CLARE INVASIVE ALIEN SPECIES PROJECT

THE ESTABLISHMENT OF A BASELINE ON INVASIVE ALIEN SPECIES IN COUNTY CLARE AND THE DEVELOPMENT OF A DRAFT COUNTY-LEVEL MANAGEMNT STRATEGY

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EirEco Environmental Consultants

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Table of Contents

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SUMMARY

Invasive alien species (IAS) are recognised as one of the most significant threats to biodiversity throughout the world. The impacts of IAS extend beyond biodiversity loss to include effects on ecosystem services, agricultural and fisheries production, and water quality and supply. The economic cost of IAS within the EU has been estimated at €12.7 billion/year (Kettunen et al. 2008).

This project aims to provide a current review of the distribution and threats posed by IAS in County Clare, and to present a draft strategy for a coordinated control programme. It is intended that this strategy will form the catalyst for the establishment of a county level working group on IAS control involving all stakeholders.

A series of workshops were held over the duration of the project which aimed to bring together relevant stakeholders, determine the scale of impacts IAS were having within the different sectors, and to explore potential options for dealing with IAS at a county level. Questionnaires were circulated to gather additional information on these elements. A baseline of the current distribution of IAS within County Clare has been established by compiling existing data from all available recourses. This was added to by undertaking recording over the duration of the project. A database of six hundred and ten records was created covering a total of twenty seven IAS within the county. This database has been provided to the National Biodiversity Data Centre and the Clare Biological Record Centre. The NBDC have prepared distribution maps for each species within County Clare using DMAP, a programme that allows each record to be represented using a single geo-referenced dot displayed at a two kilometre square resolution on a ten kilometre grid square.

An overview of the IAS present in Clare is presented detailing the main vectors of spread for the various species and an indication of their impacts on biodiversity and on socio-economic implications. A summary of the European and national legislation relevant to IAS is presented along with an overview of current strategies or initiatives in dealing with them.

A proposed strategy for managing IAS at the county level is presented which is based on the European Union (2008) approach. This hierarchical approach incorporates three key elements:

1) Prevention,
2) Early detection and eradication,
3) Control and long-term containment.

A series of recommendations are proposed that would enable this strategy to be adopted within the county, the principle one being the establishment of a cross-sectoral working group to lead the implementation. Action at a county level is imperative at this moment in time as neither European and national legislation or IAS policies are in place and are unlikely to become operative in the near future.

The key actions of the working group should be aimed at implementing a management strategy for IAS within County Clare. This would include:

- Developing a structured approach to monitoring and recording;
- Developing a framework for early detection;
- Defining the black list of established and potential IAS in County Clare;
- Undertaking risk assessments on black-listed species to determine the scale of threat ecologically and socio-economically;

- Identifying the optimal approach for control or eradication.

1. INTRODUCTION

1.1 Project Aims

The project aims to provide a county wide assessment of the distribution, abundance and threats posed by invasive alien species and to present a draft strategy for their control in County Clare. It is intended that the strategy will form the catalyst for the establishment of a county level working group on IAS control involving all relevant stakeholders (Statutory and non-statutory).

1.2 Project Rationale

Invasive alien species (IAS) are recognised as one of the most significant threats to biodiversity throughout the world. The economic cost of IAS within the EU has been estimated at €12.7 billion/year (Kettunen et al. 2008), the majority of which is associated with the provisioning of food (agriculture, fisheries, etc). The ecological impacts of IAS include habitat alteration, competition and predation, disease transmission and genetic dilution though there are few evaluations of the cost associated with such impacts. There are estimated to be over 1,300 alien species in Europe with identified negative socio-economic impacts (DASIE, 2009).

In County Clare a total of 24 invasive alien species have been identified during the current study with a number of them established at high densities in specific environments, such as Zebra Mussels in Lough Derg and Japanese Knotweed throughout the county. While not all alien species have the potential to become invasive or cause problems, there are many that can significantly alter habitats and affect the associated biota, or result in a reduction in the quality of economic services. Scientific data on the subject is limited and there are few quantified assessments of the overall cost associated with particular species in Ireland. The typical pattern of establishment for IAS is for an initial lag period following their arrival followed by rapid spread. The vectors that facilitate IAS movement determine their subsequent geographic spread. This pattern has been well represented by the establishment of Zebra Mussel in Lough Derg and other lakes within Clare. Control of an IAS is most cost-effective and often only feasible during the lag phase. Two alien plants, Red Valerian and Cotoneaster, have established profusely at a limited number of sites within the Burren where they have become dominant in the vegetation. Their future spread threatens the unique assemblage of plants within this world renowned site, a cost difficult to quantify in monetary terms but with an unquantifiable loss to our biodiversity and natural heritage.

In Ireland, considerable attention is at last being focussed on the various plant and animal species that have been intentionally or accidentally introduced over the last 100 years or so. A major initiative has been the establishment of the cross border *Invasive Species Ireland* project, which is moving towards the development of a national strategy as well as providing guidance on control and eradication of the major problematic species. Considerable efforts have been made by the Central and Regional Fisheries Boards to halt the spread of a number of aquatic weed and invertebrate species (in particular African Curly Weed and Zebra Mussel). The National Biodiversity Data Centre (NBDC) has recently established a National Invasive Species Database in an attempt to determine the current distribution of the various species and monitor their spread. The level of information currently available on the distribution of IAS is limited and does not yet form an adequate baseline of the distribution and abundance of the various IAS throughout the country.

At the county level, no coordinated action is currently being undertaken due to the absence of governing legislation and a national strategy relating to IAS. Some local authorities are however progressing control programmes for specific IAS in response to particular problems (such as Mayo Co. Co. who are piloting control of giant rhubarb). The NBDC were recently commissioned to compile county-level inventories of IAS based on their existing available data, which are due to be presented to each local authority in 2010.

This project has established a baseline of the current distribution of IAS within County Clare by compiling data from all available recourses as well as undertaking recording over the duration of the project. From this we have identified the main invasive species and their current distribution within the county. In combination with an assessment of their various modes of transfer, this information will guide the development of specific strategies for their control at the county level.

1.3 Expected Outcomes

The principle outcome of this project is the establishment of a baseline for IAS in County Clare and the development of an outline strategy for their control. Controlling the spread of IAS can only be achieved through a strategic approach based on a thorough understanding of the ecology of the various species, their means of spread and current distribution. The proposed strategy takes account of the current legislative framework, the diversity of government agencies, authorities and interest groups involved, and the inevitable short-comings in funding and technical expertise that exist at present. The approach focuses on integrating and coordinating the existing expertise, facilities and infrastructure available at the county level through the establishment of a cross-sectoral Working Group on Invasive Alien Species. The project has targeted the relevant key stakeholders within the county and has engendered an awareness of the impacts and threats posed by IAS on socio-economic activity and biodiversity.

The project outcomes have been broken into four key elements covering the following areas:

A) The establishment of a current baseline on IAS in Co. Clare.

B) An assessment of the threats and potential impacts posed by IAS in Co. Clare.

C) The development of a proposed strategy for the control of IAS in Co. Clare.

D) The establishment of a Working Group on IAS in Co. Clare.

2. Methods

2.1 Establishing a Baseline of IAS

In order to establish a baseline of invasive alien species in County Clare, all known species records have been collated. The National Biodiversity Data Centre (NBDC) has created a recording format for the collection of such data and this format was used to ensure consistency in data submissions and allow for integration into the NBDC database. The recording format details the recorder, taxon name, date, location, precise grid reference (six figures min.), determiner, abundance and habitat associated with the species (following Fossitt, 2000). Record cards were sent out to identified stakeholders (see list in Appendix 1). Records were sought from the National Biodiversity Data Centre, Clare Biological Records Centre (CBRC) and the Environmental Protection Agency (EPA). Records were submitted by a number of individuals who undertook specific recording during the project. All records compiled and submitted as part of this project retain their original recorders name.

2.2 Workshops

A series of workshops were held during the project, commencing with an introductory one at the outset (1st April 2009). The identified stakeholders were invited to attend this half day event hosted by Clare Co. Co. at their Ennis offices. Due to constraints in time and resources, the public were not invited to participate in this process. The workshop was aimed at introducing the project to the stakeholders, explaining its objectives and timeframe. The process for the collection of records and information

on the impacts of IAS at the county level, along an overview of the main species was presented. Dr Dan Minchin of the Lough Derg Science Group presented an overview of aquatic IAS at the workshop and provided a detailed insight into the current problems faced by Lough Derg from IAS.

A second workshop was held on 15th July at Clare Co. Co. offices aimed at providing guidance on the identification and submission of records for the various IAS. This workshop targeted primarily local authority staff, as it appeared that there was an apparent skill deficit in this area.

A third and final workshop was held on the 29th September 2009, again hosted by Clare Co.Co. This workshop presented the results of the data collection and responses to questionnaires (see 2.3 below) and included a presentation on a detailed study of Zebra Mussels in a series of lakes in County Clare by John Grennan of NUIG (as part of doctoral thesis). The approach to developing a county-level strategy for IAS control was discussed and views sought from stakeholders to help guide this process. These views (along with those expressed in the returned questionnaires) have been integrated into the recommendations within this report.

2.3 Questionnaires

A questionnaire was prepared and sent to the all stakeholders (See Questionnaire A in Appendix 2). This however, elicited a very limited response possibly due to a limit in the level of knowledge or concern over IAS by the various stakeholders. Resultantly, a simplified questionnaire was sent out in order to probe the level of awareness and knowledge that did exist (See Questionnaire B in Appendix 2). A total of four completed questionnaires were returned, though follow up calls were made to key stakeholders in order to determine the occurrence, impacts and approach to management of IAS across different sectors. Twelve stakeholders provided responses to the questionnaires in this way.

2.4 Mapping

The collated records for all IAS were logged on an Excel Spreadsheet format. This was submitted to the NBDC who prepared distribution maps for each species within County Clare using DMAP. The DMAP programme allows each record to be represented using a single geo-referenced dot displayed at a two kilometre square resolution on a ten kilometre grid square. While this gives an overview of the distribution of each IAS at a county level, it does not reflect abundance. A total of twenty two maps were created (presented in Appendix 4). The data has also been provided to the CBRC for uploading to their GIS system.

2.5 Data Storage

Distribution data for IAS in County Clare has been copied to both the NBDC and CBRC allowing for graphic distribution map presentation at both the national and county level. Both bodies will manage these records and future records submitted will be copied to both organisations. The results will be displayed graphically using DMAP, and will be accessible to all users on their respective websites.

3. Results

3.1 Database Records

A database of six hundred and ten records was created covering a total of twenty seven IAS within County Clare. While the database is still very incomplete, it does however provide an overview of the current spread and distribution of certain species and establishes a rough baseline for the county.

Despite the threats posed both ecologically and economically to by IAS, there has been limited research undertaken to date on the abundance and spread of the various species at a national level or within County Clare. Focussed surveys having been carried out on IAS in Lough Derg by the Lough Derg Science Group on behalf

of the Shannon River Basin District and Waterways Ireland (LGSC, 2007a, 2007b, 2008). A limited amount of records on IAS was available on the County Clare Biological Records Centre, which was recently set up under Heritage Council funding. Data was also held on the NBDC database compiled from various sources. Records were also submitted by a number of individuals who undertook specific recording during the project.

The twenty seven IAS recorded from County Clare are detailed in Table 1 along with the number of records for each (these are not listed in order of abundance or significance). The distribution of the various species within County Clare is presented in Appendix 4. Twelve of these species occur on the STRIVE high impact priority lists (see Appendix 3). STRIVE is an EPA research programme for the period 2007-2013 is entitled Science, Technology, Research and Innovation for the Environment (STRIVE), focused on biodiversity including combating Invasive Alien Species.

Table 1. Invasive Alien Species Recorded from County Clare

Common Name	Latin Name	No. of records *	Habitats / Species at Risk
Terrestrial plants			
Butterfly-bush	*Buddleia davidii*	2	Low risk
Red Valerian	*Centranthus ruber*	11	Limestone pavement
Cotoneaster	*Cotoneaster integrifolius*	28	Dryas Heath
Japanese Knotweed	*Fallopia japonica*	245	Various
Himalayan Knotweed	*Polygonum polystachum*	33	Various
Giant Rhubarb	*Gunnera tinctoria*	5	Various
Wilson's Honeysuckle	*Lonicera nitida*	31	Hedgerows
Giant Hogweed	*Heracleum mantegazzianum*	7	Humans health, Riparian
Indian Balsam	*Impatiens glandulifera*	14	Riparian
Rhododendron	*Rhododendron ponticum*	24	Woodland, bog & Heath
Montbretia	*Crocosmia x crocosmiflora*	119	Hedgerows
Aquatic plants			
Canadian Pondweed	*Elodea canadensis*	24	Low risk
Nuttall's Pondweed	*Elodea nuttallii*	11	Lakes & Ponds
African Curly Weed	*Lagarosiphon major*	3	Lakes & Ponds
Water Violet	*Hottonia palustris*	6	Lakes & Ponds
Small Duckweed	*Lemna minuta*	8	Lakes & Ponds
Chord grass	*Spartina anglica*	5	Estuarine mudflats
Wireweed	*Sargassum muticum*	3	Marine inshore
Aquatic invertebrates			
Zebra Mussel	*Dreissena polymorpha*	56	Lakes & Ponds
Ciliate of Zebra Mussel	*Conchopthirus acuminatus*	1	Unknown
Amphipod	*Gammurus tigrinus*	3	Macroinvertebrates
Bloody-Red Shrimp	*Hemimysis anomala*	3	Unknown
Northern River Crangonyctid	*Crangonyx pseudogracilis*	3	Unknown
Eel swim bladder nematode	*Anguillicola crassus*	-	European eel
Mammals			
American Mink	*Mustela vison*	7	Water Birds
Fallow Deer	*Dama dama*	36	Woodland
Muntjac Deer	*Muntiacus sp (cf. M. reevesi)*	1	Woodland

* *(See Distribution Maps for IAS in County Clare in Appendix 4 Maps)*

3.2 Responses to Questionnaires

In order to determine the level of awareness surrounding IAS within County Clare, a questionnaire was sent out to all stakeholders (Questionnaire A in Appendix 2). As there were no responses to this initial questionnaire, a more basic alternative was prepared and circulated. The response to this second questionnaire (B in Appendix 2) was however also limited; the overall lack of response could be interpreted either as a lack of knowledge or concern. In order to determine which, a follow up was made with key stakeholders who were deemed likely to encounter IAS in their sector (Fisheries, Forestry, Roads, etc.). A total of 12 individuals from different sectors were contacted and completed Questionnaire A during a phone interview.

The results from this process indicate that IAS are considered to be a significant problem by the majority of stakeholders. The main problematic species were listed as Zebra Mussel, Japanese Knotweed and Rhododendron. Impacts of IAS detailed by the various stakeholders include issues relating to biodiversity loss, reduction in water quality, competition with native species, and fouling (on boats, shellfish tressels and navigational equipment). There was an overall lack of knowledge as to how and when the various species first arrived in Co. Clare.

All responding stakeholders agreed that assessments of the socio-economic impacts associated with IAS should be carried out. None of the respondents had undertaken such a study though Coillte are currently investigating the impact of fallow deer on commercial conifer plantations in the east of the county. Concerns over the future arrival of new invasive species, such as Chinese Mitten Crab and Signal Crayfish were apparent amongst many respondents.

Many stakeholders claimed to take in to consideration the risk of spreading IAS when dealing with operational planning. Such considerations include the EU Plant Directive, undertaking studies of IAS, cleaning of equipment to avoid spread, and deer management. However, none of these measures appear to have proven successful in the control or management of IAS due to a variety of reasons including the difficulty in identifying or controlling vectors of spread.

When asked where the responsibility for the management of IAS lies at county level, all key stakeholders were mentioned. However it was unanimous that a central body should fulfil the function of co-ordination and maintaining the data and knowledge base. It was suggested by many that this role should be within the Department of Environment, Heritage and Local Government. Many stakeholders believe that a multi-sectoral IAS Working Group could undertake this co-ordinating role at the county level. Concerns raised with regard to this approach relate to regulations, funding, management and the difficulty in reconciling the variable priorities each stakeholder would bring to the process. When asked what resources each stakeholder could provide, responses ranged from raising awareness and advisory measures to practical and operational help. The resources ultimately made available by any stakeholder may reflect the level of concern or impact they are subject to from IAS.

All stakeholders felt that a national strategy with supporting legislation for the management and control of IAS should be implemented. The values of a national approach were identified in relation to defining management responsibilities, controlling the importation (wittingly or otherwise) of IAS, and helping to guide local policies. Some stakeholders believe that a focus on awareness, not legislation, is required for controlling the spread of IAS.

A majority of stakeholders believe that the issue of IAS should be addressed within the County Clare Development Plan. It was generally agreed that this would increase awareness of IAS and facilitate the development of a county level strategy for management and control. In order for this to become effective it was felt that the issue of IAS should be taken in to account in all planning and development. It was doubted by some however, whether marine IAS management would work at a county level as opposed to a zoned or national approach.

The majority of stakeholders identified the need for public awareness and education relating to IAS. It was felt that only affected people know about IAS and that increased awareness would enhance peoples willingness to implement control measures. In response to the need for specific studies in relation to IAS, some respondents highlighted the requirement for research into control measures for certain species, though it was also acknowledged that proven control measures have already been established for a number of species. It was agreed by most that there was a need to establish risk assessments for potential new invaders and to develop action plans for existing IAS.

3.3 Vectors for Introduction and Spread

The routes by which alien species enter new areas are known as pathways, while the ways they travel to new destinations are known as vectors (UNEP, 2001). Shipping, activities and air transport of living organisms are the main modes of transmission for primary introductions (Minchin and Gollash, 2002). Secondary introductions result from the expansion of an IAS from its first established location and will generally involve a

number of different vectors. The vector will vary depending on whether the IAS is terrestrial or aquatic, flora or fauna, etc.

Many terrestrial plants have been introduced in to Ireland for their decorative qualities through private gardens, parks and garden centres including Rhododendron, Giant Hogweed and Indian Balsam. They have subsequently spread into natural habitats particularly along river corridors for the latter two species. Ground disturbance and movement of soil containing plants or plant fragments can facilitate spread. This is typically associated with:

- Quarrying,
- Movement of inert material and infilling,
- Construction and earthworks,
- Road works or road margin disturbance (pipe laying, banking up road margins)

Landscape planting of public areas and new road schemes has commonly included non-native species and non-native strains of native species (Fasham & Trumper, 2001), which may also affect the gene pool of native plants.

A number of species have been introduced for sport including Fallow Deer, Sika Deer and more recently Muntjac Deer. Fallow deer are the most widespread of the deer species in Ireland and were introduced to the country in the 13th Century by the Normans (Hayden and Harrington, 2000). They are most widespread in the southwest of the country and are well established in West Clare and continuing their expansion in suitable habitat. Lord Powerscourt first introduced Sika Deer in Wicklow in 1860 and subsequently to the Muckross Estate in Killarney (Ibid). They have established at very high densities in both areas and are recognized as a major factor in preventing native woodland regeneration as well as having a significant economic impact on commercial forestry activities. In addition they are also capable of hybridising with native Red Deer (*Cervus elaphus*) as they have done in Co Wicklow, though strangely not in Killarney. They are recorded from Co. Limerick south of the Shannon and there are isolated records from eastern Galway. The Muntjac deer has only been introduced to Ireland since about 2006 (Purser et al, in prep). They were initially known only from Wicklow, Kildare, Longford and possibly Wexford within the Republic (ibid), but have recently been reported from south-east Clare (D. Lyons, NPWS pers.com). This diminutive species has a high reproductive capacity and can establish itself in a variety of habitat types where adequate cover is available.

The American Mink has spread widely following their establishment in the country as escapees (and in some cases intentional releases) from mink farms. Private control is undertaken by some landowners and hunting organizations. Mink pose a serious threat to wildlife, fisheries and game.

Freshwater plants are openly imported in to the Republic of Ireland for sale in aquarium and garden centres. African Curly Weed is commonly sold as an oxygenating pond plant in garden centres. It spreads throughout freshwater by fragmentation and takes root at new sites, producing a massive biomass and growing up to six metres in length. Surplus material from ponds may be dumped or otherwise find its way into ditches or streams enabling transfer to the wild from private gardens. Passive drift may be a significant vector for aquatic plants; during a light easterly breeze, specimens of Nutall's Pondweed were observed been blown upstream in the Woodford River at least 0.5km from Lough Derg (Lough Derg Science Group, 2007).

Marine and freshwater plants and animals are regularly transferred as fouling on boat hulls. Transfer can occur through commercial shipping and fishing industries, in addition to leisure craft. Boats moored in marinas allow time for hulls to accumulate encrusting plant and animal life. Leisure crafts were the most likely vector for the initial

transfer of Zebra to Ireland, probably arriving encrusted on the hulls of boats and subsequently transferring between river systems through the movement of such craft (Lough Derg Science Group, 2007). They were first recorded in Lough Derg around 1993-1994 and are now found in all parts of the lake to depths of at least 18m (ibid). A more recent arrival on the lake is the Bloody Red Shrimp (*Hemimysis anomala*), which has rapidly established itself throughout the Shannon between Lough Derg and Lough Key in Sligo over the last 5 years.

The swim bladder nematode, a parasite of the freshwater eel (*Anguila anguila*) also occurs in Lough Derg. They cause extensive damage to the air bladder and other organs of the eel interfering with their capacity to swim and possibly preventing their spawning migration to the Sargasso Sea (Lough Derg Science Group, 2007).

Certain species such as the Pacific oyster (*Crassostrea gigas*) have been introduced for cultivation and have subsequently established as wild populations. Within County Clare Wireweed (also known as Jap Weed) has become established around Finivarra and Ballyvaughan. This seaweed is typically 2-3m in length but has the potential to grow up to 16m. It reproduces both sexually and via floating fragments and can very rapidly form dense mats.

4. The Impacts of Invasive Alien Species in Co. Clare

There is currently very little known on the impacts of IAS in County Clare. Todate the most thorough national overview of ecological and socio-economic impacts has been by Stokes et al (2004) who undertook a comprehensive review of Invasive Species in Ireland. While this highlights many of the actual and potential ecological impacts, it has not been able to place these impacts into a detailed economic perspective. For accurate assessments on the economic impacts of invasive species, additional data from abroad must be looked at. For the purpose of this study, only examples from other European countries have been used where valuations of economic services and costs associated with losses etc are more directly comparable.

While some authors have questioned whether IAS are a real or imagined problem (Pearman and Walker, 2009), the question arises only in relation to those species which do not warrant the title of Invasive Alien Species. There are numerous species that have moved outside of their former range either with the helping hand of man or through natural events. Those that survive the transition to a new environment may co-exist with the existing biotic communities without significant effect. However, there are certain species that have expanded their populations to problematic proportions due to the lack of natural predators or control agents. Islands frequently suffer most from such events as they typically have a reduced range of native species and a simplified ecological web. Assessing the potential for an alien species to become invasive or problematic is a key element in the process of management (Risk Assessment).

4.1 Ecological Impacts

The ecological impacts of IAS include habitat alteration, competition and predation, disease transmission and genetic dilution. Giant Hogweed, which is widespread on the lower Shannon catchement, provides an example of habitat alteration. It colonises river banks, shading out local flora and forming monotypic stands. When it dies back in the winter, it exposes the soil to erosion by floods, increasing levels of nitrates and phosphates and suspended solids in watercourses, resulting in an increase in aquatic plant growth and a reduction in spawning salmonid substrate. Cord grass, which rapidly colonises estuarine mudflats, reduces habitat availability for feeding and roosting by wintering populations of waders and wildfowl. It also alters the morphology of shallow estuaries turning them into poorly-drained marshes with steeply sloping seaward edges and deep, steep-sided channels. This leads to an increase in flooding, blocking of navigational channels and a reduction in recreational value. Cord grass is very extensive in the Lower Shannon and Fergus River estuaries.

Zebra Mussels are excellent filter feeders and resultantly remove a lot of material from the water column, increasing water quality and light penetration but conversely increasing the depth at which macrophytes (aquatic plants) can grow. Zebra Mussels attach to any firm substrate and will settle on the shells of the native swan mussel (*Anodonta cygnea*) thereby suffocating them. Large Zebra Mussel populations increase nitrogen levels within waterbodies with implications for water quality and compliance with the Water Framework Directive, (Grennan, in prep.). High densities of Zebra Mussels reduce zooplankton and phytoplankton decreasing these important food sources for juvenile fish. They also compete for space with native freshwater mussels (physically smothering them) and other benthic invertebrates, reducing the overall complexity of the ecosystem.

Nutall's pondweed and African Curly Weed are both highly prolific species that can significantly alter lake habitats by clogging sheltered shallow areas. These plants can grow in several meters depth extending to the surface where they spread to form tangled masses that impede boat traffic. Both Zebra Mussels and Nuttall's Pondweed are widespread in Lough Derg (Lough Derg Science Group Report, 2007).

Competition with native species is a common feature of IAS. Rhododendron commonly invades into natural broadleaf woodlands on acidic soils, forming a dense canopy that prevents natural regeneration of native tree species. This has resulted in a reduction in the biodiversity of Atlantic oak woods (Reynolds, 1999) and threatens the long term viability of the wood. Lowland heath and blanket bog vegetation and soils are similarly dramatically altered by rhododendron. The spread of Wireweed along the coast of Clare is likely to compete with indigenous algae and may also smother eelgrass beds. Indian Balsam may also out-compete native plants for pollinators (bees), thereby reducing native plant seed production. (Kettunen et. al., 2008).

American Mink are significant predators, causing population declines of ground nesting birds and small mammals. They have been implicated in the radical decline of common gull and tern nesting colonies in the western lakes, and also the decline in the population of common scoter in Lough Erne. The NPWS have recently commissioned a study into the impacts and control of mink as a result of their predation on breeding gulls, terns and waterfowl in the Western lakes (Roy et al, 2009).

Many IAS will carry various diseases along with them that may in turn infect our own native species. Rhododendron is known to carry *Phytophthora ramorum*, a fungus that is believed to cause "Sudden Oak Death" in California. Crayfish plague (*Aphanomyces astaci*) is carried by the American Signal Crayfish (*Pacifastacus leniusculus)*, which is immune to the disease but threatens local populations of native crayfish with extinction. While outbreaks of crayfish plague have occurred in Ireland (Demers, et al 2005), the American Signal Crayfish has not yet been recorded in the country though it is widespread in mainland Europe and in Britain.

The Grey Squirrel is recognized as a serious threat to the native Red Squirrel through competition for food and habitat. In addition however, the Grey Squirrel can carry and spread a Parapox virus to which they are immune, but which can be potentially fatal to the Red Squirrel. While the Grey Squirrel has not yet been recorded from Clare, they are continuing to expand their range across the country.

Genetic dilution may also result from hybridisation between native and closely related introduced species such as happened with native red deer with Sika Deer. Hybridisation has also occurred between native stocks of Atlantic salmon (*Salmo salar*) and escaped farmed salmon, most of which are of Norwegian or Scottish origin. The use of exotic strains of native species for roadside planting poses a risk of genetic dilution to a number of woody species such as Ash (*Fraxinus excelsior*) and Oak (*Quercus* sp.) (Fasham and Trumper, 2001).

An analysis on the impact of IAS on ecosystem services within the EU also shows that they are known to have a negative impact on regulating services such as erosion control, water quality and resistance of ecosystems to wild fires with obvious consequential severe socio-economic impacts (European Commission, 2008).

4.2 Socio-economic Impacts

In general, the economic impact of IAS is recorded only when ecosystem services (i.e. ecosystems' capacity to maintain material flows and processes that are beneficial to human wellbeing) are disrupted by IAS (EUROPEAN COMMISSION, 2008). A study to relate the socio-economic impacts of IAS (covering both damage and control) found the vast majority of the impacts identified (covering 54 species) were related to provisioning of food, such as declines in fish catch, aquaculture, crop and wood production or where IAS have negative effects on livestock health (Kettunen et al. 2008). In addition, significant impacts have been reported relating to the blocking of waterways and water services by IAS such as Zebra Mussel, Water Hyacinth and New Zealand Pigmyweed.

Based on available information on documented costs, the total known monetary impact of IAS in Europe amounts to €9.6 billion/year (Kettunen et al. 2008). Given the limited availability of documented costs however, Kettunen carried out an extrapolation to provide a more accurate picture of the economic impact in Europe. The extrapolation was based on information on the area affected by IAS and their known range in the EU. From this, the costs of IAS were estimated at €12.7 billion/year. This can also be taken as an underestimate as it only covers a only 25 out of a known 125 IAS within Europe.

Breaking down this figure by sector within the EU, the impact costs for the agricultural sector are highest at €4.9 billion/year, of which €4.19 billion/year relates to damage costs and €725 million/year to control costs. This is of significance in Ireland where farming accounts for 3% of gross domestic product, 7% of total employment in the country and 6% of all exports (Teagasc Website, 2009). The impact of American mink predation on free-range poultry in the UK is estimated at €0.55 million/year (European Commission, 2008).

In the aquatic environment IAS can adversely impact the recreational and amenity use of infested watercourses by restricting angling, boating, swimming and other water-based leisure pursuits. Zebra Mussels in particular have serious consequences for water intakes for both hydro-electric plants and domestic water supply abstractions with significant costs accruing in maintaining such systems free of blockage. The impact of Zebra Mussels on intake pipes, water filtration equipment and power plants cost the US $3.1 billion during the period 2000-2010. No costs are available for Europe (European Commission, 2008).

The economic impact of IAS on fisheries and aquaculture is estimated at €162 million/year within the EU. Aquaculture in Ireland is worth approximately €85 million a year while domestic spending on recreational fishing in Ireland estimated at €70 million per year and that of foreign tourists estimated at €65 million (Bullock et al, 2008). Zebra Mussels are prolific in Lough Derg, and have had significant, if un-quantified affects, on the fisheries and angling of the area. A variety of marine IAS (including colonial tunicates, slipper limpets and various algae) pose threats to both oyster and mussel cultivation through fouling.

The impact of deer on forestry is well recorded though little studied in the Irish context. The information available within the EU is also under-represented with control measures estimated at €22.7 million/year while costs of control in the UK are estimated at €0.82 million /year. Information may be available in the near future from a currently ongoing study of the impact of Fallow Deer in East Clare by Coillte. The value of processed timber produced in Ireland annually, is estimated at €395 million and employs directly or indirectly 16,000 people (Bullock, et al, 2008). Grey Squirrels can also impact on forestry production by stripping the bark of young trees thereby killing them. Diseases associated with IAS can also have detrimental impacts on the forestry sector, such as *Phytophthora ramorum,* a fungus carried by Rhododendron and believed to cause "Sudden Oak Death".

IAS can affect human health in some cases such as phytophotodermatitis resulting from contact with Giant Hogweed. The cost to the health sector within the EU from IAS (excluding cost of epidemic animal and human diseases) was estimated at €59.45 million/year (€55.65 million/year in damage costs and €3.8 million/year in control costs) (European Commission, 2008). The potential economic cost of IAS may become a major burden in the future for healthcare (ibid).

IAS destabilizes river banks when they dieback over winter leaving the soil exposed and unbound by a substantial root network associated with native riparian vegetation. In Germany, estimated costs are €12.3-21.2 million/year for river bank stabilisation works while flooding in October 2004 led to insurance claims of €38million

(Huyskes et al. 2006) There are also major associated impacts on both agriculture and fisheries, through soil loss and siltation of spawning beds respectively.

Species such as Japanese Knotweed can impact on infrastructure by plants roots penetrating masonry, pipes, road surfaces, etc, and eventually leading to the decay and premature deterioration of the structure. The presence of Japanese knotweed on land can cause an increase in costs for clearance for development running to tens of thousands of euro for total eradication. In Germany, estimated costs are €5.9-6.6 million/year for plant control, €2-7.7 million/year for clearance of railways and €3.5-10.5 million/year for repair of foundations (European Commission, 2008). In Wales, the estimated annual control costs for Japanese Knotweed for one county council alone were £300,000 in 1994.

Within Clare, many of these issues are likely to increase in severity and associated cost due. Species such as Japanese Knotweed, Giant Hogweed and Himalayan Balsam are widespread along waterways and ditches throughout the county. The spread of Zebra Mussel throughout the lakes of east and central Clare are likely to bring about fundamental changes in the ecology of these waterbodies which may be further altered through the expansion of aquatic water plants such as African Curly Weed and Nutall's Pondweed. Fisheries and aquaculture are both important industries in County Clare, especially in the west and along the Shannon Estuary. Both industries are prone to damage by a variety of marine IAS. Tourism within the county will also be negatively affected by IAS impacts on lakes, watercourses and a reduction in biodiversity. The unique plant assemblages of the Burren could be threatened by IAS such as Cotoneaster, which has established at Abbey Hill (O'Loughlin-Irwin, 2008) or Red Valerian, which is prolific along the New Line and a few other locations.

5. Legislation

5.1 European Legislation

Stokes et al (2004) have undertaken a review of the legislation relating to IAS at both the national and international level. More recently, a comprehensive investigation of the relevant legislative framework for both Northern Ireland and the Republic was completed by Sharon Turner of Queens University (Turner, 2008). Among the key findings of this study were a number of critical areas requiring consideration including:

- Fragmentation of legislative provisions leading to a high degree of legal complexity and uncertainty in reviewing, administration, enforcement and policy in relation to IAS.
- The absence of overall guiding policy in either jurisdiction.
- No lead agency tasked with co-ordinating policy development, risk assessment, data management or regulatory action.
- Inconsistent approaches to the preventing the introduction of IAS.

The situation at the European level is little better. Some of the principal constraints acting on prevention and control include outdated or inadequate legislation and poor co-ordination between government agencies, neighbouring States and other stakeholders (Genovesi & Shine, 2003). Table 3 below shows the European legislation relating to non-native species, (Fasham & Trumper, 2001).

Table 3. European Legislation relevant to Non-Native Species (*after Fasham & Trumper, 2001*).

Name	Year	Subject
Wildlife Trade Regulation	1997	Trade agreements/Biodiversity conservation
Habitats Directive	1992	Biodiversity Conservation
Birds Directive	1979	Biodiversity Conservation
Environmental Impact Assessment Directive	1985, updated 1997	Environmental Protection
Water Framework Directive	2000	Environmental Protection

Forest Reproductive Material Directive	1999	Phytosanitary & Biodiversity
Plant Health Directive	2000	Phytosanitary Measures
Plant Protection Products Directive	1991	Phytosanitary Measures
Fish Health Directive	1991	Sanitary Measures
Animal Health Directives	1990	Sanitary Measures

The EU's response todate on the problem of IAS has mainly been driven by commitments to International agreements such as the World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures and the Convention on Biological Diversity (Article 8h of which states "*prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species*" (Hulme, et al, 2009).

Free trade amongst EU countries also impacts on the distribution of IAS within Europe, as regulations on trade have to pass through the legislation of each country before the EU as a whole can accept it. However, there are countries within the EU who are adopting international legislation on IAS in response to their awareness of the impacts they cause. For example, France and Spain have ratified the International Convention for the Control and Management of Ships' Ballast Water and Sediments in order to prevent the spread of IAS in this fashion. As mentioned above, the transfer of IAS through ship's ballast water is common and probably a significant pathway for IAS transfer in to Ireland.

5.2 National Legislation

There is currently very limited specific legislation on IAS in Ireland, though domestic legislation does refer to non-native species under a broad suite of acts as detailed in Table 4.

Table 4 Domestic Legislation relevant to non-native species *(after Fasham & Trumper, 2001)*.

Name	Year	Subject
Wildlife Act	1976, amended 2000	Biodiversity Conservation
Environmental Protection Agency Act	1992	Biodiversity Conservation
Heritage Act	1995	Biodiversity Conservation
Marketing of ornamental plant propagating material	1995, amended 1999	Phytosanitary Measures
Marketing of Forest Reproductive Material Regs.	2002	Forestry
The Foot and Mouth Disease	2001	Sanitary Measures
Forestry Act	1998	Forestry
The Fisheries Act	1980	Fisheries
Dumping at Sea Act	1996	Marine

The Wildlife (Amendment) Act 2000 provides the principle legislation affording protection to species and their habitats, including control of wildlife trade and introductions of alien species. With regard to non-native species it is prohibited, without licence,

- *To release, wilfully cause to escape or transfer within the State for the purpose of establishment in the wild any species of wild animal or spawn and any wild bird or the eggs thereof*.

- *Plant or otherwise cause to grow in a wild state in any place in the State any species of flora, or the flowers, roots, seeds or spores thereof*.

Power is also given to the Minister for controlling the introduction of potentially invasive alien species. Where a non-native species has been introduced, measures can be taken, as liable under the Wildlife Act, to ensure the non-native does not pose a potential hazard to native stocks. However, the Act is limited in its effectiveness for a number of reasons including lack of enforcement and while most introductions are unintentional or accidental, there is no consideration of threats from unintentional introductions via new developments (for example by soil contaminated with Japanese knotweed, or the use of non-native plants in landscaping). In addition, time delays are created by inflexible codes of practice for regulation of industries and trade sectors.

Despite the strengthening of the 1977 Act by the 2000 Amendment, the legislation still remains inadequate to deal with the control on importation, ownership (or possession), sale or transfer of IAS. However, a review of the Wildlife Act is currently underway with a view to filling the gaps on IAS and is due for completion by early 2010 (Peter Carvill, NPWS, pers.com); adequate enforcement of the modified legislation may take a bit longer.

The interpretation of domestic legislation is not easy and this lack of clarity has led to few prosecutions in the accidental or intentional release of IAS (Stokes et al, 2004). This in turn does not help in highlighting IAS as a problem within Ireland. One of the key problems appears to be the lack of people with the power to enforce domestic legislation. This leads to a dependency on the support of key sectors such as trade and transport to establish codes of conduct to be compiled with and enforced by trade associations (ibid).

There is also no specific legislation regarding the import of non-native species for the purpose of biological control. Currently the Department of Environment, Heritage and Local Government grants licences for importing animals under the Wildlife

(Amendment) Act (2000). However, legislative systems for dealing with the importation of biological control agents within these licences are not very clear. The European FAO Code of Conduct for the import and release of exotic biological control agents provides a safe framework to be followed (Stokes et al, 2004). This code introduces internationally acceptable procedures for nearly all public and private bodies involved. While not currently adopted in Ireland, this should be introduced as a standard to provide guidance and regulation concerning the importation of IAS (ibid).

Many European Directives and codes relevant to invasive alien species have been transposed in to Irish Law. However, it would appear that this has little effect outside of the network of European designated sites. A good model of legislation does exist for plant health, whereby the Department of Agriculture and Rural Development produced four legislative documents which regulate against infestations of non-native plant pests and outbreaks of non-native plant diseases. This could be used as a basic model for IAS legislation (Stokes et al, 2004).

At a county level, there are no codes of practice on IAS in operation anywhere in the country. In order to protect Clare's Biodiversity, Codes of practice must be implemented at the county level in order to ensure containment of IAS as well as good management in the prevention of further spread or future introductions.

6. Existing Management Strategies for Invasive Alien Species

6.1 European and Irish strategies

Currently, both European and national legislation relating to IAS is under review. This includes the formation of "Black Lists" for high risk species at both levels. It is intended that European legislation will complement and work together with national legislation and not "over-rule" it (Ketunnen et al, 2008). The Department of the Environment, Heritage and Local Government (DoEHLG) are responsible for the preparation of a "Black List" for Ireland, which is due by early 2010 (Peter Carvill, NPWS, pers.com). These species will form the focus for amendments to the Wildlife Act aimed at curbing their spread.

The EU strategy currently in development will cover both intentional and unintentional IAS introductions both within the EU itself and between the EU and other countries. This will include guidance and measures involving the EU as a "single market" where IAS can spread quite easily at present. These measures are hoped to create a more willing and aware European environment in which there will be good communication and co-ordination between member states, and which will include community and regional level actions (Hulme et al, 2009). Key mechanisms that should follow on from this include an early warning and information system, risk assessment, monitoring and funding mechanisms for both early eradication and long-term control and restoration.

An Irish strategy on IAS should follow on from the EU strategy. However, at present there is no set timeframe or responsible authority in place for IAS in Ireland. The implementation of a "Black List" of species formulated by the DoEHLG will help in aiding the awareness of IAS Nationally, though the revised legislation currently being drafted could take a number of years before reaching ground level. The extended timeframes inherent in the development of a national response to the IAS problem highlights the importance of initiating a county level response at this stage. Deferring management and control of IAS can only result in significantly higher costs.

6.2 Invasive Species Ireland Project

The Invasive Species Ireland Project was set up as a joint venture between the Northern Ireland Environment Agency and the National Parks and Wildlife Service (DoEHLG) to implement the recommendations of the 2004 Invasive Species Ireland Report (Stokes et al, 2004). This project was for a three year operating period (May

2006 to May 2009). It is expected to continue for a second three year phase commencing in the coming months. The Invasive Species Ireland Report (Stokes et al, 2004) contains a number of key action recommendations to both jurisdictions for control and management of IAS including:

- Detailed risk assessments and contingency plans should be prepared for IAS that are likely to invade Ireland, in advance of their arrival. A risk assessment for established and potential invaders was completed in 2007 by Invasive Species Ireland (available at http://www.invasivespeciesireland.com/files/public/Risk%20Assessment/Invasive%20Species%20Ireland%20Risk%20Assessment.pdf). Risk assessments should be continually up-dated and this is expected to occur under Invasive Species Ireland Phase Two.

- Barriers to a rapid and decisive response to new invasions should be minimized by high level cross-jurisdictional and inter-departmental support for and funding of contingency plans. Engagement with specific industrial, trade and commerce sectors is vital at this point and has not yet been implemented.

- The ecological and economic impact of long-standing alien species and technology for their control should be investigated in detail in order to plan and execute cost-effective strategies for control and eradication. Within the European wide study on the ecological and socio-economic impacts of IAS (European Commission, 2008), Ireland was found lacking in information on such impacts due to an overall lack of awareness and knowledge of IAS.

- Legislative provisions should be analysed and new legal frameworks developed specifically for dealing with IAS, while facilitating beneficial introductions. This will include review of legislation by environmental lawyers, consultation with all stakeholders and government correspondence with the trade industries etc related to Codes of Practice. These provisions will follow on from implementation of European legislation.

- A framework, including support for specialist identification skills, should be established for the collation and cross-border exchange of information on non-native species. This includes recording of invasive species in a centralised database. The National Biodiversity Data Centre has developed a specific IAS database for this function. County Clare have also developed the Clare Biological Records Centre, which includes an IAS database. Training on identification skills needs to be provided to a much wider audience; at present most recording is undertaken by specialist parties whom already possess the necessary identification skills and limits the extent of recording taking place.

- Measures for the prevention and eradication of invasive species should be incorporated into agri-environment schemes, such as the Rural Environmental Protection Scheme (REPS). This allows education and awareness to be supplied to farmers and landowners.

- The dissemination of information to the public and the engagement of stakeholders, particularly in the commercial sector, should be prioritised by developing online, educational and scientific resources, and by targeted public awareness campaigns. This includes raising awareness to initiate public consciousness on IAS problems, targeted information provided to specialist groups and stakeholders, as well as education on IAS to be provided in both schools and higher education centres.

- The use of native species in amenity planting and stocking, and related community actions to reduce the introduction and spread of non-native

species should be encouraged. Native species of local provenance should be used as much as possible in conservation or amenity planting schemes.

These recommendations have yet to be implemented (with the exception of the current review of the Wildlife Act and the establishment of a Black List), with one of the principal shortcomings being the lack of a coordinating body. Isolated investigations into the impacts of IAS and their associated socio-economic and biodiversity costs are being carried out but in general outside of any joined-up or strategic framework. Waiting for a national strategy and associated national structure to operate a coordinated and funded control programme will prove to be a missed opportunity in dealing with the problem of IAS. Immediate action at a local level with pooled resources and a pragmatic approach to coordination will, in the heel of the hunt, prove to be the most cost effective strategy.

6.3 Other National Efforts

"*Current inaction by many, though not all countries, is becoming increasingly disastrous for the region's biodiversity, health and economy*" (Hulme 2007). At present, there is no responsible body or legislation concerning IAS in Ireland. Any control action currently taking place tends to occur in isolation and in response to specific localised problems such as African Curly Weed control in Lough Corrib or Rhododendron control in Killarney National Park. The National Biodiversity Data Centre has recently established a National Database for IAS but existing data on the distribution of IAS is very poor for most taxa and there is no nationally coordinated recording taking place. There are a number of research projects on IAS being undertaken by third level institutes around the country, which are piecemeal filling gaps in our knowledge of the impacts and control of particular species.

6.4 National Biodiversity Data Centre - Local Authority IAS Awareness Project

The National Biodiversity Data Centre have recently been commissioned to collate and circulate information to all local authorities within the Republic of Ireland covering a list of priority IAS. Existing county records on the NBDC database will be presented along with location information, sources for control measures and Codes of Practice. The NBDC currently have 17,054 records, representing 65 IAS species throughout the whole of Ireland. It is hoped that that this will initiate local authorities to undertake baseline surveys and implement surveillance, monitoring and control programmes as appropriate for their region. Awareness, recording and management of IAS are most readily implemented at a county level and it is hoped that this will be promoted by the NBDC action.

7. Developing a Management Strategy for Invasive Alien Species in County Clare

7.1 Existing Situation in County Clare

Invasive Alien Species do not currently fall under the remit of any specific local authority body. There is no county level strategy or policy in relation to IAS. Clare Biodiversity Ltd has made submissions to the current Draft County Development Plan (2010-2015) in relation to the control of IAS, though the plan has not yet been adopted.

Isolated assessments on specific IAS or impacted environments within Clare have been undertaken in recent years. The Lough Derg Science Group undertook studies on IAS in Lough Derg for Waterways Ireland and the Shannon River Basin District Board in recent years (Lough Derg Science Group, 2008 and Lough Derg Science Group, 2007). Jon Grennan, a PhD student at NUIG, is currently investigating the effects of Zebra Mussels on the ecology of lakes in West Clare. The Shannon Regional Fisheries

Board, in conjunction with Limerick County Council and the Office of Public Works have commenced a project on the Mulkear Catchment (within the Lower River Shannon Special Area of Conservation which extends into Co Clare). Coillte are currently assessing the impact of Fallow Deer on conifer plantation in east Clare. This study is the first attempt to combine the results of research into a county database, and develop a county-level approach to IAS management within Clare.

7.2 The European Commission Approach to Management

There are two principle options for management of invasive alien species within County Clare; the "*Business as Usual*" option and the "*Maximise the Use of Existing Approaches*" option (European Commission, 2008). If a "*Business as Usual*" approach is taken in dealing with IAS, then further increases in economic losses will occur (currently estimated at €12.7 billion annually within the EU (Kettunen et al. 2008). An increase in IAS will also further the pressure on biodiversity within County Clare and hamper the efforts to halt biodiversity loss – a stated objective in the Clare County Development Plan (2010 to 2015) and in the Clare Heritage Plan (2008-2013). The resilience of ecosystems will be lowered as well as their capacity to adapt to climate change, leading to further and possibly irreversible damage.

The "*Maximise the Use of Existing Approaches*" option involves making the best use of existing legislation, combined with voluntary codes of conduct, the establishment of an early warning and information system, maintenance of an IAS inventory, awareness-raising activities, exchange of best practice, and eradication and control measures (European Commission, 2008). A hierarchical approach is recommended incorporating three key elements:

4) Prevention,
5) Early detection and eradication,
6) Control and long-term containment.

This strategy addresses potential new introductions (via prevention) as well as established species (via elements 2 and 3). Risk assessment of IAS is required to establish which species pose the greatest threat within County Clare. This process will identify the black list of IAS that should form the priority for control measures in addition to identifying potential invaders that should be prevented from colonising and establishing within the county. The existing system for Pest Risk Analysis used for assessing and mitigating plant pest risks can be used as an example. Work is in hand within the EU to develop more generic assessment tools (European Commission, 2008).

7.3 Prevention & Monitoring

The three stage hierarchical approach to IAS recognises that prevention is far more cost-effective and environmentally desirable than measures taken following establishment of an IAS. Therefore, prevention is a key objective. This requires the identification of relevant species for attention through risk analysis to determine which species require prohibition or control.

7.4 Early Detection & Eradication

At present there is no standardised monitoring of the abundance and spread of IAS at a county or national level. Recording and monitoring has been primarily confined to a limited number of targeted studies or undertaken by concerned individuals. In order to effectively manage IAS, monitoring is a crucial tool. Rapid monitoring techniques are required to target likely locations for the arrival of new species (such as harbours in both marine and freshwater environments).

The role of monitoring could potentially be integrated into the existing tasks for staff from a variety of agencies to cover the marine, freshwater and terrestrial environments with the Clare Biological Records Centre forming a suitable repository for the database. If a species become established monitoring should pick it up at an early stage in colonisation when the potential for eradication is at its most feasible.

Early action has been proven to be much more economically and environmentally effective. Rapid intervention should be preferred to a long approval process for plans, so that eradication remains feasible.

7.5 Control & Containment

This strategy may be the only feasible option when a species cannot be realistically eradicated. This approach entails limiting the potential for the IAS to move outside of a defined area and typically requires constant intervention and adherence to codes of conduct to avoid further spread. Control measures for IAS vary considerably in their approach and efficiency. Methods are dealt with in Stokes et al (2004) and on the Invasive Species Ireland webpage.

7.6 Awareness

Awareness of IAS in Ireland and within County Clare is extremely low. This is partially explained by the lack of a single responsible authority for IAS in Ireland. The Invasive Species Ireland project during its first phase did much to heighten awareness amongst the public and commercial sectors, and have produced numerous valuable Codes of Practice, Identification and Control guidance documents available on their website www.invasivespeciesireland.com.

The National Botanic Gardens (NBG) act as the focal point for Irelands National Strategy for Plant Conservation, which includes as a target *(No. 10)* to have "*Management plans in place for at least 10 major alien species that threaten plants, plant communities and associated habitats and ecosystems in Ireland*" www.botanicgardens.ie/gspc/inspc.htm. The NBG periodically run public talks dealing with IAS and highlighting the issues associated with their spread.

At a local level, very little knowledge about IAS is provided to the general public. An exception would be the widespread signage at waterbodies highlighting the risk of Zebra Mussels transfer, although good sanitary protocol measures between watercourses are not always provided. Some information leaflets have been developed on IAS and made available through various public outlets such as libraries. However, there is currently no readily accessible and digestible publication available to the public of County Clare to inform them about the various IAS and how they can prevent their future spread. Awareness from the public will only increase willingness on IAS eradication and is crucial in any sustainable management strategy.

7.8 Resources

Within the Government budget or structure at present, there is no sole allowance of finances or other resources dedicated to IAS control. Limited funding for projects can be sought from The Heritage Council who have placed IAS as a significant priority on their agenda. LIFE is the EU's financial instrument supporting environmental and nature conservation projects throughout the European Union. The Mulkear Catchment Restoration Project (*Restoration of the Lower Shannon SAC for Lamprey, Atlantic salmon and European Otter*) received almost 50% of the total budget from the LIFE fund (€ 842,920.).

The Clare Biological Records Centre serves as a valuable tool for monitoring the distribution and spread of IAS. All data is also made available to the National Biodiversity Data Centre for compilation at a national level. However, records are generally submitted by a small number of individuals due to an overall lack of awareness and training in identification and recording techniques.

As determined from the questionnaire results (Section 3.2), all stakeholders who responded are willing to contribute in some way to the control and management of IAS within County Clare, whether it is at an advisory or operational level. This highlights how existing facilities and personnel can be used as valid resources. Not only does this cut down on costs but it also facilitates management of IAS in the integrated and strategic manner required to combat this cross-sectoral problem.

7.9 Establishing a Working Group on Invasive Alien Species in County Clare

Action at a county level is imperative at this moment in time as neither European and national legislation or IAS policies are in place and are unlikely to become operative in the near future. It is hoped that a pro-active rather than a reactive approach is adopted in County Clare at this stage in order to reduce the associated ecological and socio-economic impacts.

The establishment of a cross-sectoral working group is necessary as the subject of IAS "*requires a culture of shared responsibility, information and accountability*" in order to work effectively (Ketunnen, 2008). During the course of this project participating bodies included Clare County Council, National Parks and Wildlife Service, Shannon Regional Fisheries Board, The Forestry Service, Teagasc, Coillte, The Clare Biodiversity Group, Botanical Society of the British Isles, National Biodiversity Data Centre, Waterways Ireland, Bord Iascaigh Mhara, Shannon River Basin District, The Marine Institute and the National University of Ireland, Galway. The working group should be comprised of representatives from these key organisations and may be sub-divided into two subgroups to deal with aquatic and terrestrial IAS.

The key actions of the working group should be aimed at implementing a management strategy for IAS within County Clare. This would include:

- Developing a structured approach to monitoring and recording;
- Developing a framework for early detection;
- Defining the black list of established and potential IAS in County Clare;
- Undertaking risk assessments on black-listed species to determine the scale of threat ecologically and socio-economically;
- Identifying the optimal approach for control or eradication.

8. Conclusions & Recommendations

At present, there is no responsible body or legislation concerning IAS in Ireland. Any control action currently taking place tends to occur in isolation and in response to specific localised problems. The costs of IAS are currently estimated at €12.7 billion/year within Europe. Within Clare, there are at least 27 IAS recorded at present. Within Lough Derg, 10 new species have arrived in the last decade (Lough Derg Science Group, 2008). Despite the threat posed by IAS both ecologically and economically to County Clare, there has been limited research undertaken to date on the abundance and spread of the various species within the county.

While the issue of IAS demands attention at all levels - local, regional, national and international, it may however, be best managed and implemented at the county level. The Local Authorities existing responsibilities for planning, operation of public facilities, and associated management structures provide an adaptable framework for the management of IAS. The following recommendations are made in relation to addressing the existing and potential problems posed by IAS in County Clare:

1) The commitment to the management of IAS should be incorporated in to the County Development Plan (2010 to 2015) currently under review.

2) A cross-sectoral working group should be established with the responsibility for implementing a management strategy for IAS at the county level with additional key stakeholders drafted in from outside of the local authority.

3) Codes of Practice dealing with a number of key specific industrial, trade and commercial sectors have been developed by Invasive Species Ireland and these should be adopted by the working group as standards for the county. Circulation of Codes of Practice would facilitate awareness and highlight the joint responsibilities in dealing with IAS.

4) A monitoring and recording programme should be established with appropriate levels of training provided to facilitate identification, monitoring and management. The role of existing staff from various sectors in monitoring should also be explored. Rapid monitoring techniques are required to target likely locations for the arrival of new species (such as harbours in both marine and freshwater environments).

5) Awareness strategies should be developed which could include involving local schools, volunteers or local groups in a targeted control of IAS within local communities or high profile sites. General public awareness and involvement is crucial in order to reach a wider audience of people who aren't aware of the IAS problem. Job creation within FAS for removal and eradication would also create further involvement as well as employment benefits.

6) Targeted research should be undertaken to determine the effectiveness of removal and eradication processes on individual IAS. However, a large amount of research has already been undertaken at the European level and much of this information has already been assimilated into existing guidance documents available on the Invasive Species Ireland and European Commission's Invasive Species website.

7) Control and management must be structured and ongoing in order to work effectively. The standard conditions for success are proper planning, a commitment to completing the task, dealing with the entire population of the target IAS, removing them faster than they reproduce and preventing re-invasion (Veitch and Clout, 2002).

References

Bullock, C., Kretsch, C. and Candon, E. (2008). *The economic and social aspects of biodiversity: Benefits and costs of biodiversity in Ireland.* The Stationary Office, Dublin.

Carden, R.F., Carlin, C.M, Marnell, F., McElholm, D., Hetherington, J. and Gammell, M.P. (In prep.). *Distribution and range expansion of deer in Ireland*.

Clare County Council, (in prep.). *Clare County Development Plan (2010 to 2015)*.

Clare County Council, (2008). *Clare Heritage Plan (2008-2013)*.

DASIE (2009). *Handbook of invasive alien species in Europe*. Springer.
European Commission, (2008). *Towards an EU Strategy on Invasive Species Impact Assessment*. Communication from the Commission to the Council, The European Parliament, The European Economic and Social Committee and the Committee of the Regions

Demers, A., Lucey, J., McCarrigle, M.L. and Reynolds J.D. (2005). *The distribution of the white-clawed crayfish* Austropotamobius pallipes *in Ireland.* Biology and Environment: Proceedings of the Royal Irish Academy, Vol. 105b, No. 2, 65_69 (2005).

European Commission's Invasive Species website. (http://ec.europa.eu/environment/nature/invasivealien/index_en.htm).

Fasham, M. & Trumper, K., (2001). *Review of non-native species legislation and guidance*. Ecoscope Applied Ecologists, Stocks Bridge Way.

Fossitt, J, (2000). *A Guide to Habitats in Ireland*. The Heritage Council.

Genovesi, P. & Shine, C., (2003). *European Strategy on Invasive Alien Species, third draft*. Convention on the conservation of European wildlife and natural habitats. Council of Europe, Strasbourg.

Grennan, J., (In prep.). *Dreissena polymorpha Populations in the Lakes of County Clare*. PhD Thesis, NUIG.

Hulme, P. (2007). *Biological Invasions in Europe: Drivers, Pressures, States, Impacts and Responses*. The Royal Society of Chemistry.

Hulme, P.E., Pysek, P., Nentwig, W. and Vila, M. (2009). *Will threat of biological invasions unite the European Union?* Science Vol 324. pp40-41.

Huyskes, E., Thornton, P. & Joyce,T., (2006). *The Public and Climate Change*.

Invasive Species Ireland. (www.invasivespeciesireland.com)

Kettunen, M., Genovesi, P., Gollasch, S., Pagad, S., Starfinger, U. ten Brink, P. & Shine, C. (2008). *Technical support to EU strategy on invasive species (IS) - Assessment of the impacts of IS in Europe and the EU (Final module report for the European Commission)*. Institute for European Environmental Policy (IEEP), Brussels, Belgium. 40 pp. + Annexes., May 2008 (DG ENV contract).

Lough Derg Science Group, (2007). *Investigation into the distribution and abundance of alien biota in Lough Derg: an assessment of impacts, 2005-6*. A report to the Shannon River Basin District Working group.

Lough Derg Science Group, (2008). *Distribution, biology and monitoring or alien aquatic plants in Lough Derg, 2008*. A report to Waterways Ireland.

Minchin, D. & Gollasch, S., (2002). *Vectors – how exotics get around. In: Invasive Aquatic Species of Europe: Distribution impacts and management*. Leppäkoski, E., Gollasch, S. & Olenin S. (eds); 206-216. Kluwer Academic Publishers, Dordreicht, The Netherlands.

O'Loughlin-Irwin, S., (2008). *Garden Escapes in the Burren – A Pilot Study of the Invasive Shrub* Cotoneaster Integrifolius *(Small-leaved Cotoneaster.)* Slideshow Presentation.

Pearman, D., Walker, K. (2009). *Alien Plants in Britain – A Real or Imagined Problem?* British Wildlife Vol. 21. No 1 pp 22-27.

Reynolds, S., (1999). *Recent higher plant introductions into Ireland'* presented by Sylvia Reynolds at the Royal Irish Academy seminar in February 1999 on 'Biological invaders: the impact of exotic species'; this paper will be published in the Proceedings of that seminar by the Academy, edited by Dr. Declan Murray.

Roy, S., Reid, N., McDonald, R.A., (2009). *A review of mink predation and control in Ireland.* Irish Wildlife Manuals, No. 40. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin, Ireland.

Stokes, K., O'Neill, K. & McDonald, R.A. (2004) *Invasive species in Ireland.* Report to Environment & Heritage Service and National Parks & Wildlife Service. Quercus, Queens University Belfast, Belfast.

Teagasc Website. www.teagasc.ie

Turner, Sharon (2008). *The control of Invasive Alien Species: A Review of legislation and Governance for Ireland and Northern Ireland.* Queens University, Belfast.

UNEP/CBD/SBSTTA/6/INF/11 (2001). *Invasive alien species: Status, impacts and trends of alien species that threaten ecosystems, habitats and species*. Convention on biological diversity. United States Central Intelligence Agency.

Veitch C.R. and Clout M.N. (2002). *Turning the Tide of Biological Invasion: The Potential for Eradicating Invasive Species*. Proceedings of the International Conference on Eradication of Island Invasives. Publisher IUCN Switzerland. 414pp

Appendix 1
List Of Stakeholders

Name	Organisation
Andrew Hersey	Clare County Council Executive Planner
Bernadette Kinsella	Clare Co.Co. Director of Services (Environment, Development & Planning)
Bob Wilson	Clare Biodiversity Group / Centre for Environmental Living & Training
Brendan Dunford	BurrenLIFE
Brian McCarthy	Environmental Chemist Clare County Council
Carol Gleeson	Burren Connect
Catherine Dalton	Clare Biodiversity Group / University of Limerick
Catherine Hannon	National Parks & Wildlife Service
Christopher O'Grady	Larch Hill, Ennis (Irish Farmers Association)
Cliona O'Brien	Heritage Council
Colette O'Flynn	National Biodiversity Data Centre
Congella McGuire	Clare County Council – Heritage Officer
Cyril Feeney	Clare County Council - Area Engineer Kilrush
Dagmar Stengel	National University of Ireland, Galway
Dan Minchin	Lough Derg Science Group / National University of Ireland, Galway
Daniel O'Brien	Coillte
Dave Lyons	National Parks & Wildlife Service
David Timlin	Clare County Council Director of Services Roads & Water
Declan Murphy	Teagasc
Dennis Doherty	ESB Ardnacrusha Power Station
Donal Hogan	Clare County Council - Area Engineer Shannon
Dr Cathy Maguire	Invasive Species Ireland
Dr Ciaran Byrne	Central Fisheries Board
Dr Enda Thompson	Shannon International River Basin District Project/Limerick Co. Co.
Dr James Hannon	Department of Agriculture, Fisheries & Food
Dr Micheline Sheey-Skeffington	National University of Ireland, Galway
Dr Peter Heffernan	Marine Institute
Dr T.K. McCarthy	Zoology Department
Eamon O'Dea	Clare County Council - Area Engineer Ennis
Eamonn Cusack	Shannon Regional Fisheries Board
Ellen Carey	Executive Planner
Emma Glanville	National Parks & Wildlife Service
Eugene O'Shea	Road Design Clare County Council
Fiona Murren	Clare County Council – Assistant Planner
Flan Quilligan	Shannon Development
Fran Giaquinto	Clare Biodiversity Group
Francis O'Brien	Marine Institute
Ger Dollard	Clare County Council Director of Services (Environment)
Geraldine Tobin	Clare Biodiversity Group
Grainne O'Connor	Clare County Council – Grad. Planner
Joan Tarmey	Clare County Council Environment Awareness
Joe Caffrey	Central Fisheries Board
Joe Spellisy	Clare County Council Environment
John Bradley	Clare County Council Director of Services Planning
John Breen	University of Limerick
John Kelly	Invasive Species Ireland
John Murphy	BirdWatch Ireland
Jon Grennan	National University of Ireland, Galway
Julie Fossitt	National Parks & Wildlife Service
Ken Bond	Clare Biodiversity Group / University College Cork
Kenneth O'Reilly	Clare Biodiversity Group
Kevin Donnellan	Coillte
Kevin Keary	Forest Service
Kieran McCarthy	National University of Ireland, Galway

Leonard McDonagh	Clare County Council, Enforcement Planning section
Liam Murphy	Ennis Town Council
Lianda D'Auria	Clare County Council – SEA Officer
Liz Gabbett	Waterways Ireland
Lorraine O'Donnell	Shannon Regional Fisheries Board
Maighread Brewitt	Killaloe Garden Designs
Martin McKeown	Clare Biodiversity Group
Mary Burke	Clare County Council, Environment Section
Maura McNulty	Clare County Council, Environment Section
Michael Gormally	National University of Ireland, Galway
Michael J. Hynes	National University of Ireland, Galway
Morgan Lahiffe	Clare County Council, Roads Engineer
Nora Kay	Clare County Council, Director of Services Housing
Paddy Mathews	Failte Ireland
Pat Henchy	Clare County Council - Area Engineer Scarriff / Killaloe
Paul Butler	Failte Ireland
Paul Moroney	Clare County Council, Director of Services (Engineering Section)
Paula Tracey	Waterways Ireland
Penny Bartlett	National Parks & Wildlife Service
Peter Donnellan	Bord Iascaigh Mhara
Peter Tyndall	Bord Iascaigh Mhara
Rory Mc Donnell	National University of Ireland, Galway
Seamus Hassett	National Parks & Wildlife Service
Sean Ward	Clare County Council - Senior Engineer Water
Shane Casey	Clare County Council, Biodiversity Officer
Sharon Parr	BurrenLIFE
Simon Berrow	Clare Biodiversity Group / Irish Whale & Dolphin Group
Sinead Biggane	National Parks & Wildlife Service
Stephen Ward	Clare Biodiversity Group
Steve Lahiffe	Clare County Council - Area Engineer Ennistymon
Tom Lynch	BirdWatch Ireland
Tom Tiernan	Clare County Council - Senior Area Engineer Roads

Appendix 2
Clare Invasive Species Stakeholder Questionnaires

Information On The Impacts Of Invasive Alien Species

No.	Questions	Answers
1	Do you perceive invasive alien species as a significant problem in your sector? (Please scale from 1-5 for insignificant to major).	
2	What invasive alien species are problematic in your sector? (Please list).	
3	In what way do these species impact on your sector?	
4	Do you know how these species arrived in County Clare?	
5	Are you aware of when these species arrived or began to develop as problems?	
6	Have you undertaken any assessment or estimation of the scale or costs of such impacts?	
7	If so, could you make this information available?	
8	If not, do you see a need for such an assessment?	
9	Do you have concerns over the future spread or arrival of new invasive alien species?	
10	Please provide any additional comments you see fit.	

CLARE INVASIVE SPECIES STAKEHOLDER QUESTIONNAIRE A cont.

Information On The Control, Management Or Study Of Invasive Alien Species

No.	Questions	Answers
1	Is the control of, or risk of spreading invasive alien species taken into consideration in operational planning within your sector? If so, please elaborate.	
2	Do you undertake any current control or management measures for any invasive alien species? (If so please elaborate and indicate costs or inputs).	
3	Have you achieved success in control or management and if not why?	
4	Where do you see the responsibility for the management of invasive alien species lying at the county level?	
5	Do you think there should be a central co-ordinating body for invasive species management?	
6	Do you think a multi-sectoral working group could meet this function?	
7	What resources would your sector be able to provide to a co-ordinated management strategy – whether financial, administrative or practical?	
8	Do you feel legislation should be enacted nationally to deal with the issues of invasive alien species including management responsibilities?	
9	Do you think the issue should be addressed within the County Clare Development Plan or some other county level mechanism?	
10	Do you see a need for public awareness and education relating to invasive alien species?	
11	Do you see a need for any specific studies, risk assessments or research to be undertaken on invasive alien species and if so, please	

	elaborate?	
12	Please provide any additional comments you see fit.	

CLARE INVASIVE SPECIES STAKEHOLDER QUESTIONNAIRE B

Invasive Alien Species Questionnaire

No.	Questions	Answers
1	What sector do you work in?	
2	Are you aware of what an alien invasive species is?	
3	Would you be able to identify any alien invasive species? If so, please list.	
4	Are you aware of the potential problems alien invasive species pose?	
5	Are you aware of how alien invasive species are spread?	
6	Are you aware of the published Codes of Practice* aimed at reducing the spread of invasive alien species? *(www.invasivespeciesireland.com)	
7	Is there any policy or procedures in place within your sector or department in relation to alien invasive species?	
8	Please provide any additional comments you see fit.	

Appendix 3
Strive Priority Species Lists

The EPA research programme for the period 2007-2013 is entitled Science, Technology, Research and Innovation for the Environment (STRIVE). In 2007, the EPA STRIVE funding call for Water Quality and the Aquatic Environment resulted in a successful submission by lead organisation Queens University Belfast, to set-up the Alien invasive species in Irish water bodies' project, in association with EnviroCentre and the National Biodiversity Data Centre.

STRIVE* Priority Established Species List (high impact)

Scientific Name	Common Name
Aquatic Plants	
Lagarosiphon major	Curly Waterweed
Elodea nuttallii	Nutall's Waterweed
Myriophyllum aquaticum	Parrots Feather
Crassula helmsii	New Zealand Pigmyweed
Azolla filiculoides	Water Fern
Lemna minuta	Least Duckweed
Nymphoides peltata	Fringed Water-lily
Hydrocotyle ranunculoides	Floating Pennywort
Riparian Plants	
Heracleum mantegazzianum	Giant Hogweed
Impatiens glandulifera	Himalayan Balsam
Fallopia japonica	Japanese Knotweed
Invertebrates	
Dreissena polymorpha	Zebra Mussel
Gammarus pulex	Freshwater shrimp
G. tigrinus	Freshwater shrimp
Eriocheir sinensis	Chinese Mitten Crab
Fish	
Leuciscus cephalus	Chub
Leuciscus leuciscus	Dace

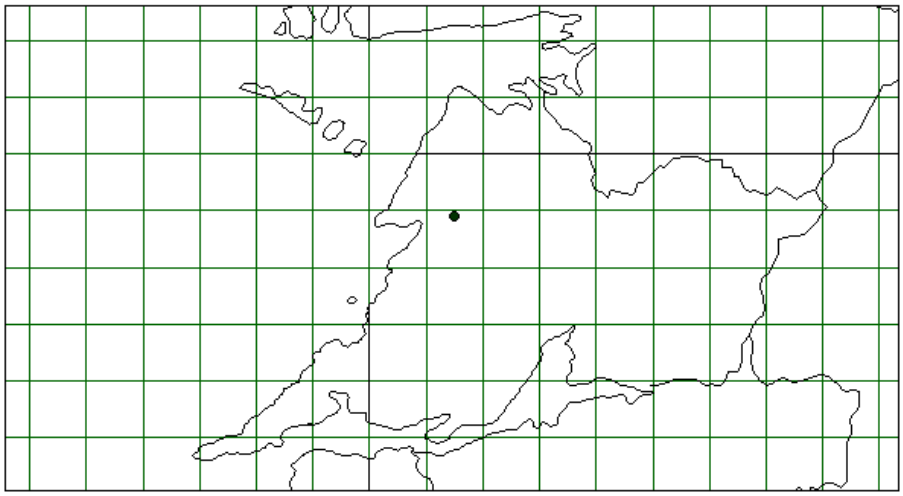
STRIVE Priority Potential Species List (high impact)

Scientific Name	Common Name
Aquatic Plants	
Ludwigia peploides / L. grandiflora	Water Primrose
Invertebrates	
Astacus astacus	Noble Crayfish
Astacus leptodactylus	Turkish Crayfish
Pacificastacus leniusculus	Signal Crayfish
Orconectes limosus	Spiny-cheeked/striped Crayfish
Procambarus clarkii	Red Swamp Crayfish
Hemimysis anomala	Ponto-Caspian Mysid
Gryodactylus salaris	Parasite
Dreissena bugensis	Quagga Mussel
Corbicula fluminea	Asian Clam
Fish	
Gymnocephalus cernuus	Ruffe
Zander lucioperca	Zander
Pseudorasbora parva	Topmouth Gudgeon

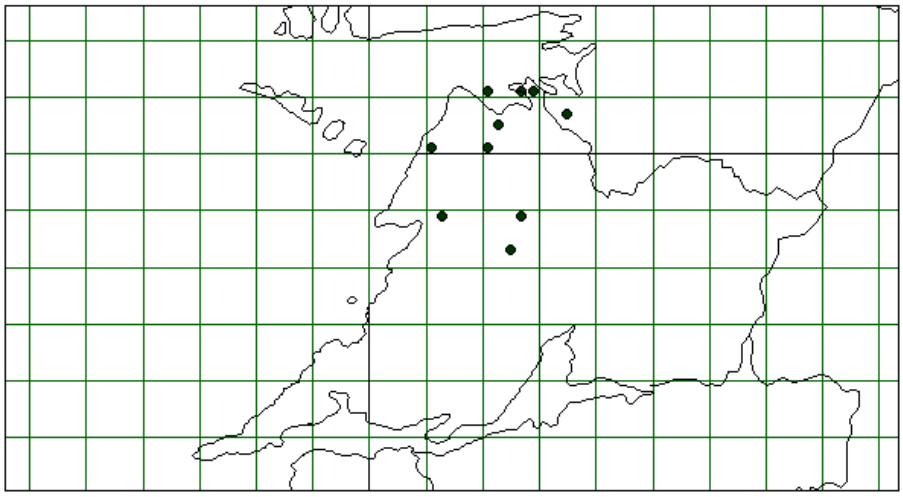
Appendix 4
Distribution Maps Of Invasive Alien Species In Co Clare

(Prepared by the National Biodiversity Data Centre using DMAP)

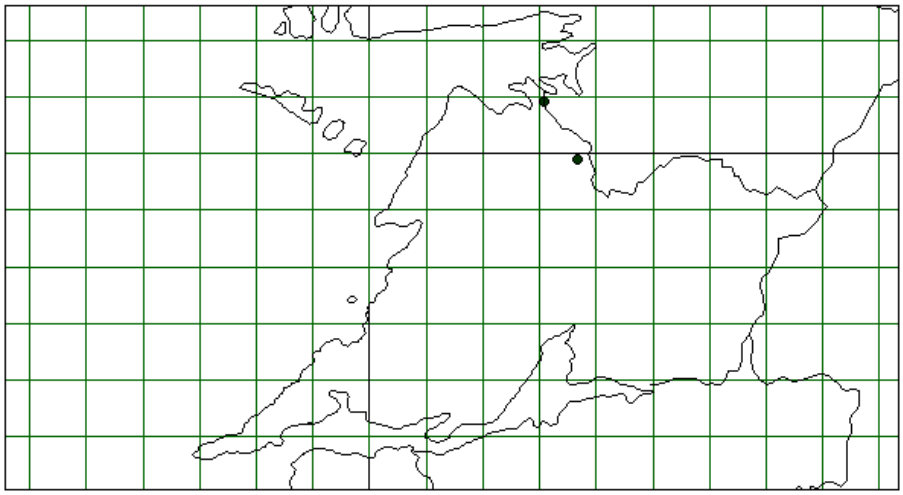
Buddlia



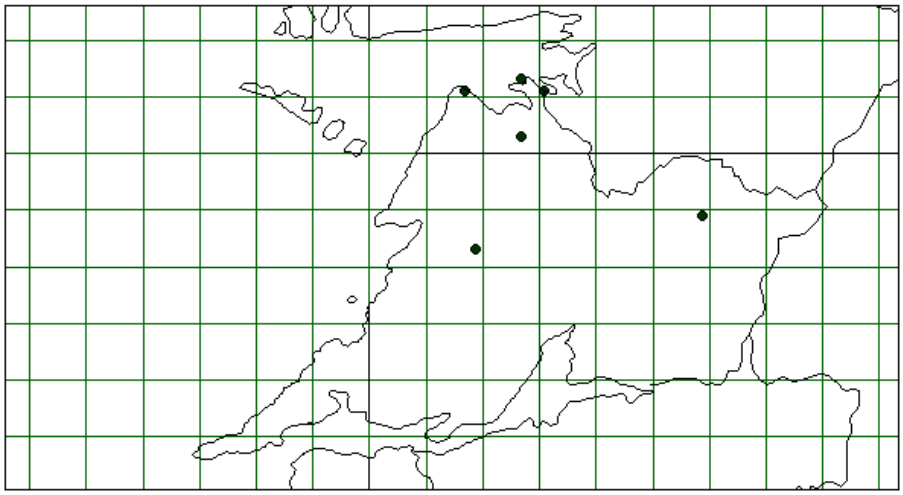
Centranthus ruber



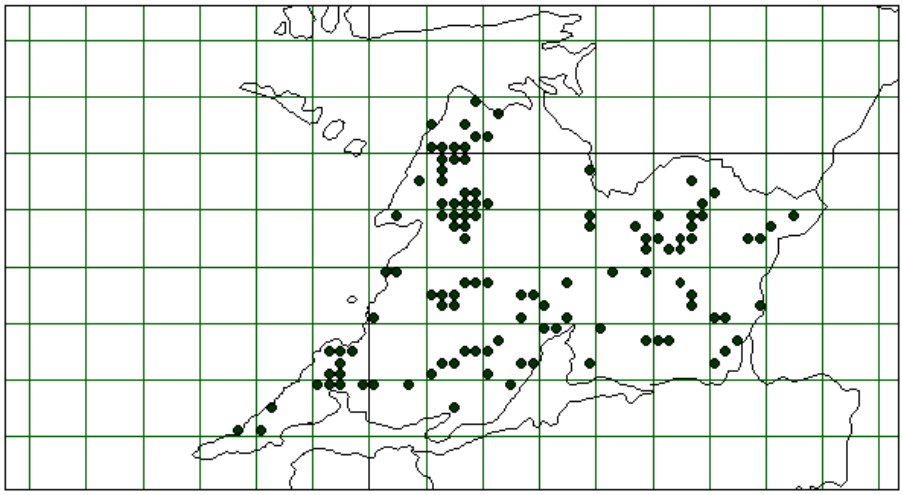
Cotoneaster integrifolius



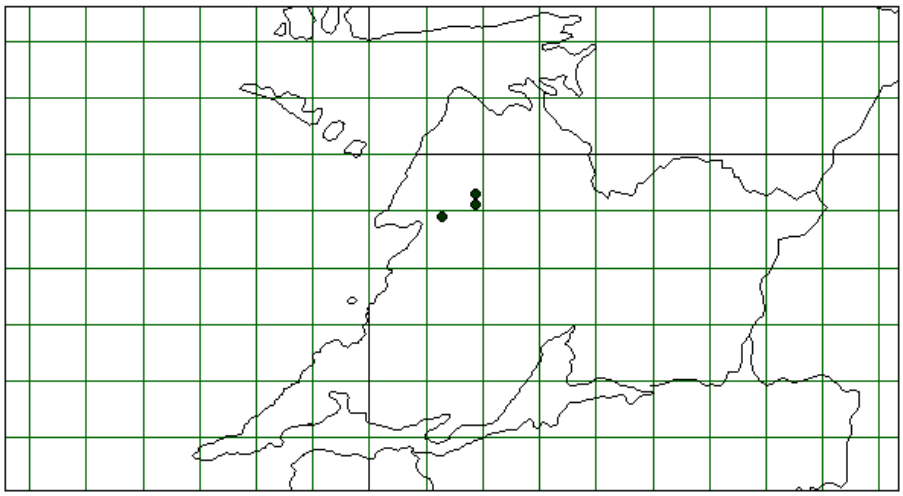
Cotoneaster sp



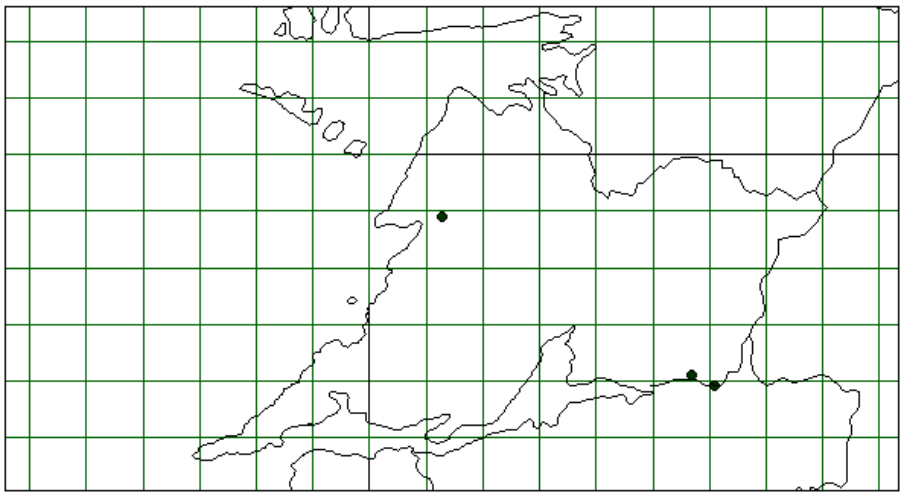
Fallopia Japonica



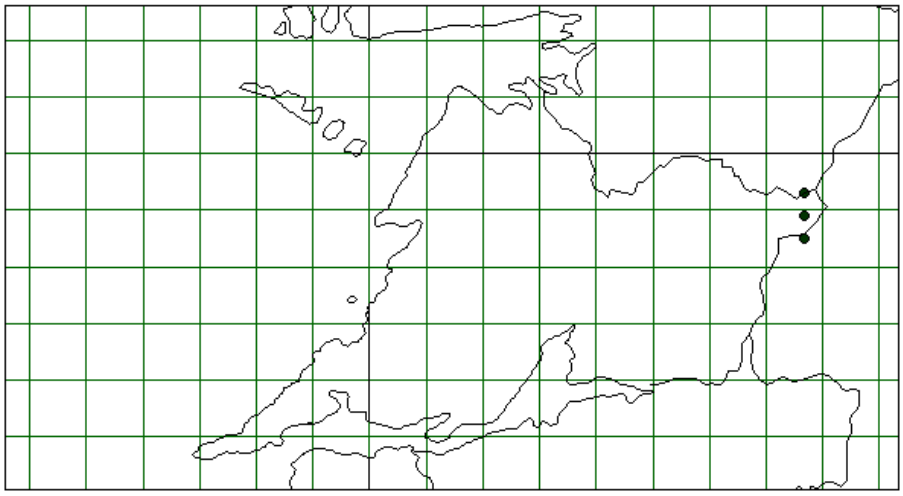
Gunnera tinctoria



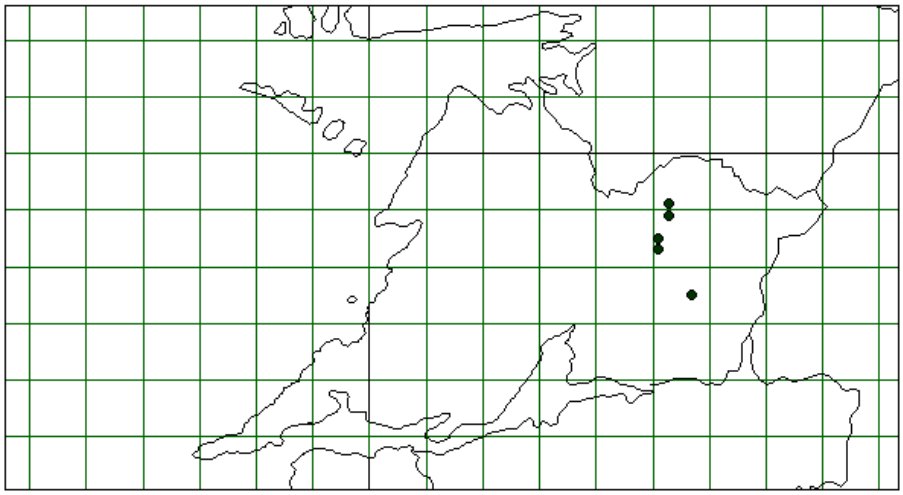
Heracleum mantegazzianum



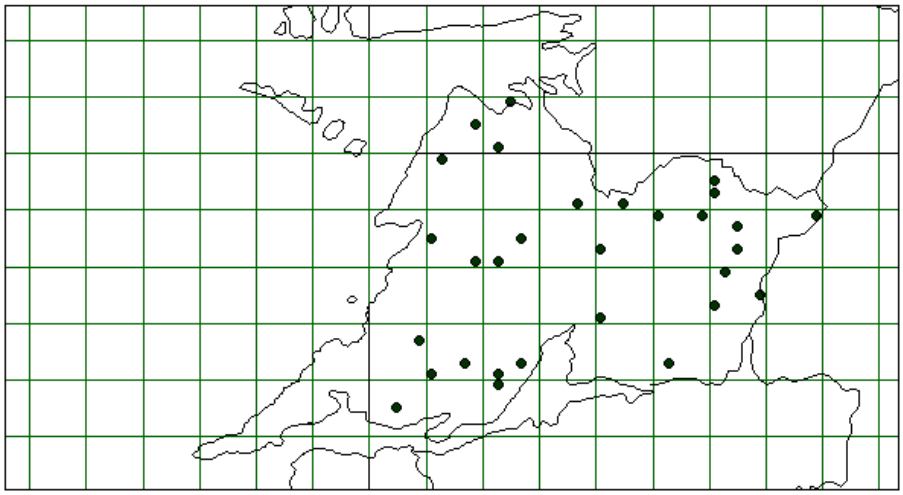
Hottonia palustris



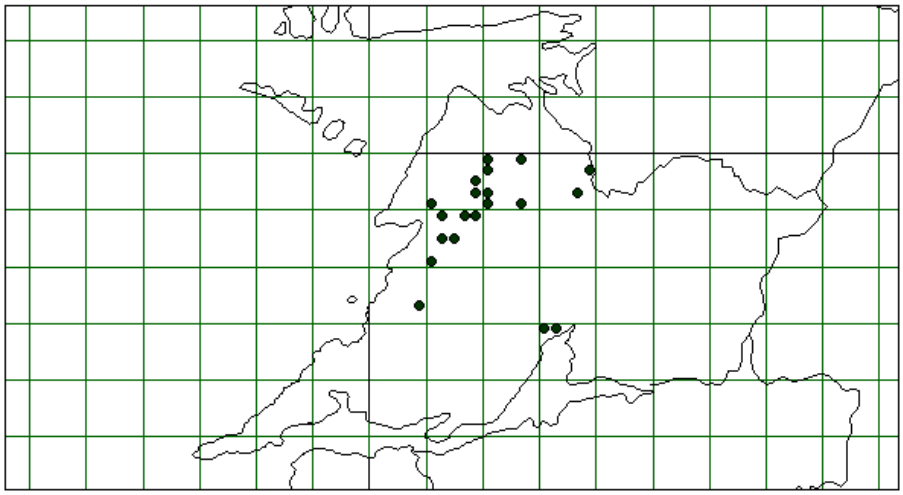
Impatiens glandulifera



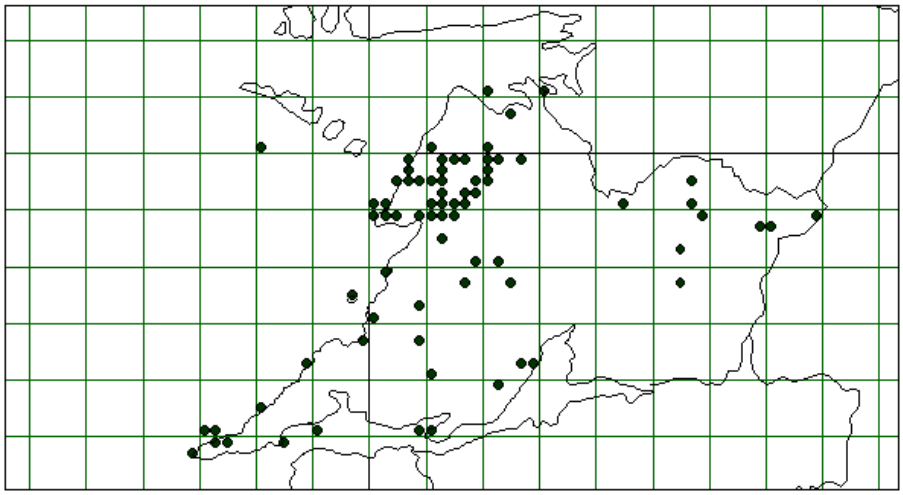
Lonicera nitida



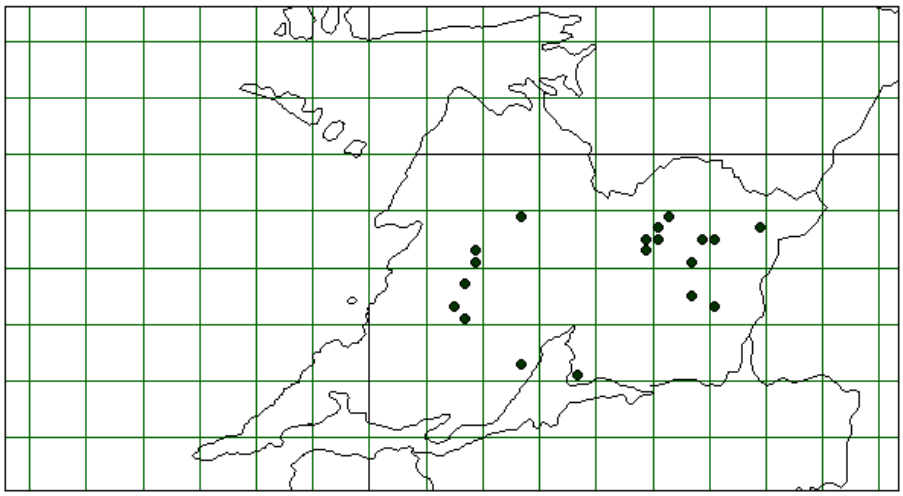
Polygonum polystachum



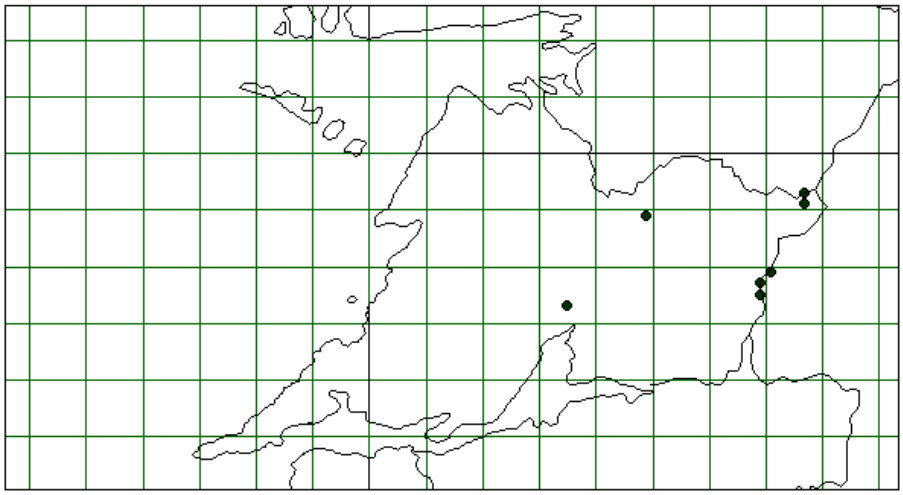
Montbretia (C. aurea x pottsii)



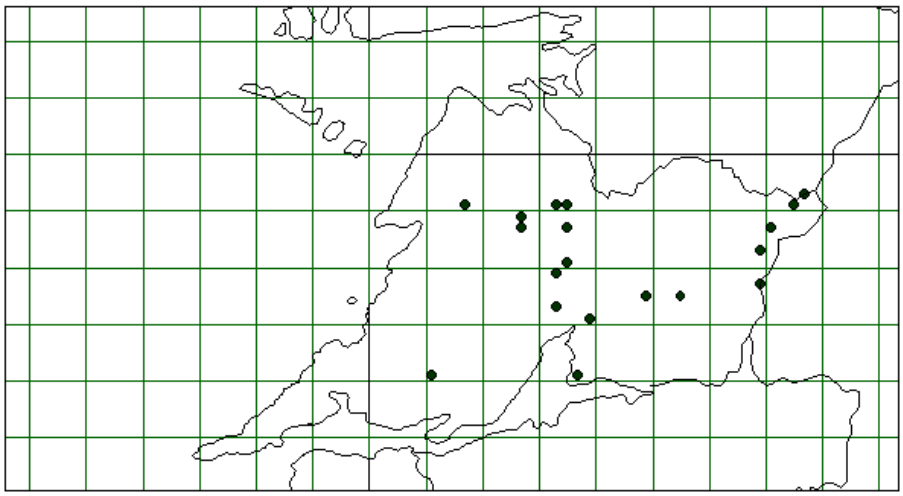
Rhododendron ponticum



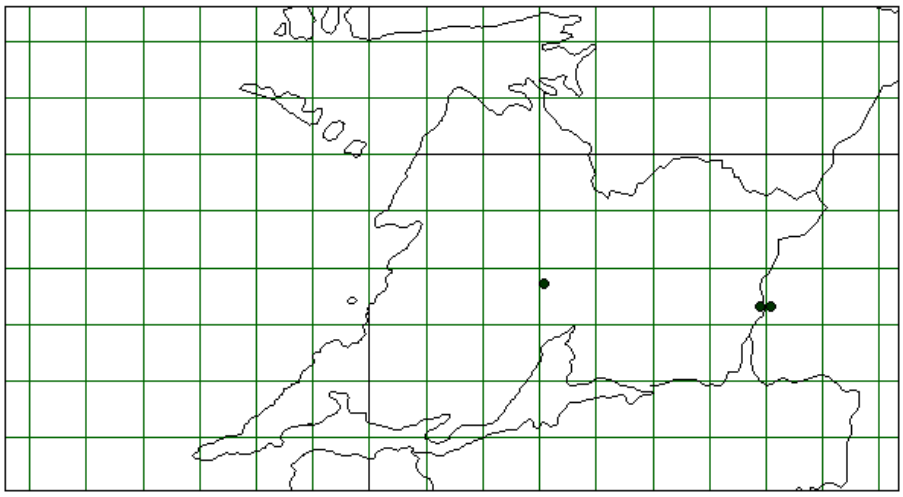
Elodea nuttallii



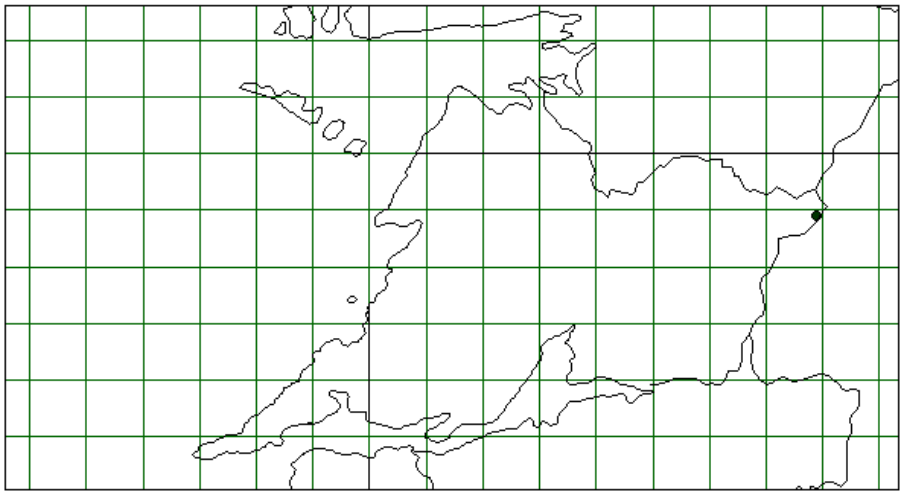
Elodea canadensis



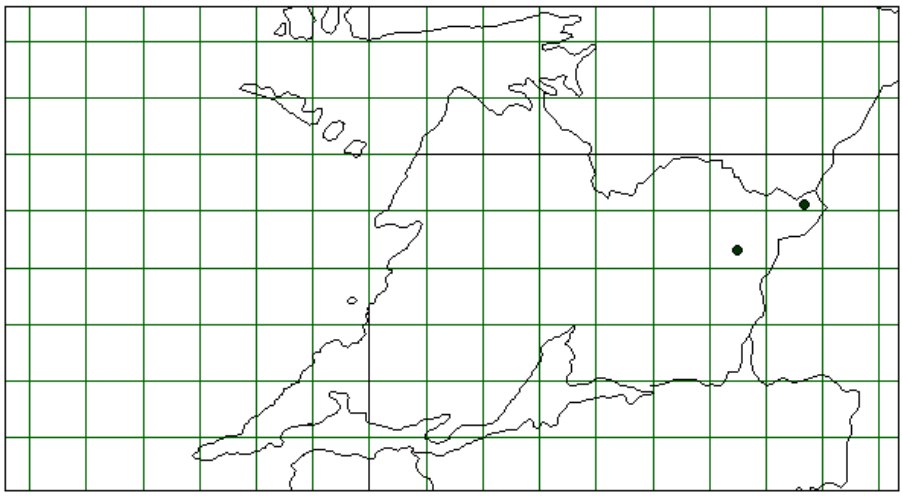
Lagorosiphon major



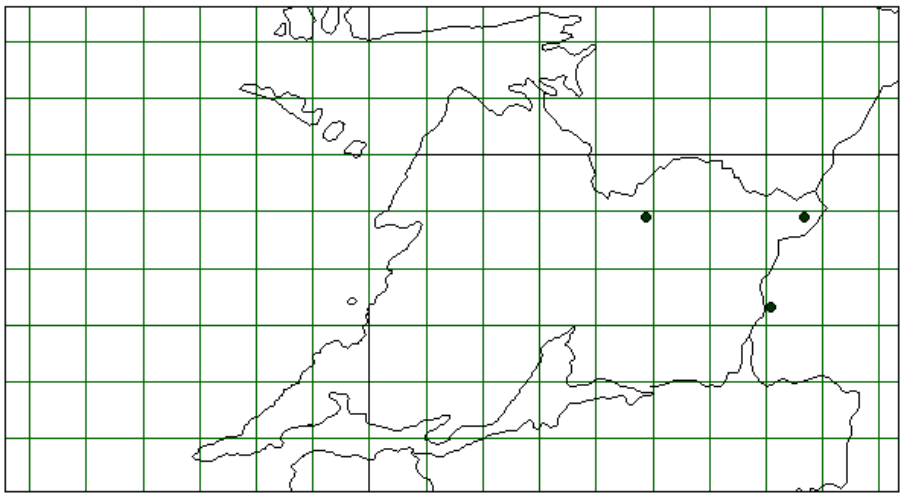
Conchopthirus acuminatus



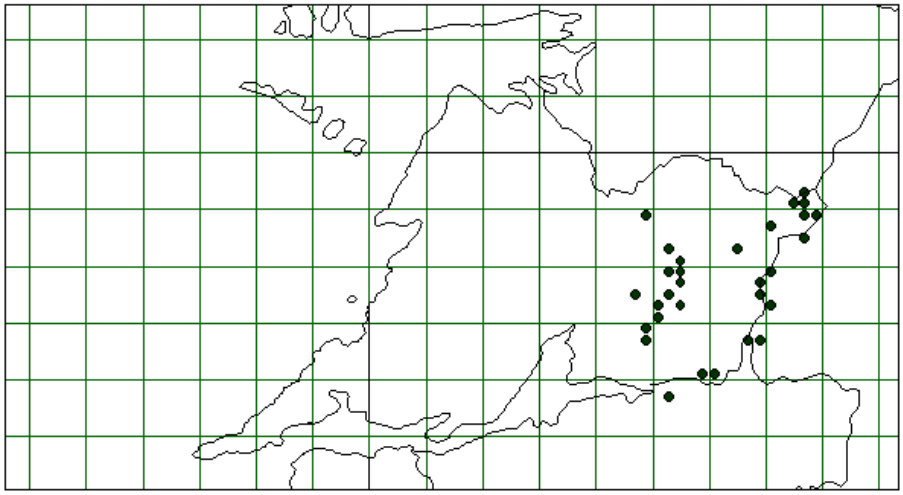
Lemna minuta



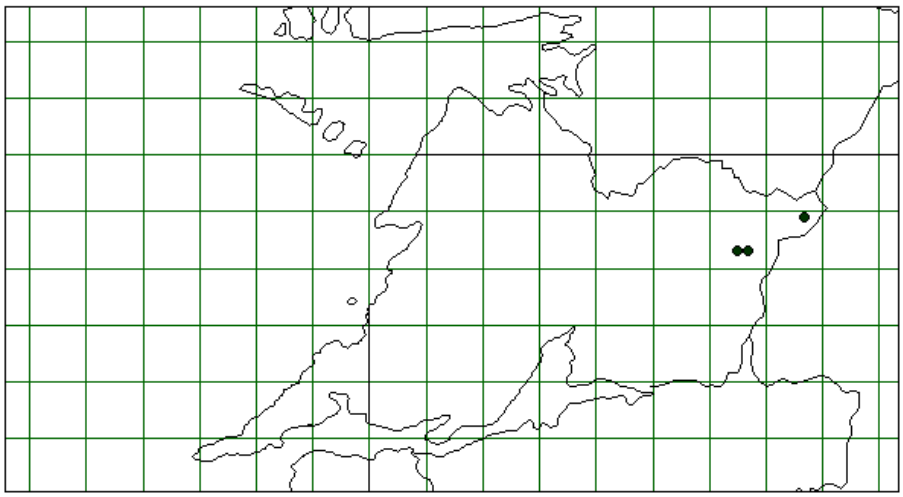
Crangonyx pseudogracilis



Dreissena polymorpha



Gammarus tigrinus



Hemimysis anomala