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Authors: DeMatteo, Karen E., Davenport, Barbara, and Wilson, Louise E.

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Communications

Back to the basics with conservation detection dogs: fundamentals for success

Karen E. DeMatteo, Barbara Davenport and Louise E. Wilson

K. E. DeMatteo (https://orcid.org/0000-0002-9115-6857) ✉ (karendematteo@outlook.com), Dept of Biology and Environmental Studies, Washington Univ. in St. Louis, 1 Brookings Drive, Box 1137, St. Louis, MO 63130-4899, USA, and: WildCare Inst. at the Saint Louis Zoo, St. Louis, MO, USA. – B. Davenport, PackLeader Dog Training LLC, Gig Harbor, Washington, USA. – L. E. Wilson, Conservation K9 Consultancy, Wrexham, UK.

The use of detection dogs in conservation studies has expanded across species, conditions and habitats. However, it is incorrect to assume the potential associated with these surveys is automatically linked to the dog's sense of smell. Instead, an accurate detection dog rate is directly linked to many caveats in dog–handler training. Selecting a detection dog is directly linked to a clearly defined study design and must balance various factors, including: olfactory ability, physical structure, energy level, personality and social traits. Selection of training samples should ensure sufficient variation in target and nontarget species, independent of whether the goal is to locate evidence of the animal (e.g. scat, feather) or the physical animal. Just as not all dogs are appropriate, not all persons are suitable for this type of work, as the handler must be consistent and attentive to details with an incredible physical and mental endurance to sustain the time in the field. Testing in controlled and field situations can determine if the personalities of the dog and handler balance, with time needed for each to gain the ability to 'read' the other. Proper training for the dog and handler is essential, with special attention paid to the innate reactions of the latter. After training of the team is complete, testing trials should mimic field conditions. While there is no single model to becoming a handler in wildlife detection dog studies, incorporating these fundamental concepts with professional training can help optimize sample detection rate, minimize handler and dog frustration, and maximize overall success with this technique.

Keywords: conservation detection dogs, fundamentals, handler, samples, testing trials, training

Multiple studies have stated that the use of detection dogs in conservation studies increases survey accuracy and decreases survey time (Bryson 1991, Long et al. 2007a, Wasser et al. 2012, Woollett (Smith) et al. 2014, Orkin et al. 2016). Surveys with detection dogs are not limited to a single species or even single taxonomic group. Various projects have demonstrated how detection dogs are aiding conservation efforts by allowing the detection of rare, endangered or difficult to study species (Smith et al. 2003, Cablk and Heaton 2006, Long et al. 2007b, DeMatteo et al. 2009, Goodwin et al. 2010, Kerley 2010, Arandjelovic et al. 2015, Cristescu et al. 2015, Lehnert and Weeks 2016, Nielson et al. 2016, McLean and Sargisson 2017, Hollerbach et al. 2018). Their use has even expanded to include investigations to detect invasive species, poaching and environmental hazards (Engeman et al. 2002, Hauser and McCarthy 2009, Vice et al. 2009, Gsell et al. 2010, Woollett (Smith) et al. 2014, Richards 2015, Glen et al. 2016, Springer 2016, Ward et al. 2016). Detection dogs eliminate the need to attract an animal to a particular area to capture its presence directly (e.g. live traps, hair snares) or indirectly (e.g. camera traps, tracking stations, response to vocalization playbacks) allowing studies to expand off-trails and outside of protected areas (Wasser et al. 2012, DeMatteo et al. 2014a, Woollett (Smith) et al. 2014). In fact, the ability of detection dogs to work in a variety of conditions has allowed studies to expand to a range of habitats, ecosystems and ecoregions (Wasser et al. 2004, Harrison 2006, Rolland et al. 2006, Vynne et al. 2011, Oliveira et al. 2012, DeMatteo et al. 2014b, Clare et al. 2015). The information gained from samples located by detection dogs have been used to develop applied management actions, including deriving population estimates (Long et al. 2007a, Wasser et al. 2011, Russell et al. 2012, Thompson et al. 2012, Davidson et al. 2014) and modeling a multispecies biological corridor (DeMatteo et al. 2017).

The potential associated with detection dog surveys can result in the misconception that there is an automatic link between a dog's sense of smell and ground-breaking, meaningful survey results. Instead, an accurate detection rate can be directly linked to many caveats in dog–handler training (Wasser et al. 2004, Kerley and Salkina 2007, Long et al. 2007a, MacKay et al. 2008, Jezierski et al. 2014, Clare et al. 2015, Minhinnick 2016, Johnen et al. 2017). In addition to the fact that not all dogs and not all persons are suitable for this type of work, there are some key factors that should be evaluated prior to starting any dog–handler training and others that need to be considered during this process. This paper will not be a training guide to become a handler in wildlife detection dog studies, as there is no single model that captures the inherent variation and unique requirements across studies (Johnen et al. 2013, Beebe et al. 2016). Instead, the potential dissimilarities in selection and training strongly encourage professional training or guidance (Beebe et al. 2016; Orkin et al. 2016). In addition, this paper will not look to evaluate or recommend an optimal search strategy or pattern (Glen and Veltman 2018, Glen et al. 2018), as the factors that influence these decisions are numerous (e.g. terrain, vegetation, characteristics of target species, weather, dog–handler team, survey objectives, sample condition) and vary on a day-to-day basis within and between studies. Instead, the goal is to provide a guideline to the fundamental components that can help improve accuracy and reliability in conservation detection dog surveys: detection dog selection, training samples, handler selection, dog and handler training and testing trials. It is essential that handler choice and training be considered just as important as dog selection and training. Balancing the visual criteria (e.g. physical build, energy, drive) used to select a detection dog with the handler's personality, the target species and the study conditions will optimize sample detection rate, minimize handler and dog frustration and maximize overall success in wildlife surveys with detection dogs (Jezierski et al. 2014, Beebe et al. 2016, Jamieson et al. 2017).

Study design

Prior to any dog–handler selection or training, it is essential that the goals and objectives of the study be clearly defined, including: defining target species, habitat conditions, potential seasonality, type and number of samples needed and study duration. By defining data collection needs and the scope of the project, one can then consider what techniques could be used and the pros/cons of each technique. This process is essential to determining if a detection dog is the best technique given the project design (Long et al. 2007a, MacKay et al. 2008, Hayes et al. 2018). If a detection dog is seen as the best approach, then the team can take the next step to select a dog, gather training samples, select a handler, train the dog and handler and conduct testing trials. These preparations can extend into the use of pilot studies where proposed protocols are tested and modified (Long et al. 2007a).

What is not appropriate is to make a project design fit the use of a particular detection dog. When the process occurs in this direction it is possible to have multiple conflicts or problems arise. This can include the resistance of the detection dog to locate a particular odor (e.g. fear response), behaviors that prevent collection of located samples (e.g. dominance urine-marking on target samples, digging, mouthing samples), or even actions that physically risk local wildlife (e.g. innate response to chase and/or capture live animals). In addition, the dog's physical characteristics may make the work difficult or dangerous, including improper stature (e.g. too short, too leggy), wrong physical characteristics (e.g. long coated, thin skinned), or discomfort in the environmental conditions (e.g. too muscular, brachiocephalic or short-nosed).

In addition, commonly used field methods (e.g. transect searches) will likely require modifications to make them suitable for use with a detection dog (MacKay et al. 2008). It is unrealistic to set search times with detection dogs equal to what is expected for human-only teams. With the latter, a 10 km transect could be covered in a single day, as the main line is held. However, because a detection dog's coverage extends off of the main transect and expands the area covered (e.g. 4–5x; DeMatteo et al. 2009) multiple days may be required. Another common restriction that does not work with detection dogs is the practice of defining transect width. While this is appropriate for humans, a set distance from the main line has zero meaning to a dog that is cataloging all odors the air currents bring to him. In fact, one actually risks destroying the competency of the dog by restricting it to within a set parameter or distance. In addition, transects are by nature a systematic approach to data collection. Applying these strict standards to detection dogs can result in problems, as they may fail to account for changes that affect the dog's olfactory search, including: terrain, wind direction, ambient temperatures and relative humidity. In addition, forcing a systematic search may result in the failure to detect samples, especially in species that deposit scats in a clumped pattern or when transects fail to cover species-specific habitat (Long et al. 2007a, Glen et al. 2016).

If a detection dog is determined appropriate to the project, part of project planning needs to address what is done with the dog at the end of the season (MacKay et al. 2008). Commonly the dog is given to someone (e.g. handler) to take home. If it is the handler, are they a year-round or seasonal employee? How will the dog be housed during the off-season? How will the dog be maintained for future deployment (e.g. weight, training)? Is it possible to continue training and testing trials during the off-season or is the target species seasonally limited (e.g. endangered live species)? Is the dog's temperament/drive such that it will maintain its work ethic during the off-season? While there are always exceptions, one must prepare for the possibility that a highly driven dog who will work long hours and cover the shear miles a project may need, may not want to turn back into a normal pet dog left at home for long hours while the people go off to work. This is especially true of younger/newer dogs, although this issue can improve with age depending on the dog's base temperament and work ethic. In addition, taking the dog on nonworking hikes in the woods with no finds can erode the dog's optimism and work ethic. No matter the amount of time spent off-season or if using the same handler as last time, when bringing a dog back to work after a period of time not working it is important to not short-change the training and testing time needed to get the team back in shape. The time required for these refresher trials will be independent of the number of odors the dog is trained to locate (Williams and Johnston 2002) and instead depend on the individual dynamics of the dog–handler team.

Detection dog selection

Selecting a detection dog is not an easy task. There is not one breed, age or sex that is most appropriate. Instead, the selection must balance various factors, including: olfactory ability, physical structure, energy level, personality and social traits (Wasser et al. 2004, Maejima et al. 2007, MacKay et al. 2008, Clare et al. 2015, Jezierski et al. 2014, Beebe et al. 2016). Each step of the selection process is directly linked to having a clearly defined study design (Smith et al. 2003, MacKay et al. 2008), which should be used as a guide throughout the process.

First, the physical structure of the detection dog must be put relative to the conditions that will be present in the study area, including terrain, ambient conditions and vegetation. Is the area flat, hilly, rocky, muddy or sandy? Will it be hot, cold, windy, icy, humid, dry or wet? Is the vegetation short, high, spiny, thick or sparse? Second, the dog's physical structure must be considered relative to the target species. Is the target species fossorial, terrestrial, aquatic or aerial? Do you expect to find samples underground, in trees, near water or in open areas? Is the dog finding samples from the target species or the actual target species? Third, the physical structure of the dog must be weighed relative to the location of the study. Is the study local or international? What types of transportation are involved (e.g. ground, air, boat)? Do any of these transportation methods involve weight restrictions or breed restrictions? Are there breed restrictions in the study country or region?

The variation among these considerations means the process may identify more than one potential detection dog. This is ok; as this first step is aimed at determining potential detection dogs that would contain physical characteristics allowing for optimal survey coverage and minimizing the potential of physical harm to the dog. The physical characteristics that need to be evaluated include paw size, chest breadth, muscular structure, rough or smooth coat, short or long coat, long or short legs, nose structure and belly height. These characteristics may shift between advantageous, neutral or negative depending on the combination of conditions. For example, the ideal paw size or structure will vary depending on if the terrain is sandy, muddy, snow covered, rocky or flooded. Similarly, an optimal coat type can shift with search area habitat, including whether the vegetation is sparse, spiny, woody or dense. While supplemental equipment (e.g. boots, vests) can be added, their use must not interfere with the dog's mobility. Selecting a dog should avoid characteristics that would negatively affect the dog's ability to effectively complete the goals and objectives of the proposed study design.

A follow up to this selection process is to evaluate the dog's attitude or drive to the environment relative to the behaviors of the target species and the habitat that has been identified. Does the dog avoid wet areas or is it overwhelming committed to bodies of water? Will the dog break brush/vines/stickers or does it avoid samples located in these locations? Is the dog tolerant of heat either through extended physical exercise or ambient conditions? This evaluation is needed to identify dogs that may be physically suited to the conditions but mentally say 'I don't think so'.

Second, one must determine if the potential detection dog has any behaviors that would negatively affect its ability to work with the target species. Does the dog have a negative reaction, fear response or physical avoidance to the target odor? Does the dog demonstrate inherent dog behaviors (e.g. urine-marking, coprophagy, digging, retrieving) that would damage the quality of the sample or prevent its collection? Does the dog demonstrate innate predator behaviors (e.g. chasing, capturing) that put the survival of the target species or other species in the area at risk? Does the reward fail to overcome the dog's natural behaviors because it lacks sufficient importance to the dog (e.g. the need for a ball fails to distract a sporting breed from birds in the environment or a herding breed from livestock while working)? That is, is the dog's internal-drive towards natural behaviors stronger than its internal-drive for the reward? In each of these situations, the only option that should be considered acceptable is to select a different detection dog. These behaviors may prevent a successful study and risk the lives of the dog and local wildlife. These behaviors may also result in the dog being distracted and affect its efficacy and reliability (Long et al. 2007a, Maejima et al. 2007).

Third, selecting a dog because of the tight emotional connection with the handler (e.g. best partner, emotionally satisfied with a dog that looks only to them) can be detrimental to the success of the project (MacKay et al. 2008, Minhinnick 2016). While it has been suggested that detection dogs are motivated by human affection (Orkin et al. 2016), a dog that is too bonded to the handler may turn into a therapy dog if the handler is unhappy, angry or sick. A dog that works for his personal and overwhelming need (i.e. internal-drive) for the reward rather than the handler is far more reliable. The presence of this strong internal-drive is also important when considering whether the dog will be expected to change handlers from project-to-project or field season-to-field season. Selecting dogs that are so driven that they do not care who the handler is allows the flexibility of moving dogs between projects. This is not to say that it is not possible to bring a personal pet and make it a working dog; however, it will depend on the dog and handler. The main issue that needs to be addressed is changing the dog's perception of the relationship, which is much easier to establish in a working environment than to change the dog's general attitude.

Finally, it is important to determine what training reward is optimal. Both toys and food are will work; however, initial trials suggest that the use of play after a successful training session can enhance memory and positively affect short-term and long-term memory (Affenzeller et al. 2017). No matter which reward is selected, there are special factors that need to be considered with both. With toy rewards (e.g. ball, tug), drive under field conditions (e.g. hot, tired) can be maximized by limiting their use to work time (Hurt and Smith 2009). The handler's control of the toy reward means the dog learns that it is only rewarded when it is at the source of odor. That is, there is a direct connection between locating the source of the odor and receiving the toy. This allows for the dog to work remotely and out-of-sight from a handler, as the dog knows that it must show the handler to the source of the odor before it receives its reward. So, even if the handler recalls the dog off of an odor and back to their position, the dog knows its reward depends on leading the handler back to the source of the odor.

We would be remiss if we did not mention the Bringsel method, a play-oriented method that has been considered and attempted by some handlers in scent work (L. Wilson unpubl.). While this technique has been effectively used in search and rescue dogs (single find per search), it will likely fail with most conservation dogs (multiple finds per search). In the Bringsel method, the dog locates the targeted odor, takes the signal device/item (e.g. typically a short stick shape) suspended from its collar, or around its neck, into its mouth, returns to the handler with the stick as a visible signal that the dog made a find. The handler then sends the dog to re-find the target where upon the handler rewards the dog at the source. While there can be exceptions, in dogs that have a strong internal-drive for the reward, it may be almost impossible to reliably train the dog to search because the dog will be focused on trying to play with the signal device hanging from the collar. In other cases, it may be difficult or impossible for the handler to locate the target sample once the dog focuses on the signal device rather than making the re-find. In the latter, the dog may fail to re-find the odor that was already found because in its mind it was already rewarded for it. Beyond these issues, great care must be taken if the Bringsel method is used with conservation detection dogs for two reasons: 1) the safety of the dog, as anything hanging from the collar or around the neck has a strong possibility of getting hung up on something in the environment endangering the dog, and 2) as the dog searches, especially near the target source, there is a high probability that anything that is hanging from the collar or around the neck will contaminate the sample as the dog reaches the source.

A food reward can involve using the dog's normal diet or it can be a special treat that is only used when the dog is working. In both cases, one factor that must be considered and evaluated is how the dog reacts to a food reward in conditions that reflect an actual field survey versus a training scenario. With the latter, the work time is typically shorter and it is possible to conduct it during optimal environmental conditions. However, understanding how the dog performs in ambient conditions that reflect an extended period of field work is important to deciding whether food is still seen as a reward by the dog. That is, when the dog is hot and tired, will the dog still respond to the possibility of food? Is the dog still willing to work if the dog's appetite is satisfied? Does the dog become sluggish or less willing to work the more it eats? If the dog is still willing to eat regardless of the number of finds, one must consider whether it would be at risk of bloat or gastric torsion. Dogs willing to work for food are at increased risk of these life-threatening medical conditions, especially in hot environments, due to the dog's intake of water, combined with food and continued exercise (Bell 2014, Gazzola and Nelson 2014). In addition, one must consider the fact that not all food rewards can sustain the long hours and environmental conditions found during field surveys. While a dry kibble or treat is easy to transport, foods that are sensitive to temperature (e.g. meat, cheese) can be difficult to maintain through a typical survey day. In addition, depending on the location of the field surveys and sleeping accommodations some foods may be difficult to obtain or maintain throughout the study period. If any problems are identified related to providing food as a reward to the dog during a normal work survey, consideration should be given to selecting a dog that is play-driven versus food oriented. With the former, even after long, hot surveys most dogs are still driven by the reward even if it involves using a low-intensity (versus high-intensity) play session. It is important to note that under no circumstances should a dog whose toy drive diminishes during training be switched to a food reward to salvage their investment, as this is unlikely to work long term and it will skew or even provide false data (B. Davenport unpubl.).

An alternative reward that should be mentioned is the use of praise in exchange for work. Dogs that work for praise can be very inconsistent (B. Davenport unpubl.), as there is no payment linked to the effort that only happens when the sample is found. After all, we praise our dogs for a variety of things that require minimal effort from the dog throughout the day completely unrelated to finding a sample that requires a substantial, long-term effort. In addition, when praise is used as the only reward, the bond with the handler tends to be closer, which can result in the dog deciding whether to work that day or not (B. Davenport unpubl.). Dogs that work solely for praise are more likely to be affected by a handler that is off baseline (e.g. unhappy, angry, sick).

Training samples

The selection of training samples is fundamental to optimizing the success of detection dog surveys. This is true whether the goal is to locate evidence of the animals (e.g. scat, feathers) or the physical animal. In all cases, training samples should not be limited to the target species but expanded to include nontarget species (DeMatteo et al. 2014a, Johnen et al. 2017). A nontarget species can be defined as a species that one does not want to survey; however, its physical presence in the area and similarity to the target species (e.g. taxonomic overlap, shared diet) suggests a potential similarity in its olfactory profile. Presenting the odors of these nontarget species to the detection dog during training is essential to 'fine-tuning' the dog's olfactory profile to the target species. This process allows the dog to catalogue similarities between target and nontarget samples, as well as those unique characteristics of the target species. These similarities range from basic traits of the samples (e.g. all samples stored in plastic bags) to more complex features (e.g. dietary overlap).

If the focus is on locating scat, maximizing the potential variety (e.g. diet, individuals, sex, age) for targeted and nontargeted species (Williams and Johnston 2002, Smith et al. 2003, Wasser et al. 2004, DeMatteo et al 2009, Vynne et al. 2011, DeMatteo et al. 2014b, Browne et al. 2015, Hurt et al. 2016, Oldenburg et al. 2016) is important, as each of these factors can shift the scat's olfactory profile (Martin et al. 2010, Hayes et al. 2018). If training samples come from captive animals, it is important to find a way (e.g. physical separation of individuals, use of diet markers) to identify the source (e.g. individual, sex) of the samples and confirm the expected sample variation is actually obtained. If training samples come from wild animals, it is important that species-identity is genetically confirmed versus visually identified (Hurt et al. 2016, DeMatteo et al. 2018). If training samples come from captive animals or areas outside of the study area, it is important to reinforce and test the dog on scat from wild animals in the region to prepare the dog on the variety of diet shifts that a species can have (e.g. salmon-based, berry-based, scavenger-based in bears) (Smith et al. 2003, Hurt and Smith 2009, Hurt et al. 2016). This is especially true of inexperienced dogs that have completed training but lack field experience, as they tend to be very specific and do not generalize across odors. For example, if target and nontarget samples are from captive animals fed 'zoo chow' or kibble, a similarity within and between species can be introduced resulting in the dog missing samples when the zoo chow component is absent. However, reinforcing the dog (especially new dogs) on wild scat before actual deployment can overcome a missing component (e.g. no zoo chow) or a similarity between target-nontarget scats (e.g. both with zoo chow).

Similar variety is important if the focus is locating the actual target species. This extends to exposing the dog to both target and nontarget odors (Williams and Johnston 2002, Browne et al. 2015); so that the dog's olfactory profile is focused versus generalized (DeMatteo et al. 2014b). If training samples are portions of dead animals or dead animals, it is important to reinforce and test the dog on live captive or wild animals. If this is not done, results can be confounded (Glen et al. 2018) making it difficult to accurately estimate detection rates and potential problems in the field. The same reinforcement with live animals is true even if training samples are scent samples or residual scent collected from live animals (Cablk and Heaton 2006, Nielson et al. 2016). In these cases, if the goal is to avoid the dog alerting on scat or urine, care must be taken to when the scent samples are obtained (Cablk and Heaton 2006, Nielson et al. 2016). If training samples are live animals, care must be taken so that direct contact between the dog and target species is avoided. The containment of live species in escape-proof containers (Engeman et al. 2002, Vice et al. 2009) or marked with radio transmitters (Gsell et al. 2010) might be essential when dealing with invasive species.

The short- and long-term storage of samples is important to maintaining the integrity of the original olfactory profile. Independent of their storage type (e.g. air dried, frozen, room temperature), target and nontarget samples should be stored separate so that the odors do not become mixed. If this occurs, the unique qualities of the species-specific samples will be lost and their use will cause confusion in the detection dog. Often, samples may be dried to prevent the growth of mold in humid conditions and provide samples for use under field conditions throughout the survey; however, it is important that during this process, target and nontarget samples are maintained separate. An optimal technique is natural drying in the sun versus in a drying oven, as the latter can result in contamination of the oven's interior preventing its use for both target and nontarget species. Storage of samples can be more complex depending on the need for whole animals or animal parts. In both cases it is important that preservatives are not used, as this can shift the olfactory profile resulting in the dog's inability to locate samples on-site.

Sample storage must also address the need to use a containment system with samples, which minimizes loss of training materials and contamination of the environment training is taking place in, as the training environment may need to be reused (Jezierski et al. 2014). Contamination of the training environment will set up a situation where the handler's confidence is weakened due to a dog indicating on a previous location (when parts of a samples are left behind) but the handler cannot see or find the sample. A containment system allows for complete retrieval of the sample and prevents cross contamination during pick up at the conclusion of training. When working with multiple species, especially when samples (target and/or nontarget) are similar in appearance, containment allows for correct identification of samples at all phases (e.g. training, long-term storage). For example, with scat, fine mesh or organza bags (e.g. 13×17 cm) that are color-coded by species (e.g. jaguar = brown, puma = green) are an inexpensive but efficient containment system. Training samples should be set up in the selected containment well in advance so that the containment is thoroughly contaminated by the samples when training begins. In addition, both target and nontarget samples should use the same containment system, so this additional odor is not unique to either one. In addition, uncontaminated examples of the containment system need to be placed in training environment to proof the dog from alerting to the 'containment' system itself. Failure to expose the dog to the containment system during training or switching the containment system used in training versus testing trials can result in false alerts (O'Connor et al. 2012) and the inability to accurately access detection rates.

Handler selection

While the idea of going to work each day with one's dog may seem idyllic, the rigors of training or testing trials (Browne et al. 2015) and long days in rough terrain under difficult conditions (Arandjelovic et al. 2015) can crush this idea. Wildlife surveys are not typically for a few days but instead are for a few weeks, months or even longer. This requires the handler to have incredible physical and mental endurance to sustain the time in the field, as well as time away from family-friends. For example, a handler that is uninformed and not physically ready for the rigors of a study area can be the limiting factors in locating samples (Arandjelovic et al. 2015). It also requires shifting one's thinking away from the idea that a wildlife survey is a hike with your dog. In persons who are accustomed to taking long walks with their personal dogs there is typically a firmly established muscle/mental memory to disregard when the dog is in field conditions. The handler must be observant of their behaviors, the actions of their dog, and ongoing events in order to analyze situations, generate potential solution and ensure the team's safety (Hurt and Smith 2009, Hurt et al. 2016, Minhinnick 2016).

This means that the handler must shift from focusing on birds, animal tracks or the incredible scenery to their dog's behavior and movement patterns. This can be difficult for persons that are experts with the target odor or those people who are experienced dog trainers in other disciplines (e.g. hunting, patrol). Persons who are not experts with a species or technique are frequently less biased toward what they know and are frequently more willing to believe the dog rather than trusting their knowledge and previous experience (Davenport unpubl.). In these cases, extensive and varied field trials can provide valuable opportunities for handlers to gain experience and maximize detection probability (Cablk and Heaton 2006, Long et al. 2007a). The handler needs to focus on environmental (e.g. sun, shade, wind) and physical (e.g. terrain shifts, vegetation) variation that could affect the dog's ability to detect odor and provide guidance to help minimize these effects (Wasser et al. 2004, Hepper and Wells 2005, Long et al. 2007a, Reed et al. 2011). The handler must know how to assist the dog who is working a change of behavior that the dog is having difficulty resolving. The handler's job is helping get the dog's nose near the odor. A distracted handler can mean that subtle cues from the dog are overlooked resulting in missed samples. Quantifying the number of samples missed due to distracted handlers is missing in the literature; however, use of video recordings (Lasseter et al. 2003) or concealed observers (Engeman et al. 2002) may help identify this. While Engeman et al. (2002) used concealed observers used to quantify the number of missed target samples due to an inadequate search pattern by the handler, it was not clear if this was associated with handler distraction, handler error or another reason. While it is almost impossible to ensure every sample is found in a survey area, the handler's attention or inattention to their dog's cues directly affects the number of samples located. This need for the handler to focus on the field survey is mirrored in the dog's need to shift from play to work mode. With a personal dog that is accustomed to romps in the same habitat exploring its own interests, it can be virtually impossible to create a sustained change in the dog's attitude while working in the same conditions before and after training.

When selecting a handler there needs to be a balance between the personalities of the dog and the handler (Smith et al. 2003, MacKay et al. 2008, Hayes et al. 2018). One may think that a well-trained dog can work with any person; however, this may not always be the case. For example, if the dog has experienced violence from previous owners, a raised voice or lots of physical movements from the handler can negatively affect its desire to work. Alternatively, the pairing of a head-strong dog with a timid handler could generate an out-of-control field situation. Determining whether a balance exists between the dog and handler involves testing in both controlled and field situations to see how both respond to each other.

While an internally-driven dog will strive to search regardless of the handler, this is not to say you can substitute handlers on a whim, as the handler's ability to 'read' the dog is critical (Johnen et al. 2017). However, having a dog that will search regardless of the handler provides a significant increase in the reliability of the dog (Hurt and Smith 2009). It is important to note that substituting a handler requires time and a single 30-min set of practice runs under the guidance of the primary handler (Jamieson et al. 2018) is likely insufficient. This fact is independent of the person's prior experience as a handler or if the dog has worked with multiple handlers previously. Instead, a new dog–handler team must spend time working under varying environmental (e.g. hot, cold) and physical (e.g. tired, bored, excited) conditions, so the handler can learn how the dogs' cues (normal and subtle) and movement patterns shift (Greatbatch et al. 2015, Hayes et al. 2018). In addition, the substitute handler must learn through repetition how vocal tone and body movements affect the dog's behavior. Each dog will differ in its training history, which can influence the strength of its human-directed communication or that gaze between the target and handler that indicates a find (Marshall-Pescini et al. 2009). For example, dogs initially trained for agility or search and rescue may have higher levels of human-directed gazing behavior compared to untrained pet dogs. Knowing how to read the dog is essential in order to avoid having canine alerts go unrecognized by their handlers (Lasseter et al. 2003).

Training, testing trials and acclimatization

While the bond between a dog and handler is essential for many aspects of the work, ensuring proper training of each is essential to optimizing results (Smith et al. 2003, Goldblatt et al. 2009, Long et al. 2012, Minhinnick 2016, Hayes et al. 2018). In fact, some say that it is easier to train the dog and harder to train the handler, as the latter needs to overcome their innate reactions to various circumstances. While an experienced dog can help an inexperienced handler, a poorly trained handler can ruin an experienced dog. For example, rushing a dog when it is exploring a new odor can push the dog into false alerts and shifting to include nontarget species in their repertoire (Sargisson and McLean 2010, Greatbatch et al. 2015). This same scenario can occur if the handler fails to provide rewards to the dog in a consistent manner resulting in a false-indication by the dog (Long et al. 2007a, MacKay et al. 2008, Goldblatt et al. 2009).

There is not a single type of training or a single protocol that is appropriate for all detection dog surveys. When introducing odor with conservation detection dogs, which often locate more than one odor, it is common to have a single command and alert associated with a group of scents (Lit 2009). This alert is a passive, trained response (e.g. sitting) or a change in behavior (e.g. shift in search pattern) that involves no barking, scratching or pawing (Smith et al. 2003, MacKay et al. 2008, DeMatteo et al. 2009, Cablk and Harmon 2011, Hurt et al. 2016, McLean and Sargisson 2017). While the no-touch response is essential in ensuring that the target odor is not contaminated (e.g. DNA profiles of target sample) or harmed (e.g. live targets), the no-vocal response minimizes disturbance of local wildlife.

What is essential is that the type of training and the testing trials for dog–handler reflect potential field conditions (Johnen et al. 2017). Controlled trials can help identify potential dog–handler issues and reinforce behaviors of both; but it is not a given that the high detection rates seen in these trials transfers to field conditions. Controlled trials focused on testing the accuracy of the team can negatively affect accuracy due to handler anxiety (Jezierski et al. 2014).

Controlled trials can help assess detection distance and environmental effects on a dog; however, the accuracy of these estimates will likely shift when the terrain and vegetation is variable (Reed et al. 2011). The results in the latter may never reach 100% due to circumstances beyond the team's control, including wind direction, terrain features and how they react together to affect the scent (Wasser et al. 2004, Hepper and Wells 2005, Reed et al. 2011). However, it is possible to provide trials that allow the dog–handler relationship to mature with reciprocal confidence displayed by both. For example, trials should vary in the number of samples used and the placement of those samples. This includes trails with no target samples, which allows the handler to understand shifts in the dog's motivation and avoid situations where desperation on the part of the dog or handler can force a shift to nontarget odors.

It is equally important to include trials where sample location is known and unknown (Engeman et al. 2002, Smith et al. 2003, Goldblatt et al. 2009, Johnen et al. 2013, 2017). Known locations allow the handler to identify those involuntary physical changes (e.g. ear set, tail wag, overall animation, change in concentrated sniffing) that occur when a detection dog encounters an odor that it has been trained to believe will result in a reward (Concha et al. 2014). Unknown locations are important to ensure the handler is not unknowingly affecting a change in the detection dog's specific trained response through nonverbal cues or physical prompting (Marshall-Pescini et al. 2009, Lit et al. 2011, Cooper et al. 2014).

It is also important that trials use samples from target and nontarget species (Smith et al. 2003, DeMatteo et al. 2014b). All species should be clearly marked (e.g. different color mesh bags), so that the handler can ensure nontarget samples are not mistakenly rewarded. In addition, knowing which target species the dog located can help the handler learn any innate cues the dog may give when it detects the olfactory profile of a particular species. There should be variation in the way that these trials are setup, including: physical interval between samples, order of species and location of samples. For example, if it is likely that more than one sample may be found in an area, it is essential that the trials mimic this to help the dog and handler become accustomed to a pattern of locate–reward-search in a single area. If you expect sample location to be clearly visible, hidden, in unique locations or a combination of these, the trials should present the appropriate scenarios. Or, perhaps the target species is rare and it is likely that the dog may pass many nontarget samples prior to finding a target sample. In this case the handler can learn to read the limits of when the dog is losing motivation or is becoming frustrated, so it can be avoided in field surveys. For these reasons when working with a single, rare species it may be beneficial to train the dog on at least one additional species that is more common but with a distinct form of scat, so the dog has the opportunity to be rewarded more often but unwanted samples are not collected. Training a dog on more than one odor does not negatively affect its detection performance or the time needed to train additional odors decreases indicating an ease on the dog's part (Williams and Johnston 2002).

Finally, in preparing for a project, equipment that is expected to be used in the field should be used on every training scenario allowing both dog and handler to become accustomed to both the actual equipment and the routine for use. For example, will the search be conducted on a long lead, off lead or a combination of the two? Are boots, a harness, chest protector or other gear required for the dog? Will the dog wear a GPS unit or collar? How is the reward stored by the handler? In addition, if the project is out of the dog's accustomed training habitat, a period of acclimatization should be built in where training takes place in the actual project location. This will assist the dog with the temperature and climate change and allow the dog to catalog the new smells and wildlife the dog has not encountered before.

Summary

The use of detection dogs provides an approach to gather data on one or more species independent of many factors, including species behavior, its rarity, physical habitat and environmental conditions. The expansion of this noninvasive technique worldwide reinforces the need for all involved to remember that an accurate detection rate is directly linked to a strong dog–handler foundation. A study should not be designed to fit a particular detection dog nor should one select a dog based on its tight bond with the handler. Instead the study design should be used to determine whether the use of a detection dog is appropriate and then as a guide in the selection of an appropriate dog, variety in training samples and a handler. In addition, it should be used to ensure the testing trials for both the dog and handler mimic field conditions and allow the dog–handler time to learn how to read each other. This guide to the fundamental components of conservation detections dogs combined with professional training can help ensure that the use of this incredible conservation technique maintains the level of accuracy associated with the origins of the technique (e.g. military, police).

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