Assessing Beaver Reintroduction through Geospatial Analysis in the River Lowther, Cumbria

1. Introduction

The reintroduction of beavers to the River Lowther catchment represents a significant opportunity to enhance ecosystem health, reduce flooding, and increase biodiversity (Gaywood et al., 2016; Wright et al., 2002). However, it is important to note that their activities may also threaten infrastructure, agriculture and the fish that swim upstream (Auster et al., 2020; Wohl, 2013). To assist the Lowther Rivers Trust in making an informed decision, this report examines the maximum number of beaver dams the catchment can support. This is achieved by analysing key ecological and human factors using geospatial technology.

The River Lowther is in Cumbria, North-West England. The catchment is rich in broadleaf woodland along the river, which is very important to beavers for foraging and dam building (Kimball & Perry, 2008). However, because the habitats are all distributed and close to human areas, it's important to be careful about where we place sites to balance the benefits to the environment with the risks to people and the economy.

The objectives of this report are mainly on:

- Identifying river segments that meet the habitat requirements for beavers (for example, areas with a gentle slope of 17% or less and rich broadleaf woodland within 30 to 100 meters of the river).
- Assessing the risks associated with proximity to urban areas by considering different buffer distances (150 m versus 400 m).
- Delivering practical, map-supported recommendations that can help guide the decision-making process for beaver reintroduction.

2. Data Processing

2.1. Data Source

This analysis integrates multi-source geospatial data obtained from Moodle and Digimap, which have been carefully quality controlled and standardized. The key datasets include:

- Digimap, Land Cover 2023: Define broadleaf woodland (AC=1) and built-up & gardens areas (AC=10). It follows the standards set out by the UKCEH (2023).
- Digimap, Digital Terrain Model (DTM): Calculate slope (%), which is divided into three categories: <17%, 17–23%, and >23% (Macfarlane et al., 2017).
- Digimap, 1:25k/1:50k OS basemap: Provide topographic context for spatial visualization.
- Moodle, National River Centreline: Vector data of river networks for spatial distribution analysis.
- Moodle, Catchment: Clip all data layers to the Lowther catchment.

2.2. Data Analysis

The workflow combines automation (Model Builder) and manual validation in ArcGIS Pro (Figure 1):

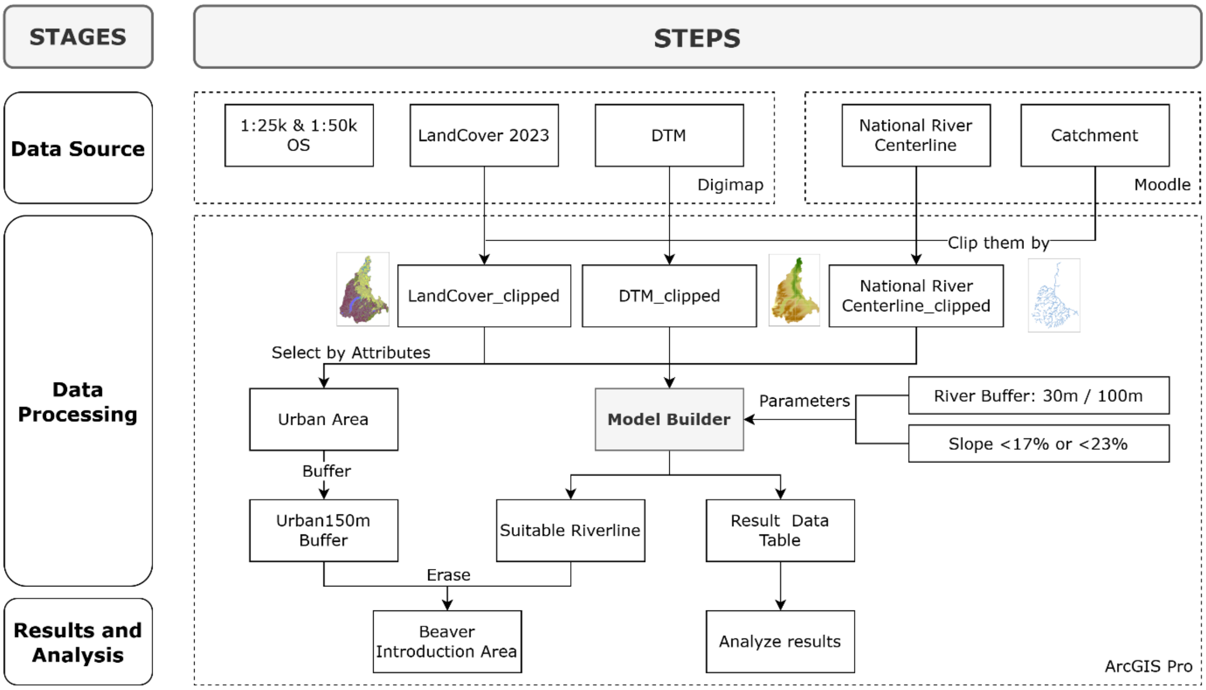

Figure 1 Flow Chart of Beaver Reintroduction Project

Clip all layers to the catchment boundary to focus on the study area, and then automate the analysis process to obtain suitable reaches by model builder. Details of the model builder in ArcGIS Pro are following:

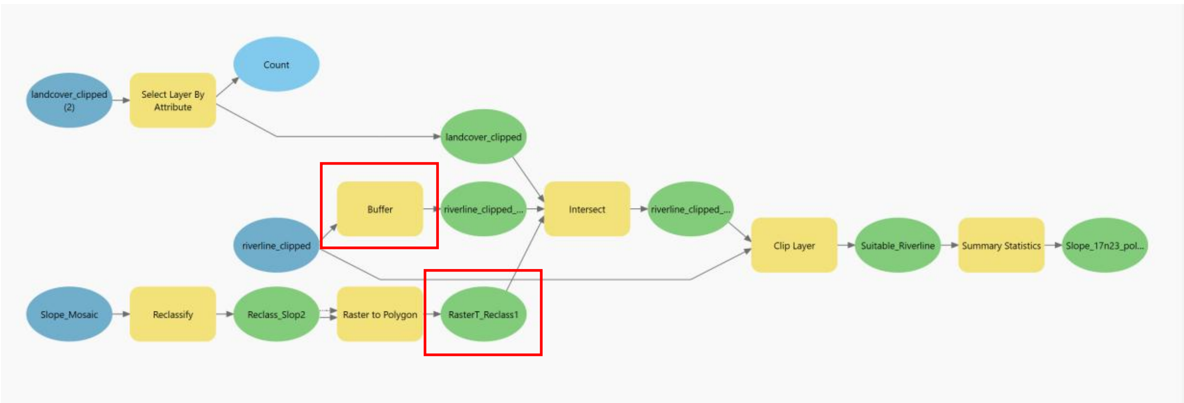

Figure 2 Model Builder Details

- Broadleaf woodland was extracted using *Select by Attributes* tool (AC=1), ensuring alignment with beaver habitat preferences.
- Slope was calculated from the DTM, reclassified into three tiers (<17%, 17%-23%, >23%), and converted to polygons to spatially constrain suitable zones.
- Buffers of 30 m and 100 m were generated around riverlines to model foraging ranges (Barnes and Malik, 2001; Allen, 1983).
- Intersection of vegetation, slope, and buffer layers identified composite areas meeting all ecological criteria.
- Suitable river segments were clipped to retain only those fully within composite zones.
- Total and average lengths of suitable segments were calculated using Summary Statistics.

- Sensitivity analyses tested parameter impacts (e.g., slope <17% vs. <23%, buffer widths), revealing minimal variation in outcomes.

3. Key Methodological Steps Explanation

3.1. Landcover Classification Basis

Denney (1952) and Kimball & Perry (2008) both pointed out that broadleaf woodland is the preferred habitat for beavers. According to their product document, the Aggregate Class (AC) Identifier (represented in the attribute table as the _agg field) assigns a value of 1 to Broadleaf Woodland and a value of 10 to Built-up Areas and Gardens. So, when clipping the data, we use values of 1 for areas where beavers can live (broadleaf woodland) and values of 10 for urban and suburban areas.

UKCEH Aggregate Class (AC)	AC Identifier	UK BAP Broad Habitat	UKCEH Land Cover Class	LC Identifier
Broadleaf woodland	1	*Broadleaved mixed and yew woodland*	Deciduous woodland	1
Built-up areas and gardens	10	*Built-up areas and gardens*	Urban Suburban	20 21

3.2. Slope Processing

When converting the slope raster to polygon, the “simplify the polygon” option was not selected. This decision might cause a minor impact on the final result, but the overall influence is minimal.

3.3. Riverline: The choice between clip and intersect

The Clip tool ensures that parts of the river remain connected, which is important for statistics (such as the need for at least 400m of continuous habitat). This is better than using the Intersect tool, which makes parts of the river that do not meet. Using the Intersect tool could split the river line, which would lead to problems and make it more difficult to manage.

3.4. Buffer Distance

The vegetation buffer is set to 30 meters based on vegetation requirements. Barnes & Malik (2001) indicate that beavers primarily utilize vegetation within 30 meters, although an extension to 100 meters is acceptable (Allen, 1983). Observations from the OS background map reveal that the vegetation adjacent to water bodies is relatively scattered; therefore, there is minimal difference in outcomes between a 30 m and a 100 m buffer.

For urban risk, a buffer of 400 meters is established. Although the Lab 4 scenario guidelines suggested an urban buffer of 150 m due to infrastructure risks (Macfarlane et al., 2017, show that beaver activity can impact areas up to 150 m from their dams), a 400 m buffer was chosen based on several considerations:

- The study area does not contain a continuous 2 km river reach that meets the requirement.
- Beaver activity has been based on territorial reaches up to 2 km as noted by Gurnell et al., 2008, but typically recorded at 400 m.
- The areas of interest within the study region are generally small and densely distributed, making a 400 m analysis standard more appropriate.

4. Results

4.1. Recommended Beaver Reintroduction Sites (Figure.3)

The River Lowther catchment shows that it is partly suitable for beavers to be reintroduced, with four river reaches (IDs 1-4) meeting all the ecological criteria (Figure 3, Table 1). Segment 3 (803.71 m) is the longest continuous habitat available, making it the ideal location for establishing a beaver colony. Its extended length increases the likelihood of successful dam construction and long-term colony sustainability.

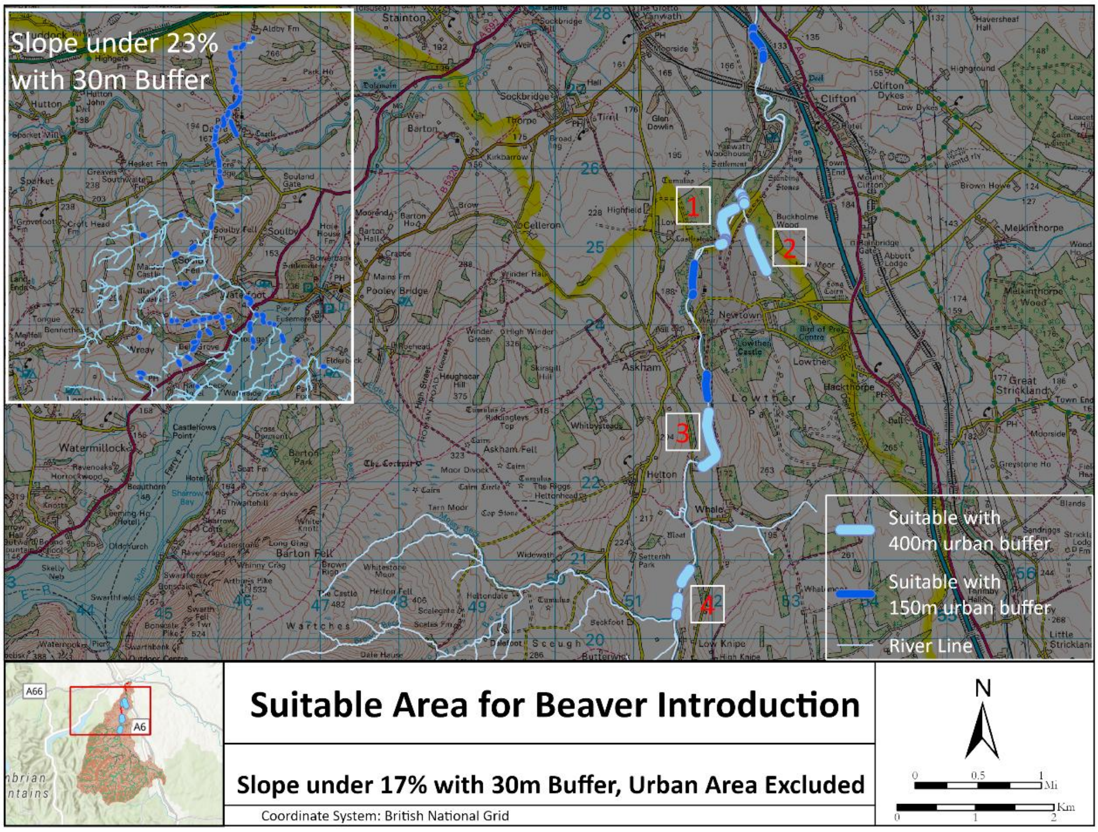

Figure 3 Suitable Area for Beaver Reintroduction

- Low Slope (≤17%), ensuring stable dam construction (Curtis & Jensen, 2004).
- Adequate Vegetation: Broadleaf woodland within 30–100 m (Kimball & Perry, 2008).
- Minimal Infrastructure Risk: >400 m from urban zones, reducing conflict (Auster et al., 2020).
- Excluded sites (IDs 5–7): Initially met habitat criteria under a 150 m urban buffer but were excluded under the 400 m buffer due to proximity to built-up areas (shown in dark blue on the map).

Object ID	Reach Length(m)
1	568.59
2	625.07
3	803.71
4	407.22
5*	388.82

6*	339.34
7*	314.86

*Excluded due to urban proximity

Table 1 Length of Suitable Reaches

4.2. Scenario Comparison (Slope and Buffer Variations)

To assess parameter sensitivity, three scenarios were tested (Table 2):

- 30 m vs. 100 m Vegetation Buffers: No significant difference in outcomes, as riparian broadleaf woodland in the Lowther catchment is sparse and fragmented.
- Impact of Slope Thresholds: It identified 86 reaches under 17% slope, while increasing suitable reaches by 4 segments (total length: 13,877.33 m), mainly in southern steeper areas under 23% slope. Southern segments were omitted from final recommendations due to higher urbanization risks.

	Attributes Settings	Number of Reaches	Total Length (m)	Mean Length (m)
1	Slope under 17% with 30m buffer	86	12673.87	147.37
2	Slope under 17% with 100m buffer	86	12673.87	147.37
3	Slope under 23% with 30m buffer	90	13877.33	154.19
4	Slope under 23% with 100m buffer	90	13877.33	154.19
5	Slope under 17% with 30m buffer Urban area excluded	76	10505.25	138.23

Table 2 Sensitivity in Different Scenarios

5. Discussion and Limitations

Multi-criteria analysis, integrating slope, vegetation, and infrastructure factors, ensured integral habitat assessment. What is more, the application of scenario testing increased the clarity and reliability of parameter selection. However, there are several areas where further improvements could significantly enhance the depth and Professionalism:

- Data Constraints: Although slope was taken as a measure of the suitability of the area for dam construction, the study did not include information on water depth. As Gurnell et al. (2008) stated, at least 1 metre of water is needed to ensure that the entrance to the lodge stays underwater. In future studies, it would be beneficial to include more detailed information about the water, such as its depth and the speed of its movement.
- Methodological improvements: The decision to use clip rather than intersect tools ensured that stream segments remained intact, which is necessary to maintain the continued reach required for beaver habitat (≥400 m continuous reach). However, this might lead to the accidental exclusion of marginally suitable segments along the boundaries.
- Process optimization: Because of network limits and environmental setup limitation, the analysis was performed using ArcGIS Model Builder rather than an automated Python script. In future studies, the automation of workflows using Python has the potential to make processing more efficient, reduce the potential for human error and improve reproducibility.
- Map visualization: To improve visual clarity, future studies should involve high-resolution basemaps, such as aerial imagery. Moreover, the areas of potential conflict between beaver activity and human infrastructure would be better illustrated by enhancing the maps with clearly labelled key infrastructure elements (e.g. roads and culverts within 400m buffers).

- User-friendly design: The creation of interactive web maps could serve as a user-friendly tool for non-GIS users, facilitating more intuitive exploration of spatial data and comprehension of the recommendations.

6. Conclusion

A thorough analysis of the Lowther River area has identified four sites that meet the selection criteria and have generated decision support maps for beaver reintroduction. It shows that these sites not only meet the ecological requirements, such as low slope conditions, sufficient nearby broadleaf woodland, and safe distances from urban areas, but also offer continuous river reaches that are essential for the construction of stable beaver dams (Gaywood et al. 2016). In particular, segment 3 of 803.71m is considered to be a prime location for the establishment of a beaver settlement.

Overall, the study supports the reintroduction of beavers into the River Lowther catchment, but with a focus on monitoring and managing their impact on local flood risk and fish migration. The decision support maps generated in this report provide a clear visual framework to aid stakeholders with social and ecological considerations.

7. References

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