REPORT OF THE

WELSH BEAVER ASSESSMENT INITIATIVE

An investigation into the feasibility of reintroducing European Beaver *(Castor fiber)* to Wales

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PROJECT DETAILS

Welsh Beaver Assessment Initiative

The Welsh Beaver Assessment Initiative (WBAI) is investigating the feasibility of reintroducing European (or Eurasian) beaver *(Castor fiber)* to Wales. This WBAI study has been led by the Wildlife Trusts Wales and has been funded by the Countryside Council for Wales, People's Trust for Endangered Species, Environment Agency Wales, Wild Europe Initiative, Wildlife Trusts Wales and Welsh Power Ltd.

Project Management Group

The management group has included: Toby Aykroyd (Wild Europe Initiative), Julian Branscombe (Gwent Wildlife Trust), Derek Gow (Derek Gow Consultants), Liz Halliwell (Countryside Council for Wales), Derek Moore OBE, Rob Parry (Wildlife Trust of South & West Wales), Rob Strachan (Environment Agency Wales), Dave Thorpe (Environment Agency Wales), Mark Potter (Environment Agency Wales), Mike Jenkins (Environment Agency Wales), Chris Tucker (Forestry Commission Wales), John Turner (Countryside Council for Wales) and Tristan Hatton-Ellis (Wales Biodiversity Partnership Freshwater Ecosystem Group).

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Ecological Contractors

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1. Mae Menter Asesu Afancod Cymru'n edrych pa mor ymarferol fyddai ailgyflwyno'r afanc Ewropeaidd (neu Ewrasiaidd) (Castor fiber) i Gymru. Mae astudiaeth Menter Asesu Afancod Cymru wedi cael ei chyflawni gan Ymddiriedolaethau Bywyd Gwyllt Cymru a'i hariannu gan Gyngor Cefn Gwlad Cymru, Ymddiriedolaeth y Bobl dros Rywogaethau mewn Perygl, Asiantaeth yr Amgylchedd Cymru, Menter Ewrop Wyllt, Ymddiriedolaethau Bywyd Gwyllt Cymru a Phŵer Cymru.

2. Mae'r ddogfen hon yn rhoi adroddiad ar y gwaith a wnaethpwyd gan Fenter Asesu Afancod Cymru. Mae hyn wedi cynnwys edrych ar effeithiau tebygol ailgyflwyno afancod mewn ffordd reoledig yng Nghymru, ymgynghori â rhanddeiliaid allweddol, ac asesu a dethol mannau posibl.

3. Ar un adeg roedd dosbarthiad afancod yn eang ar draws Ewrasia, o Brydain i Siberia, ond oherwydd i bobl eu hela am eu crwyn ac at ddibenion meddyginiaethol prinhaodd eu poblogaethau yn Ewrop yn fawr iawn. Roeddent wedi diflannu o Brydain erbyn yr 16eg ganrif yn fras; nid colli cynefinoedd achosodd iddynt ddiflannu. Mae'r cofnod olaf o bresenoldeb afancod yng Nghymru o afon Teifi yn 1188 OC ac mae'n debyg bod afancod wedi diflannu o Gymru erbyn y 15fed ganrif.

4. Trwy ail-gytrefu naturiol a rhaglenni ailgyflwyno mae afancod yn dychwelyd i rannau helaeth o'u hen ddosbarthiad. Ar hyn o bryd mae yna boblogaethau sefydledig mewn rhannau helaeth o Sgandinafia a Chanol a Dwyrain Ewrop, ond mae'r poblogaethau'n gymharol fach a gwasgaredig o hyd yn y rhan fwyaf o Orllewin Ewrop. Hyd yma mae afancod wedi cael eu dychwelyd yn llwyddiannus i 24 o wladwriaethau Ewrop o fewn hen ddosbarthiad naturiol afancod, gan ddarparu profiad sylweddol o'r effeithiau yn sgil hynny. Prydain, Portiwgal, yr Eidal a'r Balcannau i'r de o Bosnia-Herzegovina yw'r unig wladwriaethau sydd heb ailgyflwyno afancod i'r gwyllt eto. Fodd bynnag, mae cynllun ailgyflwyno prawf ar y gweill yn yr Alban yn dilyn rhyddhau afancod yno ym mis Mai 2009 ac mae cynllun rhyddhau tebyg yn cael ei ystyried yn Lloegr.

5. Cnofilod lled-ddyfrdrig mawr (tua 20kg) sy'n byw mewn cynefinoedd llinellol ar hyd afonydd yw afancod. Maent yn chwilio am fwyd o fan canolog ac yn meddiannu tiriogaethau o ryw 1-6km (gan ddibynnu ar ansawdd y cynefin) fel arfer. Maent yn creu gwalau mewn tyllau o dan y ddaear neu mewn ffeuau uwchben y ddaear wedi'u gwneud o ganghennau, brigau a llaid (neu gyfuniad o'r ddau). Fel arfer mae'r mynedfeydd i'r tyllau a'r ffeuau o dan ddŵr.

6. Gall afancod adeiladu argaeau, sy'n codi lefelau'r dŵr '(i ddyfnder o fwy na 0.7m) er mwyn darparu lloches yn y dŵr, cynnig mwy o le i symud drosto, sicrhau bod mynedfeydd eu ffeuau/tyllau'n aros o dan ddŵr, darparu cyflenwad bwyd a/neu ei gwneud yn haws cludo deunyddiau adeiladu. Fel arfer mae'r argaeau wedi'u gwneud o fonion coed, canghennau, brigau a llaid. Mae'n well gan afancod feddiannu tiriogaeth nad oes angen argae arni ac felly'r duedd yw iddynt adeiladu argaeau yn hwyrach yn y broses cytrefu. Ceir argaeau'n gymharol anfynych ar ddalgylchoedd hyd yn oed pan fo'r poblogaethau ar eu huchaf posibl, ond mae nifer yr argaeau'n ddibynnol ar amodau lleol.

7. Mae afancod yn bwyta llystyfiant yn unig, gan gynnwys planhigion dyfrol a daearol. Byddant hefyd yn bwyta rhisgl coed, yn arbennig yn ystod y gaeaf pan nad yw ffynonellau bwyd eraill ar gael, a gallant gwympo coed wrth wneud hynny. Mae'r rhan fwyaf o'r coed sy'n cael eu cwympo gan afancod yn aildyfu o'r bôn gyda llawer o flagur yn darparu bwyd hawdd ei gyrraedd yn y blynyddoedd wedyn.

8. Nid yw afancod yn hoffi crwydro ymhell o ddŵr. Maent yn cyflawni eu gweithgareddau bron i gyd, gan gynnwys cwympo coed, o fewn 20m i lan y dŵr, a'r rhan fwyaf o fewn 10m. Mae afancod yn gyfyngedig iawn i gynefin glan afon addas. Maent yn amharod iawn i groesi tir agored ac felly nid ydynt yn lledu o'r naill ddalgylch i'r llall yn rhwydd, yn enwedig os yw hyn yn golygu symud trwy dir bryniog neu fynyddig.

9. Yn aml ystyrir afancod yn rhywogaeth allweddol mewn amgylcheddau dyfrol, am fod ganddynt y gallu i newid cynefinoedd afonydd a gwlyptiroedd er budd llawer o rywogaethau eraill, gydag ychydig iawn o effeithiau negyddol. Mae rheoli gan afancod yn tueddu i greu canopïau coed mwy agored ar lan afonydd, gyda mwy o amrywiaeth o blanhigion. Mae argaeau a phyllau afancod, ynghyd â phren marw o ganlyniad i weithgareddau afancod, yn cynyddu amrywiaeth a thoreithrwydd y rhywogaethau anifeiliaid sy'n gysylltiedig â chynefinoedd o'r fath.

10. Mae rhyngweithiadau afancod gyda physgod yn gymhleth ac yn dibynnu ar lawer o ffactorau newidiol. Mae'r rhan fwyaf o'r dystiolaeth yn awgrymu bod ailgyflwyno afancod yn debyg o fod o fudd i boblogaethau pysgod ar y cyfan, gan greu cynefin i amrywiaeth fawr o rywogaethau, gan gynnwys y rheiny a ystyrir yn bwysig yn fasnachol. Gellir cael effeithiau andwyol ar rai rhywogaethau pysgod ac mae'n bosibl y bydd angen cymryd camau i fynd i'r afael â hwy ar ôl ailgyflwyno afancod.

11. O dan y rhan fwyaf o amgylchiadau, credir mai effaith ddibwys mae afancod Ewropeaidd yn ei chael ar bysgod mudol ar raddfa dalgylch dros gyfnodau hirach. Fodd bynnag, mae'n bosibl y gallai rhai argaeau afancod rwystro pysgod rhag mynd heibio pan fo llif y dŵr yn isel. Mae'n bosibl y byddai angen ymyrryd i newid neu waredu rhai argaeau.

12. Gyda'r gweithdrefnau cwarantîn a milfeddygol cywir ni fernir bod afancod yn creu unrhyw risg arwyddocaol o glefydau i bobl, anifeiliaid fferm na physgod. Nid oes unrhyw dystiolaeth i awgrymu y gall afancod fod yn garwyr clefyd arwyddocaol.

13. Mae'n bosibl y gallai gweithgareddau afancod fod o fudd i reoli cyrsiau dŵr, gan gynorthwyo i liniaru llifogydd ac enghreifftiau o lif isel, gwella ansawdd y dŵr, lleihau erydu a siltio afonydd. Awgrymir y gallai'r effeithiau hyn fod o fudd wrth fynd i'r afael â rhai o'r materion sy'n gysylltiedig â'r newid yn yr hinsawdd.

14. Ymgynghorwyd â rhanddeiliaid allweddol er mwyn rhoi gwybod i Fenter Asesu Afancod Cymru am y syniadau, y pryderon a'r safbwyntiau sydd ynglŷn ag ailgyflwyno afancod. Defnyddiwyd y trafodaethau hyn i ddarparu gwybodaeth ar gyfer y materion y mae'r adroddiad hwn yn ymdrin â hwy.

15. Mae'r arolygon ecolegol a wnaethpwyd fel rhan o Fenter Asesu Afancod Cymru wedi canfod bod yna doreth o gynefin yng Nghymru sy'n addas i afancod. Canfuwyd hefyd bod ailgyflwyno afancod i Gymru'n ecolegol ymarferol. O ganlyniad i'r arolygon cychwynnol hyn, detholwyd chwe dalgylch i'w hastudio ymhellach fel safleoedd posibl ar gyfer cynllun peilot ailgyflwyno afancod: Dyfrdwy, Glaslyn, Rheidol, Teifi, Cleddau Ddu a Chleddau Wen.

16. Mae profiad yn dangos bod tebygrwydd llwyddo wrth ailsefydlu afancod yn fwy os rhyddheir o leiaf 20 pâr o afancod sy'n bridio, o bosibl gan ddefnyddio ffeuau artiffisial. Gellid eu rhyddhau dros gyfnod o ddwy flynedd, er y ffefrir eu rhyddhau ar un adeg os yw'n bosibl yn logistaidd. Gellir cael stoc addas o afancod o Norwy, Ffrainc ac o bosibl yr Almaen.

17. Petai afancod yn cael eu hailgyflwyno i Gymru, wedi hynny mae'n debyg y byddai rhywfaint o wrthdaro o dro i dro ac mewn mannau gyda rhai gweithgareddau dynol a seilwaith megis creu argaeau mewn mannau amhriodol, difrod i gnydau, cwympo coed pan nad oes eisiau hynny, a rhwystro cwlferi. Felly er mwyn ailsefydlu afancod yng Nghymru'n llwyddiannus byddai angen gwneud rhywfaint o waith rheoli i fynd i'r afael yn fuan ag unrhyw ddigwyddiadau a allai godi. Cynghorir ffurfio rhwydwaith o wirfoddolwyr hyfforddedig i ymdrin â materion o'r fath ar hyd yr un llinellau â'r model yn Bafaria.

18. Gall costau ailgyflwyno afancod i'r gwyllt fod yn fach. Gellir rhyddhau afancod a sicrhau gwaith rheoli am 5 mlynedd ar ôl eu rhyddhau, ac arian ar gyfer strategaeth ymadael, am lai na £400,000. Gyda gweithgareddau megis canolfannau ymwelwyr, gweithgareddau addysgol a staff ychwanegol, byddai'r costau'n uwch, ond gellid eu cydbwyso trwy incwm uniongyrchol o dwristiaeth natur ac incwm anuniongyrchol yn deillio o broffil uwch.

19. Mae profiad yn awgrymu bod gan afancod ddigon o arwyddocâd eiconig fel rhywogaeth i alluogi cynhyrchu symiau sylweddol o arian newydd. Felly ni fydd ailgyflwyno afancod o angenrheidrwydd yn tynnu adnoddau oddi wrth flaenoriaethau cadwraethol sy'n bodoli eisoes.

20. Er mwyn bwrw ymlaen ag ailgyflwyno afancod i Gymru byddai angen nifer o gamau pellach gan gynnwys: cytundeb gan Lywodraeth Cymru i ailgyflwyno afancod yn amodol ar lwyddo i ddethol safle i'w rhyddhau (ar ôl rhagor o waith astudio ac ymgynghori); datblygu cynllun ailgyflwyno a rheoli wedi'i gostio'n llawn; a sicrhau cyllid priodol.

21. Mae ailgyflwyno afancod i Gymru'n ymarferol yn ecolegol, ac mae'r gwaith ailsefydlu a rheoli effeithiau'n bosibl ar gost ariannol gymharol fach. Mae afancod yn cynnig buddion sylweddol yn nhermau gwasanaethau ecosystem a diogelu bioamrywiaeth. Hefyd mae yna fuddion cymdeithasol yn nhermau ysgogi twristiaeth yn ogystal â chyfleoedd o ran addysg a hamdden. Bydd angen rhagor o ymgynghori ac ymchwilio i broblemau lleol posibl, ond mae maint a manylder profiad ailsefydlu afancod ar draws Ewrop yn cynnig tystiolaeth ragorol y dylai'r effeithiau ar ddefnyddiau tir yng Nghymru fod yn gyfyngedig ac yn rheoladwy. O ystyried hyn oll, ceir achos cryf dros ddod i'r casgliad y byddai ailgyflwyno afancod i Gymru yn ddymunol.

EXECUTIVE SUMMARY

1. The Welsh Beaver Assessment Initiative (WBAI) is investigating the feasibility of reintroducing European (or Eurasian) beaver *(Castor fiber)* to Wales. This WBAI study has been undertaken by the Wildlife Trusts Wales and has been funded by the Countryside Council for Wales, People's Trust for Endangered Species, Environment Agency Wales, Wild Europe Initiative, Wildlife Trusts Wales and Welsh Power Ltd.

2. This document reports on the work undertaken by the WBAI. This has involved examination of the likely effects of a managed re-establishment of beavers in Wales, consultation with key stakeholders, and assessment and selection of candidate areas.

3. Beavers were once widespread across Eurasia spreading from Britain to Siberia, but hunting by humans for their pelt and medicinal uses dramatically reduced their populations in Europe and lead to their extinction in Britain by around the 16th century; their extinction was not caused by habitat loss. The last record of beaver presence in Wales is from the River Teifi in 1188 AD and it is likely that beavers were extinct in Wales by the 15th century.

4. Through both natural recolonisation and reintroduction programmes beavers are returning to much of their former range. Well established populations are currently present in large parts of Scandinavia and Central and Eastern Europe, but populations remain relatively small and scattered in most of Western Europe. To date beavers have been successfully returned to 24 European states within the former natural range of beavers, providing substantial experience of subsequent impacts. Britain, Portugal, Italy, and the Balkans south of Bosnia-Herzegovina are the only remaining states yet to reintroduce beavers to the wild, but a trial reintroduction is underway in Scotland following a release in May 2009 and a similar release is being considered in England.

5. Beavers are large (around 20kg) semi-aquatic rodents that occupy linear riparian habitats. Beavers are central-place foragers and occupy territories typically around 1-6km (depending on habitat quality). They create dens in underground burrows or in lodges above ground made of branches, sticks and mud (or a combination of both). The entrances to burrows and lodges are normally submerged underwater.

6. Beavers can construct dams, which serve to raise water levels (to over 0.7m deep) in order to provide beavers with an aquatic refuge, increase their range of movement, ensure lodge/burrow entrances remain submerged, provide food supplies and/or ease the transport of building materials. Dams are usually made from tree stems, branches, sticks and mud. Beavers prefer to occupy territory that does not require damming and so dams tend to be built later in the colonisation process. Dams can remain relatively infrequent structures on catchments even when populations are at full capacity, but frequency is dependent on local conditions.

7. Beavers feed exclusively on vegetation including both aquatic and terrestrial plants. Beavers will also feed on tree bark, particularly during winter when other food sources are unavailable, and can fell trees to do so. Most beaver-felled trees coppice and regrow with abundant shoots providing easy to reach food in subsequent years. Beavers tend not to utilise coniferous trees.

8. Beavers do not like to stray far from water. Almost all beaver activity, including tree felling, is undertaken within 20m of the waters edge, and most of this is within 10m. Beavers are strongly restricted to suitable riparian habitat. They are extremely reluctant to cross open land so do not readily spread from one catchment to another, especially if this involves movement through hilly or mountainous terrain.

9. Beavers are often considered a 'keystone' species in aquatic environments, with an ability to modify riverine and wetland habitats to the benefit of many other species, with few negative effects. Beaver management tends to create more open riparian tree canopies with increased plant diversity. Beaver dams and ponds together with dead wood resulting from beaver activity, increases the diversity and abundance of animal species associated with such habitats.

10. Beaver interactions with fish are complex and are dependent on many variables. The weight of evidence suggest that on the whole beaver reintroduction is likely to benefit fish populations creating habitat for a wide variety of species including those that are considered commercially important. Adverse effects on some fish species can occur and steps may need to be taken to address them following a reintroduction.

11. In most circumstances, European beavers are thought to have a negligible impact on migratory fish at the catchment scale over longer timescales. However, some beaver dams might have the potential to hinder fish passage during low flow conditions. Intervention may be required to modify or remove some dams.

12. With correct quarantine and veterinary procedures beavers are not considered to pose any significant disease risk to humans, livestock or fish. There is no evidence to suggest that beavers can be significant vectors of disease.

13. The activities of beavers could potentially be beneficial to watercourse management, helping to ameliorate flooding and instances of low flow, improving water quality, reducing erosion and siltation of rivers. It is suggested that these impacts could be beneficial in addressing some issues related to climate change.

14. Key stakeholders were consulted to inform the WBAI of the ideas, concerns and opinions that exist regarding beaver reintroduction. These discussions have been used to inform the issues covered in this report.

15. The ecological surveys undertaken as part of the WBAI have determined that there is abundant habitat within Wales suitable for beavers. It has also been determined that a beaver reintroduction to Wales is ecologically feasible. As a result of these initial surveys, six catchments were selected for further study as potential sites for a pilot beaver reintroduction: Dee, Glaslyn, Rheidol, Teifi, Eastern Cleddau and Western Cleddau.

16. Experience indicates that the chances for successful reintroduction of beavers are increased by the release of at least 20 breeding pairs of beavers, possibly involving the use of artificial lodges. A release could be undertaken over two years, although a single release is favoured if logistically possible. Suitable beaver stock can be sourced from Norway, France and possibly Germany.

17. Following any reintroduction to Wales it is likely that there would be some occasional and localised conflicts with certain human activities and infrastructure such as the creation of dams in inappropriate areas, crop damage, unwanted felling of trees and the blocking of culverts. Therefore to successfully re-establish beavers in Wales some management would need to be undertaken to promptly address any incidents that may occur. The formation of a network of trained volunteers to deal with such issues is advised along similar lines to the Bavarian model.

18. The costs of reintroducing beavers to the wild can be modest. A managed beaver release with 5 years of post-release management and funding for an exit strategy could be undertaken for less than £400,000. With add-on activities such as visitor centres, educational activities and additional staff, costs would be higher, but these could be balanced through direct income from nature tourism and indirect income resulting from increased profile.

19. Experience suggests that beaver has sufficient iconic significance as a species to enable significant generation of new funding. Reintroduction need not thus divert resources away from existing conservation priorities.

20. In order to proceed with a beaver reintroduction to Wales a number of further actions would be required including: agreement from the Welsh Government for a beaver reintroduction conditional on the successful selection of a release site (following further study and consultation); development of a fully costed reintroduction and management plan; and the securing of appropriate funds.

21. Beaver reintroduction to Wales is ecologically feasible, with re-establishment and the management of impacts being possible at a relatively low financial cost. Beavers offer substantial benefits in terms of ecosystem services and biodiversity conservation, whilst there are social benefits in terms of stimulation of tourism as well as educational and recreational opportunities. Further consultation and exploration of potential local issues will be needed, but the breadth and depth of experience of beaver reintroduction across Europe provides excellent evidence that impacts on land uses in Wales should be limited and manageable. Given these considerations there is a strong case for concluding that the reintroduction of beavers to Wales is desirable.

1. INTRODUCTION

1.1 BEAVER REINTRODUCTION: A DEFINITION

The International Union for the Conservation of Nature (IUCN) defines a reintroduction as 'an attempt to establish a species in an area which was once part of its historical range, but from which it has been extirpated or become extinct.'

In the case of European (Eurasian) beaver *(Castor fiber)*, the principle long-term aim of a reintroduction to Wales would be to establish a viable, free-ranging population in the wild to an area within the species' former natural habitat and range.

With reference to IUCN guidelines, the objectives of a reintroduction of beavers to Wales would be:

- to enhance the long-term survival of beavers
- to re-establish a keystone species in wetland ecosystems
- to help maintain and restore natural biodiversity
- to provide long-term economic benefits to local and national economies
- to help promote conservation awareness
- to address climate change impacts
- to reinstate a species formerly present, as proposed by EU legislation

1.2 REASONS FOR BEAVER REINTRODUCTION

A number of reasons have been put forward for the reintroduction of beavers (e.g. Macdonald & Tattersall, 1999; Coles, 2006; Gaywood *et al.,* 2008; Gurnell *et al.,* 2008). These include:

Environmental services

Beavers may be considered a missing element of our native fauna lost due to human activities. Beavers are regarded by many to be a 'keystone' species (e.g. Collen & Gibson, 2001) actively creating and managing wetland and riparian habitats. The reintroduction of beaver is seen by some as a management tool for the conservation of wetland and riparian habitats, and many associated species. Wetland habitats also act as carbon sinks and the activities of beavers can create and maintain these habitats and in the longer term can help to regulate water flow and improve water quality in streams.

International agreements

Article 22 of the European Community Directive on the Conservation of Natural Habitats and of Wild Flora and Fauna (Council Directive 92/43/EEC, the 'Habitats Directive') states that Member States shall:

'study the desirability of re-introducing species in Annex IV that are native to their territory where this might contribute to their conservation, provided that an investigation, also taking into account experience in other Member States or elsewhere, has established that such re-introductions contributes effectively to re-establishing these species at a favourable conservation status and that it takes place only after proper consultation of the public concerned.'

The aim of the Habitats Directive is to achieve Favourable Conservation Status for certain threatened habitats and species listed in its annexes (beavers being included in Annexes II and IV).

Beaver is listed in Annex III of the 'Bern' Convention on the Conservation of European Wildlife and Natural Habitats 1979, which was drawn up by the Council of Europe to ensure the conservation of European wildlife by means of cooperation between states. This means that appropriate and necessary legislative and administrative measures should be taken by signatories to ensure the protection of endangered species. This does not necessarily entail reintroduction to countries where they have become extinct, but in view of the goals of the Habitats Directive a case for reintroduction under the Bern convention may be made (e.g. Gamborg & Sandøe, 2004).

Conservation strategies

Due to the conservation efforts of other EU states, the status of beavers in Europe is improving. It is felt by many within the conservation movement that the constituent countries of Great Britain need to play their part in the conservation of beavers.

Scottish Natural Heritage (SNH) has recognized this in its Species Action Framework, which was published in 2007. This includes beavers on the Species Action List as one requiring conservation action in Scotland. This has culminated in the Scottish Beaver Trial currently underway at Knapdale.

Natural England and The Peoples Trust for Endangered Species have published their 2008 report *'The feasibility and acceptability of reintroducing the European beaver to England'* which makes clear the potential conservation benefits of beaver and the increased understanding that a pilot reintroduction to England would bring.

The Countryside Council for Wales (CCW) *State of the Environment Report – Summary (2000)* mentions restoration initiatives for landscapes and '...wildlife which has been lost from it'. As a former native species in Wales, beavers fall into this category.

Most recently, the Welsh Government is currently developing a Natural Environment Framework (NEF) for Wales which aims to take a truly integrated approach to sustainable land management in Wales and adopt an ecosystems approach to the management of the environment. Beavers could be a highly effective method of sustainably managing wetland and riparian habitats in Wales.

Social and economic reasons

Beavers are known to offer great potential for boosting tourism in areas where they are present, which can significantly enhance local incomes and employment - particularly in remoter areas affected by changes in the agricultural sector and where alternative livelihoods are less in evidence. When linked to educational initiatives, beaver reintroduction can offer a strong hook for wider environmental awareness and sustainability strategies. The provision of environmental services as a result of beaver activities (see above) also has economic benefit.

Public desire and moral considerations

The beaver is an iconic and endearing animal that is popular with the public. For an animal extinct in Britain for many years, beavers remain familiar to most people due to their frequent representation in stories, films and wildlife television programmes.

Where they have been undertaken, studies have shown that a significant majority of the public wish to see beavers back in the British countryside. One Welsh study undertaken in 2004 revealed that 71.7% of respondents were in favour of a beaver reintroduction to Wales (Lang, 2004).

Beavers were driven to extinction in Britain primarily as a result of over-hunting by humans. It is fair to assume that had a small population of beavers managed to survive in Britain they would now be the focus of major conservation initiatives. Some feel that the reintroduction of beavers would put right the historic wrong of their extinction (e.g. Morris, 1986; Yaldon, 1986; Gaywood, 2001; Asbirk, 2001).

It is for these reasons that the Welsh Beaver Assessment Initiative has been set up to further investigate the potential for a reintroduction of beavers to Wales.

1.3 THE WELSH BEAVER ASSESSMENT INITIATIVE

The Welsh Beaver Assessment Initiative (WBAI) was established following a meeting in 2005 involving some two dozen agencies and NGOs, to consider the issue of beaver reintroductions in Wales (see Appendix VIII).

This meeting led to a series of recommendations and a period of consultation with all key parties – both through direct meetings and establishment of the *'Beaver Information Exchange'* website.

The WBAI was established to formalise this process. Its aim has been to investigate the feasibility of a reintroduction of European beaver *(Castor fiber)* to Wales. This report presents the results of the WBAI study, which has included an assessment of the availability of beaver habitat in Wales, consultation with key stakeholders and consideration of the likely effects of beavers, as well as reintroduction and management options. It also builds on the scoping study on beaver reintroduction commissioned by the Countryside Council for Wales in 2005 (Anthwal *et al.*, 2005; *Scoping Study for the reintroduction of the Eurasian Beaver into Wales.* Just Ecology Environmental Consultancy).

The results of the WBAI are presented in two main documents:

- The WBAI Report (this document).
- Halley, D.J. *et al.* (2009). The reintroduction of the Eurasian beaver *Castor fiber* to Wales: an ecological feasibility study. NINA report 457. (2nd Phase catchment survey report).

Other supplemental reports are included as Appendices:

- Identification of potential beaver sites in Wales (GIS study).
- 1st Phase catchment survey reports (North Wales & South Wales).
- WildCRU report: Economic Impacts of the Beaver.

The WBAI report was undertaken under the auspices of the Wildlife Trusts Wales (WTW). It was guided by a Management Group comprised of representatives from the Countryside Council for Wales, Environment Agency Wales, Forestry Commission Wales, the Wildlife Trusts Wales, Wild Europe Initiative and individuals with relevant experience.

The WBAI has been funded by the Countryside Council for Wales, People's Trust for Endangered Species, Environment Agency Wales, Wild Europe Initiative, Wildlife Trusts Wales and Welsh Power Ltd.

2. BACKGROUND

2.1 HISTORY

Beavers once lived across much of Eurasia, stretching from Britain to Siberia. In Britain, beavers (*Afanc or Llostlydan* in Welsh) lived throughout the country on rivers, streams and wetlands, being a key constituent of our native wildlife. Beavers were hunted by humans for fur, meat and castoreum (produced by glands at the base of its tail) which was widely used as a medicine in medieval times as it is rich in salicylic acid - a basic ingredient of modern aspirin drugs. In the days of Hywel Dda (circa 950 AD) a single beaver skin was worth 'six score pence' the equivalent of up to £10,000 in today's terms. In his journal, The Journey Through Wales (1188 AD), Gerald Cambrensis wrote:

'The Teify, of all the rivers in Wales and those in England south of the Humber, is the only river where you can find beavers. In Scotland, or so they tell me, there is again only one stream where beavers live, and even there they are exceedingly rare.'

Beavers are unaggressive and easy to hunt, and this combined with their high value meant that they were eventually driven to extinction throughout most of their European range. At the beginning of the 20th century only around 1200 individuals remained in Europe in eight isolated populations. Beavers had probably disappeared from Britain by the 16th century. Exactly when they disappeared from Wales is unclear, but it is likely that beavers were extinct by the 15th century.

Since 1922 following a reintroduction from Norway to Sweden, there have been initiatives throughout Europe to reintroduce the beaver to its former range. This combined with natural spread from relict colonies in Europe has enabled beavers to make a remarkable comeback in both range and population.

Wild beaver populations have now been re-established in 24 of the 29 European states within their former range. The only states yet to have re-established wild populations are Portugal, Italy, the southern Balkan states and the United Kingdom, although a trial reintroduction to Knapdale in Scotland is currently underway as of May 2009 (the Scottish Beaver Trial). A reintroduction to England is also currently being considered.

2.2 BEAVER BIOLOGY & ECOLOGY

2.2.1 Biology

The Eurasian or European beaver *(Castor fiber)* is a semi-aquatic rodent that lives in rivers, streams, lakes and wetlands. Adult beavers are approximately 1.3 metres long (including a tail of approximately 30cm) and tend to weigh around 20 kg (max 38 kg). Females tend to be slightly larger than males but without close examination it is not possible to distinguish males from females (e.g. Rosell & Pedersen, 1999). European beavers are a separate species from the North American beaver *(Castor canadensis)*, having a different number of chromosomes, but the two species are very similar in appearance with only very minor differences. The two species cannot hybridise. Beavers are stocky with flat hairless tails and short limbs. Their rear toes are webbed for propulsion through water and their highly dexterous front paws can be used like hands for grasping, manipulation of objects, digging and grooming.

Figure 1. The European Beaver. Ian Sargent

2.2.2 Lifestyle

Beavers live on the margins of slow flowing or still water bodies, occupying linear territories that can range from 0.25km up to 20km or more, depending on habitat quality and population size, although 1-6km is typical with an average of around 3km of shoreline in average quality habitat at carrying capacity. They are territorial and will defend their territories from other invading beavers. Beavers can live up to around 12 years in the wild (typically around seven years) in small family groups of two parents and young. The average size of family groups is 3-3.5 individuals, but they can sometimes consist of two adults up to six young under three years old including two generations of offspring (Rosell & Pedersen, 1999). Beaver families have close social contact whilst they are together. They breed in January and February and give birth approximately three months later during spring. Young adult beavers tend to disperse at this time to establish territories of their own. Beavers are monogamous and once adult beavers pair up, they stay together for life. Female beavers usually first breed when three years old (Nolet, 1997).

Beavers live in dens immediately adjacent to water bodies, which are created by burrowing into suitably soft banks (a burrow) or created within lodges built from tree stems, branches, twigs and mud. Beavers often build a burrow-lodge, which is a combination of both types, usually beginning as a burrow but roofed with sticks. Lodges are typically around 1.5m in diameter and 1m in height with the visible portion of burrow-lodges usually being around 1m in diameter and 50cm in height. If appropriate habitat is available, beavers will also create dens in naturally occurring holes in banks. Three den types are shown below.

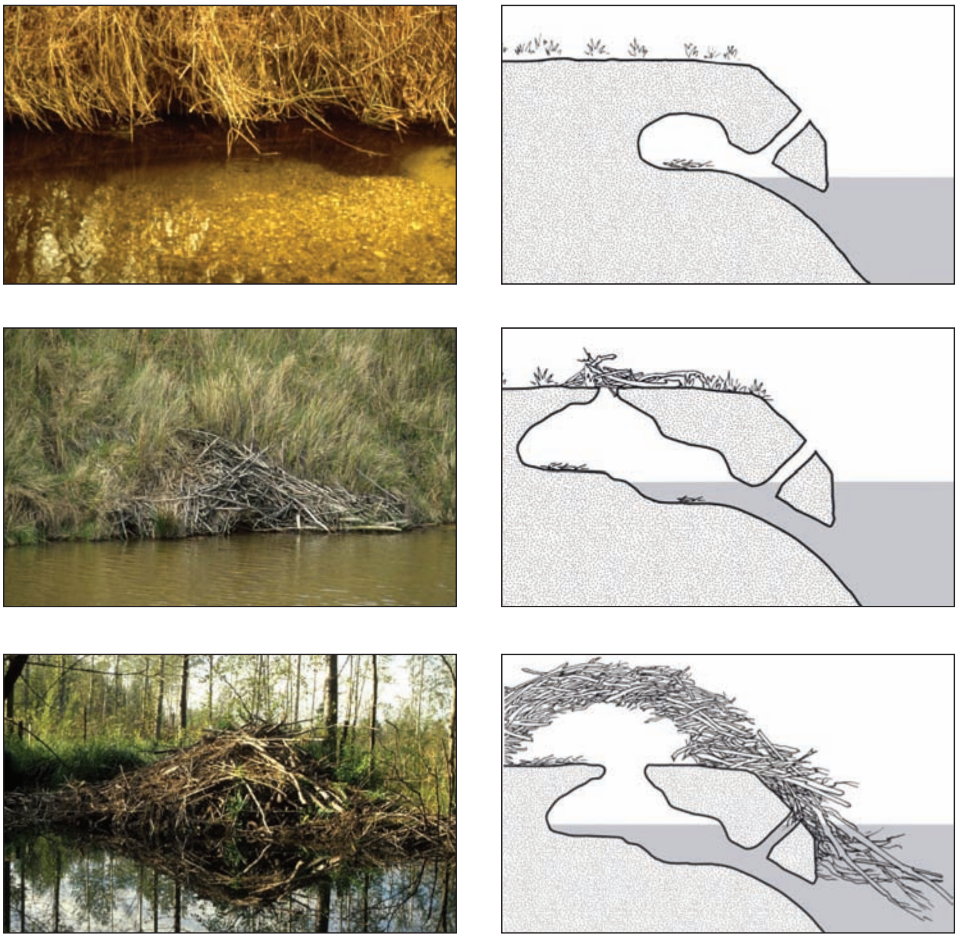

Figure 2. Three types of beaver den. Photographs: G. Schwab; diagrams drawn by Mike Rouillard for Coles, 2006. Beavers in Britain's Past.

The entrance to a beaver den is almost always submerged, with the living chamber always above water level. Free-standing lodges are built out into the water to ensure an underwater entrance. Larger lodges can have several entrances and chambers.

There are normally several beaver dens in a territory but one will be the main residence and usually the only one inhabited during the winter months. Beavers use water as a refuge from predators and do not like to travel far from it, quickly retreating back to it when alarmed. Beavers use their tails to slap the water to warn other beavers of danger, before submerging and swimming to their underwater entrance.

This pattern of behaviour tends to restrict beaver activity to a narrow strip of land close to the water's edge (see below).

2.2.3 Feeding

Beavers are herbivores and can feed on a wide variety of woody and herbaceous vegetation, but have favoured foods when available. Broadleaved deciduous tree bark is mostly eaten during the winter months when other food is less available (e.g. Elmeros *et al.,* 2003).

Beavers fell trees to access bark, upon which they can feed. They also use the stems, branches and twigs as building material. Tree species particularly favoured by beavers for food are aspen, willow and birch. European beavers are not fond of alder and tend to avoid it unless other sources of food are scarce (D. Halley, pers. comm.). European beavers rarely fell or feed upon coniferous tree species (Haarberg & Rosell, 2006; Parker *et al.,* 2001) enabling commercial plantations to coexist adjacent to beaver inhabited sites.

Whilst trees of up to 1m in diameter can be felled, beavers tend to fell trees with diameters less than 10cm (Wilson, 1971; Hartman, 1992; Reynolds, 2000) with up to 95% of stems being less than 5cm in diameter (Haarberg & Rosell, 2006). Felling of deciduous trees by beavers effectively coppices them resulting in abundant re-growth of leafy stems (e.g. Reynolds, 2000). As the new growth is close to the ground it is more readily accessible to beavers. Beavers can preserve live stems and branches underwater by sinking them into mud and this provides them with a food source in winter months. Halley (2009) suggests that tree felling for bark may be relatively less common in Wales compared to other regions in Europe, as its mild climate and long growing season would result in other food sources being available for more of the year.

Figure 3. Although beavers do sometimes feed on large diameter trees (left) they more typically feed upon smaller diameter trees (right). Felled trees are coppiced and re-grow with abundant stems. G. Schwab

Almost all beaver activity tends to be restricted to within 20m of the water's edge (Elmeros *et al.,* 2003; Baskin & Sjöberg, 2003).

In Russia, 90% of cut stems were within 13m of water and 99% within 20m (Baskin & Sjöberg, 2003) and in Denmark 95% of beaver cut stems were found to be within 5m of water (Elmeros *et al.,* 2003).

It is very rare for beavers to forage further than 100m from the water's edge (Simonsen, 1973; Howard & Larson, 1985; Nolet *et al.,* 1994) but they have been known to occasionally do so to access aspen and poplar trees (D. Halley, pers. comm.).

Beavers are central place foragers, i.e., they prefer to stay relatively near to their lodges so foraging activity tends to decrease with distance from them. Beavers are active all year round, especially so during spring and autumn. In spring, beavers need to replenish fat reserves and young adults disperse. Summer is a time of abundant food and mild weather. In autumn, beavers build up their fat reserves for the winter months, and are also particularly active in repairing dens and dams. In winter, beavers tend to stay in their dens during poor weather conditions.

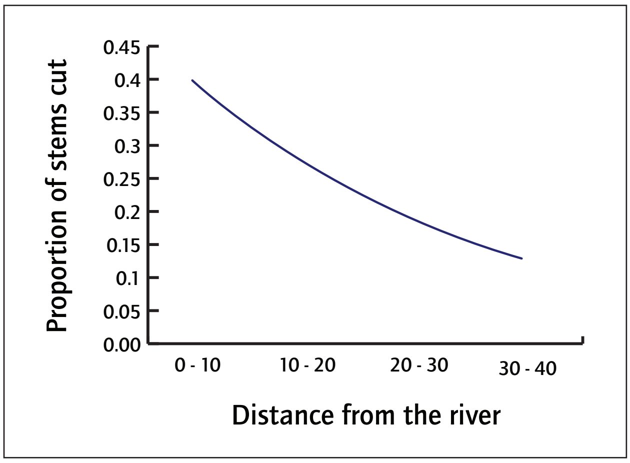

Figure 4. Most beaver activity occurs within 20m of the water's edge. (From Haarburg & Rosell, 2006)

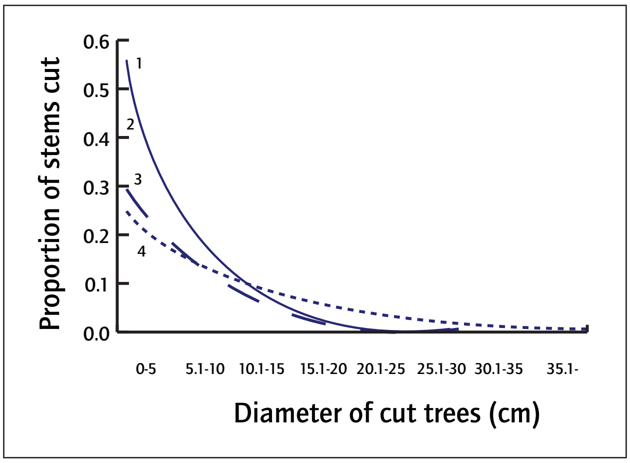

Figure 5. Tree diameter selection with distance. 1 = 0-10m; 2 = 10-20m; 3 = 20-30m; 4 = 30-40m. (From Haarburg & Rosell, 2006)

2.2.4 Beaver dams and canals

Beavers can modify their habitats through the construction of dams and canals. Dams are constructed using a combination of small diameter tree stems, branches, sticks and mud, but other materials can sometimes be used if trees are absent.

As the creation of dams involves significant effort, beavers usually prefer to inhabit sites where dam building is not necessary, so often occupy favoured territories before they begin to occupy the less favoured territories that do require damming. Only once these favoured territories are occupied do beavers begin to occupy the less favourable territories that do require damming. This means that damming tends to occur later on in the colonisation process when beaver populations have grown (Halley & Rosell, 2002; Zurowski & Kasperczyk, 1986).

European beavers do not usually build dams across rivers more than a maximum of 6m wide (Hartman & Törnlöv, 2006). The purpose of damming is to create areas of deeper water. These areas provide beavers with a refuge and ensure lodge/burrow entrances remain submerged. In addition to this, deeper water is used as an underwater food storage area and enables beavers to transport building and food materials more easily (e.g. Muller-Schwartze & Sun, 2003). The size and shape of the water bodies created behind dams are strongly influenced by the dimensions of the water channel and the local topography with dams in v-shaped river valleys tending to create smaller ponds than those in flood plains (Johnston and Naiman, 1990a; G. Schwab, pers. comm.).

European beavers tend to build smaller dams than North American Beavers and less often (Halley *et al*., 2009). European beavers will not build dams across major rivers and tend only to dam smaller streams with a depth of less than around 0.85m. Studies have shown that most dams are less than 3m across and less than 1m in height (e.g. Hartman & Törnlöv, 2006). Studies indicate that beavers attempt to create a water depth of over 0.7-1.0m immediately behind the dam (e.g. Hartman & Törnlöv, 2006), so in general, deeper waters require smaller dams and water bodies over 0.7-1.0m deep do not require damming.

Figure 6. The broadleaved trees in this picture mark the course of a small stream containing a cascade of beaver dams and ponds (see Figure 7. below). Tree stems remain abundant despite coppicing by beavers.

The location of dams is influenced by gradient. Studies have shown that gradients of over 2% usually seem to be too steep for dam construction (Halley *et al.,* 2009) with only one recorded case of a stream steeper than this (2.5%) being dammed (Schulte, 1989 cited in Halley *et al.,* 2009).

Figure 7. One of a series of small ponds formed by dams creating a cascade on an otherwise small and unremarkable stream in Bavaria. Maximum dam height is around 0.5m. Despite only moderate flow conditions water can be seen breaching the dam (far left and right of the picture).

Apart from in flat terrain beaver dams can remain relatively uncommon structures in the landscape, even when beavers are at maximum population levels (Halley *et al.,* 2009). A study from Norway on the Numedalslaget watershed (a capacity population, in a landscape similar to those found in Wales) determined that in 2003 there were 29 beaver territories on the river system, of which only three (approximately 10%) contained actively maintained dams. Two other dams present were no longer maintained and would have been breached at the next spate (Parker & Rønning, 2007). However, in some parts of Bavaria around 50% of territories may have dams present (D. Gow pers. comm.).

Beaver dams tend to be breached when rivers are in spate, either from water over-topping or due to collapse as a result of the force of water flow (Halley *et al.,* 2009.). Beavers will usually repair damaged dams if they continue to occupy the territory so long as the dams are not holed beneath the waterline, as beavers are unable to repair such damage (Halley *et al.,* 2009; G. Schwab, pers. comm.).

As dams require maintenance they are rarely permanent structures in the landscape and typically last 3-10 years, although they can last longer in some circumstances. Once food resources immediately behind dams are depleted, beavers search for new territories, or shift the focus of the existing one, and the dams are abandoned and left to degrade, usually breaching during the next period of heavy flow (Halley *et al.,* 2009). The breaching of dams can result in the formation of lush 'beaver meadows', which develop on the rich sediment deposited in the beaver ponds. A photograph of such a meadow is shown overleaf.

Figure 8. A 'beaver meadow' forming behind a collapsed dam (first summer of regrowth) D.J. Halley

Another feature that may accompany beaver habitation is beaver canals. They tend to be approximately 0.5m wide and 0.7m deep and are sometimes created in flat, marshy terrain to enable beavers to stay in the water as they move around and transport building materials more easily.

Such canals usually begin as beaver trails, which become deepened by both continual use and active excavation and lead from the pond or stream bank outwards to a foraging area.

Most are quite short, being around 5-10m long, but occasionally can be up to 25m long (Halley, *et al.,* 2009).

Figure 9. Beaver canals and trails. D.J. Halley, G. Schwab.

2.2.5 Population dynamics

Following initial colonisation of an area beavers tend to disperse widely throughout a catchment and then gradually infill as the population increases.

Population growth is slow at first and then increases more rapidly until all suitable habitat is occupied. Natural colonisation can take around 30-50 years to complete. The pattern has been noted widely throughout Europe (Bevanger, 1995; pers. obs; G. Schwab pers. comm.; Halley & Rosell, 2002; Kostkan, 1999; Hartman, 1994a, b; Hartman, 1996; Nolet & Rosell, 1994; Valachovic, 1997). This process can be more rapid following deliberate reintroduction depending on numbers of beavers released and catchment size.

A typical example of this pattern is shown below (Hartman, 1995).

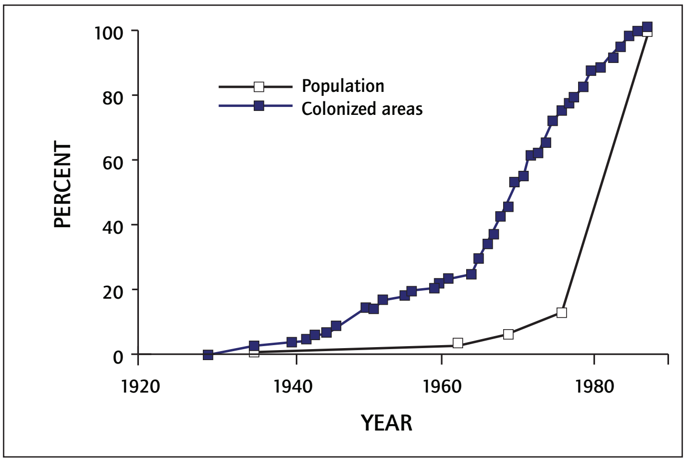

Figure 10. Beaver population growth over time. Hartman, 1995

Population sizes are naturally capped by habitat availability and following the rapid growth phase populations typically decline somewhat before stabilising.

2.2.6 Spatial dispersal patterns

As beavers are strongly restricted to narrow margins (Barnes & Dibble, 1988; Donkor & Fryxell, 1999; Parker *et al.,* 2001) they are reluctant to cross open land between water bodies and do not readily spread between catchments, especially in hilly or mountainous landscapes (e.g. Hartman, 1994a,b; 1995).

In Wales it is considered unlikely that beavers will readily colonise one catchment from another, even when populations are high (D. Halley, pers. comm.). For example, beavers have always been present in Telemark, Norway where they never became extinct, but have so far failed to recolonise any of the adjacent river valleys on the west coast because of the intervening treeless and mountainous terrain despite populations being at capacity in Telemark. In Trondheim, beavers recolonised the Ilabekken stream in the early 1980s but have so far failed to spread across the 300m between that stream and the Kyvannet stream system, over a gentle, continuously wooded ridge.

When habitats are at their maximum carrying capacity beavers will fight each other to defend territories, often resulting in death as a result of injuries or the inability of individuals to secure a territory and thus resources. Reproduction, survival, and dispersal are density dependent, so as population density increases, so do mortality rates. Pregnancy rates and litter size also decrease, and sexual maturity and dispersal are delayed (Heidecke & Ibe, 1997; Hartman, 1994a,b; Halley *et al.,* 2009). These factors result in beaver populations being self-regulating over time achieving 'rough stability' in 30-40 years depending on local conditions (Hartman, 1994a, b; 1995; Halley *et al.,* 2009). The following graph shows what is considered to be the typical model for beaver population growth and stabilisation:

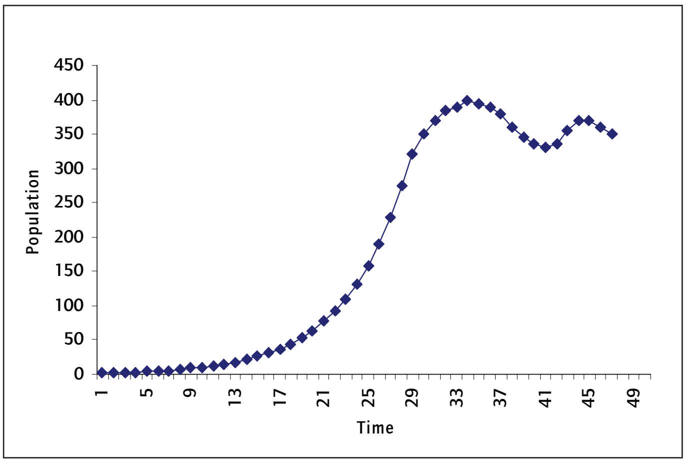

Figure 11. A graphical representation of beaver population growth and stabilisation over time. G. Schwab.

2.2.7 Predation

Due to their habits and lifestyle beavers have very few natural predators (Rosell & Czech, 2000). Predation of beavers by wolves, otters, foxes and other predators does occur in some parts of mainland Europe (Rosell *et al.*,1996) but it is not generally considered to be a significant factor in the regulation of most beaver populations (e.g. Curry-Lindahl, 1967).

In Wales it is possible that some predation of juvenile beavers by otters, foxes or possibly mink may occur, but this is considered unlikely to have a significant effect on beaver populations (D. Halley, pers. comm.).

3. LIKELY EFFECTS OF BEAVER REINTRODUCTION

This section outlines the effects that beavers are likely to have in Wales following a managed reintroduction scenario as outlined in this document. The information presented below has taken into consideration issues raised by stakeholders during the consultation process.

3.1 HYDROLOGY, GEOMORPHOLOGY AND BIOCHEMISTRY

The activities of beavers can have significant effects on the hydrology, geomorphology and biochemistry of wetland and riparian habitats.

Beaver dams, ponds and wetlands can have a cumulative effect in slowing water flow through catchments (Grasse, 1951) including during spate conditions. This can help to ameliorate downstream flooding events during periods of heavy rainfall (Bergstrom, 1985; Harthun, 2000). The effect is more pronounced on small upland streams than flood wetlands (Johnston & Naiman, 1987), reducing the quantities of sediment that can be carried by the water (Naiman, Johnston & Kelley, 1988) and reducing bank-side erosion (Parker, 1986).

Sediment tends to be deposited within the ponds that exist immediately behind beaver dams (where the water flow is slower). This sediment accumulates over time and can result in the creation of lush beaver meadows with rich soils following the abandonment and collapse of the associated dam (Halley *et al.,* 2009). There may be occasions where silt accumulation in a particular location is unwanted (e.g. on salmon spawning areas). In such instances dam removal or modification can be undertaken to prevent this.

Although beaver dams normally reduce the severity of flooding events, they could in some circumstances contribute to them if dam failure occurs on ponds that are particularly large (Butler, 1991, 1995). However such occurrences can only occur on low gradient streams and are considered to be extremely rare (see Gurnell, 1997).

The landscape and land management conditions prevalent in Wales are such that the formation of beaver ponds large enough to be capable of creating significant flood events further downstream in the event of a breach are thought most unlikely (D. Halley, pers. comm.). Beaver dams considered to pose a significant risk could be quickly and easily modified to negate risk or removed.

In most European scenarios beaver dams are usually naturally breached or destroyed during times of high flow when rivers are in spate (Halley *et al.,* 2009). In spate conditions the additional water that a breached beaver pool adds to the flow volume is insignificant (D. Halley, pers. comm.).

Damming of small rivers and streams generally results in an increase in open water and wetland habitat along watercourses and water tables are elevated (Bergstrom, 1985; Johnston & Naiman, 1987). By increasing water storage capacity of streams, beaver dams may lead to greater flows during drought conditions (Parker, 1986), which may result in less intermittent flows on some streams (Rutherford, 1955; Yeager & Hill, 1954).

Beaver activity on a watercourse can have a significant effect on water chemistry, which can have a considerable influence on the productivity of fresh waters (Rosell *et al.,* 2005). The conditions within beaver ponds lead to the accumulation of large quantities of organic matter (Naiman *et al.,* 1994) and can greatly enhance microbial activity (Songster-Alpin & Klotz, 1995). Accumulation of organic matter as a result of beaver activity can be very important to phosphorus and nitrogen dynamics within water bodies (Devito & Dillon, 1993). Levels of organic pollution within water courses can be reduced and acidity decreased (e.g. Margolis *et al.,* 2001a).

Coarse and large woody debris within streams and rivers can increase as a result of beaver activity and has the potential to impact on man made infrastructure, although techniques have been developed in Europe and North America to counter problems, mostly involving low-tech solutions (see Section 6). The presence of coarse and large woody debris within rivers is often considered greatly beneficial to river hydrology, geomorphology and biodiversity (Boyer, *et al.,* 2003; Gurnell *et al.,* 1995; Godfrey, 2003; Linstead & Gurnell, 1999; Mott, 2005), but is considered by some to impede movement of fish (see Kemp *et al.,* 2010) and could make fishing more difficult in some locations.

Forest Research (the research agency of the Forestry Commission) has been experimenting with man-made woody debris dams as a management tool for slowing water flow through catchments and thereby reducing flooding further downstream. Small dams can each delay the passage of the flood peak and collectively retain significant volumes of floodwater upstream to be released more slowly over time rather than as a single pulse.

It is possible to consider these man-made debris dams as artificial beaver dams, as they perform much the same function. Beaver dams within an inhabited territory, however, would require no costs for creation or maintenance.

3.2 BIODIVERSITY

The effects that beavers have on habitats and species are the subject of many studies. The general opinion appears to be that the habitat modifications undertaken by beavers can have a significant positive effect on wildlife in riparian and wetland habitats (e.g. Rosell, 2005; Gurnell, 2008).

Beavers are often referred to as a 'keystone species' in wetland ecosystems on account of their disproportional influence on those habitats, the analogy being to the keystone of an archway that holds the other stones in place (e.g. Gaywood *et al.,* 2008).

The impacts that beaver activity could have on native flora and fauna is outlined below.

3.2.1 Flora

The activities of beavers seem to have a positive impact on plant diversity in wetland and riparian areas (see Gurnell *et al.,* 2008). The foraging activity of beavers in wooded areas results in the localised coppicing of riparian trees and woody shrubs. This results in an initial opening up of the tree canopy, increasing light-levels entering the riparian zone and encouraging the growth of diverse ground flora and tree regeneration (Reynolds, 2000). River banks generally remain well-wooded, with trees and shrubs being thinned rather than clear felled (see Ashmole & Ashmole, 1996; Jones 1996; Currie, 1995; Reynolds, 2000). Beavers can maintain coppices whilst present at a site, but once a site is vacated (which tends to occur in the longer term) coppices regrow and the canopy closes. Tree regeneration stimulated by beaver foraging was noted by Fustec *et al.,* (2001) to also help stabilize the banks of water bodies.

Figure 12. Left: Occupied riparian beaver habitat in Bavaria; Right: Tree saplings spring up in a bankside glade created as a result of beaver activity.

The initial felling of tree stems by beavers creates an increase in fallen dead wood within the habitat. Larger diameter trees, if not protected, can be ring-barked by beavers, and so eventually die-off creating standing dead wood. Fallen and standing dead wood is essential to many invertebrate and fungal species, as well as the species that feed upon them (Currie, 1995; Reynolds, 2000). Deadwood is an important (and often seriously lacking) element of most British broadleaved woodlands.

Figure 13. Potential fallen and standing dead wood. D.J. Halley

A typical result of long-term beaver foraging within a defined territory is the creation of 'beaver coppice', characterized by coppiced trees among a rich ground layer of grasses and herbs. Tree standards do remain in the vicinity of these beaver territories. Trees deemed important (e.g. for wildlife, landscape or amenity reasons) can be protected from beaver activity if required using low cost solutions such as placing wire mesh around tree trunks.

Figure 14. A typical example of beaver coppice/pasture within a suburban reservoir park (Theisandammen) in Trondheim, Norway created after >35 years of continuous occupation. D.J. Halley

The construction of beaver dams, ponds and associated activities undertaken by beavers results in the creation of diverse riparian habitats with benefits for a wide range of species. The activities of beavers result in a general increase in the abundance and diversity of herbaceous plants in the riparian zone and within the water (e.g. Reynolds, 2000; Wright *et al.,* 2002; Elmeros *et al.,* 2003; Gurnell *et al.,* 2008;)

3.2.2 Invertebrates

Beaver activity can have a significant effect on invertebrate species. Beaver ponds favour lentic (pond) species, with dam side-channel flows and lengths of main channel between dams providing habitats for lotic (stream) species. An increase in aquatic habitats of all types is thought likely to support a high diversity of macro-invertebrates (Gurnell *et al.,* 2008).

Beaver ponds store increased organic material and sediment (Francis *et al.,* 1985), which can result in an increase in the density and biomass of the invertebrate community. McDowell & Naiman (1986) found these attributes to be 2–5 times greater in beaver ponds than at riffle sites in spring and summer. Pond-living invertebrates such as dragonflies, damsel flies, caddis flies and molluscs benefit from the presence of beaver ponds (Harthun, 1999). Although conditions within beaver ponds tend not to favour lotic species, dams themselves can support them (Clifford, Wiley & Casey, 1993) and they can play an important role in maintaining lotic fauna in slow-flowing streams (Rosell *et al.,* 2005).

Invertebrates can also benefit from increased coarse woody debris in rivers, which provide them with additional living and breeding habitat (Godfrey, 2003; Linstead & Gurnell, 1999; Mott, 2005).

A study on streams in central Europe by Rolauffs *et al*. (2001) showed an overall increase in macro invertebrate numbers and diversity in response to beaver activity with a only a few groups showing a negative impact.

Increases in fallen and standing deadwood resulting from beaver activity can benefit terrestrial invertebrates reliant on dead and decaying wood (see Spieth, 1979; Rosell, 2005; Gurnell *et al.,* 2008). Localised increased light levels and plant diversity in the riparian zone resulting from beaver coppicing may also encourage a wider diversity and abundance of invertebrate species increasing potential food supplies for many other animals, including amphibians, reptiles, birds and mammals (see Gurnell *et al.,* 2008).

The freshwater pearl mussel *Margaritifera margaritifera* is present on a small number of rivers in Wales with some colonies numbering just a few individuals. This species requires clean, oligotrophic, well oxygenated, moderate to fast flowing water and a substrate of sand or gravel patches stabilized amongst larger stones or boulders. One can assume therefore that this species would not survive in beaver ponds. However, as beavers prefer to inhabit riparian zones where water is slow flowing, presumably sites suitable for freshwater pearl mussel would not be ideal for beaver habitation. Also as beaver dams and ponds retain water so help to regulate flow, trap sediment, pollutants and nutrients (e.g. Gurnell 1998; Rosell *et al.,* 2005) beaver activities might benefit freshwater pearl mussel populations (Campbell, 2005).

Nonetheless, any beaver dams constructed in locations likely to adversely affect freshwater pearl mussel colonies would need to be promptly removed or modified.

3.2.3 Fish and fisheries

Introduction

Beavers are herbivorous so do not eat fish and therefore have no direct impact on fish populations. Beavers can substantially modify their local habitat and are often described as 'ecosystem engineers'. These habitat modifications can affect fish populations and communities, at least at a reach scale. Catchment scale effects (both positive and negative) are less clear, because few studies address this issue.

The majority of studies on the effects that beavers have on fish are from North America rather than Europe (Kemp *et al.,* 2010). As these studies involve North American beavers, eco-regions and fish species not found in Britain, and were often undertaken where the effects of beavers are not actively managed, it can be difficult to relate them directly to the scenario likely to occur following a managed re-establishment of beavers to Wales. However, in order to give an overview of the relevant issues, this section examines the potential effects that beavers can have on fish.

This report takes a two-pronged strategy to this, based on a risk assessment approach. So far as is possible we have attempted to identify the impacts of beaver activity on the various fish species concerned using available knowledge of their habitat preferences (e.g. Maitland, 2003; Maitland & Hatton-Ellis, 2003; Hendry & Cragg-Hine 2003; Harris & Milner (eds), 2006; Tomlinson & Perrow, 2003). Where specific empirical evidence documenting the magnitude of a potential impact exists, we have included this also (e.g. Kemp *et al.,* 2010).

Detailed reviews of the scientific literature covering beavers and their impacts on fish have been undertaken by Collen *et al.* (1997); Rosell *et al*. (2005); and most recently Kemp *et al.,* 2010. The information below is taken from these and other sources.

Background

Welsh fish communities are dominated by migratory species. Atlantic salmon *(Salmo salar)*, trout *(Salmo trutta)* and European eel *(Anguilla anguilla)* are very widespread. Shads *(Alosa spp.)* are abundant in the larger rivers in South Wales, and Wales is thought to contain up to 75% of the UK spawning population of these species. Welsh rivers also support large populations of lampreys. Fish species that do not have a migratory phase such as grayling, barbel, minnow and chub have been unable to colonise most Welsh rivers, but some species have been introduced by man. Economically, the most important river fish are salmon and trout.

Fish populations in Wales are currently subject to a range of pressures. In upland streams acidification still has a significant effect, though both the severity and extent of this impact is slowly decreasing. Climate change may also be leading to increased flashiness of rivers and consequent washout of eggs (Williams & Duigan (eds), 2009).

In lowland areas, agricultural intensification has had serious effects. Increased run-off of silt, nutrients and agrichemicals (especially sheep dip) have all reduced water quality. Overgrazing or even cultivation of riparian margins has also reduced cover for fish and their invertebrate prey. Lack of coppicing of riparian corridors means that other sections become overshaded, thereby reducing habitat quality.

Modification of river habitat for flood defence purposes or to reclaim land for agriculture has in places reduced instream habitat diversity and disrupted the natural riffle-pool sequence. Barriers to migration remain a significant issue on some watercourses.

The Rivers Trusts in Wales have carried out a large number of restoration projects to reduce these negative impacts. The main strands of work have focused on coppicing to reduce overshading and increase habitat diversity; removal of barriers to migration by re-engineering man-made structures and modifying debris dams so fish can pass; fencing to exclude stock; and liming to reduce acidification.

General effects of habitat modification by beaver

The foraging and damming activity undertaken by beavers can create a mosaic of habitats, forming ponds along stream corridors and increasing the levels of coarse woody debris within them (Hanson & Campbell, 1963; Kauffman *et al.,* 1993, Rosell *et al.,* 2005) which can create riffle areas that are important for many aquatic invertebrates. Beaver foraging can result in the localised coppicing of riparian trees, which can allow more light to reach the water in these areas, increasing primary production and providing a food supply for grazing mayflies and other invertebrates on which many fish populations depend. These habitat modifications are likely to benefit most river species including salmonids, but under certain circumstances (see below) there is some potential for negative effects to occur. A number of studies are outlined below which give examples of the potential positive and negative effects that beaver activity may have upon fish.

Beavers are efficient consumers of aquatic plants and may remove as much as 65% of plant material in ponds and lakes. Beaver activity could therefore reduce the standing crop of aquatic plants to some extent. This may be detrimental to fish where grazing is intense as it may leave them vulnerable to fish eating birds; however in lowland areas it may also reduce the risk of oxygen sags during the night caused by excessive vegetation growth. We are not aware of any research in this area.

In a study of the effects of beaver reintroduction to Denmark, Elmeros *et al.,* (2003) report that there was no overall change in the abundance of aquatic vegetation in streams as a result of beaver presence apart from where heavy foraging had caused a localised reduction in riparian scrub and therefore shade. At these sites aquatic vegetation increased in both abundance and diversity.

Beavers may build dams on small streams within their territories if water depth is less than approximately 0.7m and this creates ponds behind them (see section 2.2.4). These ponds characteristically support higher densities of aquatic invertebrates compared to un-impounded water bodies (Rasmussen, 1941; Call, 1966; France 1997, Longcore *et al.,* 2006). The importance of increased invertebrate abundance as food for fish is highlighted in a number of studies (e.g. Rutherford, 1955; Gard, 1961; Rosell, 2005).

Murphy *et al.* (1989) report that this increased food availability results in faster growth in Pacific salmon *(Oncorhynchus spp.)*. Hägglund & Sjöberg (1999) reported increased body size in brown trout *(Salmo trutta)* inhabiting beaver ponds compared with those in riffle sections and Gurnell *et al*. (2008) presume this was a result of beaver activity leading to an increase in food availability. Sigourney *et al*. (2006) found during a study in New Brunswick, Canada, that Atlantic salmon *(Salmo salar)* parr from a beaver pond had higher growth rates than those sampled from above or below the pond and that they better maintained their condition than those above and below during the summer.

In North American studies, the presence of slow-flowing beaver ponds with abundant invertebrates along watercourses were thought to provide important rearing habitat for a range of anadromous species including Atlantic salmon (see Kemp *et al.* 2010).

Schlosser (1995) demonstrated that beaver ponds in North America could act as production or source habitats for species such as creek chub *(Semotilus spp.)*, which then disperse into adjacent streams. Emeros *et al.,* (2003) suggest that European beaver ponds benefit roach *(Rutilus rutilus)* and stickleback *(Gasterosteus aculeatus)* populations.

Build-up of silt above beaver dams is likely to provide good habitat for lamprey ammocoetes. Beaver managers in Bavaria report that brook lamprey *(Lampetra planeri)* use beaver dams as refugia and are frequently seen swarming out of beaver dams when they are modified or removed (G. Schwab, pers. comm.).

A potential negative effect was found during a study by Rabe (1970) in Colorado which found that brook trout in beaver ponds were present at such high densities that individuals tended to be stunted. In the Welsh scenario such over abundance could be avoided by encouraging recreational fishing in such sites, although at present most fishing in Wales is 'catch and release'.

Beaver ponds can increase densities and species richness of salmonids and coarse fish, by providing refuges during low-flow conditions (Bruner, 1990; Cook, 1940; Duncan, 1984) and extreme cold conditions (Cunjak, 1996) as well as providing deeper water to enable young fish to better evade predators such as goosanders and otters (Scruton *et al.,* 1998).

The US National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service in Oregon is undertaking research into the potential for beavers to improve habitats for juvenile steelhead *(Oncorhynchus mykiss)* by providing extra structural support to beaver dams to attract beaver activity in specific areas of a tributary of the John Day River, Oregon (Kemp *et al.,* 2010). The supported dams are intended to increase silt deposition and elevate the floodplain water table to increase summer flows, decrease stream temperatures, improve the stream channel and establish new riparian vegetation. The results of recent study suggest that restoration strategies that encourage the recolonisation of streams by beaver can rapidly expand riparian habitat along incised streams (Pollock *et al.,* 2007). Incised streams with low habitat diversity are common in Wales due to agricultural and flood defence activities.

Effects of instream woody debris

Beaver activity can increase the amount of large woody debris (trees, large branches) and coarse woody debris (smaller branches, twigs and leaves) that naturally occurs within freshwater ecosystems. Woody debris created by beavers exists in the form of lodges, food caches, dams and feeding remains. Woody debris is often a feature of rivers and streams regardless of beaver presence and may be managed to varying degrees by local fishing and angling groups, as well as the Environment Agency.

Woody debris within water bodies is considered to be generally beneficial to fish species (e.g. Mott, 2006; Gurnell *et al.,* 1995) although its abundance in relation to that of fish varies depending upon stream and fish type (Kemp *et al.,* 2010). It is widely acknowledged that Woody debris can benefit fish by providing cover, stabilising river substrate, causing localised scouring and increasing instream habitat diversity, creating riffle areas and indirectly providing increased food resource for fish (see Kemp *et al.,* 2010).

Coarse woody debris (CWD) is considered important for providing habitat for juvenile salmon, as well as other species, while contributing to overall stream habitat and species diversity (House & Boehne 1985, Bjorn & Reiser 1991, Hendry and Cragg-Hine 2003). Sedell *et al*. (1984) found that side channels with CWD had eight times more juvenile coho salmon than side channels without it and considered it to create high quality salmonid spawning habitat by stabilising channel substrate. Other studies (e.g. Bryant, 1985; Hortle & Lake 1983) also considered CWD to increase the abundance of fish species.

Kemp *et al*. (2010) report that in small streams in the New Forest, England, Atlantic salmon, brown trout, and eel *(Anguilla anguilla)* were found in higher densities within debris-dam matrices than in ponds without woody material. It was concluded that salmonids were using the wood matrix or, deeper water as refugia. Angling clubs in Wales are being encouraged by EAW Fisheries staff to retain and in some cases introduce CWD. Anglers on the River Alyn in NE Wales have reported an increase in trout size after adopting such measures (D. Thorpe, pers. comm.).

Beaver created CWD can provide cover and habitat for fish (Rasmussen, 1941; Rutherford, 1955; Sayler, 1935; Beedle, 1991) including salmonids and percids (Collen & Gibson, 2001) and lamprey (G. Schwab, pers. comm.). In Bavaria a study involving electro-fishing within aquatic woody debris created by beavers near to their lodges found fish numbers to be up to 80 times higher than average (Bavarian Anglers Society and Bavarian Institute for the Environment Report: *Totholz bringt leben in Flüsse und Bäche.* 2005).

Obstructions to water flow caused by woody debris may hinder fish passage during very low flow (Cowx & Welcomme, 1998; Bisson *et al.,* 1987) but as flows increase the accumulations of coarse woody debris usually become passable (Kemp *et al.,* 2010). Coarse woody debris can be unpopular with anglers, because fishing lines become snared. However, woody debris arising from beaver activity could still be managed on fishing beats whilst being encouraged to increase in nursery areas.

Effects on water quality and flow

Damming by beavers can help to mitigate the negative effects of extreme flow conditions by storing water and slowing flow through catchments in spate conditions thus helping to stabilise hydrological conditions in rivers (Grasse & Putnam, 1955; Halley, 1995; Gurnell, 1997; Rosell *et al.,* 2005). This can also reduce bank erosion and bed scouring (Parker *et al.,* 1985) so decreasing the sediment load carried by the water.

Beaver dams and ponds trap sediment which can also reduce siltation of salmonid spawning gravels downstream (Macdonald *et al.,* 1995; Rosell *et al.,* 2005) and reduce organic pollution within watercourses (Rosell *et al.,* 2005). The chemistry of beaver ponds can also help to reduce acidity in watercourses (Cirmo & Driscol, 1993; Margolis *et al.,* 2001), which can benefit all species downstream including salmonids (Halley, 1995).

As beaver dams trap silt immediately behind them (Rasmussen, 1941), and in some cases immediately below them (Knudsen, 1962), there may be occasions where silt accumulation could adversely affect pre-existing salmon spawning areas. Such occurrences could be avoided by appropriate management such as dam removal or modification. Also, the collapse of very large, long-established beaver dams and subsequent release of trapped silt could potentially cause siltation of spawning beds downstream. These effects are likely to be temporary but locally significant.

The presence of slower flowing beaver ponds along watercourses provides important rearing habitat for andromous fish species (e.g. Taylor, 1999; Swanston, 1991; Johnson & Weiss 2006) and also allows young fish to expend less energy, resulting in increased growth rates (Hutchings, 1986; Enders *et al.,* 2003; Sigourney *et al.,* 2006). During drought conditions these ponds can also function as important refugia for all fish (e.g. Cook, 1940; Bruner, 1990).

Beaver dams can alter (although not necessarily reduce in number) the local distribution of riffles and runs on a particular stretch immediately associated with a dam. Under some circumstances dams can reduce water flow downstream, which could pose a problem for juvenile salmonids (Bryant, 1984).

The removal or modification of individual dams considered to be causing problems would obviously be an effective method of negating any detrimental effects they may be causing.

Effects on water temperature

Water temperature is an important factor for the reproduction and survival of fish species and this can be particularly important for salmonids. The EU Freshwater Fisheries Directive (EU 1978; NRA 1994b) requires that for the protection of salmonid fisheries, water temperatures should be maintained below 25˚C.

There are two activities that beavers undertake that have potential to influence water temperature. Firstly, beavers can create ponds, which have thermal characteristics that differ from river channels and can hold water upstream, and secondly, beavers coppice riparian trees and so can cause a localised reduction in shade and increased exposure of water bodies to air.

Most of the studies covering this subject have been undertaken in North America and owing to differences in climate, eco-region, scale, fish species and beaver impact management, their relevance to a likely Welsh scenario is limited. These studies illustrate that the effects that beaver activity may have on water temperature appear to vary greatly depending on region and site characteristics (Collen, 1997). In addition to this, the effects that water temperature alterations may have on fish depend upon particular circumstances, such as whether temperatures are already close to the upper or lower limits of thermal tolerance of fish species (e.g. Huey & Wolfrum, 1956; Baker and Hill, 2003).

Studies undertaken in Canada and the Western United States (Colorado and Wyoming) showed that there were few problems with temperature changes caused by beaver activity where waters are well below critical temperatures (Wayne *et al.,* 1951), but a study by Hale, (1966) in the Eastern United States (Minnesota) suggested that increases in the summer temperatures of ponds may have reached the upper limits of temperatures tolerated by trout. Also, Adams (1949) working in Michigan reported that excessive temperatures in ponds may have caused problems for trout, but that the presence of beaver ponds had helped to maintain trout populations during an unusually dry season. In studies undertaken in Utah (Rasmussen, 1941), New Mexico (Huey & Wolfrum, 1956) and Wyoming (Grasse & Putnam, 1955) increased water temperatures were considered to be beneficial to trout where temperatures were too cold for optimum development. However, few species in Wales are limited by low water temperatures with the main problem being raised water temperatures. This could be a problem that becomes more widespread as a result of climate change. Whilst some migratory fish species – especially shad and sea lamprey – are thought likely to benefit from warmer water, salmonids are considered sensitive to increased water temperature, especially where this exceeds 25˚C (Hendry & Cragg-Hine, 2003).

Water temperatures were often not the primary focus of these studies, but owing to concerns over beaver induced warming of coldwater fish habitats, a study by McRae and Edwards (1994) on the thermal characteristics of streams in Wisconsin occupied by beaver investigated this issue directly. The authors found that stream temperatures followed air temperatures, even near groundwater sources and considered there to be no consistent relationship between size or number of beaver ponds and the degree of downstream warming. They found that large beaver impoundments, although often warming downstream temperatures slightly, acted as thermal buffers, dampening temperature fluctuations immediately downstream. Local groundwater inflow and vegetative and topographic shading also dampened warming by impoundments thus making their thermal effects highly site specific. The removal of beaver dams did not generally reduce the difference between upstream and downstream temperature and in some cases dam removal increased the warming rate. The authors also pointed out that any thermal benefits of dam removal in headwater streams may be outweighed by the potentially disruptive effects on the composition of fish and invertebrate communities downstream.

Beaver foraging can open smaller water bodies to the air and sunlight and this has the potential to influence water temperature. The removal of trees can result in lower water temperatures due to greater exposure to the air (Sayler, 1935) or higher temperatures due to exposure to sunlight (Swanston, 1991), again depending on local conditions.

Shading is assumed to have the strongest effect on small, surface water influenced streams where water volumes are small and not mediated by groundwater. Such streams are most likely either not to be used by beaver or be dammed due to them being generally less than around 0.7m deep.

Beavers typically alter the woodland structure only locally, in proximity to their lodges. This is likely to reduce shading locally in the short-medium term (depending on how long a beaver family occupies a specific site) as the eventual regrowth of tree stems should result in there being no significant local loss of shade in the longer term.

As many Welsh rivers are unsuitable for beaver colonization along significant portions of their length, beavers would only colonise and forage within a relatively small percentage of the total riparian area of a catchment so changes in shading as a result of beaver activity would remain naturally limited. The effects on water temperature as a result of changes in riparian tree cover are therefore likely to be small, probably having a similar or lesser effect than current riparian habitat management undertaken for recreational fishing and flood management.

As an example, the Nidelva River in Norway supports a healthy Atlantic salmon population and has had beavers present on it for over 16 years. During this time, the structure of the riparian woodland canopy has remained largely unaffected even at sites where beavers are present and many local people remain unaware that beavers are present at these sites. (Halley *et al.,* 2009).

Effects on fish movement

The effect of beaver dams on migratory fish populations can be a contentious issue in Britain. In Britain some have expressed great concern about the effects that beaver dams could have on the movement of fish through catchments and how this might affect fish populations in the long term. It is a fact that European beavers do construct dams, some of which can be barriers to fish movement. However, this does not necessarily mean that beaver damming activity will have a negative effect on fish populations at a catchment scale. This is because: (i) beaver dams are typically constructed in narrow streams (i.e. close to the source); (ii) dams are temporary structures; (iii) damming activity is generally quite limited in European beavers; and (iv) the negative effect of damming activities may be compensated for by the positive effects of beavers on habitat elsewhere in the catchment. In addition to this, a managed reintroduction of beavers to Wales would include provision to remove or modify dams thought likely to present a significant problem for fish movement. Some studies that considered fish movement are outlined below.

Collen (1997) reviewed the literature on the effects of beavers on fish migration. He found that in a study undertaken in the Rocky Mountains in North America by Rasmussen (1941) dams could present obstructions to fish movements during periods of low flow, but that the native trout studied experienced little difficulty in passing dams during spate conditions. Grasse (1955) also found that Rocky Mountain cut-throat trout and rainbow trout could pass through dams in spring, but that brook trout could be hindered during autumn low flows when dams are in their best condition. Other North American studies (Cook, 1940; Munther, 1983; and Rupp, 1955) found that brook trout and brown trout (autumn spawners) could be hindered by dams during low flow conditions. Gard (1961) concluded that dams on a stream in California were not complete barriers to brown trout, brook trout and rainbow trout and that movement could occur in all seasons being influenced by river flow conditions. These results suggest that some beaver dams are likely to be obstacles to salmonid migration in dry autumns.

Anthal *et al.* (2005) considered the potential impacts beaver activity might have on European shads and suggested the possibility of beaver dams presenting migration barriers, but also that the benefits beavers may have on flow regulation, reduced siltation of spawning beds and water quality could be beneficial to shads. The report points out that shad are returning to the Loire where beavers are now well established and that current data does not appear to show any correlation between beavers and shad. This is not surprising, as shads generally spawn in river sections greater than 20m wide (Maitland & Hatton-Ellis, 2003) which are normally too large for European beavers to dam.

Hägglund & Sjöberg (1999) undertook a study in Sweden and found mostly overall positive effects on fish species, but thought that dams could act as barriers to colonisation and migration, especially for slow dispersing fish such as bullhead *(Cottus gobio)*. Bullhead are also likely to find some beaver dams impassable in Wales.

In Norway, where salmon and trout fisheries exist on beaver colonised watersheds, Halley and Lamberg (2001) investigated the populations of juvenile Atlantic salmon and trout on Litlelva, a stream tributary of the Aursunda river in North Trondelag. They recorded salmon fry above and below a series of beaver dams up to 1.6m high, illustrating that beaver dams are not routinely impossible for salmon and sea trout to cross.

Mitchell & Cunjak (2007) suggested that a group of beaver dams studied in Canada may have reduced salmon movements and spawning past them in some years but not in others and Taylor, *et al.,* (2009) undertook a study in Nova Scotia and found that some beaver dams may have posed serious obstacles to migrating salmon, particularly in times of low-flow. However this study also found that most beaver dams in most years had no detectable effect on the distribution of spawning redds, and in years of normal rainfall, Atlantic salmon were not hindered by dams. In their paper the authors noted the benefits that beaver dams have for salmon, so proposed dam modification rather than removal to address problems caused by dams.

Parker & Ronning (2007) undertaking studies on the Numedalslagen catchment in Norway, concluded that due to the low frequency, small size and relatively short lifespan of beaver dams, the effects on upstream and downstream migration of salmonids would be negligible. The study also surveyed landowner attitude to having beaver on salmon and sea trout streams and found that nine of fourteen landowners in the area were 'unequivocally positive' about having beaver together with salmon and sea trout. The authors concluded that the presence of beaver on similar catchments is likely to have only an insignificant negative impact on the reproduction of sea trout and salmon.

The UK Salmon & Trout Association supports this view and states that 'Research suggests the view that beaver dams are routinely impassable for anadromous species to cross is now untenable'. (Salmon and Trout Angling Association, Briefing Paper (2007). *Reintroducing Beavers into the UK*).

Many of the studies that suggest beaver activity can hinder fish passage also qualify the information by referring to the fact that dams are relatively uncommon, non-permanent structures in the landscape, so their detrimental effects at the catchment scale over longer timescales are limited or insignificant (e.g. Taylor, 1999; Schlosser & Kallemeyn, 2000; Mitchell & Cunjak, 2007; Parker & Ronning, 2007).

The situation in Norway is considered a good example to illustrate the likely impacts on fish of a beaver reintroduction to Wales as this country has successfully reintroduced beaver alongside existing salmon populations. The beaver populations in eastern, mid, and northern Norway (i.e., the whole range outside the south-east) are descended entirely from reintroduced animals, and so comparable to reintroductions elsewhere. Norway has a valuable salmon sport fishing industry and there are well-established beaver populations in five of the top ten salmon fishing rivers in Norway. Spawning by salmon and sea trout on beaver-dammable side streams is usual in Norway. Beavers have been on these rivers for decades and on many others where salmon and trout populations are found.

Conclusion

The evidence suggests that

- There are many mechanisms by which beaver and fish are likely to interact.
- Positive impacts on fish populations and diversity relate to beaver coppicing activities and consequent improvements to river habitat diversity. These effects are not well quantified in studies but in the Welsh environment they have the potential to be significant. Many beneficial activities of beavers are presently carried out by man, often at considerable cost.
- The most significant potential negative impact of beavers on fish populations in Wales is the construction of dams and consequent negative effects on fish migration and dispersal, especially for salmonids and bullhead. Dams may also have localised impacts on spawning gravels and water temperature. These potentially negative impacts could be prevented through appropriate management.

- A wide range of evidence from Scandinavia and North America suggests that
  - i). Most beaver dams are passable to salmonids most of the time.
  - ii). There is no clear evidence of a negative relationship between beaver activity and salmonid populations at a catchment level.
  - iii). Without appropriate management there could be, on those smaller side streams where active beaver dams occur, negative effects on salmonid migration during dry autumns.
  - ix). There is some potential for beaver activity to have an effect on water temperature which might be influenced by climate change, although these effects are likely to be highly site-specific and small overall.
- Beavers are very unlikely to cause the extinction of any fish species in Wales at a catchment level. The most significant risks are for migratory species in small coastal streams that can be dammed low down.
- On agricultural catchments beavers may help to mitigate some of the negative effects of intensive agriculture such as siltation, nutrients and chemical run-off.
- Beaver activity is expected to boost habitat suitability for various invertebrates, especially shredders by increasing instream woody and leafy debris and grazers by coppicing, which can provide a food source for fish.

In summary, most of the potential negative effects of beavers on fish are related to dam construction. It is debateable whether this activity is likely to have significant effects on fish populations at a catchment level, but this is the leading issue about which concern has been expressed in Britain. However, with appropriate management undertaken as part of a reintroduction to minimise negative impacts, beavers are likely to have a net beneficial impact on fish species including those of commercial and recreational importance.

Should a beaver reintroduction to Wales occur, it would be important that a mechanism is put in place to assess dams for their impact on fisheries and where necessary remove or modify them. Existing activities such as the Environment Agency's flood defence teams could help assess and manage beaver dams, and this work could also be undertaken by trained volunteers. It is recommended that a beaver reintroduction to Wales includes a monitoring programme to assess impacts on fish, using data from the Environment Agency's existing monitoring programme as far as possible. This would allow any potential effect, both positive and negative, to be assessed and appropriately addressed. A key requirement for successful beaver reintroduction would be an agreed licensing framework to enable prompt removal of problematic dams.

3.2.4 Amphibians & reptiles

Native amphibian species are likely to benefit from a beaver reintroduction to Wales. Beaver ponds with their abundant invertebrate populations and vegetation provide excellent living and breeding habitat for amphibian species such as frogs, toads and newts (Cunningham *et al.,* 2006; France, 1997; Gurnell *et al.,* 2008; Metts *et al.,* 2001).

Beaver activities would probably have a less noticeable benefit for native reptiles, but a study in Carolina found that that reptile abundance and diversity were significantly higher at beaver ponds compared with unimpounded streams (Metts *et al.,* 2001). In Wales beaver ponds would provide excellent hunting opportunity for grass snakes, which could also benefit from using beaver lodges as nesting habitat. A more open riparian canopy could also provide more basking opportunities for reptile species.

3.2.5 Birds

Beaver habitat management, especially dam and pool creation, could be beneficial to many bird species. Beaver ponds produce an abundance of invertebrates providing food for birds species (Danell & Sjöberg, 1982; Nummi, 1984; Whitman, 1987; McKinstry *et al.,* 2001; Rosell, 2005). Likewise, increases in amphibians and fish resulting from beaver activity would also provide food for certain bird species such as Kingfisher, Mergansers and Grey Heron and their use of beaver habitats has been noted (e.g. Salyer, 1935; Grover & Baldassarre 1995). Studies have shown significantly more species and increased bird abundance at sites where beavers are active than at other comparable sites lacking beavers (e.g. Medin 1990; Grover & Baldassarre, 1995; Brown *et al.,* 1996).

Beavers also create and manage habitats in ways that benefit water birds, providing increased opportunities for nesting, roosting and foraging (e.g. Arner & Hepp, 1989; Dieter & McCabe, 1989; Nummi, 1992; Nummi *et al.,* 2005). Changes to vegetation abundance and structure also provide greater protection from predators for ground-nesting birds (Carr, 1940; Nummi & Hahlota 2008) and the bushy nature of coppice re-growth is beneficial to many species including songbirds (e.g. Reese & Hair, 1976; Longcore *et al.,* 2007). Standing dead trees provide sites for perching, feeding and nesting for various species such as woodpeckers, owls and other bird species (Carr, 1940; Gibbs *et al.,* 1991; Hilfiker, 1991; Grover & Baldassarre, 1995).

3.2.6 Mammals

The presence of beavers on a catchment is considered to have a beneficial impact on many mammalian species (Rosell *et al.,* 2005). Beaver ponds, being areas of slow flowing water with shallow margins, would provide excellent feeding and nesting habitat for water voles and water shrews. The foraging activities of beavers in the riparian zone encourage the growth of grasses and herbs which can increase food resources for water voles and other small mammals. It is likely that these species would benefit from beaver activity (see Rosell, *et al.,* 2005; Gurnell *et al.,* 2008).

Water voles also create nests in beaver lodges and burrows (Danilov, 1995). Bank voles can benefit from an increase in potential nest sites in dead wood and cover from predators within resultant denser vegetation.

Otters seem to benefit significantly from the presence of beavers on a catchment, with studies in North America showing that North American otters (Lutra canadensis) are frequently associated with beaver ponds (e.g. LeBlanc *et al.,* 2007). Increased numbers of invertebrates, fish, amphibians and small mammals provide food for otters (Reid *et al.,* 1994a; Rosell *et al.,* 2005).

Otters commonly utilize beaver lodges and burrows as holt sites (Grasse, 1951; Tyurnin, 1984; Müller-Schwarze, 1992; Danilov, 1995; Rosell & Parker, 1996) and beaver activity benefits otter habitat (Tumlison *et al.,* 1982). In areas of marginal otter habitat or where otter habitat is being lost, beavers play a crucial role in preventing local extinction (Rosell *et al*. 2005). Tumlison *et al* (1982) and Polecha (1989) suggest that the relationship between otters and beavers is facultative commensal to the benefit of otters.

Otters may occasionally prey upon beaver kits, but this is uncommon (Reid *et al.,* 1994b) and unlikely to pose a significant threat to beaver populations (D. Halley pers. comm.).

American mink Mustela vison may benefit from beaver presence in much the same way that otter do (Sidorovich, 1992). Otter are dominant competitors over mink (Bonesi *et al.,* 2004) and the presence of otter was shown to significantly reduced mink density in the Upper Thames catchment (Bonesi & MacDonald, 2004). Like otter, mink may occasionally kill young beaver (Recker, 1997) but, as in Europe, this is thought unlikely to have a significant impact on any beaver populations reintroduced to Britain (D. Halley, G. Schwab, pers. comms.).

Increases in the abundance of invertebrate species that accompany beaver activity are also likely to provide food for insect-eating mammals, including bats (Solheim, 1987; Gurnell *et al.,* 2008, Ciechanowski *et al.,* 2010). Studies in Europe and North America have shown the relative abundance and number of species of small mammals to be higher in beaver occupied sites than in unoccupied sites. (Suzuki & McComb, 2004; Ulevičius & Janulaitis, 2007).

Standing dead wood can also provide nest sites for other small mammals, bats and mustelids (Hilfiker, 1991). Pine martens can also use abandoned lodges as dens and resting sites (Rosell & Hovde, 1998), and like all predatory mammals, would benefit from increased abundance of prey (Gurnell *et al.,* 2008). In addition to this, browsing and grazing mammals (such as rabbits, hares and deer) can also benefit from the creation of beaver coppice/pasture.

3.2.7 Invasive non-native species

As outlined above, we consider that beaver activity in rivers is likely to benefit various native species, and it is generally understood that beaver activities result in an increase in river and wetland biodiversity. It is possible, therefore, that some non-native species may also be able to exploit the altered environmental conditions created by beavers. (Note: American mink are considered in section 3.2.6 above).

A diverse range of freshwater invasive non-native species are currently present in Wales or are likely to arrive in the near future. The Freshwater Task Team Alien Species Group has published a list of those species of highest concern, which includes aquatic plants, molluscs, crustaceans and fish (UKTAG, 2009). Both running water and standing water species are included.

Some authors (e.g. Green, 2003) have suggested that more natural environments are resistant to invasion by non-native species, because healthy ecosystems provide fewer opportunities for establishment and subsequent dominance of new taxa. According to this view, beaver reintroduction should re-establish lost ecological processes and thereby reduce invasive freshwater species pressures. Whilst we hope this hypothesis is true, there is at present no substantial evidence to support it, and this view is highly non-precautionary. We have therefore briefly reviewed the potential ecological effects of beavers in relation to invasive species.

Although invasive species are diverse, they all share the ability to rapidly multiply and dominate communities. Many species are also good colonizers and most are able to reproduce from small fragments or numerous seeds or eggs. These traits mean that newly created beaver ponds are disproportionately likely to be colonized by invasive species. In addition, the location of beaver ponds in the upper portions of river systems means that any invasive species establishing in these locations will be a constant source of propagules downstream.

We have presented a list of the most serious freshwater invasive species and the likely effects of beaver reintroduction on habitat suitability for invasive species and spread in Table 1. For all invasive species there is a high level of uncertainty regarding their effect on all native species, including beaver. Consequently, unless supported by field studies, any conclusions should be viewed as tentative.

Invasive animals

Invasive animals are likely to be primarily affected by beaver habitat modification. Although a number of freshwater invasive animals are widespread in Wales, notably signal crayfish *(Pacifastacus leniusculus)*, Chinese mitten crab *(Eriocheir sinensis)* and most recently, killer shrimp *(Dikerogammarus villosus)*. The likely effects of beavers on any of these species is unknown. Signal crayfish is most likely to exploit beaver habitat because it is already widespread in eastern Wales and can utilize both running and standing water. Although beaver activities may lead to local changes to populations, there is no known mechanism by which beavers could promote its spread, and beaver dams may even help restrict dispersal.

In general, the habitat effects of beaver on invasive animals is likely to be small, either because no ecological effects are likely or because colonization of beaver ponds or beaver modified habitat is considered unlikely. Likewise, beavers are not predicted to have a significant effect on the dispersal of any animal at a Wales-wide level, though for the three fish species there could be significant positive and negative effects on populations and dispersal associated with dam-pool complexes.

Invasive Plants

Since beavers are herbivorous, plants may be affected both by positively by creation of new habitat, and negatively by beaver grazing. In addition, beavers are likely to graze selectively on different species of plant, resulting in unique communities. The effects of these on invasive species are difficult to predict.

In the majority of river sections beavers will not build dams, but they are likely to have other effects through coppicing activity. This creates open areas for riparian herbs to exploit, including Japanese knotweed *(Fallopia japonica)* and Himalayan balsam *(Impatiens glandulifera)*. Both of these are already widespread problem species in Wales. There is no evidence to suggest a likely impact beavers may have on Japanese knotweed or Himalayan balsam, but they have been noted feeding upon the latter in Bavaria (G. Schwab pers. comm.). Himalayan balsam is likely to be highly sensitive to grazing as the plants are annual and do not regenerate, but Japanese knotweed is a long-lived perennial and fragments can regenerate into new plants, potentially reducing vigour and altering distribution on waterways. The long-term effect of beaver on these two riparian species will depend critically on their relative palatability to beavers compared to co-occurring native riparian species.

There is some evidence that plants native to the beaver's range have coadapted to its presence either by becoming unpalatable or developing coppice/regrowth responses, resulting in non-native species being at a severe disadvantage. Parker *et al.,* (2007) working in Georgia, USA, reported that selective beaver foraging reduced the abundance of parrot's feather *(Myriophyllum aquaticum)*, an invasive non-native aquatic plant both in the UK and USA, by almost 90%. In South America, where beaver is an introduced invasive species, grazing has had a severe negative effect on native shrubs and trees because these species do not regrow when grazed. However, this argument would not apply to invasive species that naturally co-occur with beaver, such as Canadian pondweed *(Elodea canadensis)* or Nuttall's water-thyme *(E. nuttallii)*.

Beavers could potentially act as vectors for invasive species, for example by transporting seeds or eggs attached to hair or as gut contents. However, since beavers rarely move between catchments, this does not seem an especially serious problem. In addition, movements of existing mammals and birds such as otter, water vole, mink and waterfowl already act as effective vectors for these, so the additional contribution made by beavers is likely to be negligible.

For plant species that increase primarily by fragmentation, such as Japanese knotweed, Canadian pondweed and Australian swamp stonecrop *(Crassula helmsii)*, beaver feeding activities may act to break up and disperse existing clumps of material. However, it is not clear whether this will significantly increase the rate of spread of these taxa, as other natural and human processes such as floods, decay, livestock grazing and weed cutting may all have a similar effect.

Table 1: Potential Effects of Beaver Introduction on High Impact Invasive Freshwater Species (UKTAG, 2009) in Wales.
Ecological knowledge of the habitat requirements of all these species is limited.

Species	Distribution in Wales	Habitat Type	Beaver Impact on Habitat Suitability	Impact on Dispersal (excluding indirect population effects)
Australian swamp stonecrop (Crassula helmsii)	Widespread	Lakes and Ponds	Unknown. (Depends on palatability. Could use beaver ponds).	Potential increase (fragmentation while feeding)
Water fern (Azolla spp.)	Widespread	Mainly ponds and ditches. Occasionally rivers.	Probably none. (Presumed unpalatable. However, already controlled by specialist weevil. Could use beaver ponds)	No direct effects identified
Parrot's feather (Myriophyllum aquaticum)	Local	Lakes and ponds	Strongly negative. (Highly palatable)	Potential increase (fragmentation while feeding)
Curly water-thyme (Lagarosiphon major)	Local	Lakes and ponds	Unknown. (Probably palatable, but regrows strongly from fragments. Could use beaver ponds)	Potential increase (fragmentation while feeding)
Water primrose (Ludwigia grandiflora agg.)	Not present.	Lakes and ponds	Unknown. (Probably palatable, but regrows strongly from fragments. Could use beaver ponds)	Potential increase (fragmentation while feeding)
Canadian pondweed / Nuttall's Water-thyme (Elodea spp.)	Widespread	Lakes, canals, ditches and ponds. Rarely rivers.	Probably positive. (Not very palatable, and regrows strongly from fragments. Could use beaver ponds.)	Potential increase (fragmentation while feeding)
Japanese knotweed (Fallopia japonica)	Very widespread	Mainly riverbanks	Probably negative. (Probably palatable. Regrows from fragments. Grazing will weaken plants)	Probably none (feeding activities likely insignificant compared to other river processes)
Himalayan balsam (Impatiens glandulifera)	Very widespread	Mainly riverbanks	Probably negative. (Probably palatable. Increases from seed and susceptible to grazing)	No direct effects identified
Giant hogweed (Heracleum mantegazzianum)	Local	Mainly riverbanks	Probably positive. (Presumed unpalatable and likely to be favoured by beaver grazing. Increases from seed.)	No direct effects identified
Rhododendron (Rhododendron spp.)	Widespread	Mainly riverbanks	Probably positive. (Presumed unpalatable. Woody species that increases from seed.)	No direct effects identified
Signal crayfish (Pacifastacus leniusculus) and other non-native crayfish	Local	Rivers and lakes	Slight positive (Minor increase in habitat area. Suitability of beaver-managed river reaches unknown. Could use beaver ponds.)	Negligible (Dams may slightly restrict dispersal, but unlikely to be significant)
Killer shrimp (Dikerogammarus villosus)	Very local	Lakes; lower rivers	Probably none. (Unlikely to reach beaver ponds. Beaver management of rivers not thought likely to have much effect.)	Negligible (Dams may slightly restrict dispersal, but unlikely to be significant)
Carrion shrimp (Hemimysis anomala)	Not present	Lakes	Probably none (Beaver management of lakes unlikely to have much effect)	No direct effects identified
Chinese mitten crab (Eriocheir sinensis)	Local	Lower rivers	Probably none. (Beaver management of rivers unlikely to have much effect)	Negligible (Dams may slightly restrict dispersal, but unlikely to be significant)
Zebra mussel (Dreissena polymorpha / bugensis)	Local	Lakes with hard substrate / canals	Probably none. (Beaver management of rivers and lakes unlikely to have much effect)	No direct effects identified
Common carp (Cyprinus carpio) / Goldfish (Carassius auratus) / Topmouth gudgeon (Pseudorasbora parva)	Local	Lakes and ponds, rarely rivers	Possible positive (Beaver ponds are shallow and nutrient-rich and therefore highly suitable for carp. However, dammed ponds are unlikely to be accessible)	Unknown (Dams will prevent upstream dispersal, but populations above dams may breed and spread downstream)

3.3 LAND USE

3.3.1 Agriculture

The predominant form of agriculture in Wales is livestock farming. Beavers do not pose any physical threat to livestock. There is no evidence to suggest that beavers are a significant vector for disease transmission to livestock (see section 3.5).

Beavers can feed on arable crops if they are sufficiently close (within c. 20m) to river banks on which beavers are established. Crops affected include maize and root vegetables, especially sugar beet. Impacts are usually highly localized and crop damage/loss is rarely considered financially significant (G. Schwab pers. comm.).

Preventative action can be undertaken if considered necessary and a number of management options are available. Mesh fencing and standard low-voltage electric fencing have proven to be highly effective and can be deployed both alongside and across waterways. Beavers have good memories and electric fencing placed for one week can prevent them from attempting entry to fields for up to three months (G. Schwab pers. comm.).

Arable farming is not a major land-use in Wales compared to livestock farming, so related problems are likely to be relatively uncommon. Farm diversification in the future in Wales could lead to more land being used to grow arable crops and this could make problems more likely. Experience from Europe demonstrates that beaver related problems are readily addressable, both in terms of cost and manpower.

Figure 15. Electric fencing is a very effective method of keeping beavers away from arable crops. G. Schwab

Prior to any beaver release it might be advisable to undertake pre-emptive works on arable fields in proximity to riparian zones likely to be inhabited by beavers.

Beavers can build dams or burrows in places inconvenient to humans and in such instances work is required to minimize or negate resultant problems.

Dams can cause localised flooding to farmland, roads, buildings or other sensitive features. They can be modified or removed to limit or negate their effects. Non-technical methods to accomplish this are well-developed and generally simple to employ. On average, materials to address problems in Bavaria cost in the region of €250 per incident (G. Schwab, pers. comm.). Such incidents are not frequent and in the Welsh situation would be unlikely to be more significant than elsewhere in Europe.

Beavers can create burrows in soft earth banks that may occasionally cause problems. Burrows usually (90%) extend no more than 5m from the water body but may very occasionally extend further than this to around 20m. Burrows may collapse if heavy machinery is driven over them. The resulting holes are usually not significant in themselves, but can result in vehicles requiring extraction by tractor and occasional damage to machinery. Although burrow collapse is a potential hazard, the land use and farming methods prevalent in Wales are unlikely to pose a serious concern in most cases.

In Bavaria, where arable crops are widespread and there are over 14,000 beavers, such incidents remain relatively uncommon, usually totalling less than five incidents every few years (G. Schwab pers. comm.).

In Bavaria farm machinery is often used close to beaver inhabited ditches within flat arable farmland, so it is likely that such incidents would be less common in Wales.

If standard methods of controlling beaver activities are deemed inappropriate or ineffective, animals can instead be removed from an area and relocated, or humanely dispatched as necessary. A standard beaver trap is shown below.

In the longer term having beavers present managing wildlife habitats on landholdings could be beneficial to landowners in terms of access to and payments from agri-environmental schemes.

Figure 16. A Devonshire farmer assessing beaver impact on a Bavarian maize field. Crop damage from beaver activity tends to be highly localized and is not regarded as financially significant by farmers in Bavaria.

Figure 17. The signs of beaver activity in a Bavarian maize field are obvious and make the locating of a beaver trap a simple exercise. This trap was not set to tackle beaver feeding on the maize (which is considered insignificant) but because of the possibility of a dam being constructed on an adjacent ditch (left of shot) that could have led to localised flooding. Captured beavers are either relocated or humanely dispatched.

3.3.2 Forestry

Most commercial plantations in Wales do not generally provide suitable habitat as beavers tend neither to eat nor use coniferous trees, and avoid water bodies bounded only by conifers (Halley, 1995; Parker *et al*., 2001; Haarberg & Rosell, 2006). Beavers may occasionally use coniferous trees for building material and can debark them but trees used by beaver are almost exclusively broadleaved: birch, willow, oak, rowan, and especially aspen being the favourites (e.g. Simonsen 1973; Reynolds, 2000). Most current commercial plantations can, therefore, exist in immediate proximity to beavers without problems. It is noted that the land for the Scottish Beaver Trial is supplied by the Forestry Commission Scotland which has extensive plantations in the area.

As part of the Welsh Government's Woodlands for Wales strategy, in the future there will be more of an emphasis on the planting and restoration of native broadleaved woodland with some coniferous plantations being gradually converted over time to broadleaved woodland. Broadleaved woodlands are more vulnerable to beaver activity, but as outlined in sections 2.2.3 and 3.2.1 where broadleaved trees do exist close to beaver occupied territory most activity occurs within 20m of the riverbank and most of this is concentrated within the first 10m, with some studies showing that 95% of beaver cut trees were within just 5m of water (Elmeros *et al.,* 2003; Baskin & Sjöberg, 2003). Virtually all beaver activity occurs within 100m of the water body (Simonsen, 1973; Nolet *et al.,* 1994).

Broadleaved saplings newly planted within the foraging areas of an existing beaver colony could be vulnerable to beaver activity, but standard plastic guards would offer them adequate protection.

Any effects beavers may have on forestry would, therefore, be restricted to non-protected broadleaved trees on woodland edges immediately adjacent to water bodies. As shown in section 3.2.1, beaver occupied river bank usually remains well-wooded, so such limited activity is very unlikely to have a significant impact on the economic viability of timber operations in Wales.

It is noted that the Norwegian Forest Owners Association does not consider beaver damage to be significant enough to require taking out insurance against it (D. Halley pers. comm.).

Figure 18. Wire mesh placed loosely around the base of tree trunks is sufficient to prevent damage by beavers.

Where concerns remain, however, broadleaved plantations and important individual trees (such as amenity trees) can be protected from beaver activity by simple methods such as fencing (post and wire or electric), the application of sand-paint, or the placement of wire mesh around tree trunks.

Flooding from dam construction can also cause localized death of trees. This generally occurs over relatively small areas and often in terrain that is already naturally boggy where commercial forestry is less productive (D. Halley, pers. comm.). In many cases, natural topography of the land prevents beaver ponds extending further than the water channel, and this is likely to often be the case in Wales. If beaver dams are found to cause significant flooding to commercial plantations or important trees the dams can be removed or modified to negate or limit the adverse effects.

As beaver activities tend to be restricted to defined home ranges the presence of a beaver on a stretch of watercourse is quickly and easily determined enabling preventative action to be undertaken if required.

In the longer-term, beavers could become a useful option in the management of riparian woodland areas. Currently, riparian management work is undertaken by humans at considerable expense.

The Forestry Commission Wales are now required to clear trees from riparian areas within plantations. Following this, scrub begins to develop in the cleared areas, requiring repeated control. The costs of these activities can reach hundreds of thousands of pounds. As beavers coppice deciduous trees as part of their natural foraging behaviour there is potential for them to be utilised in some key areas as a riparian woodland management tool.

Similarly, Forest Research (the research agency for the Forestry Commission) has been experimenting with soft-engineering techniques to work with nature to trap potential floodwaters in the uplands and slow its passage downstream to the benefit of vulnerable villages and towns. Series of natural, small woody dams along upland streams have been constructed, which allow the flow of water in normal conditions but slow it down at times of spate. Combined with floodplain and riparian planting to recreate wet woodland habitat, water quality and freshwater biodiversity can be improved. There is a potential future role for beavers in the creation and maintenance of such dams and the management of these wet woodlands.

3.3.3 Road and rail infrastructure

Beavers in continental Europe do not have a significant impact on road or rail infrastructure (G. Schwab, pers. comm.). Beavers do have the potential to fell trees across roads and rail tracks if they are within the range of beaver activity. This is restricted to specific sites where beaver habitat and roads/railways meet. This limits the probability of felled trees causing problems to very specific areas that could be indentified prior to the release of beavers into the wild.

Vulnerable trees that if felled by beavers could affect roads or railways can be protected by a range of measures including pre-emptive felling, using wire mesh or sand paint around the base of the trunk, or the erection of exclusion fencing. Areas where beaver habitat and roads/railways run adjacent to each other can be protected by stretches of low fencing.

In a study in France by Fustec *et al.,* (2001) it was suggested that beavers may reduce streamside erosion by converting larger trees to coppice so that wind-throw of exposed bank-side trees becomes less of a problem. Presumably, this could, if properly managed, benefit roads and railways adjacent to beaver inhabited rivers.

Flooding may also be an issue if dams are constructed in inappropriate areas or culverts and drains are blocked. Dams can be removed or modified if deemed a threat with no significant impact upon beavers. Culverts, drains and similar structures can also be protected by simple constructions, and new designs can be incorporated into new-build infrastructure if required.

Burrowing activities of beavers could potentially have an impact on road or rail infrastructure and can be prevented by the placement of wire mesh. The areas where roads and railways are located on soft earth embankments within 5m of watercourses likely to be colonized by beavers are limited, thus limiting the potential problem to specific stretches of road. Potentially vulnerable stretches of road can be identified for pre-emptive work before a beaver release if necessary.

Works to prevent adverse impacts to road and rail infrastructure need not be overly costly. On average such works in Bavaria cost in the region of €250 for wire and timber constructions.

The Trunk Roads Agencies and Network Rail undertake regular checks of trees alongside roads and railways, and carry out frequent safety-felling and management of trees. These activities would by default minimise adverse impacts from beaver and also highlight any potential issues with little additional effort.

Reintroduced beavers are most likely to be legally protected (see section 6), although this would not preclude operation of management measures, including translocation and culling under licence. Licenses may be required to undertake work in certain instances. In general, however, most work undertaken on roads or railways is unlikely to have any significant effect on beavers or their burrow or lodge sites and so may not require licensing. Beaver dams are not protected under the EC Habitats Directive so need not be protected under UK law.

As with any large mammal, traffic collisions involving beavers may occasionally happen (e.g. Sager *et al.,* 2005; G. Schwab, pers. comm.) with a similar effect to badger collisions (D. Halley, pers. comm.). The natural behaviour of beavers makes them less likely to be encountered on roads than other wild mammals such as badgers, otters or deer which frequently, even regularly, cross roads. Warning signs and fencing may need to be placed along stretches of road where traffic is thought likely to encounter beavers.

3.3.4 Canal infrastructure

Canals in Wales are the responsibility of British Waterways, which is a public corporation responsible to for the maintenance and management of British waterways. Beavers can have detrimental impacts on embanked sections of canal networks. Burrows could cause canal embankments to fail and lodges constructed on canal banks or trees felled across canals can also cause problems for passing traffic. There are four canals in Wales: the Montgomery Canal, Llangollen Canal, Monmouthshire & Brecon Canal, and Swansea Canal. There are also rivers such as the Severn and Wye that that flow into England and have canals associated with them in England. Although canal embankments can be protected by relatively inexpensive methods (such as wire netting placed over vulnerable areas) these costs can mount if work is required along extensive sections.

Whilst in the longer-term such measures may be considered, any initial reintroduction would be advised to avoid river catchments linked to canal networks unless adequate steps can be taken beforehand to prevent beavers from entering the canal network (such as the erection of exclusion fencing in key locations). In the case of the River Dee, the proximity of the Llangollen canal for part of its length means that a beaver reintroduction to this catchment would need to be carefully considered taking into account the likely costs of excluding beavers from the canal. In addition to this, regular patrols might have to be increased along the Llangollen Canal to ensure that any evidence of beaver habitation is discovered at the earliest opportunity. Due to limited resources such an increase in canal monitoring would most likely require volunteer input rather than being undertaken directly by British Waterways staff.

3.3.5 Water management infrastructure

In most cases, works to prevent beavers blocking drains, culverts, water inlets and related infrastructure is a relatively simple affair involving low-tech solutions such as post and wire constructions to prevent beaver access. Similarly, trees with potential to cause problems can be protected by a range of measures including pre-emptive felling or protection of the tree base (e.g. by use of wire mesh). Estimating the costs of protecting infrastructure on a river or entire catchment is very site specific as it depends on what facilities vulnerable to beaver activities are present in any given location. On average, work to protect vulnerable infrastructure in Bavaria costs in the region of €250 for each post and wire construction (G. Schwab, pers. comm.). Costs for materials could be drawn down from a variety of funding sources. The work could be undertaken by volunteers coordinated by the Wildlife Trusts and similar groups and not necessarily from the water industry operators. The funding and delivery of such work has the potential to offer sponsorship opportunities that may be attractive to some commercial organisations.

Figure 19. Post, wire and corrugated metal constructions are very effective at protecting culverts from beaver activity. They are relatively inexpensive and easy to install. S. Lisle, S. Tippie.

3.3.6 Flood defences

Beavers do not ordinarily burrow into flood defence structures where flood banks are over 10 metres back from watercourses above normal water levels.

Figure 20. Embedded metal piling and wire grids protect flood embankments on the Danube from animal burrowing, including from beavers.

There may be some risk of digging of flood banks up to 30m back from water courses during periods of prolonged flooding where a beaver lodge is submerged and the a flood bank provides a dry-land refuge for beavers, but this appears to be uncommon having only occurred once in Bavaria in the past 40 years (G. Schwab, pers. comm.). Such occurrences could also be minimized by monitoring flood defences that are in proximity to beaver lodges during prolonged flood events. The risks posed to flood defences by other animals such as badgers, foxes and rabbits are thought to significantly outweigh the risks posed by beavers (G. Schwab, pers. comm.).

Where flood banks are immediately adjacent to watercourses, and therefore at some risk, protection is possible by the insertion of sheet metal piling or heavy gauge wire.

For an initial reintroduction to Wales, it would be recommended that catchments with significant flood defence embankments are avoided unless ample resources are available for their protection and maintenance.

3.3.7 Recreation

Recreational activities such as rambling should not be adversely affected by the reintroduction of beavers.

It would not be necessary to restrict access to areas where beavers have established a territory, apart from perhaps a short time period immediately following a release. Evidence from Europe shows that beavers are able to live in close proximity to humans and can become accustomed to their presence (e.g. in Theisandammen Park, Trondheim, Norway, beavers ignore humans down to a distance of approximately 10m).

Beavers tend to emerge at around 8:00pm in the evening regardless of light levels and latitude (D. Halley, pers. comm.). They spend up to 18 hours a day foraging. This could offer great potential for wildlife watching activities during the summer months.

Recreational activities that are undertaken on Welsh rivers such as canoeing, swimming or fishing would not need to be restricted as a result of beaver presence.

With regard to canoeing, the main traversable rivers in Wales are too wide to be dammed by beavers. Dams on smaller tributary streams may sometimes be constructed but would not pose a significant obstacle for canoeists. During the consultation exercise (see section 5) the Welsh Canoeing Association stated that it has no concerns regarding a beaver reintroduction to Wales and considers the presence of beavers on Welsh rivers to be desirable, enhancing the canoeing experience.

3.3.8 Landowners

Concerns were raised regarding the effects beavers may have on landowners. The evidence suggests that with appropriate management landowners need not be significantly affected by beaver presence on stretches of river passing through their landholdings, even if the land is part of an active beaver territory.

Beaver presence on a water body would not generally have any major implications on land use within water bodies or on riparian areas. Most beaver dams do not require protection under the Habitats Directive and there is no reason for them to be given special protection under UK law following a reintroduction. Beaver dams in almost all circumstances could be removed or modified if they are likely to cause problems to landowners. Dam removal or modification mimics various natural causes of dam failure, rarely causes significant problems to beavers, and has no significant effect on beaver populations (D. Halley, pers. comm.).

Although beaver lodges and burrows would most likely be protected by law (as they are breeding and resting sites), they do not usually cause significant conflicts with human land use in Europe (D. Halley; G. Schwab, pers. comm.). In the Welsh scenario, if beaver lodges or dens were found to be causing significant problems, remedial action could be undertaken under licence.

Damage to particular trees of amenity or other value can occur. Such trees may require protection such as the placement of wire mesh or application of sand-paint to the lower trunk, or by the erection of low fencing. There are potential liability issues resulting from beaver damaged trees falling and causing damage to property or death or injury. However, based on the European experience, the risks appear to be far less than currently exist with windblown or flood-damaged trees. Risks can be minimized and controlled by low-level surveillance. In practice such worries seem to be more theoretical than actual. There are no known cases from Europe of landowners being sued for the actions of beavers.

It is recommended that a reintroduction should include the monitoring of beaver activity and the undertaking of action necessary to address any problems. This could be delivered via a network of trained beaver managers and volunteers (see section 7.3).

Figure 21. Culverts placed through a beaver dam in Bavaria lower the water level in the pool behind it. The left-hand end of the culvert incorporates an angled section of pipe that can be turned to raise or lower the water level. The electric fencing along the top of the dam is temporary to deter further dam creation downstream. The bare earth will grass over during the coming spring. The total cost for materials was less than **€**250.

3.4 SOCIAL AND ECONOMIC IMPACTS

A reintroduction of beavers to Wales could have significant economic and social benefits, especially to rural communities. Wildlife tourism is becoming increasingly popular and there are many examples of iconic species being a major draw for visitors: the reintroduction of white-tailed eagles to Mull in Scotland has been estimated to inject around £1.7 million per year into the local economy; the Osprey Centre at Loch Garten in Scotland attracted 33,048 visitors in 2005 with an entrance fee of £3 per adult; and in Wales the Red Kite Feeding Centre alone attracted 33,350 visitors in 2004 at a charge of £2.50 per adult (Campbell *et al.,* 2007).

Examples from Europe show that beavers are also a major attraction for wildlife watchers. Beavers were introduced to the Klosterheden Forest in Denmark in 1999 and now organised tours to see beavers are undertaken involving over 2000 people per year. Following the reintroduction of beavers to Belgium in the late 1990s beaver-watching holidays are now advertised worldwide and tours are organised for visitors employing dedicated beaver guides. Similar tours are undertaken in Poland where beavers play a significant role in wildlife tourism.

One significant advantage that beavers offer to local economies is that they are most active during dawn and dusk. This results in visitors tending to make overnight stays in an area to see them, which is valuable to local hotels, guesthouses, restaurants and shops. The importance of wildlife tourism is recognised by Visit Wales, the Welsh Government's tourism team within the Department for Heritage, and 'welcomes the potential of the Welsh Beaver Assessment Initiative to develop tourism in Wales'.

In addition to income and employment from creation of visitor centres and guiding tours, there exists further earnings potential from accommodation, restaurant facilities, transport, retail and crafts – with potential to benefit precisely those remoter areas likely to be most favoured by beaver where alternative sources of livelihood are less readily available.

Study on the economic impact of beavers

A study undertaken in 2007 by the University of Oxford WildCRU Consultancy *'Economic Impacts of the Beaver'* (see Appendix VII) estimated that a beaver reintroduction could inject over £2 million per year into a local economy, with a pessimistic estimate yielding £750,000. The study consulted providers of wildlife-based holidays in the UK and Europe to British people, and found all were keen to offer UK-based holidays to areas into which beavers are released. Some providers were willing to expand operations into new geographical regions were beavers ever reintroduced to them.

A healthy functioning environment provides 'ecosystem services' that benefit humans but may not be easy to value, and they are usually expensive and difficult to emulate through artificial management measures. The ecosystem services associated with beavers, although equally difficult to quantify, are significant. Beaver activities help to manage riparian and wetland sites and the benefits include flood amelioration, sediment and pollution reduction, maintenance of water in river channels during low-flow conditions, scrub management, and the resulting increases in biodiversity including greater fish abundance which can boost fishing and angling opportunities.

The WildCRU Consultancy suggested that beaver presence could provide benefits to local economies that would make reintroducing beavers a worthwhile goal regardless of environmental and biodiversity benefits. When environmental services are included the report suggests that the costs of dealing with negative impacts associated with beavers could be outweighed by the benefits by as much as 100 times.

Public support for beaver reintroduction

There is considered to be high levels of support among the general public for a beaver reintroduction to Great Britain, with most research into public opinion having been undertaken in Scotland, preceding the Scottish Beaver Trial (which began in May 2009).

Scottish Natural Heritage undertook a national consultation in 1998. A survey of opinion among the 'passive' general public (i.e., those who would not actively seek to voice their opinions, but, if asked, may have an opinion) was undertaken and received 2,141 responses. Of these, 63% supported reintroducing beavers, with 12% against and 25% without a view. A survey of opinion among the 'pro-active' public (i.e., those who would actively seek to voice their opinions if given an opportunity) received 1,944 responses via a self-completion questionnaire. Of these, 86% supported a beaver reintroduction to Scotland.

A subsequent public consultation in 2000 undertaken in Mid Argyll for the trial release of beavers to Knapdale found similar levels of public support with 64% in favour of beaver reintroduction with 27.5% of respondents being opposed.

In 2007 the Scottish Beaver Trial undertook a further public consultation using a variety of methods to gather opinion and found that 73% of all respondents favoured plans to reintroduce beaver to the Knapdale site with 2% being opposed.

A study undertaken by Lang (2004) sought the opinions of key stakeholders to the prospect of a reintroduction of beaver to Wales. At that time three catchments (Rivers Teifi, Conwy and Gwendraeth Fawr) had been suggested as potential release sites for beavers and local respondents from these areas were sampled. The results showed that 71.7% were in favour of a beaver reintroduction and for this to occur within 5 years.

The support of the general public may not currently be based on in-depth technical knowledge, but this Welsh Beaver Assessment Initiative study and any future awareness-raising activities and consultations should go some way towards informing the public about the effects of a beaver reintroduction.

3.5 DISEASE

Concerns have been raised regarding the possibility of beavers being a source or vector of disease. Based on the European experience, the presence of beaver on a river catchment or lake is not thought to pose any significant disease risk. Beavers are common in many parts of Europe including areas where stock-raising is a major component of the rural economy such as Bavaria, Norway, the Netherlands, and the Loire and Rhone valleys.

Leading beaver experts in Europe confirm that they do not know of any public or livestock health incident related to beavers. There is no evidence in the scientific literature that beavers are a disease transmission problem for either humans or livestock.

Like any other animal, beavers can contract various diseases. There is, however, no evidence to suggest that their reintroduction would pose any additional health risk to humans or livestock over and above other mammals such as water voles or otters which are already present in Welsh rivers and wetlands.

In order to ensure that imported beavers would not introduce diseases, any beavers reintroduced to Wales should undergo a rigorous health screening process involving thorough veterinary examination, removing any danger of importing any health risks. Diseases raised by concerned stakeholders regarding beaver reintroductions are addressed below:

Rabies

The rabies virus is a mammalian disease that attacks the nervous system. The virus is present primarily in the saliva, brain tissue and spinal fluid of a rabid animal. Humans can be infected through bites from infected animals. In Western Europe rabies is mainly carried by foxes but other wild mammals, including beavers, have been known to carry the virus. Strict quarantine regulations prevent the introduction of infected animals into Britain.

Giardia lamblia

This unicellular protozoan gut parasite is already present in Britain and can be carried by almost all mammals. It is not especially associated with beavers. It can be removed from water by normal filtration methods. Norway has around 75,000 beavers and despite much of the rural population having water supplied from untreated streams the only *Giardia lamblia* outbreak in recent years was near Bergen, where beavers are absent. There are no reported instances of European beavers causing health problems in humans from *Giardia lamblia*.

Leptospirosis

This disease is caused by the *Leptospira* bacterium. Beaver, along with water voles and other rodents can carry this disease. *Leptospira* is already present in British waterways and the presence of beavers within an ecosystem is thought most unlikely to pose a significant increase in the risk to humans or livestock of contracting this disease.

Cryptosporidium

This protozoan parasite can cause gastro-intestinal illness with diarrhoea in humans. It is already present in Britain with livestock often acting as a vector. Beavers should not have any significant effect on the occurrence of this parasite in humans or livestock. There are no reported instances of European beavers causing health problems in humans from *Cryptosporidium*.

Tularaemia

This is caused by the bacterium *Francisella tularaemis*. Vectors include rodents. Transmitted by infected air and water, this bacterium occurs in Europe but is not presently found in the UK. Imported beavers would require health screening before release into any reintroduction site.

Pseudotuberculosis

The *Yersinia pseudotuberculosis* bacterium, causing pseudo-TB, already occurs in the UK and is not considered a significant issue for people or livestock. Most human infections are food-borne. Beavers are not especially associated with this disease.

Bovine Tuberculosis

There is no evidence that beavers carry bovine tuberculosis (bTB). As most mammals can be infected by bTB it is theoretically possible for beavers to become infected. However, the natural behaviour of beavers is such that it is highly unlikely that beavers could act as an effective reservoir for the transmission of bTB to livestock species.

Gyrodactylus salaris

This is a small (0.4mm) freshwater obligate ectoparasite of salmonids found in parts of Europe. It can only live for a short time away from a fish host and cannot swim. It is normally spread by direct contact between fish and is not carried by beavers. There are no known cases of any non-fish species acting as vectors, apart from humans.

Echinococcus multilocularis

This is a tapeworm that causes disease (echinococcosis/hydatidosis) in certain terrestrial mammals including humans. The lifecycle of *E. multilocularis* involves a definitive host and an intermediate host, each harbouring different life stages of the parasite. Canids are the definitive hosts for the adult stage of the parasite whilst rodents are the main intermediate host. Various mammals, including beavers and humans, can be infected as intermediate hosts by ingesting eggs. *E.* multilocularis is very difficult to treat in its intermediate stage and in both beavers and humans long term infection can be fatal. *E. multilocularis* occurs in wide areas of the Northern Hemisphere but is currently not present in Britain. There are currently no tests that will allow the reliable screening of beavers for infection with *E. multilocularis* (although work to develop a blood test is underway) and thus sourcing from populations that are free of this parasite will currently be essential in ensuring that the importation and release of beavers into Wales is not associated with its introduction.

4. HABITAT SURVEYS

For a beaver reintroduction to be successful there must be enough suitable habitat to support beavers in the long-term. One of the main aims of the Welsh Beaver Assessment Initiative, therefore, has been to assess the quantity and quality of habitat in Wales suitable for beaver. This information also enables candidate sites for a possible reintroduction to be selected.

An assessment of potential beaver habitat has previously been undertaken in three stages: a GIS-based desktop survey; an initial ground-truth survey of all potentially suitable catchments in Wales; and finally, a more detailed survey of suitable potential catchments in Wales for a beaver reintroduction. A summary of each of the stages is outlined below. Reports of these surveys are included in the Appendices.

4.1 PRELIMINARY GEOGRAPHICAL INFORMATION SYSTEM (GIS) STUDY

The following summarizes the report of a GIS study undertaken by Sarah Chesworth in 2008 with help from the Countryside Council for Wales, Environment Agency Wales and Bangor University. The full report is presented in Appendix VI.

To efficiently use the resources available it was decided that the priority for the initial site surveys of Welsh watersheds would be the catchments most likely to be suitable for a reintroduction. In order to determine this, a desktop survey was undertaken using a Geographical Information System (GIS) to highlight areas in Wales theoretically suitable for beavers. The primary factors identified to determine habitat suitability for beavers were:

1. Water channel gradient

Beavers favour slow flowing or still waters. In general terms, the shallower the gradient the more suitable the site is for beavers. A threshold of 6% gradient was used and stretches with a steeper gradient were excluded. Tidal stretches of water are unsuitable so were also excluded from the study.

2. Presence of broadleaved woodland

Beavers forage on a wide range of vegetation, but in most cases they require trees as a source of winter food and construction material. The presence of broadleaf tree species generally provides a good indicator of suitable habitat.

3. Proximity of broadleaved woodland to water

The majority of beaver activity occurs close to the water channel's edge. In this study, a 10m distance was used as the most suitable and 50 metres as the maximum. (Further maps were also produced for the survey team based on a 30m distance).

River catchments were then ranked according to their suitability based on the premise that this correlated with a greater quantity of suitable riparian habitat. Catchments were weighted according to the amount of wooded bank available. They were then studied at a smaller scale to identify specific areas that may have warranted further in-situ assessment as potential reintroduction sites.

The results of the GIS study provided a procedure for surveying of Welsh catchments to be developed, enabling surveys to be focused on the areas most likely to be suitable for an initial beaver reintroduction.

4.2 1st-PHASE CATCHMENT SURVEY SUMMARY

Following the GIS study, most of the major Welsh watersheds were surveyed for beaver habitat quality between June and August 2008 according to agreed criteria. The survey team had received prior training in Norway on the identification and classification of potential beaver habitat from the Norwegian Institute for Nature Conservation (NINA), under the tutelage of Dr. Duncan Halley.

The purpose of this survey was to undertake a rapid appraisal of river catchments, to identify five river catchments with good potential to support an initial beaver reintroduction. Once selected, more detailed survey work would then be undertaken on the selected catchments. Six separate catchments were eventually selected.

The Severn and Wye watershed was excluded at this stage as this river system flows into England where a major part of its basin lies, so reintroduction of beavers to the Welsh sections of the watershed would result in a de facto reintroduction to England. It was felt, therefore, that this could increase the political complexity and expense of any reintroduction programme. Thus it was considered most practical and appropriate to concentrate on river systems entirely within the borders of Wales, or (in the case of the Dee) where only short sections of the river form the border.

The surveys required examination of a variety of characteristics including quantity and type of riparian woodland present, river width and depth, speed of river flow, general character of river bank (rocky, sandy, earth), adjacent land-use and general habitat characteristics as well as any other factors related to the suitability for beavers.

Using the information gained, sections of river were rated on a six-point scale from Perfect to Unsuitable. The categories are outlined in the following table:

Table 2. Rating criteria for catchments as prospective reintroduction sites (developed by D. Halley, Norwegian Institute for Nature Conservation)

CATEGORY	DESCRIPTION
Perfect	As per the excellent category (below), but a large proportion of the trees are Populus species, e.g. aspen, poplar.
Excellent	The habitat is of sufficient extent for a family group (rule of thumb: 2km of bankside, though can be as little as 1km), and contains all of the following elements: • At least one patch of relatively deep (>1.25m), muddy bottomed water near the bankside, sheltered from strong currents or wave action and ideally close to a steep, non-rocky bank suitable for a burrow. Banks of shallower aspect, or rocky substrate, are reasonable as lodge sites. The muddy patch need not be large, 2.5x2.5m is enough, but is a critical habitat requirement, necessary for anchoring the winter food store; • Still or slow, laminar flowing water at least 30cm deep; • Riparian vegetation dominated by deciduous woodland (not alder) in a strip at least 5m wide, including bushy growth and/or saplings; • Abundant bankside understory of forbs, grasses and/or sedges, including patches dominated by such vegetation; • Patches of aquatic vegetation such as lilies, sedges and pondweeds.
Good	The habitat is of sufficient extent for a family group (rule of thumb: 2km of bankside), and contains the following elements: • Food store site as for excellent habitat, above; • Water may be of moderate speed (up to about brisk walking pace) and/or pool-riffle in flow type, but average depth mid-channel at least 30cm; • Riparian vegetation dominated by deciduous woodland (not alder) in a strip at least 5m wide, including bushy growth and/or saplings; • Bankside understory of forbs, grasses and/or sedges, and/or more open patches of bankside dominated by such vegetation; may be relatively more restricted in availability than in Excellent habitat; • Aquatic vegetation such as lilies, sedges, and pondweeds may be rare or absent.
Reasonable	Sufficient extent for a family group, but one or more of the following is the case: • Suitable conditions for food storage only if a dam is constructed. Site is suitable for dam construction; • Water depth >30cm in normal flow conditions, requires damming to make suitable for beaver activities; • Fast flowing water (faster than brisk human walking pace); • Suitable water conditions interrupted by stretches of white water; • Bankside vegetation not dominated by deciduous trees, or dominated by alder, or where the trees are all mature and non-bushy in form; • Limited availability of forbs/grasses/sedges; • Rapid changes in water level (e.g. on rivers regulated for hydro power); • Sites liable to seasonal flooding.
Poor	Serious deficiencies in habitat extent, vegetation quality, or stream flow conditions. Likely to be viable as beaver habitat only relatively temporarily. One or more of following is the case: • Less than 2km of suitably vegetated bankside; • Isolated ponds in streams dominated by white water; • Streams subject to flash floods; • Seasonal streams which normally (i.e. without damming) dry up in summer.
Unsuitable	Riparian situations unsuitable for beaver territories. One or more of the following is true: • No or very few riparian deciduous trees; • Continuous rapids / white water; • 'Strainer' rivers where water flows between emergent boulders; • Entirely stony/pebbly substrate but too wide (>c. 20m) or deep (>c.1m) to dam; • Steep rocky or stone/concrete embanked banks which beavers cannot climb/burrow into (beavers may burrow into steep soil banks to create lower gradient access to banksides).

These site surveys concurred with the previous GIS study results in that they determined an abundance of suitable habitat for beavers in Wales and that a beaver reintroduction is indeed feasible in ecological terms. However, it was also clear that use of GIS based information is no substitute for on the ground survey, as the ranking of catchments resulting from the GIS survey did not correlate closely the results from the site surveys. Although this was to be expected to some degree, it is perhaps worth noting the limitations of GIS map-based information.

Following the completion of the initial surveys of the Welsh catchments, the survey team identified six highly suitable catchments for an initial reintroduction of beaver. A number of further factors were considered along with quality and quantity of habitat suitable for beavers, such as proximity to urban populations and likelihood of adverse disturbance, potential cross-border issues, proximity of canal systems, adjacent land uses, and the presence of vulnerable flood embankments. Following full consideration of all factors, six catchments were finally identified as having good potential for a beaver release and put forward for further investigation:

1. **River Dee**
2. **River Glaslyn**
3. **River Rheidol**
4. **River Teifi**
5. **River Cleddau West**
6. **River Cleddau East**

The locations of these catchments are shown on the following map.

Figure 22. Locations of the six catchments identified

4.3 2nd-PHASE CATCHMENT SURVEY SUMMARY

Following their initial selection, a further, more intensive assessment of the six catchments named above was carried out by Dr. Duncan Halley of the Norwegian Institute for Nature Research (NINA) with assistance from individual fieldworkers familiar with their local river systems and others. The full report is presented in Appendix IV. Fieldwork was conducted during August 2008 and was combined with desktop mapping and remote sensing information work. Habitat was assessed both qualitatively and using a modification of the Allen Habitat Suitability Index Model for beavers (Allen, 1983). The Allen index scores a number of factors relevant to beaver foraging habitat quality to generate a suitability index from 0-1, based on vegetation extending from the water's edge.

The index used for this assessment excluded waters as unsuitable if they were too steep, too fast, or too turbulent, as these variables are closely correlated to habitat suitability for beavers. The vast majority of Eurasian beaver activity occurs within 20m of the water's edge and beavers in many places survive on considerably less than this width of suitable riparian vegetation. Therefore, the model was modified using vegetation within 20m as standard (rather than 200m suggested in the original Allen model which was originally designed for use in North American landscapes). In addition to this, alder has been excluded from the list of preferred deciduous tree species, as it tends to be avoided by European beavers unless other food sources are particularly scarce.

Using this information a conservative estimate of the potential beaver population for each watershed was made. It was assumed that in favourable habitat beaver territories would average 1 per 3 linear km of bankside; in less favourable habitat 1 per 4.5km, and in relatively poor (but still suitable) habitat, 1 per 6km. This may be a relatively conservative figure, given the much milder climate and much longer growing season in Wales compared to Scandinavia and most of the current European beaver range.

A summary of the findings for each of the six river catchments is given below.

1. River Glaslyn

The Glaslyn flows down from the slopes of Snowdon reaching the sea at Tremadog Bay in North-West Wales. The watershed upstream of Pont Aberglaslyn is mostly too steep for beavers, but the lower part runs through areas where beaver settlement would be possible. The section between the floodplain and Pont Aberglaslyn is good to excellent beaver habitat being relatively slow-flowing and of optimal depth with well wooded albeit occasionally narrow riparian strips. The size and depth of the river makes damming both unnecessary and difficult for beavers to achieve, and so is unlikely to occur; any dams built would in any case be liable to being washed out in spate conditions after rain, a frequent occurrence on this river.

Side-streams on this river section are mostly short, but the lower Nanmor, Dylif and Maesgwyn tributaries would each be suitable for colonisation by beavers. Each is relatively shallow and would be likely to develop beaver dams. A public road runs close to the tributaries at a few points, and any dams constructed here would need to be removed or modified to prevent flooding. Beavers being killed on the roads are also a potential problem and some low-level fencing along roads at certain points might be required.

The potential population for this river is not large. It is estimated that five territories on the main river between the floodplain and Pont Aberglaslyn are likely with one or two more on the floodplain should it not be too brackish, and one each on the Nanmor, Dylif and Maesgwyn tributaries. This equates to around 26-32 individual beavers. The mild Welsh climate with its long growing season may increase these figures slightly, but the population size still would remain relatively low. Small but sustainable beaver populations are found in many places in Europe so the Glaslyn remains a candidate site for reintroduction.

2. River Dee

The River Dee has its source on the slopes of Dduallt in the mountains of Snowdonia and is approximately 170km in length. It passes through Llyn Tegid (Bala Lake) before flowing eastwards through Llangollen and then meandering northwards to flow through Chester, eventually forming the Dee Estuary west of the Wirral Peninsular.

The Dee is a large watershed and contains a considerable amount of suitable habitat on Llyn Tegid, the main river, and the Alwen and Clewedog tributaries. The other tributaries are generally unsuitable for beaver occupation. Dam construction on the main river would neither be possible nor necessary, but may occur on the Alwen and Clewedog. The Llangollen Gorge section of the river is unsuitable for beaver occupation so beavers on the Dee would be split into two sub-populations. These populations would have restricted gene flow occurring between them, with some beavers from the upper sub-population dispersing downstream but very few dispersing upstream from the lower sub-population.

The population estimate for above Llangollen Gorge is 19-28 family groups, or about 60-90 individuals; for below the gorge 33-36 family groups, or about 105-116 individuals; in total 52-64 family groups, or 165-205 individuals. This is the largest potential population of any of the rivers examined, although it is divided, as noted, into two semi-isolated sub-populations. Each sub-population is, however, large enough to persist indefinitely.

Evidence from colonisation of other river systems in Europe suggests it would take over 30 years for the population to reach full capacity, but this would depend on how many beavers were initially reintroduced, and where they were reintroduced to. There is considerable potential for riparian habitat restoration along the Dee and if undertaken this would increase the carrying capacity of the watershed.

The Dee forms the border with England for part of its lower course, and flows into England for its final few kilometres. A reintroduction to the Welsh part of the river would, therefore, be likely to affect the English part of the watershed, so liaison with the relevant authorities in England would be recommended for a beaver reintroduction to the Dee.

The Dee also feeds water into the Llangollen Canal. Significant issues can arise from beaver presence on canals, due to beaver burrowing in soft banks. Canal embankments that are stone or concrete lined or cored are safe from beaver burrowing but earth embankments are not. Furthermore, felling of trees by beavers could block the navigation, making removing of trees felled into the canal an occasional maintenance requirement.

Any beaver presence on the canal would quickly become evident, and trapping would need to be undertaken to remove animals. However, there are measures that could be employed to lessen the chance of this occurring. The Horseshoe Falls is an artificial weir on the Dee at the terminal end of the Llangollen Canal, which provides water to the canal. The nearest stretches of the canal are fringed with very suitable habitat. Low beaver-proof fencing at the ingress to the canal at Horseshoe Falls would be the primary management measure for reducing the chances of beavers dispersing into the canal. Further security could be provided by such fencing along the riverside adjacent to the canal above Llangollen town. From Llangollen town downstream, beaver dispersal from the Dee to the canal is most unlikely due to the river being too turbulent and the presence of a road, a railway and housing which would act as effective barriers.

3. River Rheidol

The Rheidol rises in the headwaters of the Nant y Moch reservoir on the western flanks of Pumlumon and flows south and then westward entering Cardigan Bay through Aberystwyth. Its upper length as far as Pontarfynach (Devil's Bridge) is mainly very steep and unsuitable hydrologically for beaver settlement. The main exceptions, the reservoirs at Dinas and Nant-y-Moch, and the stream between them, are largely treeless, except for some commercial conifer plantations, and so are also unsuitable habitat.

The Rheidol below the Cwm Rheidol dam contains sufficient habitat, mostly of very high quality, for around 7-10 beaver territories (22-32 animals). If the habitat above the dam is included, 9-13 territories (29-42 animals) could be supported on this catchment. The topography of the valley is such that dispersal out of it to other river systems is unlikely, except on a very long timescale. If beavers were reintroduced here, the population would resemble that of many similar smaller watercourses in Europe, which although not large, appear to be indefinitely viable.

This population could be boosted by habitat restoration in key areas which could add enough habitat for a further seven family groups. The degree to which the reservoirs would be suitable would also depend on the extent of fluctuations in water levels. Measures to promote connectivity past the large man-made dams at each reservoir would also be necessary. Habitat restoration on the north bank of Cwm Rheidol reservoir would also enhance carrying capacity. The nature of the current landscape is such that the only potential significant conflict with human activities would be at the Tair Llyn ponds, which are managed for intensive sport fishing. Although beavers would probably be compatible with this land use, if they were not desired at the site, low fencing around the perimeter of the river meander would prevent colonisation.

Damming is unlikely anywhere on this river: the main river is large and subject to strong variations in discharge, while the steep U-shaped form of the valley means the side streams are not habitable for any length and lack suitable riparian habitat. The valley supports a considerable tourist industry, and there would be scope for wildlife tourism related to the beaver.

4. River Teifi

The Teifi has its source in Llyn Teifi in Ceredigion, Mid Wales and is approximately 120km in length. The river flows through Cors Caron (Tregaron Bog) and then meanders south-west in a gentle arc finally reaching Cardigan Bay just south-west of Cardigan town.

The river becomes tidal below Llechryd and descends into Cardigan town through the steep-sided Cilgerran Gorge. Below Cardigan town the river broadens into a wide estuary, passing the seaside resort of Poppit Sands before finally entering the sea in Cardigan Bay. Although varying in quality, the entire main course of the Teifi from Cors Caron downstream is suitable as beaver habitat. Excluding those areas of the lower Teifi possibly subject to tidal effects, an overall conservative estimate for the potential population is 39-45 family groups, or about 125-144 individuals, plus beavers without an established territory. Assuming the lower Cilgerran Gorge and Teifi Marshes were also suitable, the estimate rises to 44-53, or about 140-170 individuals. This is a substantial population - the second largest of any of the rivers examined, and unlike the Dee would not be divided into two semi-isolate sub populations.

Most, though not all, tributaries of the Teifi do not seem to be suitable as habitat for beavers due to steep gradients or a lack of suitable riparian habitat. Damming on this catchment would probably be a late developing phenomenon, except perhaps in areas that are already marshland, with dams being relatively ephemeral structures, lasting only a few years.

Well-targeted habitat enhancement measures could significantly increase the carrying capacity of the catchment both on the river and tributaries and at Cors Caron. As a return to a more natural regime at Cors Caron marshes is already the goal of the CCW, enhancement of beaver habitat at that site would most likely be both achievable and compatible with other management goals.

5. Western Cleddau

The Western Cleddau in Pembrokeshire rises from branches at Llygad Cleddau and Penysgwarne. It flows mainly southward and meets with the Eastern Cleddau to form the Daugleddau estuary. Despite its relatively short length (approximately 25km), the estimated potential population for the Western Cleddau is up to 29-34 family groups. This is because very much of the watershed consists of suitable vegetation, with only relatively short unsuitable stretches, and because of the unusually large number of long tributary streams with suitable hydrology and riparian vegetation. Damming is likely to be relatively common on this watershed, as so much of the potential habitat lies by the side of narrow and relatively shallow tributary streams. In most places this would be unlikely to cause conflicts with human land use, as the riparian strips are fairly broad, and exist largely because the land is unsuitable for other purposes. However, it is possible that some beaver ponds may cause inconvenience to some human land uses. The perception of conflict may also be higher than the actual conflict, measured economically, given the novelty of beaver activity in Wales and the unfamiliarity of the public with the immediate consequences of dams in a wooded landscape, such as standing dead timber, however valuable for conservation purposes they may be. Educational activities in advance of likely dam construction would be useful in this respect.

6. Eastern Cleddau

The Eastern Cleddau rises from the foothills of Mynydd Preseli in Pembrokeshire and meanders in a south-westerly direction to meet with the Western Cleddau at the Daugleddau estuary. This river is similar to the Western Cleddau in general characteristics and many of the same remarks apply. This river is approximately 15km long and the habitat available can support an estimated 17-22 beaver families. Damming is likely to be relatively common on the watershed, given the shallow and narrow nature of both the main branches of the watershed in their upper reaches, and of tributaries throughout their lengths.

5. STAKEHOLDER CONSULTATION AND FACT-FINDING

5.1 OVERVIEW

The feasibility of a beaver reintroduction to Wales entails considering much more than the habitat suitability and availability. Potential conflicts with human activities and interests also need to be examined and solutions devised. With this in mind the Welsh Beaver Assessment Initiative consulted with a wide range of stakeholder organisations to gather opinions, concerns and ideas so that potential issues could be raised at an early stage with the aim of proposing realistic solutions.

Stakeholders were not asked at this stage whether or not they supported a beaver reintroduction to Wales, as such a decision is dependent upon robust knowledge regarding the effects of beavers, possible management options and the likely nature of a proposal - all of which this study endeavours to address.

Where possible, consultation with stakeholders was undertaken by way of face-to-face meetings or telephone conversations. Where this was not possible consultation was undertaken by response to a list of questions:

1. What are the concerns, if any, that your organisation has regarding a beaver reintroduction to Wales?
2. Have you any suggestions as to how these concerns could be allayed or addressed?
3. Are there any benefits that your organisation can see in a beaver reintroduction?
4. How might these benefits be achieved?
5. Are there any specific site / location features that you would see as critical to any successful reintroduction?
6. Is there anyone else, either in your organisation or in some other that you would recommend we speak to about this issue?
7. Can you recommend any sites or areas that you feel could be suitable for a beaver reintroduction.

(Questions adapted from a study by the People's Trust for Endangered Species and Natural England)

5.2 ORGANISATIONS CONTACTED DURING CONSULTATION

- Afonydd (Welsh Association of River Trusts)
- British Association of Shooting and Conservation (BASC)
- British Waterways
- Countryside Council for Wales (CCW)
- Country Land and Business Association (CLA)
- Coed Cymru
- Confederation of Forest Industries (Confor)
- Dwr Cymru / Welsh Water
- Farming Union of Wales (FUW)
- Farming & Wildlife Advisory Group (FWAG Cymru)
- Game and Wildlife Conservation Trust
- National Trust Wales
- National Farmers Union (NFU Cymru)
- PONT (Grazing Animals Project in Wales)
- Royal Society for the Protection of Birds (RSPB Cymru)
- Ramblers Association
- Severn Trent PLC
- Transport Wales (WAG)
- Welsh Trunk Road Agencies (North Mid and South)
- Visit Wales (WAG)
- Welsh Assembly Government Biodiversity Department (WAG)
- Welsh Association of National Park Authorities
- Welsh Canoeing Association
- Welsh Salmon & Trout Angling Association
- Woodland Trust / Coed Cadw

5.3 OUTCOMES OF STAKEHOLDER CONSULTATION

A wide range of concerns, ideas and opinions were gathered during the consultation process. Many of the concerns raised hinged upon the details of a reintroduction proposal, particularly with regard to post-reintroduction management of beavers. There was broad recognition of the benefits that beavers can offer but some groups expressed strong reservations relating to the potential for undesirable impacts of beavers affecting certain human activities. Although no groups were asked to give an opinion on beaver reintroduction at this stage (as one of the aims of this study is to enable decisions to be made) some chose to express a position. As expected, some groups opposed beaver reintroduction and others supported a beaver reintroduction, had a neutral stance, or wished to reserve judgement until further information became available.

The issues raised have been collated and summarized below:

- Impacts upon farming, forestry, trees and fisheries
- Potential to cause flooding
- Impacts on human activities and infrastructure
- Legal status of beavers and potential liabilities and restrictions on land-use and operations
- Impacts upon biodiversity and protected sites
- Logistics of beaver management
- Costs of a beaver reintroduction/management and effects on other areas of conservation
- Length of time beavers have been absent from Wales
- Impact on existing native species and undesirable species
- Disease risks to humans and livestock
- Population control issues
- Problems with beavers experienced in some countries
- Impacts of global climate change
- Adherence to IUCN/JNCC guidelines

The consultation process has enabled the WBAI to address the various concerns raised in the information provided by this and accompanying reports.

5.4 FACT-FINDING VISITS

Bavaria

In October 2008 a fact-finding visit to Bavaria was organised. The visit was sponsored by Welsh Power Ltd and lead by Derek Gow (UK based beaver consultant) and Gerhard Schwab (Beaver Manager for Southern Bavaria, Bund Naturschutz in Bayern e.V.). Attendees visited a variety of sites in Bavaria that beavers have colonised and were able to see the positive effects that beavers have on habitats and species, as well as the potential negative effects they can have on some human activities and how these are addressed.

Examples were seen of effective techniques to prevent the activities of beavers having undesirable consequences. Meetings with representatives from the farming, flood defence, and forestry sectors took place, providing opportunities to discuss with them the reality of living with beavers and the solutions devised to help them deal with human/beaver conflicts. There were also meetings with members of the network of local beaver consultants who deal with problems that landowners may occasionally have with beavers.

Conclusions from the Bavaria visit

Bavaria has more intensive arable agriculture than occurs in much of Wales, which results in a higher level of interaction between beaver and farming interests than would be expected in the Welsh scenario.

Local representations suggested that such interactions were very localised and managed on a satisfactory basis by a range of methods including provision of information and advice, beaver impact control and translocation of beavers where required. Lethal control is also used as a last resort option where other measures do not provide a long-term solution.

Norway and Scotland

Visits to beaver occupied sites in Norway (hosted by the Norwegian Institute for Nature Research) and Scotland (hosted by the Scottish Beaver Trial) were also undertaken. Experience and information has been shared to inform work in Wales.

5.5 OTHER CONSIDERATIONS

Most of the concerns raised by stakeholders during the consultation process have been incorporated into the information given in previous sections. However, some other issues relating to a potential beaver reintroduction to Wales were raised and these are addressed in the following pages.

Length of time that has elapsed since beavers were last present in Wales

The length of time that beavers have been absent from Wales is considered insignificant in evolutionary terms, so in this respect it does not pose a problem. However, many habitats in Wales have changed since beavers were last living wild in the countryside. The return of beavers to much of their former European range during the 20th century demonstrates that rivers and wetlands often still contain the necessary habitat to support beavers. A good example is Denmark, where beavers had been extinct for at least 1000 years, but have been successfully reintroduced.

Beavers require only a narrow strip of suitable bankside habitat to support a viable population and the habitat surveys undertaken as part of the WBAI project have determined that such habitat is still abundant within many river systems in Wales. In addition to this experience from Europe (e.g. Netherlands) shows that beavers can live well in close proximity to humans and human developments. Their absence from Wales for approximately 600-800 years is not considered to pose a significant problem to the success of their reintroduction.

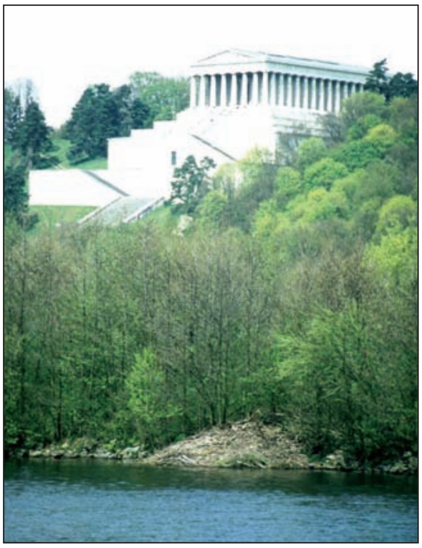

Figure 23. Beavers can live happily in close proximity to humans, even within major centres of population if habitat conditions are suitable. G. Schwab

Diversion of resources from other areas of conservation

Concerns have been raised regarding the possibility that resources could be diverted away from other areas of conservation to fund beaver re-establishment. The iconic status of beaver suggests that reintroduction and management would attract supplementary funding from sponsorship and public support and so should not require a net extra demand on existing conservation resources.

Beavers play a crucial role in managing wetland and river ecosystems and are often referred to as a 'keystone' species, having a disproportionately important function in their ecosystems. Reintroducing beavers would benefit many other species and habitats in need of conservation action.

Beavers naturally undertake their work and require relatively small amounts of funding for management, so in the long-term it is possible that fewer resources might need to be spent managing the wetland and river ecosystems that support beavers than is currently the case. This would have the potential to free up resources that could then be focused on other areas of conservation as necessary.

Beaver impacts and management in other countries

Management of beavers is undertaken in some European countries, notably Denmark, and Germany. Such management does not occur because beaver populations require controlling per se (as beaver populations are limited by habitat availability), but because beaver activities can sometimes cause conflict with certain human activities. This may include building dams or lodges in undesirable places, feeding upon crops, or gnawing/felling trees that people would rather are left intact. In these instances beaver activity is controlled by managing the effects of beaver activity, managing the perception of beaver activity, and the removal of 'problem' beavers if considered necessary. Captured beavers are either translocated to other areas where they will not pose a problem (including other countries for reintroduction programmes) or humanely dispatched.

Experience from Bavaria shows that up to 98% of all problems occur within 20m of the water's edge and control/impact mitigation is considered very straightforward. Beavers can be live-trapped easily, so can be promptly removed from an area if required (G. Schwab, pers. comm.).

Beavers have returned to nearly all countries in continental Europe and this process has not posed any significant problems. No reintroduction programme in Europe has had to be halted or reversed.

The situation is Latvia is often raised as an example of the problematic impact of beavers on commercial forestry through flooding. However, the beaver situation in Latvia is exceptional. In Soviet times immense areas of marshland were drained mainly for forestry purposes. The combination of an expansive flat landscape drained by man-made branching systems of narrow and easily dammed ditches creates a situation where a single dam can flood a very considerable area and drown many trees (the natural situation of drainage is broad, shallow, slow-flowing meanders of the sort beavers rarely find necessary to dam). Beavers have taken advantage of the mostly man-made habitat that exists.

There is little similar landscape in Britain, and virtually none in Wales. In Finland or lowland Sweden where similar flat terrain exists, the presence of beavers (mostly North American beavers in Finland) does not cause large-scale problems (D. Halley, pers. comm.).

The hilly character of the Welsh landscape and land management practices makes a similar situation extremely unlikely to develop in Wales. The formation of a network of beaver consultants (i.e., a Beaver Advisory Service) to deal with any potential issues would serve to further guarantee that such adverse impacts are prevented.

The beaver situation in Tierra del Fuego in Argentina is also raised as an example of beavers becoming a pest. North American beavers were introduced to Tierra del Fuego in the 1940s in an attempt to establish a commercial fur industry. The industry was never viable due to beaver fur becoming unfashionable, so the beavers were left unmanaged for many years.

Beavers are not native to Tierra del Fuego (or indeed South America) and this has had an enormous bearing on the situation there, as they were introduced into ecosystems that are not evolutionarily adapted to their activities. As a result the impacts of beaver activity was very different to that which occurs naturally, as research comparing the region with North America conclusively demonstrates (Anderson *et al.,* 2006). Unlike temperate broadleaved trees in the northern hemisphere, many of the tree species affected in Tierra del Fuego lack chemical defences deterring browsing and do not coppice when felled; in time beaver activity has, therefore, removed trees from riparian landscapes.

In Wales, as in the rest of Europe, riparian and wetland habitats have adapted over millions of years to the presence of beavers. A more appropriate parallel for Wales is therefore continental Europe, where European beaver are present as a native species and where impacts are well studied, rather than Tierra del Fuego where North American beaver occurs unnaturally in a very different and unsuitable ecosystem.

6. LEGAL STATUS

Concerns were raised during the consultation process regarding the legal implications of a beaver reintroduction. The following summary is considered to be an appropriate interpretation of the relevant legislation. It is drawn from a report by Tony Mitchell-Jones of Natural England, which is presented in full in Appendix II.

The relevant legal framework in Wales is currently the same as that in England, although there are differences in licensing arrangements as a result of devolved responsibilities held by the Welsh Government, which is the licensing authority in Wales. Since March 2011 the Welsh Government has law making powers in this area.

Beavers are currently listed in Annex IV of the European Union Habitats Directive. As they are not currently an established wild species in the UK they are not listed in the Conservation of Habitats and Species Regulations 2010 (commonly referred to as the Habitats Regulations), which transposes the Habitats Directive into UK law. This means that, apart from issues concerning possession, they are not currently protected by the Habitats Regulations in the UK.

Legal position regarding possession

With certain exclusions, it is generally an offence under regulation 41(3) of the Habitats Regulations to possess, transport, sell or exchange any live or dead beaver or parts of without an appropriate licence (although this does not apply to captive bred beavers). Beavers imported from most other Member States (some are excluded from the legislation) for the purpose of reintroduction need to be covered by an appropriate possession and transport licence. The Welsh Government is the appropriate authority for the issuing of such licences in Wales.

Legal position regarding release

Section 14 of the Wildlife and Countryside Act 1981 (WCA) makes it an offence to release or allow to escape into the wild any animal species which is not ordinarily a natural resident or visitor to Great Britain or is considered an unwelcome non-native species (listed in Part 1 of Schedule 9) unless carried out under an appropriate licence. Licenses can be issued by the Welsh Government to permit actions that would otherwise be an offence under this section.

Although the term 'into the wild' used in the legislation has not been defined, the Welsh Government apply it to large enclosed areas if natural habitats are likely to be adversely affected. If a release of beavers in Great Britain establishes a sustainable population, then subsequent releases would not currently require licences under Section 14 of the WCA. For control over subsequent releases in Great Britain to be established, other mechanisms would need to be introduced, such as inclusion of beavers on Schedule 9 of the WCA.

If beavers are deliberately released into the wild (or escape and are not pursued), they are then considered to be wild animals. Currently, the species is not especially protected by any UK legislation (other than for the offence of possession), so reintroduced beavers could be disturbed or killed so long as other legislation is not breached (e.g. the Animal Welfare Act 2006 and laws pertaining to prohibited methods of capture).

As beaver is currently listed in Annex IV of the Habitats Directive the UK government would ultimately be obliged to give it protection by including it on Schedule 2 of the Habitats Regulations. However, there is arguably a degree of latitude in when this protection needs to be implemented. It could be argued that following initial release(s) and before the establishment of a viable population, there is a period during which assessment of the success and desirability of the venture should take place, and during which the process may be reversed, if deemed necessary.

Legal position regarding post release management

Experience from Europe indicates that it is advisable to have a beaver management strategy in place to deal with possible problems resulting from conflicts between human and beaver activities. Protection under the Conservation of Habitats Regulations 2010 would have implications for the management of the species, as it would be illegal to deliberately kill, injure or take beavers, or to damage or destroy breeding and resting places, unless appropriately licensed.

Two licensing routes are available. The Welsh Government can grant licenses permitting otherwise illegal acts for the prevention of serious damage to property (including crops and trees). Secondly, following changes to the Habitats Regulations it is now possible to issue licenses under regulation 53(4) for the management of Annex IV species, subject to appropriate safeguards. In both cases, licenses could only be issued where there was no reasonable alternative and where the Favourable Conservation Status of the species is not adversely affected. This is the case in Bavaria, where beaver may be lethally controlled as a management measure.

Beaver dams are not breeding or resting sites so would not usually require legal protection, so licensing of dam modification or removal would not generally be required. An exception might be during the beaver breeding season where a dam is keeping a den entrance submerged. In a study by Hartman & Törnlöv (2006) around 10% of dams had this function. In such cases the removal or modification of the dam could be considered to have a significant adverse impact on a breeding site and a licence would be required before work on the dam could be undertaken. Dam modification or removal outside the breeding season should not be affected.

7. REINTRODUCTION AND MANAGEMENT PROPOSALS

This section outlines how a reintroduction to a suitable receptor site in Wales could be undertaken. It has been developed in collaboration with Derek Gow who has much experience of beaver biology and habitat requirements based on successive field visits to assess management and reintroduction projects in continental Europe. Derek Gow is a member of the European Beaver Working Group and has supervised the import of over 60 individual beavers into the UK, including those for the Scottish Beaver Trial. Derek Gow produced a paper for Scottish Natural Heritage (Gow, D. 2002. The transport, quarantine and captive management of European beaver *Castor fiber*) on which the following is based.

7.1 OUTLINE PLAN FOR TRANSLOCATION AND RELEASE

The IUCN Guidelines for re-introductions (1995) have been adopted by the British statutory conservation agencies for implementing conservation translocations policy in Britain. Based on these IUCN guidelines the Joint Nature Conservation Committee (JNCC) has agreed criteria for evaluating proposed conservation translocations to Britain. The JNCC criteria are addressed with regard to a Welsh beaver reintroduction in Appendix I.

7.1.1 Size of release population

Some studies have suggested that the minimum viable population for a reintroduction is 25 breeding pairs. Natural recolonisation of catchments in Europe has occurred from relict populations significantly smaller than this (as few as six breeding pairs on the Rhone) so it is possible that reintroductions could be undertaken using fewer numbers of beavers than commonly recommended. For an initial managed reintroduction to Wales the exact number released is likely to be influenced by the local conditions present in the selected reintroduction site(s) so should be agreed upon at the appropriate time.

7.1.2 Sourcing of Donor stock

The IUCN/JNCC guidelines include consideration of the use of the most appropriate donor stock, taking into account the ecology, behaviour and genetic constitution of the species.

There has been some debate regarding European beaver taxonomy, with some older studies proposing that as many as eight sub-species exist. More recent, genetic studies (Ducroz *et al.,* 2005; Durka *et al.,*2005) have cast doubt on this conclusion, and have suggested that differences in supposed sub-species are more likely to be the result of genetic bottlenecks and inbreeding within the small relict populations that survived in Europe into the 19th century. It is now generally considered that only two lines (Evolutionarily Significant Units – ESUs) can really be justified: *Castor fiber fiber* (incorporating previously described *C. fiber fiber, alibicus and galliae*) in Western Europe; and *Castor fiber vistulanis* (incorporating *C. fiber vistulanis, belarusicus, osteuropaeus, pohlei, tuvinicus and birulei*) in Eastern Europe and beyond. As certain watersheds (e.g. the Danube) span the supposed historic territories of both groups of beavers, there would have presumably been some mixing of the two lines after the last Ice Age. This mixing of eastern and western ESUs currently occurs where the two lines meet.

Taking the IUCN guidelines into consideration, a beaver reintroduction to Wales should only use *Castor fiber fiber* (as per the latest classification). It has been suggested that in order to improve genetic diversity a mixture of German, French and Norwegian beavers could be used for reintroductions.

Some consider that there is little need to avoid using beavers with some mixed eastern and western heritage, as this would further increase genetic diversity, which is likely to be beneficial to European beavers in the long term, but this could be considered a deviation from IUCN guidelines.

(Note: The sourcing of donor stock is considered in Halley, D.J. (2010). Sourcing Eurasian beaver *Castor fiber* stock for reintroductions in Great Britain and Western Europe*.* Mammal Review 2010, Mammal Society.).

Experience from Europe indicates that wild caught beavers tend to have significantly better survival rates once released than captive bred stock, so a reintroduction to Wales should ideally involve the capture and translocation of wild beavers.

The most appropriate sources of beaver for a reintroduction to Wales are perhaps Norway and Germany where large populations of beavers exist and local management is already in place that regularly removes sufficient numbers from the population to supply reintroduction programmes.

7.1.3 Capture and collection of donor stock

Collection of donor stock would be undertaken in collaboration with appropriate individuals and organisations in the donor countries with experience of beavers and their reintroduction (e.g. Norwegian Institute for Nature Research (NINA) and Telemark University College, Norwegian University of Science and Technology) as well as with advice from the Scottish Beaver Trial and others in Britain with experience of beaver importation (such as the Wildwood Trust and Derek Gow).

7.1.4 Timing of capture

Beavers would be captured in late summer or early autumn to avoid taking pregnant females and so that work is not undertaken in harsh winter weather, which can impede capture. Beavers would be captured in live-catch traps situated on well-established beaver trails. Trapped animals would then be transferred into transport crates for movement to a holding facility. Prior to departure from country of origin all animals would undergo appropriate health screening. This substantially reduces the risk of carriage of animal-borne disease or the transportation of animals that are not in good health.

7.1.5 Transport from holding facility to port of exit

Beavers from holding stations can be transported to Britain either by road (and sea), or by air. If transport is undertaken by road beavers can be transported in approved International Air Traffic Association (IATA) crates or in metal travelling boxes (which are lighter and easier to use than IATA crates). These metal travelling boxes have been used with considerable success and are approved as rabies carrying crates for road import into the UK. The design of these crates may not be acceptable for air transport however.

Although many beavers have been moved in crates over land by road for periods in excess of 24 hours without any substantial mortality, transport by air is considered a better option if funding is available.

Licenses and reports needed for importing and holding beavers in Wales would come under The Animal Health Act 1981 and The Rabies (Importation of Dogs, Cats and Other Mammals) Order 1974 (as amended). These include: an Import Licence from DEFRA; an Authorisation of Quarantine Premises (DEFRA); and a licence for entry at a British port (Boarding Document).

7.1.6 Quarantine

Only a DEFRA approved rabies quarantine carrier, operating an approved quarantine vehicle, can move imported animals from the port of entry to quarantine facilities. Suitable carrying agents would be contracted prior to arrival in Britain. Imported animals are subject to statutory containment in approved quarantine facilities for a period of six months in order to comply with the Rabies (importation of Cats, Dogs and Other Mammals) Order 1974 (as amended). Quarantine facilities require approval from DEFRA. Approved facilities that could be used for a Welsh reintroduction have been identified at: the Wildwood centre in Kent; facilities in Devon owned and managed by Derek Gow (this facility has been used for the Scottish Beaver Trial); and Chester Zoo have also offered the use of their facilities. Depending on where beavers are imported from the beavers would stay in quarantine facilities throughout the autumn and winter for a period of at least six months before release at a recipient site in the spring. At the end of the quarantine period DEFRA would be contacted to approve release from quarantine. A self-certifying domestic animal movement document would be needed accompany the animals on any journey they might make.

The Scottish Government agreed in 2010 that beavers imported from Norway are no longer required to be kept in quarantine for six months (as rabies in not present in Norway). It is possible that Defra would adopt a similar position. Beavers imported from elsewhere in Europe would still be required to spend six months in quarantine.

Regardless of quarantine procedures, all beavers imported for a Welsh reintroduction should undergo a thorough health examination to ensure that they are not carrying undesirable diseases.

7.1.7 Transport to release site

The mode of transport from the quarantine facility to the release site is dependent on the distance between the two. In all probability, a reintroduction to a Welsh release site would involve transportation by road in secure boxes on a trailer or suitable air-conditioned vehicle. Normal animal transport regulations for domestic animals would apply.

The use of transportable artificial lodges has been suggested. This would involve relocating artificial lodges used to house beavers during quarantine to the release areas. This has not been tried before but could help to make released beavers used to a release site with the rationale that they would use the lodges for a while prior to moving to their own selected locations.

Trials in Norway and in Britain have demonstrated that beaver can easily be retained in small ponds and lagoons by encircling these on a temporary basis with electrified sheep netting for a week or so.

7.1.8 Release

Prior to release all animals could be fitted with a number of identifying features if deemed appropriate including numbered ear tags and subcutaneous microchip responders. The use of internal or external transponders is not recommended as they can cause severe stress to beavers and seriously affect their survival. Transponders are not particularly effective at long distances and are unlikely to be required to track the location of beavers as signs of activity are easy to spot (D. Gow, pers. comm.).

There are two general options available for the release of beavers: hard release and soft release. Hard release involves the direct release of animals to the wild from the transit cages. It is a cheaper option but has the potential to cause the animals greater stress, and this can make them more susceptible to disease and death. Soft release involves the use of artificial lodge structures to provide shelter for released animals. This is a more expensive and time-consuming method, but if done properly can reduce stress to the animals by providing instant shelter; reduce the need for animals to seek out shelter; allow animals time to acclimatise to new conditions; and reduce the risk of animals moving away from the specific re-introduction sites. This last point could be an important consideration if it is felt important to visually assess beavers for a period of time immediately following release, or where potential public viewing facilities already exist within a proposed reintroduction site.

The Scottish Beaver Trial ultimately undertook a combination of both hard and soft releases. The initial release in May 2009 was essentially a hard release as beavers escaped from artificial containment sooner than expected and decided to construct their own dens. Subsequent releases in 2010 used well-prepared artificial beaver lodges that contained food, bedding and scent from the released animals. These lodges were placed near to the water weeks earlier to allow time for the scent of humans to dissipate. The beavers were then released directly into the water near to the lodges. Of the three releases in 2010, two sets of beavers quickly chose to use the artificial lodges. As this method involves minimal human contact and allows the beavers to choose for themselves, it is considered by the Scottish Beaver Trial to be the least stressful method of beaver release (Simon Jones, pers. comm.).

It is recommended that, if possible, all translocated beavers are released at the same time in a single release, as it is considered easier for the released beavers to establish their own territories. However, as this can be logistically challenging, two releases spread over two years would be acceptable.

Projected costs of a release are given in section 7.5.

7.1.9 Statutory designated sites (SSSI, SAC)

The release and conservation of beaver is not explicitly linked to the conservation objectives for any statutorily designated sites in Wales. Prior to any release an Appropriate Assessment would be undertaken to consider the impacts of beaver on the ecological functionality of any European site affected by the proposal. This would then inform conditions in respect of field implementation of the scheme. Any works to mitigate impacts on statutory site would be undertaken before an actual release.

7.2 POST-RELEASE MONITORING

7.2.1 Monitoring of beavers

Monitoring of released animals would be required to some degree so that their progress can be tracked, but the intensity of monitoring required depends upon the objectives of the monitoring programme. The Netherlands reintroduction involved a minimum of monitoring in the initial stages with little further work being undertaken, whereas the Denmark reintroduction involved the monitoring of a wide range of aspects including beaver numbers, territories, impacts on other species and effects on forestry, landowners and angling. Beavers were not radio tracked as the monitoring of field signs was considered sufficient. The Scottish Trial reintroduction goes even further and involves the radio tracking of individual beavers.

Whilst it is possible to have intensive monitoring regimes, including tracking the locations of individual beavers via the use of radio transmitters, the costs are substantial and the benefits questionable unless undertaken purely for scientific reasons. Tracking the progress and distribution of beavers on a catchment does not require highly intensive or intrusive monitoring and can be effectively achieved by regular site survey bolstered by the involvement of the public, especially landowners, in reporting signs of beaver activities.

7.2.2 Monitoring of habitats and species

The effects that beavers have within river catchments are well known and understood. Most beaver reintroductions in Europe have not included any habitat and species monitoring as an integral part of the reintroduction programme and post-release monitoring is not a legal requirement per se.

Apart from the monitoring of certain key species or key indicators of habitat condition that might be required due to statutory designations that may exist within a release area, the extent of monitoring the effects of beaver activity on a catchment is essentially dependent on what is deemed necessary to monitor. As a minimum the monitoring of beaver activities in spatial terms would be advisable as an integral part of any reintroduction plan to Wales. This would include low-intensity non-intrusive monitoring of the development of beaver lodges, territories and dams as well as beaver foraging activities on a catchment so that the progress of beaver colonisation can be followed. Such work could be undertaken by a combination of trained beaver consultants, volunteers (see section 7.3) willing landowners and managers, and where possible as part of normal activities of staff employed by statutory agencies and environmental NGOs. More intensive monitoring of the effects of beavers could be undertaken by involving universities and colleges as part of MSc and PhD related research projects, or by separately funded scientific investigations by government agencies and NGOs. The option of including wider and more intensive monitoring as an integral part of a reintroduction programme is certainly possible, but would be likely to dramatically increase overall costs.

7.2.3 Monitoring of fisheries

One important area that it would be advisable to monitor, given the sensitivity of the issue in Britain, is the effect that beaver activities have may have on fish populations within any reintroduction area, particularly with regard to Atlantic salmon. Discussions with the Environment Agency Wales have established that the organisation already undertakes monitoring of fish species on certain catchments and that there is scope for this activity to be incorporated into a beaver reintroduction and monitoring programme.

7.3 MANAGEMENT OF BEAVER IMPACTS

7.3.1 Overview

The survey work undertaken during this assessment has established that there is abundant habitat in Wales to enable beavers to thrive on many catchments. However, as outlined above, experience from Europe and North America shows that there is the potential for beaver activities to conflict with certain human activities. This has resulted in the development of very effective systems to control beavers and mitigate any detrimental impacts.

With such systems in place before a release comprehensive evidence from previous reintroductions elsewhere in Europe suggests that there should be no significant problems associated with a reintroduction to Wales. It is important, however, that an effective system for Wales is devised that can respond quickly to any problems that might occur as a result of the activities of beavers.

Most beaver-human interactions tend to occur within a narrow zone alongside the water's edge and careful management of this zone can minimise and, in many cases, avoid conflicts. Flood prevention can in most circumstances be achieved by installing beaver-proof culverts, devices that control water levels, or by dam removal. Damage to vegetation or crops can be reduced or prevented by using physical (e.g. fencing) or chemical (e.g. repellents) barriers. In extreme cases, problem individuals or family groups may be removed by live-trapping or netting, and either translocated to other suitable sites or humanely dispatched.

7.3.2 Beaver management in Wales

In Wales, beavers could be effectively managed by the establishment of a network of trained volunteers available to deal with any issues arising from conflicts between human activities and those of beavers. Such a network would include beaver experts, members of local communities and landowners and would be operational in any reintroduction area.

A similar system works well in Bavaria where a site-specific beaver management programme operates to minimise conflicts and solve problems that may arise from human-beaver interaction.

The programme involves over 200 trained beaver consultants who work as volunteers covering over 70,000 hectares including extensive areas of arable farming, which is a major land-use in Bavaria. This arable landscape contains extensive networks of drainage ditches (ideal for beavers) that cover large flat floodplains and so present a 'worst-case scenario' with regard to potential beaver problems.


Figure 24. Beavers are easily caught in live-catch traps (left) or can be hand netted at night using torches to dazzle and immobilize foraging beavers (right). S. Tippie, F. Rosell

The management programme advises land-owners, implements measures to avoid, minimise or remove related problems, including, if necessary, humane dispatch of beavers.

As a result of the drainage ditch networks present in Bavaria there is considerably more habitat available to beavers than is the case in Wales, where beavers would be restricted to river channels, certain tributaries and some associated wetlands. Beaver activity therefore has a significantly greater impact in these Bavarian landscapes than would be the case in Wales.

Whereas over 200 trained beaver consultants are employed on a voluntary basis to undertake this work in Bavaria, the numbers of volunteers required to undertake beaver management work in Wales would most likely be considerably less than this.

Volunteers could be recruited from the conservation sector. The Wildlife Trusts in Wales are supported by over 1,570 volunteers across Wales. Many of these volunteers are already engaged in practical conservation management and would be keen to be involved in beaver management work. Recruitment of volunteers for such work is not considered a problem, and past experience suggests that it is highly likely that the number of volunteers wishing to be involved in beaver management work would far exceed demand.

The conservation sector has much experience of setting up and managing networks to help deliver effective wildlife management. One good example is the Roads and Otters Steering Group (ROSG) which has been running successfully in Wales since 2001. The ROSG network is extremely effective at responding quickly to otter road casualties and greatly improving the flow of information from initial incident reporting to influencing road mitigation. The ROSG group is comprised of representatives from a range of organisations including private, statutory and volunteer organisations including:

Welsh Government
North, Mid and South Wales Trunk Road Agencies
Environment Agency Wales
Countryside Council for Wales
Local Authorities
Welsh National Parks Authorities
Welsh Police Forces
Cardiff University Otter Project
Wildlife Trusts Wales
Other conservation NGOs
Otter Specialists

A similar network of beaver consultants would work well in Wales to ensure proper and effective management of beavers and their effects.

The training of volunteers would have cost implications that would need to be accounted for in any reintroduction scenario. In addition to this, funding would need to be made available to pay for the capital works required.

The methods that would be employed in Wales to deal with undesirable beaver activities would be modelled on those employed in Bavaria, which are generally very low-tech and inexpensive. As mentioned above, the cash costs required to address undesirable beaver activities tend to be in the region of €250 per incident in Bavaria, which covers the costs of the materials used.

A telephone and web-based reporting service could enable landowners and the general public to inform local beaver consultants about any undesirable beaver activities that may occur. This would ensure that remedial action is undertaken with a minimum of delay. The Environment Agency Wales already has an incident hotline set up to deal with a wide range of issues such as pollution to water or land, blocked watercourses and other incidents involving harm to the environment. Discussions with the Environment Agency Wales have established that beaver related reports could be dealt with by this system at negligible additional cost.

7.3.3 Network Management Group

The creation of a small management group to oversee the work of the network would be advisable, and would ideally comprise of representatives from the relevant government agencies and NGOs, as well as local landowners & managers and other appropriate individuals.

7.4 EXIT STRATEGY

Experience from Europe suggests that following a release of beavers to the wild it is extremely unlikely that they would cause significant and unacceptable harm to habitats, species, infrastructure or livelihoods that could not be reasonably ameliorated. However, techniques are well developed that could effectively reverse a reintroduction if such issues were to arise. This would involve the removal of all beavers from the wild. Beavers could be transferred to other reintroduction programmes, zoological collections or be humanely dispatched. A combination of all of these options is possible.

7.5 PROJECTED COSTS

The costs of a beaver reintroduction to Wales are dependent on a number of factors including: the source of the donor population; location of the release site and its potential for human/beaver conflicts; capital costs involved in the actual release; and the costs of any associated activities deemed necessary such as monitoring. Almost open-ended additional costs can be applied for add-on activities such as publicity, educational resources, interpretation materials, visitor centres, additional staff etc. Estimated minimum costs for a basic reintroduction into the wild are outlined below.

This assumes post-release monitoring of beavers and management of beaver activity by trained volunteers for five years (although a successful re-establishment would need modest but continual funding for management into the future).

The cost for training volunteers is included in 'Beaver impact management costs' in year 1, which also includes an estimate for undertaking pre-emptive measures (such as protection of vulnerable infrastructure, historical sites, crops, amenity trees etc.).

Figures for 'Project management' relate to the costs of employing a Project Manager to oversee the release and setting up of the beaver management network.

The costs below include funding for humane destruction of beavers in years 6 and 7 if the reintroduction is deemed to cause unsustainable negative impacts.

Table 3. Projected costs of a beaver release

Core project costs	**YR1**	**YR2**	**YR3**	**YR4**	**YR5**	**YR6**	**YR7**
Collection of donor stock	16,000	0	0	0	0	0	0
Importation costs	4,000	0	0	0	0	0	0
Transportation within UK	3,000	0	0	0	0	0	0
Quarantine facilities (if required)	70,000	0	0	0	0	0	0
Extraneous vet fees	5,000	5,000	5,000	0	0	0	0
Release costs	6,000	0	0	0	0	0	0
Field equipment & materials	20,000	2,000	2,000	2,000	2,000	0	0
Beaver impact management costs	20,000	10,000	10,000	10,000	10,000	0	0
Monitoring	8,000	8,000	8,000	8,000	8,000	0	0
Project management	28,000	28,000	28,000	28,000	28,000	0	0
Exit strategy (humane destruction)	0	0	0	0	0	10,000	5,000
Sub-total	**180,000**	**53,000**	**53,000**	**48,000**	**48,000**	**10,000**	**5,000**
TOTAL							**397,000**

8. FUNDING FOR BEAVER REINTRODUCTION IN WALES

Beavers are an iconic species that capture the public imagination and perform an important ecological function. A beaver re-establishment programme for Wales would represent a flagship for freshwater species and habitat conservation. Beaver re-establishment, including appropriate monitoring and advisory support and assistance for landowners and managers in a chosen catchment, would require investment, but the nature of the project is likely to enable sufficient funding to be found, providing there is a comprehensive fundraising strategy put in place. The best evidence for the likely success of this is provided from instances all around Europe, where the resources have been found for numerous beaver re-establishment programmes in over twenty countries. The Scottish Wildlife Trust and the Royal Zoological Society of Scotland have sourced substantial funding for the Scottish Beaver Trial.

A specific fundraising strategy would be required for any specific project in Wales. It would be based on a background of consultation, support, a clear lead organisation or partnership with clear governance and management arrangements, and timed, costed proposals. Investment would be required in the fundraising effort itself, and linked partnership working and communication management. Such project development programmes are a familiar way of working for voluntary sector conservation bodies, with statutory agencies being increasingly involved in such ventures.

The range of funders who might support beaver re-establishment in Wales can be broadly broken down as following:

- European Union
- Welsh Government
- Independent funding bodies
- Companies
- Voluntary sector conservation bodies
- Appeals to the general public and individual philanthropists

Whilst all these sectors are affected to some extent by the global economic recession, substantial funds remain available. There are clear links between beaver re-establishment and an ecosystem services approach which represents appropriate adaptation to the pressures of climate change. High profile activity driven through the tourism industry as part of an integrated approach to rural development, means that such funds should be readily accessible to a well-organised fundraising programme.

A summary review of each of the funding areas identified above is given below:

European Union

A large part of Wales (West Wales and the Valleys) is in the EU Convergence funding area. There is opportunity for funding up to half of any project costs which meets the relevant funding criteria, and can get through the complex application process. There would seem to be opportunities for beaver re-establishment to be funded by this source given the possible links to economic regeneration and stimulating visitor numbers. Further EU funding exists for rural development, and further programmes with this aim would also be a high priority for investigation. Lastly, the listing of European beaver in the EU Habitats Directive would assist in allowing consideration of a beaver re-establishment project, or a wider wetland habitat project incorporating beaver re-establishment, for funding under the EU LIFE funding programme. However, competition for LIFE funding is high, and there is a need to demonstrate transnational co-operation as part of such project development.

Welsh Government

CCW, as an Welsh Government Sponsored Public Body, has already supplied some grant aid funding towards the WBAI, as has Environment Agency Wales to a lesser extent. The experience in Scotland is that devolved Government and their agencies, including the Forestry Commission, have been able to incorporate beaver re-establishment within statutory duties to fund biodiversity conservation, sustainable land-management and rural development. This demonstrates that funding via statutory mechanisms is a possibility that could be replicated in Wales. This funding could stem from WG direct or its agencies, and/or funds that it manages, particularly the element of the Aggregates Levy Sustainability Fund which exists for redistribution towards biodiversity benefit and communities affected by mineral extraction. It is recognized that in the aftermath of the cuts in public spending, it is likely that there will be a squeeze on statutory funding.

Independent funding bodies

There is a large amount of funding held by independent funders, such as Charitable Trusts and the Lottery Funds. There is an enormous diversity of such funders, and a wide-range of criteria. Some bodies, such as Esmée Fairbairn Foundation, may be more willing to consider substantial investment if a beaver re-establishment programme was integral to the strengthening of the voluntary nature conservation sector in Wales. This area of potential funding can make a significant contribution, in terms of one or two larger contributions, and larger numbers of smaller contributions.

Companies

The Bavarian study-trip element of the WBAI has already received support from Welsh Power Ltd. The recession is likely to reduce the available levels of corporate support in the near-future, with the exception of companies with a land-filling need who generate landfill tax credits which could be redistributed to a beaver re-establishment programme. Indeed, landfill tax has been a major funder of the Scottish Beaver Trial. A large number of companies have beavers in their title or as a logo, which increases the opportunity for the corporate support, and a sample list of prospective targets has been drafted.

Voluntary sector conservation bodies

Conservation charities generate unrestricted income from members, legacies, gifts and earned income. The charitable purposes of such organisations are such that some are likely to be open to a strategic decision to put part of their unrestricted funds towards the costs of a beaver re-establishment programme itself, and/or the development costs which will be required to build partnerships and bring in other funding. Furthermore, such organisations are also able to employ direct marketing and fundraising techniques to attract fresh public support which will be spent directly on a beaver project.

9. FUTURE ACTION

If a Welsh beaver reintroduction was to be actively pursued, a number of further steps would need to be undertaken:

1. Consultation

Further consultation on practicalities of reintroduction with stakeholders, the public, national and local government, government agencies and involved NGOs will be required to supplement that already undertaken, including at the local level within each candidate catchment area. This would include awareness of how a reintroduction and management programme is likely to be undertaken, who will have the long-term responsibility for beavers, and what impacts both positive and negative a reintroduction would be likely to have. This would aid the development of a detailed reintroduction plan.

2. Selection of release site and related opportunities

Using information obtained during the consultation process one or more suitable sites for a beaver release can be chosen and some site specific analysis of likely impacts undertaken as part of reintroduction planning, which would be undertaken in tandem with local interested parties. In addition to this, opportunities for maximising benefits can be further examined with regard to related activities such as potential for tourism, general business opportunities, education, visitor centres etc; in this respect consultation would be undertaken with local chambers of commerce as well as communities.

3. Production of a detailed reintroduction plan

A detailed reintroduction and management plan would then need to be produced addressing all relevant issues, such as: final release site(s); sourcing, importation and quarantining of donor stock; post-release management and monitoring; volunteer recruitment and training; implementation timescale and full cost profile.

4. Funding and implementation

The production of a detailed costed reintroduction and management plan would assist in the securing of funding from all appropriate sources to implement the plan.

Other issues that require addressing are:

5. Legal issues

The current somewhat ambiguous legal status of beavers needs to be addressed to provide adequate protection and management of wild beavers in the long term. This would be best achieved in collaboration with the relevant licensing authorities in Wales.

6. Approval for a beaver release

It is recommended that before significant resources are committed to production of detailed reintroduction plans and related activities, approval from the Welsh Government for a beaver reintroduction is sought beforehand, with appropriate conditions as required.

10. CONCLUSION

The WBAI has attempted to answer three key questions:

1. Is it ecologically feasible to reintroduce beavers to Wales?
2. Is it feasible in terms of beaver management?
3. Is it desirable?

The studies undertaken as part of this project have determined that a beaver reintroduction to Wales is feasible in ecological terms, there being abundant habitat present in Wales suitable for sustaining viable populations of beavers in the wild.

This report also highlights that the negative impacts of beavers are limited and usually manageable. In Wales it would be possible to manage any negative impacts that might occur at low overall expense.

The benefits that beavers offer to ecosystem services, biodiversity, economic prosperity, tourism, education and recreation are many and appear to very substantially outweigh the costs of their reintroduction and management. This is borne out by the experience of the 24 European states that have already re-established sustainable populations of beavers.

Given these considerations there is a strong case for concluding that the reintroduction of beavers to Wales is desirable.

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12. APPENDICES

APPENDIX I: JNCC (IUCN) CRITERIA FOR PROPOSED CONSERVATION TRANSLOCATIONS

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APPENDIX I

JNCC CRITERIA FOR EVALUATING CONSERVATION TRANSLOCATIONS

In 1995 the International Union for the Conservation of Nature (IUCN) approved guidelines for reintroduction of species. These have been approved by the statutory conservation agencies in Britain. Based on these guidelines the Joint Nature Conservation Committee (JNCC) has developed a process for evaluating and undertaking species translocations for conservation purposes. Any reintroduction to Wales should follow these guidelines. The criteria are addressed below:

AGREED CRITERIA FOR EVALUATING PROPOSED CONSERVATION TRANSLOCATIONS:

i. There should be good evidence that the species is absent from the proposed release site(s) before the initial conservation translocation;

Beavers are no longer present in the wild in Wales having become extinct during the Middle Ages. As of May 2009 a trial reintroduction is currently underway in Knapdale, Argyll in Scotland. In addition to this beavers have recently been discovered living wild on some rivers in Scotland having presumably escaped from private collections.

ii. The release site(s) proposed for establishment should be within the historic range (post 1600, to take account of the first documentation of species distributions in Britain) of the species;

It is not known exactly when beavers became extinct in Wales or the rest of Britain, but they were probably extinct in Wales by the 15th century. It is widely accepted, that beavers were distributed throughout Britain before over-hunting resulted in their extinction.

iii. There should be a good understanding of the reasons for the original decline and disappearance of the species considered for translocation and the causes of their reduction or elimination from the site(s) proposed for establishment of the species;

Beavers became extinct in Britain (and Wales) primarily due to over-hunting by man. Habitat loss may have played a part in some instances, but the surveys that have been undertaken in 2008 show beyond doubt that there is plenty of suitable habitat in Wales to support a sustainable population of beavers.

iv. Consideration of the outcome of any previous translocations of the species involved, either in GB or elsewhere;

Translocations of beaver have occurred in many European countries with over 200 reintroductions and translocations having taken place since 1922. Beavers are now living wild within every country within their former European range except for Portugal, Italy and the countries of the southern Balkans. A trail reintroduction is underway in Scotland (since May 2009). Experience gained from all these projects would help to inform a reintroduction to Wales.

v. Consultation with other organisations and individuals who may be interested in or affected by the proposed translocation project;

Consultation with the key stakeholder organisations has occurred since 2005. Opinions, concerns, and ideas have been collated so that opportunities and potential problems are highlighted to enable practical solutions to be developed. Further consultation is planned, especially at the local level, to ensure that all organisations and individuals potentially affected by a reintroduction of beaver to Wales are able to feed into the assessment process.

vi. An assessment of the benefits to the species concerned arising from the proposed translocation (over both short and long timescales);

A reintroduction to Britain would contribute to the underlying aim of the Council Directive 92/43/EEC (Habitats Directive) to return native species to their former range. Reintroduction of European beaver to Wales would make a contribution to the favourable conservation status of the species in the EU by considerably extending its range.

vii. Consideration of any possible harmful effects to donor populations;

Potential donor populations used to source a reintroduction programme would not be adversely affected by the removal of animals. Beaver management in Bavaria involves the annual removal of up to 300 animals, some of which could be used to supply a reintroduction to Wales.

viii. Assessment of any possible harm to other species or habitats at the proposed recipient sites;

Studies show that the activities of beavers significantly increase biodiversity within riparian and wetland habitats and have an overall beneficial effect on habitats and species.

ix. The fit with other conservation objectives of the statutory agency concerned;

As a keystone species beavers have the potential to be a major management tool in river and wetland systems in Wales, benefiting a wide range of species and habitats thus helping to achieve certain core objectives of the Countryside Council for Wales. The reintroduction of beavers would also comply with one of the aims of the Habitats Directive to return native species back to their former range. Beavers as a sustainable management tool could also help achieve certain core objectives of the Environment Agency Wales and Forestry Commission Wales, as well as being in line with key objectives of the Welsh Assembly Government's proposed Natural Environment Framework.

x. The likely chances of success of the proposed conservation translocation;

Reintroduction/translocation of beavers in Europe has been overall highly successful. To date over 200 translocations have taken place throughout Europe since 1922 with the vast majority being successful and lessons have been learnt from the few failures that have occurred. There is now a wealth of experience to draw upon and approved procedures and best practice are well understood. The chances of a successful Welsh reintroduction would be extremely high.

xi. Confirmed availability of earmarked funds to complete the planned translocation and subsequent monitoring;

Preliminary investigations into potential sources of funding have been undertaken. More detailed plans would be developed as the assessment continues and exact locations for release sites are selected.

xii. Use of the most appropriate donor stock, taking into account the ecology, behaviour and genetic constitution of the species.

Recent studies have suggested that there are two lines of Eurasian Beaver: *Castor fiber fiber* in Western Europe and *Castor fiber vistulanis* in Eastern Europe and beyond (see Halley, D.J. (2010). Sourcing Eurasian beaver Castor fiber stock for reintroductions in Great Britain and Western Europe. *Mammal Review* 2010, Mammal Society). A reintroduction to Wales should as far as practical seek to involve the translocation of *Castor fiber fiber*, using donor stock from Germany, France or Norway. A combination of all three donor stocks could help to improve the genetic diversity of a newly established population.

APPENDIX II

BEAVER REINTRODUCTIONS TO ENGLAND: THE LEGAL POSITION

Report by Tony Mitchell-Jones, Natural England, 2008. (Note: This was prepared prior to the consolidation of the Habitats Regulations into the Conservation of Habitats and Species Regulations 2010. As a result of this, paragraph references will now be different.) Apart from issues relating to devolved responsibilities the following applies equally to the legal situation in Wales.

As a former native species not currently present in the wild in Britain, the beaver has a complex legal position.

Possession

A recent (2007) amendment to regulation 39(2) of the Conservation (Natural Habitats &c.) Regulations 1994 extended the offence of possession to all Habitats Directive Annex IV species instead of just those occurring in the UK (European protected species). This means that it is now an offence to possess, transport, sell or exchange any live or dead beaver or parts of a beaver.

This offence only applies to beavers taken from the wild after 10th June 1994 (or if taken in another Member State, the date it became a Member State). In addition, certain populations of beavers are not included in Annex IV, so specimens originating from Estonian, Latvian, Lithuanian, Polish, Finnish and Swedish, populations, as well as those taken from outside the EU, may be possessed legally and are not covered by the Habitats Regulations. However, regulation 39(8) makes it clear that the onus lies on the possessor to show that the specimen in question came from an exempt population. Any offspring of exempted beavers born in the wild in Great Britain would not be covered by the defence in regulation 39(8) and so a licence would be needed to possess them legally.

Regulation 39(2) applies only to animals taken from the wild, so the possession of captive-bred beavers would not be an offence, though the onus would be on the possessor to demonstrate that the animal in question had not been taken from the wild (regulation 39(9)).

Licences can be issued by Natural England to permit the possession etc. of live or dead beavers, or parts of beavers, for various purposes, including science, education and conservation. Any beavers imported from other Member States (except from excluded populations) for the purpose of reintroduction would thus need to be covered by an appropriate possession and transport licence.

Release

Section 14 of the Wildlife and Countryside Act 1981 makes it an offence to release or allow to escape into the wild any animal which -

(a) is of a kind which is not ordinarily resident in and is not a regular visitor to Great Britain in a wild state; or

(b) is included in Part 1 of Schedule 9

Licences can be issued by Natural England, on behalf of the Secretary of State, to permit actions that would otherwise be an offence under this section.

No definition of 'ordinarily resident in Great Britain in a wild state' is included in the Act or has been the subject of judgement by the courts, but it could be taken to mean that the species should have a self-sustaining population in the wild in Great Britain. If this interpretation is correct, then the consequences include:

- If a release into the wild establishes an ordinarily resident population, then subsequent releases do not require a licence. If control over subsequent releases is considered desirable, then it would be necessary to introduce another control mechanism, such as adding the beaver to schedule 9 of the WCA.
- As section 14 refers to Great Britain, a release into England, Scotland or Wales that established an 'ordinarily resident' population would remove the need for licensing in the other two countries.

The definition of 'into the wild' in this context (only) is considered by Defra and Natural England to apply to animals released into large enclosed areas in some circumstances, such as when the release has the potential to impact on natural or semi-natural habitats or wild species. This area of policy is currently being developed.

Other legislative considerations

Beavers in captivity are covered by the requirements of the Animal Welfare Act 2006. This Act probably also applies to beavers held in large enclosures where the owner of the animals continues to have some control over their welfare.

The legislative position of released beavers and beaver management

Current domestic legislation

If beavers are deliberately released into the wild (or escape and are not pursued) they become wild animals and are no longer owned by anyone. For the purpose of ownership, 'into the wild' probably does not include large fenced enclosures, where the rights of ownership persist as the owner still has a degree of control over the animals (and probably the land). In this case, the owner of these beavers may need two licences, one under section 14 of the WCA to release them 'into the wild' and one under regulation 44 of the Habitats Regulations to possess them.

Once in the wild (i.e. free and not subject to ownership), beavers are not currently protected by UK legislation, as the species is not on schedule 2 of the Habitats Regulations. Specimens could, therefore, be taken, killed or injured by anyone, provided they did not breach other legislation (e.g. animal welfare) or use methods of capture prohibited by legislation, such as self-locking snares. However, if a beaver was captured alive or killed and the corpse collected, a licence would be needed to possess it. Although the beaver is included in European Union legislation (the Habitats Directive), this legislation is binding on Member States, not individuals, and so would not provide direct legal protection.

The Habitats Directive

The beaver is included in Annex IV of the Habitats Directive. Article 12 of the Directive requires Member States to establish a system of strict protection for these species in their natural range. With respect to the latter, the European Commission's Article 12 guidance states *"When a species or habitat spreads on its own to a new area/territory or when a species has been re-introduced into its former natural range (in accordance with the rules in Article 22 of the Habitats Directive), this territory has to be considered part of the natural range. Similarly, the restoration/re-creation or management of habitat areas, as well as certain agricultural and forestry practices, can contribute to the expansion of a habitat or a species and hence its range. However, individuals or feral populations of an animal species introduced deliberately or accidentally by man to locations where they have never occurred naturally, or where they would not have spread to naturally in the foreseeable future, should be considered to be outside their natural range and consequently not covered by the Directive. Vagrant or occasional occurrences would also not be considered as part of the natural range."*

It is likely, therefore, that if beavers have been reintroduced into the wild within their former natural range and established a viable population, the Member State concerned would be obliged to protect the species using its domestic legislation transposing the requirements of Article 12. Great Britain is indisputably within the former natural range of the beaver, so it would be necessary in these circumstances to add the beaver to Schedule 2 of the Conservation (Natural Habitats &c.) Regulations for England, Scotland and Wales. If this was not done, the European Commission could begin infraction proceedings against the UK to, ultimately, oblige it to implement the necessary legislation.

Although there is clearly a requirement to protect beavers which have been reintroduced to part of their former natural range, there is arguably a degree of latitude in when this protection needs to be implemented. It could be argued that following initial release(s) and before the establishment of a viable population, there is a period during which assessment of the success and desirability of the venture should take place, and during which the process may be reversed, if necessary.

Beaver management

The beaver has been widely introduced to parts of its former European range and populations have readily established. One constant lesson from such reintroductions is the need to have a beaver management strategy in place should individual beavers or family groups cause problems for agriculture of forestry.

The possible addition of the beaver to Schedule 2 of the Habitats Regulations has significant implications for the management of the species as it would become illegal to deliberately kill, injure or take beavers or to damage or destroy their breeding or resting places. Should such actions be required for population management purposes, there are two possible licensing routes:

- The licensing authority (Natural England) can grant licences permitting otherwise illegal acts for the purpose of preventing serious damage to crops, timber or any other form of property.
- Recent amendments to the Habitats Regulations have introduced a new licensing purpose, reflecting a provision in the underlying Directive that has been used in other Member States to allow the management of Annex IV species. The new licensing purpose (regulation 44(2A)) allows the licensing authority to grant licences to permit the taking or possession or control of specimens of Annex IV species, subject to certain safeguards regarding numbers taken, selectivity and supervision.

In both cases, licences could only be issued where there was no reasonable alternative to the proposed action and where the action would not adversely affect the favourable conservation status of the species.

Within parts of its restored range, it is the dams built by beavers that are sometimes associated with damage to forestry or agriculture. Devices are available to manage the water level in beaver dams, but complete dam removal may occasionally be necessary. Dams are not used by beavers for breeding or resting, so the dam structures themselves are not protected. In some situations, the removal of a dam may have an adverse impact on a nearby beaver burrow or lodge by lowering the water level, so it may be a matter of judgement whether such action would constitute damage to a breeding or resting place. If a proposed dam removal operation is considered to have a damaging effect on a nearby breeding or resting place, a licence may be required in order for the work to be undertaken without committing an offence.

Tony Mitchell-Jones
Natural England
February 2008

APPENDIX III

KEY EUROPEAN REINTRODUCTIONS

By the turn of the last century beaver populations had been reduced to around 1200 individuals in eight isolated populations across Eurasia. In Western Europe there were only two relict populations left; on the River Rhone in France and the River Elbe in Germany. Since then the beaver population in Europe has increased in number and range by natural colonisation, translocation and, most importantly, re-introduction.

Over 200 European reintroductions and translocations have taken place since 1922 and the species is now present in every country within its former range with the exception of Italy, countries in the Southern Balkans and Britain. The vast majority of European states have undertaken 'full' reintroductions as opposed to trials.

A brief resume of the key reintroductions that have occurred is given below.

The following information is taken from Halley, D.J. (2002). *The beaver's reconquest of Eurasia: status, population development and management of a conservation success* (Mammal Review) plus updated information from Dr. Halley; information supplied by the Scottish Beaver Trial (Royal Zoological Society of Scotland and Scottish Wildlife Trust); and information supplied by Gerhard Schwab, Beaver Manager for Southern Bavaria (The Bund Naturschutz in Bayern e.V.).

Austria

Beaver became extinct in Austria in 1869. Forty individuals were released between 1976 and 1985 to the Danube near Vienna, others came from a Bavarian reintroduction to the Inn. The population increase was initially slow, but since 1994 has reached the rapid increase phase. Their range has expanded rapidly along the Austrian Danube. Ranges of the two release populations have fused and distribution is now continuous with the Bavarian population. The total population is estimated to be around 3,000 in 2008 with a further 200 in adjacent parts of Slovakia and the Czech Republic.

Belgium

Beavers became extinct in Belgium in 1848. Beaver reintroduction in Belgium started as a NGO project in 1998 with the release of a family of beavers from the Elbe population. Ninety-seven beavers from Bavaria were reintroduced to Wallonia in 1998 to 2000, (11 were released at several sites in the Ardennes in 1998, supplemented by 58 additional animals in 1999, an 28 in 2000 ,and 41 were released in Flanders in 2003. Although government departments were involved in some releases it did not have official approval from the authorities and was considered illegal. Following the releases the Belgian authorities set up a survey and management structure for dealing with possible conflicts. Public viewing opportunities and 'beaver safaris' are now available and are highly successful. It is currently the responsibility of local government, operating via an NGO, to deal with beaver related issues. The current beaver population in Belgium is estimated to be around 250 animals.

Bosnia

Forty beavers were reintroduced at two sites on the river Vrbas, a tributary of the Sava, in 2005 and 2006.

Croatia

Beavers became extinct in Croatia in the middle of the 19th century and were reintroduced to Croatia in a three-year programme from 1996 to 1998. Twenty-nine beavers from Bavaria were released at the Mura/Drava confluence near the Slovene/Hungarian border and 56 at two sites on the Sava River and its Cesma tributary near Zagreb. Both populations are now firmly established. Some beavers from the Drava site have moved into Hungary and signs of beaver activity have been reported from Serbia and Kärnten in Austria. In the south, beavers have crossed into Bosnia. The current population estimate is around 500 beavers.

Czech Republic

Beavers from the Austrian reintroduction reached the Czech Republic in the 1980s. By 1997 they had spread up the Morava River as far as Kromeriz. Beaver have also reached southwestern Czechia from Bavaria in the Oberpfalz/Cesky Les region. In addition to this, beaver were directly reintroduced near Olomouc on the Morava in the mid 1990s. The current population is estimated to be over 500 beavers.

Denmark

The most recent known sub-fossil remains in Denmark are well over 2000 years old; however, place-name evidence suggests that beavers probably survived to about 1100 AD. Reintroduction was recommended in a document published by the European Union / Bern Convention in 1997. The decision was taken to reintroduce beavers in order to restore native fauna and to utilise the ability of beavers to manage wetland habitats and thereby help maintain and increase Denmark's biodiversity. Information from other parts of Europe was examined, particularly in relation to any effects on land uses and the conclusion was that there would be only minor localised effects, such as some limited flooding. However it was agreed that adverse effects could be mitigated through a variety of mechanisms.

The Danish Forest and Nature Agency produced a national beaver plan that was subject to consultation, and release sites were proposed. Due to concerns raised by a fishing organisation a trial reintroduction was proposed and eighteen beavers were released to a network of small streams and ponds in the Klosterheden in Jutland in 1999. There was no attempt to confine them to a defined area nor was any radio tracking used. By autumn 2003 there was a minimum of 51 animals in 13 territories. The release site does not have natural containment features and lies upstream of a larger river system and in 2003 one beaver was seen in a new river catchment some 25-30 km downstream from the reintroduction area. The trial ended in 2003 and Ministerial approval for beavers to remain was granted in 2004, subject to a management plan being developed. Monitoring was undertaken by the Natural Environment Research Institute. A wide range of aspects were monitored including beaver numbers, territories, impacts on other species and effects on forestry, landowners and angling. Key results of the study included:

- An overall positive effect of beaver on habitats and populations of aquatic invertebrates, dead wood insects, amphibians, breeding birds (especially water birds).
- Increase in suitable hunting grounds for Daubenton's bats.
- Number of locations with evidence of otter presence had increased throughout the catchment.
- Localised reduction in willow scrub and shading.
- Temporal effects on sea trout movements and an assumption made that populations may become isolated upstream of dams (although not present, researchers considered salmon would not be affected in this way). The barrier effects of beavers dams is a dynamic process as dams are constantly created and abandoned (after which they disintegrate).

- Minimal effects on populations of eel and brook lamprey expected based on results to date. Populations of certain fish species, such as roach and stickleback, may benefit from beaver ponds in longer term.
- Minor management problems on private land with landowners generally reacting positively to the presence of beavers.
- A large increase in numbers of visitors to the area.

The state forest service frequently liaises with affected landowners who are mostly tolerant of minor localised flooding of agricultural land that tends to be used for grazing. The raising of the water table affects relatively small areas immediately adjacent to the burns. Dams can be created only in the vicinity of areas where woody materials are available - if not available beavers just pass through. Beavers in Denmark have not used intensively farmed land. At three sites where there has been a problem with dams flooding land, pipes have been placed in the dams to lower the water level (the use of pipe systems or 'beaver deceivers' is a standard method of controlling beaver pond water levels), and at another two sites the dams have been removed. A few clogged culverts under roads, and the inlet gate to a fish farm, have had to be cleared. Fencing material has been provided by the forest service to private owners to protect vulnerable trees.

There have been guided beaver tours within the release site with increasing numbers of people attending (in 2002 there were over 70 trips brought in over 2300 people). Beaver tours are organised by both the forest service and privately. Viewing platforms are used in some locations to reduce disturbance. Beavers have contributed to the local economy through tourism. Although the forest service has not promoted them widely, the local tourist association uses them for publicity. The forest service did not plan for visitors before the release, although release sites were selected where people may have a better chance of seeing animals. Another positive benefit identified by the forest service has been 'public health' with the presence of beavers encouraging people to visit the forest and therefore to exercise. The river habitats and otter population at Klosterheden have been put forward as qualifying interests for a candidate Special Area of Conservation (cSAC). The cSAC proposal was made after the beaver release and the Danish Forest and Nature Agency consider beavers integral to the cSAC management. The current population was estimated to be approximately 50-70 beavers. This estimate may now be increased as in October 2009 beavers were reintroduced to a second Danish site, near Copenhagen. Further releases to the site were scheduled for 2010.

Estonia

Extinction of the original population occurred in 1841. Reintroduction began in 1957 with 10 beavers from Belarus, and beavers appear to have spread from a reintroduction on the Russian shore of Lake Peipus at about the same time. Population development has followed the usual pattern of lag phase and rapid growth. In 1970 the population was 50, in 1980 400-500, in 1992 around 4,000 and currently stands at around 11,000 beavers.

Finland

Beavers became extinct in Finland in 1868. In 1935 seventeen European beavers *(Castor fiber)* from Norway and seven North American beavers *(Castor canadensis)* were released in 1935-1937 (Eurasian and North American beavers were then thought to be a single species). In contrast to Poland and Austria (where European beavers appear to have competitively displaced North American beavers) the North American beavers spread much more quickly than European beavers, and ousted the Europeans from many areas where the two species came into contact. The two species do not appear to coexist together except in the very short term. Outside the main range of *C. fiber* in the southwest, a small population of European beavers persists in Norra Tavastaland in the south. Heavy harvesting (18% of the *C. canadensis* population and 9% of the *C. fiber* population in 1998) appears to be the cause of the very slow population growth observed up until recent years. In 1998 a survey produced a figure of 10,500 *C. canadensis* and 1,500 *C. fiber* beavers. This is now thought to be have grown to around 2,000 individuals. In Finnish Lapland, the population of North American beavers abuts that of the expanding Swedish European beaver population, which is now established along the Torne river on the Finnish border. Action to eliminate North American beavers from Lapland is underway (in 1999 the remaining population was only approximately 40 animals).

France

A relict population of 30 individuals survived in the lower Rhone and has formed the source population for all reintroductions within France. 16 reintroductions have been made, of which 11 are reported as successfully increasing in population. In addition, the Rhone population has expanded greatly in numbers and in range. The current population is estimated to be around 7,000 – 10,000. A population of *C. canadensis,* established for some years on a reservoir near Paris, has now been removed from the wild.

Brittany reintroduction

Beavers were reintroduced into the River Ellez catchment of Amorique Regional Park, Brittany in the late 1960s. They were released onto private land without official permission and without any subsequent monitoring. The population has increased slowly over the last 30 or so years and now numbers approximately 60 animals. The beavers have to a large extent been contained in the release area by the topography and large artificial dams on the main river, and their rate of spread has been slow. Around five years ago beavers began to colonise another catchment area. The Ministry of Agriculture does not regard them as a major problem and there have only been two cases of damage to trees in the last 13 years. The Ministry encourages preventative action in the form of barriers or fencing. The only other reported problem is flooding of a minor road. A local farmer receives agri-environmental funding for the management of his land, including areas that have been affected by beaver activity. Access for the public is difficult but an NGO takes visitors across private land to see beavers and their signs.

Germany

A relic population of beavers (numbering around 200 animals in 1950) survived on the Elbe river. This population has since increased greatly in numbers and range and now occupies much of the Elbe river system. From 1966, beaver were reintroduced to Bavaria, mainly on the Danube and lower course of the Inn, using animals of diverse non-Elbe origin. In the 1980s beavers were reintroduced to the Eifel, the Peene river; in the 1980s to Hesse; and in 1994 to Saarland and Baden-Wurtemburg/Rhine close to Karlsruhe. The Bavarian reintroductions, in particular, have been successful in establishing a strong population, now continuous with the expanding Austrian reintroduction. Bavarian beavers have been the source population for many recent reintroductions into the lower Danube basin and to Belgium. The total population is now thought to be over 20,000 animals, approximately 12,000 of which are present in Bavaria.

Hungary

In 1993 beavers were reintroduced to Tisa-Stausee in central Hungary and in 1996 eight beavers were introduced in Gemenc National Park in southern Hungary. Beavers immigrated to the Szegetköz area from Austria in the late 1990s, and in April 2000 eight beavers from Bavaria were released at Fertõ-Hanság National Park. Both sites are in NE Hungary. Individual beavers have also immigrated along the Drava river system from Croatia. In total, 242 beavers from 1998 to 2008 have been released to Ferto Hansag National Park, Drava National Park, Gemenc National Park and several parts of the Tiza National Park. The reintroduction programme is co-ordinated by WWF. The beaver population was estimated by WWF to be 500 in 2008, but is likely to be nearer 1000 (as there was already in 2005 an estimate of 200 in Szigezköz on the Border to Slovakia).

Latvia

Beavers became extinct in Latvia in 1871. Reintroduction began in 1927 (2 pairs) and 1935 (1 pair), using beavers from Sweden. By 1950 this nucleus had increased to 78. In 1952, 10 beavers were reintroduced, and from the late 1950s beavers spread into Latvia from Belorussia. The characteristic pattern of slow increase followed by rapid exponential population growth was exhibited and populations were estimated as 70,000 in 1997 and were estimated at over 100,000 in 2008. Beaver are now found throughout the country, except for the north-western corner. Beavers are reported to be a problem in Latvia. This is wholly due to the history of land-use and forest management in the country. In Soviet times immense areas of marshland were drained mainly for forestry purposes. The combination of an expansive flat landscape drained by man-made branching systems of narrow and easily dammed ditches creates a situation where a single dam can flood a very considerable area and drown many trees. The natural situation of drainage, however, is broad, shallow, slow-flowing meanders of the sort beavers rarely find necessary to dam.

Lithuania

Beavers survived in the wild until 1938 in Lithuania. The country has a dense network of watercourses and marshes, so contains ideal beaver habitat. Seventy-eight beavers were reintroduced between 1947 and 1959. Subsequently, natural beaver immigration has occurred from Latvia, Belarus and the Kaliningrad enclave of Russia. The whole country is now occupied, and the current population has been estimated to be between 50,000-70,000 beavers.

Netherlands

Extinction of the original population occurred in 1826. Beavers were reintroduced to two sites in the Rhine delta, Biesbosch and Geldersee Poort, from 1988-1997. The reintroduction project was led by the Dutch Forestry Commission. It was felt necessary to reintroduce beavers to the Netherlands as they were required as natural habitat managers (cattle, ponies and deer are already used by the Dutch Forestry Commission and it was argued that beavers should also be used). There was also a wish to restore extinct species as part of the natural ecosystems. The situation on the Elbe in Germany was examined and journalists were taken to see beaver sites and their effects to ensure that there was information in the Dutch media to help inform the public. Forestry staff also visited the settlements in the proposed release areas to provide information to the local community. Initially there were objections from agricultural interests in the Biesbosch area, but fears were allayed when compensation was agreed for any damage. There are two official reintroduction sites at Biesbosch and Gelderse Poort, both on state forestry land.

Fifty-two animals were released at Biesbosch during 1988-92 and a similar number at Gelderse Poort during 1994-2000. Populations at both sites have increased more slowly than expected and the beavers have not dispersed from the area. Both reproduction and mortality is low. The reasons for this are unclear, but may be due to relatively poor habitat quality, or cadmium pollution from contaminated river sediments. However, the populations are now around 60-70 beavers at Gelderse Poort and around 100 at Biesbosch.

Scientific study was undertaken at the time of release but little systematic work has been done since. There is no overall plan for the reintroduction and no long-term management plan has been developed. Currently some limited research work and monitoring is being carried out but not on biodiversity impacts (however, local staff reported that during drought conditions in 2003 beaver ponds helped fish to survive).

Prior to release, possible damage to dykes and riverbanks was not considered a significant issue and the Government agreed to pay for all damage to agriculture and dykes. Since release there has been very limited damage to agriculture and only €250 was paid in compensation up to summer 2003.

In terms of effects on crops, only small areas of maize adjacent to water have been affected and farmers have not complained. There have also been minor problems with fruit trees and sugar beet. Farmers were able to obtain fencing, including electric fencing, for fruit trees in the early years and the cost of this totalled around €10,000, but as crop damage is so negligible it is not considered necessary any longer.

As well as the official reintroductions there was an unplanned reintroduction in Flevoland resulting from beavers escaping from a wildlife park where they had bred successfully since 1988. The Agricultural Ministry instructed the wildlife park to recapture the escapees but since the official releases began the area was regarded as a third reintroduction site. The park is immediately adjacent to intensive agriculture but no significant damage has occurred. There was some limited grazing of maize up to 10m from the water edge but this had no significant impact on crop yield. It is thought that the current population is around 200 beavers.

Norway

A population of around 100 beavers survived in south-west Norway and has provided the source stock for all modern populations in the country. Beavers gained legal protection from 1899. By 1910 the population had increased to around 1000 animals and had grown to around 7000 by 1919 when limited hunting was again permitted. In the later 1930s, population growth was halted due to over-hunting and during WW2 the population sharply declined. However, in 1942-43 the first beaver from the reintroduced population in Sweden immigrated to eastern Norway on the Trysil watershed. From 1925-1965 reintroductions also took place with 40 animals being released at eight sites from the south to the extreme north. The population in 1965 stood at 5-10,000 so was effectively unchanged from the 1919 figure. There were further reintroductions in Trøndelag and northern Norway in the following decade. In 1975 the range in southern Norway remained substantially unchanged but large scale natural immigration began from the expanding Swedish population. Beaver also spread into South East Sør-Trøndelag at this time. Reintroductions were made on the Orkla in western Sør-Trøndelag and in northern Norway. Between 1975 and 1996 beavers continued to spread, bolstered by further reintroductions. There are now two major disjunct populations in the southeast wholly descended from natural spread, and in eastern Norway continuous with and largely derived from the Swedish population, supplemented by reintroduced animals. The population derived from the Orkla reintroduction in the 1970s is now continuous with a population of Swedish origin spreading down the Orkla watershed. The population in 1999 was estimated at over 50,000. Beaver are protected in areas with low, or newly colonising, populations; a hunting season with a variable quota (depending on the local population size) is permitted elsewhere and around 10% of the population is harvested annually. In some areas, guided beaver safaris generate additional income. There seems to be no barrier to continued rapid expansion in Trøndelag, where beaver are common on the Namsen and small populations are established on all other major river systems. Significant spread may also be expected in south-central Norway, where beaver have reached the main Gudbrandsdal watershed. North of Trøndelag, except in Finnmark, watersheds are small and isolating barriers high, and the climate very harsh, so that population expansion will probably continue to be slow. The current population estimate for beavers in Norway is thought to be around 80,000.

Poland

Beaver became extinct within the present borders of Poland in 1844. 3-4 pairs were reintroduced in 1949, in addition to an unknown number of unclear origin during the German occupation in 1942-43. From 1975-86 223 individuals were released at various sites throughout the Vistula river system. 48 beavers were released between 1974 and 1985 on the Oder. Beavers from Norway have also been supplied to Poland for reintroduction purposes. Other, unofficial, reintroductions have also taken place, and there has been considerable immigration from Lithuania and Belarus. Further reintroductions are continuing. The population in 2005 was estimated to be approximately 18,000-23,000.

Romania

Beavers became extinct in Romania in 1824. Eight beavers from Bavaria were reintroduced to the Olt river near Brasov in November 1998 as the first stage of a co-operative reintroduction project by ICAS Romania, WGM of Bavaria and WWF. Nineteen beavers were released in the same area in 1999 and further releases took place until 2003. In total 255 beaver were released from 1998 to 2003 into Olt river, Mures River and Ialomita River.

Scotland

Fur taxation records indicate that beavers remained relatively common in Scotland into the mediaeval period and documentary evidence suggests the species persisted around Loch Ness until around 1550 AD.

Reintroducing beaver to Scotland has been discussed in conservation circles for many years, and reintroduction to Britain was specifically recommended in a document published by the European Union/Bern Convention in 1997. The current reintroduction initiative dates from 1994. Investigation of the history of beaver in Scotland was studied and a comprehensive survey of relevant scientific knowledge was compiled in 1995. Further studies concluded that a reintroduction of 20 animals to any one of a number of defined release sites would have a high probability of successfully establishing a viable population.

In 1997, a full public consultation was held by Scottish Natural Heritage (SNH). Results indicated strong support from the general public, including in rural areas where beaver were likely to be released, but reservations were voiced by many landowners and strong opposition was registered by some angling interests, who feared beaver dams would damage salmon stocks.

Further studies were undertaken including work to identify a specific trial site. Discussions with the Forestry Commission Scotland (FCS) resulted in three candidate reintroduction sites being selected on FCS landholdings: Knapdale, Loch Awe and Loch Shiel. Knapdale, in Mid-Argyll, was finally judged to be more suitable for a trial. Further local consultation was undertaken following the announcement of the Knapdale site in 2000.

Plans for a trial reintroduction were developed and these were unanimously approved by the SNH board. An application for a trial reintroduction was submitted by SNH to the Scottish Executive in 2002, but this was rejected by the Scottish Executive in 2005 mainly on the grounds that there could have been possible negative effects on the Western Atlantic Oak Woodlands SAC and that an exit plan involving the lethal control of beavers may have run contrary to European legislation. (Both of these concerns were based on flawed interpretations of the EU Habitats Directive by the Scottish Executive).

In 2007 the European beaver was included in the SNH Species Action Framework with the following justification:

"The European beaver meets criterion 1b of the Species Action Framework as a species for conservation action. It is listed on Annex IV (and Annex II) of the EC Habitats Directive. The Directive requires European Union Member States to study the desirability of reintroducing such species where they have become extinct. The beaver also qualifies for the Species Action List since we now have a large amount of ecological information on the species which can inform management actions. Effective species management action can be identified, namely the identification of a suitable site and the running of a reintroduction project, subject to the receipt of a licence. The beaver is a charismatic species which would serve to raise wider biodiversity issues such as riparian woodland management, aspen restoration, wetland biodiversity and dead wood habitat. There are few species which have such significant influences on ecosystem function and health"

The Scottish Wildlife Trust (SWT) and the Royal Zoological Society of Scotland (RZSS) formed a new partnership, and a joint application for the Knapdale trial was submitted to the Scottish Government in 2008. This time, SNH were not joint applicants as had been the case in the previous application, so that its role purely as an advisor to the Scottish Government was more clearly defined. In May 2008 the Scottish Government approved the trial. Further local public consultation was undertaken in the autumn of 2008, which again showed that the majority of the general public supported a trial reintroduction.

The Scottish Beaver Trial is now underway. It is a scientifically monitored, time-limited and site-specific trial re-introduction and allows the release of four families into the wild. The trial runs from 2009-2014. Three beaver families from Norway were released at specific locations within the trial area in May 2009, with another beaver family initially held in captivity as a 'reserve'.

The Scottish Beaver Trial ultimately undertook a combination of both hard and soft releases. The initial release in May 2009 was essentially a hard release as beavers escaped from artificial containment sooner than expected and decided to construct their own dens. Subsequent releases in 2010 used well-prepared artificial beaver lodges that contained food, bedding and scent from the released animals.

As a trial the Knapdale release involves a much high level of monitoring work compared to many European reintroductions and this comes at a cost. The overall Scottish Beaver Trial project is currently forecast to require around £2 million over the six years.

The topography of the Knapdale site is itself fairly effective in restricting released beavers to the trial area, but provision has been made for the rapid removal of beavers straying out of the trial area and shall be implemented where animals take up residence in an area against the wishes of the landowner, or where their activities are felt to be unacceptable.

Criteria for success and failure of the trial have been agreed and are shown below:

Criteria for success:

- Survival of introduced animals is similar to successful re-introduction programmes elsewhere in Europe at similar period of population establishment.
- A stable or increasing core population is achieved within the limits of the study site.
- The beaver population demonstrates a positive contribution to ecosystem function.
- Beaver re-introduction is integrated with habitat management/restoration.
- The impact on the economy of the area as a result of the presence of beavers is positive.

Criteria for failure:

- Mortality levels preclude establishment of a population.
- Significant and unsustainable damage is incurred by the ecosystem within the study site.
- The area suffers significant economic loss as a result of beaver activities.
- Costs of project/damage/management significantly exceed expectations.

Regular updates on progress are published by the Scottish Beaver Trial.

Slovakia

The species became extinct during the 19th century. Beaver immigration from Austria was recorded as early as 1976 with proven establishment being recorded in the late 1980s. Beaver are now well established on the lower Morava, and in the western foothills of the Malé Karpaty. In 1995 a further five individuals from Poland were reintroduced to Horná Orava in northern Slovakia. The population in Slovakia was estimated to be around 150 in 1997 and is currently estimated to be over 500.

Sweden

Beavers became extinct in Sweden by 1870. Legal protection for beavers was enacted in 1873. Reintroduction from Norway commenced in 1922 and beavers were released at 19 sites (11 of which were successful). Reintroduction sites were well spread from south-central to northern Sweden, mainly in the western mountains near the Norwegian border. The geography of Sweden is well suited to beaver range expansion; major river systems run in parallel west-east; except for the mountain spine on the Norwegian border, the topography is largely flat, and the landscape heavily wooded. Isolating barriers between river systems are therefore low. Beaver populations spread rapidly in range and numbers increased rapidly in the 1970s. In 1940, there were about 400 animals; in 1977 around 40,000; and in the early 1990s populations were estimated at over 100,000. Populations are either completely protected, or open for unrestricted hunting when in season (from 1st October - 10th/15th May, depending on locality). The actual harvest is about 6% per year. As late as the early 1990s, the beaver population in Sweden was divided into two main ranges in west-central and north-central Sweden. Major range expansion has continued and the two main ranges are now continuous. Beavers now occupy the whole country apart from the south and far northwest. With the Norwegian population, the range is now continuous from the Baltic to the Atlantic.

Switzerland

Beavers were extinct in Switzerland by 1820. From 1956-1977 141 beavers were reintroduced to 30 sites. Many of these sites were to unsuitable habitat in fast-flowing mountain rivers, and too few beavers were released for a viable population at each site. In addition, mountain barriers and habitat fragmentation greatly restricted spreading, so that population growth has been much slower than in most countries. The population remains relatively fragmented. The total Swiss population was estimated at around 350 individuals in 1997.

Publication information:
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