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speciesaction FRAMEWORK

Eurasian Beaver

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Author

Martin J. Gaywood
Scottish Natural Heritage, Great Glen House, Leachkin Road, Inverness, IV3 8NW.
martin.gaywood@snh.gov.uk

Summary

- The feasibility and desirability of reintroducing beaver to Scotland has been explored over many decades, and progressed in detail since the mid-1990s.
- The inclusion of beaver in the Species Action Framework (SAF) demonstrated the continued interest in beaver reintroduction issues, and prompted a licence application to release beavers at Knapdale, Argyll, for the purpose of running a scientifically monitored trial. The licence was approved (2008) and the first animals were released in May 2009 as part of the 'Scottish Beaver Trial' (SBT).
- The SBT was a complex project, which required careful planning and management, involving issues ranging from the identification of necessary resources, capture and quarantine requirements, animal tracking and veterinary requirements, independent scientific monitoring, local consultation and engagement, visitor management and associated education programmes, and potential impacts on designated site interests.
- Other initiatives and projects concerned with beavers ran over the same period. These included the work of the Tayside Beaver Study Group (TBSG), the Beaver-Salmonid Working Group (BSWG), the National Species Reintroduction Forum, and a number of stand-alone projects.
- The results of all of this work were collated as a package of information and sent, together with the *Beavers in Scotland* report produced by Scottish Natural Heritage (SNH), to the Scottish Government in June 2015 to support their decision making.
- On 24 November 2016 Roseanna Cunningham MSP, Cabinet Secretary for Environment, Climate Change and Land Reform, announced that beavers will remain in Scotland.

Introduction

On 24 November 2016, it was announced by Scottish Government that beavers will remain in Scotland. This represents the first, formal reintroduction of a mammal species anywhere in Britain.

The potential for reintroducing beaver to Scotland has been explored in detail since the mid-1990s. The launch of SAF in 2007 led to the historic 'Scottish Beaver Trial' project. Since 2007 a number of other beaver projects and initiatives were also established and, although they were not directly funded through SAF sources, they are also reported here because they were all inextricably linked to the overall purpose of collating information to support decisions on beaver reintroduction.

Figs 1 and 2. Beavers will occasionally try to fell large trees, but most trees selected by beavers at Knapdale have been 2-6 cm diameter. Some, such as this rowan, have shown signs of re-sprouting.

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Species background

The Eurasian beaver (*Castor fiber*) is a large, semi-aquatic rodent that is believed to have died out in Britain about three centuries ago. It is listed on Annex IV (and Annex II) of the EC Habitats

Directive, and therefore there is a requirement for European Union Member States to study the desirability of reintroducing such species where they have become extinct. The beaver is a species that many claim can have a significant influence on ecosystem function and health. It is a charismatic species that could serve to raise wider biodiversity issues such as riparian woodland management, aspen restoration, wetland biodiversity and dead wood habitat creation. It was therefore included on the SAF list as a species worthy of further conservation action, in particular through a trial reintroduction.

Habitat, distribution and abundance

The Eurasian beaver inhabits riparian broadleaved woodland or scrub bordering fresh standing waters or slow-moving watercourses. It occurs from western Europe eastwards to the Chinese-Mongolian border region. By the beginning of the twentieth century there were thought to be only around 1,200 animals surviving in eight populations (Halley and Rosell, 2003). Three discrete western European populations survived in southern Norway, on the Elbe in Germany, and the Rhone in France. In the east, small populations persisted in Belarus, Russia, Ukraine, Mongolia and China. The twentieth century marked a dramatic turnaround. As a result of changes in wildlife legislation, management practices and enhancements, translocations/ reintroductions and natural recolonisation, the total population is now estimated to be a minimum of one million animals (Halley *et al.*, 2012) although this is heavily weighted towards eastern and northern Europe. This represents one of the most strikingly successful conservation feats for a European vertebrate.

General ecology

The beaver is herbivorous, and feeds on herbaceous and woody, broadleaved species (Figs. 1 and 2). It favours burrows in banks as 'nesting' places, but may build lodges of piled logs where it is unable to burrow (Fig. 3). The beaver will sometimes dam streams to maintain water levels and construct canals that allow it to travel further away from the main body of water (Figs. 4 and 5). It is monogamous and lives in family groups. The Eurasian beaver has been described as a 'keystone' species and it is argued that its restoration would be beneficial to a wide range of species and habitats.

Fig 3. Beaver lodge on Tayside, 1.5 m high.

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Figs 4 and 5. Beaver dams, such as these two at Knapdale, vary considerably in size and construction.

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Aims

Aims for 2007-2012

At the beginning of SAF the key, over-arching aim was:

- To support at least one reintroduced Eurasian beaver population in the wild in Scotland.

A wide range of aims and objectives were later identified for the various beaver initiatives that were run (e.g. see the aims of the Scottish Beaver Trial in the following section), but these all related to the overall need to collate necessary information by 2015 to support a decision on the future of beaver reintroduction.

Management Action

Background

SNH started investigating the feasibility and desirability of reintroducing beaver to Scotland in 1995, prompted to some extent by the inclusion of Eurasian beaver on Annex IV of the EC Habitats Directive. During the 1990s a number of projects were set up to look at the issues surrounding beaver reintroduction (see below) and these were used to help inform a national consultation held in 1998. This led to a decision to run a trial reintroduction to allow some of the issues raised during the consultation to be looked at in more detail. The whole process took account of the IUCN Reintroduction Guidelines (IUCN, 1998).

The next decade was dominated by efforts to obtain approval for, and organise, a trial reintroduction. Knapdale Forest in Argyll was identified as a possible site for a trial as early as 2000, and in the same year a local consultation was organised. SNH applied for a licence in 2005 to release beavers at Knapdale but the Scottish Government turned this down. Two years later the beaver was included on the SAF list as a species to be prioritised for conservation action (SNH, 2007), thereby setting beaver within a wider, national context of strategic, targeted management. Two Scottish NGOs, the Scottish Wildlife Trust (SWT) and Royal Zoological Society of Scotland (RZSS), then made a second licence application which was approved in 2008. As a result the SBT was established, and the first ever licensed release of a mammal species into the wild in Britain took place in May 2009 when three families of beavers were released at Knapdale.

After the launches of SAF and the SBT, new challenges and opportunities arose, and new beaver initiatives were developed. These are listed below. The outputs of all of these formed a package of information that SNH collated and submitted to Scottish Government, together with the *Beavers in Scotland* report (Gaywood, 2015), in June 2015. They were designed to support Ministers in making a decision on the future management of beavers, and beaver reintroduction, in Scotland.

The main projects and initiatives

The Scottish Beaver Trial

The SBT was the central beaver-related project that developed out of the SAF process. Five years of post-release monitoring by a consortium of independent scientists ended in May 2014 after which there was a year of final data analysis and report writing that was incorporated in the *Beavers in Scotland* report in 2015.

The Tayside Beaver Study Group

A population of beavers has developed on Tayside. This arose through unauthorised escapes from private collections, and possible deliberate releases. Initial attempts to capture and re-house the beavers stopped when it became apparent the numbers were far higher than originally estimated. The Scottish Government decided to 'tolerate' the presence of the beavers until the Ministerial decision, and the 'Tayside Beaver Study Group' (TBSG) was set up in 2012 to help collate more information on the population and their impact. A part-time project officer supported the work of the group.

The Beaver-Salmonid Working Group

Concerns regarding the potential impact of beaver dams on migratory salmon and trout were raised by fishery organisations and this led to the formation of the Beaver-Salmonid Working Group (BSWG) in 2009. This group was given the aim of examining the issues surrounding the interactions between beavers and salmonid fish. Its membership included representatives from government and non-government, science and fishery sectors. A part-time project officer supported the work of the group.

The National Species Reintroduction Forum

The National Species Reintroduction Forum (NSRF) was set up in 2009, is chaired and supported by SNH, and is made up of a wide range of land use and conservation bodies from both the public and NGO sectors. It has an advisory role, and its remit covers all types of conservation translocation, and deals with broad scale, strategic issues, most recently with the development of the 'Scottish Code for Conservation Translocations' (National Species Reintroduction Forum, 2014). It has been involved with a number of initiatives that relate to beaver reintroduction.

Other beaver projects and initiatives

There were several other projects that were due to be completed before the report to the Minister in 2015. These included developing methods to examine beaver genetics, reviewing beaver management, and refining a beaver population modelling tool. This is in addition to research and review projects which were completed before the release of beavers in Scotland, and the work being undertaken in England (Gurnell *et al.*, 2009), Wales, the rest of Eurasia and North America.

The pre-release work – key issues and the work done

Historical evidence and cause of extinction

Early questions were: Can we confirm the beaver once lived in Scotland, why did it die out, and was the cause of dying out still a problem for any reintroduction?

Initial work (Conroy and Kitchener, 1996; Kitchener and Conroy, 1996) found that the Eurasian beaver appeared to have been widespread throughout Britain, including Scotland. Some palaeontological and archaeological remains, together with written historical information, suggest that it was present here until the early 16th century – the last Scottish record is mentioned in the 1526 'Cronikils of Scotland' and refers to beavers as being abundant in the Loch Ness area. More recently Coles (2006) has found evidence that beavers may have been present well into the late 18th century in England. The cause of this loss to Scotland, as elsewhere across Europe, is believed to have been unsustainable levels of hunting for the valuable beaver pelts, and to a lesser extent for castoreum and meat. These causes are unlikely to be a problem for any new reintroduction. Habitat loss is thought to have been a relatively minor and localised factor.

Provenance

What would be the most appropriate source of beavers for any Scottish reintroduction?

Morphological studies of British fossil beaver material led Kitchener and Lynch (2000) to recommend Norway as the most suitable donor source. This recommendation was applied to the Scottish Beaver Trial for which only Norwegian animals were used. This was felt to be a defensible, precautionary approach until more information could be gathered on beaver genetics and donor source suitability. However, animals of mixed provenance now live in Tayside where there have been unplanned releases.

Genetic work undertaken several years later suggested that there may be a western 'form' (variously described as an 'evolutionary significant unit' or 'haplogroup') of beaver which originates from the remaining Norwegian, French and German relict populations, and an eastern form which originates from another five relict populations, suggesting at least two refugia existed during the last ice age for the species (Ducroz *et al.*, 2005; Durka *et al.*, 2005). Many beavers across Europe are now of mixed stock due to extensive translocations over past decades. However, a recent study by Senn *et al.* (2014) has demonstrated, through additional sampling and nuclear genetic analysis, that this eastern-western division is not as obvious as previously thought. These studies, and associated provenance issues and implications, are further examined in the SNH *Beavers in Scotland* report (Gaywood, 2015).

There is a North American species of beaver (*Castor canadensis*) that cannot easily be distinguished from the Eurasian species in the field. There is broad agreement across the conservation sector that this non-native species should not be released in Britain. The North American species has been introduced into parts of northern Europe and is now well established in Finland. It has only recently become clear that the species appears to be present in some numbers in the Germany-Belgium-Luxembourg border area (Schley *et al.*, 2009). The two species are not known to hybridise in the wild, although there are suggestions that the North American species out-competes the Eurasian species, at least in more northern latitudes. It seems unlikely that the North American species

has been released in Scotland, intentionally or unintentionally, and it has not been detected during the genetic screening on Tayside to date.

Public and animal health factors also need to be considered when sourcing beavers. Beavers imported from Europe to the UK have usually had to undergo a six months rabies quarantine, although more recently Scottish Government has agreed that beavers from Norway (which is rabies-free) only need to a undergo a limited period of health surveillance (one month in Norway), subject to certain veterinary conditions. This has significant animal welfare and cost benefits, and potential knock-on effects in terms of increasing the success of any reintroduction.

The presence of a range of other pathogens should be checked during quarantine, although it became clear that animals were not being effectively screened for the taenid tapeworm *Echinococcus multilocularis*, and consequently importers were often unaware whether their beavers were infected or not. This tapeworm is a public health concern because it can cause human alveolar echinococcosis, a hepatic disorder that resembles liver cancer and is highly aggressive and potentially lethal. Britain and Norway are currently free of the tapeworm, but it does occur in other parts of Europe (such as Germany) from which beavers have been sourced for collections around Britain, including Tayside. Although some of the Tayside animals escaped into the wild, the probability that this resulted in the establishment of the tapeworm in native wildlife is thought to be low, although there is a level of uncertainty (Defra, 2012). Any future proposals to release beavers would need to demonstrate there was no risk of infection, for example by ensuring the animals come from tapeworm-free countries or captive-bred sources.

Identifying potential beaver habitat at the national scale

Can we be confident that there is sufficient and suitable habitat in Scotland that would allow a self-sustaining, viable beaver population to establish itself in Scotland after any reintroduction?

Modelling and GIS tools have been used to identify potential beaver habitat across Scotland, and to predict possible population levels following any release. A first map of potential beaver habitat was published by Webb *et al.* (1997), although this was revised by SNH using updated GIS datasets (Gaywood *et al.*, 2008), and was revised again using new datasets and criteria based on the latest ecological research (Stringer *et al.*, 2015). These illustrate that there are some extensive networks of freshwater and riparian broadleaved woodland habitat across many parts of the country. Preliminary estimates of potential population size were 178-386 family groups within 45 distinct patches across the country (South *et al.*, 1999; Rushton *et al.*, 2001), although these figures are probably an underestimate.

Examining the potential effects of beaver presence - Pre-release work

What effect might beavers have on the environment in Scotland?

A number of reviews were commissioned before permission was sought to undertake a trial reintroduction. These involved literature reviews, and collation of information provided by specialists on the European and, to a lesser extent, North American experience with beavers. They included:

- Development of beaver habitat survey protocols (Macdonald *et al.*, 1997).
- Review of beaver dam-building and hydrology (Gurnell, 1997).
- Review of beavers and fish/fisheries (Collen, 1997).
- Review of beavers and woodland habitats (Reynolds, 2000).

These identified some of the potential risks and benefits of beaver presence in Scotland. A very thorough assessment of the risks and benefits on natural and human environments is presented in the *Beavers in Scotland* report (Gaywood, 2015).

Assessing public desirability – consultations

Do people want the beaver back in Scotland? This question was posed during a national consultation during which the provisional evidence that SNH had collated was presented (Scott Porter Research & Marketing Ltd., 1998). The results of the consultation showed a majority of the public supporting the idea of beaver reintroduction, although strong reservations were expressed by some organisations within sectors such as agriculture and field-sports. This led to a decision to run a trial reintroduction to allow some of the concerns, and potential benefits, to be looked at in more detail. There have also been a few other surveys which involved an examination of public

perceptions on beaver reintroduction, and which have tended to give results in support of releases (Gaywood *et al.*, 2008).

The post-release work – The SBT

The trial approach set out in the SBT was developed in response to the national consultation and SAF. It has been a complex programme of work that has been reported on in detail in a wide range of final outputs, but some key components are summarised here.

Aim of the trial

The aims of the SBT were set out in the original licence application. They were to undertake a scientifically monitored trial reintroduction of the Eurasian beaver to Knapdale, mid-Argyll, for a five year period in order to:

- Study the ecology and biology of the Eurasian beaver in the Scottish environment.
- Assess the effects of beaver activities on the natural and socio-economic environment.
- Generate information during the proposed trial release that will inform a potential further release of beavers at other sites with different habitat characteristics.
- Determine the extent and impact of any increased tourism generated through the presence of beaver.
- Explore the environmental education opportunities that may arise from the trial itself and the scope for a wider programme should the trial be successful.

The licence application also sets out a range of success and failure criteria to help measure the SBT

Identification of a release site

The agreement and cooperation of sympathetic land owners was needed for the trial site. Early in the process Forestry Commission Scotland (FCS) offered their support, and so a first stage was to overlay the FCS land holding with the SNH map of potential beaver habitat (Webb *et al.*, 1997). Shortlisted sites were then field-validated using the protocol of Macdonald *et al.* (1997), and practical issues discussed with relevant personnel. It was never going to be possible to find a perfect site, but Knapdale (Fig. 6) was put forward based on its ecological suitability, its uncomplicated land ownership (FCS was the sole owner), practical benefits (e.g. proximity to SNH and FCS offices, visitor facilities and extensive forest track network) and its relatively contained network of catchments, therefore reducing the risk of extensive beaver dispersal outside the trial area. A model to predict the possible outcomes of any release at Knapdale was produced (Rushton *et al.*, 2002). Knapdale is also designated as a Special Area of Conservation, Special Protection Area and Site of Special Scientific Interest, and therefore, because it was decided the project would have a 'significant effect' on the relevant Natura natural heritage features, an 'appropriate assessment' had to be done.

Fig 6. Knapdale forest, the release site for the Scottish Beaver Trial.

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Local consultation

SNH had run a local consultation in 2000, but SWT/RZSS updated this with a further consultation in late 2007. This involved local meetings and open days, the distribution of leaflets and an invitation to individuals and organisations to submit views, and highlight any potential issues. The results showed strong support across mid-Argyll as a whole, although a small majority against the trial amongst those living near to Knapdale. A further public consultation carried out by the SWT/RZSS in early 2014 showed a majority support for beaver reintroduction (Jones and Campbell-Palmer, 2014.).

Licence application process

Section 14 of the Wildlife and Countryside Act 1981 makes it an offence to release into the wild any animal that is of a kind 'not ordinarily resident' in Great Britain. The SWT and RZSS therefore required a licence from Scottish Government to allow release. The application set out full project

details, including overall aims, success and failure criteria and exit strategy options. The subsequent licence issued by the Scottish Government contained 32 conditions relating to subjects such as how the project would be monitored and managed, including in relation to the designated site features. Now that The Wildlife and Natural Environment (Scotland) Act 2011 applies in Scotland, SNH will be the licensing authority for any future proposals of this type. Licences will be required before any further beaver releases in Scotland are permitted.

Timescale

The overall project was seven years, with one year preparation, five years post-release monitoring, and a seventh year of analysis with reporting to be completed by May 2015. This timeframe had to be a compromise between ensuring sufficient time was allowed for useful information to be derived from the project, but short enough that there was a good chance of sufficient resources being made available.

Project management and organisation roles

The SWT and RZSS were the licence holders and project managers. FCS was the landowner and 'host partner'. A 'Project Team' and a number of working groups were set up by the partners to coordinate project management and ensure delivery of work on the ground. FCS led on ensuring health and safety issues were properly addressed during the trial period. One licence condition set by the Scottish Government was that SNH should coordinate the independent monitoring programme in collaboration with other parties, and ensure the licence conditions were being addressed, and a 'Research and Monitoring Coordination Group' was therefore established to coordinate the independent monitoring programme. Also, and importantly, an independently chaired 'Local Stakeholders' Forum' was organised to help set up good lines of communication between members of the local community and those managing the SBT.

Resources

It was necessary from an early stage to ensure sufficient funding was in place to cover the whole project period. The SWT and RZSS were responsible for sourcing the approx. £2 m required for the entire project. A number of contributions were secured, not least £1m from Biffa Award. SNH contributed approximately £250 K specifically to the monitoring work, with significant additional resources contributed by the independent monitoring partners

Capture, holding, transport, quarantine/screening

This complex process started with identifying personnel in Norway prepared to assist with the capture and holding work. Full details of the methods used are given in the 'Captive Management Guidelines' for beavers (Campbell-Palmer and Rosell, 2013). The Norwegian specialists identified wild beaver families suitable for capture. Initially a decision was made to catch and release whole families to try and reduce the risk of post-release dispersal, although this approach also created some problems (e.g. increased capture time and cost, and quarantine mortality), with the result that subsequent releases used young single animals paired in captivity prior to release. Captured animals were held in purpose-built holding facilities, and checked by vets. Relevant export and import permits had to be arranged, and transport crates sourced. The first and main group of animals had to undergo a six-month rabies quarantine at a facility based in Devon. Six animals died during this initial quarantine (Goodman, 2014). Subsequent imports went direct to RZSS holding facilities in Edinburgh and Kincraig, and did not have to undergo the six-month rabies quarantine, although other health checks had to be made (see above).

Release

Release points with suitable quality habitat were identified around Knapdale, sufficiently spaced to reduce the risk of territorial disputes between neighbouring animals during the sensitive period immediately after release. Soft release methods were used in the early stage of the project. Artificial lodges were built from straw bales, bedding was marked with the animals' scent, and the animals were placed inside and blocked in temporarily. In the event, these artificial lodges were not used to any great extent. Temporary lines of open fencing (designed to allow the movement of otters) were placed along two key water bodies at one release site which might have been used as dispersal routes out of the trial area. Sixteen animals were released at four loch sites during the first sixteen months of the trial (Fig. 7) – this relatively small number was designed to address the aims of the time-limited trial, and is probably insufficient for any long-term 'founder' population

for Knapdale. Further details on the release process are given in Campbell-Palmer and Rosell (2013) and Jones and Campbell-Palmer (2014).

Fig 7. A beaver at Knapdale.

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Management of animals

This element was led by SWT and RZSS, in consultation with FCS and SNH. SBT field staff were based locally throughout the whole trial period, an office and equipment store were established near the site, and dedicated vehicles provided. An un-fenced trial site boundary was agreed. Protocols were established on how to deal with animals that moved out with the boundary or which were not observed within the trial site after fixed periods of time. Attempts were made to trap and return any animals detected outwith the trial site. The movement of animals was monitored for management purposes through a combination of radio telemetry/GPS tracking, direct observations, field sign surveys, camera traps and trapping/releasing (details on some of these methods are provided in Campbell-Palmer and Rosell, 2013; Jones and Campbell-Palmer, 2014). Some of this information was also used for the scientific monitoring work, and the methods are described in Campbell *et al.* (2010) and Harrington *et al.* (2011, 2012, 2013, 2015). Animal health and welfare issues were managed by RZSS veterinary staff with support by local vets, with additional independent monitoring by the Royal (Dick) School of Veterinary Studies of Edinburgh University. Floating mink raft traps were set up at a number of sites around Knapdale, and records made of the small number of mink that have been detected, trapped and dispatched.

Scientific monitoring of the trial

A Monitoring Programme was developed by SNH in collaboration with its independent monitoring partners. To ensure the process was independent, SWT and RZSS did not contribute to the scientific design, interpretation and reporting, but were involved in discussions relating to the practical application of work on the ground, and undertook some of the data collection. SNH worked in direct partnership with a range of organisations leading on various natural heritage issues:

- Beaver ecology – with the University of Oxford .
- Riparian mammals – with the University of Oxford.
- Fish ecology – with the Argyll Fisheries Trust.
- Dragonflies and damselflies – with the British Dragonfly Society.
- Woodland habitat – with The James Hutton Institute.
- Loch ecology/aquatic plants with the University of Stirling.
- River habitat – with the University of Stirling.
- Hydrology – with the University of Stirling.
- Socio-economics – with Scotland's Rural College.

Other independent organisations led on issues outwith SNH's specialist remit (historic sites, public health, animal health and water chemistry):

- Beaver health – Led by the Royal (Dick) School of Veterinary Studies.
- Water chemistry – Led by the Scottish Environment Protection Agency.
- Public health – Led by Argyll and Bute Council.
- Scheduled monuments – Led by Historic Scotland.

The final reports for these monitoring projects can be found on the SNH website, and the results are summarised in the SNH *Beavers in Scotland* report (Gaywood, 2015).

Additional opportunities

The SWT and RZSS developed an education programme focussed around the SBT, and set up an education officer post to engage with the public, educational institutions and special interest groups. Visitor interpretation opportunities and facilities were also developed in close collaboration with

FCS. A programme of guided walks was run, and a floating viewing platform and boardwalk viewing area built at one beaver loch (Figs. 8 & 9).

Figs 8 and 9. Guided walks, and a floating pontoon to allow visitors to see the largest beaver dam at Knapdale, were set up during the Scottish Beaver Trial.

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The post-release work – The information that was collected

The projects described above helped to produce a range of information, briefly summarised below. Full results from these studies are published on the SNH website. All of this, together with information gathered from other European and North American sources, helped to inform the decisions on the future of beavers in Scotland.

Beaver ecology and genetics

The monitoring of the beavers at the SBT was led by the University of Oxford in collaboration with SNH. Data were collated by SBT field staff using methods established by the University of Oxford/ SNH. A combination of direct observations, field sign surveys, trapping, radio telemetry and GPS was used to study the population dynamics and habitat utilisation. Some of this information was also used by the SBT for project management purposes, for example establishing whether beavers were still within the study site or had moved away. The methodological design and results are available (Harrington *et al.*, 2015).

On Tayside, a survey was undertaken in 2012 to assess the distribution and establish the size of the beaver population beavers within the catchment (Campbell *et al.*, 2012). It was estimated about 38-39 family groups were present, with each family using a mean waterway length of 2.9 km ± 1.5 SD. Lodge productivity surveys were also carried out during the summers of 2013 and 2014 to see how many kits are born to a sample of the family groups (Campbell-Palmer *et al.*, 2015). All of this TBSG and SBT data was used to test and refine the existing beaver population model referred to in the description of the pre-release work above (Shirley *et al.*, 2015).

A sample of the Tayside animals were also trapped, and any dead animals found were examined, to assess their genetic status. All animals caught were confirmed as Eurasion beaver, and issues relating to their 'genetic health' assessed (McEwing *et al.*, 2015).

Animal and public health

Animal health and welfare within the SBT was managed by the RZSS, with independent monitoring by the Royal (Dick) School of Veterinary Studies. The programme design is described in Goodman *et al.* (2012) and Goodman (2015). Post-release monitoring was done through visual observations, and annual trapping and examination during which blood, faecal and other samples are taken.

Public health issues have also been raised in relation to beavers, in particular giardiasis although a study undertaken several years ago found little evidence that this has been a concern in parts of Europe where beavers occur (Galbraith and Gaywood, 2002). A programme of public health monitoring was set up within the SBT, led by Argyll and Bute Council. This involved the

collection of water samples from key points around the trial area, and analysis for protozoan parasites such as *Giardia* and *Cryptosporidium*. The results from the pre-release, baseline monitoring are given in Morrison (2004), and the final SBT results are provided in Mackie (2014). A further and wider examination of public health risk associated with beavers in Scotland was organised by the Centre of Expertise on Animal Disease Outbreaks (EPIC, 2015).

A beaver screening programme was also undertaken on Tayside, led by the RZSS. Since the precise origin of the Tayside beavers could not be confirmed, a particular focus of the work was assessing whether the tapeworm *Echinococcus multilocularis* was present. No signs of disease were found (Campbell-Palmer *et al.*, 2015). The Scottish Government also increased the screening of the fox population, since fox is a primary host of the parasite. The fox screening also produced negative results.

Aquatic and semi-aquatic biology

The University of Stirling, in collaboration with SNH, led on the monitoring of loch ecology at the SBT, with a particular focus on the macrophyte communities and the indirect effects of dam creation and water level changes, and the direct effects of herbivory (Figs. 10 and 11). This is a topic that has been poorly studied elsewhere, probably in part due to the technical difficulties of working in aquatic environments. The methods and interim results are presented in Willby *et al.* (2010, 2011), with the final results in Willby *et al.* (2014). Some additional loch habitat characteristics, such as invertebrate communities and bathymetry were also assessed at one particular loch that had been particularly affected by the construction of a beaver dam. Beaver interactions with loch ecology were also the subject of a University of Stirling PhD which was completed in 2014, and which involved fieldwork at the SBT and at a site on Tayside. Some initial work has been published on beaver foraging behaviour in relation to water lilies (Law *et al.*, 2013), and builds on the methods and results of an earlier PhD undertaken at the same university and using the same Tayside field site (Jones, 2006).

Fig 10. Macrophyte monitoring at Knapdale.

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Fig 11. Trees flooded as a result of beaver damming at the Dubh Loch, Knapdale, have died and increased the resource of standing dead wood habitat.

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Hydrological change was monitored through the use of automatic loggers set up at key points around the SBT site, together with automatic rain gauge loggers and stage boards (Fig. 12). Data on fluvial geomorphology and river habitat was collected using the standard River Habitat Survey (RHS) method and a bespoke geomorphic assessment (Gilvear and Casas Mulet, 2010), although most beaver activity at Knapdale has been within the lochs, rather than on the interconnecting network of small streams. Monthly

water chemistry samples were collected by SBT field staff and analysed by the Scottish Environment Protection Agency (SEPA).

Fig 12. Hydrology monitoring at Knapdale. Automatic loggers and stage boards were used.

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Woodland

A woodland monitoring programme was established at Knapdale by the James Hutton Institute, in collaboration with SNH (Moore *et al*., 2010, 2011, 2013; Iason *et al*., 2014.), partly informed by an initial assessment of potential methods (Armstrong *et al*., 2004). This established 17 transects, comprising 65 (4 x 10 m) permanent vegetation plots between zero and 30 m from the water's edge. Data were collated on factors such as tree species and size selection, felling intensity in relation to distances from lodges and water's edge, and regrowth from felled stumps (Fig. 13).

Fig 13. Woodland monitoring at Knapdale has included the use of tags to identify individual tree stems.

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The woodland at Knapdale is a qualifying feature for the SAC, and the lichen assemblages associated with a number of hazel stands around the site are an important component. There was very limited beaver activity within these hazel stands in the early years of the SBT, but more recently there has been an increase in the number of hazel stools felled, or partly felled. These stands were therefore carefully monitored by SNH, to inform any decisions that may be needed on their future management.

Species and biodiversity

Within the monitoring programme, the emphasis was on looking at the effects of beavers on habitats at the site, and this was used, together with information from other sources, to judge how habitat changes may affect specific species or groups of species. It was not possible, with the limited resources available, to monitor beaver effects on many individual species, or different groups of species. There were some exceptions however. Otter is a qualifying interest for the SAC at Knapdale, and has also been highlighted as a species valued by local people. Annual otter sign surveys were therefore undertaken by SNH. Any mink signs were also recorded at the same time (water vole is not believed to be present at Knapdale). Dragonflies and damselflies (Odonata) are a notified feature for the SSSI at Knapdale, and therefore the British Dragonfly Society monitored two species of particular interest, the hairy dragonfly (*Brachytron pratense*) and beautiful demoiselle (*Calopteryx virgo*).

Information from the standard 'Site Condition Monitoring' for the designated site features at Knapdale, which includes black-throated diver, marsh fritillary butterfly, the bryophyte assemblage and woodland breeding bird assemblage, were also made available for the final reporting on the SBT.

Fish species were also monitored at the SBT by the Argyll Fisheries Trust in collaboration with SNH. This was done by electrofishing and redd count surveys on a number of the small streams both within and outwith the SBT site (Argyll Fisheries Trust, 2015), some of which contain trout populations.

The potential effects of beaver on fish and fisheries has been a particularly controversial topic during the beaver reintroduction debate, in particular the specific issue of beaver dam presence and potential impacts on the movement of Atlantic salmon and sea trout. The SBT does not have any salmon populations within its study area, and therefore other means of examining the issue were initiated.

Recent work on this topic started with the most comprehensive review of the beaver-fish issue undertaken to date anywhere (Kemp *et al.*, 2010, 2012), and involved a meta-analysis of the literature and expert opinion. This found that most research is biased towards North America (88%), with benefits to fish cited more frequently than costs (184 times to 119 times). Positive findings were more frequently based on quantitative evidence (51%), while discussion of negative effects was often speculative (71%). During the survey of expert opinion, perceived positive effects were recorded as increased fish abundance and productivity, and perceived negative effects as impediments to movement due to damming, and impacts on available spawning habitat.

More recently the BSWG examined the beaver-salmonid issues in the Scottish context. This included some preliminary field examinations of fish movements in relation to a series of dams on one of the Tay tributaries (Fig. 14), a mapping study to assess to what extent potential beaver habitat may overlap with salmon habitat within a number of catchments, and the collation of further information on beaver and fish/fisheries ecology and management issues. This was incorporated in to a final report (BSWG, 2015). The discussions also led to the creation of a new PhD studentship based at the University of Southampton from 2014, which is looking at fish movement and behaviour in relation to beaver dams.

SNH also undertook its own detailed meta-analysis of published studies on the role of beavers as 'ecosystem engineers', and their possible impact on the biodiversity of Scotland (Stringer and Gaywood, 2016). This showed that, overall, beavers have a very positive influence on biodiversity, and a widespread positive effect is predicted in Scotland. There are some specific habitats and species of conservation importance, such as the Atlantic hazelwood climax community and aspen woodland, where there may be detrimental impacts and therefore where targeted management would be required.

Fig 14. Electrofishing in areas around a beaver dam on the Lunan Burn, Tayside.

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Socio-economics

Scotland's Rural College (SRUC), in collaboration with SNH, led on the monitoring of the socio-economic factors relating to the SBT (Moran and Lewis, 2014). Work was also done on examining the socio-economic implications of beaver presence on Tayside (Hamilton and Moran, 2015). These socio-economic studies involved measures from business surveys, visitor and guided walk counts, volunteering and education programmes, damage cost estimates and non-market valuation.

Scheduled monuments

At the south end of Loch Coille-Bharr, one of the beaver release lochs at the SBT, there are the remains of the underwater foundations of a crannog. Historic Scotland (now known as Historic Environment Scotland) therefore monitored any possible effects of beaver presence on this scheduled monument (Cavers, 2009; Brann, 2014).

Land use and management

The SBT and Tayside present different and contrasting situations where various issues relating to land use and management were examined. The SBT was on a relatively contained site where there is a significant forestry operation managed by FCS, and where biodiversity conservation and visitor recreation management are significant factors. On Tayside the catchment area is much larger, with extensive areas given over to agriculture and other land use activities.

On Tayside the experiences of local land users with beavers on their land were recorded by the TBSG using questionnaires. Concerns such as the damming of drainage channels and burrowing into flood defence banks were identified (TBSG, 2015). There were also some preliminary trials of mitigation techniques such as tree guards, and flow control devices for beaver dams.

One of the key issues that land users raised is the extent to which beavers might be managed in the future if their long term presence is eventually approved, and they are added to Schedule 2 of the Habitats Regulations 1994 as a 'European Protected Species'. To help answer that question, SNH commissioned a project on behalf of the NSRF. The work was carried out by legal and conservation specialists based at the University of Aberdeen, and involved assessing the extent to which protected species had been the subject of conservation translocations in Europe, and examining some specific case studies of the more contentious species such as wolf, lynx, sea eagle and beaver (Pillai *et al.*, 2012).

The case studies found that some of these reintroduced species had their populations or habitats controlled, when their numbers were healthy and thriving and there were conflicts with other land uses. Under current European laws, legal protection for protected species is strict, but member states may 'derogate' from the rules, subject to satisfying certain conditions, including that the species concerned are judged to be in favourable conservation status. Such derogations allow control of a particular protected species, and are regularly used in species management throughout Europe. The report recommended that the key to meeting the EU legal requirements is to have a national species management strategy in place, which outlines the needs and threats faced by the species, and the problems it may pose for human activities.

There is also the related issue of improving the security of captive beavers to try and minimise the risk of accidental escapes, which in turn might lead to 'uncontrolled' reintroductions and conflict. This was looked at through a combination of improved husbandry advice, discussions with owners and consideration of the conditions that are attached to licences for the keeping of beavers.

Details of specific beaver management techniques, the legal implications relating to beavers and their management, and the type of issues that might need to be covered in any future national beaver management strategy, are covered in more detail in the SNH *Beavers in Scotland* report (Gaywood, 2015).

Further Work

SAF finished in March 2012 but the SBT, and other beaver projects and initiatives described above, carried on until May 2015. The final reports associated with the work of the SBT, TBSG and BSWG and other initiatives are now available via the SNH website. In June 2015 SNH provided the Minister for Environment, Climate Change and Land Reform with a package of the relevant reports produced by various authors, together with the *Beavers in Scotland* report, which summarised the key findings, identified the main issues and examined a range of potential future scenarios for the future of beavers and beaver reintroduction in Scotland. This was used to support the decisions on the future of beaver reintroduction to Scotland, including the beavers currently present at Knapdale and Tayside.

The NSRF have published a Scottish Code for Conservation Translocations and associated Best Practice Guidelines (National Species Reintroduction Forum, 2014). The project was led by SNH in partnership with the Royal Botanic Garden Edinburgh. The aim of the Code is to guide the process of evaluating whether a translocation is appropriate, and if so, how to increase the likelihood of successful outcomes, and reduce the likelihood of problems and conflict. The Code is consistent with the revised IUCN Guidelines for Species Conservation Translocations (IUCN, 2012). The experience of the beaver reintroduction in Scotland, and of other species translocations, have helped to inform the content of the Code. Any new beaver conservation translocation proposal will need to address the principles set out in the Code, and any further releases would need a licence from SNH.

On 24 November 2016, Roseanna Cunningham MSP, Cabinet Secretary for Environment, Climate Change and Land Reform, announced that the Eurasian beaver will remain in Scotland. Efforts will now need to focus on working with key stakeholders to develop a planned and strategic approach to future beaver management.

Further Information

- www.scottishbeavers.org.uk – SWT and RZSS website for the SBT.
- www.snh.gov.uk/beavers-in-scotland – SNH website with beaver-related reports and information.

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Project manager partners

- Royal Zoological Society of Scotland
- Scottish Wildlife Trust

Landowner partner

- Forestry Commission Scotland

Independent Monitoring Partners

- Argyll and Bute Council
- Argyll Fisheries Trust
- British Dragonfly Society
- Historic Scotland
- James Hutton Institute
- Royal (Dick) School of Veterinary Studies
- Scottish Environment Protection Agency
- Scottish Natural Heritage
- Scotland's Rural College
- University of Oxford
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This account comes from the Species Action Framework Handbook published by Scottish Natural Heritage. For more information on the handbook please go to www.snh.gov.uk/speciesactionframework

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