Considerations for the use of Electric Fencing in Beaver Mitigation

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Natural England Commissioned Report NECR600
March 2025

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Catalogue code: NECR600

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Keywords

Appropriate use, crop protection, culverts, dam building, effectiveness, electric fencing, Eurasian beaver, exclusion, infrastructure retention, welfare, use, impacts on other species, mitigation.

Acknowledgements

We gratefully acknowledge the advice, help and review of Gerhard Schwab, Derek Gow and Professor Frank Rosell, Dr Giles Wagstaff, Dr Claire Howe, Jake Chant, Matt Heydon of Natural England, and feedback from Devon Wildlife Trust and other practitioners.

Citation

Campbell-Palmer, R, Pizzi, R, 2024, Review of the Use of Electric Fencing in Beaver mitigation. Natural England Commissioned Report NECR600. Peterborough.

Foreword

This Commissioned Report is to inform best practice guidance, in relation to the use of electric fencing as a beaver mitigation technique. Some processes will be associated with licensable activity (eg, release/translocation) and some not. This report also provides a source of referenced evidence for current best practice and recommendations for assessing efficacy and welfare implications to inform future best practice.

Electric fencing is typically deployed as a retention or deterrent tool to keep a specified target animal species within a prescribed area or to exclude a target species from a prescribed area. They have been used to reduce or prevent damage to crops and gardens by wildlife, etc, and successfully in conservation, eg, to deter predators. It is a common non-lethal mitigation method as a deterrent for some species which is seen as reliable and economical but for beaver this should only be used for limited and specific purposes. There are mandatory guidelines on British welfare standards which must be followed, the details of which are outside the scope of this review. Improperly maintained or designed fences can seriously injure or kill animals.

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Contents

1.0 Aim of Review

- To inform best practice guidance in relation to the use of electric fencing as a beaver mitigation technique. Some processes will be associated with licensable activity (eg, release/translocation) and some not.
- To have a source of referenced evidence for current best practice and recommendations for assessing efficacy and welfare implications to inform future best practice.
- To ensure consistency in advice, application and training.

1.1 Scope of review

The commission was for a review of the use of electric fencing as a beaver mitigation technique. The scope requested the following:

- Retention tool: Primary use/proposals are related to release sites where there may be temporary holding of an animal/animals using electric fencing. There may be other situations where electric fencing is used as a retention feature. Provide a list of pros and cons for welfare and effectiveness with references and evidence/experience from other sources including beaver managers in Great Britain and wider where relevant. If not included, please explain why.
- Deterrent or exclusion tool: Proposals are for use related to prevention of dam building, instream deterrent upstream of culverts or other infrastructure. Provide a list of pros and cons for welfare and effectiveness with references evidence/experience including from other sources including beaver managers in Great Britain and wider where relevant. If not included, please explain why.
- Deterrent as exclusion tool: proposals are for use to provide crop protection or other circumstances where exclusion is desired.
- For each of the above, to provide detail on types of specification/methodology to differentiate where use is appropriate and what conditions, eg, timings, temporary or permanent nature are recommended. In other words, is all electric fencing unacceptable or are there conditions and circumstances where it is acceptable. For example, if acceptable define what temporary is classed as in terms of time and if, for example across stream fencing can be “re-used” intermittently and how this would be defined.
- To consider implications and incidental impacts of electric fencing on other species when making recommendations for beavers, eg, otter, badger in particular & other species in the riparian zone.
- To consider the use of fencing in respect to the Dubois et al (2017) principles in relation to the range of mitigation techniques and objectives as described in this scope.
- To provide recommendations on the use of electric fencing and alternatives to using this methodology.

2.0 Introduction

Electric fencing is typically deployed to either retain a target within a prescribed area or to exclude a target from a prescribed area. Electric fences have been used to reduce or prevent damage to crops and gardens by wildlife, including badgers (Poole et al., 2002), rabbits (Mckillop and Wilson, 1999) and feral pigs (Hone and Atkinson, 1983). They have also been used successfully in conservation, eg, predator deterrent resulting in higher survival / productivity at wader or seabird colonies (Williams et al., 2020); and discourage livestock predation by wolves, bears and big cats (Cavalcanti et al. 2012). Electric fencing represents a common non-lethal mitigation method, generally viewed as reliable and economical, but requires much more frequent maintenance than fixed fencing. There are also well recognised risks to animals posed by electric fencing, and these can incur legal liability (Cavalcanti et al. 2012). There are some guidelines and regulations regarding the sale, installation and use of electric fencing including specified standards and specifications, for domestic animals especially (most relevant BS EN 60335-2-76). Any implementation must follow these first and foremost, the details of which are outside the scope of this review. Improperly maintained or designed fences can seriously injure or kill animals.

3.0 Considerations with Electric Fence Use

When an animal touches an electric fence (note this should always be pulsating current via an energiser, never straight from the mains) it causes transitory muscle contraction or cramping which can range from unpleasant to painful depending on:

- Power source and output strength
- If the wire or object is wet
- The degree of hair coverage and thickness
- An animal's ability to move away from source

Fatalities are rare but highly dependent on the type of animal and an individual's behaviour towards the fence. Beavers have been killed by electric fences on at least five instances in Britain over the course of the last 20 years (personal communication Roisin Campbell-Palmer and Derek Gow). The British Veterinary Association (BVA) recognise that electric fences elicit different fear responses in various species, so that the effectiveness and acceptability of certain interventions can be species specific (Hosey et al., 2013). Different species may try to jump over, walk through or push under a fence. If an animal gets trapped or entangled in a fence (if wires are slack or long enough to wind around body parts) and not able to extract itself this can lead to trauma, injury and potentially result in death. Frogs, toads, common lizards, water voles and hedgehogs have also been killed on beaver electric fences deployed within beaver enclosures when they were working around beaver enclosures (personal communication Derek Gow). The amount of power supplied is critical to avoid inhumane shocks. Generally, animals with longer and/or thicker fur typically require higher levels of voltage to produce a shock. Animals with poorer eyesight should have more visible fencing. Younger animals tend to have more energy and risk jumping or pushing through fences than mature adults (Hansen, 2013).

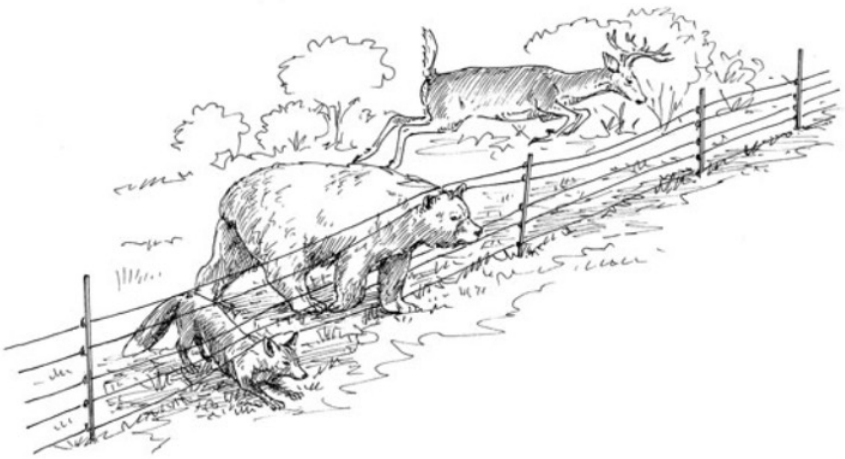

Figure 1. Electric fence wires must be set high, low and close enough together to be effective against target species. Fencing must be visible especially to poor sighted species. Illustration © Elara Tanguy, excerpted from Hansen 2013.

It is key that any electric fence design takes animal behaviour into account (reviewed by McKillop and Sibly, 1988). As an unfamiliar object, first encounters with electric fences typically result in investigation and /or accidental contact, often with the nose (Prior, 1983). Livestock typically learn to recognise electric fencing after exposure and then don't tend to investigate repeatedly (Plant, 1980), but this may not be the case for wild or free-ranging animals. If animals don't see or recognise the fence, they typically try to push through gaps in the wire thereby making contact on their neck, back or chest (Pharoah, 1976). The degree of shock can determine an individuals' subsequent reaction. The nose has little insulation therefore it receives a more severe shock and often results in an animal retreating backwards (McKillop and Sibly, 1988). An animal that has started to partially push through before receiving a shock on its neck or back, however, usually moves forward, therefore pushing through the fence (Floyd, 1960; McCutchan, 1980). If animals get trapped on the 'wrong' side of the fence this can be totally counterproductive, with an animal being conditioned to avoid a shock after receiving it. For example, coyotes which received electric shocks on fencing causing forward flight, became trapped within supposedly protected sheep flocks, resulting in numerous sheep deaths (Shelton, 1981). If electric fences are used to deter beavers temporarily, these should always be at the lower agricultural voltage settings used for cattle (2,000-3,000V), rather than those for sheep (>4,000V) which may be insulated by their thick dry fleece. Beavers encountering electric fences are often wet and may touch the fence with their nose or face, so low voltage is sufficient deterrent, and less likely to result in driving a beaver through an electric fence.

After receiving a shock typical defensive animal reaction may be flight (most often away from but may also be into the intended protected area); withdrawal (physical or to a nearby shelter); or retaliation (McKillop and Sibly, 1988). Hedgehogs for example, are more prone to fatalities in association with electric fences as their typical defence to a threat is to curl into a ball rather than elicit a flight mechanism (McKillop and Wilson,

1987). Given such defensive behaviours they may therefore be subjected to continual electrical shocks, similar to various tortoise species for example, with numerous fatalities at electric fences reported in both these species (eg, Pietersen, 2022). Sheep and many wild mammals have highly insulated coats, in comparison to horses or cows, making them harder to deter from trying to pass through an electric fence. Retaliation towards a shock from an electric fence has been recorded in a small number of species and cases. Numerous species of wild rodents and rabbits have been recorded as biting electric wires (Srinivasalu et al., 1971; McKillop and Wilson, 1987). Anecdotes of elephants, bears and goats charging at electric fences have also been reported (McKillop and Sibly, 1988). Other animals, eg, snakes, may be provoked to attack a source of pain and attempt to bite a fence. Latching of teeth or horns on electric fences without the animal being able to disentangle themselves typically results in death. This is exacerbated by the nature of muscle spasms induced. There are also reports of certain species learning to avoid receiving shocks by digging under fencing, eg, bears (Porter, 1983), kangaroos (McCutchan, 1980), and coyotes (Shelton, 1981). There are some reports of beavers 'listening' for electric fencing after repeated exposure (personal communication RCP and Gerhard Schwab). However, this has not been assessed and use of electric fencing especially for retention purposes has been revised since its first usage from the early 2000's by those advising beaver retention fencing in Britain, resulting in all recent licensed enclosures purposively not including electric fencing due to learnt experience from captivity (personal communication RCP and Derek Gow).

In Britain badger mitigation with electric fencing is potentially the most comparable. Badgers are protected under the Protection of Badgers Act 1992, as well as the Wild Mammals Protection Act 1996. When captive "under the care of man" they are further subject to protection under the Animal Welfare Act 2006. This legal protection requires mitigation methods to focus on behavioural manipulation as opposed to lethal control to remove animals (Poole *et al*., 2002). Electric fencing is used to exclude badgers from areas, such as arable crops (Harris *et al*., 1994) but has not been consistency successful (Roper *et al*., 1989; Wilson, 1993), although using 4 strands of wire significantly increases success (Poole *et al*., 2002). Crop feeding by badgers in England and Wales varies greatly in impact with the majority of instances of little economic significance (Moore *et al*., 1999), although localised instances have been deemed unacceptable, and thus requiring humane and cost-effective management (Neal, 1986). The use of electric fencing to mitigate crop damage by badgers has been shown to dramatically change their foraging areas and routines soon after fences are erected; this didn't have impacts on use of resting sites, but increased impacts on nearby unprotected areas resulted including previously unused high value assets such as fruit fields and residential gardens (Poole *et al*., 2002). Poole et al. (2002), discuss two instances of badgers becoming trapped in the protected area. The authors argued that animal welfare was not significantly negatively impacted, as badgers generally remained in their same setts, and nightly activity did not appear affected, though displacement of foraging was evident, but no other welfare assessments were performed. They did raise welfare concerns for any individuals trapped behind fences, indicating that prolonged separation from their setts would generate stress. Recommendations from this study for badgers included: the decision to erect a fence, or not, needing to reflect level of damage and crop value; four-

strand electric fences; use with high-value crops over 10 years seem cost-effective provided voltage is maintained (4.0-7.5 Kv); and regular fence inspections every 1 to 2 days during first 2 weeks then weekly intervals. They recommended that all of these factors should be assessed against each other to make an informed decision on a site-specific basis.

The ability of a species to both recognise and then learn to avoid an electric fence also varies greatly, for example cats are more sensitive to picking up electromagnetic fields so can generally be aware and avoid repeated encounters, whereas species with poor eyesight, such as bears, typically hit a fence before realising it is there. The BVA's policy position on the use of electric containment fences clearly states the use of highly visible tape or rope-like fencing for flight animals such as horses, and the attachment of flags or visual markers to ensure boundaries are visible (BVA, 2022). Warning signs must be displayed on any fencing accessible to the public (at the start, end and every 50m) according to existing European regulations.

Caution is needed when evaluating some of the published scientific literature regarding electric fence usage and wildlife. The term "successful" is frequently very loosely applied, with the only consideration being that an electric fencing approach prevented a target species from entering an area or having an impact. Published reports frequently fail to consider the real welfare impacts on individuals of the targeted species or compare these to other mitigation methods that may have lower welfare impacts. Many published cases and approaches fail to include any ethical or animal welfare framework in decision making considerations (Dubois *et al.*, 2017).

3.1 Recommended fencing specifications

- Strained-wire fence system recommended, not electric netting fencing.
- Tape should be used over wire.
- 3 or 4 electrified parallel conducting wires should be set at heights of 10cm off the ground and from each other, held by plastic insulators supported on metal stakes.
- Posts should be at most. 10m apart.
- Fencing must be attached to an energiser that is either battery or solar powered, at a maximum of 2,000 to 3,000 volts.
- Note undulations in ground will determine placing and distances.
- Should fencing be used across an existing beaver forage trail ensure a post is placed in the centre of this with lower wire as close to ground as possible. Wires must not bridge a worn beaver path as animals may easily push underneath.

4.0 Application of Electric Fencing and Beavers

Techniques for the effective management of beaver impacts are now well developed and reported across Europe and North America (Campbell-Palmer et al., 2016). Electric fencing has been deployed to deter beavers. It is accessible, easy to install and can be relocated rapidly in response to any change in activity. Electric fences are significantly

cheaper than conventional fencing but do require ongoing maintenance and checking. Cost and convenience, rather than animal welfare evidence, appears to be the major driver of electric fence deployment for beavers in both retention and mitigation scenarios.

4.1 Deterrent fencing

The Eurasian Beaver Handbook: Ecology and Management of *Castor fiber* describes a range of instances in which electric fencing has been previously utilised in beaver management (Campbell-Palmer et al., 2016), noting these existing methods are not typically widespread, and with no assessment of efficacy or welfare implications. Their existing use works on the principle of dissuading beavers from accessing an area for a temporary period, such as crop ripening. Electric fencing has been used quite successively, most commonly for reactive short-term deterrent with the aim of protection of a feature or asset such as crop protection. There has been little monitoring and assessment of beaver responses to this mitigation, so its effectiveness is largely anecdotal and site specific. Therefore, recommendations based on limited publications and communications are included here for completeness. Strong electrical outputs are not required, with suggested currents equivalent to standard livestock fencing with low power (Vorel et al., 2016). As with any electrical fencing, this should be viewed as a deterrent and should not hurt the animal; if this is not the case it should be removed and another mitigation method sought. As a shy nocturnal species, impacts to welfare are difficult to observe and monitor without the use of camera traps. Ideally a minimum of three strands should be set at appropriate heights to prevent animals from digging under or pushing through, with all vegetation removed under and around these wires to ensure circulation (Campbell-Palmer et al., 2016). In Bavaria, beaver managers have found that, in general, direct crop loss through beaver foraging is low and tolerated by farmers but the flooding of crops through damming and/or erosion due to bank burrow collapse is a much more significant issue (Schwab and Schmidbauer, 2003). Therefore, if electric fencing is deployed, this is typically associated with crop feeding in close proximity to a water course, ahead of crop harvesting. If beavers are able to burrow underneath the fence and re-emerge in fields, this technique may be less effective, but it is often an effective deterrent against crop feeding. It has also been utilised as a temporary measure to deter beaver activity in a variety of situations, eg, dam-height restriction or deterring beaver movement between a water body and an ornamental pond or garden. In a very small number of instances electric fencing strung across the top of a dam (above water level) has been installed as a short-term dam building deterrent in Bavaria and Devon. However, this is not a commonly deployed use, and this is still considered a trial-and-error based approach, especially in fence positioning, and the number and spacing of wires. It should be noted that the only issues reported by Bavarian beaver managers in relation to beavers and electric fence deployment have been when electric netting has been used for sheep retention. Beaver injuries and deaths have been reported after becoming entangled and received multiple shocks as they were unable to free themselves and retreat (personal comment Gerhard Schwab). No long-term monitoring and assessment of beaver reaction have systematically been undertaken, and so this application cannot be currently recommended without further agreed standards for application, deployment, assessment of effectiveness as a mitigation tool and impact on

animal welfare (including non-target species). Monitored trials as a temporary deterrent in a hierarchy of mitigation as an alternative to lethal control and trapping for relocation, would be a key recommendation.

Photos: © Roisin Campbell-Palmer

Figures 2 and 3. Electric fencing use in Bavaria, predominantly for crop protection. Note: previous beaver foraging trails into field and use of herbicides to prevent vegetation growth and shorting of fence. Strands are set around 10/15cm of the ground and then again around 30cms. This technique may also benefit from a significant riparian vegetation buffer (in background) with alternative feeding options available but crops near a water course will always provide a high value attractive feeding resource, beavers often resume feeding after fencing is switched off.

Limited Northern American based beaver management websites do describe the use of electric exclusion at beaver dams. Often this includes breaching the dam and then installing electric polywire along the length of the dam. This has been recommended as a method to prevent beaver dam rebuilding, followed by lethal control or trapping (Noble Research Institute), or working on the principle if they are ‘shocked enough, they will move to another area’ (University of Kentucky). No measure of effectiveness of these techniques nor any welfare assessment was presented. It should be noted that the Beaver Institute mitigation manual (2015), an active source of beaver mitigation advice online, does not recommend the use of electric fencing for beaver mitigation, although it describes its use. It states that although it may be ‘tempting’ to install electric fencing to protect trees, with years of working practice experience they feel properly installed tree guards are a more effective, non-lethal tool for managing impacts. Electric fencing is viewed as ‘unnecessary and excessive, and not as effective as standard fencing’. They continue ‘the electric shock delivered by these fences is unpleasant but not lethal or harmful to the animal and is considered humane because the shock will only continue if

the animal repeatedly contacts it. However, should the animal get caught in the fence, repeated shocks can cause severe stress resulting in an inhumane death' along with 'the risk of other wild animals, pets, or humans coming into accidental contact with the fence'. Included in their advice section are practical considerations including vegetation and objects contacting the fence and causing short circuiting, legal liability issues and requirement for ongoing maintenance especially in wet and onerous conditions. The application of electric fencing to deter dam building is not currently recommended.

4.2 Retention fencing and beaver releases

Beaver retention fencing is typically used in captivity, zoological or private collections, or more recently for more naturalised release projects, eg, Wild Ken Hill in Norfolk, Knepp Estate Beaver project in Sussex. These fully enclosed projects require licensing by Natural England, and along with many others have not incorporated electric fencing. Earlier zoo enclosures and some private collections have used electric fencing to retain captive beavers. It must be noted that these were in conjunction with standard fencing as 'hot wires', with electric fencing wires along the bottom and/or top of a fence to dissuade climbing and/ or burrowing. At least three fatalities have been recorded with such fencing, despite daily fence checks, and the relatively small number of beavers housed this way (note zoo licensing requires two daily checks which are far more frequent than any use in the wider environment). These were all found on morning checks with teeth locked on hot wire and occurred with both low and high fence wires (Roisin Campbell-Palmer and Derek Gow Pers. Comms). This demonstrates the potential retaliation behaviour some individuals display to fences.

Photo: Beaver retention fencing. © Roisin Campbell-Palmer

Figure 4. Licensed beaver retention fencing with overhang and mesh skirt to omit need for additional electric fencing requirements. Note this is retention fencing but similar design can be used as deterrent fencing. Anything below these specifications can quickly result in beaver circumnavigating any fencing. Drawbacks include price and potential impacts on non-target species movements. Therefore, alternative migration techniques, including more selective protection but also more focus on release site criteria and permitted animal choice movement is emphasised in this report.

It should be noted that the vast majority of all beaver releases, both across Europe and North America can be considered as ‘hard releases’ with retention on site not considered as a priority, giving beavers the ability to colonise and select suitable sites according to their habitat needs. Once beavers are in a catchment, the early colonisers will select the most suitable habitat, often holding larger territories than needed before population densities rise over time and increased infilling occurs (Campbell et al., 2005). Some projects have sought to select release sites and employ soft release techniques. These

releases seek to increase site fidelity through reducing animal movement, typically by temporary confinement on site, providing supplementary resources (eg, food, water, access to shelter) or a combination of both (Cid *et al*., 2014). Soft releases of mammals in general are believed to give animals a chance to acclimatise to their new surroundings and therefore be less likely to immediately disperse once released. These are in comparison to 'hard releases' in which animals are immediately released into the receptor site with no artificial site constraints. Results vary greatly with some authors reporting that soft release reduced dispersal, increased site fidelity, and improved survival (Tuberville et al., 2005; Mitchell et al., 2011; Knox and Monks 2014), while others reported minimal to no effects (Hardman and Moro, 2006; de Milliano et al., 2016; Bannister et al., 2018) or even suggest it can be detrimental to project success (Thompson et al., 2001; Richardson et al., 2013; Batson et al., 2017). Stress is a significant challenge to any translocated animal (Teixeira et al., 2007), potentially making individuals more susceptible to diseases, as identified in recent beaver disease risk analyses (Girling et al., 2019; Howe et al., 2024). Unnecessary stressors should therefore be limited as much as possible.

As large and strong mammals, capable of rapid burrowing, travelling large distances via swimming and traversing shorter distances over land – temporary retention of beavers onsite is very challenging without installing robust fencing, and including access to water is both expensive and impractical. In a small number of instances temporary electric fencing has been used for short periods (1-3 weeks) as a 'soft' release technique, similar to how it is deployed occasionally for rehabilitating otter and badgers for 1-2 weeks. Using a negative stimulus to encourage site fidelity and retention is a questionable strategy and has not retained beavers onsite, more importantly assessment of success and standardised monitoring of animal welfare has not been undertaken. Individuals exposed to negative reinforcement to increase site fidelity are exposed to an unnecessary additional stressor and there is no evidence to date that this system is effective, with beavers not present either before or after fencing removed.

Beaver releases tend to be more successful when releasing paired or related animals together or releasing a single male and female to encourage pair formation. Individual behavioural reactions to any electrical retention fencing should be considered. Fight and flight behaviours could lead to an animal pushing through the fence, becoming separated from others, and then proving reluctant to return to the protected release site, resulting in dispersal into the surrounding area. Beavers can quickly circumnavigate retention electric fencing and therefore this is not considered to be a viable retention feature.

Dispersal distances following release, and fidelity to a release site vary greatly. Numerous projects have implemented habitat suitability models to identify favourable release sites, only to experience high rates of dispersal (McKinstry and Anderson, 2002; Methow Beaver Project, 2014; Babik and Meyer, 2015; Pollock et al., 2015). Typical mean dispersal distances of 17 translocated individuals were 14.6 km (9miles), according to Hibbard (1958), while Denney (1952) reported an average of 16.7km dispersal distance (10.4miles) for 26 beavers; Hodgdon and Larson (1985) 11.3km (7miles) in 12 Maine beavers; and Courcelles and Nault (1983) 18km (11miles) in 18

individuals translocated to northern Quebec. McKinstry and Anderson (2002) determined that 51% of the 114 beavers translocated in a project in Wyoming dispersed >10km from their initial release site. However, from a species restoration point of view this raises the question of how much does this matter when undertaking wild releases on a catchment. Additionally, it should be noted that most official wild releases of beavers in Britain have been to unenclosed sites with successful long-term occupation of the release site including several lochs at the Scottish Beaver Trial, Danes Mill at the River Otter Beaver Trial in England and Argaty Beaver Project Doune in Scotland.

Release site fidelity has been improved at various projects using techniques such as forming initial release pools through either digging ponds or partially blocking existing small water courses to impound water, so beavers have immediate access to deeper water, or forming deeper banks to facilitate the building of burrows. Artificial lodges have been constructed by some projects, either to release the beavers directly into and potentially hold for a few hours to allow them to settle or just to ensure some form of shelter is present (Jones and Campbell-Palmer, 2014; Scottish Beaver Trial). Use of artificial lodges by beavers is very variable, with only the minority of released animals utilising them in some form. The addition of food and / or scent from the released animals has improved use and animal retention at a release site. It must be noted that the key to encouraging release site fidelity is the selection of high-quality release sites, paying particular attention to habitat requirements. These include:

- stable deeper pooled water
- range of forage immediately lining the water course including trees, but also ground storey vegetation
- lack of immediate disturbance
- banks suitable for burrowing, and ideally with numerous shoreline complications, included felled trees and steeper bank profiles
- connectivity with other beaver populations

5.0 Animal Welfare Principles

Human-wildlife conflicts lead to a range of animal management tools ranging in design and application according to species involved, potential extent and degree of impact, and ranging from deterrent techniques to lethal control. Obviously, such management techniques may have varying welfare impacts on both the target species and potentially non-target species. These may also be ethically sensitive and range in social acceptability by different stakeholders. The UK is often regarded as having high standards of animal welfare legislation under which wildlife management is included. Ethical decision-making about animal welfare and wildlife control has received much attention in the last decade, with the need for standardisation in guidance and the incorporation of international perspectives identified (Dubois *et al*., 2017). These principles act as a list of questions that can be asked in sequence when decisions on human-wildlife conflicts are being made, in this instance, beavers.

They are used by professional bodies such as the British Veterinary Association (BVA), the British Veterinary Zoological Society (BVZS), Defra's Animal Welfare Committee (AWC), and the Wild Animal Welfare Committee (WAWC), amongst others.

International principles for the ethical management of human-wildlife conflicts have been proposed, in stepwise order (excerpted from Dubois *et al*., 2017), include:

- Modify human practices when possible – through developing a culture of coexistence, by identifying human behaviour and addressing the root causes of conflict rather than just focusing on the problematic outcome. Typically, long-term education, based on preventative action and increased tolerance required (Ramp and Bekoff, 2015). This may result in some control actions judged as being unnecessary, particularly where the wildlife conflict is relatively insignificant.
- Justify the need for control – with evidence that substantial harm is being caused to people, property, livelihoods, ecosystem and other animals.
- Have clear and achievable outcome-based objectives – these should be monitored and adapted based on lessons learned. Ethically defensible decisions to control wildlife require clear objectives and evidence that the proposed methods can achieve the objectives. These objectives should be specific, measurable and outcome based. An understanding of population size, ecology, behaviour and effectiveness of the chosen action should all be assessed to judge likelihood of success. Monitoring is critical and often over-looked (Clayton and Cowan, 2010). It is key that these are rooted in an adaptive-management framework (Warburton and Norton, 2009).
- Cause the least harm to animals – predictably and effectively cause least animal welfare harms to the least number of animals. Harms may also include indirect effects on non-target animals, disruption of social groups and ecological systems. To establish this, the method causing the least welfare harm, and systematic scientific evaluation of the possible harms is required.
- Ongoing development and evaluation of methods are needed. The predictability (repeatability) of the welfare outcome and effectiveness (rate of welfare outcome success) are important criteria in decision making. Typical effects and worst-case scenarios need to be evaluated. In addition, methods that result in the least welfare harm when used by knowledgeable and competent professional may be more harmful when used by untrained individuals.
- Consider community values and scientific information – social acceptability is key. Decisions involve balancing benefits and harms but inevitably involve human values. The diversity of interest calls for an open process of community engagement informed by science and a transparent process.
- Include long-term systematic management – control actions should not be used on an ad-hoc basis, without being integrated into a systematic, long-term management program. Otherwise, any benefit is likely to be short lived, and control actions may be used repeatedly without achieving a sustainable solution (Clayton and Cowan, 2010).

- Base control on the specifics of the situation. Animals assigned labels with negative connotations, or potential detrimental effects of their presence or behaviour, often receive less welfare consideration than valued species. This last step serves as a check that all decisions made in the previous steps are based on comprehensive analysis of the concerns and outcomes.

The BVA highlights that poorly designed containment systems or fencing of any kind may lead to negative health and welfare outcomes for animals (both livestock and wildlife) due to potential entanglement (BVA, 2022). BVA supports the use of electric fencing to ensure safe, efficient grazing and livestock management, which is designed, selected and maintained so that it does not cause any more than momentary discomfort to animals. They strongly recommend careful placement, and that where possible, flags should be attached to fencing or there should be other visual markers in close proximity to fencing to ensure boundary visibility. The BVA's position on the use of electric containment fences is that they risk causing pain, injury and distress if not used and maintained properly.

Under the Animal Welfare Act 2006, and associated advice note: (Wildlife management advice note: The animal welfare act 2006 - what it means for wildlife) for England and Wales and Animal Health and Welfare (Scotland) Act 2006, people responsible for animals must ensure that animals under their care or control (including beavers) are protected from pain, suffering, injury and disease. This includes protecting animals from pain or suffering caused by inappropriate and aversive training methods, containment systems or fences. Adverse welfare outcomes that result from a failure to take appropriate measures may result in a criminal offence under the acts. Failing to avoid preventing suffering to free-living beavers from any electric fencing deployed could possibly incur criminal prosecution under the Animal Welfare Act 2006 (England and Wales) or the Animal Health and Welfare (Scotland) Act 2006. While currently untested under UK law, this offence could occur if any electric fencing was deployed such that it was likely to entangled or trap beavers, if it caused beavers to be enclosed, or if it forced beaver into unavoidable electric fence contact due to its placement. It could legally be argued that beavers were hence in a situation where they were then under the control, and hence care responsibility, of humans. To avoid the legal risks of an animal welfare offence every reasonable precaution should be taken to avoid the inadvertent enclosure or entrapment of not only beavers but other non-target species by the application of mitigation electric fencing. For exclusion fencing regular (daily) visual inspection and testing of fencing should occur and be recorded to show all reasonably attempts have been made to avoid inadvertent entanglement by beavers or other species.

6.0 Benefits & Risks Summary

Please note that these list Pros and Cons rather than recommendation for use. Please see final recommendations and conclusions.

6.1 In-stream use as dam (or infrastructure) deterrent and/or dam extent mitigation

	Pros	Cons
Practicality of installation	Quicker than dam removal and flow device installation. Can be reused across multiple sites.	Working in and around water with electrical source.
Duration	May be effective short term	Further evidence needed to establish if limited fence use generates a physiological barrier when not turned on or do beavers quickly resume previous behaviours. Current observation is that behaviours quickly resume.
Reliability	Reasonably reliable but depends on installation and maintenance. Considered more economical than standard fencing.	Electric fencing is less reliable compared to more physical structures, which are far less likely to wash out, for example. Ongoing maintenance required to ensure vegetation and objects not causing short circuiting. Economic advantage requires consideration against ongoing maintenance resources, long-term effectiveness against alternative more permanent measures.
Equipment risk	In stream location may be a deterrent to vandalism and theft	Electric fencing is highly portable, some people may object to its use – it could potentially be subject to theft and vandalism. Fallen objects, flood events may cause damage. Washed away equipment may add to littering of watercourse.
Impacts on beavers		More likely to be wet thereby receiving greater shock. Dam function will influence determination to rebuild dam and therefore risk of repeated shock. Deployment for this method would usually not be consistent with established principles of ethical wildlife management (Dubois et al, 2017). Based on the precautionary principle and current lack of scientific evidence of no significant welfare harms/risk this technique is not recommended as a dam deterrent.
Impacts on other species	Correct placement can be reactive and targeted to fresh beaver behaviours and activity.	Multiple non-target species recorded as using horizontal dam face as access routes across water therefore greater exposure risk.

6.2 Deterrent or exclusion for protection

	Pros	Cons
Practicality of installation	Quicker, potentially cheaper than tree protection and installation of standard fencing. Can be reused across multiple sites.	Ongoing maintenance resource requirements should be assessed against long-term effectiveness.
Duration	Temporary feature could limit impacts at sensitive times, eg, crop maturity. Can be used in a targeted manner to protect seasonally sensitive crops.	From a mitigation aspect - foraging activity and normal behaviours can resume quickly once electric fencing is switched off or removed. This could also constitute a positive animal welfare consideration
Reliability	Fairly reliable but depends on installation and maintenance.	No electric fence is 100% reliable especially compared to more physical structures. Regular clearance of vegetation needed to function.
Equipment risk	Fairly common agriculture equipment, easy and cheap to replace. Fairly robust.	Electric fencing is highly portable, some people may object to its use and potential impacts therefore may be subject to theft and vandalism Flood events can damage, destroy or render equipment ineffective
Impacts on beavers	Used correctly can be an effective non-lethal mitigation. May generate behavioural change lasting beyond fence use.	More likely to be wet thereby receiving greater shock. Risk of beaver going through fencing and being 'trapped' on wrong side, potentially increasing damage and separation stress.
Impacts on other species	Correct placement can be reactive and targeted to fresh beaver behaviours and activity.	Multiple non-target species could be exposed, especially if associated with common animal runs, badgers for example also attracted to crops.

6.3 Retention tool

	Pros	Cons
Practicality of installation	Quicker and significantly more cost effective than beaver exclusion fencing. Can be reused across multiple sites and easily removed	Unnecessary additional stress, and related immunosuppression; Negative conditioning; violates principles of ethical wildlife control, as other better animal welfare methods well evidenced and established Ongoing maintenance resource requirements should be assessed against long-term effectiveness. Messaging – future beaver releases should focus on catchment not site-specific release and retention. Retention fencing could be perceived wrongly as showcasing where beavers can and cannot be accepted.

	Pros	Cons
Duration	Temporary feature	Beavers can exit site as soon as fencing removed.
Reliability	Fairly reliable but depends on installation and maintenance	No electric fence is 100% reliable or effective especially compared to more physical structures
Equipment risk		Electric fencing is highly portable, some people may object to its use and potential impacts therefore may be subject to theft and vandalism Flood events can damage, destroy or render equipment ineffective
Impacts on beavers		Potential to induce negative reinforcement in relation to holding site
Impacts on other species		Multiple non-target species could be exposed.

7.0 Use of Electric Fencing with alternative Mitigation Options

– See also Appendix 3 **(Note: some cells have been left blank)**

Beaver Concern	Electric fencing recommended yes/no	Mitigation hierarchy →			
Crop feeding	**Temporary only**	Significantly wide buffer strip	Deterrent fencing (non-electric)	Electric fencing - temporary proposed no more than 3 months to account for crops coming into season – noting beavers typically feed on crops slightly before and during coming into season so much shorter time periods equally as effective	Beaver removal (Prime Agricultural Land – PAL - in Scotland)
Tree foraging	No	Buffer strip /	Individual tree		

Beaver Concern	Electric fencing recommended yes/no	Mitigation hierarchy →			
		additional planting	guards/ stand protection fencing		
Bank side foraging with digging	No	Buffer strip / additional planting	Mesh fronting		
Accessing specified and priority bankside infrastructure, eg, gardens, sewage plants	**Temporary only**	Non-electric deterrent fencing – if permanent mitigation required	Other physical barriers (walls, rocks, etc)	Electric fencing – only if temporary access can resolve issue in 2-4 weeks maximum	
Canal building / forage trail	No	Non-electric retention fencing	Mesh fronting	Metal piling and / or Backfilling	
Burrowing	No	Buffer strip/ additional planting	Mesh/stone fronting Bank core protection, eg, metal piling, gravel trench core	Backfilling	Beaver removal (PAL in Scotland)
Lodge construction	No	Buffer strip / additional planting	Non-electric retention fencing to isolate lodge	Lodge removal	Beaver removal (PAL in Scotland)
Dam construction	No	Removal (depending on age and function)	Flow device – where appropriate and use of fish passage boxes		Beaver removal (PAL in Scotland)
Animal exclusion	No	Non-electric Deterrent fencing	Beaver removal		
Animal retention	No	Suitable release site selection	Non-electric retention fencing		

8.0 Recommendations

8.1 Practical Application

- Currently only short-term, temporary deployment for crop protection (1-3 months max) or if a high value asset requires immediate protection there may be scope to use electric fencing as a short-term/temporary solution (max. 2-4 weeks) while permanent long-term structures are installed. Note long-term alternative mitigation options are always recommended first as electric fencing typically results in the conflict returning after fencing removed. Once crops are harvested, beaver motivation to forage in such areas is removed. Electric fencing to prevent entry to areas they may be highly motivated to continually access, requires permanent exclusion methods.
- Deployment must meet UK safety standards (BMI); follow manufactures guidelines must be followed; energiser and fence electrical output must be tested regularly and checked daily along the entirety of its perimeter.
- Due to lack of evidence on harm (physical/welfare/non-target species), temporary electric fence use for beavers should always be recorded, and data collated. Please note the overall “not recommended” advice.
- Any electric fencing should be monitored via camera trap footage to assess any impacts and effectiveness.

8.2 Mitigation Prioritisation

- The implementation of long-term mitigation methods over temporary measures should be prioritised, noting seasonal crop protection as an exception.
- The use of alternative mitigation measures to electric fencing should be prioritised.
- Electric fence deployment for retention within enclosures or for a soft release of other purposes cannot be supported given the potential for repeated exposure and use of a negative stimulus to achieve purpose of retention. Soft release as a technique for beavers generally lacks evidence of success in beaver retention or increasing long-term survival, so use of electric fencing is not considered a sufficient justification for use. Habitat selection criteria and acceptance of beaver presence on a water course should be prioritised.
- Monitored trials under licence as a temporary deterrent in a hierarchy of mitigation as an alternative to lethal control and trapping for relocation.

8.3 Animal Welfare

- Adhere to accepted ethical principles of wildlife management (Dubois et al., 2017) in all considerations of electric fence usage for the mitigation or retention of beavers.
- Failure to adequately protect any enclosed animals, including beavers, from suffering due to the deployment of retention electric fencing may constitute a criminal offence under the Animal Welfare Act 2006 (England and Wales) or the Animal Health and Welfare (Scotland) Act 2006.
- Although untested under UK law, failure to adequately prevent suffering to a free-living beaver from electric fencing deployed in mitigation could still incur criminal prosecution under the Animal Welfare Act 2006 (England and Wales) or the Animal Health and Welfare (Scotland) Act 2006, if the fencing was deployed in such a manner that it either entangled or trapped beavers, enclosed beavers, or forced them into unavoidable contact due to its positioning, as it could then be argued that they were forced into a situation where they were then under the care of humans.
- Future standardisation of use and development of agreed protocols need to be established, by means of establishing an animal welfare and harm likelihood evidence base. This currently does not exist. Most published reports of electric fence deployment with beavers contain no welfare assessment evidence. The claimed meaning of deployment success is highly variable in published reports, and again normally has no welfare assessment evidence.
- As there is a paucity of evidence on the frequency and severity of adverse welfare effects of electric fencing on beavers, the actual effectiveness as a technique, and the harmful impacts on non-target species, electric fencing cannot currently be recommended for instream and retention use.

9.0 Standardising data collection

The British Veterinary Association specifically recommend species-specific research on the differing fear responses and welfare outcomes elicited by electric containment fences to ensure that any proposed interventions are developed with due consideration of species-specific responses (BVA, 2022). Though the BVA recognise electric containment fencing is an acceptable intervention in terms of efficient and safe herd management when used safely and responsibly, they state ‘’it is regrettable” that non-aversive interventions are not available and strongly encourage further assessments of any such interventions that do not have the potential to result in negative welfare outcomes.

This review does not advocate research with regard to beavers and further use of electric fencing as a mitigation tool. However, if electric fencing is ever used as a temporary mitigation tool, then it is crucial that consistent information is recorded, to allow further assessment, both on animal welfare grounds but also as the actual efficacy for its intended purpose in England-specific situations. It would be recommended that

any use is limited to experienced beaver managers, working in conjunction with Natural England, and must involve detailed monitoring to an agreed protocol.

The following information should be recorded, and fencing monitored as standard (see Appendix 2 also).

- Primary purpose of electric fencing usage/ reason for deployment, i.e. deterrent of behaviour; exclusion from a feature; and/or retention.
- Primary type of behaviour/s electric fencing is targeting (eg, damming, foraging, burrowing, dispersal).
- Discussion of why alternative mitigations were not possible.
- Fencing specification; voltage/amps; power source; length of fencing; fencing type (eg, wire, tape, rope, net, etc); management; placement location (eg, distance from nearest water, distance from key feature);
- Fencing maintenance requirements; human conflicts/ interference; fence modifications, eg, height of strands; instances of shorting including cause and actions to rectify
- Length of time deployed
- Instances of non-target species (wildlife, livestock, pets); record all non-beaver species interactions including species, number of instances, any mortalities; detail of the interaction, eg, passes through fence, makes visible contact, change of direction of travel etc.
- Beaver interactions and behavioural reactions; number and type of interaction; any seasonal and time impacts. Any impact on animal welfare (including non-target species).

10.0 Conclusion

Current justification of use of electric fencing deployment for beavers appear largely based on ease/low-expense considerations, rather than real efficacy, or consideration of the risk to beavers and other wildlife (that may use dam walls for transit), and the animal welfare impacts when compared to other available methods. While there are numerous citations of electric fence use, especially in North American beaver mitigation (noting differences in animal welfare legalities between the UK and USA), these frequently fail to consider any ethical framework or assess animal welfare in any meaningful way. While different types of electric fencing have been used in the short term (such as 2-3 weeks for badgers or otters) for wildlife rehabilitation and pre-release conditioning, there is a real paucity of animal welfare data on the use of electric fencing with beavers specifically. This makes it difficult to justify or encourage any widespread use, especially when other low animal welfare impacting techniques often exist and evidence that electric fencing being effective is lacking. There are also wider questions on impacts on other wildlife and the ongoing maintenance requirements such as vegetation strimming. The most likely acceptable use for electric fencing in beaver mitigation is temporary, portable livestock equipment, using tape as a visible marker, as a potential, seasonal, deterrent to high

value crop plants (noting that the longer beavers spend in an area the more likely additional and more-significant issues are likely to develop such as burrowing and damming). In this application, exposure is likely to be lower and every individual has the capacity to exercise flight away from the protected area and immediately retreat into a water-based shelter.

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Appendix 1. Suggested monitoring for temporary use of electric fencing

Physical checks

Date	Beaver Activity Noted	Fence Functioning Check	Power Source Test	Output Test	Vegetation Management	Battery Change
	Still active? Which side of fencing? Any breach attempts?	Fence still complete? Wire strands taught?	Still functioning?	Test output? Any adjustments? Energiser functioning?	Strimming required?	Any actions taken

Camera trap footage analysis

Beaver seen	Behaviour at fence	Fence function	Animal Impact	Any other animals seen?
Seen at fence? Age class est.? Repeated visits?	Approach? Contact made? Fence registered without contact?	Breached? Return journey? Location of breach?	Any? Reacted to shock? Any suspected injury?	What? Behaviour? Any impact?

Appendix 2. Mitigation Hierarchy