evaluation of potential benefits from additional biosecurity measures. As Perrings *et al* (2000: 228) observe, 'measuring the effectiveness of such interventions by focusing purely on successful examples is analogous to predicting likely winnings from lotteries by considering only the winning tickets'.

A number of authorities (such as Perrings *et al*, 2002: 5-6) have argued in favour of a precautionary approach towards any threats to ecosystem resilience, stressing that the effects may not be incremental but sudden, potentially extremely expensive and irreversible. Effects of this kind would warrant substantial increases in the level of biosecurity to prevent the introduction of harmful species. These arguments emphasise the key role of biosecurity measures in assessing the economic impacts of invasive species. The optimal level of biosecurity must be a function of the nature of the threat posed by invasive species. Risk analysis implies that intervention levels will reflect local biological and socio-economic circumstances. A lower exposure to risk together with a higher penalty for any failure of protection may encourage jurisdictions to invest more in biosecurity. However, risk analysis has yet to incorporate non-user values.

## 6.6 Overall conclusions

The overall conclusion from this study, despite its limitations, is that invasive species have a large impact on the economies of Ireland and Northern Ireland and the island as a whole. The high economic costs presented are likely to be a surprise to many people, which reflects the lack of knowledge relating to invasive species and their ecological and economic impacts. People are likely to be aware of the threat some species pose to biodiversity but are unaware of the cost to the economies. Making people aware that invasive species have an influence on food prices or other commodities may provide an impetus for people to act or inform management of invasive species, for example, reporting sightings/records to NBDC. There are significant knowledge gaps that need to be addressed, along with problems in gathering data, in order to provide better economic assessments of the damage caused by invasive species.

It is likely that we have underestimated the true economic costs of invasive species as we have only been able to estimate market costs. Many assumptions were made in the calculations and it is possible that we failed to consider sectors or areas that are impacted by invasive species. CABI (2010) encountered similar problems and have estimated that the market costs that they were able to estimate for GB were likely to be only about 2% of the actual costs of invasive species to the economy. A considerable amount of primary research work would be required to validate our estimates for non-market costs and add these to the estimates for market costs.

Kaphengst *et al* (2011) believe that the overall economic activity within the EU would fall without invasive species prevention and control measures. They argue that the benefits of these measures may exceed the costs, such that the net cost of conserving biodiversity may be significantly smaller or even negative in the long-term. Clearly there is a trade-off between effective invasive species controls and the subsequent loss of resources due to impacts from them. The costs of these programmes should not simply be added to the losses attributable to invasive species; better controls should reduce such losses. Some examples of expenditure on invasive species programmes by the NIEA and the Heritage Council are provided in Appendix 1.

The costs of invasive species are likely to rise as more species arrive each year and species that are already present become invasive or more widespread. Investment in biosecurity measures to prevent new invasive species arriving on the island of Ireland is paramount. It is also obvious from the case studies that controlling invasive species early in the invasion process will reduce the impact that they will have on the island of Ireland's biodiversity, whilst reducing the costs associated with their long term control or management.

We agree with the CABI study for GB in that measures should continue to be taken to prevent the introduction and establishment of new non-native species to the island of Ireland. Effective control becomes increasingly difficult when the scale of an invasion increases along with its impacts. It is therefore equally important to eradicate species that are currently having an impact as soon as possible, to limit the further spread of locally or regionally established invasive species, whilst not ignoring the need to reduce the impact of widespread invasive species that have the highest costs. Although the cost of these control measures may appear high, it is money well spent, as without them the future costs of invasive species to the Irish and Northern Irish economies will be much higher. This is reflected in comments by Shine *et al.,* (2010) who estimate that the costs of policy inaction in invasive species in the EU are likely to be much higher than the costs of policy action on invasive species.  Inaction will simply increase the figures we have presented in this report in the years to come.

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# APPENDIX A

## NIEA and Heritage Council expenditure on invasive species

**Table 1:** Details of NIEA costs associated with Invasive Species Ireland.

| **Subject summary** | **Period** | **Value** |
|---|---|---|
| Invasive Species in Ireland report | 2005 - 2006 | £50,000.00 |
| Invasive Species Ireland - Phase 1 | 2006 - 2009 | £120,000.00 |
| Invasive Species Ireland - Phase 2 | 2009 - 2012 | £150,000.00 |
| www.invasivespeciesireland.com | 2006 - 2012 | £6,000.00 |
| NIEA project management | 2006 - 2012 | £225,000.00 |
| Invasive Species Ireland Forum Wellington Park | 2007 | £3,000.00 |
| Invasive Species Ireland Forum QUB | 2009 | £3,000.00 |
| Invasive Species Ireland Forum Museum | 2011 | £3,000.00 |
| Invasive Species Ireland Start-up Conference | 2006 | £2,000.00 |
| Invasive Species Ireland Way Forward Conference Athlone | 2009 | £2,000.00 |
| **Total budget** | **2006 - 2012** | **£564,000.00** |
| **Cost per annum** | | **£94,000.00** |

**Table 2:** Details of NIEA costs controlling Spartina

| **Subject summary** | **Period** | **Value** |
|---|---|---|
| Spartina: mapping | 2007 - 2009 | £18,000.00 |
| Spartina: herbicide research | 2007 | £5,000.00 |
| Spartina: control | 2007 | £8,700.00 |
| Off licence approval | | £1,000.00 |
| Staff training | | £5,000.00 |
| Spartina: control | | £5,000.00 |
| Spartina: control | | £14,000.00 |
| Spartina: control | | £2,000.00 |
| **Total budget** | **2007-2012** | **£58,700.00** |
| **Cost per annum** | | **£11,740.00** |

**Table 3:** Details of NIEA miscellaneous costs centres

| **Subject summary** | **Period** | **Value** |
|---|---|---|
| Wild boar research | 2012 | £2,000.00 |
| Bloody red shrimp | 2009 | £9,000.00 |
| InterReg IVA | Not specified | £650,000.00 |
| Training council staff: time | Not specified | £14,000.00 |
| Training council staff: material | Not specified | £3,000.00 |
| Events | Not specified | £8,000.00 |
| 15th ICAIS | 2007 | £5,000.00 |
| Zebra mussel management strategy | Not specified | £30,000.00 |
| Zebra mussel awareness campaign | Not specified | £25,000.00 |

| | | |
|---|---|---|
| Zebra mussel signage and placement | Not specified | £32,000.00 |
| Zebra mussel leaflets and distribution – estimated | Not specified | £5,000.00 |
| Survey work during 2011 | 2011 | £2,000.00 |
| PhD funded by NIEA. | 2005 | £70,000.00 |
| **Total** | **2005 - 2012** | **£855,000.00** |
| **Averaged cost per annum** | | **£106,875.00** |

**Table 4:** Costs provided by the Heritage Council

| Project Title | Year | Grant |
|---|---|---|
| Rhododendron Clearance, Poulgorm Wood, Glengarriff | **2007** | €34,468.00 |
| Ballyseedy Wood: Woodland Removal of Invasive Species e.g. Rhododendron Ponticum | | €32,000.00 |
| Development of measures for the control of Gunnera tinctoria on Achill Island | | €15,000.00 |
| Invasive Weed Investigations. | **2008** | €10,896.00 |
| Removal of invasive plant species Doorly Park | | €35,000.00 |
| Removal Rhododendron Ponticum Upper Heathland | | €15,000.00 |
| Development of measures for the control of Gunnera tinctoria on Achill Island, Co. Mayo | | €17,000.00 |
| Eradication of Japanese Knotweed | | €1,200.00 |
| Eradication of Japanese Knotweed on the Banks of the Lee Walkway. | | €3,739.40 |
| Cherry laurel removal from Glenbawn Fox Covert, Clonmel | | €45,000.00 |
| Establishment of a Baseline on Invasive Alien Species in Co Clare | **2009** | €11,500.00 |
| Ballyseedy Wood: Woodland Improvement/Removal of Invasive Species | | €8,600.00 |
| Removal of Invasive Species Doorly Park Sligo | | €35,000.00 |
| Control of Gunnera Tinctoria in Leenane, Co Galway | | €3,451.80 |
| Eradication of Gunnera Tinctoria from Clare Island & Eradication & Restoration at Sea Cliffs, Achill Island | | €21,248.28 |
| Eradication of Japanese Knotweed on Bere Island | | €1,128.00 |
| Follow up Treatment of Laurel Stumps at Glenbawn, Clonmel | | €6,400.00 |
| Survey of Selected Invasive Plant Species in Co. Donegal | **2010** | €10,000.00 |
| Invasive Species Management at in the immediate vicinity of Lough Cullin, Kilkenny's only lake and a NHA | | €5,900.00 |
| Controlling invasive species on the Manch Estate | | €5,000.00 |
| Invasive Species Eradication, Bere Island by BPG | | €1,000.00 |
| A Collaborative Strategy for the Management and Control of Invasive Deer Species in Wicklow | | €6,795.64 |
| Lough Corrib Control of Invasive Species - Lagarosiphon Major Project | | €15,000.00 |
| Invasive Species Database | | €16,085.00 |
| Árainn Mhór Island Japanese Knotweed Eradication | | €1,952.00 |
| Control of the invasive exotic Hottentot Fig (Carpobrotus edulis) in the Republic of Ireland | **2011** | €15,000.00 |
| Lough Corrib Control of Invasive Species - Lagarosiphon Major | | €15,000.00 |
| A method to confirm the presence of muntjac deer in Co. Wicklow | | €10,000.00 |
| Invasive Species Eradication, Bere Island | | €1,000.00 |
| Eradication of giant hogweed in Sluice River and Marsh | | €2,500.00 |
| Reenagross Woodland Park - Management of Invasive Species | | €5,738.00 |

| | | |
|---|---|---|
| Control of Gunnera tinctoria in Mayo | | €8,788.00 |
| Removal of Invasive Species from Abbey Hill, the Burren, Co. Clare | | €5,000.00 |
| Fingal County Council wishes to remove invasive species from the woodlands at St. Catherines Park (pNHA) and Luttrelstown demesne (pNHA) and restore a wetland and ponds at St. Catherines Park | | €4,900.00 |
| Invasive Species Survey | | €10,125.00 |
| Invasive Species - Pilot County Mapping and Eradication Training Project. | | €5,000.00 |
| **Total budget** | | **€52,926.00** |
| **Cost per annum** | | **€10,585.20** |