

## Information about GB Non-native Species Risk Assessments

The Convention on Biological Diversity (CBD) emphasises the need for a precautionary approach towards non-native species where there is often a lack of firm scientific evidence. It also strongly promotes the use of good quality risk assessment to help underpin this approach. The GB risk analysis mechanism has been developed to help facilitate such an approach in Great Britain. It complies with the CBD and reflects standards used by other schemes such as the Intergovernmental Panel on Climate Change, European Plant Protection Organisation and European Food Safety Authority to ensure good practice.

Risk assessments, along with other information, are used to help support decision making in Great Britain. They do not in themselves determine government policy.

The Non-native Species Secretariat (NNSS) manages the risk analysis process on behalf of the GB Programme Board for Non-native Species. Risk assessments are carried out by independent experts from a range of organisations. As part of the risk analysis process risk assessments are:

- Completed using a consistent risk assessment template to ensure that the full range of issues recognised in international standards are addressed.
- Drafted by an independent expert on the species and peer reviewed by a different expert.
- Approved by an independent risk analysis panel (known as the Non-native Species Risk Analysis Panel or NNRAP) only when they are satisfied the assessment is fit-for-purpose.
- Approved for publication by the GB Programme Board for Non-native Species.
- Placed on the GB Non-native Species Secretariat (NNSS) website for a three month period of public comment.
- Finalised by the risk assessor to the satisfaction of the NNRAP.

To find out more about the risk analysis mechanism go to: [www.nonnativespecies.org](http://www.nonnativespecies.org)

### Common misconceptions about risk assessments

To address a number of common misconceptions about non-native species risk assessments, the following points should be noted:

- Risk assessments consider only the risks posed by a species. They do not consider the practicalities, impacts or other issues relating to the management of the species. They therefore cannot on their own be used to determine what, if any, management response should be undertaken.
- Risk assessments are about negative impacts and are not meant to consider positive impacts that may also occur. The positive impacts would be considered as part of an overall policy decision.
- Risk assessments are advisory and therefore part of the suite of information on which policy decisions are based.
- Completed risk assessments are not final and absolute. Substantive new scientific evidence may prompt a re-evaluation of the risks and/or a change of policy.

### Period for comment

Draft risk assessments are available for a period of three months from the date of posting on the NNSS website\*. During this time stakeholders are invited to comment on the scientific evidence which underpins the assessments or provide information on other relevant evidence or research that may be available. Relevant comments are collated by the NNSS and sent to the risk assessor. The assessor reviews the comments and, if necessary, amends the risk assessment. The final risk assessment is then checked and approved by the NNRAP.

\*risk assessments are posted online at:

<https://secure.fera.defra.gov.uk/nonnativespecies/index.cfm?sectionid=51>  
comments should be emailed to [nnss@fera.gsi.gov.uk](mailto:nnss@fera.gsi.gov.uk)

## GB NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

For more information visit: [www.nonnativespecies.org](http://www.nonnativespecies.org)

<b>Name of Organism:</b>		<b><i>Hydropotes inermis</i> - Chinese water deer</b>	
<b>Objectives:</b>		Assess the risks associated with this species in GB	
<b>Version:</b>		Original draft 22/02/11	
<b>Author:</b>		A. Cooke	
<b>Suggested citation:</b>		Cooke (2011). GB Non-native Organism Risk Assessment for <i>Hydropotes inermis</i> . <a href="http://www.nonnativespecies.org">www.nonnativespecies.org</a>	
N	QUESTION	RESPONSE	COMMENT
1	What is the reason for performing the Risk Assessment?		Request by the GB Programme Board for Non-native Species
2	What is the Risk Assessment area?	Great Britain	
3	Does a relevant earlier Risk Assessment exist?	NO OR UNKNOWN (Go to 5)	
4	If there is an earlier Risk Assessment is it still entirely valid, or only partly valid?		
<b>Stage 2: Organism Risk Assessment</b>			
<b>SECTION A: Organism Screening</b>			
5	Identify the Organism. Is the organism clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	YES (Give the full name & Go to 7)	<i>Hydropotes inermis</i> - Chinese water deer. Two subspecies exist. <i>H.i. inermis</i> is found in parts of China and is the subspecies assumed to have been introduced into Britain. <i>H.i. argyropus</i> is found in Korea.
6	If not a single taxonomic entity, can it be redefined?		
7	Is the organism in its present range known to be invasive, i.e. to threaten species, habitats or ecosystems?	YES (Go to 9)	In historic times the water deer was 'a common animal that roamed over most of China' (Zhang, 1996). Swinhoe (1870) described Chinese water deer as abundant on islands in the River Yangtze above Chinkiang. He considered that, although they probably fed on crops such as sweet-potatoes and cabbages, they could not do much damage as the farmers allowed them to exist in such numbers. There is, however, reference to 50 deer being killed because they fed on farm crops (Sheng & Lu, 1985). The species has become rare in China, numbering only 10000-30000 in the early 1990s (Sheng, 1992; Sheng & Ohtaishi, 1993), and having decreased further since then (Harris & Duckworth, 2008). In 2008, it was classified on the IUCN Red List as "Vulnerable" (Harris & Duckworth, 2008). Zhang (pers. comm.) has estimated the total population to be about 10000 in 2009.
8	Does the organism have intrinsic attributes that indicate that it could be invasive, i.e. threaten species, habitats or ecosystems?		
9	Does the organism occur outside effective containment in the Risk Assessment area?	YES (Go to 10)	About 1500 Chinese water deer were estimated to be living wild in Britain in 2004 (Ward, 2005a). Populations have continued to increase (Ward, Etherington & Ewald, 2008), and the total in the wild in 2009 was estimated to be in the region of 4000 (personal observations Cooke 2009c).
10	Is the organism widely distributed in the Risk Assessment area?	NO (Go to 11)	Chinese water deer occur patchily, mainly in an arc from east Buckinghamshire to Norfolk. There are several isolated records from elsewhere in southern Britain resulting from releases or escapes (Ward, Etherington and Ewald, 2008), but introductions have been largely unsuccessful (Ward 2005).
11	Does at least one species (for herbivores, predators and parasites) or suitable habitat vital for the survival, development and multiplication of the organism occur in the Risk Assessment area, in the open, in protected conditions or both?	YES (Go to 12)	The Chinese water deer is a selective feeder on a range of grasses, sedges and herbs with some woody species also being taken (Cooke & Farrell, 1998). In China, deer tend to live in vegetation about 1 m in height and with cover >90%, within a few hundred metres of water but >1 km from human disturbance (Zhang, Teng & Wu, 2006). Highest densities in Britain occur in wet habitats such as reed-beds, but they can also persist at lower densities in drier habitats including agricultural land (Cooke & Farrell, 1998; Cooke, 2009b, c).
12	Does the organism require another species for critical stages in its life cycle such as growth (e.g. root symbionts), reproduction (e.g. pollinators; egg incubators), spread (e.g. seed dispersers) and transmission, (e.g. vectors)?	NO (Go to 14)	
13	Is the other critical species identified in question 12 (or a similar species that may provide a similar function) present in the Risk Assessment area or likely to be introduced? If in doubt, then a separate assessment of the probability of introduction of this species may be needed.		

14	Does the known geographical distribution of the organism include ecoclimatic zones comparable with those of the Risk Assessment area or sufficiently similar for the organism to survive and thrive?	YES (Go to 16)	The main difference between its native range and the Risk Assessment area is the hot and humid summers and abundant late summer rainfall of east and central China (Zhang, 1996 and pers. comm.). Single populations have survived in England for more than 40 years (e.g. Cooke & Farrell, 2000) and the species continues to spread its range in East Anglia (Ward, Etherington & Ewald, 2008).
15	Could the organism establish under protected conditions (e.g. glasshouses, aquaculture facilities, terraria, zoological gardens) in the Risk Assessment area?		
16	Has the organism entered and established viable (reproducing) populations in new areas outside its original range, either as a direct or indirect result of man's activities?	YES (Go to 17)	In addition to populations in Britain, Chinese water deer populations also occur in France, both in captivity and in the wild (Dubost, Charron, Courcou & Rodier, 2008; G Dubost, pers. comm.; Harris & Duckworth, 2008).
17	Can the organism spread rapidly by natural means or by human assistance?	YES (Go to 18)	After first escaping from Woburn Park during the 1940s (Whitehead, 1964), water deer were recorded through much of the west of Bedfordshire by 2006 (McCarrick, 2007). The first escapes in the Norfolk Broads occurred in the late 1960s (Chapman, 1995) and by 2002 they were recorded generally from Broadland (Ward, 2005b). These colonisations suggest a rate not greater than 1 km per annum. More recent records from Norfolk indicate a more rapid rate (Ward, Etherington & Ewald, 2008). Transporting them to new areas where escapes occur could increase the rate of spread.
18	Could the organism as such, or acting as a vector, cause economic, environmental or social harm in the Risk Assessment area?	YES OR UNCERTAIN (Go to 19)	Some potential exists, but impacts on vegetation to date are considered negligible (e.g. in woodlands (Putman & Moore, 1998; White, Smart, Bohm, Langbein & Ward, 2004) and farmland (Cooke, 2009b, c). Water deer are involved in road traffic accidents in Britain but at a lower rate than other species of deer because of their rarity (Langbein, 2007). They are susceptible to all the diseases of ruminants. While water deer could be infected with a range of diseases and be involved in their transmission, there is currently little evidence of this occurring.
19	This organism could present a risk to the Risk Assessment area and a detailed risk assessment is appropriate.	Detailed Risk Assessment Appropriate GO TO SECTION B	
20	This organism is not likely to be a harmful non-native organism in the Risk Assessment area and the assessment can stop.		

<b>B</b> SECTION B: Detailed assessment of an organism's probability of entry, establishment and spread and the magnitude of the economic, environmental and social consequences		
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Probability of Entry		RESPONSE	UNCERTAINTY	COMMENT
1.1	List the pathways that the organism could be carried on. How many relevant pathways can the organism be carried on?	few - 1	LOW - 0	Captivity (releases and escapes) and natural spread from current feral populations. The British population may be isolated as it is possible that no individuals have been imported for many years. Chapman (1995) reported that only 19 were imported between 1896 and 1913 to Woburn Park. This population may be the founder of all British water deer (Whitehead, 1964). Some more recent importation cannot, however, be ruled out. Any transport will involve animals born here.
1.2	Choose one pathway from the list of pathways selected in 1.1 to begin the pathway assessments.	Natural spread		
1.3	How likely is the organism to be associated with the pathway at origin?	very likely - 4	LOW - 0	The species has been spreading since the middle of the 20th century (Whitehead, 1964; Cooke & Farrell, 1998; Ward, Etherington & Ewald, 2008).
1.4	Is the concentration of the organism on the pathway at origin likely to be high?	moderately likely - 2	LOW - 0	The most recent estimate of 4000 Chinese water deer living in the wild in this country (Cooke, 2009c) was based on their recorded distribution and information on their population densities. This is likely to be a conservative estimate as recorded distribution will always lag behind reality and this is a species that tends to occur at its highest densities in quiet, undisturbed tracts of countryside (Cooke, 2010). It is, however, the rarest of our six deer species (Ward, 2005a) and has the most restricted distribution (Ward, Etherington & Ewald, 2008).
1.5	How likely is the organism to survive existing cultivation or commercial practices?	likely - 3	LOW - 0	Chinese water deer have survived on farmland close to Woburn Park in Bedfordshire since the 1940s (Whitehead, 1964; McCarrick, 2006). They can also survive well in wet semi-natural habitats (e.g. Cooke & Farrell, 2000), but not in drier wooded habitats (Cooke, 1998; Cooke & Farrell, 2001). Introductions usually fail to establish a colony (Ward, 2005b).
1.6	How likely is the organism to survive or remain undetected by existing measures?	likely - 3	MEDIUM - 1	Water deer can be confused with muntjac <i>Muntiacus reevesi</i> and roe deer <i>Capreolus capreolus</i> (Cooke & Farrell, 1998), although naturalists are now much more aware of their existence and how to identify them. County- and country-wide recording schemes exist, but many sightings will not be reported and will be unavailable to policy makers.
1.7	How likely is the organism to survive during transport /storage?	likely - 3	LOW - 0	Survival is likely to be reasonably good, but deer caught for scientific purposes have died, apparently from hyperthermia or capture myopathy (Cooke & Farrell, 1998).
1.8	How likely is the organism to multiply/increase in prevalence during transport /storage?	very unlikely - 0	LOW - 0	Conditions render such an event very unlikely.
1.9	What is the volume of movement along the pathway?	moderate - 2	MEDIUM - 1	Updating Ward (2005a), there are currently estimated to be about 4000 water deer living in the wild in this country (Cooke, 2009c).
1.10	How frequent is movement along the pathway?	very often - 4	LOW - 0	Given that water deer are established in this country, the pathway of natural spread will be in constant operation.
1.11	How widely could the organism be distributed throughout the Risk Assessment area?	moderately widely - 2	HIGH - 2	The potential exists for some colonisation through rural lowland Britain at least. Its particular habitat requirements (Zhang, 1996; Cooke & Farrell, 1998; Zhang, Teng & Wu, 2006) probably preclude it becoming generally abundant. In Norfolk and Suffolk, many water deer are found close to the coast (Ward, Etherington & Ewald, 2008), and the species may be able to exploit suitable coastal habitat elsewhere. Cold summers lead to poor recruitment and cold, wet winters can increase adult mortality (Cooke & Farrell, 1981, 2000 and unpublished observations), so the species may not fare so well in the west or north of Britain or at higher altitudes.
1.12	How likely is the organism to arrive during the months of the year most appropriate for establishment ?	very likely - 4	LOW - 0	The species is already established in the wild.
1.13	How likely is the intended use of the commodity (e.g. processing, consumption, planting, disposal of waste, by-products) or other material with which the organism is associated to aid transfer to a suitable habitat?	N/A	LOW - 0	The water deer is the commodity.
1.14	How likely is the organism to be able to transfer from the pathway to a suitable habitat?	moderately likely - 2	LOW - 0	The species can survive at relatively low densities in agricultural situations (Cooke & Farrell 1998), and any individual is very likely to find such habitat, but the chances of it finding prime wetland habitat are much lower due to scarcity of this resource.

	Probability of Establishment	RESPONSE	UNCERTAINTY	COMMENT
1.15	How similar are the climatic conditions that would affect establishment in the Risk Assessment area and in the area of current distribution?	similar - 3	LOW - 0	Chinese water deer are established in the Risk Assessment area and are spreading (Ward, Etherington & Ewald, 2008). Summers are hotter and wetter in China (Zhang, 1996) which may favour better recruitment there.
1.16	How similar are other abiotic factors that would affect establishment in the Risk Assessment area and in the area of present distribution?	similar - 3	LOW - 0	Chinese water deer are already established in the Risk Assessment area (Ward, Etherington & Ewald, 2008).
1.17	How many species (for herbivores, predators and parasites) or suitable habitats vital for the survival, development and multiplication of the organism species are present in the Risk Assessment area? Specify the species or habitats and indicate the number.	very many - 4	LOW - 0	It is a selective feeder on a range of grasses, sedges and herbs with some woody species also being taken (Cooke & Farrell, 1998). Reed-beds, wet fen and other wetland habitats are preferred, but farmland may suffice, especially low intensity land with some cover (Cooke & Farrell, 1998; Zhang, Teng & Wu, 2006).
1.18	How widespread are the species (for herbivores, predators and parasites) or suitable habitats vital for the survival, development and multiplication of the organism in the Risk Assessment area?	widespread - 4	LOW - 0	Populations have survived in some lowland situations, in both the wild and in parks, for several decades (Cooke & Farrell, 1998). The ubiquitous nature of farmland means that dispersal should not be a serious problem, but high density populations are less likely to occur (Cooke & Farrell, 1998; Zhang, Teng & Wu, 2006; Cooke, 2010). To be particularly suitable, farmland should be relatively undisturbed and provide sufficient food and cover throughout the year. Low intensity pasture or mixed, with some cover, preferably damp, may prove ideal. There should also be a source of water deer in the vicinity.
1.19	If the organism requires another species for critical stages in its life cycle then how likely is the organism to become associated with such species in the risk assessment area?	N/A	LOW - 0	Water deer do not need another species for establishment.
1.20	How likely is it that establishment will not be prevented by competition from existing species in the Risk Assessment area?	likely - 3	MEDIUM -1	Water deer have been reported to be out-competed by muntjac in China (Sheng in Zhang, 1996). While competition has not prevented Chinese water deer from becoming established in England, they have apparently been out-competed by muntjac in woodland sites (Cooke, 1998; Cooke & Farrell, 2001, 2002). Roe deer and other deer species are likely to exert a similar effect, thereby slowing the rate of colonisation of water deer. Where water deer have established populations on farmland in Bedfordshire and Cambridgeshire, roe deer have only recently started colonising (Cooke, 2005; McCarrick, 2007). At Wicken Fen in Cambridgeshire and Redgrave and Lopham Fen in Suffolk, where muntjac and roe are established, water deer are still rare or occasional (National Trust, 2008; L. Farrell, pers. comm.; personal observations).
1.21	How likely is it that establishment will not be prevented by natural enemies already present in the Risk Assessment area?	very likely - 4	LOW - 0	Populations are already established. Predation of fawns, e.g. by foxes <i>Vulpes vulpes</i> , will occur (Zhang, 1996), but is insufficient to prevent the spread of water deer in East Anglia as recorded by Ward, Etherington & Ewald (2008).
1.22	If there are differences in man's management of the environment/habitat in the Risk Assessment area from that in the area of present distribution, are they likely to aid establishment? (specify)	moderately likely - 2	MEDIUM -1	One factor that could aid spread is the switch from spring to winter sowing in arable areas. Previously, over-heating of young deer was noted as a significant cause of mortality in a farmland study area at Woburn, Bedfordshire (Chaplin, 1977). More recently, winter sown crops have afforded young protection from both predators and hyperthermia (C. Thomson, pers. comm.). The creation of new areas of fen and reed-bed will aid the species.
1.23	How likely is it that existing control or husbandry measures will fail to prevent establishment of the organism?	very likely - 4	LOW - 0	There is shooting, sometimes for trophies, with long-tusked bucks being especially prized. Generally, the stalking community seems pleased to have an additional deer species living locally and will make no attempt to eradicate it. In part this is related to the species being known to be rare on a world scale (Anon, 2008). For example, a population is maintained by shooting at a relatively high stable density on farmland outside Woburn Park partly as a conservation measure (C. Thomson, pers. comm.).
1.24	How often has the organism been recorded in protected conditions, e.g. glasshouses, elsewhere?	N/A	LOW - 0	No examples are known.
1.25	How likely is the reproductive strategy of the organism and duration of its life cycle to aid establishment?	moderately likely - 2	LOW - 0	The Chinese water deer is capable of mating successfully during its first winter and has multiple births with average litter size usually being 2-3 (Cooke & Farrell, 1998). These reproductive features can allow rapid colonisation or recovery. However, water deer have a high mortality rate for a species of deer (Dubost, Charron, Courcou & Rodier, 2008). The calculated turnover in the adult population at Woodwalton Fen in Cambridgeshire is on average roughly 20% per annum (Cooke & Farrell, 2000).
1.26	How likely is it that the organism's capacity to spread will aid establishment?	moderately likely - 2	MEDIUM -1	Water deer bucks are territorial and young deer will be forced to disperse (Cooke & Farrell, 1998, 2000). However, bucks' territories can be <10 ha so rate of dispersal is not necessarily rapid, and has been no greater than 1 km per annum in Cambridgeshire (Cooke & Farrell, 1998) and Bedfordshire (see Nau, 1992; McCarrick, 2007).

1.27	How adaptable is the organism?	slightly adaptable - 1	HIGH -2	Harris & Duckworth (2008) cited low adaptability as a reason for the species being sensitive to environmental change and declining in its native range.
1.28	How likely is it that low genetic diversity in the founder population of the organism will not prevent establishment?	unlikely - 1	MEDIUM -1	Low genetic diversity has not prevented establishment. However, the founder population was probably composed of very few animals (Chapman, 1995), and this could be one reason for the failure of many introductions (see Ward, 2005b). Low genetic diversity could play a part in restricting further spread.
1.29	How often has the organism entered and established in new areas outside its original range as a result of man's activities?	moderate number - 2	LOW - 0	It has established populations in a number of areas in Britain and also in France as a result of man's activities (Whitehead, 1964; Chapman, 1995; Cooke & Farrell, 1998; Harris & Duckworth, 2008; Ward, 2005b).
1.30	How likely is it that the organism could survive eradication campaigns in the Risk Assessment area?	moderately likely - 2	MEDIUM -1	Water deer can be conspicuous on farmland, particularly in winter. Thus in an area near Woburn in Bedfordshire where there are about 120 deer (C. Thomson, pers. comm.), single counts have exceeded 40 (McCarrick, 2006). They present an easy target in the flat open landscapes of East Anglia (Cooke & Farrell, 1998). Concerted efforts in arable areas could lead to eradication. Within large wetland areas where there is dense cover, eradication would be much more difficult and probably impossible. During the late winter months, wetland water deer do, however, tend to forage out onto adjacent farmland where they can be readily shot (e.g. Cooke & Farrell, 1981, 1987; Cooke, 2009b). Hunting and poaching (as well as habitat loss) are the main reasons for the water deer becoming rare in China (Zhang & Guo, 2000; Harris and Duckworth, 2008). This suggests that shooting could have a major impact on the British population, although in China methods include trapping and snaring in addition to shooting.
1.31	Even if permanent establishment of the organism is unlikely, how likely is it that transient populations will be maintained in the Risk Assessment area through natural migration or entry through man's activities (including intentional release into the outdoor environment)?	unlikely - 1	LOW - 0	They are kept in a number of zoological collections in this country, so escapes are always possible. However, this would be unlikely to be sufficient to maintain a population in the wild in the absence of breeding. From April 2010, it is illegal to release water deer into the wild in Britain (Defra, 2009).

	<b>Spread</b>	<b>RESPONSE</b>	<b>UNCERTAINTY</b>	<b>COMMENT</b>
2.1	How rapidly is the organism liable to spread in the Risk Assessment area by natural means?	intermediate - 2	MEDIUM -1	Initially rate of spread was not greater than 1 km per annum (Cooke & Farrell, 1998). Recently, the rate seems to have increased, particularly involving dispersal away from the Norfolk Broads, but this conclusion is based on unvalidated reports (Ward, Etherington & Ewald, 2008). The British Deer Society has argued that the species is geographically constrained by suitable habitat (Anon, 2008).
2.2	How rapidly is the organism liable to spread in the Risk Assessment area by human assistance?	intermediate - 2	MEDIUM -1	There is potential for greater spread if animals escape from captivity away from the areas where they are already established. From April 2010, it is illegal to release water deer in this country. In the past, most introductions were unsuccessful (Ward, 2005). Some isolated populations have persisted, such as in Sussex and the Mendips (Ward, 2005b), but it is uncertain whether substantial populations will result in the longer term.
2.3	How difficult would it be to contain the organism within the Risk Assessment area?	with some difficulty - 2	MEDIUM -1	Elimination of outlying populations and containment within its current core area of East Anglia and adjacent counties would be a possibility by means of shooting. Containment within a smaller area would be more difficult. Recent changes to the legislation under the Regulatory Reform [Deer] [England and Wales] Order 2007, amending the Deer Act 1991 and set out in Statutory Instrument 2183, protect the species by introducing a close season for shooting for seven months of the year.
2.4	Based on the answers to questions on the potential for establishment and spread define the area endangered by the organism.		MEDIUM -1	This is mainly countryside in lowland Britain, including coastal situations, especially in the east and south of England. There is no evidence that it will invade towns and gardens like the muntjac has done.

	Impacts	RESPONSE	UNCERTAINTY	COMMENT
2.5	How important is economic loss caused by the organism within its existing geographic range?	minimal - 0	LOW - 0	In China it is still sometimes trapped as a pest (Harris & Duckworth, 2008), but, as it is now valued for its meat, it is unclear whether this is used as an excuse for killing it. Because the species is very rare in China, economic loss will be negligible. The Korean subspecies is said to be 'a low-concern pest of rice fields' (Harris & Duckworth, 2008).
2.6	Considering the ecological conditions in the Risk Assessment area, how serious is the direct negative economic effect of the organism, e.g. on crop yield and/or quality, livestock health and production, likely to be? (describe) in the Risk Assessment area, how serious is the direct negative economic effect of the organism, e.g. on crop yield and/or quality, likely to be?	minor - 1	MEDIUM - 1	It is not a woodland animal, and the reviews of economic impacts of wild deer by Putman & Moore (1998) and White, Smart, Bohm, Langbein & Ward (2004) did not even consider it as a problem in forestry. These authors also concluded it had a negligible impact on agriculture in lowland Britain and the East of England respectively. Woodwalton Fen National Nature Reserve in Cambridgeshire represents a worst case situation as many individuals from its large population of water deer regularly feed on adjacent fields in the winter and spring (Cooke & Farrell, 1987; Cooke, 2009b). Damage has been detected occasionally in fields of carrots, sugar beet and barley, but was judged by the farmer to be of negligible significance (Cooke, 2009b). Animals seen in arable fields are often feeding on weeds along the field boundaries or on potatoes or beet tops left after harvest (Cooke, 2009b). During the winter of 2008/9, grazing outside the reserve was primarily concentrated on the grasses <i>Phleum pratense</i> and <i>Dactylis glomerata</i> , sown as a conservation seed mix on previously cropped land, and <i>Holcus lanatus</i> growing along the field edges (L. Farrell in Cooke, 2009b). Deer activity was considerably reduced by 300 m from the reserve boundary (Cooke, 2009b). Although of no economic consequence in this situation, there is potential for competition with livestock beside localities with dense deer populations (Cooke, 2009c). No reports are known associating this species with livestock health, but water deer could be infected and transmit diseases of ruminants. Cattle are used as a management tool in Woodwalton Fen NNR, but deer usually avoid areas being grazed (Cooke & Farrell, 1981; Cooke, 2009c).
2.7	How great a loss in producer profits is the organism likely to cause due to changes in production costs, yields, etc., in the Risk Assessment area?	minor - 1	MEDIUM - 1	See 2.6. Although agricultural damage is slight, deer do occur in numbers on agricultural land in some localities and there is potential for losses to increase in future. On the other hand, farmers sometimes undertake or sanction stalking (Cooke & Farrell, 1998) and outside Woodwalton Fen NNR, letting stalking rights compensated the farmer for any loss in agricultural yield (Cooke, 2009b).
2.8	How great a reduction in consumer demand is the organism likely to cause in the Risk Assessment area?	minimal - 0	LOW - 0	See 2.6. There is no evidence of loss of quality of products or loss of yield that would affect consumer demand.
2.9	How likely is the presence of the organism in the Risk Assessment area to cause losses in export markets?	very unlikely - 0	LOW - 0	See 2.6. There is no evidence that export markets would be affected.
2.10	How important would other economic costs resulting from introduction be? (specify)	minor - 1	LOW - 0	If a focused agronomy study was funded, it would aid understanding of the implications of further spread of this species.
2.11	How important is environmental harm caused by the organism within its existing geographic range?	minor - 1	LOW - 0	No reports are known of environmental harm in its native range.
2.12	How important is environmental harm likely to be in the Risk Assessment area?	minor - 1	LOW - 0	The highest densities of Chinese water deer in the Risk Assessment area occur in wetland areas such as Woodwalton Fen National Nature Reserve and the Norfolk Broads (Cooke & Farrell, 1998). Site managers at Broadland reserves showed no concern about water deer when replying to a questionnaire (White, Smart, Bohm, Langbein & Ward, 2004). On the Bure Marshes reserves, grazing is still 'virtually unnoticeable' (R. Southwood, pers. comm.). An area at Woodwalton Fen, where water deer density was at least 0.5/ha, was assessed as having 'intermediate stage 1-2, slight impact' in 2008/9 (Cooke, 2009c), using a scale of impact classification devised for woodlands (Cooke, 2009a). Compared with the muntjac, which is well known to damage conservation features in woodland reserves (e.g. Cooke, 2004), the water deer does not build up to such high densities, is not such an extreme concentrate selector and lives in more robust habitats (Cooke, 2000). One potential area of concern is if a palatable, rare species of plant is locally abundant in a wetland with water deer, it could be affected. However, populations of rarities at Woodwalton Fen, such as fen violet and great water dock, appear unaffected.
2.13	How important is social and other harm caused by the organism within its existing geographic range?	minimal - 0	LOW - 0	In China, they do not cause any recorded social harm. Indeed, deer are poached for food and neonates collected for the colostrum in their stomachs, which is used as a traditional medicine (Zhang & Guo, 2000; Harris & Duckworth, 2008).

2.14	How important is the social harm likely to be in the Risk Assessment area?	minor - 1	LOW - 0	Social benefits occur from the presence of water deer. Members of the public generally enjoy seeing deer, and stalkers are provided with an additional quarry and trophy species, and, in some cases, a source of income. A limited amount of grazing and browsing can benefit biodiversity. Water deer have, however, been reported as disrupting pheasant shoots in the Norfolk Broads (J. Ellis, pers. comm.). Water deer were implicated in 0.5-0.6% of deer-related road traffic accidents in Britain during 2003-2005 (Langbein, 2007). Being small deer of body mass c15 kg, the damage done to vehicles or personnel may be less than that inflicted by larger species. Water deer involved in traffic accidents are often animals dispersing away from population centres and so are likely to be adding to the total number of deer-related accidents.
2.15	How likely is it that genetic traits can be carried to native species, modifying their genetic nature and making their economic, environmental or social effects more serious?	very unlikely - 0	LOW - 0	Phylogenetic studies have indicated the water deer to be closely related to the roe deer (see Cooke & Farrell, 2008). Even in the most improbable event of the two species mating successfully, the roe deer is a much more damaging species economically and environmentally (Putman & Moore, 1998).
2.16	How probable is it that natural enemies, already present in the Risk Assessment area, will have no affect on populations of the organism if introduced?	very likely - 4	LOW - 0	Fawn predation by foxes, and maybe other species, has failed to prevent the recorded spread of water deer in the Risk Assessment area.
2.17	How easily can the organism be controlled?	with some difficulty - 2	MEDIUM -1	In China, hunting, including by shooting, is one of the main reasons for the dramatic decrease in the water deer population (Zhang & Guo, 2000; Harris & Duckworth, 2008). In agricultural situations in Britain, water deer can be easy to shoot during winter. There are no national statistics for numbers shot per annum, but the total number is likely to be in the low hundreds. A similar estimate has been derived for the total killed per annum on England's roads (Langbein, 2007). In a relatively dense population on farmland outside Woburn Park, numbers are controlled by shooting about 30 per annum (C. Thomson, pers. comm.). Even populations based in semi-natural habitat will venture onto adjacent farmland in winter (Cooke & Farrell, 1981, 1987), where they can be shot. A concerted programme of shooting could in theory substantially reduce numbers in the wider countryside, while inhibiting dispersal from wetland areas. In most large wetland areas, it would probably be impossible to eradicate them in the unlikely event of that being deemed desirable.
2.18	How likely are control measures to disrupt existing biological or integrated systems for control of other organisms?	very unlikely - 0	LOW - 0	Shooting is specific and will not disrupt such systems.
2.19	How likely is the organism to act as food, a host, a symbiont or a vector for other damaging organisms?	moderately likely - 2	MEDIUM -1	In the future, water deer may be implicated in the transmission of a range of human and livestock diseases, such as Lyme disease, bovine TB and bluetongue, but so far direct evidence seems lacking.
2.20	Highlight those parts of the endangered area where economic, environmental and social impacts are most likely to occur			Currently, impacts are considered to be slight. They are most likely to occur in agricultural situations adjacent to wetland sites that hold the densest concentrations, particularly in Broadland and on the Cambridgeshire fens. Damage might also be seen in some purely agricultural localities in eastern England, where densities are relatively high - but in such situations control by shooting should be easier.

<b>Summarise Entry</b>	very likely - 4	LOW - 0	About 100 years ago, Chinese water deer were imported in small numbers to Woburn Park. All water deer in Britain appear to be descended from these few founders. Releases and escapes have occurred from Woburn and from some other localities to which the deer were taken by man.
<b>Summarise Establishment</b>	very likely - 4	LOW - 0	Water deer have been established in part of the Risk Assessment area since the middle of the 20th century. In 2009, they were estimated to number about 4000.
<b>Summarise Spread</b>	intermediate - 2	MEDIUM -1	Up until a few years ago, the rate of spread had been slow, but there are indications of an increasing rate, particularly near the East Anglian coast. There is a need to understand whether there are genetic constraints on the colonising ability of this species - this will be addressed by a postgraduate study that has just started at Imperial College, London. Hopefully, this project will allow predictions of further spread to be made with greater confidence.
<b>Summarise Impacts</b>	minor - 1	MEDIUM -1	Unlike other deer species, it is not a woodland species, and impacts in commercial forestry or conservation woodland will be negligible. Despite building up to high densities in some wetland areas, impacts on conservation features are slight due to its habits and the robustness of the habitat. In arable crops and pasture grown in the vicinity of dense populations, damage has occasionally been seen, but has been insignificant economically. A detailed study on the agricultural implications of further spread would help reduce some uncertainty.
<b>Conclusion of the risk assessment</b>	LOW - 0	MEDIUM -1	The Risk Assessment area has an introduced population of Chinese water deer that appears to be descended from very few animals. The species has been established here for about 50 years. It is still by far the rarest of the six species of deer living wild in Britain, but its rate of spread may be starting to
<b>Conclusions on Uncertainty</b>		MEDIUM -1	This assessment is mainly based on literature and unpublished information concerning water deer in its native range and here in Britain. There is no uncertainty that the species is established here and is continuing to spread. Similarly, no significant impacts have become apparent. The principal areas of uncertainty relate to the degree to which it will colonise if unchecked and the extent to which any agricultural damage translates into economic loss.

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