Faculty of Science & Technology

The extent and distribution of suitable beaver *(Castor fiber)* habitat in Dorset.

A dissertation submitted as part of the requirement for the BSc Ecology and Wildlife Conservation.

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Abstract

Following widespread reintroductions across Europe, the topic of the European beaver *(Castor fiber)* in Britain is one of the principal issues in conservation currently. After a successful trial in Scotland, locating other viable areas is crucial. Geographic Information Systems (QGIS) was used to develop a habitat map, using raster data from the Land Cover Map and Ordnance Survey, to display suitable habitat in Dorset. Five sites with high potential were identified from examination of the map, and landscape metrics analysis was performed on these sites with FRAGSTATS software. The resulting statistics were used to rank each site on its habitat suitability, and compare that to habitat in the rest of the county. The findings indicate that these sites could support an estimated 70 families, or 280-350 individuals. This paper is only a preliminary assessment, and is more of an indication of the current condition of Dorset. The number of individuals the area could potentially support is a very rough estimation, and more research, such as physical habitat surveys of the identified sites, is recommended. Nevertheless, the results are promising and provide future researchers with some guidance on areas of focus.

Acknowledgements

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Contents

1 Introduction

1.1 Question and aim

The European beaver *(Castor fiber)* (hereafter referred to as 'beaver', any reference to *Castor canadensis* will be as North American beaver) has been extinct in the wild in Britain for hundreds of years, with the last records coming from Wales in the 12th century (Harting 1880 cited by MacDonald et al. 1995) and Scotland in the 16th century (Conroy and Kitchener 1996). A similar pattern of decline spread across Europe (Nolet and Rosell 1998), however since then many European countries have implemented reintroductions which have been successful in most cases (Bajomi 2011, Dewas et al. 2012, Kostkan and Lehky 2016), and the beaver is now classified as 'Least Concern' by the IUCN (International Union for Conservation of Nature) (Batbold et al. 2016). In response to these reintroductions across Europe, the topic of a similar project in Britain has been discussed extensively. Consequently, beavers were released in Knapdale, Scotland, in 2009 as part of a five-year trial. Following on from this, it is imperative that other areas be studied to determine if beaver can be reintroduced throughout Britain.

Dorset is potentially suitable for beaver as it has considerable density of watercourses, particularly the four rivers which flow into Poole Harbour, as well as having reasonable coverage of broadleaved woodland (Campbell-Palmer at al. 2016). However, the main limiting factor is the amount of arable and horticultural land in the county. Whilst constructing the habitat map, the Land Cover Map clearly showed there is significantly more farmland than broadleaved woodland. This presents several problems. Proximity to agricultural land is used throughout literature as a negative quality for beaver habitat (MacDonald et al. 1995, Czech and Lisle 2003, Campbell-Palmer and Rosell 2010). This is due to both the disturbance from modern agricultural processes and machinery, as well as beavers only occasionally dispersing over open land such as farmland (Hartman 1994). Conversely, beaver disturbance to farmland is a major argument against reintroducing the species. Dam building can cause localised flooding, and beavers are also capable of creating canals through agricultural land, both of which can severely disrupt food production (Czech and Lisle 2003).

The aim of this paper is to determine the extent and distribution of suitable beaver habitat in Dorset, which should provide a groundwork for further research. The objectives of the study are to answer the following questions.

1.1.1 Objectives

- What are the physical habitat requirements for beaver?
- What is the extent and distribution of suitable beaver habitat in Dorset?
- Which areas contain the most suitable habitat?
- How many beaver could these areas support?

1.2 Beavers in Britain

While beavers are naturally extinct in the wild in Britain, there are currently several populations. While the Scottish Beaver Trial in Knapdale, 2009, is the most well-known population, there is also a wild, unlicensed population living on the River Tay, which contains an estimated 38 active territories (Campbell-Palmer et al. 2015), with reports of sightings as early as 2006 (Raye 2015) and possibly 2001 (Halley 2011, Halley et al. 2012). Interestingly, this population was unlicensed as it was thought to have come from illegal releases or escapees from neighbouring enclosed beaver populations. Nevertheless, Scottish Natural Heritage decided to allow the population to remain for the duration of the Scottish Beaver Trial (Campbell-Palmer and Jones 2014). The findings issued in the final report of the Tay beavers study show that the population is successful, and currently experiencing growth, and indicates that the area can support many more families than the 56 surveyed territories currently hold if the population can remain (Tayside Beaver Study Group 2015).

At the time of writing, the final report on the Scottish Beaver Trial has been published by Scottish Natural Heritage, highlighting the success of the project and observations for the future. It was suggested that if the Government decides that beavers may remain, the current populations will need bolstering to prevent inbreeding, as current numbers are not large enough for a founder population. As such, further investigation is required for new parts of Scotland and Britain in general, which the results of this trial should encourage (Gaywood et al. 2015).

In addition to the two populations in Scotland, there are also populations in England, and an investigation into releasing the species in Wales has been published (Jones et al. 2009) Currently, Devon has both wild beaver on the River Otter, and a smaller population in an enclosure on private land. It is unknown where the wild beaver originated from, however after individuals were captured for health assessment in 2015 it was determined that they were very closely related and at severe risk of inbreeding, and in October 2016 two individuals of suitable stock were released (Devon Wildlife Trust 2016). This population has been allowed to remain as part of a trial which will allow study and further supplementation if required until 2020. The enclosure population has just come to the end of its five-year trial, yet at time of writing results have not been published.

1.3 Literature Review

Due to the scale of beaver reintroduction across Europe, there is a huge quantity of literature for the species. This section includes an assessment of methodology used in beaver reintroductions, both physical and theoretical, to illustrate the decision behind this investigations method.

The investigations into Scotland and Norfolk as potential reintroduction sites both employ the use of a habitat map developed in GIS to locate areas of suitable habitat (MacDonald et al. 2000, South et al. 2001). At the time of writing, it is unlikely the authors knew of any beavers on the River Tay, if any existed, so all work was based on reintroductions throughout Europe, particularly the Netherlands. Studied over three years, a population of beaver was translocated from Germany to the Netherlands (Nolet and Baveco 1996). While the population initially experienced a high mortality rate, which was hypothesised to either be attributed to shock from translocation or poor habitat availability, the study provided valuable data, which along with data from a study of beaver in Germany (Heidecke 1984 cited by Nolet and Baveco 1996) was used in their model to predict the likely future of the population. The development of this model helped facilitate their work, however without access to any real-world examples to study, the addition of the habitat map and multiple model parameters was necessary to combat any hypothetical uncertainties in beavers' behaviours.

In addition to GIS, Vortex was included in the studies of Norfolk (South et al. 2001), Scotland (MacDonald et al. 2000) and the Netherlands (Nolet and Baveco 1996). Vortex is population dynamics software which performs analysis either on an individual or population, and includes demographic and environmental stochasticity (Lacy and Pollak 2014).

In contrast to these papers, the current Welsh Beaver Project, managed by Wildlife Trusts Wales, implemented a different methodology to investigate habitat suitability. A combination of physical habitat quality assessment, and a modified version of a Habitat Suitability Index (HSI) model originally produced for assessment of North American beaver habitat (Allen 1983). This model used data such as tree and shrub canopy height and cover, and distribution of food tree species, which gives a numerical value to each site to determine suitability.

Both the spatial population model and habitat map method, and the physical habitat suitability and index model method are effective approaches to determining viability of a site for beaver reintroduction. Interestingly, an investigation into beaver habitat in Austria used a combination of a GIS-based habitat map to locate potential sites and a similarly modified HSI model to determine the quality of each site, and used data from literature to predict how many beaver families could be supported (Maringer and Slotta-Bachmayr 2006). For future investigations, there is now a selection of methodology to implement, which can be tailored to fit a wide range of situations, and all provide relative confidence in their predictions.

Through reading reports of real-world reintroductions, it is apparent that not all releases received appropriate planning through modelling and instead were the product of desire and urgency. For example, 58 beavers were translocated from Germany to the Netherlands between 1988 and 1994. It was later discovered that 22 had died due to the infectious diseases yersiniosis and leptospirosis, which was hypothesised to be gained from a weaker immune system attributed to translocation stress (Nolet et al. 1997), however prior to this paper, excessive cadmium pollution in the new site was investigated, although it was assumed unlikely to have had any impact (Nolet et al. 1994) Similarly, between 1965 and 1967 nine beavers were reintroduced to the Champagne region of France. This population grew quickly and consequently expanded to 20 sites in the 1970s, yet at the end of the 1980s, it declined rapidly to occupy only four of those sites (Léger 1996 cited by Fustec et al. 2001).

Nonetheless, there are examples of reintroductions that featured appropriate forethought and planning in their application. In 1991, 22 beavers were introduced to the Morava River basin area of the Czech Republic (John et al. 2010) which hadn't seen a population for several hundred years. While the reintroduction did not feature modelling prior to release, the area was assessed for habitat suitability to determine suitable release sites. After the release, a model was used, based on a habitat map produced in GIS, to predict where individuals would disperse to. The results indicated that after an initial indiscriminate dispersal pattern, the most important variable was presence of willow *(Salix sp.),* and beaver settlements ended up closer to roads and urban areas. Similarly, in France, (Fustel et al. 2001) a reintroduced population was studied for colonisation and dispersal, which produced similar results: dispersal along rivers is irregular, and while lack of willow does not have a negative impact, presence increases probability of beaver establishing a territory.

A real-world reintroduction of beaver to Hungary (Bajomi 2011) used a very similar methodology to the Welsh Beaver Project with resounding success, with the species being found throughout the reintroduced range. This project used similar physical habitat surveys in combination with an American habitat suitability model, which was unnamed, but is likely the same Allen Index mentioned previously.

2 Method

2.1 Habitat Map

The habitat map was designed in QGIS using data provided by EDINA (EDINA Digimap Service, 2016). This data included the 2007 Land Cover Map from the Centre for Ecology & Hydrology (Morton et al. 2011), and Ordnance Survey Open Rivers data. The Land Cover Map classifies each 25m cell into one of 23 habitat types, however for this investigation only broadleaved woodland is displayed within the map itself, though coniferous woodland, arable and horticulture, and improved grassland were included in the analysis discussed in section 2.2. Due to the Land Cover Map and Open Rivers being provided on a national scale, further Ordnance Survey data was used in the form of boundary lines, which enabled the habitat map to be clipped to the Dorset county line, removing everything outside. This greatly eased computational requirements and map responsiveness.

To locate potential sites in detail, an intersect was performed on the habitat layer, with only broadleaved woodland being processed, and the river layer, which produced a new layer highlighting all the areas where the two habitats connected. Due to the nature of the intersect process, which only requires a single cell or edge of each layer to be overlapping, it is not enough to simply measure the length of the intersects and say how much potential habitat is available.

This inaccuracy was avoided by using the buffer feature. By applying a 500m buffer, which is dissolved so that a buffer forms around a patch of intersects rather than individual cells, the habitat map is clipped using the buffer as a mask layer to show only habitat which falls within 500m of an intersect (Figure 3, section 3 below). This buffered view of the habitat map is useful as it provides manipulated data which will be used later in FRAGSTATS (McGarigal et al. 2012) to directly compare the total habitat land cover and that within potentially suitable areas. This was achieved by using the select feature tool to select polygons from the dissolved buffer layer and copying this feature to a new vector layer. This new layer was used as a mask layer to once again clip the Land Cover Map layer to show only habitat within the selected buffer.

2.2 FRAGSTATS analysis

FRAGSTATS was used to run cell-level class metrics on the habitat map, which resulted in detailed information on each habitat class. Due to the computational requirements of performing analysis on a large, detailed map, the resolution of the habitat map had to be changed from 25 to 50m for FRAGSTATS to successfully analyse the area. Resolution was also increased to 100m to see how much resolution effected accuracy of results, which was negligible. The following metrics were applied:

- total area (TA)
- percentage of landscape (PLAND)
- number of patches (NP)
- patch density (PD)
- area mean (AREA_MN)
- area range (AREA_RA)
- area standard deviation (AREA_SD).

Total area and percentage of landscape are vital statistics to understanding landscape composition, particularly at class level, which shows the amount of land each habitat class covers. Coniferous woodland, arable and horticultural land, and improved grassland were included in FRAGSTATS analysis to provide some context and comparisons to land cover.

The remaining functions don't provide as much information when interpreted individually, for example mean patch size and patch density give an idea of the spread and size of patches. However, two landscapes could have identical results yet look very different as there is no indication of variability of patch size which is vital for understanding fragmentation of patches. Consequently, area standard deviation and number of patches can be referenced when looking at these results to better understand the landscape, as standard deviation is a measure of absolute variation within patch sizes. To interpret area standard deviation, it must be viewed as a function of mean patch size. For example, two landscapes with identical area mean and patch density, but different standard deviations, will mean that one landscape has evenly sized, uniform patches, whereas the other would have large variation in patch size.

2.3 Estimation of families supported

Adapting the methodology from the Norfolk (South et al. 2001) and Scotland (MacDonald et al. 2000) studies, an estimation on number of families and individuals was achieved in QGIS. Using the select feature tool, all river data within each chosen buffered area was selected and saved to a new layer. Using the field calculator, length was calculated in kilometres (km), which was added to the attribute table of the new layer. Using basic statistics tool for vector layers, a sum of the length of each river section was shown, which can then be divided by numbers gained from the above literature. The lowest parameter value for family habitat requirements (4km) was used as it was deemed prudent to provide a very conservative, rough estimation.

3 Results

3.1 Criteria for habitat map

Key findings from literature	Citation
Dietary staple is birch (Betula spp.), with poplar and aspen (Populus spp.) and willow (Salix spp.) favoured if present. Conifers rarely consumed.	Nolet 1997, Jones et al. 2009.
A single beaver family (breeding pair with sub-adults and juveniles) requires a minimum of 2km of wooded banks within a maximum of 11km of banks total.	Nolet & Rossell 1994 cited by Macdonald et al. 2000, South et al. 2001.
During the early stages of colonisation, beaver rapidly expand in search of resource-heavy sites (particularly willow) to establish settlements. Once established, expansion into sub-optimal habitats, for example areas of heavy human activity, became more common.	Halley and Rosell 2002, John et al. 2010.

Table 1. Summary of key findings from literature review, providing criteria for creation of habitat map.

Table 1 shows the results of the literature review which met the first objective; what are the physical habitat requirements of beaver? The first two rows outline the criteria that was used throughout the method in the development of the habitat map and in the FRAGSTATS analysis: beavers require at least 2km of wooded river bank, ideally containing broadleaf species such as aspen and willow. The third row is less applicable to the map in that it outlines beavers' dispersal pattern, which assumes they have been released. However, the tendency for beavers to immediately disperse over a relatively long range after reintroduction helped in the selection of potential sites, and will be discussed further later.

3.2 Habitat map

Following the method, QGIS was used to develop a habitat map to locate suitable areas. Using the Land Cover Map and Ordnance Survey data for rivers, the distribution of broadleaf woodland in Dorset is shown in Figure 1. The Land Cover Map data includes other habitats, such as arable and horticultural land, which was included in the FRAGSTATS analysis, however it was not included in Figure 1 to display broadleaf woodland distribution.

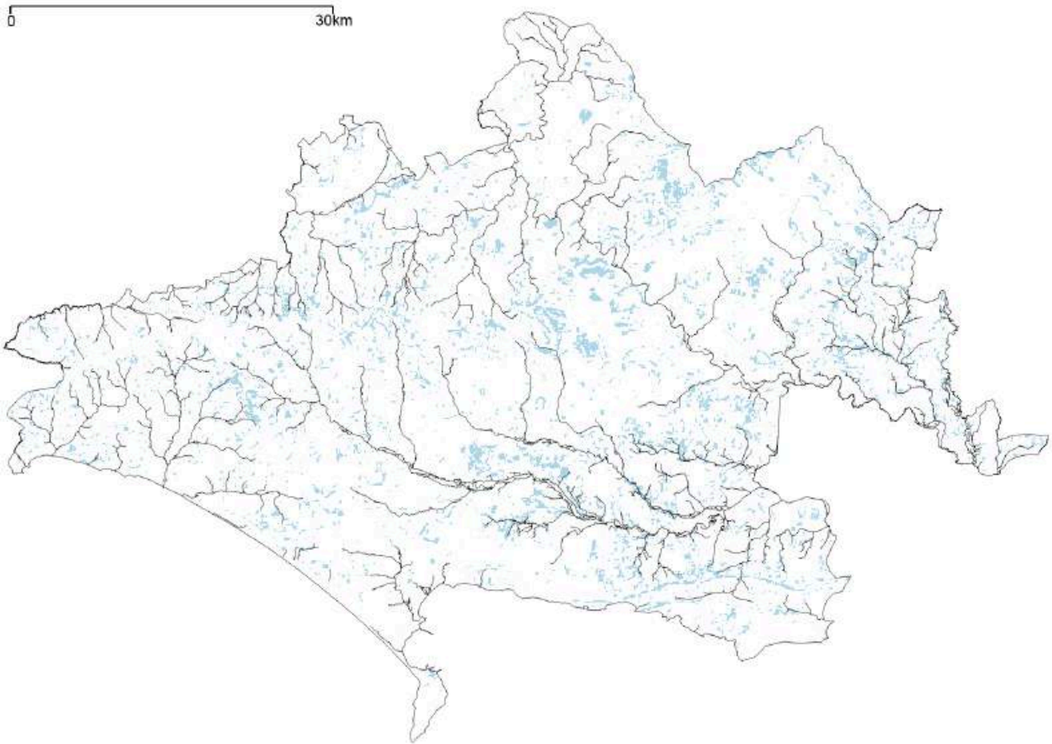

Figure 1. Habitat map of Dorset, showing broadleaved woodland in blue and rivers in black.

Examining Figure 1, it is evident that broadleaved woodland occurs regularly throughout Dorset, however it is mostly small, fragmented patches, with few large areas of woodland. While fragmentation is a negative quality for habitat, Dorset has high density of rivers which can be seen in Figure 1. This results in broadleaved woodland being relatively more connected than it otherwise would be, and indicates that there should be areas of suitable habitat throughout the county.

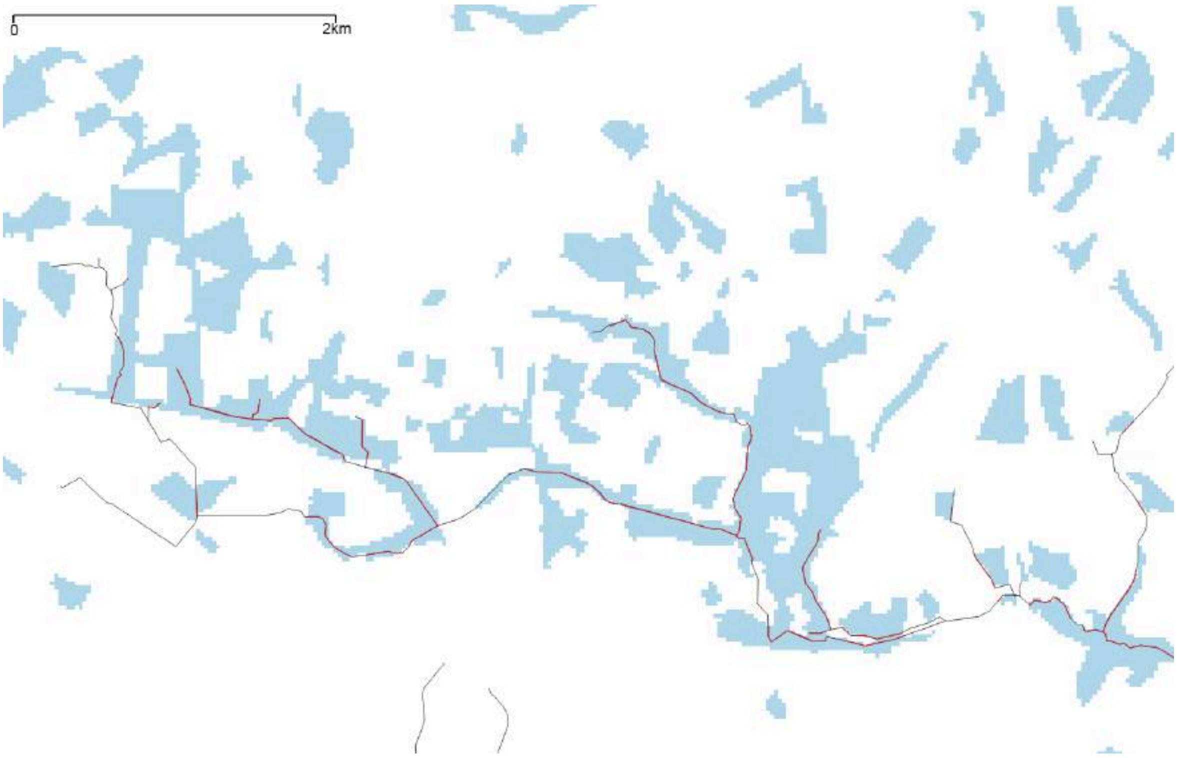

Figure 2. A stretch of the River Sherford, south of East Moredon, Wareham. Intersect is shown in red, highlighting areas where broadleaved woodland and rivers connect.

The intersect function locates potentially suitable areas by highlighting points where the broadleaved woodland and river layers overlap (Figure 2). As described in the method, the intersect function simply identifies areas where two chosen layers connect, and creates a new layer highlighting this. Figure 2 shows the problem with using this function as a standalone, there is no way to limit within the function how much of each layer must connect, it can either be a large patch of woodland or a single cell. The intersect function is used as a preparation step to identify applicable areas that can then be further manipulated, in this case with a buffer. The buffer function initially creates a buffer of the desired size, in this case 500m, around each intersect, however by dissolving the buffer each one joins together to form a large buffer around a patch of intersects. With the buffer applied to the intersect, the habitat map now clearly identifies suitable areas and how isolated from or connected to each other they are. As well as this, by clipping the habitat layer, suitable habitat can be limited to within the 500m buffer (Figure 3), which makes identifying viable patches much easier.

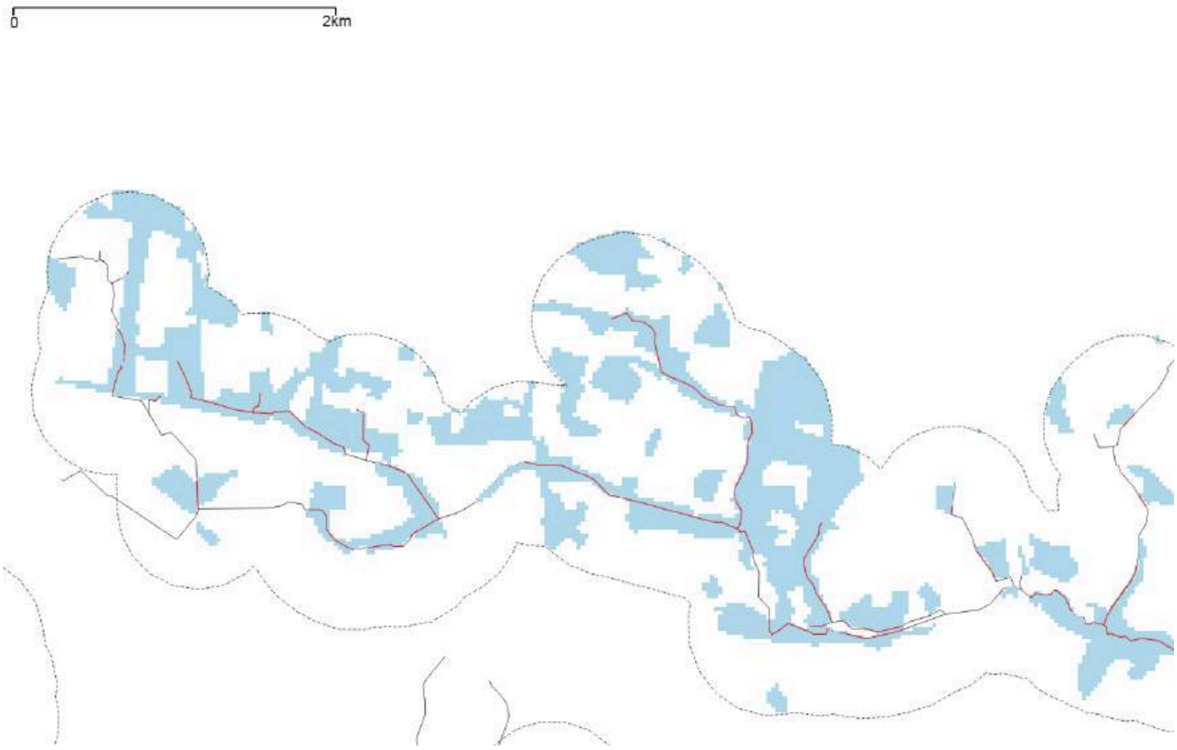

Figure 3. The same area in Figure 2, with a 500m buffer applied.

Beavers require linear habitat in the form of wooded river banks, typically around 4km (South et al. 2001). It has been found that beaver rarely forage for food beyond 100m, with most foraging taking place within 20m of the river (Allen 1983). While this suggests that a 500m buffer is excessive, it was chosen as it better visualises habitat availability and allowed suitable sites to be selected more easily.

Looking at the map with the buffered habitat layer applied, it becomes much easier to locate potentially viable habitat patches. In this way, five patches were selected for further analysis (Figure 4), and by using the select feature tool, habitat for each individual patch was clipped out and saved as a new file raster image which can then be analysed by FRAGSTATS. This allowed a direct comparison and ranking of each patches suitability.

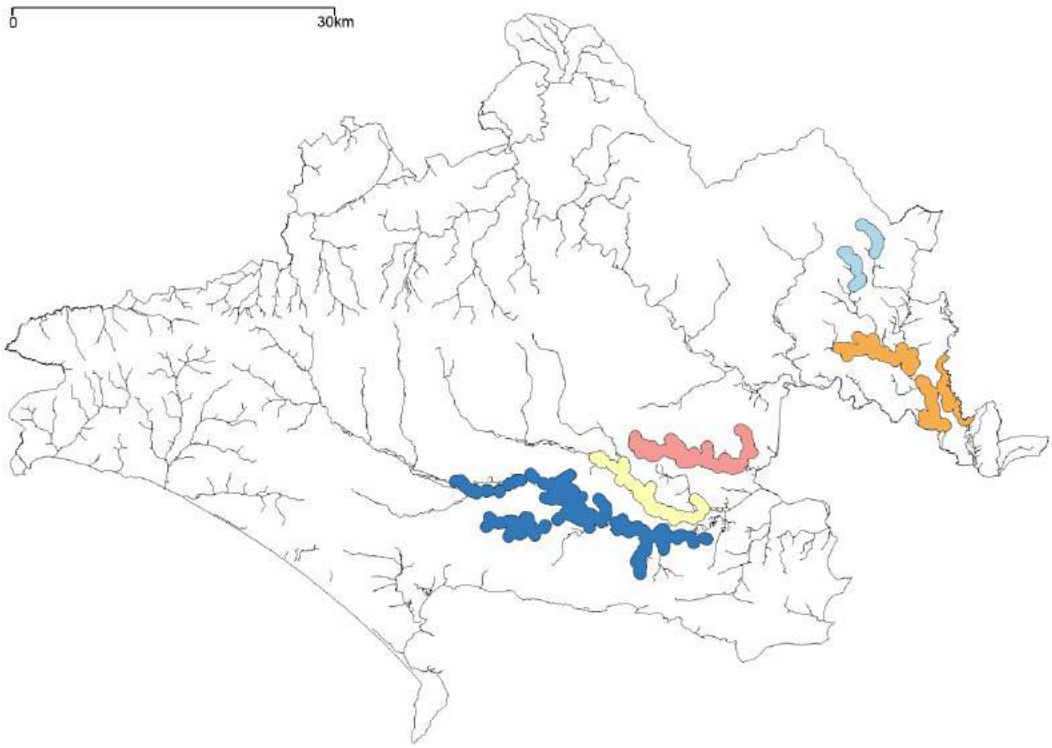

Figure 4. Map of Dorset, showing rivers in black, with five patches highlighted. River Crane in light blue, River Frome in dark blue, River Piddle in yellow, Moors River in orange, and Sherford River in pink.

The criteria for selecting these sites was that they featured at least 2km of wooded banks within 5-10km of banks (Table 1). This was estimated by overlaying a 5km grid over the map. Each square that had a river running through it is assumed to have around 10km of banks, which is close to the maximum size for a single beaver family (South et al. 2001). This is a potentially inaccurate way of measurement, but due to the likelihood of over and underestimating depending on how the river runs through the 5km square, it should balance itself out. Any patches that were close to each other were grouped together, particularly if it was on the same river system, as it was deemed likely that beaver would move between them. This can be seen on Figure 4, rivers Frome, Moors, and Crane all feature two or more patches that are connected either by the river or a patch broadleaved woodland (not shown in figure).

3.3 FRAGSTATS analysis

Initially, FRAGSTATS analysis was performed on the whole habitat map to gain perspective on the land cover for the county (Table 2). This was important to put any identified habitat patches into context within the landscape, and see how fragmented they are.

50m Resolution – Dorset County							
Habitat	**PLAND (%)**	**TA**	**NP**	**PD**	**AREA MN**	**AREA RA**	**AREA SD**
Broadleaved Woodland	7.53	19384.5	4408	1.71	4.39	384.75	14.54
Coniferous Woodland	3.09	7973.75	884	0.34	9.02	478.75	32.85
Arable & Horticulture	38.72	99628.75	3825	1.48	26.04	36643.25	604.36
Improved Grassland	35.13	90373	2963	1.15	30.5	30981.5	591.23

Table 2. Results from FRAGSTATS analysis of whole habitat map for Dorset. Percentage Landscape Cover, Total Area, Number of Patches, Patch Density, Area Mean, Area Range, and Area Standard Deviation.

The first results are percentage land cover and total area (TA). As the Land Cover Map contains 21 other habitats, the percentage does not equal 100. However, most land cover in Dorset is arable land and grassland, equalling almost 75% between them. Comparing this to land cover of broadleaved woodland, extent of suitable habitat is not very large.

The remaining functions all portray more detailed information about the landscape. Number of patches (NP) and patch density (PD) are used as indicators of landscape configuration, as they may determine number and dispersal of sub-populations, and their interactions. The area statistics indicate patches rather than the landscape area (McGarigal 2015);

- area mean refers to mean patch size
- area range refers to range in size between smallest and largest patch
- area standard deviation is a measure of patch size variability

As outlined in the method (section 2.2 above), the patch and area statistics are best interpreted as a group to best understand landscape composition and function. For Table 2, the results show that both arable land and improved grassland dominate the landscape. Looking at the area mean and number of patch sizes, this land cover is mostly made up of lots of relatively small patches. Due to the patch density and total area, it can be assumed that these patches are relatively well connected if they are present through that much of the landscape. The area range and standard deviation indicate, however, that there is huge variability in size, which indicates that there is a mixture of some very large and medium sized patches, with lots of small patches connecting them. In contrast, the two woodland habitats have different landscape configurations. Broadleaved woodland covers twice the area that coniferous woodland does, however its area mean and number and density of patch results show that this is through high quantity of small patches. Conversely, coniferous woodland covers the smallest area in Dorset out of the four habitats. The results show very low number of patches and patch density, followed by a relatively high area mean and standard deviation compared to broadleaved woodland.

50m Resolution – 500m Intersect Buffer							
Habitat	**PLAND (%)**	**TA**	**NP**	**PD**	**AREA MN**	**AREA RA**	**AREA SD**
Broadleaved Woodland	11.28	5641.75	1678	3.35	3.36	152	8.77
Coniferous Woodland	5.14	2570.25	410	0.82	6.26	156	14.45
Arable & Horticulture	26.64	13323	1838	3.67	7.24	288.5	15.67
Improved Grassland	40.53	20267.25	1344	2.68	15.07	647.25	39.05

Table 3. Results from FRAGSTATS analysis for habitat within 500m buffer around intersect of broadleaved woodland and rivers. Percentage Landscape Cover, Total Area, Number of Patches, Patch Density, Area Mean, Area Range, and Area Standard Deviation.

Comparing Tables 2 and 3, it is immediately apparent that habitat suitability noticeably increases within the 500m buffer. It is important to remind that this buffer is not applied around all rivers, only to the intersect between broadleaved woodland and rivers. Nonetheless, percentage landscape cover goes up by 4%, and patch density is almost doubled. Performing a basic percentage formula in Microsoft Excel reveals that 29% of total area and 38% of number of patches for broadleaved woodland in Dorset is within 500m of these intersects. These numbers sound a lot more influential than the 11% percentage land cover, which seems negligible when compared to arable land and improved grassland. While arable land may have implications for beaver being reintroduced to the county, the high percentage of grassland cover may not have such negative connotations, as it would be easy to allow succession to happen to provide more habitat if a beaver trial occurred and was successful.

50m Resolution – River Patches (Broadleaved Woodland)							
River Name	**PLAND (%)**	**TA**	**NP**	**PD**	**AREA MN**	**AREA RA**	**AREA SD**
Crane	25.44	223.5	40	4.55	5.59	76	13.11
Frome	15.02	8032	172	3.22	4.66	113	11.75
Piddle	15.67	269.25	55	3.2	4.89	67	10.72
Moors	17.08	454.5	111	4.17	4.09	65.25	9.02
Sherford	22.45	477	60	2.82	7.95	136.75	22.21

Table 4. FRAGSTATS analysis of broadleaved woodland in river patches (Figure 4).

Table 4 shows statistics for broadleaved woodland landscape cover within the 5 identified habitat patches shown in Figure 4 as being potentially suitable release sites. The applications of using the habitat map to locate potential sites are clear, as each patch shows much higher percentage land cover of broadleaved woodland than the results from tables 2 and 3, with increases ranging from 5-14%. Referring to figure 4, it is interesting that the River Crane patch has the highest percentage land cover of broadleaved woodland, as well as highest patch density, as this patch is the smallest and is split into two. In contrast, the River Frome patch is noticeably larger than the other four patches, yet has the lowest percentage land cover of broadleaved woodland. However, the total area and number of patches of broadleaved woodland within the Frome patch is significantly greater in comparison to the other patches. Using the results from Table 4, the five patches can be provisionally ranked in order based on their size and amount of suitable habitat (Table 5).

50m Resolution – River Patches Ranked on Habitat (Provisional)						
River Name	**Patch Size (m^2)**	**PLAND (%)**	**TA**	**TA (m^2)**	**NP**	**PD**
Frome	53337131	15.02	802	8020000	172	3.22
Moors	26571374	17.08	454.5	4545000	111	4.17
Sherford	21170423	22.45	477	4770000	60	2.82
Piddle	17155231	15.67	269.25	2692500	55	3.2
Crane	8767819	25.44	223.5	2235000	40	4.55

Table 5. Provisional ranking of river patches on habitat, based on number of patches (NP) and total area (TA).

This provisional ranking of the patches is to simply show which has the highest quantity of suitable habitat. It is also used to show that this statistic alone is not enough to say the area is suitable, as Figure 5 indicates.

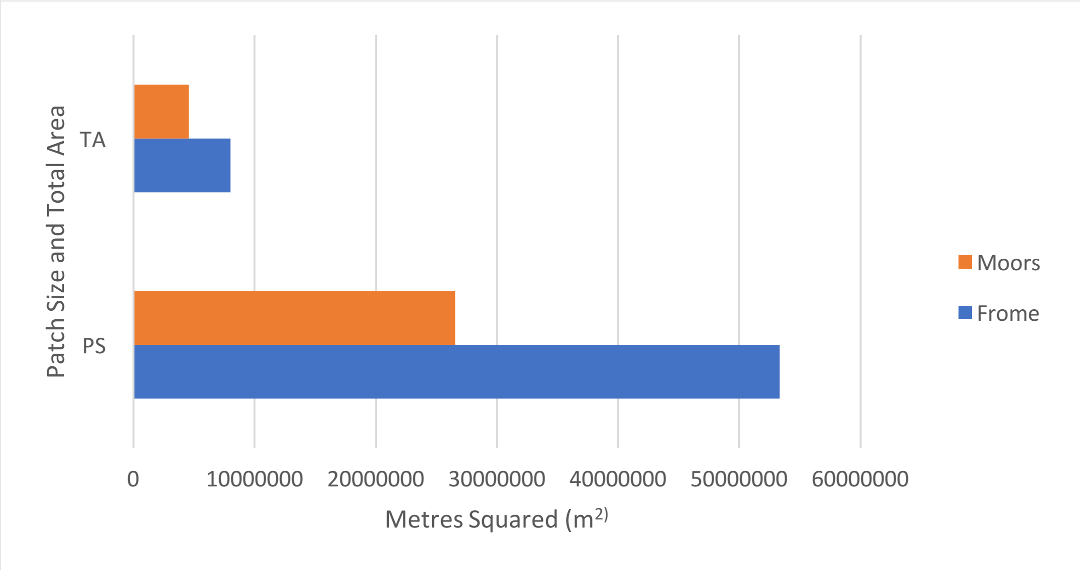

Figure 5. Comparison of patch size and total area in Moors and Frome patches.

TA refers to total area of the class or habitat, in this case broadleaved woodland. FRAGSTATS produces this result in hectares (ha), which for graphical display is converted to m^2 by multiplying by 10,000 (Table 5). Patch size is the area of each patch shown in Figure 4. On initial viewing of Table 5, the Frome patch appears to be significantly larger than the other patches, and with almost double the total area of broadleaved woodland of the Moors patch. However, when viewed as a graph, it is easier to see that the Moors patch features more woodland for its size. Referring to Table 4, the other results can be analysed to gain a better understanding of the landscape configuration of each patch, which will reinforce the interpretation that the Moors patch has a higher concentration of suitable habitat in a smaller area. Figure 6 displays two results; area mean, and area standard deviation. The area mean shows the average size of a single patch of broadleaved woodland, and both habitat patches have very close values. By relating this to the standard deviation, which is a measure of patch size variability, the comparatively lower value for the Moors patch indicates that patches are closer in size, whereas the Frome patch shows that there is slightly more variation.

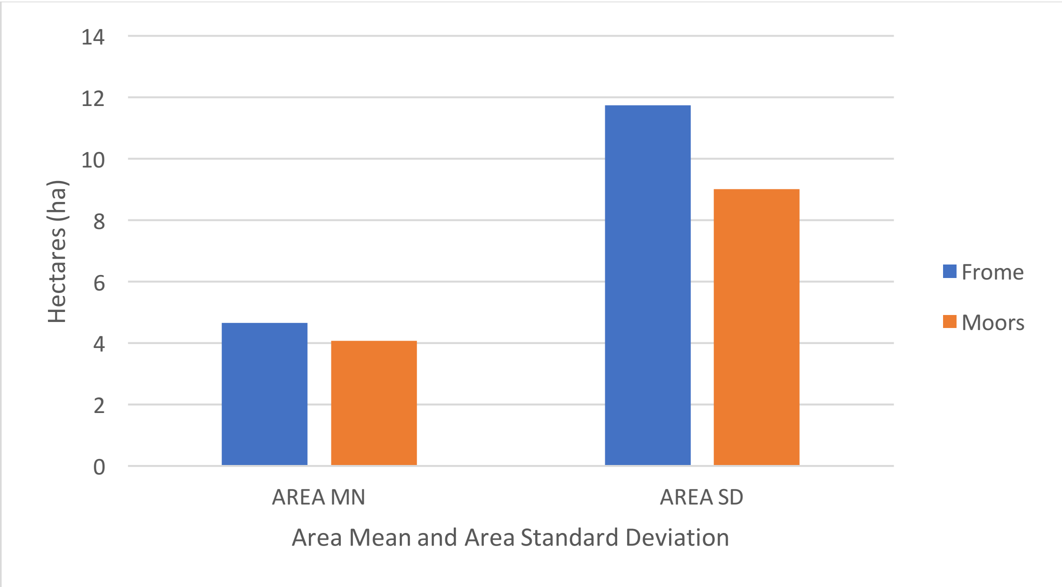

Figure 6. Comparison of area mean and area standard deviation in Frome and Moors patches.

While the above shows that the Moors patch has a higher concentration of suitable habitat than that of the Frome patch, it is necessary to perform further comparisons on other patches. The River Crane patch was initially ranked last (Table 5), owing to its low number of patches and total area of broadleaved woodland, however that is due to the significantly smaller patch size. When viewed as a graph (Figure 7), it is evident that interpreting numbers is not that simple, and the extent of suitable habitat within this patch is considerable. The Moors patch was previously identified as having a very high concentration of suitable habitat in comparison to the Frome patch, however it is not that straightforward. Looking at Figure 7 and Table 5, the total area of broadleaved woodland in the Crane patch is very close to half of that in the Moors patch, yet the overall patch size is considerably smaller. Interestingly, the Crane patch has the smallest number of patches, yet the highest patch density and a somewhat high standard deviation. This indicates that there may be some large patches of broadleaved woodland, which would explain the high amount of broadleaved woodland for such a small area.

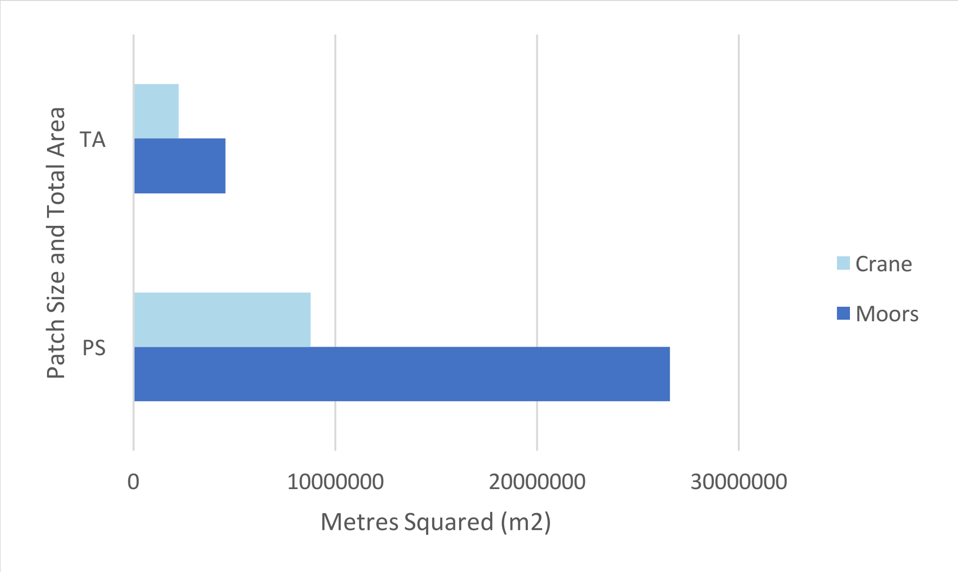

Figure 7. Comparison of patch size and total area in Crane and Moors patches.

Taking the above into account, a final ranking of sites on their viability for beavers based on extent and concentration of suitable habitat within them has been achieved (Table 6). Previously it was stated that interpretation of all the FRAGSTATS results is required to understand landscape configuration, which is true, however in the case of the river Sherford and Piddle patches, the differences were negligible. Further analysis of the habitat map led to the ranking of the Sherford patch above the Piddle patch due to the distribution of the suitable habitat. In the river Piddle patch, there is a long stretch of river with broadleaved woodland either side, which is obviously very suitable. However, the Sherford patch features many smaller stretches of river, each with relatively larger patches of woodland than the Piddle patch, which was deemed more useful as it would potentially support more individual families.

50m Resolution – River Patches Ranked on Habitat (Final)						
River Name	**Patch Size (m^2)**	**PLAND (%)**	**TA**	**TA (m^2)**	**NP**	**PD**
Crane	8767819	25.44	223.5	2235000	40	4.55
Moors	26571374	17.08	454.5	4545000	111	4.17
Frome	53337131	15.02	802	8020000	172	3.22
Sherford	21170423	22.45	477	4770000	60	2.82
Piddle	17155231	15.67	269.25	2692500	55	3.2

Table 6. Final ranking of river patches on habitat, grouped into two larger habitat patches based on proximity and ease of movement between individual river patches. Ranking within each group is based on concentration and extent of suitable habitat as discussed above.

As Table 6 shows, the decision was made to group the river patches into two larger patches, based on their proximity and availability of habitat between them to enable movement (Figures 8 and 9). The first large patch, containing patches Crane and Moors, will be hereafter referred to as Verwood patch, whilst the second will be Wareham patch. The Verwood patch was ranked ahead of the Wareham patch due to the high concentration of broadleaved woodland within relatively smaller areas, which was outlined above.

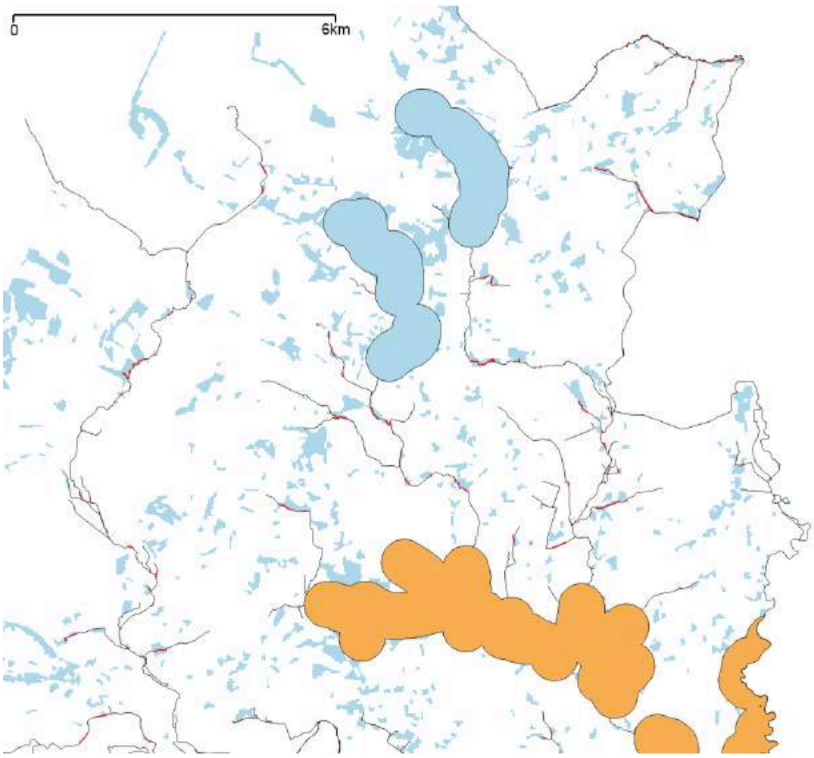

Figure 8. Habitat map showing Crane (light blue) and Moors (orange) patches proximity and habitat availability between them.

Figure 8 shows that whilst broadleaved woodland cover between the two patches is sparse, there are a variety of routes available to move between each patch, as there are several small tributaries as well as the main body of each river. The issue with this patch is that a part of the patch is buffered around the River Avon, which for the most part is a river in Hampshire, which slightly skews the results. Nonetheless, most the Moors patch is within Dorset and therefore applicable to this study.

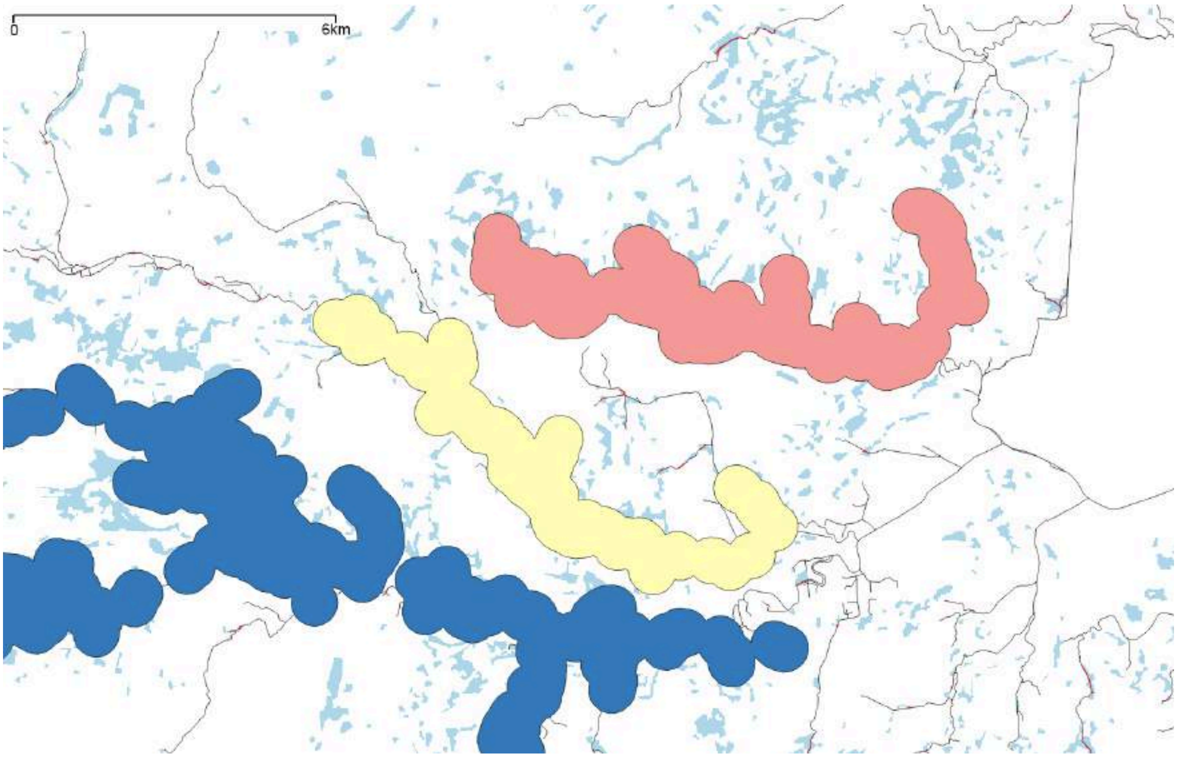

Figure 9. Habitat map showing Sherford (pink), Piddle (yellow), and Frome (blue) patches proximity and habitat availability between them.

In contrast, the three patches grouped together into the Wareham patch were comparatively less concentrated in terms of suitable habitat, yet their size and proximity mean that they could potentially be a more viable site if a reintroduction were to happen. Figure 9 shows that, while broadleaved woodland in between the patches is again sparse, though arguably slightly better in this case, the three rivers are very close together, with some tributaries in between, meaning movement between the three would be relatively easy for beaver.

Despite initially ranking the sites based purely on habitat (Table 6), an additional ranking is provided to include some context and a more accurate classification. As the 500m buffer is potentially unusable by foraging beaver, the ranking of sites on those numbers alone may not accurately represent how suitable the area is. By including an approximation of the number of families each site could support (Table 7), an understanding of how much of the habitat is physically required for beaver is gained. The previous ranking placed the River Crane site first, as it was the smallest but had highest percentage landscape cover of broadleaf woodland, which was the criteria for a suitable site. However, due to the small size, it was estimated that the Crane site could only support three beaver families. The previous explanation of Table 6 suggested that the Sherford River site would be more suitable than the nearby River Piddle as it featured higher percentage cover of broadleaf woodland along with several tributaries, as well as being the larger area overall. The result of QGIS analysis of river length indicates that the shape of the Sherford River site is deceptive, and that the River Piddle's linear structure could support more beaver, though the difference is small.

River Patches Ranked on Families Supported	
River Name	**Families Supported**
Frome	35.75
Moors	13.75
Piddle	9.5
Sherford	8.75
Crane	3

Table 7. River patches ranked on families supported. Habitat requirement for one family (four to five individuals) is 4km of banks.

4 Discussion

The aim of this investigation was to determine the extent and distribution of suitable beaver habitat in Dorset. The objectives were to find answers to the following questions:

- What are the physical habitat requirements for beaver?
- What is the extent and distribution of suitable beaver habitat in Dorset?
- Which areas contain the most suitable habitat?
- How many beaver could these areas support?

Knowledge of physical habitat requirements for beaver was gained from examination of current literature. Beavers are monogamous, and usually exist in a family group, known as a colony, which typically contains an adult pair, sub-adults, and juveniles, though occasionally a colony can contain a single individual (Rosell et al. 2006). These colonies defend a territory which may change size seasonally, but is always a minimum of 2km of wooded banks within a maximum of 11km of river (Nolet and Rosell 1994). Dietary requirements consist of birch, with poplar and willow favoured if present (Nolet et al. 1994, Haarberg and Rosell 2006), and foraging typically takes place within 20m of the river (Nolet 1997, Campbell-Palmer et al. 2016). This material informed the design of the habitat map and was the criteria used when analysing it in FRAGSTATS. The results of which answer the remaining objective questions.

Extent and distribution of suitable habitat in Dorset is shown in Figure 1, which shows broadleaved woodland distribution within the county, and Table 2, the results of FRAGSTATS analysis on the habitat map, comparing landscape statistics on four habitat types. Examining these two results, broadleaved woodland is quite fragmented, with very few large patches, and this is corroborated in the analysis which shows less than 8% of Dorset is broadleaved woodland. Due to the fragmentation of broadleaved woodland, and high quantity of agricultural land, suitable habitat is mostly limited to several areas, which were located by close inspection of the habitat map within QGIS.

The next objective was to locate any areas that show the most suitable habitat for a potential reintroduction, and determine how many beaver they could support. Firstly, five sites were identified as having the most suitable habitat, three in the Poole catchment area around Wareham, and two in the Stour catchment area around Verwood. These sites were identified by using the buffer feature. By clipping the Land Cover Map layer to the 500m buffer, suitable areas were immediately evident, as they would appear as large patches of blue cells around rivers. These sites were ranked on their habitat suitability (Table 6, section 3.2 above) which indicated that the two Stour catchment sites (River Crane and Moors River) featured the highest concentration of suitable habitat in relation to total size. In comparison, the three Poole catchment sites (Rivers Frome, Sherford, and Piddle) had comparatively less suitable habitat in relation to the size of the site.

Finally, an estimation of how many beaver could be supported was required to answer all the questions set out in the objectives. Literature suggests that a beaver family (which consists of a breeding pair with sub-adults and juveniles) requires a minimum of 2km of wooded banks within a maximum of 11km of banks (Nolet and Rosell 1994). Similar territory ranges of 3.1-6.5km have been observed in Germany (Heidecke 1986 cited by South et al. 2001). Furthermore, investigations into reintroductions in Scotland and Norfolk applied high, medium, and low parameter values when predicting carrying capacity and beaver distribution (MacDonald et al. 2000, South et al. 2001). By using these numbers, and the low parameter value from the above papers (4km), an approximation of number of beavers the area could support was achieved. The five sites could support around 70 beaver families, or 280-350 individuals. It should be reminded that these numbers are a very rough estimation and should be taken as an indication rather than a precise calculation of carrying capacity for Dorset.

These findings answer the questions set out in the objectives, and provide a solid base for future research in Dorset. The results from paper highlight the general landscape pattern in the county, and reveal there are several areas with suitable habitat and high potential if a reintroduction were planned.

The results of this paper are important for several reasons, but an understanding of beaver dispersal patterns during reintroductions is helpful to appreciate this. At release, beavers disperse in a method known as ideal despotic distribution (Nolet and Rosell 1994), which means that areas with the highest quality habitat are sought out first, and sub-optimal habitat is expanded into later. Depending on location and density of optimal habitat, the population experiences high range expansion primarily, with population growth occurring after through space-filling (Calsbeek and Sinero 2002, Bartâk et al. 2013). This dispersal pattern of immediate range expansion in search of optimal habitat has also been observed in many European countries (Halley and Rosell 2002) such as Sweden (Hartman 2004) France (Fustec et al. 2001, Dewas et al. 2012), and the Czech Republic (John and Kostkan 2009, John et al. 2010). If this dispersal pattern is true, in the event of a reintroduction of beaver to Dorset, it can be assumed with some confidence that upon release, the released individuals would immediately disperse and end up in one of the five identified areas, depending on release location. This information is valuable as it would enable a degree of control over where the beavers disperse to. It has been suggested that beavers disperse further downstream than upstream (Heidecke 1984 cited by Barták et al. 2013), it has also been observed in several studies that damning and felling behaviour typically happens upstream, which is stimulated by sounds of water running over obstacles such as rocks or wood (Wilsson 1971 cited by MacDonald et al. 1995, Tayside Beaver Study Group 2015). For example, applying these findings from literature to a reintroduction to Dorset, the initial release site could be upstream of the River Frome or River Piddle (Figure 9). This would then allow immediate dispersal downstream into one of the three rivers within the Poole catchment area. Once colonisation occurs and population is stable, both upstream and downstream areas are available for damming and felling and further range expansion. Similarly, with the area in Stour catchment, the release site could be between the River Crane and Moors river (Figure 8), which would allow initial range expansion into optimal habitat both up and downstream.

This paper builds up on the current literature of using GIS to locate suitable habitat for beaver. This method was used prior to the Scottish Beaver Trial in several papers (Webb et al. 1997, MacDonald et al. 2000, South et al. 2000), as well as being adapted for a preliminary assessment in Norfolk (South et al. 2001). GIS was also used in studies in Austria (Maringer and Slotta-Bachmayr 2006) and the Czech Republic (John et al. 2010, Barták et al. 2013), however it is noteworthy that in these studies, beavers were already present, and GIS was used to predict where they were likely to spread to. Furthermore, a two-year study in Germany

(John and Klein 2003) used GIS to track changes in open water surface and wetland creation by beaver damming. These papers highlight the usefulness of GIS as a tool not only for reintroductions, but all stages of wildlife management. Similarly, GIS has been used in many studies in North America such as tracking nitrogen availability through beaver impoundment (pond creation) (Johnston and Naiman 1990), predicting colony density through monitoring impoundment trends (Broschart et al. 1989), locating areas for relocation of beaver to create habitat for waterfowl (McKinstry et al. 2001), and monitoring amphibian populations through mapping of beaver ponds (Stevens et al. 2007). While these studies concern the North American beaver, the intention is to highlight the importance of GIS as a management tool. Studies have also discussed similar benefits which would be applicable to Britain, such as landscape heterogeneity and species diversity (Rosell et al. 2005) through creation of dams which create complex environments (Stringer and Gaywood 2016). If beaver reintroduction continues in Britain, developing tools such as these that can quantify benefits the species provides will ensure everyone is behind the reintroduction, reducing potential conflicts. This paper shows a basic implementation of GIS, and the results should be taken as indications. Consequently, there are some limitations to the study.

Primarily, the criteria for optimal habitat was somewhat simplified. In comparison to some papers, water quality and level were not included in the criteria when designing the habitat map. In studies that used the habitat suitability index methodology (Allen 1983, Maringer and Slotta-Bachmayr 2006, Jones et al. 2009), one of the criteria that was required for optimal habitat was water level, stating that beaver colonisation depends on water level being more than 50cm and seasonally stable. While this is true, the Allen index, that was adapted for the European environment by these two papers, is originally designed for the North American beaver. In comparison to the large rivers there, the rivers in Dorset are comparatively small and calm. Water level and river bank slope do contribute to likelihood of beaver colonisation; however, due to this papers intention of being a preliminary assessment and indication of general landscape pattern, was left out to avoid over complication.

Another limitation of the study is the lack of a second assessment aspect in the methodology, such as population modelling or field surveys. While the aims and objectives of the paper are clear in that it is to be taken as an indicative and preliminary insight, if the study were to be repeated the inclusion of field surveys would likely provide additional accuracy and confidence in the results. Nevertheless, the lack of such does not negatively affect the results shown here. If field surveys were included, a standardised methodology for assessing areas on habitat suitability for beaver could be developed which would provide real benefit for future investigators.

Finally, the use of a 500m buffer is arguably inaccurate as beavers are unlikely to utilise habitat that far from the river. While beaver don't often disperse over land, it does occur, and due to the density and structure of rivers in Dorset, particularly in the Poole area, it was deemed possible that beaver may disperse over wooded land between the rivers and their streams and tributaries. Also, beavers are known to create canals which are used to move between dammed areas and for moving felled wood. Canal networks have been recorded amounting up to 420m (Stocker 1985 cited by MacDonald et al. 1995). A 500m buffer also allowed much better visualisation of results and inspection of the map to locate suitable areas, which better fit the aim and objectives of the study. In addition, in a similar study, a 500m buffer was included due to the potential inaccuracies of the source data, as both the Land Cover Map and Ordnance Survey river data are different resolutions and formats, so using a 500m buffer allowed for any discrepancies in alignment to be accounted for (Webb et al. 1997). Furthermore, no consideration is given to the quality of habitat being analysed. The classification used by the Land Cover Map does not provide any data on which species make up broadleaf woodland. Also, it has been found that the Land Cover Map is roughly 79-84% accurate due to spectral miss-classification and field surveyor mistakes (Fuller et al. 1998). This concludes that while a smaller buffer may have provided more accurate numbers, the use of a 500m buffer provided better visualisation of landscape pattern, and potentially accounted for any errors and discrepancies with the source data. It is less of a limitation rather than something that should be noted when considering the numbers provided in the results.

Following the positive widespread reintroduction of the species across Europe (Halley and Rosell 2002, Halley et al. 2012), the discussion surrounding beaver in Britain has been a source of controversy and debate for years, particularly after the success of the Scottish Beaver Trial (Gaywood et al. 2015) and the consequent support from Scottish Government in support of this, declaring formal recognition as a native species and encouraging further additions to the population (Scottish Wildlife Trust 2017). A major contribution to this discussion in the past was a legal obligation under European Law to reintroduce species, in the form of Bern Convention 1979 and Convention on Biological Diversity 1992 (Rees 2001). However, as of the 29th March 2017, Article 50 was triggered, formally indicating Britain's intention to the European Union. What this means for the reintroduction of the beaver, and other species, is yet unknown, as national law does not impose the same obligations to reintroduce. The Countryside Rights of Way Act 2000 highlights the need to restore and enhance certain priority species that appear on the UK Biodiversity Action Plan, however this does not include any nationally extinct species (Joint Nature Conservation Committee, 2016). It is likely that reintroductions will continue to be trialled in England and Wales following Scotland's lead, whether there is a legal obligation or not, as there are benefits for the Government such as providing income from wildlife tourism, as the public often widely support reintroductions, particularly if a species is 'likeable' or charismatic (Arts et al. 2012). Consequently, many papers have been published the detailing reintroducing species to the United Kingdom (Wilson 2004, Hayward and Somers 2009, Brown et al. 2011, Pillai and Heptinstall 2013), such as; boar *(Sus scrofa)* (Howells and Edwards-Jones 1997, Leaper et al. 1999), lynx *(Lynx lynx)* (Hetherington and Gorman 2007) and wolves *(Canis lupus)* (Williams et al. 2002, Manning et al. 2009, Sandom et al. 2012). While these propositions are met with some debate, particularly in the case of predators like lynx and wolves, beaver is met with somewhat less opposition. Though there is disagreement from some parties, particularly those invested in agriculture and fisheries (Collen and Gibson 2000, Kemp et al. 2012) due to the beaver's dam building behaviour, there are many papers outlining the benefits such as flood risk mitigation and sustainable water quality management (Puttock et al. 2015, Brazier et al. 2016). Considering the arguments for and against reintroducing beaver, any potential trial should be carefully considered before implementation. It may be necessary to afford additional protection to beaver under national law to reduce any potential conflicts with humans (Pillai and Heptinstall 2013), particularly in agricultural areas, and sourcing suitable stock prior to reintroduction is essential to reduce the risk of inbreeding and protect the population for future expansion (Ducroz et al. 2005, Halley 2011).

5 Conclusion

This paper demonstrates that Dorset has suitable habitat that is fragmented but occurs throughout the county. The aim and objectives of the study have been met with promising results. Five sites were identified as having optimal habitat, and it was estimated these sites could support an estimated 70 families, or 280-350 individuals between them. While the results from this study are more indicative of the general condition of landscape in Dorset rather than exact delineations, they are nevertheless important, and any more precise investigation of the area is likely to result in the same areas being highlighted. It is recommended that future investigations begin with more detailed field surveys of the five sites, due to the original data not providing any information on quality of broadleaf woodland habitat or what species are present. Following this, population modelling could be adapted from several studies cited throughout this paper to gain a more accurate estimation of carrying capacity for the areas. For future investigations into other areas, a combination of GIS mapping and field surveys is suggested as the approach to planning reintroductions, as well species management in general.

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7 Appendices

7.1 Evaluative supplement

Overall, the project was a success for several reasons. Firstly, the results are what I hoped for, and with any luck they will be utilised in the future. Secondly, the project required me to learn several new skills which will be invaluable if I progress further in education or pursue a job in this field. Additionally, I have gained a lot of knowledge of the ecology of beaver, which is currently of value given it is now formally recognised as a native species in Scotland and the population will continue to grow.

To begin with, there are some limitations to the project. In terms of writing a dissertation, for many students a large part of that is performing some original data collection and analysis, which this did not include. However, given the topic and theoretical nature of the study, this was not possible anyway. The data from the Land Cover Map was almost perfect in that it enabled all the objectives to be met, however no information or detail is provided regarding each habitat. There is a manual to accompany the data set, which describes the requirements each habitat met to be classified, which in the case of broadleaved woodland was that stands were greater than 5m high, and tree cover greater than 20%. What it does not include is identification of species present, which would have provided more criteria to rank sites on, such as presence of willow.

The main limitation is the lack of a second methodology aspect, such as field surveys. Initially, field surveys were planned and outlined in my learning contract and research proposal, which were included due to my lack of experience using GIS, and I believed I wouldn't be able to meet all the objectives with that alone. However, after meeting with my supervisor, he suggested some changes and improvements to the map, and due to my progress with GIS, field surveys were not included. Additionally, around Christmas I had several problems with my car, which would have made conducting surveys extremely difficult regardless. The absence of field surveys it not a limitation as it does not decrease the value of my work or the results, however in hindsight if the study were repeated the addition of field surveys would undoubtedly add value.

An additional limitation was discussed already in that use of a 500m buffer is arguably incorrect, as beaver are unlikely to use land that far from water. I chose to use a 500m buffer for several reasons. Firstly, as the aim of the paper was not to provide precise numbers, the potential 'inaccuracy' of the numbers gained from using a 500m buffer is not detrimental. Secondly, I did experiment with running a 100m buffer in QGIS. This would have made the numbers I provided more accurate in the sense that beaver would potentially utilise all the habitat within 100m, it impacted on my ability to locate suitable areas in the habitat map, as the buffer was so small.

The benefit of focusing on GIS is that I have gained some degree of proficiency in the program, which is something to be proud of given that I did not take the GIS unit and prior to this project have only used it in very basic ways, usually by following instructions included within assignment guidance. In addition to GIS, I used a complementary program called FRAGSTATS, which performs statistical analysis on map data. Initially, this program caused me several problems and I could not get my head around the documentation provided. I discovered the issue was the resolution of the habitat map I produced in QGIS was too fine, and by increasing the resolution FRAGSTATS could process the information without crashing or freezing.

The strengths of the project are that the findings have potential benefits for future research. Primarily, the direct result of recognising sites in Dorset that have suitable habitat. If further investigations continue, either by myself or others, having areas of focus already identified is very valuable. Field surveys of the five sites would not be very time consuming and assuming the results verify the conclusions from this paper, the initial planning phase of locating suitable sites would be relatively straight forward. Furthermore, any similar papers in the future would be recommended to utilise GIS as a tool for locating suitable habitat. Depending on proficiency level in the program, developing a habitat map is not a huge undertaking, and the result is very useful. Use of GIS in combination with field surveys should be the standardised method for assessment of habitat suitability of an area, and it is important for somebody to develop a template for this methodology for others to use and apply to new locations.

At the time of writing, I have applied for and been offered a conditional place on the MSc Biodiversity Conservation here at Bournemouth University.

While I am unsure if I will continue with education, as I originally intended to pursue a career straight after university, it seemed prudent to have the option. If I do choose to do this course, the potential for more work in this topic is huge. It would be extremely interesting to develop the standardised methodology that I have discussed, as well as applying further research to the five sites I identified in the results of this paper, to provide a more accurate and influential submission to the field.

In summary, this project has several limitations, though it is my belief that the strengths outweigh these. As I have opened the paper with the recommendation that the results be taken as an indication of general pattern rather than statements of fact, the shortcomings are addressed, and results still provide value. In addition to the results, the skills and knowledge gained from undertaking this research are invaluable for my future. I now have a solid basic understanding of GIS and FRAGSTATS, which I could further progress myself through study, as well as a quite thorough knowledge of beaver ecology. Given the likelihood of beaver reintroductions continuing in the UK, I am hopeful that this project will enable me to contribute to this in some form.

7.2 Research Proposal

Introduction

The aim of this dissertation is to determine the feasibility of a trial reintroduction of European beaver *(Castor fiber)* in Dorset. It does not have the intention of saying whether a reintroduction *should* be implemented, merely to establish whether it is possible.

Objectives:

1. Locate areas of potential habitat through some form of mapping or image analysis
2. Conduct small, preliminary surveys on any areas that may be viable
3. Assess likely sites in further detail if suitable
4. Determine likelihood of success of reintroduction

Literature Review

Under Europe's Habitats and Species Directive, all member states are obligated to duly consider reintroductions of all extinct native species. Since the trial reintroduction of European beaver in Knapdale, Scotland, that began in 2009, there has been much talk of further trials within England and Wales. As well as this, beaver have seen further reintroductions and some natural spread within Europe (Halley and Rosell, 2003) which provides a wealth of research for the UK to draw on before attempting more trials.

While it is often the first thought to consider potential habitat for reintroductions and how the species to fare, it is also imperative to investigate the greater picture and wider effects of the reintroduction. Prior to the Knapdale trial, the idea was met with some strong disagreement, from land users such as farmers and estate owners. Their case was the land modification from beaver dams and burrows would cause problems, particularly flooding. While this is certainly a possibility and understandably threatening, the experiences of beaver reintroductions in Europe and modernisation of farming means this is manageable most of the time (Campbell-Palmer and Jones, 2014). In contrast, there have been many studies surrounding the benefits of beaver to the environment, as they create habitat which is uncommon in their absence and benefits many species.

Woodland is unlikely to decline, as willow and aspen were both found to regenerate rapidly even in the presence of roe deer browsing (Jones et al., 2009). As well as this, contrary to popular belief, beavers are thought to benefit local freshwater fish populations, through creation of rearing and over-wintering habitat as well as stimulating invertebrate production (Kemp et al., 2011). Benefits are also found in humans, with ecotourism being a massive boon for local business and areas when a reintroduction like this is established, particularly in the case of a larger mammal (Macdonald et al., 1995).

There are also more long-term objectives to consider surrounding a reintroduction. Sourcing individuals that meet certain criteria to be successfully reintroduced poses quite a problem. Beavers lack any significant differences in terms of physiology or morphology which makes the task a little easier, however it is still difficult to obtain specimens which are genetically suitable for reintroduction. Since Scotland already has some established beaver populations in the form of the Knapdale trial as well as a reported wild colony on the River Tay, it is pivotal for any reintroduction within England or Wales to consider sourcing of individuals with applicable DNA that will not damage the gene pool if all trials are successful and beavers are eventually fully established within the UK (Halley, 2010).

Methodology

The methodology for this dissertation will involve adapting methods outlined in two similar papers, which is shown in the objectives section of this proposal: Reintroduction of the European beaver *(Castor fiber)* to Norfolk, U.K.: a preliminary modelling analysis, and Reintroducing the beaver (*Castor fiber*) to Scotland: a protocol for identifying and assessing suitable release sites.

Initially, the Bournemouth area and Dorset generally will be analysed for potential beaver habitat sites via satellite imagery and GIS if available. It has been shown that minimum habitat for a single beaver family, including juveniles and sub-adults, is 2km of wooded river banks within a maximum of 11km river banks in general (Macdonald et al., 2000). Once suitable areas have been identified, surveys of the sites will begin. To ensure continuity from site to site, a standardised survey method will be developed which will enable quick yet effective categorisation of the site as suitable or unsuitable. Parameters which will be

looked at will include physical properties of the watercourse, bank, vegetation and woodland, as well as human access and disturbance and adjacent land use (Natural England, 2009).
After the initial survey stage, any sites that hold potential will be compared and modelled with information provided from previous research that can be adapted to this study (South et al., 2001).

Timetable

08/08-14/08/2016

Complete analysis of map and images to locate potential beaver habitat in preparation for initial surveys.

31/08/2016

Depending on number of sites identified in Objective 1, as well as distance from Bournemouth, aim to complete all preliminary surveys by end of August.

12/09-23/09/2016

Aim to meet or email supervisor in first week of Semester 1 to discuss which sites surveyed in Objective 2 show enough potential to progress to Objective 3.

03/10-14/10/2016

First interim interview with supervisor in fourth week of Semester 1, which should see Objective 3 being completed.

02/01/2017

Aim to have Objective 4 complete by the start of Semester 2, answering the research question and enabling write-up to begin.

11/04-15/04/2016

Final draft submitted to supervisor for consideration, Week 40 of Level H.

09/05-13/05/2016

Final version submission deadline, Week 44 of Level H.

References

Campbell-Palmer, R. and Jones, S. (2014). Bringing beavers back. *The Glasgow Naturalist*, 26 (1), 46-48.

Halley, D. (2010). Sourcing Eurasian beaver Castor fiber stock for reintroductions in Great Britain and Western Europe. *Mammal Review*, 41 (1), 40-53.

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7.3 Interim meeting notes

Independent Research Project Interim Interview: Agreed Comments Form

Student Name: James Thornton	Programme: EWC
Date: 06/12/2016	IRP Title: Feasibility of a trial reintroduction of Castor fiber (Eurasian beaver) in Dorset
Supervisor Name: Adrian Newton	

Map is a good start and follows proposed method adapted from previous papers. Dorset has quite a lot of potentially viable areas and looks promising for write-up.

More research is required to include more detailed analysis either within the map itself via layers, such as in depth habitat requirements etc via buffering, or field work to gain first hand habitat information.

Currently on track, with writing originally timetabled to begin after Christmas break. Aim is to have map completed or at least more fleshed out for beginning of second semester.

Two copies of this form are needed – student to retain one copy the other is to be handed in to the student admin office C114.

Student Signature:	Supervisor Signature:

7.4 Learning contract

LEARNING CONTRACT: INDEPENDENT RESEARCH PROJECT

Student Name:	**James Thornton**
Degree Programme:	Ecology and Wildlife Conservation
Proposed Project Title:	Feasibility of a trial reintroduction of European beaver *(Castor fiber)* in Dorset
Supervisor:	Adrian Newton

Research Proposal Attached ☐ **YES** ☐ **NO** **and includes:**

☐ **YES** ☐ **NO** **Risk Assessment for fieldwork and evidence of COSSH assessment for all laboratory procedures (online risk assessment completed)**

☐ **YES** ☐ **NO** **Completed booking forms for all field equipment**

☐ **YES** ☐ **NO** **Letters of permission where appropriate providing evidence of access to such things as field sites and/or museum archives**

☐ **YES** ☐ **NO** **Completed Ethics Checklist**

Copies of all relevant forms may be found on myBU - SciTech tab - Projects - Project Forms

INTERIM INTERVIEW – Progress evaluation

The nature of this review should be clearly defined and agreed. Please complete the box below with the agreed details including the agreed submission date which is normally the first week of November in Level 6/H. Submission is via a formal tutorial with the supervisor.

Assessment Due:

FINAL ASSESSMENT – RESEARCH PAPER/REPORT

This assessment is normally governed by the guidance provided in the Independent Research Project Guide. Any variance in terms of format and word limit should be agreed and specified in the box below. Submission date cannot however be changed unless evidence of mitigating circumstances are provided in accordance with the standard BU Guidelines.

As the student undertaking the above project I agree to:

- E-mail my supervisor on a fortnightly basis with a progress report
- Meet with my supervisor at least once a month to discuss progress and I understand that it is my responsibility to organise these meetings
- Comply with the terms of this learning contract and the guidance set out in the Guide to Independent Research Projects
- I understand that this is an *independent* project and that I am solely responsible for its completion
- I agree to comply with all laboratory and fieldwork protocols established by the Faculty.

As the supervisor of this project I agree to:

- Meet with the student undertaking this project on at least a monthly basis and to respond to the progress e-mails as appropriate
- To meet formally with the student during the first week in November to undertake the interim interview
- To provide guidance and support to the student undertaking this project bearing in mind that it is an *independent* research project. This is inclusive of commenting on drafts of the final report in a timely fashion.

Both of the undersigned parties agree to be bound by this learning contract:	
Student Signature:	
PRINT NAME:	
Date:	

Supervisor Signature:	
PRINT NAME:	
Date:	

When completed, this form should be handed in to SciTech Admin (C114) and a copy retained by the student to be included in an appendix to the final IRP document.

7.5 Risk assessment

REF SciTech- /

Faculty of Science & Technology

RECORD OF RISK ASSESSMENT

NAME:	James Thornton	**PROGRAMME(S) OR PROJECT:**	Ecology and Wildlife Conservation
MOBILE TEL NOS:	07961283346 *Please note that mobile must be kept on at all times*	**PROJECT AUTHORISATION:**	***F&R/IPO Signature:***
TITLE OF ACTIVITY:	IRP Fieldwork - surveying potential beaver habit	**DATE(S) OF ACTIVITY:**	14-31/08/2016 and 23/09-14/10/2016
LOCATION:	Various locations around Dorset	**DATE OF ASSESSMENT:**	09/05-13/05/2016
EQUIPMENT:	N/A	**VEHICLE HIRE:**	N/A

HAZARD/RISK	PERSONS AT RISK	RISK			ACTION		
		A PROBABILITY (5)	B SEVERITY (5)	(A * B)	WHAT	WHO	WHEN
Road accident/collision	Members of public, myself	1	5	5	Ensure safe driving at all times, car is well maintained and functioning	Myself	Before and during travel
Working near water, falling in, drowning	Myself	1	5	5	Wear adequate footwear to avoid slipping, do not work too close to water, ensure someone knows where you are working that day	Myself	Preparing for and during fieldwork
Exposure to sun	Myself	3	2	6	Wear sun screen and hat and long sleeves if necessary, take regular breaks to avoid sun burn or rash	Myself	Preparing for and during fieldwork
Dehydration	Myself	2	3	6	Pack suitable amount of water before beginning field work and as above always take regular breaks to stay hydrated	Myself	Preparing for and during fieldwork
Insect bites	Myself	2	2	4	Apply insect repellant and wear long sleeves and trousers if deemed necessary	Myself	Preparing for and during fieldwork
Seasonal allergies	Myself	4	1	4	Take antihistamines and check pollen count before travelling	Myself	Prior to fieldwork
Slipping, tripping on uneven ground	Myself	2	2	4	Wear adequate footwear to avoid slipping	Myself	Prior to fieldwork
Getting lost	Myself	1	1	1	Ensure phone and GPS are charged prior to leaving and somebody is aware of where you are working and when you plan to return	Myself	Prior to fieldwork
Unexpected weather	Myself	1	2	2	Check weather forecast prior to travel and keep suitable clothes for extreme circumstances in vehicle	Myself	Prior to fieldwork

ACTIVITY LEADER SIGNATURE: ______________________ **DATE:** ______________

7.6 Ethics checklist

Bournemouth University

Note: ***All researchers*** must complete this brief checklist to identify any ethical issues associated with their research. Before completing, please refer to the BU *Research Ethics Code of Practice* which can be found www.bournemouth.ac.uk/researchethics. School Research Ethics Representatives (or Supervisors in the case of students) can advise on appropriate professional judgement in this review. A list of Representatives can be found at the aforementioned webpage.
Sections 1-5 must be completed by the researcher and Section 6 by School Ethics

1 RESEARCHER DETAILS						
Name	James Thornton					
Email	I7624936@bournemouth.ac.uk					
Status	☐ **Undergraduate**		☐ **Postgraduate**		☐ **Staff**	
School	☐ **BS**	☐ **AS**	☐ **DEC**	☐ **HSC**	☐ **MS**	☐ **ST**
Degree Framework & Programme	Ecology and Wildlife Conservation					
2 PROJECT DETAILS						
Project Title	Feasibility of a trial reintroduction of European beaver *(Castor fiber)* in Dorset					
Project Summary ***Sufficient detail is needed; include methodology, sample, outcomes etc***	Determine the extent and distribution of suitable beaver habitat in Dorset through GIS mapping and/or field surveys if required. Also, some form of population modelling/prediction of carrying capacity if possible. Results hopefully indicate there are suitable areas for a future reintroduction of the species.					
Proposed Start & End Dates	08/08-2016-11/05/2017					
Project Supervisor	Adrian Newton					
Framework Project Co-ordinator						

3 ETHICS REVIEW CHECKLIST – PART A			
I	Is approval from an external Research Ethics Committee (e.g. Local Research Ethics Committee (REC), NHS REC) required/sought?	☐ **Yes**	☐ **No**
II	Is the research solely literature-based?	☐ **Yes**	☐ **No**
III	Does the research involve the use of any dangerous substances, including radioactive materials?	☐ **Yes**	☐ **No**
IV	Does the research involve the use of any potentially dangerous equipment?	☐ **Yes**	☐ **No**
V	Could conflicts of interest arise between the source of funding and the potential outcomes of the research? (see section 8 of BU Research Ethics Code of Practice).	☐ **Yes**	☐ **No**
VI	Is it likely that the research will put any of the following at risk: Living creatures?	☐ **Yes**	☐ **No**
	Stakeholders?	☐ **Yes**	☐ **No**
	Researchers?	☐ **Yes**	☐ **No**
	Participants?	☐ **Yes**	☐ **No**

Research Ethics Checklist (Graduate School & CRE) December 2010

	The environment?	☐ Yes	☐ No
	The economy?	☐ Yes	☐ No
VII	Does the research involve experimentation on any of the following: Animals?	☐ Yes	☐ No
	Animal tissues?	☐ Yes	☐ No
	Human tissues (including blood, fluid, skin, cell lines)?	☐ Yes	☐ No
	Genetically modified organisms?	☐ Yes	☐ No
V11 1	Will the research involve prolonged or repetitive testing, or the collection of audio, photographic or video materials?	☐ Yes	☐ No
IX	Could the research induce psychological stress or anxiety, cause harm or have negative consequences for the participants or researcher (beyond the risks encountered in normal life)?	☐ Yes	☐ No
X	Will the study involve discussion of sensitive topics (e.g. sexual activity, drug use, criminal activity)?	☐ Yes	☐ No
XI	Will financial inducements be offered (other than reasonable expenses/ compensation for time)?	☐ Yes	☐ No
XII	Will it be necessary for the participants to take part in the study without their knowledge / consent at the time?	☐ Yes	☐ No
XII	Are there problems with the participant's right to remain anonymous?	☐ Yes	☐ No
XIV	Does the research *specifically* involve participants who may be vulnerable?	☐ Yes	☐ No
XV	Might the research involve participants who may lack the capacity to decide or to give informed consent to their involvement?	☐ Yes	☐ No

4 ETHICS REVIEW CHECKLIST – PART B

Please give a summary of the ethical issues and any action that will be taken to address these.

Ethical Issue:	**Action:**

5 RESEARCHER STATEMENT

I believe the information I have given is correct. I have read and understood the BU Research Ethics Code of Practice, discussed relevant insurance issues, performed a health & safety evaluation/ risk assessment and discussed any issues/ concerns with a School Ethics Representative/ Supervisor. I understand that if any substantial changes are made to the research (including methodology, sample etc), then I must notify my School Research Ethics Representative/ Supervisor and may need to submit a revised Initial Research Ethics Checklist. By submitting this form electronically I am confirming the information is accurate to my best knowledge.

Signed		**Date**	

6 AFFIRMATION BY SCHOOL RESEARCH ETHICS REPRESENTATIVE/ SUPERVISOR

Satisfied with the accuracy of the research project ethical statement, I believe that the appropriate action is:

The research project proceeds in its present form	☐ Yes	☐ No
The research project proposal needs further assessment under the School Ethics procedure*	☐ Yes	☐ No

The research project needs to be returned to the applicant for modification prior to further action*	☐ **Yes**	☐ **No**
** The School is reminded that it is their responsibility to ensure that no project proceeds without appropriate assessment of ethical issues. In extreme cases, this can require processing by the School or University's Research Ethics Committee or by relevant external bodies.*		

Reviewer Signature		**Date**	
Additional Comments			