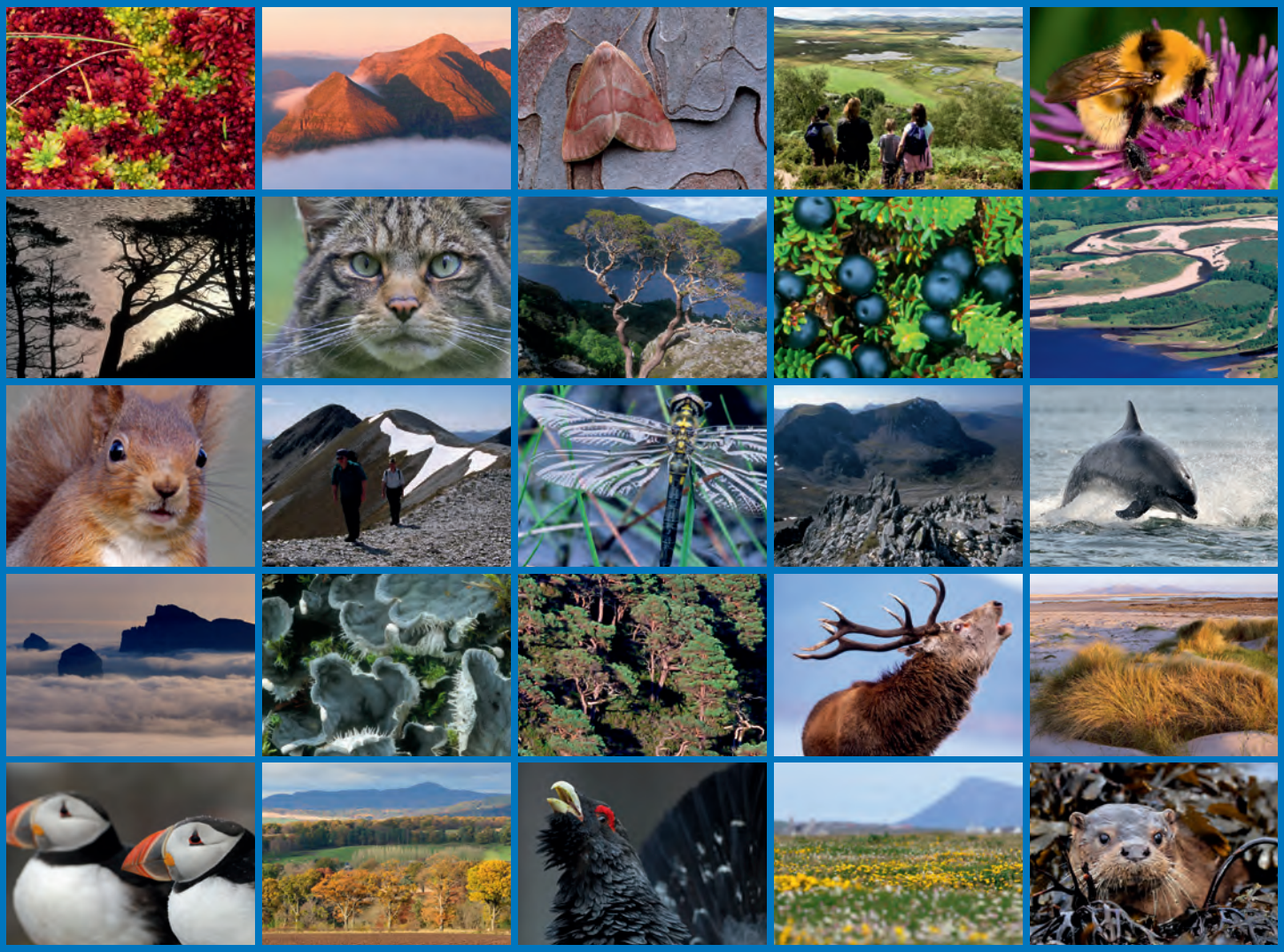
Scottish Natural Heritage
Commissioned Report No. 805

Tayside beaver socio-economic impact study



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COMMISSIONED REPORT

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COMMISSIONED REPORT

Summary

Tayside beaver socio-economic impact study

Commissioned Report No. 805
Project No: 13810
Contractor: SRUC
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Keywords

Beavers; Scotland; socio-economic; Tayside; economics; wildlife.

Background

The impacts of potential reintroduction of beavers to Scotland are currently being scrutinised in an independent trial at Knapdale in Argyll, for which the evaluation is being coordinated by Scottish Natural Heritage (SNH) on behalf of the Scottish Government. However, a further population of beavers exists in the Tay catchment. The Minister for Environment decided that these animals should be allowed to remain in place until the end of the official trial beaver reintroduction at Knapdale in 2015, at which time the Minister will take decisions on the future of all beavers in Scotland. This study was commissioned to improve evidence on the socio-economic impacts of the Tay population. It reports survey evidence of current positive and negative impacts, and provides some key pointers to possible future impacts. Surveys took place from January to March 2014, and consisted of a paper questionnaire / online survey to land managers, an online survey to tourism businesses, and a survey by telephone and online of key stakeholder organisations.

Main findings

- Of the 111 land manager responses received, 46% said they had no beavers on their land, 17% said they had seen them, with the rest seeing signs or unsure. A minority (12%) had incurred quantifiable costs per annum. These ranged from £300 to £10,000 (mean £2,653, median £1,000), with the higher costs incurred for damaged flood defences and large trees being felled, in the lower (arable) part of the catchment.
- Less impact is evident so far in the upper catchment. Land managers perceived limited benefits from current or future beaver presence, but seemed willing to tolerate them pending appropriate control and potential compensation.
- The survey of businesses focused on tourism providers. These indicated a significant level of awareness of the beaver presence and a largely positive attitude. Few businesses were categorical in terms of employment potential that might be attached to the beavers, but 26% of providers that indicated positive impacts cited increased turnover amounts (sum of £5,080; mean of £1,016), with some noting the potential for future exploitation.
- Key stakeholder organisations were contacted for their views on costs and benefits of beaver presence. Organisations representing land managers expressed concern about the legality of the beaver presence in the Tay catchment, as well as noting current costs incurred by some land managers and concern about the magnitude of future impacts.

- Conservation organisations emphasised the possible benefits, although realising that management options need to be developed. Tourism bodies also thought that beaver presence would benefit local businesses through increased tourism draw. Some organisations noted that clarification of the legal position of beavers is needed, and the need for impact monitoring systems.
- There seems to be a modest appreciation of tangible or market benefit that is offsetting some appreciable location-specific costs, the latter being mostly endured by land managers. The modest benefits are not surprising given the lack of strategic exploitation of beaver presence, and indeed possible benefits may not be apparent for many reasons. In one case, the benefits from outreach activities (mainly education) can be valued conservatively at around £16,000. In addition to the above market value, we considered non-use value (NUV) associated with the existence of a reintroduced charismatic mammal. This can potentially generate very high NUV estimates; however issues in applying the available data and the implicit assumptions mean that the results should be treated with care.
- Catchment-wide scaling of costs of future impacts is challenging due to the many assumptions in such an exercise. The current annual costs are estimated to be between £34,490 (the costs reported in the survey) and £179,900, which assumes catchment wide impacts equivalent to the survey sample, although with different impacts in the upper and lower catchment areas. Possible future impacts are estimated by scaling up the available data, with the results emphasising the lower-upper catchment divide, and the wide range of possible scenarios. It seems likely that future costs will be closer to the low estimates than the high estimates. In summary, there is the potential for impacts and costs primarily in the lower catchment. The relatively small market benefits currently being realised have the potential to increase, and the non-use value may be considerable. Taking these estimates in aggregate, the benefits of beaver tolerance are likely to outweigh the costs incurred, which can themselves be lowered by appropriate management and mitigation measures.

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Acknowledgements

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List of abbreviations

NFUS	National Farmers Union Scotland
SLE	Scottish Land and Estates
CONFOR	Confederation of Forest Industries
SWT	Scottish Wildlife Trust
JMT	John Muir Trust
SWBG	Scottish Wild Beaver Group
SEPA	Scottish Environment Protection Agency
FC	Forestry Commission
TBSG	Tayside Beaver Study Group
SRUC	Scotland's Rural College
SAC	Scottish Agricultural College
SNH	Scottish Natural Heritage
WTP	Willingness to pay

1. INTRODUCTION AND BACKGROUND

The impacts of the potential reintroduction of beavers to Scotland are currently being scrutinised in an independent trial, for which the evaluation is being coordinated by Scottish Natural Heritage (SNH) on behalf of the Scottish Government. The trial, which is located at Knapdale in Argyll, is covering both ecological and socio-economic impacts and will report in May 2015, with a view to informing a ministerial decision on beaver reintroduction.

During the trial, it became clear that the impacts of a further population of beavers in Tayside warranted attention. The Tayside Beaver Study Group (TBSG) was established in May 2012 in response to a decision by the Environment Minister to tolerate and study beavers which had become established across the Tay Catchment. The Minister for Environment decided that these animals should be allowed to remain in place for the duration of the official trial beaver reintroduction at Knapdale. At the end of the trial period, the Minister will take a decision on the future of beavers in Scotland – both those in Knapdale and on Tayside. This decision is expected to be made before the end of 2015.

In contrast to the Knapdale trial, the Tayside case represents a *de facto* release, with beavers considered present for the last decade (Jones *et al.* 2013). As noted in the SNH report (Campbell *et al.* 2012) on the population and its distribution, the presence of beavers in an area used for agriculture and fishing presents an opportunity to examine interactions between beavers and human land-use. More importantly, the impacts observed are perhaps more typical than those being measured in Knapdale, which is more remote and therefore economically marginal in terms of relevant socio-economic impacts (including agriculture and forestry).

To help inform decision-making, SNH wants to assess the socio-economic impacts of a breeding beaver population in the Tay catchment. This report sets out a methodology for scoping the costs and benefits of this population. The report uses survey evidence gained from key stakeholders in the catchment and draws on further evidence from international studies that have considered some of the socio-economic elements of beaver populations. The report is structured as follows. The remainder of section one provides further background on the impacts of beaver populations and considers the evidence on the socio-economic costs and benefits from existing literature. Section two sets out the methodological approach to gathering quantitative and qualitative estimates of both costs and benefits associated with the Tay population. Section three sets out some key results from survey responses, and section four provides some scenarios on the likely evolution of costs if the population is kept and spreads. Section five sets out the benefits, and section six establishes some further issues to consider in the event of a wider release. Section seven makes recommendations for future data collection and research. Finally, section eight draws some conclusions for this work together.

Research for this report has been undertaken by researchers in the Land Economy, Environment and Society research group of SRUC (formerly SAC).

1.1 Existing published evidence

Existing global literature on the costs and benefits of mammal reintroductions covers different facets. Costs of reintroductions typically focus on damages from predator species such as wolves or raptors. In the case of beavers, these costs have highlighted damage to forests (e.g. Parker *et al.* 2001) and potential perturbation of salmonid fisheries (e.g. Collen & Gibson, 2001). Management costs (e.g. controlled culling) can be added to these costs and more detailed scenarios involving site remediation and compensation can also be envisaged but these elements do not seem to have been costed together in any detail for any particular site.

Noteworthy qualitative studies focusing on costs include McKinstry and Anderson (1999) which looked at attitudes of land owners in Wyoming, USA. In a large survey of 5,265 private-land managers and 124 public-land managers, concerns about beaver damage primarily centred on (in decreasing order of importance) blocked irrigation ditches, girdled timber, blocked culverts, flooded pastures, roads, crops, and timber. Primary benefits perceived were, in order of importance, elevated water tables, increased riparian vegetation, and increased stock-watering opportunities. Public-land managers also listed these benefits and detriments among their top concerns for beavers. Over 45% of landowners with beavers on their property and all of the public-land managers displayed an interest in a beaver reintroduction program and in more proactive management. However, perceptions of beavers can change as impacts change (Siemer et al., 2013), as may be expected in an area such as Tayside with a dynamic population.

Other benefit studies often focused on either the market values associated with releases (e.g. hunting and recreation) or else (but often separately) non-market values associated with species status and existence. The latter studies are often based on willingness to pay (WTP) values that can vary depending on the nature of the hypothetical market constructed to describe the species status and the potential role in its ecosystem (eg Philip and MacMillan 2005). Clearly some species are more appealing than others and such preferences are reflected in WTP studies that can often report very large aggregate values for some species depending on the number of people considered to be affected by the change (i.e. the reintroduction or other management regime). Market and non-market value estimates can be additive, though non-market values need to be used with care such that the change proposed in any hypothetical market actually corresponds to the change that will take place. This lack of correspondence is often problematic when transferring values from non-market data to inform policy.

The most relevant studies have been undertaken by Campbell *et al.* (2007) and separately as part of the SNH-funded research undertaken by Rose Hanley Nickolls.

Campbell *et al.* (2007) attempted to estimate a potential value for a beaver population in Scotland using a survey of specialist wildlife tourism companies and a regional multiplier of the associated visit revenue. The analysis indicated a potential input of £1 million per annum to the Argyll economy as a result of such companies including the Knapdale area in their itineraries. The main flaw of the analysis is that companies may not actually offer tours and the regional multiplier is too generous to represent the economic flows for the Argyll economy, which is economically marginal. This is borne out by survey evidence on the Knapdale socio-economic study that suggests that employment and turnover by local businesses has been modest (Moran & Lewis, 2014). There is no obvious basis for assuming that these values would apply in the Tay.

Campbell *et al.* (2007) also estimated the possible existence value of the reintroduced population to the Scottish public as £65 million per annum. This is based on the transfer of a WTP study (MacMillan *et al.,* 2001) which indicated that people in the Glen Affric and Strathspey areas were willing to pay £67 and £91 per household per annum respectively to include a beaver reintroduction with restoration of the Caledonian Pine Forest in the area. The hypothetical nature of this study and whether it can be extrapolated to beavers on the Tay is also debatable. However, the value is only marginally higher than the £56 per household estimated by Hanley-Nickolls using a choice experiment to identify both general policy priorities in Scotland and priorities for species programmes including beaver reintroduction.

There are now 26 European countries that have reintroduced the European beaver as part of over 200 reintroduction projects (Jones *et al.* 2013), illustrating the ability of the species to recover from the estimated low of 1,200 animals in the late 19th century. There are some

notable uses of the animals in tourism, education and economic development, including Pays des Castor (Belgium) and Klosterheden Forest (Denmark), both illustrating how beavers can contribute to local economies. Beavers also contribute through ecosystem services: in Latvia beavers reportedly purify 34 billion m^3 of water a year, which if done artificially would cost in the region of £40 million (Balodis 1990). Creation of wetlands by damming is another key ecosystem service provided by European beavers; the Latvian population of 100,000 beavers was predicted to create 100-200km^2 of wetlands, worth £0.6-1.3 billion in fixed capital (Balodis 1994).

In the US, Buckley *et al.* (2011) have shown how ecosystem services can be used to describe the benefits from beaver (*Castor canadensis*) populations in Utah. More specifically, regulating and supporting services deriving from alterations they cause to ecological structures and processes in a river basin of growing economic importance (Escalante river basin, Figure 1). These values accord with significant benefits suggested from beaver reintroductions across Europe.

The benefit categories identified by these studies (sediment, wetland and water purification) may be more significant in the event of any wider release and have only been studied to a limited extent in Scotland. While informative, none of the aforementioned studies provides a clear template for considering the benefit categories to be considered in the Tay. The primary study covering the Tayside beaver population is that by Campbell *et al.* (2012), which focused on surveying distribution and activities of beaver, and then estimated the population size. Whilst this does not provide costed impacts/benefits, it does provide vital distribution information that is used in the cost scenarios section (section 4) of this report.

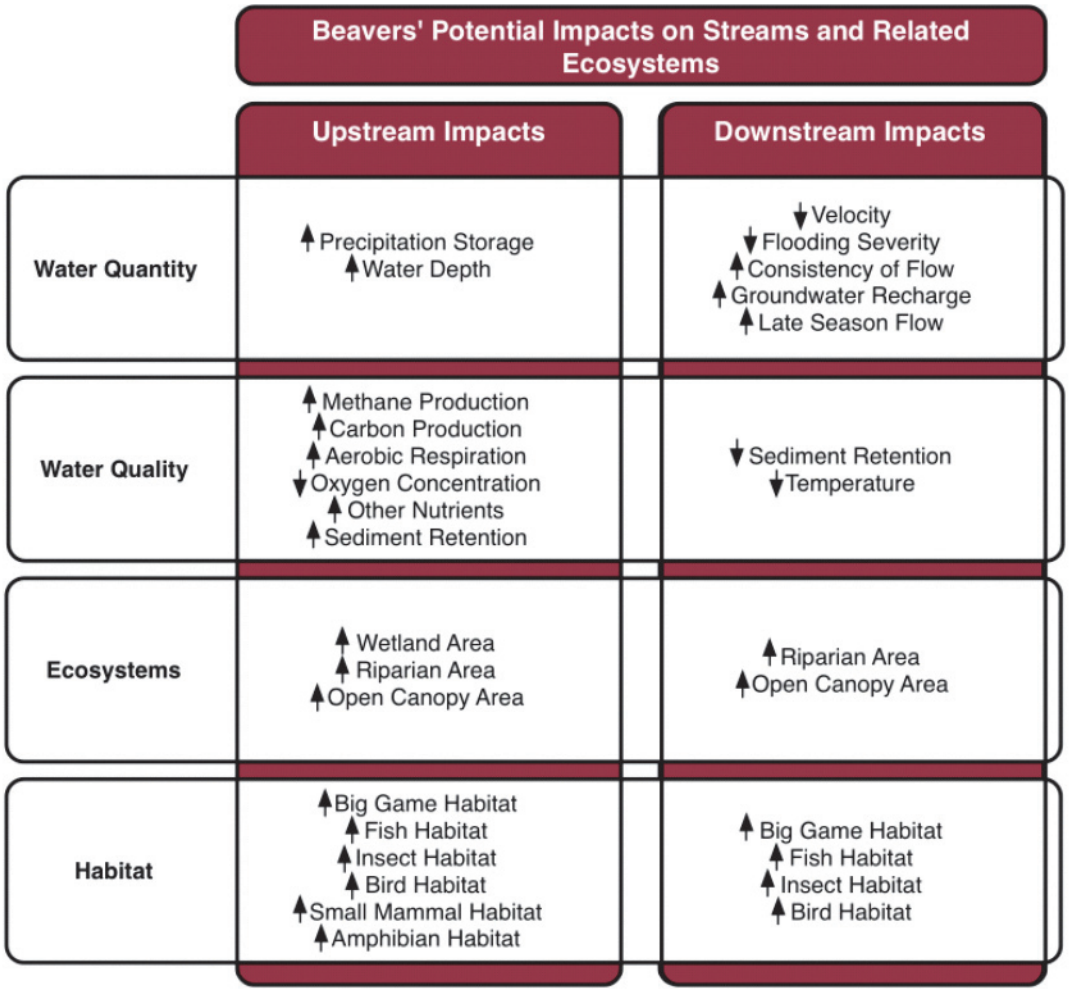

Figure 1. Ecosystem services impacted by beavers, from Buckley et al. (2011).

Note that the arrow direction indicates an increase (up) or reduction (down) in the impact of beavers. For instance, it is suggested that beavers mitigate the severity of downstream flooding.

2. METHODOLOGY

This study used surveys to seek evidence on impact costs and benefits being incurred by local landowners, including farms, estates, and tourism businesses. The study focuses on quantitative and qualitative evidence of damage and benefits, as well as seeking opinions of current and possible future impacts. While it provides an essentially *ex post* assessment (i.e. what has happened), it also looks forward, and the data gathered are used to determine cost scenarios for the Tay population in the future. There was no explicit questioning of education establishments on visits to beaver sites, although these issues will be discussed as appropriate.

2.1 Survey design and key respondents

The prime purpose of this study was to determine and quantify current beaver impacts in the area, and to this end a range of individuals and organisations were considered key to obtaining results. Surveys were designed to seek quantitative and qualitative information from key informants from specific groups. In addition, more general opinions were sought from other organisations. Three separate surveys (in addition to site visits and individual personal communications) were carried out, described separately below.

Survey 1: Land Managers
This survey targeted those engaged in land management in the catchment, whether for agricultural, sporting, forestry, or conservation purposes. This survey sought information on each respondent/property, details on any current impacts and costs/benefits from beavers already experienced, and asked about perceived future impacts and options for future beaver management. The full survey is shown in Appendix 1.

Since SRUC is actively delivering land management advice[2] through a consulting arm we used their database to identify land managers in the area. 270 paper questionnaires were distributed in January 2014 via this route, with an online version sent to Scottish Land and Estates (SLE) members (in March 2014). Seventy-seven paper questionnaires were returned after a period of 8 weeks (a response rate of 29 %). A further six questionnaires were completed online. In response to SLE e-mailing members, a further twenty eight online surveys were completed, resulting in a final response of 111 participants.

Survey 2: Tourism and recreation
Tourism is a vital part of the Scottish economy, and whilst it is hard to quantify for the Tay catchment (as catchment and other boundaries do not align), the tourism industry in Perthshire is considered to employ 9,271 people with a turnover of £354.25 million (Perthshire Tourism Partnership, ND). The main tourism businesses that may experience impacts from beaver in the Tay catchment are those associated with wildlife/ecotourism, and associated service providers (e.g. accommodation). The survey again asked respondents for current impacts and costs/benefits, as well as asking for some opinions on future impacts, as with the land managers survey (Appendix 2). General tourism businesses in Perthshire were emailed via the Explore Scotland website (http://www.highlandperthshire.com/). 588 businesses were emailed, 208 businesses opened/read the email. To target more wildlife-orientated businesses, Wild Scotland (the Scottish Wildlife and Adventure Tourism Association http://www.wild-scotland.org.uk/) emailed 115 of their members. A total of 31 individual businesses responded, an overall response rate of 4.4%.

[2] SAC consulting (an arm of SRUC) deliver services covering rural enterprise, from agronomy, livestock and dairy services to disease surveillance, farm animal diagnostics and environmental consultancy. Consultants, vets and specialists are stationed across Scotland http://www.sruc.ac.uk/info/20005/sac_consulting.

Survey 3. Key departmental, stakeholder and NGOs

Whilst the key part of this report is the impacts as perceived and quantified via the land managers and business surveys, it was also considered important to gather more general views from key organisations that have an interest in beavers in the Tay catchment. The organisations contacted are listed in Appendix 3, along with the online survey they were invited to complete. Note that some organisations completed online, whilst information from others was fed back via email/telephone conversations. There was also some overlap in completion of surveys, with some organisations responding as land managers to survey 1, as well as responding in a more general way to survey 3, where they both managed land in the area and had a wider interest in the issues.

3. RESULTS

We summarise the results and contrast these with the wider literature on impacts where relevant.

3.1 Land manager survey

Property overview

A total of 111 responses were received, showing the primary land uses on the properties surveyed to be crops (55) and livestock (48), with 3 indicating horticulture, 2 each of fishing and sport, 1 forestry and 1 conservation. Many respondents indicated that a mix of land uses occurred on their property. In total the properties surveyed cover 158,543 ha, with a mean property area of 1,428 ha. However, the data are skewed due to a few large estates being included (maximum area of 58,705 ha); the median property area was 300 ha. An estimated total of 1,405 km of streams/rivers were found in/adjacent to the surveyed properties, with a mean of 14,338 m and median of 2,750 m.

Respondents were asked if they had beavers on or adjacent to their land (Table 1), with 46% of properties reporting no beavers, and 17 % having definitely seen the animals.

Table 1 .Responses relating to beaver presence.

	No	**Maybe**	**Yes, seen signs**	**Yes, seen animals**
Count (%)	51 (46%)	15 (14%)	26 (23%)	19 (17%)

Properties reporting actual (or possible) beaver activity

Managers who had (or thought they may have) beavers on their land were asked what length of streams/rivers were impacted, resulting in a mean percentage impact of 45% (with a range of 0 to 100%, median of 30%). Given the novelty of beaver impacts in the area, some impacts may have been inaccurately attributed to beavers, or some impacts actually caused by beavers (e.g. crop damage) may not have been recognised as such. Managers were then asked for their general perception of impacts, from 0 (no impact) to 5 (high impact), shown in Figure 2.

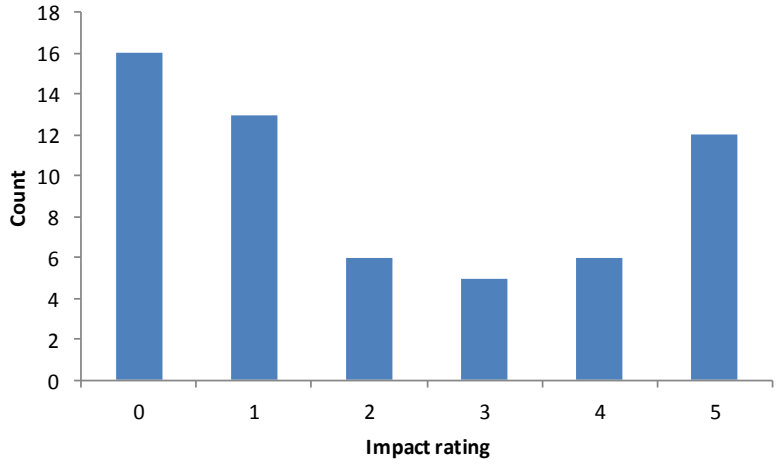

Figure 2. General impact rating (0 = none, 5 = very high) as perceived by managers with beavers present (or maybe present).

The distribution is bimodal, which is common with questions characterised by uncertainty. The most frequent category is no impact (0), with decreasing numbers to category 3, but then rising into categories 4 and 5. The mean impact score is 2.1. Campbell *et al.* (2007) asked the same question, with the same response categories, of beaver managers and researchers across Europe, therefore sampling from a population with a pre-existing interest in beavers. The mean score from that study was 1.5, which is closer to the mean from this study than might be expected, considering the different stakeholders involved in both studies.

Of the two main agricultural activities, livestock farms generally reported no or little impact, with few reporting high impacts (Figure 3). In contrast, whilst many crop-dominated properties also report little or no impact, there is also a sizable proportion that report very high impacts. This pattern of higher impacts on crop-dominated land will be discussed later.

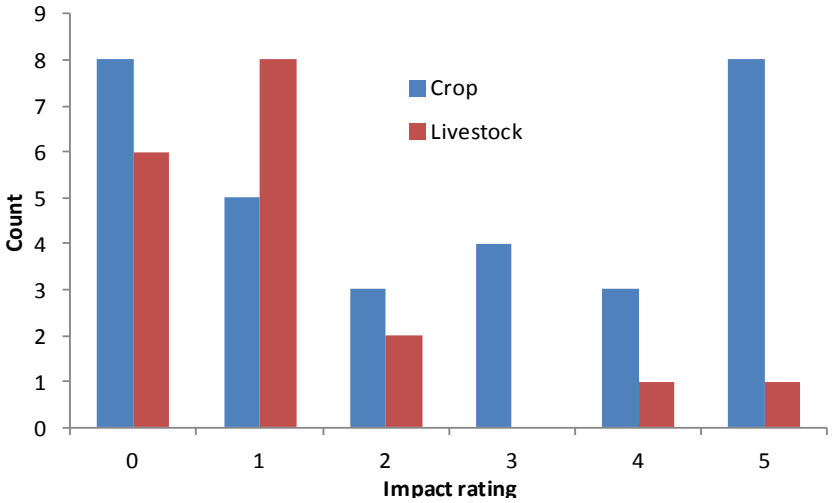

Figure 3. General beaver impact rating by the two dominant primary landuses: crops and livestock.

Respondents were asked to list all damage due to beaver they had seen (if any), and to rank in order of importance all the damage types they recorded. The main types of impact noted are shown in Table 2, where the equally important primary impacts selected are no damage, and damage to trees, closely followed by damage to banks, drains, culverts. Regardless of ranking (i.e. counting all respondents who selected that category) the top two damage categories are again impacts on banks/drains and trees. Flooding impacts are minor in comparison, indicating that damage has not (or perhaps not yet) reached the level of causing significant flooding events. These results highlight the same concerns as those from the Wyoming land manager survey (McKinstry and Anderson, 1999), which asked about beaver damage categories. The highest ranked impacts in that case were water control structures (25%), damage to trees (25%) and blocked drains (22%), with 11% indicating no damage. Comments from land managers relating to impacts and perceptions are summarised in Appendix 4.

Table 2. Number of respondents noting different damage types, in the first column the number selecting each type for the primary damage seen, and the second column showing the number that indicated that damage type, regardless of rank.

Damage type	No. listing as primary damage	Total no. selecting category
No damage	19	22
Damage to trees	19	41
Damage to banks, drains	15	49
Damage to crops	3	10
Flooded fields	1	9
Flooded trees	1	6
Flooded crops	1	4

Managers were asked in an open-ended question to state the costs of any damage they experienced, including remediation. Some managers reported only the qualitative description of damage with no costs included. Where contact information was supplied they were subsequently contacted to clarify their comments. Although 40 responses (Table 2) indicated beaver impacts, most impacts entailed no or negligible costs (e.g. '*two small trees damaged'*), and only 13 recorded notable costs. Respondents indicated that costs were incurred over the preceding year (and for high costs, it was the winter of 2012-13 where damage was incurred), therefore costs data are taken to cover one year.

Costs data ranged from a few hundred pounds to £10,000 to remove large felled trees from rivers, and/or repair damaged and breached flood protection banks. Other reasons for costs incurred were tree damage, crop damage, and removal of dams. The reasons for costs incurred are shown in Table 3. The proportion of respondents stating quantitative estimates is small so summary statistics need to be interpreted with caution, but the mean cost is £2,653, with a median of £1,000 indicating skewed data due to a few very high cost estimates. Appendix 6 gives an example of high impacts and costs incurred by one respondent, illustrating the actual impacts on flood defences and the costs of repairs for one location. Note that several respondents made more speculative comments suggesting '*large costs estimated if impacts continue or escalate'*.

Table 3. Damage described and costs incurred by respondents.

Damage reported	Cost incurred (£)
Diggers to repair banks and remove dams	300
Hire of JCB to remove dams	300
Unspecified	300
Damage to trees	450
Replacement trees	500
0.5 ha crop damage, drain blockage	640
Removal of dams (staff time)	1,000
Timber damage	1,000
Removal of felled trees	2,000
Flood banking repair (£2000); Tree replacement (£1000)	3,000
Repairing flood banks	5,000
Removal of large trees felled into watercourse	10,000
Unspecified (bank repair and tree damage)	10,000

These managers were then asked what benefits they perceived from beavers being present on their land. The majority (44 respondents) replied that there was no benefit (Table 4), with named benefits attracting little or no support (see Table 4: categories with no support were increased riparian vegetation; better fishing opportunities). These results differ slightly from

the Wyoming study (McKinstry & Anderson, 1999), which also showed that most land owners perceived no benefit (51%). However, between 10 and 20% of landowners in Wyoming perceived each of the following categories to be primary benefits: elevated water tables; riparian vegetation; increased stock watering; fishing opportunities; aesthetic qualities. This difference in results may be due to several factors, including different land-use types being impacted, or different management objectives. On the other hand it is possible that the benefits in the Tay catchment are too low to detect at present, or have not yet emerged in a perceptible way. The majority of respondents replied that they had no financial benefit from having beavesr present, but two indicated increased holiday lets (one estimating an extra £500 income over the year) and one respondent thought that beavers may become part of their nature tours in future.

Table 4. Number of respondents noting different benefit types, as primary benefit and total number noting each type.

Benefit type	No. listing as primary benefit	Total no. selecting category
No benefit	44	44
Flood prevention	2	15
Improved water quality	3	13
Increased wetlands	1	5
Aesthetic qualities	3	5

Possible future impacts and management options

This section included replies from all respondents, regardless of beaver presence. The main perceived future negative impacts are shown in Figure 4, where the primary concern is damage to river banks and flood protection, followed by damage to trees and blocked drains/flooded fields.

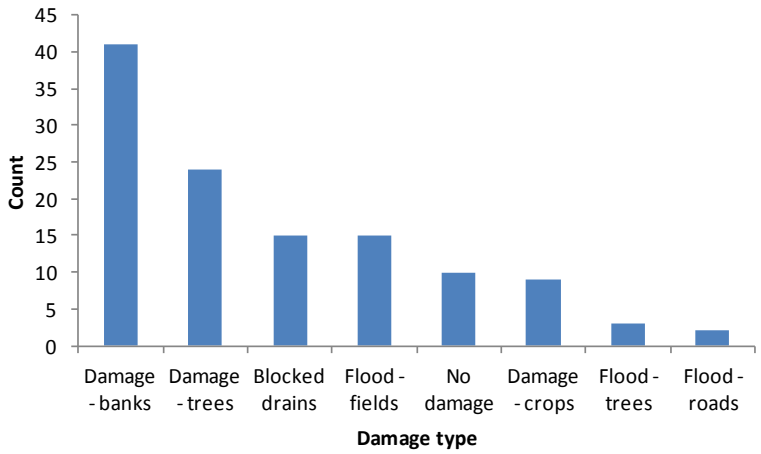

Figure 4. Possible future negative impacts (counts only of primary category recorded) as perceived by all respondents.

When asked about possible positive future impacts, the majority response indicated a perception of no benefit (Table 5). 76 respondents indicated that they primarily saw no benefits, with the next category (aesthetic qualities) being selected by 10 respondents. The total numbers selecting each category (i.e. discounting rank) show that these other categories do gain some recognition, but are simply not regarded as primary benefits.

Table 5. Possible future impacts from all respondents, listing primary choice and total selecting category.

Possible future benefit	No. listing as primary benefit	Total no. selecting category
No benefit	76	84
Aesthetic qualities	10	20
Increased wetland	4	10
Flood prevention	2	20
Improved water quality	2	16
Increased riparian veg	1	8
Improved fishing	1	4

All respondents were then asked about the general beaver management approach they would like to see adopted now in the Tay catchment. The questionnaire allowed respondents to select as many of the indicated options (listed on Figure 5) as they wished. As noted previously, few land managers saw any benefits to beaver being present, but Figure 5 shows that no single management approach is favoured above all others, with local control (i.e. local culling) and compensation getting the most votes, followed by eradication, and then 'confined to part of catchment'. 'Not sure – need more information' and complete tolerance attracted the fewest votes. Comments received on this question included calling for investigation / prosecution of those responsible for the releases.

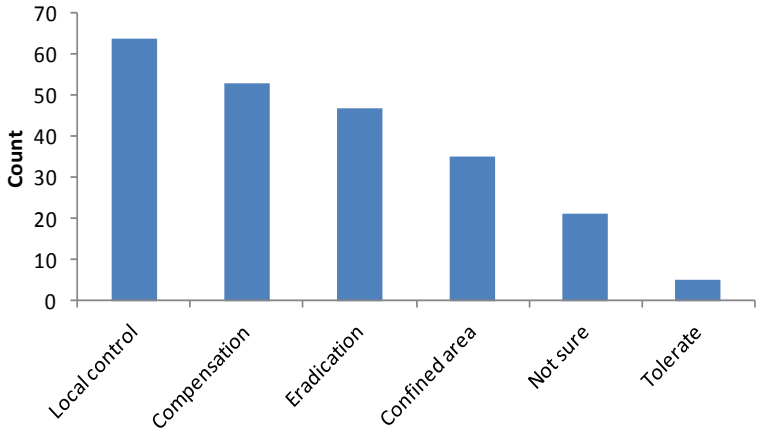

Figure 5. Votes for possible current management approaches to take towards current Tay beaver population.

Finally respondents were asked what management strategies/options they would like to see in place if the Tay beavers were to be allowed to stay. The range of options is shown in Figure 6, and these are the same options offered by Campbell *et al.* (2007) in their survey asking about options actually used in practice across Europe. Compensation for damage, dam removal and local control dominate the responses in this study (but note that even offering an option such as compensation may have biased respondent preferences). The results do indicate that land managers are open to different options for possible future management. In contrast Campbell *et al.* (2007) found the most popular techniques used were fencing (69%), removal of dams (54%), flow control devices (31%), translocation (31%) and culling (23%). It may be that the strategies that attracted fewest votes in the current study (flow control devices, anti-beaver tree paint, fencing) but which are actually used across Europe, attracted few votes because the managers are unfamiliar with how these options may work, how much they cost, and how effective they may be.

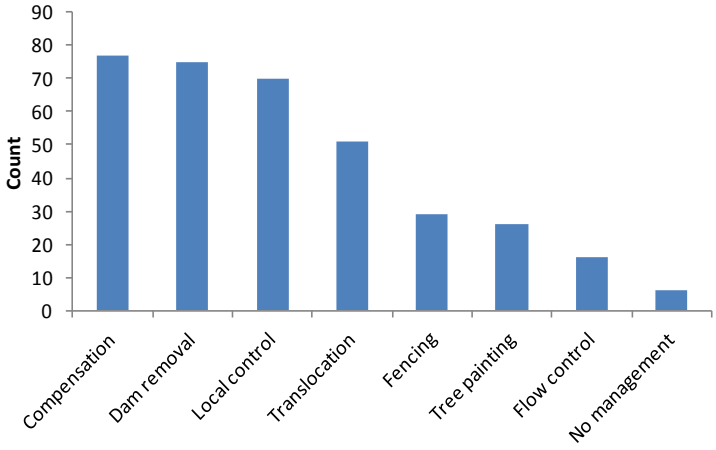

Figure 6. Preference for management strategies if beavers were to remain in the catchment.

In summary, the majority of land managers perceive little or no benefits from beaver presence, but they are aware of possible negative impacts, primarily damage to flood defences and trees. Very few land managers currently see beaver presence as a positive thing. The costs of negative impacts to date are not large overall (but can be important to individual businesses), though there is a widespread concern that further spread of beavers, particularly in the lowland arable areas, will cause large impacts and costs in the near future.

3.2 Business survey

As noted above, this survey was sent to a mix of wildlife tourism and general tourism (mostly accommodation) providers. The questionnaire was distributed online and a total of 31 were completed, though 3 were not used due to repetition and lack of information provided.

The annual turnover of each respondent is shown in Figure 7. Many businesses indicated a mix of business activities. In broad categories there were 19 tourism businesses, four forestry and consultancy, four tourism and farming, and one tourism and conservation. The tourism businesses included tour operators, accommodation providers, and visitor attractions. The businesses employed a mean of 3.89 full-time staff, 2.14 part-time staff, and one month per year of temporary staff. Only one response indicated that they were unaware of beavers in the Tay catchment before reading the survey information.

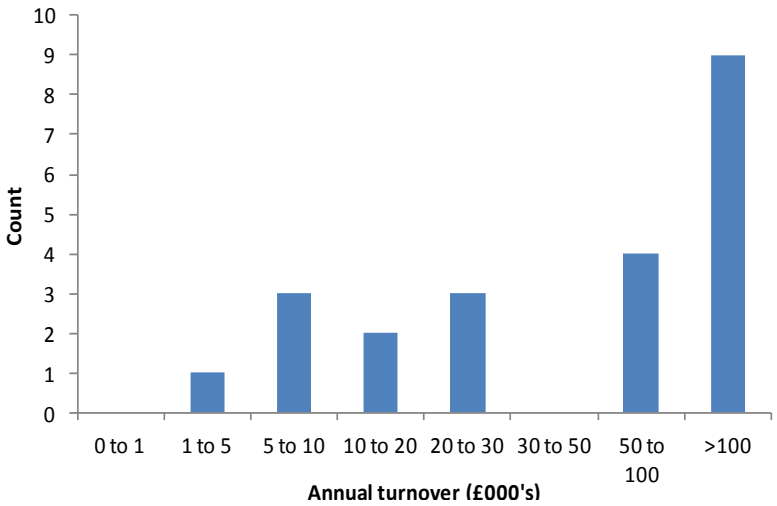

Figure 7. Number of business in each turnover category.

When asked if the presence of beavers has had an impact on their business, 17 answered no and 10 answered yes. Eight of the yes responses indicated that the beavers had a positive impact; e.g.

"positive, great to see the animals reclaiming their natural habitat. Excellent year-round tourism potential for the area"; "Great educational potential for outdoor learning opportunities and engaging with nature" and *"It has attracted people to stay in our holiday cottage".*

The businesses indicating positive impacts were accommodation providers (three), a conservation organisation, a visitor centre, and an outdoor activity provider. Five of those indicating positive impacts cited increased turnover amounts, with a total of £5,080 and a mean of £1,016 over the five businesses per annum. But two respondents indicated optimism for the future:

"we have not yet begun to "exploit" positive potential" and *"+£1000 this last year. But future prospects are even better"*.

The two respondents who noted negative impacts cited issues that relate to their land management activities (as farmers), in line with the land manager opinions described earlier.

When asked about possible future business impacts on number of employees if beavers were to remain in the catchment, most respondents (78%) did not think that they would increase the number of employees, 7% did not know, and the 15% that answered yes estimated a total of three additional full-time people may be employed. Activities that may support additional jobs are indicated by some of the information provided:

"*I take tours to see them and visit schools to give talks on them. Last year I took over 100 people to the river and spoke to over 700 local kids*", "*we run courses where people want to see evidence of beavers*", "*Many visitors come and stay because of wildlife. Even more of a reason to come to Highland Perthshire for a holiday*", and "*may bring people into the area who will be looking for my services as part of their stay*".

Respondents were then asked for their general views on beavers remaining in the Tay catchment, as well as their view on a possible wider reintroduction programme. The results are shown in Figure 8, with the majority of respondents thinking both options were either favourable or very favourable.

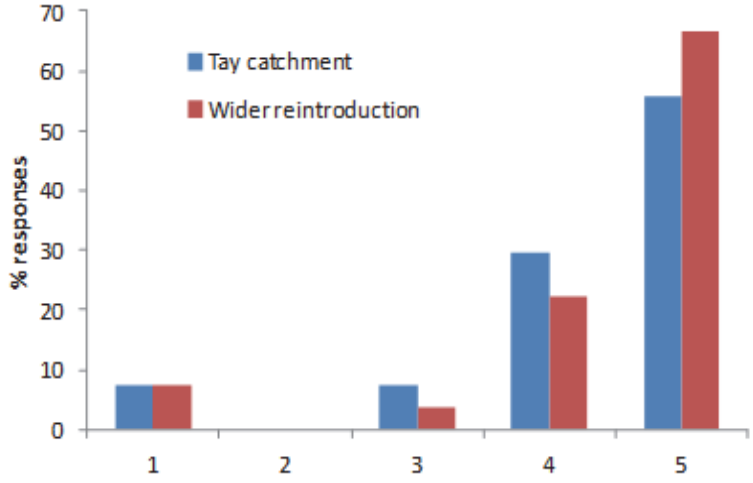

Figure 8. Views of 27 businesses towards beaver staying the Tay catchment, and towards a wider reintroduction programme.

Some of those in favour of beaver presence showed some awareness of negative impacts beyond their immediate area:

"*Except for farmers in the east of the catchment, I doubt if they are causing any business problems whatsoever. Some tourist businesses in Blairgowrie are certainly benefitting a lot*".

Likewise, some commented on the additional positive impacts that may arise, for example:

"*Apart from their value to ecotourism beavers have a contribution to make to both flood and drought mitigation as part of whole catchment management. They also purify water, which has positive economic impacts on the success of fish breeding and create habitat that benefits pollinators such as bees, which in turn benefit the business success of farmers and market gardeners* ".

In addition, it was noted that management would become a future issue if beavers were to remain in the catchment:

"*we feel generally very positive about their presence but recognise they will have to be managed pragmatically*".

The few negative opinions were backed up by comments such as:

"*This is idiocy and introducing a problem that we have not had before*", "*from reports I have read I believe beavers will have a negative impact on the delicate environment surrounding our river and river bank*" and "*I have seen the damage they cause in Canada, which is a vastly bigger country and at least has space for them*".

In conclusion, the business survey shows that most tourism businesses consider beaver impacts to be a positive thing, increasing the attraction of the area for visitors. There may be limited impacts to date, and limited scope for new businesses based on beavers in the catchment, but many businesses feel that there is scope for additional revenues, and in some cases extra jobs, in the area. This in turn will help achieve the increase in tourism revenue called for by the Scottish Government.

3.3 Organisation survey

The organisations surveyed are shown in Appendix 3, and include those representing land managers (NFUS, SLE, Confor), conservation bodies (SWT, JMT, SWBG), statutory agencies / land managers (SEPA, FC) and the tourism industry (Explore Scotland).

Organisations representing land managers were concerned about beavers in several distinct areas. Concern was expressed about the legality of the population in the Tay catchment, and the lack of action taken in this regard. Concern about current impacts focused on the high impacts found in certain areas, especially on flood defences and river banks, and consequent costs incurred by land managers. Costs of remediation were currently being borne by the land managers themselves. Finally, the magnitude of future impacts was thought potentially very large, with concern expressed about how such impacts may be addressed in the future if beavers are allowed to remain in the catchment.

The conservation organisations saw beaver presence as predominantly positive, for example:

"Increased use of the beavers by eco-tourism operators. Increased demand for guided walks, watches and other interpretation. Floodwater retention and sediment trapping by beaver dams. Increased biodiversity associated with beaver habitat."

But there is also a realisation that there would be negative impacts in places, such as:

"Beaver dams leading to small scale flooding of some agricultural and forestry land where in close proximity to water courses. Felling/gnawing of amenity/timber value trees in some areas. Blocking of culverts at some sites. Burrowing into flood banks at some sites. Feeding on arable/root crops in some areas in close proximity to water courses."

But opinion suggested these would be outweighed by the positive impacts. In addition, there was a realisation that management strategies are needed if beavers are to remain, particularly in the lower catchment area.

The Forestry Commission expressed some concern about impacts limiting operations, but also noted longer term positive effects:

"there could be issues with dams in inconvenient areas. These could impact on the economics of commercial timber harvesting for example, or on recreation facilities. Beavers are already having an impact on biodiversity, probably negative in the short term in some areas and positive in the longer term through the reintroduction of natural processes. This is likely to have a positive impact on the area, if marketed correctly, to encourage people to come and see the beaver impact and possibly see the animals."

SEPA noted that their position statement from 2007 still applies, recognising the potential benefits of beaver reintroduction, but also noting uncertainties particularly in catchment-level management, as well as asking that sufficient monitoring and control methods are in place to address significant impacts. In addition, the following was noted in relation to the Tayside beavers:

"SEPA have a representative on the Tayside Beaver Study Group (TBSG) and the Beaver Salmonid Working Group (BSWG). There have been a couple of requests to SEPA to install 'beaver deceiver' flow control devices on a trial basis to ameliorate the hydrological impacts of specific dams. SEPA's present position as regards beaver dam removal is that dam removal does not require a licence under CAR (The Water Environment (Controlled Activities) (Scotland) Regulations 2011) if machines are not required to operate within a watercourse (it would be considered to be analogous to the removal of trash). SEPA are considering whether the installation of beaver deceivers would require CAR authorisation going forward as there may be concerns about fish passage in certain situations. Ongoing trials and data gathering coordinated by BSWG and TBSG will provide further information on this topic."

BEAR Scotland have already been involved in some pre-emptive tree felling for road safety purposes, and they were keen to know

"what inspections and action is in place to ensure that no trees that could fall on or near the road, are being affected or compromised by the beavers".

The results of the organisation survey show opinions that may be expected given the remit of the various bodies. Many organisations saw both positive and negative impacts, but differed in how the importance of these ranked against each other. Some expressed a wish to know how issues should be handled now, and how they may be handled in the future, indicative of the current uncertainty felt by some respondents.

4. COST SCENARIOS

Beaver-related costs for the Tay catchment area are estimated in Section 4.1. These are the current estimated costs based upon the existing beaver population level. The longer term socio-economic impacts of the Tay beavers will depend partly on their future population and spatial distribution within the catchment. In Sections 4.2 and 4.3 we use current beaver population data, and scale this up to present a range of possible future costs. In Section 4.2, this is done using river occupation data, and in Section 4.3, we use beaver population density data. Results are summarised in Section 4.4.

The following cost estimates apply per annum.

4.1 Current costs

The sample of costs from land managers is just that – a sample from the population of Tay catchment managers – so some estimate of costs for the whole population of land managers in the Tay catchment is required. The simplest way to reach a catchment-level estimate of costs is to scale up the total cost from the survey area to the whole catchment. Ideally this would be done for the precise land areas impacted along all watercourses, but this is not possible with the data available. The responses to the land managers' survey covered a total of 158,543 ha, with total reported costs being £34,490 (the original breakdown of these costs is shown in Table 3). Assuming the same level of damage per hectare and applying this to a total land area (excluding urban and freshwater) of 572,867 ha in the catchment implies a cost of £124,623 per annum.

There are obvious assumptions that accompany such an estimate, primarily that the respondent sample represents the wider population. In reality all areas of the catchment are not equally exposed to damage: indeed the majority of respondents, and the current majority of beavers, are found in the lower arable areas of the catchment. Accordingly, it is important to adjust costs to account for the upper and lower catchment distinction.

To do this (based on costs per ha) the following steps were undertaken using ArcGIS 10:

1. Using the Land Cover Scotland 1988 dataset (which defines land use by broad categories), the catchment was divided into two broad areas (Figure 9): the lower catchment characterised by arable, improved, and other grasslands; and the upper catchment mainly defined by heathland, bog, montane, and woodland, with some arable and improved grassland in the glens. The total land area (excluding urban) was calculated for each area.
2. Land managers who supplied property contact/location details were plotted as a layer; and defined by location in either the upper or lower catchment.
3. The total area of these properties (with known location) was calculated for the lower and upper parts of the catchment separately, and a mean cost per ha for lower and upper catchment was separately calculated from those who also supplied cost estimates.
4. Known location data were used to estimate the split of reported area (158,543 ha) and costs (£34,490) between lower and upper catchments.
5. Estimated costs per ha are scaled up for each catchment area.

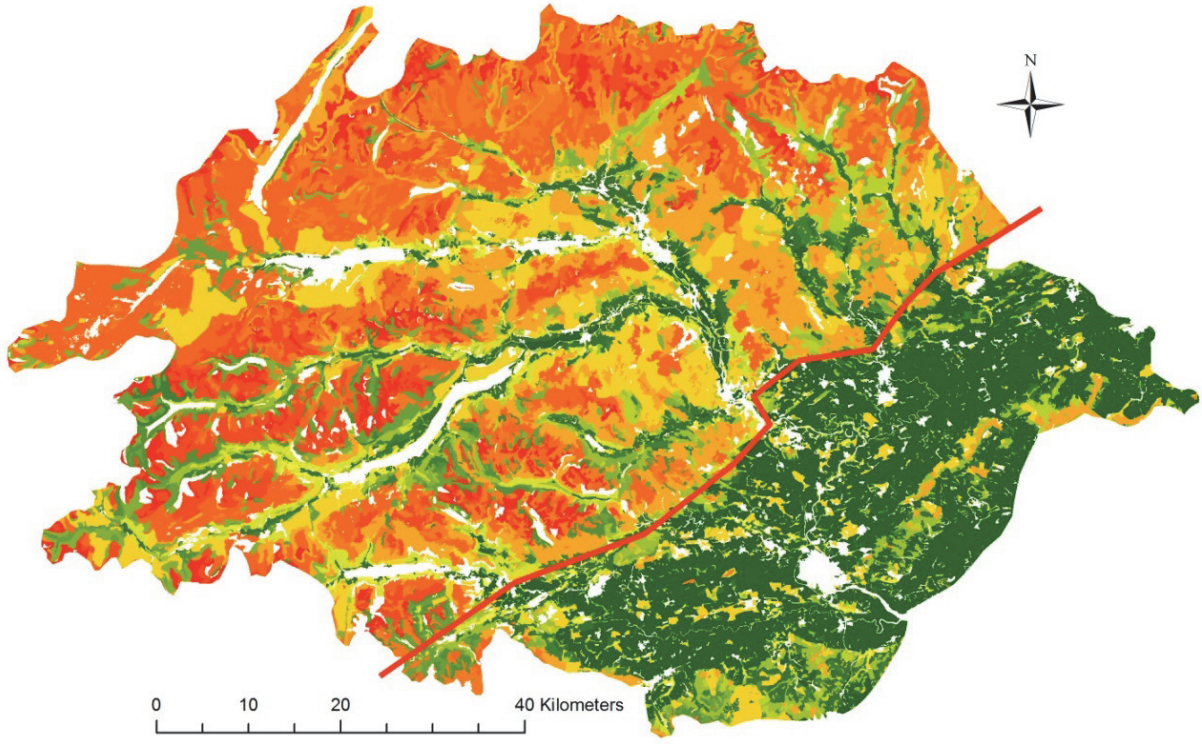

Figure 9. LCS88 data for the catchment, showing the broad division (red line) in land-use types between the upper catchment (heath, montane, bog, forestry, some arable in glens) and lower catchment (arable, improved grassland).

Table 6. Current cost estimate – split between lower and upper catchment

Stage in calculation	Lower	Upper	Total
Total land area reported on by land managers (known location)	18,837 ha	79,371 ha	98,208 ha
Total land area reported on by land managers (estimated split)	30,410 ha	128,133 ha	158,543 ha
Total reported costs (known location)	£16,390	£1,000	£17,390
Total reported costs (estimated split)	£32,507	£1,983	£34,490
Cost per ha	£1.07	£0.0155	N/A
Area of Tay catchment (excl urban, freshwater)	162,330 ha	410,537 ha	572,867 ha
Estimated whole catchment costs	**£173,500**	**£6,350**	**£179,900**

The results of this exercise are shown in Table 6. There is a clear division in the proportion of respondents in each area, probably reflecting not only the number of properties in each area, but also the higher level of interest/concern in the lower catchment area. Mean property size is much smaller in the lower catchment, reflecting smaller farms on the better lower ground, and larger farms/estates in the upper area on poorer quality ground. Arable farming is the most common land use in the lower area and livestock/estates in the upper area. Despite there being more properties included in the lowland area from the survey, there is a greater proportion of the total land area covered in the upper area (19.3% versus 11.6%). This is partly due to the inclusion of a single large estate in the upper area. The mean beaver impact cost per hectare of in the lower area is estimated to be £1.07, and £0.016 in the upper area. When these values are scaled by the total area of land, the total estimated costs for upper and lower areas are £6,350 and £173,500 respectively.

These estimates need to be used with caution, as there are several key assumptions, notably that the samples are representative of the wider populations about which inferences are made. For example, the cost per unit area of the land actually surveyed applies to the whole catchment (which will not be the case – beavers will not occupy the whole catchment). Likewise, it is assumed that all beaver impacts in sampled areas have been recognised, acted upon and costed. Judging from questionnaire responses not all costs are included, although only minor costs appear to have been excluded. Finally, as the above process relies on assigning samples to the upper or lower catchment, only samples with those data (72 from 111 responses) are known. This sample size is reduced even further when considering costs data, with only five such samples in the lower catchment and one in the upper.

Whilst these figures are speculative, we suggest that they do represent a reasonable approximation. The figures may be regarded as lower and upper limits of current costs being incurred. If we assume that the survey contacted most or all of those land managers currently incurring costs, then the true cost over the last year is near the actual survey result, i.e. £34,490. If, however, the current impacts extend across the catchment at the same intensity and incurring the same costs per unit area as in the sampled areas, then the true current cost will be close to the upper limit of £179,900 (per Table 6). We consider the true value of costs at present to be closer to the lower limit than the upper, as the survey was likely to have over-sampled impacted properties compared to non-impacted properties (land managers were passing the survey between them, and those with impacts may have been more likely to complete the survey). The results clearly contrast the two catchment areas. In the lower catchment, particularly in the flatter, drained arable land, the maintenance of flood defences is considered vital to the arable activities. Flood defences in this area can be vulnerable to beaver impacts and when impacts do occur, lost income and repair costs can be considerable. In contrast, whilst there are arable areas in the upper catchment that may be prone to the same impacts and costs, the area as a whole will be more susceptible to less intense impacts such as tree damage, and impounding of smaller streams.

4.2 Possible future costs – scaled up using river occupation data

In order to scale the current costs to investigate future impact scenarios, the river network can be used. The current costs are assigned to the length of rivers currently occupied to generate a cost per km of river, and then this can be used to scale up the costs to include unoccupied rivers.

Although the survey asked land managers for lengths of impacted streams/rivers, these data are not immediately comparable with available digitised river data, therefore the impacted length of river was calculated from physical survey data (Campbell *et al.* 2012). The river network data used as the basis for this exercise was the Strategi (OS, 2014) rivers dataset, which in the Tay catchment shows the network of main, secondary and minor rivers (Figure 10). Lochs are not included in this dataset as negative beaver impacts are more likely to be occur on rivers/streams (the exclusion of water bodies is why rivers appear discontinuous in Figure 10).

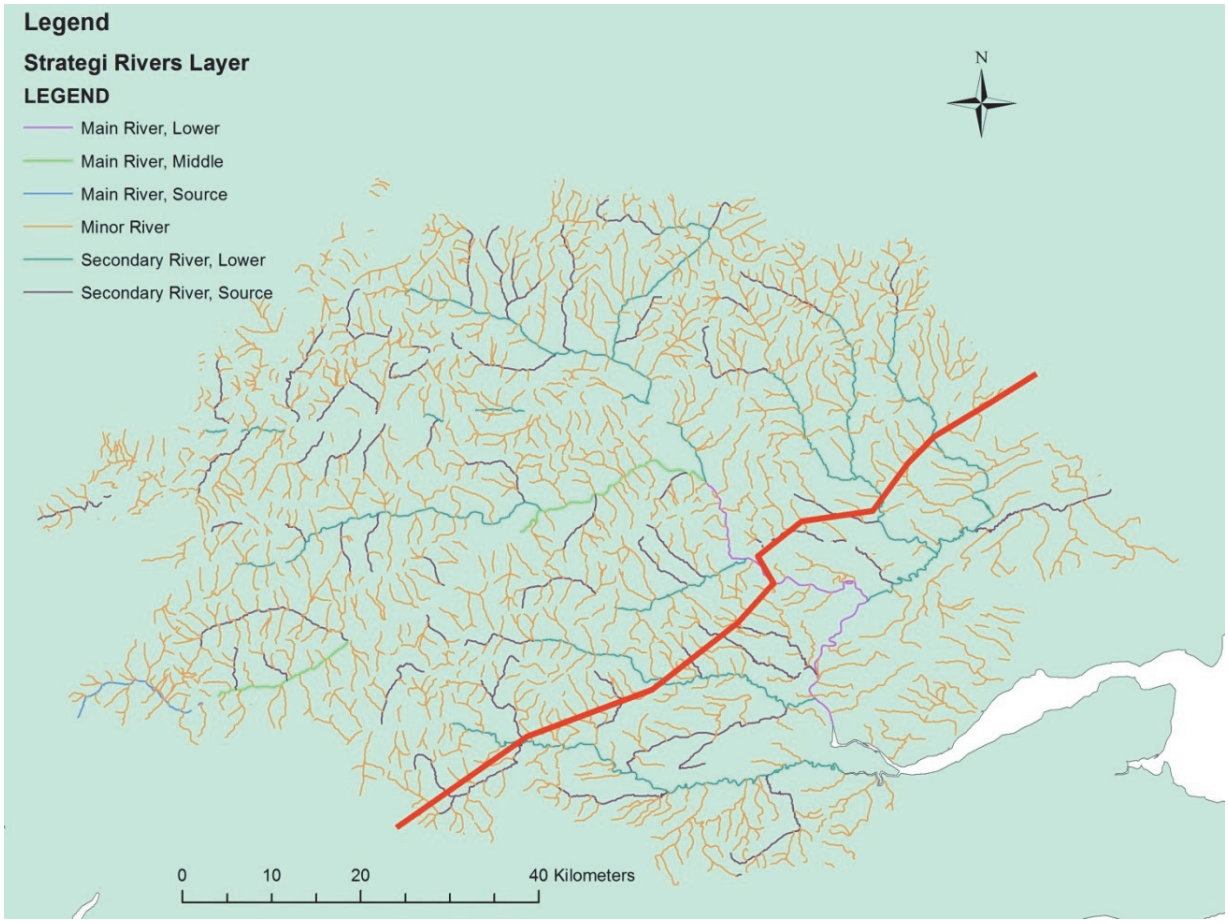

Figure 10. Rivers in catchment (from OS Strategi data) by classification. The division between lower and upper areas is also shown (red line).

Cross-referencing the river network against beaver signs recorded in Campbell *et al.* (2012) as well as additional information from the present study, revealed that the beavers are mainly along the main and secondary rivers, and not the minor rivers (Figure 11).

In order to scale current costs and predict a range of possible future costs, the following steps were followed:

1. The Strategi rivers dataset (main and secondary rivers only, Figure 11) was split into upper and lower catchment areas.
2. The total length of rivers in each catchment area was calculated.
3. The total occupied length of rivers (from Figure 12) was calculated.
4. The total low cost estimate is £34,490, but the location (upper or lower catchment) is only known for some of those costs, depending on whether the land managers submitted cost information (upper: £1,000; lower: £16,390). In order to apportion the total known costs between the upper and lower catchment areas, the ratio of costs with location (1,000:16,390) is used, resulting in 'apportioned costs'.
5. A cost per unit of river length is calculated separately for both catchment areas.
6. The resulting estimate of costs per unit river length can be used to calculate costs for different river occupancy scenarios.
7. Steps 4, 5 and 6 are repeated for the high cost estimate (£179,878).

Table 7 shows the length of river occupied by beavers in the Tay catchment by total area, estimated to be 247 km in total. This contrasts with the 112 km estimated to be occupied by

beavers in Tayside by Campbell *et al.* in 2012, and is explained by a possible spread of beavers (evidenced by land manager reports), but also in the current study, some lengths of river that separate what Campbell *et al.* 2012 identified as distinct beaver groups have been classified here as 'occupied' (on the assumption that beavers have moved along that river).

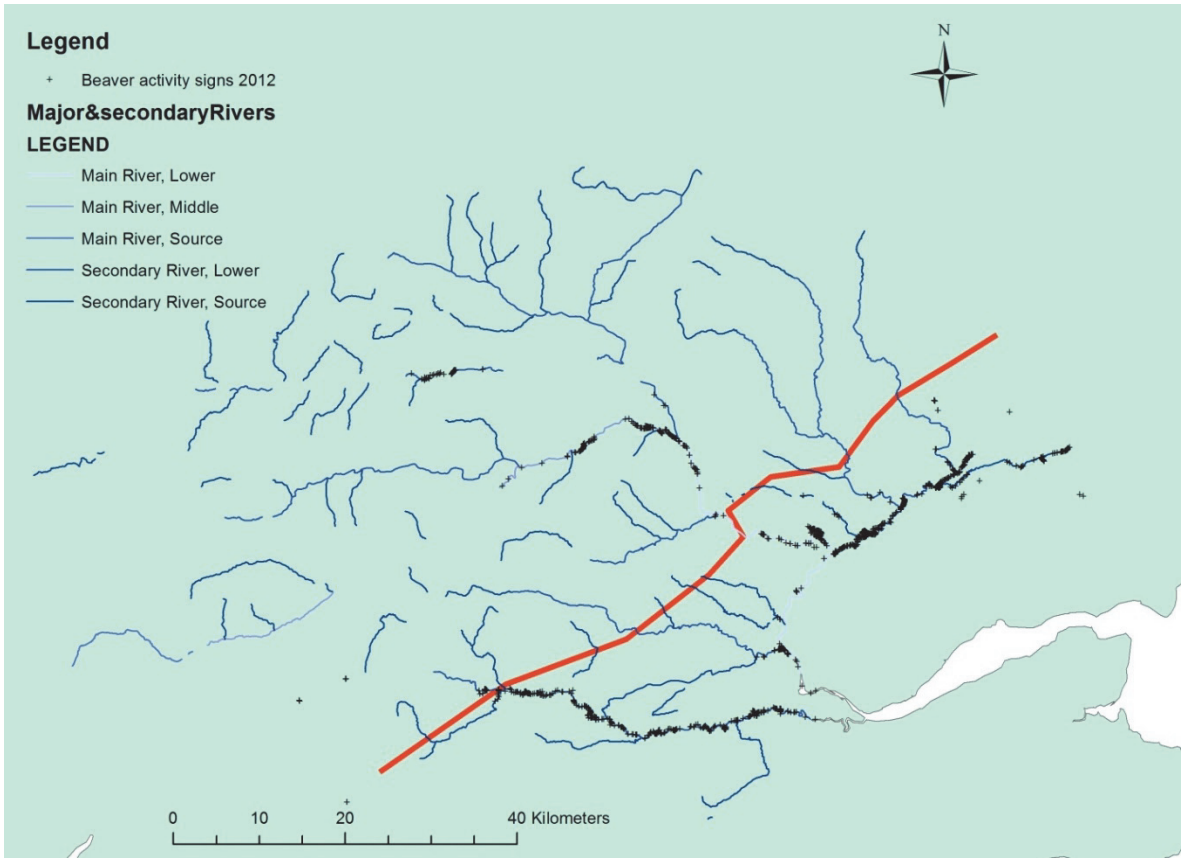

Figure 11. Beaver activity signs from SNH (2012) against the Strategi river dataset (main and secondary rivers only).

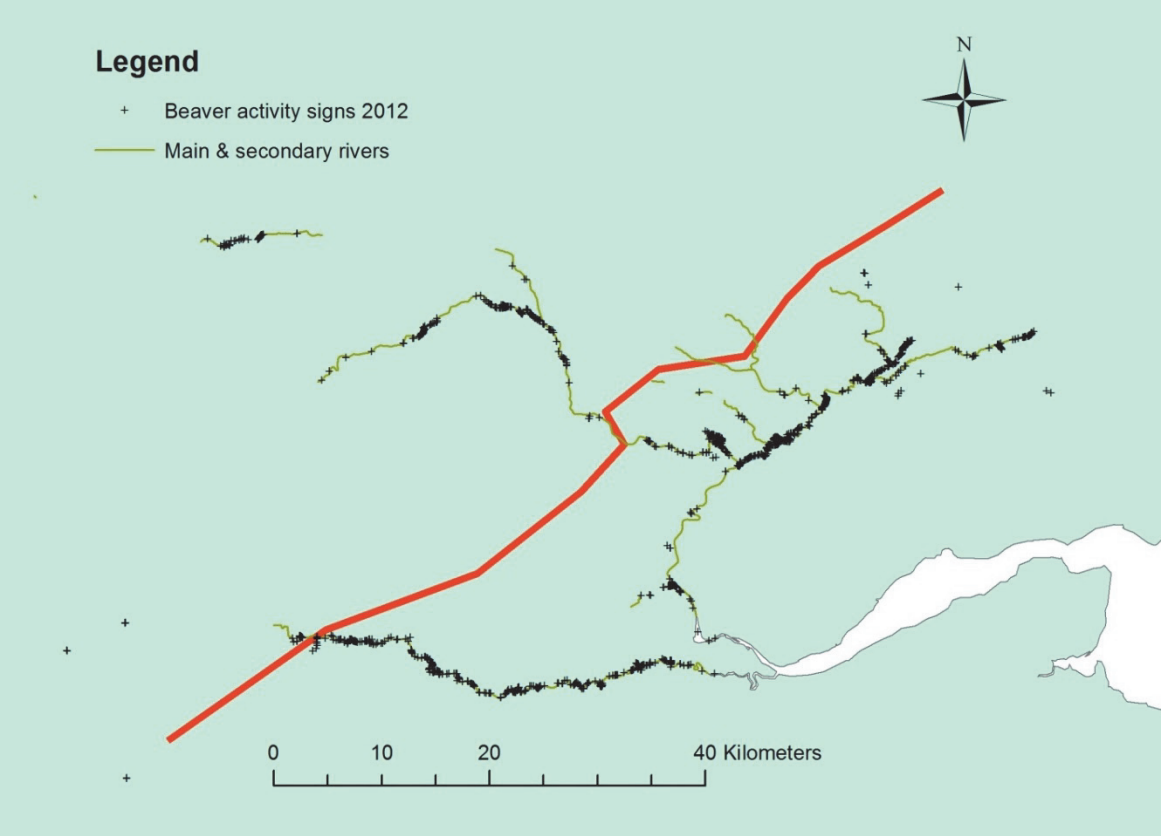

Figure 12. Beaver activity signs from SNH (2012) and the occupied parts of the Strategi river dataset (main and secondary rivers only). Reports from land managers of beaver activity are not shown on this diagram, but are used in identifying occupied rivers.

This scaling results in a 'low estimate' of costs as £57,500 in the lower catchment, and £18,300 in the upper catchment, and a 'high estimate' of costs as £306,900 and £58,700 in the lower and upper catchment areas respectively (Table 7).

Table 7. Future cost estimate using current beaver occupation data - main and secondary rivers only

Stage in calculation	Lower	Upper	Total
Length of currently occupied rivers	168,496 m	78,936 m	247,432 m
Low estimate of current costs (Table 6)	£32,507	£1,983	£34,490
High estimate of current costs (Table 6)	£173,500	£6,350	£179,900
Current cost per m – Low estimate	£0.19	£0.025	N/A
Current cost per m – High estimate	£1.03	£0.08	N/A
Length of rivers (including unoccupied)	297,975 m	729,397 m	1,027,372 m
Low estimate of possible future costs	**£57,500**	**£18,300**	**£75,800**
High estimate of possible future costs	**£306,900**	**£58,700**	**£365,600**

The same exercise can be followed but using all rivers from the Strategi dataset (Figure 10), resulting in much higher cost estimates due to the inclusion of the many minor rivers. Again, there is a considerable range between the low and high cost estimates (Table 8).

Table 8. Future cost estimate using current beaver occupation data - all rivers

Stage in calculation	Lower	Upper	Total
Length of currently occupied rivers	168,496 m	78,936 m	247,432 m
Low estimate of current costs (Table 6)	£32,507	£1,983	£34,490
High estimate of current costs (Table 6)	£173,500	£6,350	£179,900
Current cost per m – Low estimate	£0.19	£0.025	N/A
Current cost per m – High estimate	£1.03	£0.08	N/A
Length of rivers (including unoccupied)	1,063,165 m	3,392,354 m	4,455,519 m
Low estimate of possible future costs	**£205,100**	**£85,200**	**£290,300**
High estimate of possible future costs	**£1,094,900**	**£273,100**	**£1,368,000**

There is no clear way of saying what result is 'correct'. However, because as noted above the survey may have over-sampled impacted properties, the actual costs given the spread of beaver may be closer to the lower limit values. In addition, beaver will undoubtedly not occupy all the available rivers (the habitat is simply not suitable in all areas), therefore the upper limit values in Table 8 (full occupancy of all catchment rivers) are extremely unlikely, and are very much a 'worst-case scenario'. We therefore anticipate that costs, should beavers spread in the catchment, will increase, but to be closer to the lower limits, and scaled by proportion of rivers actually occupied. Modelling this in more detail requires knowledge of suitability of beaver habitat across the catchment, combined with cost data geographically attributed to habitats of different quality and land use type. SNH is currently revising its potential beaver habitat map for Scotland, and is working with the University of Newcastle to develop population model which should provide a more accurate means of predicting the potential colonisation of the catchment by beaver (Stringer *et al.*, in prep; Shirley *et al.*, in prep.).

4.3 Possible future costs – scaled up using population density data

Another method of scaling results is based on the beaver population estimates from Campbell *et al.* (2012). That study estimated a mean density of 0.145 beaver groups per km of occupied river in Tayside, which as they noted is a larger territory than that reported elsewhere. However, the Campbell *et al.* (2012) study predominantly found beavers in the lower catchment, and this value is assumed to apply to that area. Given the poorer quality and less suitable habitat in much of the upper catchment, a value of 0.0725 is used here, estimating a halving of beaver group density in the upper catchment.

Using these density values and whatever lengths of rivers are of interest, it is possible to calculate an estimated number of beaver groups, assuming beaver occupancy. This value can then be multiplied by the mean number of animals per group (3.8, estimated by Campbell *et al.* 2012), and then a total number of individuals present in hypothetical occupied rivers determined. This exercise is done for the upper and lower catchment areas, for main and secondary rivers only (Table 9), and separately for the full river dataset (Table 10)

The number of animals predicted under these scenarios can then be compared to the current population estimate in order to determine multipliers for beaver occupation for the different classes of river. The assumption is that the current population is causing the currently observed costs, and therefore the impacts attributable to any increases in population can be estimated by scaling the current impact costs accordingly. Given the known location of beavers, the current population has been approximately apportioned 150 in lower catchment area, 30 in upper catchment area.

The main assumptions for this calculation are that beavers can / will occupy the whole river length available, and that the current levels of impacts will proportionally apply to wider

beaver spread. With regards the first assumption, beavers will not occupy the whole river network for reasons indicated earlier. For the second assumption, we have taken the broad upper / lower catchment division into account here, but this will hide much variability in impacts in both areas. Despite these issues however, the relative costs between the upper and lower catchments are again considered indicative of the contrasts between the upper and lower catchments.

Table 9. Future cost estimate using current beaver population density data - main and secondary rivers only

Stage in calculation	Lower	Upper	Total
Low estimate of current costs (Table 6)	£32,507	£1,983	£34,490
High estimate of current costs (Table 6)	£173,500	£6,350	£179,900
Estimated current beaver population	150	30	180
Low estimate – current cost per beaver	£217	£66	N/A
High estimate - current cost per beaver	£1,157	£212	N/A
Length of rivers (including unoccupied)	298.0 km	729.4 km	1,027 km
Group density estimate	0.145 /km	0.0725 /km	N/A
Possible number of beaver groups	43	53	N/A
Possible number of beavers (3.8/group)	164	201	N/A
Low estimate of possible future costs	**£35,500**	**£13,300**	**£48,800**
High estimate of possible future costs	**£189,700**	**£42,600**	**£232,300**

Table 10. Future cost estimate using current beaver population density data – all rivers

Stage in calculation	Lower	Upper	Total
Low estimate of current costs (Table 6)	£32,507	£1,983	£34,490
High estimate of current costs (Table 6)	£173,500	£6,350	£179,900
Estimated current beaver population	150	30	180
Low estimate – current cost per beaver	£217	£66	N/A
High estimate - current cost per beaver	£1,157	£212	N/A
Length of rivers (including unoccupied)	1,063 km	3,392 km	4,456 km
Group density estimate	0.145 /km	0.0725 /km	N/A
Possible number of beaver groups	154	246	N/A
Possible number of beavers (3.8/group)	586	935	N/A
Low estimate of possible future costs	**£127,000**	**£61,800**	**£188,800**
High estimate of possible future costs	**£677,900**	**£198,000**	**£875,900**

Note that we have not conducted any sort of sensitivity analysis on these simple models. For example, it is possible to explore the effects of varying the group density estimate, or varying the number of animals per group, or keeping population numbers steady but increasing the cost estimate. There is also no account taken of the cumulative effect of impacts, resulting in impacts changing over time (which could either result in increased impacts through problems taking time to materialise, or may even result in reducing impacts where initial impacts are high and then impacts reduce with time). Such analysis is considered beyond the scope of this study, and may only be advisable once better data are available. In addition, such analysis should take into account the costs and benefits of mitigation and management options, which will undoubtedly reduce the overall impact of beavers.

4.4 Possible future costs – summary

The results of scaling current costs to cover the catchment are summarised in Table 11. As noted earlier, the true current costs are likely to be above the reported £34,490 due to not all

impacted land managers being included in the survey. However, the true costs are unlikely to be approaching the upper limits due to possible over-sampling of impacted properties.

Table 11. Summary of estimated current costs (all per annum)

	Lower catchment	Upper catchment	Total (Tay catchment)
Low estimate			34,490
High estimate			124,600
Low estimate – catchment divided (Table 7)	32,507	1,983	34,490
High estimate – catchment divided (Table 7)	173,500	6,350	179,900

Considering the results of the scaling exercises for possible future costs, we have a wide range of estimates. We show this in Figure 13 (which is a summary of Tables 7 and 9) and in Figure 14 (which is a summary of Tables 8 and 10).

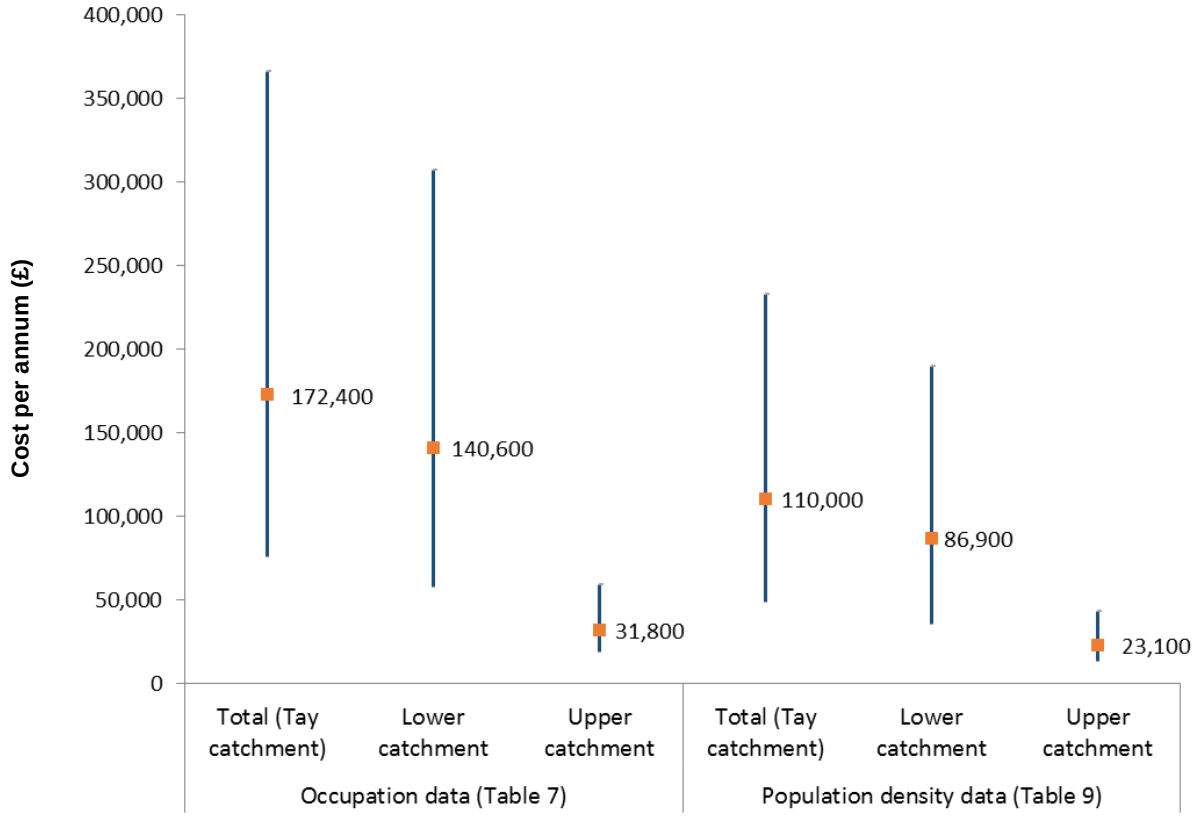

Figure 13. Range of cost estimates based upon beavers spreading to main and secondary rivers in the Tay catchment.

We first consider a scenario where beavers spread to the main and secondary rivers in the Tay catchment (Figure 13). Whether we use occupation data or population density data, likely costs in the lower catchment far exceed those in the higher catchment. However, predicted costs are higher if we base our predictions on occupation data (left side of Figure 13, based on calculations shown in Table 7) rather than population density data (right side of Figure 13, based on calculations shown in Table 9). As noted earlier, we cannot say which might be more accurate. However, we do consider that costs are likely to be closer to the lower limits than the upper, so Figure 13 shows points on each line that are 1/3 from the low

estimate to the high estimate. Selection of these values is illustrative only, as there is as yet no quantitative basis for such precise estimates of future costs.

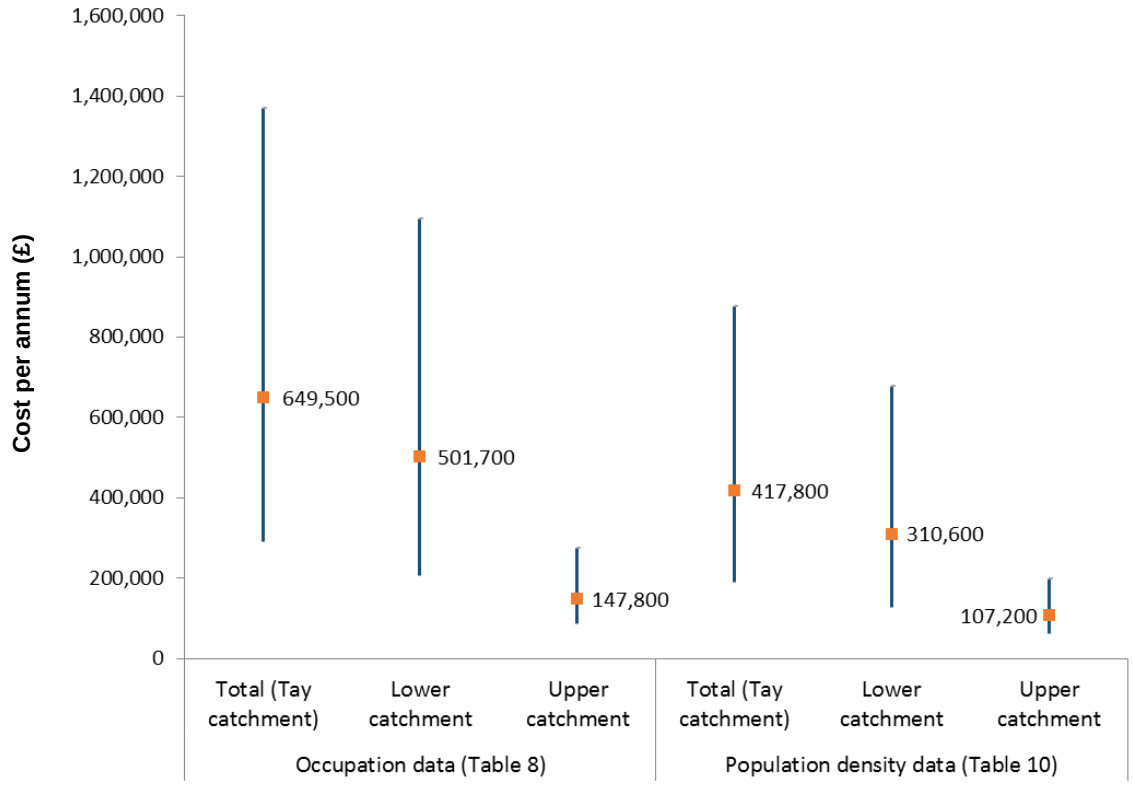

Figure 14. Range of cost estimates based upon beavers spreading to all (main, secondary and minor) rivers in the Tay catchment.

As expected, in a scenario where beavers spread to all rivers (i.e. including minor rivers) in the Tay catchment (Figure 14), cost estimates are much higher. The general patterns are similar to Figure 13: the lower catchment costs exceed those in the upper catchment, and if we base future estimates on occupation data (rather than population density data) we also see higher costs. For illustrative purposes, Figure 14 also shows points on each line that are 1/3 from the low estimate to the high estimate.

These results may be used as a broad guide: for example, controlling beavers in the lower catchment and restricting them to the upper catchment would immediately put the costs for the whole catchment onto the lowest estimated cost ranges. These figures also treat the catchment as only two areas, whereas costs (and benefits) will be variable on a much finer scale. Finally, these figures do not take into account any cumulative or future changes in intensity of impact and therefore costs, which could affect the estimates up or down. For example, it could be envisaged that it may take impacts over years to damage some infrastructure; impacts that may not be detectable until a sudden failure of the infrastructure concerned. Equally, there may be some high initial costs that then will not continue in the future; either because that cost cannot be incurred again (e.g. removing large felled trees – once removed they are gone), or because mitigation or management changes nullify the effects over time. These figures therefore could be refined to take such issues into account, but would require more detailed information on habitat suitability and impacts across the catchment than is currently available.

5. BENEFITS

5.1 Use value

In their current largely unsanctioned status the Tay beavers are not actually marketed in any systematic or strategic way, with land owners and businesses capitalising in a somewhat opportunistic way. In the absence of a sanctioned support, a charitable initiative, Scottish Wild Beavers, is mobilising local interest in beaver conservation and recreation. This is an informal group that apparently subsists on donations. In 2012 the group had 37 members, and since its foundation in 2011 has received £640 in membership fees, £1,594 in donations, and has fundraised £128.

A review of the organisation's activities suggests a variety of outreach (including education and media) contacts and activities that have a social value that might be included as benefits

The group provides some coordination for visitors and is reported to have given six to eight talks per year for the last 12 years. In 2013 they recorded 155 visitors to the Bamff beaver wetlands (made up of various groups and clubs). They suggest this is an underestimate, and with media coverage on the BBC, this figure could reasonably be expected to be higher in subsequent years. Further, the group also took 32 bookings at their holiday cottage (at least 80 people). There is no way of identifying whether this is additional activity. The group has also spoken to 700 school children. The group's website lists numerous articles and radio and TV programmes that could also have amplified the non-use value estimate (see below).

To develop an approximate benefit estimate we refer to the Knapdale beaver trial socio-economic impact study. We used the lower estimate from that report which derives a market benefit based on implied visitor expenditure of £54 per day (Moran & Lewis, 2014). The upper estimate was £79. Assuming approximately 300 visitors a year (based on 2013 records above) suggests that visits are generating some £16,200 of expenditures associated with these visits. Note that this is a lower bound market value, it does not assume to measure the actual willingness to pay of these visitors, which could be higher than their revealed expenditures.

Although additional to this value, we do not attempt to corroborate or value the reported school contacts, although this would be possible.

In terms of ecosystem service benefits (e.g. dam building, habitat creation, water quality improvements - as described in section 1.1 and shown in Figure 1), we have not attempted any monetary valuation. Land managers identified modest current and future benefits (Tables 4 and 5), and the value of beavers' activity is likely to be enjoyed by the wider population. F or instance, improvements in water quality might reduce water treatment costs, and hence prices for consumers. The extent of this benefit is unclear.

5.2 Non-use value (NUV)

In addition to what we might call the 'use values' associated with the beaver trial (as described in section 5.1), the trial also includes an element of value termed 'non-use value' (NUV). NUV is a significant value category relevant to the social impact of reintroducing a charismatic species, even if in a trial context. It is associated with the mere existence of a species irrespective of any type of direct or indirect use.

Research on NUV is not specific on how this value varies between a restricted presence of an attribute or animal (e.g. in the trial site) versus any wider presence of populations. Aside from this insensitivity to scale, NUVs are often contested since value aggregation needs to make assumptions about the populations holding these values or preferences. Aggregating

over large populations, including many people who may hold no demonstrable preferences for the species can lead to large aggregate value, which can overwhelm other benefit categories related to the reintroduction. Moreover, the juxtaposition of these wider benefits with more localised costs is often a consideration for those ultimately taking decisions when NUV is significant. Issues of fairness and equity may be particularly relevant in the context of NUVs.

As described in section 1.1, there is some evidence of willingness to pay (WTP) from previous studies, but no existing study is exactly applicable to trial conditions, and we have to be judicious in interpreting the existing evidence.

In Scotland, the most recent relevant evidence derives from a choice experiment as part of an SNH-funded PhD. This study is unpublished but indicated that Scottish participants would be willing to pay approximately £56 per household per year in a scenario of a reintroduction of beavers to over 50% of the national territory (i.e. something more significant than the extent of the trial). We have no basis for adjusting this value to fit preferences for the trial and we note that this value is less than that suggested by MacMillan *et al.* (2001), cited in section 1.1, which indicated that people in the Glen Affric and Strathspey areas were willing to pay £67 and £91 per household per annum respectively to include a beaver reintroduction alongside restoration of the Caledonian Pine Forest.

Given the difference in scale between the choice experiment scenarios and the Tay, it would seem reasonable to test this value in sensitivity analysis (Table 12). For example we might test values from £10 per household up to £56. Similarly we might also test the extent of value aggregation, i.e. the population deemed to hold preferences for reintroduction. At the upper limit this population could include all tax-paying households in Scotland (2,386,207) or the number of households in Perth & Kinross (65,122). Both figures could seriously inflate the benefits side of the evaluation. Obvious surrogate "behaviours" could include audiences for relevant TV programmes about the population or website hits. Alternatively the Facebook site of the Scottish Wild Beaver Group (Save the Free Beavers of the Tay) has 1,568 members, and the twitter feed has 456 followers.

Table 12. Non-use value estimates (WTP) multiplied by potential populations.

	2,386,207 (all Scottish households)	**65,122 (Perth & Kinross households)**
WTP value/hh/year	**Aggregate WTP (£)**	**Aggregate WTP (£)**
£10	23, 862,070	651,220
£30	71, 586,210	1,953,660
£56	133,627,592	3,646,832

6. FURTHER ISSUES TO CONSIDER WITH A WIDER RELEASE

A number of issues need be taken into account in the event of a wider release. Some of the impacts described in this report are specific to beavers, but others are 'natural' or already present impacts that beaver behaviour may alleviate or exacerbate. For example, flooding will occur regardless of beaver presence, so there will be damage costs associated with this impact whether beavers are present or not: the key issue is the change in flooding severity due to beaver behaviour.

The issue of compensation was significant to some respondents and funding such payments is clearly a consideration for management authorities. Payments could conceivably be part of the SRDP (Scottish Rural Development Programme) or a separate scheme, perhaps analogous to goose schemes. Whatever the source, it is worth noting that it is likely to be local contractors that will undertake major repairs, potentially benefitting the local economy.

There are a number of potential costs related to beaver management. These are considered below, and will be especially relevant if there is a wider release or control programme in Tayside:

Mitigation measures
If management options are put in place, these will incur costs. However, targeted use of appropriate measures to places where high impacts are evident or likely will still be considerably cheaper than repairing damage, for example to flood defences.

Inspections
If compensation is to be made to land managers for beaver damage, then it is assumed that this would be included in the current on-farm inspection process. This however would require a degree of investment in staff training, and more time required on farms with beaver impacts to inspect.

Monitoring
If it is decided that ongoing monitoring is required to map the spread and impacts of beavers, then this would require trained observers. The cost per the Campbell *et al.* (2012) study was approximately £19 per km of river, and to survey all the rivers shown in Figure 10 once every 5 years would cost £17,116 per year. This could be reduced by asking land managers to report presence/impacts, but some independent surveying would still be required (the lowest cost may be to combine this with SEPA monitoring of waterways).

Control of structures (e.g. dams)
As noted by Pillai *et al.* (2012), there is a grey area between the Habitats Directive protecting beavers, and the ability of a member state to effectively utilise derogations to allow management, and management strategies must be carefully considered and articulated. Removal of dams and lodges may require derogation, and this must be clearly and justifiably factored into any management strategy.

Control of animals
If it is decided that beavers should be controlled (killed or translocated) in those parts of the catchment where they can cause most damage (i.e. the lower catchment, especially in areas with flood defences), then the costs of that control must be determined. Again, this may require appropriate derogations as noted above.

Complete eradication of beavers will also involve the above issues, but will be much more costly. Perhaps the closest analogy we have in the UK is the removal of coypu from the Norfolk Broads in the 1980s (although the Hebrides mink eradication project may provide more up to date costings once completed). At the start of the coypu campaign in 1981, there

were an estimated 6,000 coypu (Baker, 2006), and it took until 1989 for the last coypu to be trapped and killed, despite assistance from land managers. There were 24 trappers employed in this scheme, resulting in an average of 216,000 trap nights per year (1 trap night = 1 trap set for one night). The methods used were refined throughout due to a dedicated research centre, and the funding was supplied from several bodies. The total cost of coypu eradication was estimated to be 5,000,000 €. The number of beavers in the Tay catchment is nowhere near the coypu numbers, but it would nonetheless require investment to carry out full removal. In addition, as noted by Baker (2006), such a scheme nowadays would most likely attract much more protest compared to the coypu scheme in the 1980s. Indeed, it may be that removal process would be made much more difficult if there were similar actions against the scheme as have been seen in the randomised badger culling trials in England.

Disease control

Whilst there is no indication of disease concerns in the Knapdale population (Goodman *et al.* 2012), the Tay population was not subject to the same pre-release studies, so the Tay population may require a degree of ongoing monitoring.

7. RECOMMENDATIONS FOR FUTURE DATA COLLECTION/ RESEARCH

This report and analysis highlights the available data on socio-economic impacts in the Tay catchment, but also reveals areas where further data collection and modelling would help refine both beaver population estimates and the subsequent estimates of costs and benefits. In particular, the following options are proposed for further studies:

- A mechanism for land managers and other businesses to report on impacts and costs / benefits incurred. This could be a website to upload evidence, observations, images etc. Importantly, business names/contact details and location data should be a requirement, in order to allow proper mapping and analysis, as well as verification if required.
- Part of this site should also allow statutory agencies (e.g. SEPA, FCS) and other bodies (e.g. SWT, NFUS) to record the impacts/costs/benefits that they may encounter.
- Habitat suitability mapping could be carried out for the catchment, to allow better prediction of beaver spread and established density (perhaps in conjunction with Vortex modelling for population analysis). Such detailed mapping would enable better modelling and extension of possible cost/benefit data as they are collected, particularly when combined with more detailed GIS mapping of land uses. SNH is currently revising its potential beaver habitat map for Scotland, and is working with the University of Newcastle in developing a new population model which should help provide this information (Stringer *et al.*, in prep; Shirley *et al.*, in prep.).
- An analysis of costs/benefits should be carried out on an annual basis, to further quantify ongoing impacts/changes in impacts in already occupied areas, to determine the spatial spread of beavers and their impacts, and to continually refine modelling and estimates for unoccupied areas.
- Further studies into the evolution of attitudes towards beavers may be beneficial, in particular to determine how future management methods may be considered and adopted by the range of stakeholders. This will help develop clearly articulated and agreed management policies.

8. CONCLUSIONS

From the survey evidence it is possible to say that that there is a modest appreciation of tangible or market benefit that is offsetting some appreciable location-specific costs, the latter being mostly endured by land managers and farmers. The modest benefits are not surprising. Given their current largely unsanctioned status, the Tay beavers are not actually being marketed in any systematic or strategic way to maximise the likely visitor and educational potential. Instead some landowners and businesses are capitalising in a largely opportunistic way and in many other cases may not recognise or have no means to register benefits. The current costs are not spread evenly across the catchment, with greater costs in the lower (arable) catchment area due primarily to impacts on flood defences and large trees.

In addition to the above market value, we have considered a more contentious element of non-use value (NUV) associated the very existence of a reintroduced charismatic mammal. Research on NUV is not specific on how this value varies between a restricted presence of an attribute or animal versus any wider presence of populations. Aside from this sensitivity to scale, the use of NUV is contested since value aggregation needs to make assumptions about the human populations holding these values or preferences. Aggregating over large populations, including many people who may hold no demonstrable preferences for the species can lead to large aggregate values that can overwhelm other benefit categories related to the reintroduction. Moreover the juxtaposition of these wider benefits but local costs is often a consideration for those ultimately taking decisions when NUV is significant.

The results of the scaling exercises for future costs emphasise the differing impacts on the lower and upper catchment areas. There are several assumptions made in this scaling exercise, and it is likely that actual future costs will be towards the lower end of the range of costs. These costs can be reduced by appropriate management and mitigation measures being put in place, preferably targeted at those areas where the high costs may occur.

In summary, there is the potential for high impacts and costs in certain parts of the catchment, primarily in the lower catchment; with impacts to flood defence infrastructure. The relatively small market benefits currently being realised have the potential to increase, and the non-use value may be considerable. Taking these estimates in aggregate and pending judgement on non-use value, the benefits of beaver tolerance are likely to outweigh the costs incurred, which can themselves be lowered by appropriate management and mitigation measures.

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APPENDIX 1: LAND MANAGER SURVEY

Copy of letter distributed with paper questionnaire

Dear Sir/Madam,

I am writing to ask for your help with a survey being conducted by SRUC, with the assistance of SAC Consulting.

You may be aware that beaver have been spreading through the catchment of the River Tay. The Scottish Government wishes to determine the possible positive and negative impacts of these animals to help guide their decision making process. SRUC has been contracted to carry out this survey to determine the current impacts as seen by landowners/managers (including costs / benefits).

You are being contacted through your link with SAC Consulting and your assistance in filling in and returning the attached questionnaire (or the online version at https://www.surveymonkey.com/s/bimpactsmanagers if that is more convenient) will help guide future policy. We are interested in the opinions and observations of those who have seen beaver impacts, as well as those who have not. It will be extremely helpful if we can map impacts, so the final part of the questionnaire asks for some further location and contact information. You do not have to complete this section but all data will be kept confidential and no individual/property or location will be identifiable in the results without the permission of the person concerned.

Your help with this survey is greatly appreciated and if you have any questions please do not hesitate to contact me.

Paper copy of questionnaire (online version consisted of same questions)

This survey is intended to identify possible positive and negative socio-economic impacts of beaver on the River Tay and adjacent waterways.

As a land manager/owner, you can assist us in quantifying these impacts by completing this questionnaire and returning it in the enclosed pre-paid envelope. All answers will remain confidential and no person or property will be identified, however there is an option at the end of the survey to leave contact details - we would like to ask more questions of those willing to assist further.

Many thanks for your time in completing this survey, and if you have any questions please do not hesitate to contact Dr. Alistair Hamilton at SRUC (alistair.hamilton@sruc.ac.uk).

Section 1 ABOUT YOU AND YOUR PROPERTY

1. What is the area of your property (in ha)?

2. What type of activity occurs on your property? (rank all that apply, with a rank of 1 assigned to the economically most important activity)

Ranking	
	Farming (livestock)
	Farming (crops)
	Forestry

	Fishing
	Sport (e.g. grouse, deer)
	Conservation management
	Horticulture
	Other (please specify)

3. Please estimate the approximate length (in m) of rivers/streams within or adjacent to your land boundary.

4. Do you have beavers on waterways on or adjacent to your land? (please tick one box)

	Yes, definitely seen them
	Yes, seen signs
	Not sure
	No

If you ticked 'not sure' or either of the 'yes' options, please continue on to section 2. If you answered 'no', please skip the section 2 and go directly to section 3 (Possible future impacts).

Section 2 CURRENT IMPACTS OF BEAVERS

5. In general terms, what level of conflict have you experienced with beavers (where 0 = none, 1 = very low, 5 = very high)? Please add any comments as required.

6. What length (in m) of rivers/streams on your land do you consider to be affected by beavers?

7. What type of negative impacts from beaver activity have you observed on your property? (rank all that apply, with 1 assigned to the impact you consider most important)

Ranking	
	No damage
	Damage to irrigation/drain systems (including damage to banks)
	Damage to trees
	Damage to crops
	Blocked drains/culverts
	Flooded pasture or crops
	Flooded forestry
	Flooded roads
	Other – please specify

8. If damage has been caused, please estimate any direct financial impacts (e.g. ha of crops/trees damaged, or costs involved in repairing any damage to drains, banking etc)? More detailed costs will allow us to estimate future impacts better.

9. What type of positive impacts from beaver activity have you observed on your property? (rank all that apply, with 1 the impact you consider most important)

Ranking	
	No benefits
	Flood prevention (though holding water back, slower flows)
	Improved water quality (sediment changes)
	Increase in flooded/wetland habitat
	Increase in riparian vegetation
	Fishing opportunities (better habitat)
	Aesthetic qualities (e.g. good to see beavers)
	Other – please specify

10. Have you experienced any additional income arising from beaver activity on your land?

Section 3 POSSIBLE FUTURE IMPACTS OF BEAVERS

The experience in many countries is that beavers can have both positive and negative impacts.

If you currently do not have beaver on your land, we are interested in what you perceive to be the possible future positive and negative impacts if beaver were to occupy waterways on/adjacent to your land.

If you currently do (or think you do) have beaver on your land, we are interested in what you perceive to be the possible future positive and negative impacts if beaver were to continue occupying waterways on/adjacent to your land.

11. Considering the land uses on your property, please rank the following possible negative impacts in terms of their likely economic impact (with 1 being the most important).

Ranking	
	No damage
	Damage to irrigation/drain systems (including damage to banks)
	Damage to trees
	Damage to crops
	Blocked drains/culverts
	Flooded pasture or crops
	Flooded forestry
	Flooded roads
	Other – please specify

12. Which of the following possible positive impacts may apply on your land? (please rank, with 1 being the most important)

Ranking	
	No benefits
	Flood prevention (though holding water back, slower flows)
	Improved water quality (sediment changes)
	Increase in flooded/wetland habitat
	Increase in riparian vegetation
	Fishing opportunities (better habitat)
	Aesthetic qualities (e.g. good to see beavers)

	Other – please specify

13. What general policy approach would you like to see adopted towards beavers on the Tay catchment? (tick all you consider appropriate)

	Complete tolerance
	Compensation for damage and/or repairs
	Confined to certain parts of the catchment (e.g. where impacts are minimal)
	Ability to control numbers where necessary
	Eradication from catchment
	Not sure at this stage – would need more information
	Other – please specify

14. Several management options may be available in the future if beaver remain in the catchment. Please tick all that you think may be appropriate given the land uses on your property.

	No management necessary
	Compensation for damage and/or repairs
	Removal of dams where appropriate
	Removal (translocation) of problem animals
	Installation of flow control devices (to prevent excessive flooding)
	Fencing (usually culverts/drains, to prevent dam construction)
	Painting trees with anti-beaver coating
	Localised culling
	Other – please specify

15. Please add any further information you feel may be relevant to quantifying the positive and negative impacts of beaver in the Tay catchment.

16. If you are willing to possibly help with some follow-up questions, and/or receive a summary of the final report by email, please leave your name and email address/telephone number.

Many thanks for your time and help with this survey.
Dr. Alistair Hamilton
SRUC
Edinburgh

APPENDIX 2: BUSINESS SURVEY

Impacts of beavers on the Tay catchment

As you may be aware, beavers are now spreading on waterways in the Tay catchment. SRUC has been commissioned to determine the current and potential future impacts of beaver, and this survey of businesses in the area is part of that study.

We would be very grateful if you could take the time to complete the survey - even if you think beavers have/will have no impact on your business, as all views are important.

All responses will be treated in strict confidence. For further information contact Alistair Hamilton (SRUC) alistair.hamilton@sruc.ac.uk 07981 225717

About your business

***1. Please state the nature of your business, in general terms.**

2. Please state the name of your business, and location (answering this question is optional, but this will help us interpret the overall results, and anwsers will remain confidential).

3. How many employees including yourself are employed in your business?

Full time	
Part time	
Temporary (please indicate how many months)	

4. To the nearest £1000, what is your annual sales volume (turn over)?

- [ ] A less than £1000
- [ ] B. £1001 - £5000
- [ ] C. £5001 - £10,000
- [ ] D. £10,001 - £20,000
- [ ] E. £20,001 - £30,000
- [ ] F. £30,001 -£50,000
- [ ] G. 50,001 - £100,000
- [ ] H. Above £ 100,000

Beaver socio-economic impacts - current

5. Before reading this survey, were you aware that beaver were spreading in the Tay catchment?

- ◯ Yes
- ◯ No

6. Has the presence of beavers on the Tay had any discernible impact on your business activity?

- ◯ Yes
- ◯ No

If you answered yes, please describe briefly

7. To the nearest £1000 can you estimate whether the presence of beaver on the Tay has increased or decreased your turnover (please indicate £ +/ - per annum)

Beaver socio-economic impacts - possible future impacts

In answering the following questions, please make the assumption that beavers will be permitted to remain in the Tay catchment, and may also continue to spread.

8. In very general terms, describe how you think beaver presence may affect your business either positively or negatively.

9. In response to beaver remaining in the Tay catchment and possibly impacting on your business, do you think you may need to increase the number of employees?

- ◯ Yes
- ◯ No
- ◯ Don't know

If yes, how many additional employees?

10. Looking beyond your business, on a scale of 1 to 5 (1 being very unfavourable , 3 being neutral and 5 being very favourable) how positively do you view continued beaver presence in terms of its potential economic contribution to the region ?

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5

11. On a scale of 1 to 5 (1 being very unfavourable , 3 being neutral and 5 being very favourable), how favourable are you in regards to a wider re introduction of beavers in Scotland?

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5

Final comments

12. Please provide us with any other relevant observations on the presence of beavers in the Tay catchment.

13. If you would like to receive a summary of the results via email, and perhaps answer some follow-up questions, please leave your email address below.

APPENDIX 3: STATUTORY AGENCY/NGO/STAKEHOLDER ORGANISATION SURVEY

List of organisations that responded to survey

Confor (incomplete survey)
BEAR Scotland
Explore Scotland Ltd
Forestry Commission Scotland
John Muir Trust
National Farmers Union Scotland (telecom only so far)
Scottish Land and Estates (telecom/email)
Scottish Wildlife Trust
Scottish Wild Beaver Group
SEPA (telecom only so far)
Tay District Salmon Fisheries Board (telecom only so far)

Aims of survey

This short survey is part of a study intended to identify positive and negative socio-economic impacts of beaver on the River Tay and adjacent waterways. This survey will add to more detailed information collected from land managers and tourism businesses in the Tay catchment area.

As an organisation with a possible interest in this topic, you can assist us in identifying what you regard as relevent impacts by completing this questionnaire. The two main questions in this survey ask for broad opinions on positive and negative impacts, but if you feel it more appropriate to answer via email/attachment, please use the contact details below. All answers will remain confidential, however it may be useful for us to report comments/opinions - you will be contacted for permission if we wish to do this.

Many thanks for your time in completing this survey, and if you have any questions please do not hesitate to contact Dr. Alistair Hamilton at SRUC (alistair.hamilton@sruc.ac.uk, tel 07981225717).

1. Please state the name of your organisation, and a name/contact details if we wish to clarify any comments.

2. Are you aware of any negative socio-economic impacts on your area of interest or members arising from beaver presence in the Tay catchment. Please supply details and quantify if possible.

3. Are you aware of any positive socio-economic impacts on your area of interest or members arising from beaver presence in the Tay catchment. Please supply details and quantify if possible.

4. Are there any impacts (positive or negative) that have not yet been seen as far as you are aware, but you feel could be a future impact?

5. Please add in any other comments or observations in relation to impacts of beavers in the Tay catchment that you feel are relevant.

Thank you for taking the time to complete this survey.

APPENDIX 4: SUMMARY OF COMMENTS FROM LAND MANAGERS

The following comments are compiled from all land manager replies, and comprise general comments made when asked about possible impacts, and also when asked 'Please add any further information you feel may be relevant to quantifying the positive and negative impacts of beaver in the Tay catchment." Note that these are comments from 111 responses: most respondents left no additional comments.

Comments from those respondents that indicated they had experienced financial losses/gains.

1. There is erosion of the banks in places every winter and I think it is just something that you have to accept can happen when the river is in spate but I do worry that if more lodges are built in the bankings it will increase the chances of this happening.
2. I have seen no increase in riparian vegetation in the 4 years since first seeing beavers. All the small trees are felled and they are now bringing down ones 2 ft in diameter with little sign of regeneration anywhere.
3. An odd one or two may be a curiosity, but an explosion of beaver numbers would be a serious pest.
4. In the last 3-4 years there has been a huge increase in damage caused by beaver activity.
5. They are not welcome.
6. Cannot see any positive.
7. Coypu were a problem in E. Anglia. Beavers are similar but they fell trees and dam watercourses as well, so they need controlled now.
8. This is an arable area where flood banks and drainage is paramount. There is not enough woodland next to the waterways to support beaver in the long term.
9. Destruction of natural beauty of riverside. The riverside now looks a mess with trees felled into river and away from river and no sign of natural regeneration. The beavers have destroyed the area along the banking of our river bank with no discernible gain to the beavers.
10. The presence of beavers has attracted people to our holiday cottage which has flourished in recent years. Beavers bring huge benefits many of which are invisible but nevertheless of financial value, as ecosystem services. They are therefore worth the cost of management where it is needed.
11. If contained there could be tourism benefits.

Comments from those respondents that indicated they had not incurred costs from impacts.

1. I suspect that overall beavers will have a negative impact on agricultural operations, but that is based on instinct rather than an informed opinion.
2. Dams will be built in inaccessible areas of tributaries damming back water and drains on good arable land.
3. Many of the perceived advantages (e.g. flood prevention) are clearly counter-productive once you are on the flood plain, where you need the water to get away as quickly as possible. The idea of compensation is all very well, but how do you prove a bank burst is due to beaver damage? The cost of dealing with claims is likely to be high.
4. I really don't know enough about their impact on my 600m of waterways until they actually arrive.

5. Having viewed the damage on neighbouring properties I cannot see any advantages of having beaver on the Tay.
6. I have seen the damage beavers can do in N. America and they are treated like vermin there. That's how they should be treated here.
7. These animals should not have been introduced into the Tay catchment.
8. I see only negative impacts. These animals were removed before because of damage.
9. Digging in banks.....is a serious problem. Silt from tunnelling and digging could be a major problem.
10. The Tay catchment needs drainage to work properly, any restrictions on water flow will impact land use and cause flooding to houses and some villages.
11. Big cost if flood banks burst and flood whole farm with arable crop in.
12. Benefits listed – none of this will happen.
13. The arable areas of lowland Perthshire have been kept arable by 300 years of agricultural activity. Drainage…vital and beavers would not help
14. I suspect that overall beavers will have a negative impact on agricultural operations, but that is based on instinct rather than an informed opinion.
15. Nobody wants to have drainage problems created on their properties, and in the event of a decision not to eradicate beavers, land owners and managers should be permitted to control beavers if they do not wish to have them on their land.
16. Compensation, eradication etc? While on holiday in wilderness Alaska we were advised not to drink any water from rivers and streams because of a disease the beavers carried/caused/spread (Weil's disease?)
17. Our section of the river straddles rapids, the river here is to strong for beavers to establish although they would be welcome. We have several km of double bank, here is where we could see the greatest benefit if beavers were to establish themselves. we have embarked on native plantings to help lock up the volume of run -off into the Tay system, extensive riparian planting and beavers would assist with settling out the sediments that would otherwise transfer down the river and loch.
18. We need to understand all potential impacts before the Tayside beaver release is legitimised. The precautionary principle should apply.
19. Beavers in the right place may have many positive attributes but the Carse of Gowrie is not suitable as the potential damage is out of all proportion to any benefit.
20. Beaver numbers have increase from 5(?) in 2007(?) to 140 in 2012 (SNH figs) They are plainly successful colonisers. Impacts are currently small but are inevitably going to increase. The active control measures set out above are unlikely to be workable (except those ticked). They are good to have in the countryside, but we must have the ability to control (without bureaucratic interference) them when damage is being caused.
21. One of the largest and most expensive problems will be when the levies are damaged beyond repair on the River Isla thereby flooding huge tracks of Grade 1 and 2 agricultural land.
22. Populations will continue to increase and spread until limited by food supply when they will become a major problem to farmers. Their 'benefits' have been much exaggerated and apply only to very small water courses in areas with little management. They have only negative impact on salmonoids producing silt and blocking streams.

APPENDIX 5: SUMMARY OF COMMENTS FROM BUSINESSES

The following are additional comments submitted with the business surveys, in response to the question “In very general terms, describe how you think beaver presence may affect your business either positively or negatively.”

1. Overall the affect will probably be very positive as we can see serious tourism potential in their presence, but we fell we cannot promote or exploit this yet, until the political/ legal situation surrounding them is clarified.
2. Positive as may bring people into the area who will be looking for my services as part of their stay.
3. A properly established beaver presence in the ecosystem may well improve run-off and water course management, reducing flood frequency and therefore the number of times we can't get to meetings/flights etc due to flooding.
4. Positively but not hugely. Good to see the return of a native species that by and large is a positive contributor to the environment.
5. Positively simply because it sounds ecologically beneficial and the 'green tourist' is important
6. It won’t.
7. I expect it to continue to provide an attraction for our small holiday business, and it is one of the factors that may encourage us to expand our tourism activities in future.
8. More tourism would certainly be welcomed, can’t think of a negative impact.
9. Positively because I expect to see an increase in species diversity, better juvenile habitat for fish and many of my customers are also naturalists who would be thrilled to see a beaver.
10. People like beavers - people come and stay to see beavers.
11. Negatively. I have seen the damage they cause in Canada which is a vastly bigger country and has at least space for them.
12. Positive, visitors ask about the, I have a lot of wildlife/walkers.
13. Apart from an initial curiosity value it will be extremely negative.
14. May bring in people to look at them.
15. Beavers moving into our river area will affect our business negatively- on economic & physical grounds.
16. Positive in that wildlife encourages tourists.
17. They were a native element of our wildlife until killed off, and many people are keen to see how they integrate back into the natural community to aid the return of a more natural environment.
18. Interest in wild life is very much on the increase and the knowledge that Beavers are now on the Tay adds another very good reason to visit this spectacular area.
19. No effect on business
20. May provide some very limited opportunity for woodland advice.
21. Wildlife is a significant part of the experiences we offer, and on a general level we are not against reintroductions of native species. We would see beavers being present as an additional attraction for many of our clients.
22. Attract more visitors to the area. Raise awareness of a species of animal which should be part of Scotland's fauna. I can think of nothing in the negative.
23. Beavers on the Tay may encourage more people to that area and consequently way from my area of operation, however I suspect this will be minimal and suspect that overall it will impact positively on the Scottish Wildlife industry.

24. Many visitors come and stay with us because of wildlife, we believe the ability to advertise the area as having beavers will have a positive impact on our business. Even more of a reason to come to Highland Perthshire for a holiday.
25. As a charismatic native species, I would consider running a tour/workshop focused on beaver photography.
26. May take trips to look for beavers in future
27. Positive as we run courses where people want to see evidence of beavers.
28. Provides a very positive attitude of Scottish society for visitors, that we are comfortable with our wildlife and want to see them reclaim their space in our countryside. Even if not seen, the fact of their presence is a great talking point and attraction to explore the area....and return again and again.

APPENDIX 6: HIGH IMPACT CASE STUDY: ISLABANK FARM

The following is detailed information received from one land manager. The first part outlines impacts during 2012-13, whilst the shorter second part outlines impacts so far in 2013-14.

Beavers on Islabank Farm 2013

Background

Islabank farm is family run farm extending to 320 hectares. The land is all at the top end of grade 2.1 and the soil type is sandy loam. It is situated on the west bank of the River Isla. The land runs from the edge of the River Isla at 33 metres above sea level to 75 metres at the back of the farm.

We own and maintain 2.8 miles of the river's edge. Approximately 2 miles of this has flood banks which are between 2 and 4 metres high. This protects about a third of the farm from flooding and soil erosion.

Beavers

We first noticed signs of beavers in the autumn of 2011. This did not unduly concern me as any trees that we have beside the river are of little value and I assumed that if this was all the damage they were going to cause then I was not unduly concerned about having them on my farm.

In December 2012 we had very high water level and flooding that caused a number of bursts of our flood banks. It was not until March 2013 when the land had dried out enough for us to repair the banks that we discovered the extent of the beaver damage.

This picture shows where a beaver has tunnelled into the bank to make a lodge. The river has then risen due to heavy rainfall or snow melt causing the pressure to build and then blow the roof out of the lodge.

The result is that I am left with a large hole and the start of some serious erosion. I found 6 of these holes in a 100 metre stretch.

This shows the location of an underwater entrance to a lodge.

This is the blow hole that is behind him.

The depth of the blow hole is 3 metres

The damage from this tunnel went all the way though the flood bank.

Below is a picture of what can happen when the bank bursts. It can take 5,000 tonnes of soil to rebuild the burst of this size. The bill in 2013 was £5,000 to repair my banks and I am sure next year will not be any less.

There are some major issues that have to be looked at. Firstly is residential property as we have one house that will be liable to flooding if the banks are broken. Secondly are the public roads of which we have three that pass through the farm that will be affected if the banks burst. Thirdly are the crops that are growing on the prime agricultural land that will get damaged. Fourth and last is the silting up of the river bed downstream of our farm, this will cause further flooding in both Perth and Dundee.

The only positive that I can see out of the reintroduction of beavers is a small plus to the local tourist industry though the costs far outweigh the benefits.

I have looked at protecting my flood banks with netting. The quotation that I was given was for Badger netting, which has not yet been tested for Beavers, and this was going to cost me in excess of £64,000. Sadly I do not have the funds to try this.

2014 update (as of 30th March 2014)

See below for a more recent picture taken this spring showing where a beaver has tunnelled into my flood bank causing it to burst when the river rose.

I have not started to repair the flood bank as I am waiting for the land to dry out. My budget is £5,000 for the repair and the loss of crop will be between £1,500 and £3,000. There is an additional cost and that is for cleaning the fields of debris that is left once the river subsides. This consists of trees, or bits of them, large bits of plastic and glass, all of which if left will cause considerable damage to my combine and other farm machinery.

It was suggested that I might consider moving my flood banks back from the river's edge by 20 meters: this would mean a loss of approximately 6.5 hectares and an estimated income of £1,250 per hectare per annum. There is also the capital cost to add to the bill. In that I

mean the capital value of the land, at today's prices of £37,500 per hectare for top arable land. This gives me a loss for assets to the tune on £243,750. I have not yet asked my drainage contractor for a quote for the job because I would be expecting to a figure that was way out of any budget that I could write.

I find myself in a difficult position with regards to the beavers in that I can see no easy way to reduce my losses. The beaver numbers are increasing at an alarming rate, my flood banks will be under attack on a more regular basis and as yet there is no sensible suggestion on how to protect some of the best arable land in Scotland. I am also starting to see river edge erosion happening this gives me one problem, in the loss of my lane. It also gives SEPA a problem when the soil that is washed out settles further downstream and causes blockages of the river.

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