Non-Lethal Techniques to Reduce Conflicts with Grizzly Bears: Electric Fencing and Bear Spray

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Executive Summary

This report aims to summarize the current state of knowledge regarding the use of electric fencing and bear spray to reduce human-grizzly bear conflict in British Columbia (BC), identify industries, activities, and land-uses that occur in BC that have the potential to create conflict, and identify target audiences and partners within BC that could use information to better inform their practices to reduce human-bear conflict. The report is an outcome of the Grizzly Bear Foundation's Board of Inquiry.

Preventing access by bears to non-natural attractants (e.g., human food, landfills, beehives, fruit trees, chickens) is a key step to avoiding human-bear conflicts (Davis et al. 2002). Properly designed, installed, and maintained electric fencing placed around attractants has been proven to effectively prevent bears from accessing attractants. Conflict resulting from unsecured access by grizzly bears to livestock and livestock feed and fruit trees and berries were the two most common sources of calls to the BC Conservation Officer Service between 2014-2017 (M. Badry, BC Ministry of Environment, unpublished data) and this conflict can be resolved with electric fencing. Modern fence controllers can deliver the desired effect of excluding bears while ensuring human safety during accidental contact.

Adhering to proper bear avoidance safety techniques is the first line of defence in avoiding negative human-bear interactions. However, in cases where a potentially dangerous interaction has not been avoided (e.g., bear charge or attack), deploying capsaicin-based bear spray is an effective means of self-defence. An analysis of incidents where people used bear spray from 1985-2006 found that of all persons carrying bear spray, 98% were uninjured by bears in close-range encounters (Smith et al. 2008). The rate at which bear spray successfully stops negative human-bear encounters is greater than that observed for firearms (Smith et al. 2012). While bear spray is more effective than firearms, it also reduces the number of bears killed unnecessarily, which is especially important for at-risk grizzly bear populations.

Human-bear conflicts arise because of the actions (behaviours) of both humans and bears. Much is understood about the motivations of bears (i.e., locating food) and how to mitigate conflict with people (i.e., humans remove/secure food and attractants, alert bears to their presence, use bear spray when necessary). Most of the unknown and un-addressed issues relating to human-bear conflicts relate to the choices and behaviour of humans. As such, social scientists and educational experts should be engaged to help conservation managers reduce human-bear conflicts.

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Introduction

In 2016, the Grizzly Bear Foundation undertook a Board of Inquiry to review the status and future of grizzly bears in British Columbia and to set the direction for the Foundation's work. The resulting report (Audain et al. 2017) identified human-wildlife conflict in BC as a primary area of concern and recognized that people need to feel comfortable sharing the landscape with grizzly bears, both from an economic and a safety standpoint. Because of this, the Grizzly Bear Foundation wants to ensure tools to decrease conflict (e.g., electric fencing) and increase personal safety (e.g., bear spray) are promoted and available.

The Board of Inquiry report delivered a series of recommendations to the Foundation, of which Recommendation #2 within the "education" section included the following:

> *Formulate and deliver a demonstration project to highlight the use of electric fences and bear spray in strategic locations. Do so in partnership with an existing local coexistence organization. Develop and circulate a Best Practices Guide on the basis of this work.*

This report aims to address the first aspect of this recommendation by achieving the following objectives:

1. Summarize current state of knowledge regarding the use of electric fencing and bear spray to reduce human-bear conflict.
2. Identify industries, activities, and land-uses that occur in British Columbia that have the potential to create conflict.
3. Identify target audiences and partners (e.g., NGOs, First Nations, agricultural producers, recreational organizations and different levels of government) within British Columbia that could use information to better inform their practices to reduce human-bear conflict.

State-of-Knowledge: Electric Fencing

Preventing access by bears to non-natural attractants (e.g., human food, landfills, beehives, fruit trees, chickens) is a key step to avoiding human-bear conflicts (Davis et al. 2002). Properly designed, installed, and maintained electric fences placed around attractants have been proven to effectively prevent bears from accessing attractants. The first recommendation to electric-fence landfills with the intent to restrict access to non-natural attractants by bears occurred in 1913 in Yellowstone National Park (Schullery 1980). In the 1930s, electric fencing was first implemented as a management tool to keep bears out of apiaries (bee hives) in California (Storer et al. 1938). Between the 1940s and 1960s, electric fencing became a popular tool for domestic livestock control. Since then, properly installed electric fencing has been consistently used as a highly effective management tool to exclude black bears and grizzly bears from accessing attractants; in a study in Montana, cow, horse and deer carcasses were eaten or carried off within 2 days of the removal of an electric mesh fence that had effectively excluded bears coming out of hibernation for 2 consecutive weeks (Karsky et al. 2007).

What Is Electric Fencing and How Does It Work?

Electric fences deter animals from accessing an enclosed area by delivering a short, intense electrical shock following contact with an energized fence that is unpleasant for, but does not harm, an animal. Through negative re-enforcement, animals learn to avoid contact with the electric fence, thereby excluding them from accessing the enclosed attractant. In general, an electric fence installation is comprised of the following components: an electric fence controller (also known as energizers, chargers and fencers) to deliver the charge, wires to carry the charge, posts to hold the wires, insulators to hold the wires on the posts without grounding

the charge, and ground rod(s). More details on the set-up and operation of electric fence systems are discussed in Appendix 1.

An electric fence only delivers a shock when the circuit between the wires carrying the charge and the ground terminal is completed/closed by contact with the body of an animal. The loop can be "closed" in one two ways:

1. through a "**positive system**" or "all-hot system" (Figure 1) in which the loop is closed through the use of a ground rod (allowing the current to pass from the positive (red) terminal of the controller to the wires, from the wires to the animal, through the animal into the ground, through the ground to the ground rod and back to the negative/ground terminal of the controller). The animal need only touch one wire and the ground to receive a shock. All positive/hot wires are connected in a series to each other and to the positive terminal on the controller and the negative/ground terminal is only connected to the ground rod.

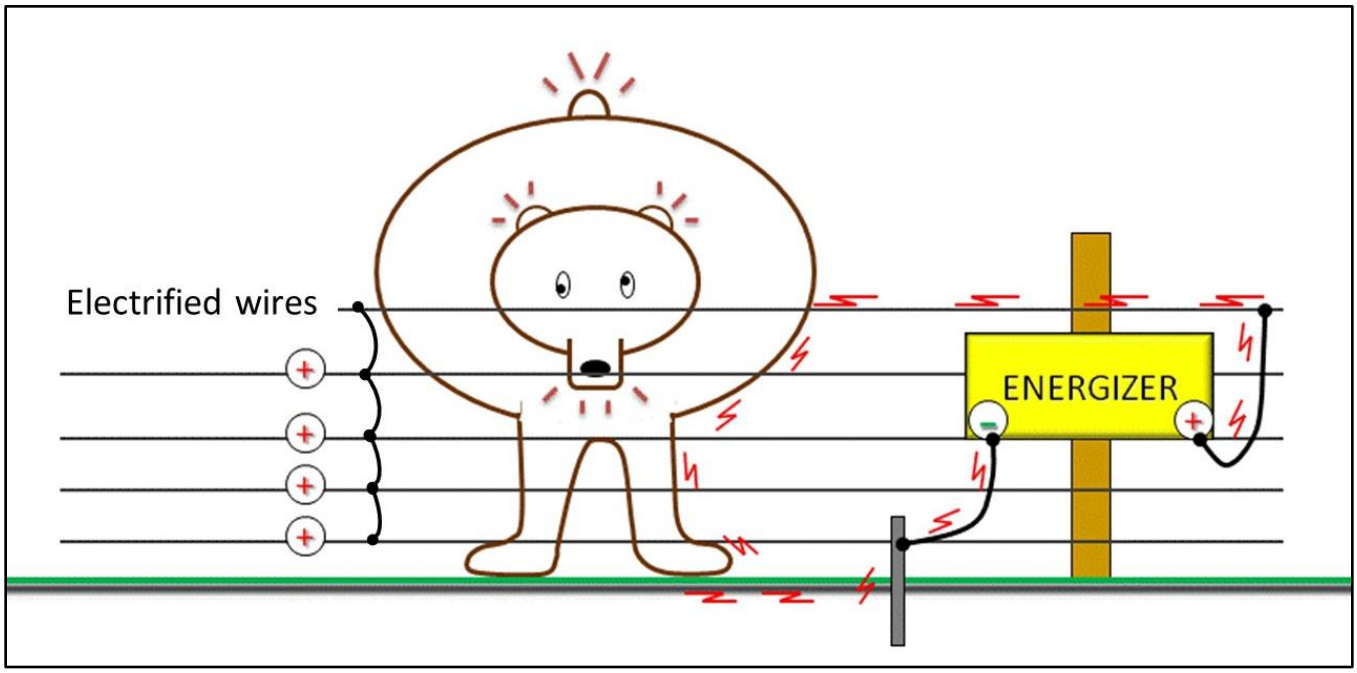

Figure 1. A bear receives a shock after touching a positive/hot wire, completing the circuit to the controller (Annis 2017; used with permission).

2. through an "**alternating positive/negative system**" or "alternating hot-ground system" (Figure 2) in which the fence wires alternate between positive/hot and negative/ground. The animal must touch both a positive/hot wire and a negative/ground wire on the fence (allowing the current to pass through the animal, back to the ground wire in the fence and back to the negative terminal of the controller) to receive a shock. All positive/hot wires are connected in series to the positive terminal on the controller and need to be attached to posts with insulators. All negative wires are connected in series to the negative terminal of the controller, as is a ground rod (Sowka 2013, Annis 2017).

Environmental conditions affect which design is most effective. The first design relies upon sufficient soil moisture to conduct the charge from the animal through the ground to a ground rod. The second design is best in dry areas where the ability of the electricity to pass from the animal through the ground to a ground rod is poor and is the best design for a fence that needs to function regardless of soil moisture and weather

conditions (Sowka 2013, Annis 2017). Controllers and various components of the system must be installed and used as per the manufacturer's instruction to ensure the safe and proper functioning of the system.

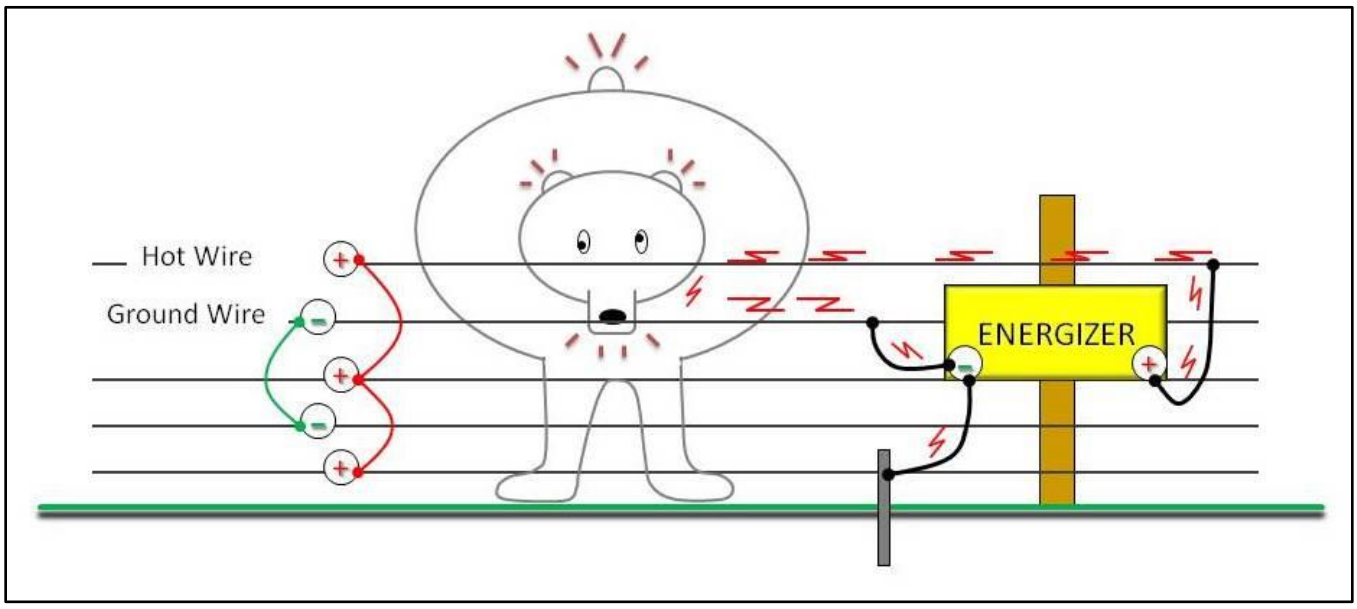

Figure 2. A bear receives a shock after touching a positive/hot wire and a negative/ground wire, completing the circuit (Annis 2017, used with permission).

Human Safety

For an electric fence to be an effective tool, it must hurt, but not harm, any animal that touches it (Davis et al. 2002). With a properly designed and activated electric fence, high voltage is combined with low amperage to produce a charge that lasts <¼ second at a rate of 40-65 pulses/minute. When the circuit is completed and a shock is delivered, the animal experiences an unpleasant involuntary muscle contraction. The cycling of the charge in the system allows the body being shocked to break contact with the wire during the >¾ second that the system is not charged. Modern fence controllers can deliver the desired effect to bears while ensuring human safety during accidental human contact. The type of current used in electric fences must not be confused with the continuous alternating current (AC) electrical system that powers lights and tools. In standard household electrical systems of 120 volts AC at 60 cycles, the power is on continuously causing the muscles to contract and only partially release, making it very difficult to let go of the shock source. From a safety standpoint, it is also important to use smooth wire (not barbed wire) so that clothing or skin cannot get caught on the wire.

Attractants that can be secured with Electric Fencing

Electric fencing is a viable option to reduce access by bears to the many attractants, including:

- Livestock and livestock feed
- Gardens, fruit trees and vineyards
- Garbage and compost
- Honeybee colonies
- Camps and smokehouses

Although electric fencing can be highly effective at reducing access by bears to non-natural foods and thereby mitigating human-bear conflict, removing attractants is still the most effective option to avoid this conflict altogether.

Livestock

Over the last 3 years, livestock was documented as the single greatest source of human-grizzly bear conflict in BC. During this time, 28% of the calls to the Conservation Officer Service (COS) about grizzly bears noted livestock (including backyard chickens) as an attractant and additional 3% of calls noted livestock feed as the attractant (when an attractant was noted; M. Badry, BC Ministry of Environment, unpublished data). Several aspects of livestock husbandry can result in conflict with bears, but fortunately, many issues can be dealt with the proper installation and use of electric fences.

Keeping small-scale poultry flocks at residences has become increasingly common in recent years, with numerous communities adopting bylaws to permit this activity. Unfortunately, bears have become increasingly attracted to chicken coops (T. Hamilton, pers. comm. 2017) and human-bear conflict has occurred as a result. Erecting an electric fence is a safe and effective solution to keep bears from accessing chickens and is required by at least two municipalities in BC (District of Squamish, Village of Kaslo) but not in most others (e.g., Kelowna, Revelstoke, Kamloops, Vernon, Smithers, Summerland). In some cases, municipalities do not allow electric fencing in residential areas at all (i.e., Powell River). Rural livestock operators can also use electric fences to keep other livestock such as sheep and goats secure from bears.

Bears are also often attracted to livestock feed, carcasses and birthing areas. Although removing cover and locating livestock away from natural cover and movement corridors can be helpful, electric fencing is the only tool known to effectively deter bears from accessing these attractants (Sanders 2013). In BC, disposal of dead livestock must follow the requirements of the Environmental Management Act and its regulations, whereby carcasses can be disposed in one of the following ways: 1) dead animal collection service, 2) composting, 3) incineration or 4) burial (see BC Ministry of Agriculture guidelines). Current regulations do not require any of these sites to be secured with electric fencing to restrict access by bears. Similarly, electric fencing can also be used to deter bears from birthing areas (e.g., calving, lambing). Grain and other feed should be housed in bear-proof structures or containers; in some areas these structures require electric fencing or placement on cement to prevent access (TVO 2017).

However, simply establishing electric fences around livestock attractants is unlikely to eliminate human-bear conflicts at livestock operations. Conservation Northwest (2015) advocates a multi-pronged approach to minimize conflicts for ranchers that includes:

- Monitoring calving operations
- Early calving
- Use of bear resistant containers
- Removal of garbage
- Use of electric fencing
- Avoiding surprising bears
- Removing dead piles

Gardens, Fruit trees and Vineyards

In some areas, gardens and fruit trees within communities can be a significant attractant to bears. Over the last 3 years, 25% of the calls to the Conservation Officer Service (COS) about grizzly bears noted residential fruit trees or berries as an attractant (when an attractant was noted; M. Badry, BC Ministry of Environment, unpublished data). As with other attractants, the easiest and most effective way to reduce this attractant is to physically remove the attractants (i.e., pick the fruit), rather than restricting access via electric fencing.

Fruit picking programs exist in many communities in BC to improve local food security as well as reduce human-wildlife conflict. Community volunteers can be very helpful in managing this particular attractant by either:

1. Picking fruit and donating it to local food banks if a landowner doesn't want it. Neglected fruit trees do not always produce attractive fruit, but the fruit is still acceptable for use in processing (canning, jams etc.) or it can be given to agricultural operations to feed livestock. Fruit gleaning programs have been undertaken in Kamloops, Castlegar, Hope, Revelstoke, Fernie, Golden, Squamish, Prince George, Quesnel and other areas. There is a guidebook on how to set up such a program available online: http://lifecyclesproject.ca/app/uploads/2015/08/Harvesting-Abudance-how-to-start-a-fruit-tree-project.pdf.
2. Removing unwanted trees for landowners (possible replacing with non-fruit bearing native varieties).

Mapping fruit trees was completed in Revelstoke (Bennett 1996) and proved effective at targeting trees for harvesting or removal by volunteers.

However, where removing fruit products is not wanted or feasible, electric fencing is a viable option in many cases. For example, agricultural operations that produce fruits in orchards or vineyards should consider adding electric fencing to the perimeter of their operations. This is typically easy to achieve, as electric fencing can often be easily added to existing ungulate fencing. For landowners with non-commercial scale fruit trees, adding an electric fence around backyard fruit trees is also easily achievable.

Garbage and Compost

Poor management of household garbage is the third greatest source of human-grizzly bear conflict in BC. Over the last 3 years, 22% of calls to the Conservation Officer Service (COS) about grizzly bears noted garbage or compost as an attractant (when an attractant was noted; M. Badry, BC Ministry of Environment, unpublished data). The majority of conflict resulting from poor management of garbage occurs at individual residences and properties where it is not practical to use electric fencing and other strategies should be recommended or employed (i.e., securing garbage in bear-proof garbage containers or otherwise removing access). However, electric fencing can be effective at securing compost piles. While most communities in BC have landfills that are electric fenced to exclude bears, some landfills are not electric fenced (e.g., Summerland) and continue to create food-conditioned bears which results in human-bear conflict.

Honeybee Colonies

Honeybee colonies (apiaries) are a non-natural attractant that are occasionally targeted by grizzly bears. Research has shown that operational electric fences are effective at deterring bears from damaging bee yards (Clark et al. 2005). However, as with all electric fence applications, maintenance of the system is key to its success; Clark et al. (2005) found in the 12 cases of damage to electric-fenced bee yards that the fences were not active because of depleted batteries. Under the BC Bee Regulation (2015), anyone keeping bees in BC must be registered and have their hive locations registered with the Provincial Apiculture Office, however there are currently no regulations that require the use of electric fencing or other exclusionary devices to keep bears from accessing apiaries. As with backyard chickens, some smaller jurisdictions require electric fencing of beehives (i.e., District of Squamish, Village of Kaslo).

Camps and Smokehouses

Camps and smokehouses, where human food and other attractants are often concentrated, can be a source of human-bear conflict and electric fences are an effective tool to secure these attractants. Brooks Camp (Alaska), which is located next to a salmon-bearing creek, experienced a significant decrease in grizzly bear-human incidents after electric fencing their campground in 2001 (Mosby et al. 2013, see Figure 6). Similarly, the Lake Louise Campground was fenced by Parks Canada (Parks Canada 2012) to reduce conflicts. Establishing electric fences around industrial camps is also promoted by the BC Oil and Gas Commission (https://www.bcogc.ca/content/bear-fencing-industrial-camps), but is not currently required under regulation. The use of electric fencing to secure attractants at small temporary sites such as back-country camps is also

useful for reducing human-bear conflict. Several all-inclusive "kits" are available from suppliers that include all the components necessary to set up an effective electric fence (see Appendix 2 for suppliers).

Conflict with bears can also arise because of the sites selected for the handling and preparation of hunting and fishing kills. Ideally, these sites should be located away from natural cover or movement corridors, but they are often associated with residences or camp sites. As these sites are usually very small in area, temporary electric fencing is a viable solution to restrict access by bears to these attractants. Other options for mitigating this attractant include commercial coolers (available in some communities) for hanging of carcasses during the hunting season and situating smokehouses away from the periphery of town (i.e., central to community).

Barriers to the Successful Use of Electric Fencing

Several barriers exist that may affect adoption of electric fences by communities and individuals. These include cost of equipment, safety concerns, inconvenience to users, and the maintenance required to ensure consistent operability.

Cost may be a deterrent to landowners considering using domestic-scale electric fencing. However, a controller that plugs into a regular power outlet with sufficient output to deter bears can be as inexpensive as $195.50 (Margo Supplies Ltd.) and a solar-powered controller as inexpensive as $299.25 (Margo Supplies Ltd.). All-inclusive fencing kits cost upwards of $378 (15 m mesh kit; 50 m mesh kit $503, both Margo Supplies; 37.6 m mesh kit $435, Kodiak Wildlife Products Inc.) to $1137 for heavy duty portable fences designed for temporary and semi-permanent applications (Margo Supplies Ltd.). All components of an electric fence system can be bought separately at local farm supply stores or online through various suppliers (see Appendix 2). Costs for deployment of large-scale fencing of major attractants (e.g., landfills, orchards), where systems need to be more robust, are significantly higher.

Safety concerns and aesthetics are other barriers to implementation of electric fences. To date, there have been no records of any person being permanently harmed by properly installed and monitored electric fencing. It should be noted that fence controllers must meet rigorous safety standards to ensure that adults, children or pets are not hurt by fence operations, so this issue is perhaps more related to perception than actual fact. Educational programs that illustrate the safety of electric fences would be useful for dispelling myths about personal safety concerns. Aesthetics concerns can partially be dealt with by allowing landowners to choose from a variety of fencing options, including wire type and whether an installation is permanent or temporary (e.g., allowing it to be removed during winter months when bears are not active).

For deployments where materials need to be transported by a person (e.g., back-country camps), barriers to use of electric fencing are likely related to weight and perceived difficulty in set up. However, kits weighing less than 4.5 kg are available and portable kits can be set up in less than half an hour. Fencing demonstrations or education programs that direct people to existing "how-to" videos available online could dispel these myths.

The greatest barrier to successful deployment of electric fencing is **proper installation and regular maintenance** (Sanders 2013). Maintaining the system to ensure a consistent electric shock is delivered to animals that contact the wire is critical to the successful use of this tool. Typically, this is achieved by ensuring that no alternate circuits, or electrical shorts or grounds (e.g., vegetation against positive/hot wire), occur in the system and that the circuit that is achieved when an animal contacts the system is strong (i.e., good power levels and connectivity to ground rod). One study found that the biggest failure of electric fences is poor construction, not fence age (Frank and Eklund 2017). Another study of the success of electric fencing bee yards found that, in 12 cases of damage to electrically fenced yards, the fences were not active because of depleted batteries (Clark et al. 2005). The issue is a human one: will people commit to the upkeep of an electric fence so that it is fully charged? This is a human-motivation question best addressed through social sciences (see "The Role of Social Science in Resolving Human-Bear Conflict" below).

Deploying electric fencing to reduce access by bears to attractants is only a part of the solution to reducing human-bear conflict in communities. Without a community-wide conflict reduction plan (such as Bear Smart; Davis et al. 2002), fencing only a portion of community attractants may result in moving "the problem" to neighboring properties. People who seek out assistance with electric fencing may be less likely to kill a bear in a conflict situation, once a bear is excluded from fenced properties they may move to properties owned by less-tolerant people and increase their likelihood of being killed. An overall community-based approach that includes monitoring human-bear conflicts, education, managing waste, implementing and enforcing bylaws, managing green space, and community planning (Davis et al. 2002) may be more effective at reducing mortality of grizzly bears.

State-of-Knowledge: Using Bear Spray to Increase Personal Safety around Bears

Adhering to proper bear avoidance safety techniques is the first line of defence in avoiding negative human-bear interactions (IGBC 2017a). However, in cases where a potentially dangerous interaction has not been avoided (e.g., bear charge or attack), deploying capsaicin-based bear spray is an effective means of self-defence. Bear spray is an aerosol product comprised of 1-2% capsaicin and related capsaicinoids that is sprayed as a cloud from a pressurized canister. Bear spray emerges from the canister at >100 km/h. When faced with a charging bear, a person can deliver the spray into the bear's path, the intense burning caused by inhalation of the spray averts the bear's attention from the person (IGBC 2017a).

Bear spray can be an effective deterrent when properly deployed during negative human-bear interactions. An analysis of incidents where people used bear spray from 1985-2006 found that bear spray stopped bears' undesirable behaviour 92% of the time when used on brown bears and 90% on black bears. Of all persons carrying bear spray, 98% were uninjured by bears in close-range encounters (Smith et al. 2008). The success rate of bear spray under a variety of situations has been greater than that observed for firearms (Smith et al. 2012) and requires less accuracy (IGBC 2017a).The use of bear spray also reduces the number of bears killed unnecessarily, which is especially important for at-risk bear populations.

Bear spray and pepper spray or personal defense spray are not the same product. Bear spray is comprised of 1-2% capsaicin and related capsaicinoids, whereas pepper spray intended for self-defence against other humans or dogs typically has lower concentrations of capsaicin (e.g., <1.33%; IGBC 2017a). Furthermore, pepper spray does not have the propulsion energy and pattern needed for bears and thus it should not be carried for self-defence from bears.

There are several key factors to consider in choosing an appropriate bear spray. In addition to ensuring the appropriate level of capsaicin and related capsaicinoids, users of bear spray should ensure that the expiration date of the canisters is current, that it is ≥225 grams net weight, will deliver a minimum range of 25 feet and last at least 6 seconds (IGBC 2008). Bear spray needs to be easily accessible (e.g., mounted on a hip or chest holster) not inside a backpack. Bear spray should be stored securely while travelling in vehicles, not be left in direct sunlight (heat can cause it to explode) and cannot be transported on commercial airplanes. It is wise to carry 2 cans of bear spray because bears sometimes need to be sprayed more than once in an encounter (IGBC 2017b). In Canada, the sale of bear spray is regulated by Health Canada and the Pest Controls Products Act, and vendors must collect the purchaser's name and address and have them sign a Notice to Purchaser Agreement. In the USA they are governed by the Environmental Protection Agency (EPA; IGBC 2008); the canister label should show the EPA registration number.

There are a number of products on the market that make bear spray more user-friendly in terms of making it more accessible while carrying it. There are various holster designs (e.g., hip and chest holsters, belts for trail

running) and carriers that fit into the water bottle bracket on a bike that make it easier to retrieve bear spray quickly.

Bear spray is only effective when the aerosol mist is inhaled by a bear; bear spray should not be applied to equipment or tents as a repellent. Grizzly bears may find the scent interesting and have shown that when the ground is sprayed with bear spray it can elicit scent-rubbing and whole body-rolling for as long as 5 days after spraying (Smith 1998). Because of this, practicing with bear spray should be done far from camps or preferably be done with inert (chemically inactive) spray (suppliers listed in Appendix 2).

Several videos are available online that demonstrate the correct use of bear spray:

- Interagency Grizzly Bear Committee: https://www.youtube.com/watch?v=HmbECUT8hG8
- Parks Canada: https://youtu.be/aIvpLzHiCrg
- Alberta government: www.youtube.com/watch?v=VDgBY2PbnO4&feature=youtu.be
- Washington State government: https://youtu.be/-ZdHXJAyiJY

Barriers to Implementation

Likely the greatest reason for resistance to carrying bear spray is a lack of belief it will work. There is some perceived "certainty" to shooting a bear (if you are successful) whereas spraying it with bear spray means it could come back. A targeted education program could be effective in dispelling these myths, using real data to validate the efficacy. Additionally, opportunities for practice are much more limited for the use of bear spray compared to guns. A person can practice with a gun at a shooting range for little cost but firing an inert bear spray is somewhat costly ($25+ per can).

Fear of an attack by a predator may cause negative attitudes that can be expressed as objections to the damage a predator causes. Kansky and Knight (2014) suggest that intangible costs (e.g., psychological costs of danger) are the most important variables explaining attitudes towards carnivores—significantly more so than tangible costs (e.g., direct monetary losses). Similarly, Kellert (1994) found that visitors to Glacier and Yellowstone National Parks viewed grizzly bears favourably and were willing to modify their behaviour to minimize disturbance to bears or their habitats whereas people permanently living in areas adjacent to grizzly populations appeared less sympathetic. Kellert (1994) suggests this may be because of both perceived threats to personal safety and the greater likelihood of depredations to livestock. This is apparent in some of the "living with bears" videos where the greatest fear of ranchers interviewed appears to be the safety risk to their children from grizzly bears on their ranches, not entirely the risk of livestock depredations or crop and building damage. Increasing bear behaviour and safety training and training people in the use of bear spray would be helpful in reducing these fears.

Electric Fence and Bear Spray Programs Currently Underway

There are several proactive programs promoting the use of electric fencing and bear spray to reduce conflicts with grizzly bears in BC. In the Kootenay region, there is the Trans-Border Grizzly Bear Project and work by Grizzly Bear Coexistence Solutions, and in southwestern BC there is the Coast to Cascades Grizzly Bear Initiative Throughout BC, the WildSafeBC program provides educational training and expertise for communities to reduce human-bear conflict on a number of fronts. Areas outside of BC (Alberta, northwest USA) also have existing programs. All programs rely on multiple funding sources and spend a great deal of time fund-raising to support their programs.

Kootenay Region

There are 2 programs operating in the Kootenay region: the Trans-Border Grizzly Bear Project (TBGBP, covering the South Selkirk and South Purcell-Yaak grizzly bear populations) and Grizzly Bear Coexistence Solutions (GBCS,

covering the Columbia basin). The two programs work closely together but cover slightly different geographic areas and have different goals and objectives; GBCS operates within and outside the TBGBP area.

Trans-Border Grizzly Bear Project

The Trans-Border Grizzly Bear Project takes a multi-pronged approach to blend science, conservation and real-world strategies to achieve on-the-ground solutions to address grizzly bear mortality and other conservation issues. The activities undertaken by the TBGBP have been successful in reducing the number of non-hunt grizzly bear mortalities in the area, in contrast to adjacent areas where mortalities have increased (Proctor 2017). Aspects of the program include:

- Purchasing critical and strategic private lands,
- Applying non-lethal management to potential problem grizzly bears to rehabilitate them,
- Attractant management programs,
- A 50% cost-share electric fencing program,
- A bear resistant garbage bin program,
- Land use planning for linkage areas,
- Workshops to encourage living and working safely in grizzly country including the use of bear spray,
- Hunter education programs, and,
- Mapping critical food resources for potential protection (access controls) and more.

The TBGBP is run by an independent research scientist (Dr. Michael Proctor) and funded by multiple agencies (e.g., Habitat Conservation Trust Foundation, Fish Wildlife Compensation Program, Wilburforce Foundation, Liz Claiborne & Art Ortenberg Foundation, Columbia Basin Trust, US Fish and Wildlife Service, National Fish & Wildlife Foundation, Great Northern Landscape Conservation Cooperative, Nature Conservancy Canada, and others). The electric-fencing program is run by Gillian Sanders of Grizzly Bear Coexistence Solutions (GBCS, see below). Different funding sources fund different aspects of the program (i.e., some only fund educational outreach activities, some fund fencing supplies).

The TBGBP has contributed approximately $68,000 (which has been matched by the landowner's 50% contribution) towards the purchase and installation of 70 electric fences (Figure 3). In most areas, fences were primarily installed to prevent and mitigate conflicts in grizzly bear population linkage areas, but also served to reduce potential grizzly bear conflict in other areas as well as prevent black bear conflicts.

The TBGBP held a very successful "Bear Fair" in 2016 for local farmers, ranchers, recreationists, hunters, and interested public that attracted over 100 participants. They conducted workshops on electric fencing, bear spray use (including practice deployments of inert bear sprays), bear safety, and more. The TBGBP hopes to hold more of these educational events in the future. Outreach to hunter groups has included discussions of access management issues and grizzly bear conservation in general; more work needs to be done on hunter education and camp and carcass handling measures (M. Proctor, pers. comm. 2017). The TBGPB is also working with area farmers towards creating a bear-proof carcass disposal system, and is now turning its focus to the area south of Cranbrook BC, where grizzly bear mortality is still a serious concern.

Figure 3. Dr. Michael Proctor inspects an electric fence retrofitted on ungulate fencing to exclude grizzly bears from a cherry orchard.

Grizzly Bear Coexistence Solutions

Grizzly Bear Coexistence Solutions (GBCS) helps landowners and local communities to share habitat with grizzly bears through education, collaboration, and the use of practical tools. GBCS is run by Gillian Sanders and has multiple funders including Columbia Basin Trust, Habitat Conservation Trust Foundation, and Kootenay Lake Local Conservation Fund and partners with various conservation and agricultural groups. Sanders began to install and cost-share electric fencing for grizzly bears in 2007 and has taught workshops on the installation and use of electric fencing for bears since 2010. These fencing workshops have primarily been in the Kootenay Region, but also in Bella Coola and on the Sunshine Coast. GBCS has assisted with the installation of over 130 electric fences for a variety of users in the Kootenay Region outside of the TBGBP study area. Fencing is conveniently coordinated through the local farm and ranch supply stores whose employees understand the needs of wildlife fencing versus livestock fencing and provides quotes to landowners and bills the program directly. GBCS is currently evaluating the success of electric fences installed over the past five years in the Kootenay Region. Future efforts of GBCS include expanding educational activities through electric fencing workshops in various parts of the province with an eye to inspiring and informing other regional electric fencing efforts carried out by their local interest groups, and to promote electric fencing for bears to large agricultural groups to protect livestock and crops. GBCS is producing a “how-to” manual for electric fencing by March 2018.

GBCS has also conducted 12 bear-safety workshops (including inert bear spray training) since 2014 for the BC Ministry of Forests, Lands and Natural Resource Operations, Fish and Wildlife Compensation Program, Selkirk College and community groups.

Coast to Cascades Grizzly Bear Initiative

The Coast to Cascades Grizzly Bear Initiative (C2CGBI) operates in southwestern BC and is a joint project between Conservation Northwest, Canadian Parks and Wilderness Society BC (CPAWS BC) and the Pemberton Wildlife Association. The C2CGBI and its goals are endorsed by St’at’imc Government Services, Okanagan Nation Alliance, Squamish, Stó:lō, Nlaka’pamux and Shuswap First Nations. C2CGBI partners include AWARE-Whistler, BC Nature, Sierra Club BC, BC Spaces for Nature, Hope Mountain Centre and Whistler and Lillooet Naturalists. The coalition seeks to protect and recover populations of threatened grizzly bears in southwest BC and maintain healthy communities through science-based planning, community involvement and environmentally responsible development. The C2CGBI works in collaboration with research scientists, First Nations, governments,

community groups and industry. The C2CGBI focuses on conservation efforts in linkage zone habitats with the goal of protecting and improving habitat permeability in and between Grizzly Bear Population Units (GBPUs), continuing positive population trends in the Squamish-Lillooet and South Chilcotin GBPUs and establishing positive trends in other GBPUs in the area and establishing metrics for measuring outcomes. The initiative focuses on impacts and solutions that they believe will provide the "biggest bang for the buck":

- Managing motorized access on back-country roads,
- Enhancing security for core and connectivity habitats,
- Managing community and household food attractants, and,
- Reducing conflict with livestock (real, potential and perceived).

The C2CGBI is funded by multiple sources including the Wilburforce and Campion Foundations. The C2CGBI is endorsed by all municipal and Regional District governments in the Sea to Sky corridor as well as non-traditional allies like the BC Wildlife Federation and Pemberton Farmers' Institute.

The C2CGBI aims to prevent or lessen real and potential human-bear conflict particularly in areas where grizzly bear populations are increasing but are still threatened and human use is growing. C2CGBI uses local contractors with deep roots in the communities.

The C2CGBI promotes the use of electric fences and bear spray to mitigate human-bear conflict on a number of fronts:

- The C2CGBI funds a local WildSafeBC coordinator who has received training in delivering electric fence workshops (J. Patrick), she is working with 11 St'át'imc First Nations and other area communities. C2CGBI also sponsored two Tsilhqot'in community members to take WildSafeBC training. C2CGBI has identified a need for Bear Hazard Assessments and much more human-bear conflict mitigation (including the promotion of the use of electric fencing, currently they do not have a cost-share program or electric fencing equipment to loan out) in the D'Arcy-Pemberton Meadows corridor because it is the primary corridor of movement between the growing South Chilcotin GBPU and the threatened Stein-Nahatlatch GBPU.
- The C2CGBI has a livestock conflict-prevention program in the South Chilcotin GBPU, which is likely the source population to "rescue" threatened GBPUs to the south. The program focuses on outreach to ranchers to promote data-gathering, non-lethal predator controls and conflict prevention while building relationships with livestock operators and political support for grizzly bear conservation. The conflict prevention coordinator (A. McEwan) has met with Big Creek area ranchers and briefed them on the C2CGBI program and assessed their interest in the program. C2CGBI hopes to establish a cost-sharing electric fencing program but currently has no ranchers as a pilot project (they are working towards that). Electric fencing program delivery will likely focus on securing attractants at "home ranches", the home base of the large ranches. The program has had positive interactions with the BC Cattlemen's Association and would like to promote a range riding program in the area. Unfortunately, due to the extensive forest fires in the area in 2017 the program was temporarily put on hold.
- C2CGBI has created "You are In Bear Country" information signs to be installed in the area that emphasizes "carry bear spray". They are planning educational events that include raising awareness of backcountry users about grizzly bears, promoting proper behaviour and training people to properly use bear spray.

WildSafeBC

WildSafeBC is a program designed to reduce human-wildlife conflict through education, innovation and cooperation. Program coordinators focus on education and give presentations to schools, have information booths at public forums such as community events and farmer's markets and occasionally tag garbage at

households that is put it out too early on collection days. WildSafeBC has a strong social media presence and also distributes its message through radio, print and TV news.

The WildSafeBC[1] program is owned and delivered by the BC Conservation Foundation and receives its base funding from the provincial government. In 2016, the BC government contributed $275,000 to the program and an additional ~$425,000 was contributed by various sources (e.g., municipalities, regional districts, communities, BC Gaming Canada summer jobs program, Columbia Basin Trust, private donors and First Nations). Communities apply to be part of the program; they must be willing to contribute at least $3,000 cash towards a coordinator to be eligible for inclusion in the program (Ritcey 2017). Community applications are ranked on several criteria, including whether they have been a part of the program in the past. After their first year with a coordinator, communities receive the highest score if they are entering year 2 and that score decreases in subsequent years to try and encourage communities to fund their own coordinators over time.

In 2016, the WildSafeBC program had 26 coordinators servicing about 100 communities throughout the province (Ritcey 2017). There are 5 WildSafeBC coordinators that work in communities within the Trans-Border Grizzly Bear Project area (Kimberley-Cranbrook, Selkirk-Purcell, Nelson and area, Trail-Rossland and Castlegar), the TBGBP provides some funding for the Selkirk-Purcell WildSafeBC coordinators. The area currently covered by the program run by Grizzly Bear Coexistence Solutions overlaps with 10 WildSafeBC communities throughout the Kootenays. The Kootenays have the highest concentration of WildSafeBC coordinators in BC due to the availability of regional funding sources.

In the past, the WildSafeBC program has concentrated on education of homeowners but has now expanded to encourage people to think about how they “live, work, play and grow” to try and reduce human-wildlife conflicts in all day-to-day activities. Their motto is “Keeping wildlife wild and communities safe”. WildSafeBC coordinators work closely with the Conservation Officers in their communities to react to areas with increasing human-bear conflict.

Electric fencing is extensively promoted by the WildSafeBC program as a way to reduce conflict with bears when coordinators talk to bee-keepers, backyard chicken farmers, and berry farmers. WildSafeBC conducts presentations about electric fencing of attractants at farmers' markets and other public venues (F. Ritcey, pers. comm. 2017). Two of the 26 WildSafeBC programs have electric fencing equipment to lend out and 7 of 26 held electric fence demonstrations in 2016 (summarized from reports: BCCF 2017). However, a number of the WildSafeBC reporting areas had the Grizzly Bear Coexistence Solutions program assisting landowners wishing to use electric fencing and these fences are not mentioned in the 2016 WildSafeBC reports. WildSafeBC coordinators are required to take additional training with the program manager (F. Ritcey) to ensure they have enough knowledge to advise landowners about electric fencing. WildSafeBC assisted with the deployment of temporary electric fences and/or fence components at 21 locations in Bella Coola in 2016 (Koroluk 2016), including fencing orchards and smokehouses. Unfortunately bears have started digging under electric fences in the area to get to fruit trees (S. Hodgson, pers. comm. 2017). There is good buy-in of the program from the Nuxalk First Nation and other locals. In the New Denver, Silverton, Nakusp and Area K region there were 2 temporary electric fence kits available to residents from the WildSafeBC coordinator.

WildSafeBC promotes the use of bear spray whenever possible; the use of bear spray is mentioned in virtually every interaction with the public when talking about bear safety (F. Ritcey, pers. comm. 2017). Twelve of 26 programs held bear spray demonstrations in 2016 (summarized from reports: BCCF 2017). Similar to electric fencing demonstrations, WildSafeBC coordinators must receive additional training from the program manager to ensure they have enough knowledge to deliver bear spray training themselves.

[1] WildSafeBC used to be the Bear Aware program but was expanded to include all wildlife species in 2013

The WildSafeBC program gathers feedback from teachers after educational presentations, monitors social media commentary on bear conflict situations, and monitors the effectiveness of its garbage tagging program (counting the number of garbage bins left out before and after tagging campaigns). However, as these assessments are not externally available it is difficult to determine how much change in behaviour has occurred as a result of the program. A more formal monitoring and evaluation component to the reporting for this program would help determine the efficacy of its educational and outreach methods at changing undesired behaviours. An improvement to the program could be to explicitly evaluate and report on how the program's audience have changed their behaviour, or secondarily, measure changes in knowledge, awareness and aspirations. However, such evaluations would require additional funding.

Alberta

In addition to programs within the Waterton Biosphere Reserve (see below), the Alberta-based Bear Conflict Solutions Institute is a federally registered charity that is involved in a variety of bear conflict management initiatives that focus on reducing negative bear-human interactions. These include specialized training courses and innovative applied research. They have a cost-share electric fencing program, promote the use of bear spray, have a Bear Bin Loaner program and provide information on conflict reduction strategies on their website (www.bearconflict.org). Of note about this program is it has a strong evaluation component to determine the efficacy of its programs at achieving their desired outcomes (i.e., changes in human behaviour).

USA

Defenders of Wildlife, an American not-for-profit, has a grizzly bear coexistence program that assists livestock producers with range riders to alert when a grizzly bear is near, livestock guard dogs, electric fencing around calving and lambing grounds and bear-resistant methods for securing garbage at homesites. Additionally, they have a 50% cost share program for electric fencing (up to $500) for securing grizzly bear attractants (e.g., garbage, fruit trees and livestock) in eligible counties in Washington, Idaho, Montana and Wyoming (http://www.defenders.org/got-grizzlies).

The Role of Social Science in Resolving Human-Bear Conflict

Human-bear conflicts arise because of the actions (behaviours) of both humans and bears. Much is understood about the motivations of bears (i.e., locating food, defending young) and how to mitigate conflict with people e.g., humans remove/secure food and attractants, alert bears to the presence of people, use bear spray when necessary). Therefore, reducing human-bear conflict is largely an issue of changing human behaviour, and while information is available on motivations and behaviour change, gaps in our understanding prevail. As Madden (2004) suggests in her report on managing human-wildlife conflict, "Biological science alone does not provide a complete understanding of or solutions to the conflict. In reality, half of the challenge of addressing the conflict is in understanding the human dimension with its social, cultural, political, economic, and legal complexities". Therefore, social scientists and educational experts should be engaged to help conservation managers examine human motivations for participating in bear conservation (or not), and to evaluate how educational interventions affect conservation outcomes (Baruch-Mordo et al. 2011, Hughes 2012). This includes longer term investments in evaluating the efficacy of educational interventions, which will in turn allow managers to deliver more effective human-wildlife conflict programs (Hughes et al. in press).

A wide diversity of communities, landowners and user groups occur in the range of grizzly bears in BC, and subsequently form key target audiences for educational outreach and promotion of proactive conservation behaviours. Indeed, it is the behaviours of, and decisions made by, these groups that affect the achievement of desired outcomes (i.e., reduction in human-bear conflict). However, each audience holds unique attitudes and behaviours towards bears, and thus solutions tailored to each specific audience are required. For example, some audiences may be more open to regulation and readily adopt conservation actions whereas others may be

resistant to change. Some people may have entrenched attitudes or procedures and do not want to change regardless of the consequences, and in fact may feel alienated if pushed to change, so providing people with options and examples of success may be more effective at eliciting desired outcomes (Sanders 2013). Indeed, different audiences require different solutions to resolving human-bear conflict. This can include identifying barriers to adopting mitigation strategies (e.g., Sanders 2013) such as electric fencing or using bear spray, to strengthening relationships between groups to achieve conservation objectives (Hughes and Nielsen 2013). It is also commonly recognized that "human-wildlife conflicts escalate when local people feel that the needs or values of wildlife are given priority over their own needs" (Madden 2004). Consequently, human-bear conflict programs often emphasize providing cost-effective solutions (i.e., stopping loss of products such as honey and fruit) or improving safety for backcountry users (i.e., electric fencing hunting camps), rather than bear conservation. However, conservation managers also need to better understand other motivating factors for bear conservation, such as why bears hold symbolic or intrinsic value for different people, and what this means for conservation outcomes. Evaluation of human-wildlife conflict mitigation tools, and follow-up adaptation of updated policies and procedures, is essential to overall program success (Baruch-Mordo et al. 2011) and is often overlooked. Certainly, change in human behaviour can provide long-term solutions to conflict versus focusing solely on managing bears (e.g., removal, translocation, aversive conditioning; Baruch-Mordo et al. 2011).

The need, then, is to go beyond evaluating the efficacy of conflict mitigation tools to understanding human behaviours and motivations for bear conservation, and evaluating educational interventions to assess "if skills were developed, if proactive behaviours are adopted and sustained and what the interventions had on conservation outcomes" (Hughes et al. *in press*). As previously stated, it is because of these factors that social scientists and educational experts should be engaged in bear conservation efforts.

Recommended Future Efforts

Target Audiences for Educational Programs

Priority audiences for education and extension programs should be identified by evaluating non-hunter caused deaths of grizzly bears in BC; those activities or behaviours found to cause the greatest number of conflict-related kills should be higher priority. There are a multitude of potential target audiences for educational messages about the use of electric fencing to decrease the amount of human-bear conflict in BC including:

- **Cities, Towns and Regional Districts**: as more and more regional governments pass bylaws allowing backyard chickens, they should be encouraged to also require electric fencing of chicken coops. Bylaws to reduce conflict with bears should also include other attractants such as bees, fruit, BBQs, compost, garbage and bird feeders (Davis et al. 2002). A starter document is available on how to work towards creating bylaws in communities at: http://www.bearsmart.com/docs/bear-aware-bylaw-committees.pdf. However, bylaws are not effective without enforcement.
- **BC Cattlemen's Association** (www.cattlemen.bc.ca) and **BC Livestock Producers Co-operative Association** (www.bclivestock.bc.ca): Several programs in the USA and Canada work with ranchers to reduce human-bear conflicts associated with their operations. For example, ranchers in the Waterton Biosphere Reserve are provided with bear-proof grain bin doors and placement of grain bins on cement to prevent grizzly bears breaking in, sheep farmers have been assisted with electric fencing their flocks and they have an electric-fenced central carcass (deadstock) disposal bin used by up to 150 ranches (TVO 2017). In the USA, Defenders of Wildlife provide monetary compensation to ranchers in Idaho and Washington State for livestock verified to have been killed by grizzly bears. Colorado and Montana have state-run compensation programs.
- **First Nations**: many BC First Nations are partners in existing programs such as WildSafeBC and C2C's Grizzly Bear Initiative. However, more outreach should be targeted towards First Nations communities

because many of them occur within the range of grizzly bears and some cultural activities such as drying or smoking fish can be major attractants for bears.

- **Alpine Club of Canada** (www.alpineclubofcanada.ca): The Alpine Club operates 36 huts across BC and Alberta. At least one back-country hut (the Guy Hut, Yoho National Park) is closed during the non-denning months so as to not disturb sensitive grizzly bear habitat. The Alpine Club should be consulted to see if they are having issues with bears breaking into any huts and the use of bear spray should be promoted to members.
- **BC Honey Producers' Association** (bcbeekeepers.com): the BC Honey Producers' Association has an annual AGM, a quarterly newsletter (Bee sCene), and a website that could be used to disseminate information about the use of electric fencing to deter bears. The beginner beekeeper course offered by the BC government mentions the use of using electric fencing but does not provide any instruction on its use. Regional apiary inspectors (there are 7 in the province: http://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/animal-production/bees/apiculturist-inspectors) could be helpful in identifying key areas for educational programs.
- **Backyard chicken owners**: a number of jurisdictions require that backyard chickens be registered and permitted; it may be possible to provide educational materials to registrars for distribution (as is being done by GBCS).
- **Outdoor Recreation Council of BC** (www.orcbc.ca), including member organizations:
    - Backcountry Horsemen of BC,
    - BC Wildlife Federation (see section on "Hunter and Trapper Education Programs" below),
    - Federation of Mountain Clubs of BC,
    - Guide Outfitters Association of BC.

  Due to the number of member organizations within the ORCBC they could be a good partner to get messages out to a wide audience.

Other organizations:

- BC Mountaineering Club (www.bcmc.ca),
- Cycling BC (www.cyclingbc.net) and other cycling clubs,
- BC Fruit Growers' Association (www.bcfga.com),
- BC Grapegrowers' Association (www.grapegrowers.bc.ca),
- BC Grain Producers Association (www.bcgrain.com), and
- other agricultural groups (e.g., various berry councils).

Major retailers could also be helpful in disseminating information, including farm supply stores, cycling stores, outdoor gear stores (e.g., Mountain Equipment Co-op), etc. Education programs need to embrace social media, most of the organizations listed above have social media pages.

Community Education Coordinators

Coordinators are the key to the success of any outreach program, and it takes a unique individual to deliver a successful program. Coordinators need to be knowledgeable, outgoing, personable, comfortable talking to strangers and giving presentations. Coordinators should be a member of at least one target audiences (e.g., have livestock, hunting, mountain biking or beekeeping experience) to increase credibility within communities and target audiences. The longer the coordinator has a lived in the community they are delivering a program, the better. Retention of coordinators is critical, which can be difficult due to the seasonal nature of the work, but being able to build on the program year-to-year will help increase compliance and buy-in from locals.

Promotion of Bear Spray

The proper use of bear spray is demonstrated very little in BC. A few programs promote its use (see "Programs Currently Underway") but even those programs generally only give one "how-to" demonstration workshop/year in a region. Overall, many more demonstration workshops should be conducted within BC every year along with updating the message regarding the efficacy of bear spray relative to firearms. Methods to increase the use of bear spray in BC could include:

- Promote carrying bear spray on signage being placed at trailheads in recreational areas (e.g., as done by groups such as Coast to Cascades Grizzly Bear Initiative) and in brochures for tourists in recreation areas and on websites (e.g., Parks Canada: https://www.pc.gc.ca/en/pn-np/mtn/ours-bears/securite-safety/gaz-spray).
- Promote the new holsters designed for bicycles and runners.
- Promote stories about successful use of bear spray (e.g., US National Park's Service "Minute Out In It" YouTube about encounter between a grizzly bear with cubs and 3 employees: https://www.youtube.com/watch?v=WGtrhatX8LA). Consider creating a new video with BC-based people who have used bear spray successfully (e.g., J. Berganski).
- Promote the use of bear spray to user groups who may encounter bears, for example, ranchers, hunters, fishermen, back-country hikers and bikers. Work on dispelling myths about bear spray (e.g., bear spray doesn't work in the rain).
- Lobby for increased reference to bear spray as a tool in the BC CORE manual (see section on "Hunter and Trapper Education Programs" below).
- Increasing bear behaviour and safety training to ranchers operating within the range of grizzly bears in BC.
- Make inert bear spray canisters much more accessible to education programs so that people can practice with them. Suppliers listed in Appendix 2.

Hunter and Trapper Education Programs

There are a number of education programs in BC to which backcountry users may be exposed. Anyone buying a hunting license in BC must take the BC Hunter Safety program called Conservation and Outdoor Recreation Education ("CORE"), for which the manual is jointly published by the BC Wildlife Federation and the Wildlife Branch of the Province of BC (2014). Currently, non-lethal deterrents are not promoted in the CORE manual. Fur trappers in BC take an education program delivered by the BC Trappers Association and the associated Trappers Education Manual also does not promote the use of non-lethal deterrents. In jurisdictions outside of BC, bear spray is promoted to hunters (Alaska; Alaska Department of Fish and Game 2017) and the Interagency Grizzly Bear Committee (IGBC) promotes its use (IGBC and Wildlife Management Institute 2013).

Recommendations:

- While most trapping occurs in the winter when bears are hibernating, not all activities are. Adding "carry bear spray in spring, summer and fall" to the Trapper Safety section of the Trapper Education Manual (Hatler and Beal 2006) would be a useful addition.
- Work with the government and BC Wildlife Federation on the next CORE manual (BC Hunter Safety manual) to add "carry bear spray" to various sections of the CORE manual. For example:
    - In the section on "Trailing an Animal" add "A wounded animal may attract predators such as bears. Carry bear spray to protect oneself in the event of a charge so as to reduce the need to kill in defense of life."
    - In the section on "Minimizing Dangers Around Wildlife"
        - under "Learn how to avoid contact" add "consider electric fencing your camp" and,
        - under "Learn procedures on how to handle wildlife when encounters do occur; deterrent methods and tools" add "For example, bear spray".

- The section on Bear and Cougar Safety should be reviewed by a bear biologist and should have the use of bear spray added to it.
- Have “bear spray” added to the Sportsman’s Checklist

Adding data on the efficacy of bear spray relative to firearms in updates to these documents would be beneficial because these groups may be skeptical regarding the use of bear spray.

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Appendix 1. Electric fence specifications

Many resources are available that provide details on electric fence design, installation and equipment specifications to exclude bears (e.g., Gasvoda 1999 and Karsky et al. 2007 are both endorsed by the Interagency Grizzly Bear Committee, Sowka 2013, Annis 2017). There are also videos available online that demonstrate how to set up an electric fence, including:

- Defenders of Wildlife: https://www.youtube.com/watch?v=3EVg_ImABg0
- Grizzly Bear Coexistence Solutions: https://www.youtube.com/watch?v=lqIRMavnahE&feature=youtu.be
- Alaska Department of Fish and Game: http://www.adfg.alaska.gov/index.cfm?adfg=livingwithbears.bearfences

In general, an electric fence installation is comprised of the following components: an electric fence controller to deliver the charge, wires to carry the charge, posts to hold the wires, insulators to hold the wires on the posts without grounding the charge, ground rods and a fence tester.

Controller

Controllers (also known as energizers, chargers and fencers) are the power source for an electric fence. The "joule rating" is the single most important factor in choosing a controller to deliver a charge sufficient to deter bears (Sowka 2013). For most wildlife, it is recommended that fence controllers deliver **≥0.7 joules.** Several commercial electric fence controllers deliver the ≥0.7 joules necessary to deter wildlife, but there are also many fence controllers on the market that do not fit this specification and use of these under-powered controllers is a common cause of ineffective electric fencing. The length of the fence to be energized must be considered when selecting the controller because longer fences require higher joule-rated controllers (Annis 2017). Occasionally, manufacturers do not display the joules output or voltage of a fence controller, only the distance over which the controller will work. However, this "distance rating" is for total length of wire being energized, not the distance covered by the fence (i.e., a controller rated for 6 km is sufficient for 1.5 km of four electrified strands of fence; BC Ministry of Agriculture 2015). Controllers may be connected to a regular 110-volt electrical outlet (powerline input models) or battery powered (the battery can be solar-charged, have 12 volt batteries or D-cell batteries in small portable units). Powerline input models are generally less expensive than solar-charged units. Controllers should be placed out of reach of bears to discourage damage to the controller.

Voltage

The amount of stored or output[2] joules does not translate to the amount of voltage a controller can deliver, nor to how powerful the electric shock will be (Annis 2017). The higher the joule rating, the higher the amperage which, depending on other factors, affects how powerful the resulting "shock" will feel (Annis 2017). Controllers with different joule output can deliver equivalent voltage; a 0.2 joule-rated controller and a 1.0 joule controller can each produce a 7,000 volt shock but that produced by the 1.0 joule controller will be a much more powerful shock (Annis 2017).

The minimum voltage needed to deter bears is generally accepted to be 6,000 volts (Sowka 2013). However, because the upper limit of some controllers is 6,000 volts, and since many operate below full capacity because of fence maintenance or local site issues, it may be best to advise that the minimum voltage is 7,000 volts (G.

[2] The joule rating of energizers typically have 1 of 2 classifications; *Stored* or *Output*. The *Stored* classification is the maximum number of joules that the energizer can store when not delivering energy to a fence. The *Output* classification is the maximum number of joules that the energizer can deliver to a fence. The number of joules *Stored* will always be higher than the amount that can be delivered to the fence (Annis 2017).

Sanders, pers. comm. 2017). Black, grizzly and polar bears all respond to the same voltage. Voltage output of controllers for livestock may be inadequate for excluding bears, as these systems operate at much lower voltage, with minimum voltage recommendations as low as 700 volts for short-haired animals and 2,000 volts for long-haired animals (e.g., sheep; BC Ministry of Agriculture 2015). The maximum amount of voltage output is determined by the unit's design and must be Canadian Standards Association (CSA) or Underwriter Laboratories (UL) tested and approved.

Programs promoting the use of electric fencing should work with local retailers (e.g., farm and ranch supply stores) to ensure they understand the requirements of electric fences installed to deter bears to ensure people buy controllers of sufficient power and appropriate conductive and insulated wire (G. Sanders, pers. comm. 2017).

Fence wire

Wire can be either smooth metal fence wire (14 gauge or heavier), stranded galvanized cable (12.5 gauge; J. Marley, pers. comm. 2017) or polywire (polyethylene interwoven with at least 6 strands of stainless steel wire). Aluminum wire may be used but it tends to break with repeated bending and is not as durable as steel over time (Sowka 2013). It is important to use smooth wire and NOT use barbed wire because it is possible that a person's clothing could get caught in the barbs. Prefabricated electric fence “nets” (see photo on report cover) with alternating positive and negative wires are also widely available. Vegetation below the fence wires must be cleared to prevent grounding the charge through vegetation, thereby reducing the shock to an animal touching the fence. Wires must be sufficiently taut to withstand an animal with an insulating fur coat attempting to pass through it and to prevent sagging of wires that then may short out to a non-insulated item (e.g., post, vegetation or ground).

It is often desirable to increase the visibility and safety of electric fence systems to warn people and wildlife of its presence. At least one warning sign should be placed on an electric fence (preferably one is hung on all sides that a human may approach) and flagging tape hanging on the wires can also help increase visibility. Polytape (wide, flat polywire) can increase visibility of the top electrified strand but should not be used for the lower strands (Sowka 2013). Some fence designs add a couple of blinking LED light to make the fence more visible to wildlife at night.

Rigid wire panels are sometimes used instead of strands of wire (Sowka 2013, Annis 2017, G. Sanders, pers. comm. 2017). Panels of cow or pig fencing are suspended just above the ground by fiberglass posts and the entire panel is positive/hot once attached to the fence controller. This is a good solution to the fence keeping bears out but also small animals (e.g., sheep) enclosed.

Fence Posts

Permanent fences should be built of metal or treated wooden posts set several feet into the ground with fence insulators holding wires. Wood and metal posts are more durable but also more expensive. Fiberglass or plastic posts may be appropriate for temporary fences but, because they can be flimsy, they often require that corners of the fence be braced. Metal corner posts (e.g., rebar, T-posts) with an insulated cover (e.g., plastic tubing) may also be suitable for bracing corners of temporary fences (G. Sanders, pers. comm. 2017). Guy-wires are not recommended on the outside of the fence line because bears and other animals can run into them and compromise the strength of the fence.

Fence Insulators

Many types of fence insulators are available that hold fencing wire without allowing the electric current to ground out to the posts or buildings. All positive/hot wires of an electric fencing system need to be secured by fence insulators or non-conductive posts (some plastic posts have built in wire holders). Insulators are often

designed for specific post-types (e.g., rebar and T-posts). Longer insulators hold the positive/hot wires further from potential sources of grounding (e.g., corners of buildings).

Ground Rod or Plate

Ground rods or plates are required for all types of electric fences and are critical to their effectiveness; an improperly grounded fence will not deliver the shock needed to deter bears. Ground rods should be made of ½" or ¾" diameter galvanized steel and be 180 cm long for permanent fences. Depending on soil conditions and fence length, electric fences need a minimum of 0.9-1.2 m (3-6') of grounding rod per 1 joule of stored energy from the controller (Annis 2017). Fences may require 3 ground rods spaced at least 3 m apart, with the rods driven into the ground leaving a few centimeters above ground to allow for attachment of the lead wire with a ground rod clamp. While 3 ground rods may be necessary for good grounding in dry or frozen ground, only one ground rod is likely necessary for short fences (less than about 60 m; J. Marley, pers. comm. 2017) and shorter (≥60 cm) rods are used for short, portable fences. Painted rods, T-posts, rebar, hollow pipes and water pipes are not recommended for use as ground rods (Sowka 2013). Ground rods should be placed in moist soil if possible (e.g., under the eaves of a building where water runs off) and water can be poured around the rod during dry spells to increase conductivity. Calcium carbonate can also be sprinkled on the ground around ground rods to enhance conductivity. A ground plate can be used if soils are too rocky to be able to pound a ground rod deeply; due to the greater surface area of a ground plate it may be better at grounding an electric fence than ground rods.

Due to the high voltage being carried, wire used to connect the controller to the ground rod or plate or between live wires needs to be of adequate insulation (rated to 20,000 volts; Annis 2017) to prevent leakage of electricity; ordinary household wire is not suitable for this application.

Gates

Several different designs can be used for gates to access electric fenced enclosures. Panels or grids of electric wires in the same array as the fence (either positive/hot wires or alternating positive/negative) can be placed on the outside of the gate in series with one connecting wire on a spring-loaded insulated handle to the electrified fence (Figure 4, 5) or for larger set-ups, such as campgrounds or landfills, a larger panelled gate or an electrified drive-over cattleguard/Texas Gate (e.g., used at Lake Louise Campground Figure 6; Parks Canada 2012) or electrified mats can be used to deter wildlife crossing where wildlife fences meet roadways. Electrified road crossing structures should be ≥3.6 m deep to prevent animals jumping over them (J. Marley, pers. comm. 2017).

Figure 4. H. Davis stands behind the electrified gate at Brooks Camp campground. Photo by D. Wellwood.

Figure 5. Gillian Sanders opens the single handle on an electrified gate to a chicken coop enclosed by electric fencing to prevent predation by bears and other wildlife. Photo by H. Davis.

Figure 6. Electrified cattle guard at Lake Louise campground. Photo by J. Marley.

Fence Tester/Voltage Meter

As mentioned previously, maintaining an electric fence is the best method to ensure that it effectively excludes bears from accessing attractants. On-site evaluation of the fence performance is done using a performance meter built into the controller or using a hand-held fence tester (e.g., glow-light scale or digital read-out). A fence tester with a digital read-out is the preferred method of checking an electric fence; readings should be taken at the farthest parts of the fence from the controller. Electric fences should be checked regularly (>1/week) to ensure a full charge is being delivered throughout the fence. A reading of **7,000 volts** is the goal for all design components (maximum 10,000 volts). Anything that touches the wires on the fence can conduct the fence's electric current to the ground and decrease the shock delivered to a bear, so vegetation often needs to be cleared from fence lines, particularly during the growing season or following storms.

Baiting Electric Fences

Some people promote baiting the hot wire of electric fences to ensure that bears receive a shock to their nose. However, baiting can pull in bears that were not initially attempting to access an attractant as well as other animals in the area such as domestic dogs. Therefore, if baiting is done it should be with something that gives no food reward (e.g., an empty sardine can) and only be used in situations where bears have already been accessing an attractant.

Motion Sensitive Cameras

It is very helpful to have electric fences monitored with motion-sensitive cameras to demonstrate the successfulness of the fences. If landowners have no issues with bears after the installation of an electric fence around an attractant, they may think it is because no bears attempted to access their attractant. However, visual confirmation of bears testing the fence generally contributes to overall acceptance and adoption of this technique by landowners. Additionally, seeing bears visiting and being repelled by the fence can encourage regular fence maintenance.

Portable versus Permanent Fencing

Whether to install a portable or permanent electric fence depends on the seasonality of the attractant being secured or the frequency in which it is being moved; protecting calving grounds or large orchards require different set-ups than a single chicken coop or beehive. Fences can be permanent for year-round attractants (e.g., landfills, chicken coops) or temporary for seasonal attractants (e.g., beehives that are moved frequently, hunting camps). Permanent fence designs are typically high-tensile, multi-strand systems that are more expensive than portable designs, but they require less maintenance than portable designs and withstand environmental conditions (e.g., snow load) better than portable temporary designs.

Placement of an electric fence enclosure is important. Regardless of fence type, there should be nothing near a fence that a bear can stand on to jump over a fence. Furthermore, the fence should be at least 1 m from the attractants it encloses. For portable attractants, choose sites with reasonably level ground to avoid large gaps under the fence. Also, it is recommended that sites are not placed near natural foods (e.g., berry patches) or along travel corridors, forest edges or near natural cover.

Permanent Fence Design

Permanent bear-proof electric fences should consist of:

- Controller: a minimum of 0.7 joule fence controller, higher joules for longer fences.
- Fence wire: permanent electric fences should consist of 5-8 strands of graduating height wire (wires closer together near the bottom of the fence, wider towards the top). If the fence is in a dry area, an alternating positive/negative fence should be constructed with the spacing and polarity of the wires (for an 8-wire fence) from the ground up as: bottom positive/hot wire 5-10 cm from the ground then negative/cold, positive/hot, positive/hot (these 2 positive/hot wires should be at nose height of bears), negative/cold, positive/hot, negative/cold, positive/hot (top and bottom wires should always be positive/hot; Sowka 2013, Annis 2017). Wire spacing should also be graduated for a positive (all-hot) fence system. Wires should be between 10 and 25 cm apart to a minimum height of 1.2 m, starting at 5-10 cm above ground level.
- Fence posts: metal or wooden posts with insulators. Posts pounded into the ground, rather than placed in pre-dug holes, tend to be more stable. Posts should be spaced a maximum of 2.5 m apart.
- Ground rods: the system is properly grounded with three ground rods, buried 2-3 m deep and spaced at least 3 m apart, connected to the negative output terminal of the fence charger by ground clamps. However, 3 ground rods are generally not needed to achieve good grounding for smaller enclosures. Depending on local conditions, alternate methods are sometimes needed to ensure adequate delivery of electric current, such as the use of ground plates, or deeply driven larger diameter rods.

Electric fencing can be added to the outside of existing wildlife exclusion fencing (i.e., elk or deer fencing) to deter bears (Annis 2017). At least 3 but preferably 4 positive/hot wires should be added. Gaps between fence types should be minimized to avoid trapping an animal between the two but not to close as to be able to touch one another (potentially grounding the electric fence).

Aprons under Permanent Electric Fences

Digging under electric fences by bears is rarely a problem with newly constructed fences, but can occur if bears were digging under a fence prior to the addition of electric fencing (e.g., it has been a problem at some landfills after electric fencing). In some cases a chain link fence buried horizontally underground (known as an apron) in front of the electric fence has prevented breaching the fence. Installation of an apron with initial erection of a permanent electric fence is not recommended because digging up the ground to install the apron may decrease the soil stability for the fence itself (J. Marley, pers. comm. 2002). If there is proper maintenance of the fence (i.e., filling in holes, fence operating at full capacity) as soon as the fence is installed and turned on, digging should not become an issue. Usually minor fence modifications to fill in gaps with electric wires at digging sites

can deter bears. An apron should be considered only if digging persists. The installation of an apron also significantly increases the cost of fencing.

Alternatively, an electrified “unwelcome mat” can be constructed at digging sites. These consist of a positive/hot metal panel placed over rubber mats or negative/grounded metal panels on the bare ground attached to the ground terminal of a controller (connected to the larger electric fence; Sowka 2013). These designs should not be used to deter bears from easily removed attractants (e.g., bird feeders), for which simply removing the attractant is a far better solution.

Portable Fence Design

Portable fences are lightweight and can be moved easily so are used to protect temporary attractants such as back-country camps or beehives. A number of pre-packaged portable kits of a range of sizes are available from various retailers (see Appendix 2). Refer to Karsky et al. (2007) for additional portable electric fence specifications and installation directions.

In summary:

- Controller: controllers for permanent fences should be ≥0.7 joules but for short, temporary fences may be as low as 0.35 joules (J. Marley, pers. comm. 2017) or 0.2 joules (for an 18 m long fence, Karsky et al. 2007). Voltage should be >5,000 (preferably 7,000; Karsky et al. 2007).
- Fence Wire: 4-5 strands of steel or polywire with a minimum of 6 stainless steel wires within it. Height of wires ≥1.2 m. The top wire may be a wider polytape to increase visibility.
- Ground Rod: ≥60 cm (more may be necessary depending on fence length and if soils are dry or frozen)
- Blinking LED lights may be helpful (Karksy et al. 2007).

Appendix 2: Suppliers

Electric Fence Suppliers

Most ranching supply stores sell fence controllers, insulators and wires. A number of companies sell complete fencing kits that include all of the supplies to set up a temporary portable electric fence (including controller, wires, posts, ground rod, warning signs and bag to carry it all in). Companies that ship throughout BC include:

Ferris Fencing
Qualicum Beach, BC
Phone: 250-757-9677
Email: info@ferrisfencing.com
Website: www.ferrisfencing.com

Kodiak Wildlife Products
St. Albert, AB
Phone: 1-866-356-3425
Email: info@kodiakcanada.com
Website: www.kodiakcanada.com

Margo Supplies Ltd.
High River, AB
Phone: 403-652-1932
Email: info@margosupplies.com
Website: www.margosupplies.com

UDAP Industries
Butte, MT
Phone: 1-800-232-7941
Email: pepperpower@udap.com
Website: www.udap.com

Bear Spray Suppliers

Bear spray is sold by most outdoor stores and can be purchased from a number of online retailers. Inert bear spray can be purchased from Kodiak Wildlife Products Inc., Margo Supplies, and UDAP Industries Inc. (all listed above).

Appendix 3. Professional guidance

The following biologists and organizations may be able to provide advice or workshops regarding the use of bear spray and/or electric fencing:

- Gillian Sanders, Grizzly Bear Coexistence Solutions, Meadow Creek, BC, grizzlybearsolutions@gmail.com
- Grant MacHutchon, Nelson, BC, machutchon@uniserve.com
- Jeff Marley, Margo Supplies, High River, AB, info@margosupplies.com
- Frank Ritcey, BC Conservation Foundation, Kamloops, BC, bc@wildsafebc.com
- Joe Scott, Conservation Northwest, jscott@conservationnw.org