

Risk Assessment of *Muntiacus reevesi*

Name of Organism:	<i>Muntiacus reevesi</i> Ogilby, 1839 – Muntjac Deer
Objective:	Assess the risks associated with this species in Ireland
Version:	Final 15/09/2014
Author(s)	Ms Colette O'Flynn, Mr John Kelly and Dr Erin O'Rourke
Expert reviewer	Dr Ruth Carden

Stage 1 - Organism Information

Stage 2 - Detailed Assessment

Section A - Entry
Section B - Establishment
Section C - Spread
Section D - Impact
Section E - Conclusion
Section F - Additional Questions

About the risk assessment

This risk assessment is based on the **Non-native species Application based Risk Analysis (NAPRA)** tool (version 2.66). NAPRA is a computer based tool for undertaking risk assessment of any non-native species. It was developed by the European and Mediterranean Plant Protection Organisation (EPPO) and adapted for Ireland and Northern Ireland by Invasive Species Ireland. It is based on the Computer Aided Pest Risk Analysis (CAPRA) software package which is a similar tool used by EPPO for risk assessment.

Notes: Confidence is rated as low, medium, high or very high.
Likelihood is rated as very unlikely, unlikely, moderately likely, likely or very likely.
The percentage categories are 0% - 10%, 11% - 33%, 34% - 67%, 68% - 90% or 91% - 100%.
N/A = not applicable.

This is a joint project by Inland Fisheries Ireland and the National Biodiversity Data Centre to inform risk assessments of non-native species for the European Communities (Birds and Natural Habitats) Regulations 2011. It is supported by the National Parks and Wildlife Service.

DOCUMENT CONTROL SHEET

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Author (s):	Ms Colette O'Flynn, Mr John Kelly and Dr Erin O'Rourke				
Authorised Officer:	Dr Liam Lysaght				
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Version Control Table

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Stage 1 - Organism Information*The aim of this section is to gather basic information about the organism.*

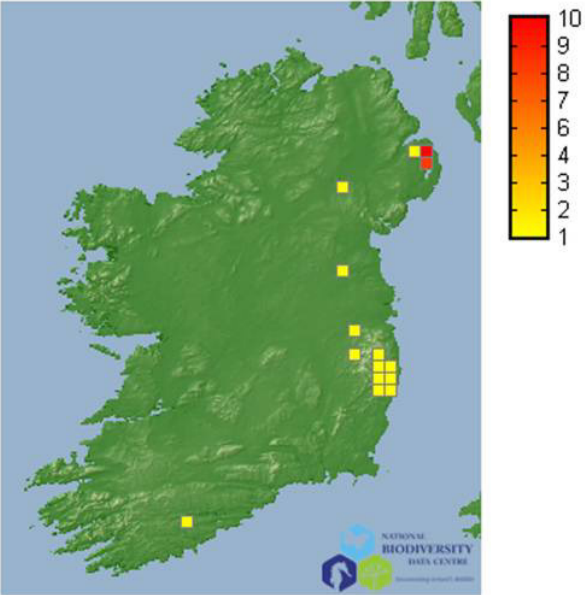
N	QUESTION	RESPONSE	COMMENT
1	What is the reason for performing the risk assessment?	-	A risk assessment is required as this species is listed as a "Non-native species subject to restrictions under Regulations 49 and 50" in the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011, SI 477/2011.
2	Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	YES	<p><i>Muntiacus reevesi</i> Ogiby, 1839 - muntjac</p> <p>Taxonomy: Kingdom: Animalia Phylum: Chordata Subphylum: Vertebrata Class: Mammalia Order: Artiodactyla Suborder: Ruminanta Family: Cervidae Subfamily: Cervinae Genus: Muntiacus Species: Muntiacus reevesi</p> <p>Synonyms: n/a</p> <p>The species is distinct from all other deer in Ireland. The genus <i>Muntiacus</i> has 12 recognised species: Indian Muntjac or Common Muntjac or Kakar <i>Muntiacus muntjak</i>; Reeves' Muntjac or Chinese Muntjac, <i>Muntiacus reevesi</i>; Hairy-fronted Muntjac or Black Muntjac, <i>Muntiacus crinifrons</i>; Fea's Muntjac, <i>Muntiacus feae</i>; Bornean Yellow Muntjac, <i>Muntiacus atherodes</i>; Roosevelt's Muntjac, <i>Muntiacus rooseveltorum</i>; Gongshan Muntjac, <i>Muntiacus gongshanensis</i>; Giant Muntjac, <i>Muntiacus vuquangensis</i>; Truong Son Muntjac <i>Muntiacus truongsongensis</i>; Leaf Muntjac <i>Muntiacus putaoensis</i>; Sumatran Muntjac <i>Muntiacus montanus</i>; Pu Hoat Muntjac <i>Muntiacus puhoatensis</i>.</p> <p>Three poorly differentiated sub spp. of Reeves' muntjac exist: 1) <i>Muntiacus reevesi reevesi</i> from the mainland of S. China; 2) <i>M. r. micrurus</i> from Taiwan (Ellerman & Morrison-Scott 1951) and 3) <i>Muntiacus r. jiangkouensis</i> from mainland China (Leasor <i>et al.</i>, 2008).</p>
3	If not a single taxonomic entity, can it be redefined? (if necessary use the response box to re-define the organism and carry on)	N/A	

Stage 1 - Organism Information*The aim of this section is to gather basic information about the organism.*

N	QUESTION	RESPONSE	COMMENT
4	Describe the organism.	-	Reeves' muntjac is the smallest deer species in Ireland. Males can range in height to shoulder from 46-52cms and females 45-50cms. Coat reddish-brown with a buff belly and extent of white on chin and inside of thighs is variable. Winter coat is a duller, greyer brown. Tail is relatively fat with a white underside and is held vertically and very prominent when alarmed. Males have short simple antlers with or without small brow tines. The pedicles of the antlers are long and continuous with bony brow-ridges which extend down the skull. The upper canine teeth are visible beyond the lip in males. Facial markings are distinct: males have black frontal stripes almost forming a V shape on the ginger coloured face along the frontal ridges and pedicles. Females have dark or black kite (diamond) shaped pattern on forehead (Chapman, 2008). Muntjac sometimes stand with back arched and commonly hold head down so rump appears higher than withers (Chapman, 2008). When disturbed they often run in a series of springing jumps. At birth, coat heavily spotted with buff spots that gradually fade and usually disappear by about 8 weeks. Fawns have female face pattern with males developing their V facial pattern by 9 months of age (Chapman, 2008).
5	Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	YES	In Ireland, a preliminary risk assessment was previously carried out. This was a prioritisation risk assessment as part of the Risk Analysis and Prioritisation for Invasive and Non-native Species in Ireland and Northern Ireland (ISI, 2012). It designated <i>Muntiacus reevesi</i> as a "high risk" invasive species.
6	If there is an earlier Risk Assessment is it still entirely valid, or only partly valid?	PARTIAL	Only a preliminary risk assessment was previously conducted in Ireland (refer to Question 5)
7	Where is the organism native?	-	The organism is a native to China; Taiwan, Province of China (Leasor <i>et al.</i> , 2008)
8	What is the current global distribution of the organism (excluding Ireland)? (map optional)	-	Native range is restricted to southeast China and Taiwan (CABI, 2014). Introduced to collections and zoos beyond native range with feral populations established in Japan, England, Belgium and the Netherlands (CABI, 2014; Chapman, 2008) and perhaps Northern Ireland (currently insufficient data available (Leasor <i>et al.</i> , 2008; Ward, 2005; Chapman <i>et al.</i> , 1994).
9	What is the current distribution of the organism in Ireland? (map optional)	-	At present, the species distribution is localised. Clusters of records exist in Counties Down and Wicklow with additional solitary records from Counties Cork, Kildare, Meath and Armagh (National Biodiversity Data Centre, 2014).

Stage 1 - Organism Information

The aim of this section is to gather basic information about the organism.

N	QUESTION	RESPONSE	COMMENT
			 <p data-bbox="940 963 1915 1015">Figure 1. Map showing all known verified records for muntjac deer per 10km² in Ireland (National Biodiversity Data Centre, 2014). Colour scale bar shows density of records per 10km².</p>
10	Is the organism known to be invasive anywhere in the world?	YES	The species is considered invasive in Britain (GB NNSS, 2011).

Stage 2 - Detailed assessment: Section A - Entry				
<i>This section evaluates the probability of entry of an organism into Ireland. For organisms which are already present, only complete the entry section for currently active pathways of entry and potential future pathways. The entry section need not be completed for pathways which have allowed an organism to enter in the past but are no longer active.</i>				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.01	How many active/future pathways are relevant to the potential entry of this organism (n/a, very few, few, moderate number, many or very many)?	FEW	HIGH	There are three possible pathways for muntjac to enter Ireland: deliberate introductions from outside Ireland e.g. from Britain; deliberate transfers from existing populations in Ireland or release/escape from captive populations within Ireland (Carden <i>et al.</i> , 2011).
1.02	List <u>significant</u> pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways.	1. Deliberate introduction/translocation/escape or release	HIGH	A native of South-east Asia with naturalised populations in Britain (Leason <i>et al.</i> , 2008) it is implausible that the species would enter Ireland naturally. Therefore, any records of this species in the island of Ireland are the result of deliberate introductions likely to be from established populations in Britain or are the result of translocations from existing populations within Ireland or are escapees or deliberate releases from captive populations. It is not known how many muntjac are currently held within private wildlife collections on the island and therefore this internal situation may prove to be a somewhat overlooked means of movement and dispersal that requires addressing.

Pathway 1 – Deliberate introduction/translocation/release				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.03	Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (e.g. the organism is a contaminant of imported goods)?	INTENTIONAL	VERY HIGH	As there is no natural pathway for this species to enter Ireland or Northern Ireland, any entry has to be intentional i.e. introduced by man. It is likely that introductions would be for sport/hunting or holdings within private wildlife collections and/or zoos.
1.04	How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year?	UNLIKELY	HIGH	There are no reliable data that exists to allow a reasonable assessment to be made of the number of animals that may, or may not, be brought into Ireland. Moreover, there is no knowledge of the number of muntjac currently held within private wildlife collections on the island. However, unknown numbers of muntjac currently held within private wildlife collections may escape (or subjected to deliberate release) may pose a

Pathway 1 – Deliberate introduction/translocation/release				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				significant problem with regards to introductions into the Irish landscape. The unknown number of muntjac currently held within private wildlife collections pose a significant threat with regards to introduction into the Irish landscape; they may escape or may be subject to deliberate release resulting in feral populations.
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	LIKELY	HIGH	It is likely that this species can enter Ireland without the knowledge of the competent authorities. This is substantiated by the records of animals recorded in Ireland that indicate successful introductions have taken place without the knowledge of the competent authorities.
1.06	How likely is the organism to survive during passage along the pathway?	LIKELY	HIGH	Deer are easily stressed but as this species has been recorded in the wild in Ireland this demonstrates that it has survived introduction to Ireland. Introduction of <i>M. reevesi</i> to Britain from native China in 1894 and 1901 (Chapman and Chapman 1982) illustrates survivalability of this species during transport over long distances and the subsequent establishment phase.
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	VERY LIKELY	VERY	As muntjac deer are aseasonal breeders, its introduction at any time of the year may result in establishment. Fawns are born in any month with no seasonal peak. Adult female muntjac exhibit a post-partum oestrus, where females often conceive within a few days of parturition (Chapman, 2008). Age at puberty is very low: first conception may occur between 5 and 6 months of age, but usually at 7 months or later (Chapman, 2008).
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	LIKELY	HIGH	Muntjac deer are a shy and secretive species and may go undetected initially until such a time their densities increase and range is extended. Muntjac deer are a mobile species that can move from their area of initial introduction wherever suitable habitat can be reached, although their overall range may be limited by mountain ranges and other natural barriers. However, due to the eagerness of individuals to establish this species in Ireland, this may lead to (illegal) secondary translocations past natural barriers (Chapman <i>et al.</i> , 1994). Muntjac are able to adapt to a range of habitats, providing they encompass suitable forage and cover (GB NNSS, 2011).

Pathway 1 – Deliberate introduction/translocation/release				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	VERY LIKELY	VERY HIGH	The likelihood is high following confirmed records of the species in Ireland (Carden <i>et al.</i> , 2011; National Biodiversity Data Centre, 2014).
1.10	Do other pathways need to be considered?	NO	HIGH	

Overall likelihood				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.11	Estimate the overall likelihood of entry into Ireland based on all pathways (comment on the key issues that lead to this conclusion).	VERY LIKELY	VERY HIGH	The likelihood of entry into Ireland is high as introductions have already taken place. It is possible, that further introductions from Britain or translocations from existing captive and/or feral populations within Ireland will take place.

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.01	Is the organism well established in Ireland (if there is any uncertainty answer 'unsure')	NO	HIGH	<p>A total of 32 verifiable records from Ireland and Northern Ireland currently exist (National Biodiversity Data Centre, 2014). The majority of the verifiable records originate from two counties: Down and Wicklow. The first verified record of this species originates from Avoca, Co. Wicklow when an animal was shot in 2007 (Dick <i>et al.</i>, 2009). Further confirmed records from Wicklow, exist for 2008 but no further records exist beyond this year for County Wicklow (National Biodiversity Data Centre, 2014).</p> <p>The second location that verified records originate from is the Ard's peninsula in Co. Down. The first record of this species in County Down comes from a sighting made in June 2009 (Dick <i>et al.</i>, 2014). This was followed by several more sightings in 2009, 2010 and 2011 (National Biodiversity Data Centre, 2014). A further photograph of an individual was recorded from the Mount Stewart estate in 2011 (National Biodiversity Data Centre, 2014). It is likely that the species is established in Mount Stewart in Co. Down although this has not been published.</p> <p>Sightings of muntjac are low (average of 4.6 records per year since 2007) in Ireland with the majority originating from two locations (National Biodiversity Data Centre, 2014). It is therefore unlikely that the species is well established at present in Ireland. However, insufficient published data to date exists for Northern Ireland (in particular Mount Stewart) thus establishment status of muntjac is undefined, as yet, within this region.</p>
2.02	How likely is it that the organism will be able to establish in Ireland based on the similarity between local <u>climatic conditions</u> and the organism's current global distribution?	VERY LIKELY	VERY HIGH	<p>There is little similarity between the climatic conditions of the muntjac's native range and Ireland. However, Ireland shares a similar climate to Britain where it is already established. Muntjac are highly adaptable to different environments. Muntjac's preferred climate is that of warm temperate climate with dry summers and winters (>10Cel to >0Cel). Therefore it is likely that the species could establish within the island of Ireland.</p>

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N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.03	How likely is it that the organism will be able to establish in Ireland based on the similarity between other local <u>abiotic conditions</u> and the organism's current global distribution?	LIKELY	HIGH	It is likely that the species could establish in Ireland due to the similarities of their abiotic conditions with Britain.
2.04	How likely is the organism to encounter habitats necessary for the survival, development and multiplication of the organism in Ireland?	LIKELY	HIGH	<p>If introduced to Ireland, introductions are likely to take place in habitats suitable for survival, development and multiplication of the organism i.e. broadleaved and coniferous woodland. These environments are the preferred habitats for this species as they provide diversity of ground flora necessary for its diet (Chapman, 2008). Muntjac are concentrate selections (<i>sensu</i> Hofmann, 1985); as a result they are primarily browsers but also select herbs and forbs of high nitrogen content as well as fruit. The species can also exist in, young un-thinned plantation and coniferous forest when small areas of deciduous planting exist (Chapman, 2008) and where suitable understorey vegetation exists (e.g. bramble, ivy, ferns, fungi, other fruits and shrubs) as well as grasses (Keeling, 1995; Harris and Forde, 1986).</p> <p>In 2012, Ireland's forest cover is 10.5% of total land area (DAFM, 2013). The low forest cover at present may reduce the areas that the species can establish in Ireland.</p>
2.05	How likely is it that establishment will occur despite competition from existing species in Ireland?	VERY LIKELY	HIGH	No evidence exists that muntjac will be in direct competition with any other species in Ireland. Studies from Britain do indicate that muntjac can outcompete roe deer (<i>Capreolus capreolus</i>) when both species occur (Hemami, 2005). However, roe deer are not currently present in Ireland. In Britain, they are sympatric with fallow deer (Ward 2005).

Stage 2 - Detailed assessment: Section B - Establishment

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N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.06	How likely is it that establishment will occur despite predators, parasites or pathogens already present in Ireland?	VERY LIKELY	HIGH	The species has no natural predators in Britain or Ireland. Although, the red fox may cause significant mortality on juvenile muntjac through direct predation (Chapman, 2008). Few diseases are known from wild populations resident in Britain and few endoparasites are known (Chapman, 2008).
2.07	How likely is it that establishment will occur despite existing management practices?	LIKELY	HIGH	At present there are no known management practices geared towards this species. Therefore, it is unknown how likely establishment will be despite the implementation of management practices.
2.08	How likely is it that management practices in Ireland will facilitate the establishment of the organism?	LIKELY	MEDIUM	Given that the species favoured habitat is woodland there would be any expectation that increases in forest land cover would aid establishment. In general, however, it is unknown at present whether sectoral (e.g. agriculture, forestry, transport) management practices will facilitate the establishment of this species.
2.09	How likely is it that the biological characteristics of the organism would allow it to survive eradication campaigns in Ireland?	LIKELY	HIGH	The species in question is shy and secretive, under one metre in height, brown in colour, prefers dense vegetation with ground cover, is most active around dawn and dusk and is solitary for the majority of its life (does not occur in herds like other deer species), and has a high reproductive potential (Chapman, 2008). Therefore, these characteristics are likely to make it hard to eradicate the species from Ireland.
2.10	How likely is it that the biological characteristics of the organism will facilitate its establishment?	LIKELY	VERY HIGH	The species has established in Britain, a similar environment to the Ireland, therefore it is likely that this species' biological characteristics will facilitate its establishment. Furthermore, the species has the capacity, unlike other deer populations in Ireland, to breed all year round, is long lived and can breed from the age of 7 months (Chapman, 2008).

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.11	How likely is it that the organism's capacity to spread will facilitate its establishment?	LIKELY	MEDIUM	Studies from Britain indicate that it is difficult to determine natural expansion rates due to secondary translocations. Rates of spread between 1 and 2.4 km per year have been suggested (Chapman <i>et al.</i> , 1994) whilst a distribution expansion of a compound rate of 8.2% per year has been recorded in Britain (Ward, 2005).
2.12	How likely is it that the organism's adaptability will facilitate its establishment?	MODERATELY LIKELY	VERY HIGH	Reeves' muntjac originates from a sub-tropical environment and has established in the temperate climate of Britain. Therefore, it is likely that the species adaptability will facilitate its establishment in Ireland.
2.13	How likely is it that the organism could establish despite low genetic diversity in the founder population?	LIKELY	LOW	There are little data available to inform whether the species could establish with low genetic diversity.
2.14	Based on the history of invasion by this organism elsewhere in the world, how likely is it to establish in Ireland? If possible, specify the instances of invasion elsewhere in the justification box	LIKELY	HIGH	If introduced to Ireland it is likely that the species could establish as Ireland shares a similar temperate environment to Britain where it is already established. Similar environments that the species is established within Britain e.g. deciduous and coniferous woodland and semi-urban/urban environments (undisturbed gardens and cemeteries) exist in Ireland.
2.15	If the organism does not establish, then how likely is it that transient populations will continue to occur?	MODERATELY LIKELY	MEDIUM	Male muntjac have been recorded up to 10 years old in the wild and females 13 years (Chapman, 2008). If not eradicated it is possible that transient populations would continue to occur.
2.16	Estimate the overall likelihood of establishment. Mention any key issues in the comments box	LIKELY	HIGH	Establishment is likely in Ireland due to the adaptability of the species, similarity of suitable habitats in Ireland for the species establishment and similarity of climate to Britain where the muntjac has already been successfully introduced. Establishment and range expansion likely given the attainment of puberty at a young age and the reproductive biology (aseasonal breeders) of this species in conjunction with the secretive nature of this small cervid species and its capability of ingesting a wide range of foods with few natural enemies.

Stage 2 - Detailed assessment: Section C - Spread

This section evaluates the probability of spread of an organism within Ireland. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.01	What area (given in % or 10km squares) in Ireland could the organism establish (0% - 10%, 11% - 33%, 34% - 67%, 68% - 90% or 91% - 100%)?	11% -33%	LOW	The habitats suitable for the establishment of muntjac are broadleaved woodland and coniferous forest (and semi-urban and urban areas). The afforested habitats are limited to approximately 11% (700,053 – 763,251ha) of Ireland and 4.3% (62,000ha) of Northern Ireland is forested (DAFM, 2011, 2013). Assuming muntjac established in Ireland and expanded at the same rate as in Britain we could assume about 15% of the island of Ireland to be occupied by muntjac in 100 years from the time of introduction. This is based on landcover of broadleaved and coniferous forest. If scrub and overgrown and undisturbed gardens were added to this then the figure could be higher.
3.02	How important is the expected spread of this organism in Ireland by <u>natural</u> means (minimal, minor, moderate, major or massive)?	MODERATE	MEDIUM	The expected natural spread of muntjac in Ireland would be expected to be similar to that for the species in Britain i.e. 1 to 2.4 km per year (Chapman <i>et al.</i> , 1994; Harding 1986).
3.03	How important is the expected spread of this organism in Ireland by <u>human assistance</u> (minimal, minor, moderate, major or massive)?	MODERATE	MEDIUM	Human assistance in Britain is thought to increase the rate of spread from 1 km per year (natural) to 2.4km per year (Chapman <i>et al.</i> ,1994). Therefore, it is likely to be an important factor in the spread of muntjac in Ireland, in particular with regards to overcoming natural barriers such as mountains.
3.04	Within Ireland, how difficult would it be to contain the organism (minimal, minor, moderate, major or massive)?	MODERATE	MEDIUM	The habitats suitable for the establishment of muntjac are broadleaved woodland and coniferous forest. These habitats are limited to nearly 11% in the Republic of Ireland in 2012 (DAFM, 2013). Therefore, it will likely be difficult to contain the organism as this is a large area within a diverse landscape mosaic.
3.05	What proportion (%) of the area in Ireland suitable for establishment, if any, has already been colonised by the organism?	0% -10%	MEDIUM	Approximately 11% (745,000ha) of Ireland and 4.3% (62,000ha) of Northern Ireland is forested (DAFM, 2011, 2013). Both commercial forestry and broadleaved woodland is suitable for this species (with a preference for broadleaved forest) therefore we can assume that these areas have the potential to be suitable for the establishment of this species. At present, there are 15 10km ² grid squares with records of muntjac but it is not known at present if these records represent individuals from established populations.

Stage 2 - Detailed assessment: Section C - Spread

This section evaluates the probability of spread of an organism within Ireland. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.06	What proportion of the area in Ireland suitable for establishment, if any, do you expect to have been invaded by the organism five years from now (including any current presence)?	0% -10%	LOW	At present, about 15% of the island of Ireland is covered in the species favoured habitat i.e. broadleaved and coniferous woodland. has suitable habitat for this species and . We know that the rate of colonisation in Britain is between 1 and 2.4km per year (Harding, 1986; Chapman <i>et al.</i> , 1994). Therefore, we could expect that if the records of this species from Ireland represent a breeding population, in five years the species would have expanded its range by 5 to 12 km in each locality. However, it is not believed that the species is established in all areas where it has been recorded therefore the area expected to be invaded by muntjac deer 5 years from now remains very low in the 0% to 10% range.
3.07	What other timeframe would be appropriate to estimate any significant further spread of the organism (10, 20, 40, 80 or 160 years)? Please comment on why this timeframe is chosen.	10 years	LOW	This time frame was chosen as it is the smallest time period available. We would recommend a shorter timeframe to monitor the species in order to assess whether records of this species increase in Counties Down and Wicklow which may suggest a breeding population. If an increase in records indicated a breeding population then appropriate management would be required. The longer a population is left to breed the more expensive the eventual management response will be.
3.08	In this timeframe, what proportion of the area (including any currently occupied areas) is likely to have been invaded by this organism?	0% - 10%	LOW	Current records of this species in Ireland are from just 15 of Ireland's approximately 1018 hectads (10km ²) with a concentration of records in two counties. As it is not expected that the species is well established in Ireland and as the total potential ideal afforested habitat for this species is about 11%, the area to have been invaded by muntjac deer in 10 years is low at 0% - 10%. However, current records are based on reported sightings and not on any systematic island-wide surveillance and monitoring and therefore, at present, we don't know how much of this habitat is invaded by this species.
3.09	Based on the answers to questions on the potential for establishment and spread in Ireland, define the area endangered by the organism. Be as specific as possible. If available, provide a map showing the area most likely to be endangered.	-	MEDIUM	Deciduous, mixed and coniferous forestry is most endangered to muntjac invasion/naturalisation. The species can also inhabit scrub, agricultural and horticultural land, gardens and cemeteries

Stage 2 - Detailed assessment: Section C - Spread

This section evaluates the probability of spread of an organism within Ireland. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.10	Estimate the overall potential for future spread for this organism in (very slowly, slowly, moderately, rapidly or very rapidly). Use the justification box to indicate any key issues.	MODERATLEY	MEDIUM	If breeding populations establish in Ireland then we can expect the rate of spread of this species to be similar to that recorded in Britain i.e. 1-2.4 km per year. The species is likely to be introduced and/or encounter suitable habitat giving it the potential to spread.

Stage 2 - Detailed assessment: Section D - Impact

This section evaluates the probability of impact of an organism within Ireland.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.01	How great is the economic loss caused by the organism within its global distribution (excluding Ireland), including the cost of any current management?	MODERATE	MEDIUM	<p>The greatest economic impact that muntjac have is via Road Traffic Collisions (RTCs) in Britain. Where the species is known in relation to RTC's, muntjac represent 28% of the collisions in England (Langbein, 2011). The estimated minimum annual cost arising from deer-related RTCs in the East of England was between £4,293,416 and £4,769,366 (White <i>et al.</i>, 2013). The proportion of this cost which can be attributed to muntjac is not known; however, it was noted that muntjac deer were considerably the most abundant deer species in the area.</p> <p>Negative impacts by muntjac on agriculture may be in the form of localised damage to arable crops, soft fruit nurseries and or horticulture. Presently, muntjac are not causing high levels of agricultural damage within Britain but local problems occur with horticulture crops (Putman and Moore, 1998) or in gardens (Chapman <i>et al.</i>, 1994).</p> <p>In Britain, localised damage to forestry affects tree establishment phase through planted saplings or natural regenerating saplings, and localised damage (browsing and stem breakage) to coppice (Cooke, 2006, 1998, 1994; Cooke and Farrell, 2001).</p> <p>Where muntjac densities are high in Britain, negative impacts on conservation woodland may be serious (Chapman, 2008; Cooke, 2005) with direct damage to ground vegetation (e.g. Cooke 2006; Tabor, 1993; Rackham, 1975).</p>
4.02	How great has the economic cost of the organism been in Ireland from the <u>time of introduction to the present</u> ? Exclude any costs associated with managing the organism from your answer.	MINIMAL	MEDIUM	It is not known if this species has had any impact within any of the areas it has been recorded.
4.03	How great is the economic cost of the organism likely to be in the <u>future</u> in Ireland? Exclude any costs associated with managing the organism from your answer.	MINOR	MEDIUM	If the species becomes widespread in Ireland the cost associated with RTCs will be lower than that recorded in Britain as the population and number of cars on the roads on the island of Ireland is lower. However, no assessment of what this figure would be can be made at the moment. There are insufficient data available at present to forecast economic losses due to negative impacts/damage by this species on commercial forest, conservation woodlands, agriculture and horticulture crops.

Stage 2 - Detailed assessment: Section D - Impact

This section evaluates the probability of impact of an organism within Ireland.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.04	How great have the economic costs of managing this organism been in Ireland from the <u>time of introduction to the present</u> ?	MINIMAL	HIGH	There is currently no management of this species in place in Ireland to estimate economic costs from.
4.05	How great is the economic cost of managing this organism likely to be in the <u>future</u> in Ireland?	MODERATE	MEDIUM	The economic cost of managing muntjac depends on whether or not breeding populations establish in Ireland and whether these populations spread. At present this information is not known for Ireland so it is difficult to make an assessment. However, Scottish Natural Heritage conducted a study to estimate the costs associated with culling and managing muntjac populations if they were to arrive in Scotland (Ward and Lees, 2011). The number of man days required to eradicate a population of 5 muntjac was between 21 and 66 days and for a population of 200 muntjac was between 34 and 127 days (Ward and Lees, 2011). The associated cost to eradicate a population of 5 animals was between £3683 and £11558 and for a population of 200, between £6250 and £22525 (Ward and Lees, 2011).
4.06	How important is environmental harm caused by the organism within its global distribution?	MAJOR	HIGH	The level of harm caused by muntjac appears to depend on the density reached within habitats sensitive to their presence (Cooke, 2004). A greater range of impacts are observed at higher densities of this species in woodland (Cooke, 2004). Grazing by muntjac can alter floral communities within woodland leading to suppression of flowering species and an increase in grasses and sedges (Cooke, 2004).
4.07	How important has the impact of the organism on biodiversity* been in Ireland from the time of introduction to the present? *e.g. decline in native species, changes in community structure, hybridisation	MINIMAL	MEDIUM	There has been no research conducted to date assessing the species impact on Ireland's biodiversity. Therefore, no assessment can be made at present.
4.08	How important is the impact of the organism on biodiversity likely to be in the <u>future</u> in Ireland?	MAJOR	VERY HIGH	The largest recorded direct impact muntjac have on biodiversity is of the flora within broad leaved woodland. At high densities, grazing by muntjac has a negative impact on coppice regrowth and flowering of ground flora species including; bramble (<i>Rubus fruticosus</i>), primrose (<i>Primula vulgaris</i>), blue bell (<i>Hyacinthoides non-scripta</i>), violet (<i>Viola sp</i>), wood anemone (<i>Anemone nemorosa</i>) and orchids e.g. early purple orchid (<i>Orchis mascula</i>) (Cooke and Farrell, 2001). High density grazing can

Stage 2 - Detailed assessment: Section D - Impact

This section evaluates the probability of impact of an organism within Ireland.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				<p>result in changes of flora communities in woodland, often leading to an increase in sedge and grasses (Cooke and Farrell, 2001). It is debatable if muntjac occurred at low/moderate densities whether such damage would be as serious and as of yet there are no studies which have examined the impact of different grazing intensities.</p> <p>As a consequence of the direct impacts of muntjac i.e. high density grazing, indirect impacts have also been recorded. Changes in invertebrate communities occur as a result in changes of flora and reduction in occurrence of some vertebrate communities have also been recorded. However, impacts on vertebrates have been recorded in species that do not occur in Ireland at present e.g. Chinese water deer (<i>Hydropotes inermis</i>) and nightingale (<i>Luscinia megarhynchos</i>) (Cooke and Farrell, 2001).</p>
4.09	How important has alteration of ecosystem function* caused by the organism been in Ireland from the time of introduction to the present? *e.g. habitat change, nutrient cycling, trophic interactions	MINIMAL	MEDIUM	There has been no research conducted to date assessing the species impact on the ecosystem functioning within Ireland. Therefore, an assessment cannot be made at present.
4.10	How important is alteration of ecosystem function caused by the organism likely to be in Ireland in the <u>future</u> ?	MINOR	MEDIUM	There is evidence from Britain that shows changes in the ground flora community within woodlands containing high densities of muntjac (Cooke and Farrell, 2001). However, no assessment (that we are aware of) has been made on the impact this has on broadleaved woodlands.
4.11	How important has decline in conservation status* caused by the organism been in Ireland from the time of introduction to the present? *e.g. sites of nature conservation value, WFD classification, etc.	MINIMAL	MEDIUM	There has been no research conducted to date assessing the species impact on Ireland's biodiversity. Therefore, we can't make an assessment at present.
4.12	How important is decline in conservation status caused by the organism likely to be in the <u>future</u> in Ireland?	MODERATE	MEDIUM	It is possible that this species will impact on priority species and rarer ground flora found in woodlands of Ireland and not Britain e.g. green flowered helliborine (<i>Epipactis phyllanthes</i>).

Stage 2 - Detailed assessment: Section D - Impact				
<i>This section evaluates the probability of impact of an organism within Ireland.</i>				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.13	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within its global distribution?	MINIMAL	MEDIUM	There is potential for livestock disease transmission to humans. Muntjac can be infected with TB but this has yet to be recorded in wild populations in Britain (Chapman, 2008).
4.14	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within Ireland?	MINIMAL	MEDIUM	At present there is no measure of the level of social or human health harm caused by muntjac in Ireland. Additionally, the illegal imports/translocations of muntjac are not veterinary checked nor quarantined, so risk is unknown.
4.15	How important is it that genetic traits of the organism could be carried to other organisms / species, modifying their genetic nature and making their economic, environmental or social effects more serious?	MINIMAL	HIGH	Reeves' muntjac can hybridise with Indian muntjac (<i>Muntiacus muntjak</i>) but the offspring are infertile (Chapman, 2008). No Indian muntjac are recorded in Ireland therefore, the importance of transfer of genetic traits is minimal.
4.16	How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?	MODERATE	MEDIUM	Deer are ruminants and share in the susceptibility to a range of infectious diseases that affect farmed ruminants (cattle, sheep and goats). Deer are at risk of acquiring infections from farm animals with which they may come into contact with. Muntjac can be infected with TB but this has yet to be recorded in wild populations in Britain (Chapman, 2008). If illegal translocations/introductions continue, the greater potential for transmission of such diseases from domestic livestock to wild (feral) deer populations (and potentially vice versa) as ranges expand and potential frequencies of meeting occur. The latter may act as a reservoir in the wild landscape with respect to the farming community is potentially serious. Deer are also at risk of acquiring diseases of farmed ruminants that transmitted indirectly in insect vectors. Such diseases include for example, Schmallenberg virus and blue tongue virus. If muntjac are illegally translocated from Britain to Ireland and are disease infected, there are no veterinary checks/quarantine procedures for something that is illegally being brought on to this island.

Stage 2 - Detailed assessment: Section D - Impact				
<i>This section evaluates the probability of impact of an organism within Ireland.</i>				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.17	How important might other impacts not already covered by previous questions be resulting from introduction of the organism? Specify in the justification box.	N/A	MEDIUM	We are not aware of any other impacts the introduction of this species would have.
4.18	How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in Ireland?	MODERATE	HIGH	Natural predator is the red fox, which may cause significant mortality on juvenile muntjac through direct predation (Chapman, 2008). Although, few diseases are known from wild populations resident in Britain and few endoparasites are known (Chapman, 2008), muntjac, as ruminants, are susceptible to a range of infectious diseases (refer to Question 4.16). As such, muntjac may negatively affect both livestock and human health through disease transmission. At high densities their impact is likely to be greatest on the flora of broadleaved woodlands having the potential to change the ground flora communities in these habitats. A secondary impact will be economic, arising from road traffic collisions.
4.19	Indicate any parts of where economic, environmental and social impacts are particularly likely to occur. Provide as much detail as possible, where possible include a map showing vulnerable areas.	-	MEDIUM	Environmental impacts will potentially be greatest in broad leaved woodlands and to certain horticulture crops Economic impacts arising from road traffic collisions will be greatest where roads and woodlands are located. To assess the risk arising from road use in these locations will require a further assessment.
4.20	Estimate the overall potential impact of this organism in Ireland. Use the justification box to indicate any key issues.	MODERATE	HIGH	The potential impact would be greatest in deciduous, mixed and coniferous forestry sector and may, when established at high densities, negatively effect plant and invertebrate communities within this habitat in Ireland. Muntjac may be vectors of disease which posing significant risks and threats to the agricultural sector i.e. ruminant industry. They may be pests of horticultural fruit production e.g. raspberries. The impact via road traffic collisions is to be considered as likely in areas where they establish in high densities.

Stage 2 - Detailed assessment: Section E - Conclusion

This section requires the assessor to provide a score for the overall risk posed by an organism, taking into account previous answers to entry, establishment, spread and impact questions.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
5.01	Estimate the overall risk of this organism in Ireland. Noting answers given in 1.11, 2.16, 3.10 & 4.20	MODERATE	MEDIUM	<p>The likelihood of entry into Ireland is high as introductions have already taken place. It is possible, that further introductions from Britain or translocations from existing populations within Ireland will take place.</p> <p>Establishment is likely in Ireland due to the adaptability of the species, similarity of suitable habitats in Ireland for the species establishment and similarity of climate to Britain where the muntjac has already been successfully introduced.</p> <p>If breeding populations establish in Ireland then we can expect the rate of spread of this species to be similar to that recorded in Britain i.e. 1-2.4 km per year. The species is likely to be introduced and/or encounter suitable habitat giving it the potential to spread.</p> <p>The potential impact would be greatest in deciduous, mixed and coniferous forestry sector and may, when established at high densities, negatively affect plant and invertebrate communities within this habitat in Ireland. Muntjac may be vectors of disease which pose significant risks and threats to the agricultural sector i.e. ruminant industry. They may be pests of horticultural fruit production e.g. raspberries. The impact via road traffic collisions is to be considered as likely in areas where they establish in high densities.</p>

Stage 2 - Detailed assessment: Section F – Additional questions

This section is used to gather information about the potential effects of climate change on the risk posed by an organism. It is also an opportunity for the risk assessor to highlight high priority research that could help improve the risk assessment.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
6.01	What aspects of climate change, if any, are most likely to affect the risk assessment for this organism?	-	LOW	As the species originates from a sub-tropical climate, climate change i.e. increase in temperatures may increase the chances of establishment in Ireland depending on suitable available forage. Possibility of expansion of biting insects that favour warmer climates and which act as vectors for certain diseases that affect wild and domestic ruminants.
6.02	What is the likely timeframe for such changes (5, 10, 15, 20, 50 or 100 years)?	100 YEARS	LOW	There is no studies at present to allow this assessment to be made.
6.03	What aspects of the risk assessment are most likely to change as a result of climate change	-	LOW	Refer to Question 6.01.
6.04	If there is any research that would significantly strengthen confidence in the risk assessment, please note this here. If more than one research area is provided, please list in order of priority.	-	MEDIUM	Modelling of the species potential rate of spread and likely distribution in Ireland would significantly strengthen the confidence in this risk assessment. Such research is currently being conducted but is not advanced enough at this time to provide assistance to this risk assessment (Ruth Carden, per. comm., 9 th February 2014).

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