Guidance for research on the use of conservation detection dogs: A variable checklist

Ecology Detection Dogs of Britain and Ireland Working Group

This document is a product of the Research Theme in the Ecological Detection Dogs of Britain and Ireland Working Group (https://www.ecologydetectiondogwg.org/).

The lead author was Beth McKeague, and members of the working group provided feedback and comments on all drafts. The document was designed by Patrice Kerrigan.

For a more detailed review of the variables mentioned in this document: McKeague, B., Finlay, C. and Rooney, N. (2024) 'Conservation detection dogs: A critical review of efficacy and methodology', *Ecology and Evolution*. 14:2 doi: 10.1002/ece3.10866

For any questions on this document, please contact the working group via email: ecologydetectiondogs@gmail.com

The Rufus Foundation funded this work through Conservation Detection Dogs Northern Ireland (www.cddni.com).

Aim

This white paper aims to provide an overview of the key variables that can affect CDD efficacy, and therefore what variables are vital for researchers and CDD professionals to include and cover in any publications that describe the training, testing, or operational use of CDDs. Each variable will be defined and justified, and a summary of the important questions to be answered by those conducting CDD work will be given (see Appendix I). Furthermore, the types of caveats and limitations that should be included in the discussion of a paper if a variable or aspects of a variable are unable to be addressed by a study will be described. Acknowledging a study's limitations demonstrates critical thought and an understanding of how you and future researchers may be able to learn and improve upon the study design going forward for greater reliability, validity, and robustness of the results.

Introduction

Conservation, or ecology, detection dogs (CDD) are a type of working scent detection dog that specifically supports conservation projects (MacKay et al., 2008; Helton, 2009; Woollett, Hurt and Richards, 2013) and work alongside a human handler to form CDD handler teams (CDDHT) (Richards et al., 2021). CDD are highly complementary to existing conservation monitoring techniques (Browne, Stafford and Fordham, 2006; MacKay et al., 2008; Kerley, 2010; Grimm-Seyfarth and Klenke, 2018; Richards, 2018; Stanhope and Sloan, 2019). However, as demonstrated in (McKeague, Finlay and Rooney, 2024), research involving CDD is often rife with methodological shortcomings and in particular, many studies do not provide an appropriate level of information about their use of CDD. As such, assessments of efficacy (i.e., "the power to produce an effect" (Merriam-Webster.com Dictionary, 2023) can vary hugely (MacKay et al., 2008).

Without a clear and agreed upon method of utilising CDD and describing what was done in a study, results of a CDD study will not be suitably replicable and therefore, untrustworthy. It is vital that the results a CDDHT deliver are as reliable as possible and this all comes down to how a CDDHT operates; their methodology.

Variables:

Efficiency

Efficacy describes the ability for the CDD to produce the desired effect of their training, usually locating a specific target.

In order to quantify efficacy, the primary measures used in CDD research are sensitivity, precision, and specificity. Bennett, Hauser and Moore (2020, p.5) defined sensitivity as the "proportion of targets found relative to the total number of targets available", and precision as the "proportion of all alerts that are directed towards a true target". Specificity is defined as the "proportion of non-targets correctly ignored" by Lazarowski et al. (2020, p.3). Other measures can and have been used, such as providing the total number of samples found, counting grid cells where finds were made, or the number of finds made per hour. However, for clearer findings with greater levels of comparability between studies, the three aforementioned measures are recommended (Bennett, Hauser and Moore, 2020; Lazarowski et al., 2020). As such, in order to judge the outcomes of a study, these questions should be answered regarding efficacy:

- **Has some measure of sensitivity, precision, and/or specificity been measured as part of this study? If not, why not?**

- **Has there been any other measures used to show that the dog is demonstrating the desired effect of their training?**

If any of the above information cannot be provided, the below caveat should be elaborated on in the study's discussion:

How the ability to accurately quantify the efficacy of the dog(s) and the CDDHT was affected if alternative or no measures were used.

Indication

Indication, also called alerting, is the distinctive change in behaviour from CDD that is trained to occur when they have found a target to signal as such to their handler (Johnen, Heuwieser and Fischer-Tenhagen, 2017).

An indication can be passive, meaning no physical or auditory interaction with the target, or active, meaning there can be interaction with the target. It is recommended that CDDHT use passive indication where possible for the purposes of safety, for both the CDDHT and the natural environment, and to conserve the integrity of any samples found (MacKay et al., 2008; Mosconi et al., 2017; DeMatteo, Davenport and Wilson, 2019; Matthew, Verster and Weldon, 2021).

A clear and obvious indication is essential for measuring efficacy and deciding whether a find has been made. It is the primary tool for assessing true positives (i.e., indication made when target present), false positives (i.e., indication made when target is not present), true negatives (i.e., indication is not made when target absent), and false negatives (i.e., indication is not made when target present); the key components to sensitivity, precision, and specificity.

In order to judge how CDD reacted to their target and how this could affect efficacy measurements, these questions should be answered regarding indication:

- **What form of indication is the dog using (e.g., sit, lie down, point, etc.), and approximately what distance has the dog been trained to indicate from the target?**
- **Why was the chosen form of indication and distance from the target considered appropriate for the target species?**
- **Consider and provide clear information whose indication performance is being assessed; the dog, the team's, or both**.

For example, are you measuring whether the dog indicates or not? Or are you measuring the circumstance where the handler recognises a change in behaviour and makes a call on where the target is, and then whether they are right or wrong? This can be study dependent (e.g., training/testing VS field).

If any of the above information cannot be provided, the below caveats should be elaborated on in the study's discussion:

The ability for the handler to accurately and reliably declare a find or positive indication from the dog based on the type of indication.

The safety of a search and integrity of finds if an active indication is used.

Training Samples

Training samples are the materials used to train the dog onto the desired target odour. The form these samples take can be limitless, with examples such as animal carcasses, animal body parts, hair or feathers, urine or scat, and swabs that were in contact with the target species just to name a few.

Without training samples, imprinting (i.e., the familiarisation of the dog(s) with the target odour (Mosconi et al., 2017)) cannot occur. In order to judge the level of training that a CDD receives, these questions should be answered regarding training samples:

- **What are the training samples/what are the training samples composed of?**
- **Where and how were training samples sourced?**
- **How many individual training samples were used across the training stage?**
- **How often were training samples reused during training?**
- **How were training samples stored before, during and after training sessions?**
- **How were training samples handled before, during and after training sessions?**

If any of the above information cannot be provided, the below caveat should be elaborated on in the study's discussion:

A lack of clarity surrounding what odour exactly the dog has been imprinted onto and trained to find based on the training samples and how they were used.

Testing Samples

Testing samples are the materials used to test the dog's training and their efficacy to find their target odour. This occurs prior to when a CDDHT conduct the actual work for their particular project and is an opportunity to examine the dog's ability to find their target odour under conditions more similar to real field work and versus other odours (i.e., discrimination) (Gadbois and Reeve, 2016; Boroski and Oliver, 2018).

Just like in training, samples must be used for the CDD to find during testing. In order to judge the level of testing that a CDD undergoes, these questions should be answered regarding testing samples:

- **What were the testing samples composed of and were they different to those used in training? If not, why not?**

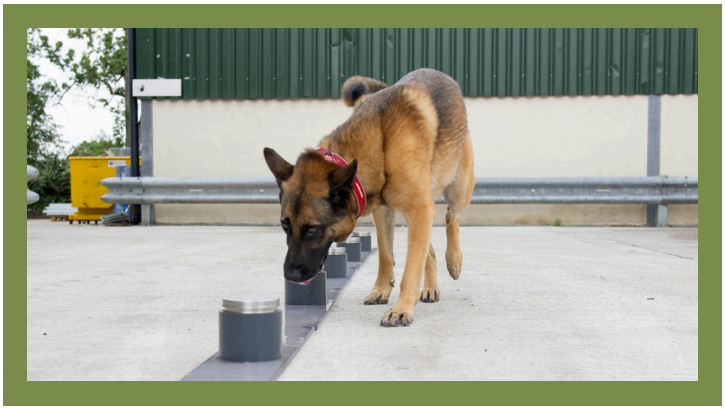
- **Were discrimination trials conducted and if so, why were the selected samples/materials chosen, how similar were they to the target odour, and did any randomisation of sample use during trials occur?**

If any of the above information cannot be provided, the below caveat should be elaborated on in the study's discussion:

Whether effective and fair testing has taken place based on the testing samples and any relation they may have to training samples used.

Blinding

Blinding refers to who is present and knows where the target is during training and testing. This is vital for acquiring reliable efficacy results (Elliker et al., 2014).



The two most common forms of blinding are single and double, and these refer to how many parties respectively are blinded to information (Monaghan et al., 2021). For the purposes of this paper, single blinding is defined as when the dog was not present when a sample was placed in the training/testing environment, but the handler was and therefore knows where the sample is. This is often the case when a CDD handler is also their dog's trainer. Single blinding should ensure that the dog is using olfaction rather than memory to find the target. However, dogs are excellent at reading human behaviour (Lazarowski et al., 2019) and as such, bias can still occur during single blinding. Double blinding is defined by this paper as when neither the dog nor the handler were present when a sample was placed in the training/testing environment, which means the risk of bias is greatly reduced. As such, double blinding is always preferable where possible (Johnen, Heuwieser and Fischer-Tenhagen, 2017; Boroski and Oliver, 2018; Stanhope and Sloan, 2019; Lazarowski et al., 2020). Ideally, triple blinding whereby no one who is present at the search site knows where the placed sample is the best way to recreate operational conditions (Lazarowski et al., 2020).

However, it is acknowledged that this can be difficult to achieve, especially under field conditions. Also, it is key that you are clear about how you are defining blinding for your specific study. In order to judge potential bias in the performance of a CDDHT, these questions should be answered regarding blinding:

- **How was blinding implemented in this study and what forms were used?**

- **During the training and testing stages for the dog, was any form of blinding used, in particular, double blinding during the last stages of training and for testing? If not, why not?**

If any of the above information cannot be provided, the below caveat should be elaborated on in the study's discussion:

The replicability of the dog's performance under double blinding testing conditions if these were not previously undertaken.

Odour Level

Odour level is the concentration or intensity level of the target odour based on the physical attributes of the target and/or how it presents in the environment.

For the purposes of CDD research, describing the odour level that the dog is trained or tested on can be in parts per million or by giving an accurate physical description of samples used like size and surface area. Depending on the concentration of samples used during training/testing, different outcomes and errors may occur during a search. If trained only on very low concentrations, a CDD could indicate on residual scent meaning no visual confirmation of the find can be made by the handler, as seen in Duggan et al. (2011) during searches for Franklin's ground squirrel.

If trained only on very high concentrations, smaller samples and those releasing less odour may be missed by the CDD, as seen in Goodwin, Engel and Weaver (2010) during searches for spotted knapweed. Both of these possibilities can skew efficacy measurements. In order to judge the capabilities of the CDD relative to their target odour, these questions should be answered regarding odour level:

- **Has the dog been trained to find a variety of odour levels? If so, do they represent what the dog will be looking for in the field?**

E.g. Dogs used to find bats around turbines should be trained to find bat body parts as well as full carcasses as that is what they will be finding in the field.

E.g. Dogs searching for great-crested newts should be trained to find low odour levels as these animals can be buried, as well as training to find singular specimens versus groups as they may shelter together.

If any of the above information cannot be provided, the below caveat should be elaborated on in the study's discussion:

Whether any discrepancies in results (e.g., false positives, false negatives) that occurred could be linked to the concentration of odour they were trained/tested on.

Other Target Odours

CDD may be imprinted onto more than one target odour across different projects, but this could have an impact on their performance depending on the relationship between species and environments.

Having a CDD imprinted onto other target odours is not inherently an issue, but it is important information to include in a study. For example, if the new target odour belongs to a species that commonly lives in the same environment as a previous target odour, then the dog may perform a false positive (i.e., performing an indication on an incorrect target) for the study in question, but this is not actually a false positive in relation to the dog's previous training. Examples of this include Hollerbach et al. (2018) during searches for Eurasian lynx, and Kretser et al. (2016) while searching for moose. If this occurs, it can affect the outcomes of efficacy measuring, as well as potentially lead to wasted time and energy for the CDDHT by finding numerous non-target odours in a particular search. In order to make accurate judgements on the quality of a study and the performance of the CDDHT, these questions should be answered regarding other target odours:

- **Have the CDD used in this study been previously trained on other target odours? If so, which odours and could these species be in the study environment?**

If any of the above information cannot be provided, the below caveat should be elaborated on in the study's discussion:

Whether any false positives or true negatives that occurred could be linked to any previous training/imprinting received on a different target odour.

Dog Selection

Dog selection refers to what dogs are chosen to work on a specific project and why.

CDD are each individual biological creatures which will each differ in many ways. Indeed, individual differences in dogs have been found to affect scent detection efficacy (Jamieson, Baxter and Murray, 2017), and these play a bigger role in suitability than inherent factors like breed (Grimm-Seyfarth, Harms and Berger, 2021). Essential elements for CDD are considered to be a high play and/or food drive, a high hunt drive, and a low prey drive (Helton, 2009; Beebe, Howell and Bennett, 2016; Jamieson, Baxter and Murray, 2017; DeMatteo, Davenport and Wilson, 2019), though it should be noted that these assessments will almost always be subjective in nature (Beebe, Howell and Bennett, 2016). In order to judge how decisions were made regarding dog suitability for the project, these questions should be answered regarding dog selection:

- **Regarding the dog(s) selected for this study, how was this done and why the selected dog(s)?**

- **Please provide information about the breeds, personality traits, diets, ages and overall health of the dog(s) selected.**

If any of the above information cannot be provided, the below caveat should be elaborated on in the study's discussion:

How characteristics of the dog(s) may have interacted with other study elements (e.g., environment, handler behaviour, etc.), thus altering efficacy.

Operational Experience

Operational experience refers to the amount or level of experience either the CDD, the handler, or the trainer has in practical real life working conditions

For CDD, this can refer to the amount of time spent conducting real searches under operational conditions (i.e., outside of training/testing), the number of operational projects they have worked on, or the length of time since they have been considered to be at an operational standard. This can be accounted similarly for the handler, whereas for the trainer this would refer more to the amount of time spent conducting real world training sessions, the number of dogs they have trained to an operational standard, or the length of time they have been a qualified dog trainer. How the people around the dog(s), most importantly the handler, behave and even think (Lit, Schweitzer and Oberbauer, 2011; Jamieson, Baxter and Murray, 2018b; Lazarowski et al., 2019, 2020) can impact the behaviour of the dog(s) (MacKay et al., 2008; Hayes et al., 2018; Jamieson, Baxter and Murray, 2018a). In order to judge the standard of training, performance, and handling that a CDDHT displays, these questions should be answered regarding operational experience:

- **·What experience do those training the dog (e.g., dog training, species expert, etc.) and the dog team have?**
- **·Has the trainer(s) previously worked in conservation or a field similar to the specific project requirements?**
- **·How long has this CDDHT been operational? Has this handler worked with this dog previously? Has the dog had previous successful finds on other species?**
- **·Is the CDDHT used to working in the specific study environment? Depending on study requirements, have they been trained to do the length or style of searches asked of them?**

If any of the above information cannot be provided, the below caveat should be elaborated on in the study's discussion:

Whether behavioural factors from the dog(s) or handler or training outcomes can be explained by examining previous operational experience.

Environment

The environment in which a CDDHT conducts their search, including weather conditions, topography, geographical features, and more, all of which plays a significant role in efficacy (Wasser et al., 2004; Bennett, 2015; Beebe, Howell and Bennett, 2016; Lazarowski et al., 2020; Kokocińska-Kusiak et al., 2021).

Indeed, CDD can and have searched across a wide range of climates and landscapes across the world (McKeague et al., 2024) so it is of no surprise that the environment cannot be separated from the search itself.

It should also be noted that the importance of the environment is not just the surroundings themselves, but also how the handler deals with them. For example, environmental conditions may impact the management of fatigue (Osterkamp, 2020) and the handler's ability to keep on-transect during a search (MacKay et al., 2008).

In order to judge how environmental variables may have affected efficacy, these questions should be answered regarding the search environment:

- **Please provide a record of the temperature, humidity, wind speed, vegetation density, and precipitation before and during any searches (N.B. data could be collected on site or using local meteorological data for the appropriate time frame, please note what method was used).**

If any of the above information cannot be provided, the below caveat should be elaborated on in the study's discussion:

The limited replicability of the study without knowing what conditions the work took place under.

Search

Operational experience refers to the amount or level of experience either the CDD, the handler, or the trainer has in practical real life working conditions

Similarly to the search environment, the search method is also integral to a study's outcomes. Key elements to the search method can include, but are not limited to, the use of transects versus free search, the use of a leash, search distance, and search time. The general recommendation is to perform off-lead searches where possible (MacKay et al., 2008; Bennett, 2015; Domínguez del Valle, Cervantes Peralta and Jaquero Arjona, 2020), with search times of approximately 30 minutes (Centre for the Protection of National Infrastructure, 2018), and a search distance of less than 15 metres (Goodwin, Engel and Weaver, 2010; de Oliveira et al., 2012; Glen and Veltman, 2018; Glen et al., 2018). However, each of these elements have stipulations, benefits, and deficits, and there will always be variations in how each individual CDDHT may operate and choose their techniques. This means that in order to judge how differing search methods may have affected efficacy, these questions should be answered regarding the search methods:

Overall, how was the search conducted?

- **Was the search conducted on-lead or off-lead or both, and why?**
- **What was the operational search distance (i.e., maximum distance that the dog(s) searched from the handler or transect lines), and why?**
- **What was the average operational search time (i.e., length of time of an individual search before finishing or taking a break), and why?**

If any of the above information cannot be provided, the below caveat should be elaborated on in the study's discussion:

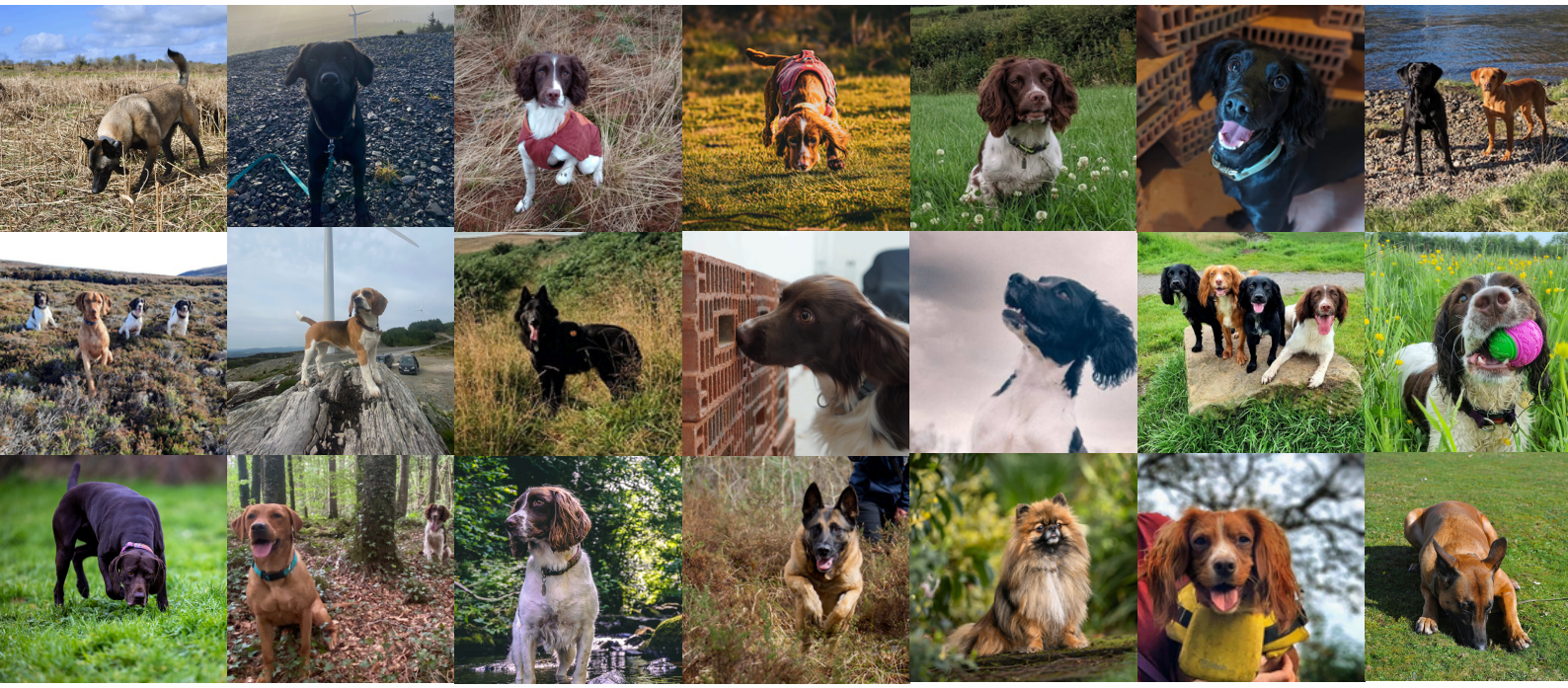
Whether search methods used were acknowledged as part of training or not, which could impact the behaviour of the dog(s).

Conclusion

In conclusion, there is no doubt that CDD research is multifaceted and there are many elements and sub-elements to be considered across every stage of the study design. However, these variables and their considerations are important for good reason, as each can have innumerable effects on a CDDHT's efficacy. Indeed, there are very likely additional variables that are relevant and useful to mention in a methodology, these are simply the critical ones highlighted by (McKeague, Finlay and Rooney, 2024). The steps taken to provide these guidelines have been made with the goal of enhancing the standardisation of CDD research and making the field more accessible to newcomers and those with less research experience. It is hoped that this summary of relevant methodological variables, along with the supplementary materials, will assist researchers and professionals across the field in their own study design and implementation by providing a basis from which to start from.

Acknowledgements

The authors of this paper acknowledge the incredibly valuable and important contributions made by members of the Ecology Detection Dogs Britain and Ireland Working Group whilst reviewing this manuscript.



Appendix

Fillable Checklist for Use During Study Design and Implementation

Key Variables	Relevant Questions	Answers
Efficacy	Has some measure of sensitivity, precision, and/or specificity been measured as part of this study? If not, why not?	
	Has there been any other measures used to show that the dog is demonstrating the desired effect of their training?	
Indication	What form of indication is the dog using (e.g., sit, lie down, point, etc.), and approximately what distance has the dog been trained to indicate from the target?	
	Why was the chosen form of indication considered appropriate for the target species?	
	Consider and provide clear information whose indication performance is being assessed; the dog, the team's, or both.	
Training Samples	What are the training samples/what are the training samples composed of?	
	Where and how were training samples sourced?	
	How many individual training samples were used across the training stage?	
	How often were training samples reused during training?	
	How were training samples stored/handled before, during and after training sessions?	
Testing Samples	What were the testing samples composed of and were they different to those used in training? If not, why not?	
	Were discrimination trials conducted and if so, why were the selected samples/materials chosen, how similar were they to the target odour, and did any randomisation of sample use during trials occur?	
Blinding	How was blinding implemented in this study and what forms were used?	
	During the training and testing stages for the dog, was any form of blinding used, in particular, double blinding during the last stages of training and for testing? If not, why not?	
Odour Level	Has the dog been trained to find a variety of odour levels? If so, do these odour levels represent what the dog will be looking for in the field?	

Other Target Odours	Have the CDD used in this study been previously trained on other target odours? If so, which odours and could these species be in the study environment?	
Dog Selection	Regarding the dog(s) selected for this study, how was this done and why the selected dog(s)?	
	Please provide information about the breeds, personality traits, diets, ages and overall health of the dog(s) selected.	
Operational Experience	What experience do those training the dog (e.g., dog training, species expert, etc.) and the dog team have?	
	Has the trainer(s) previously worked in conservation or a field similar to the specific project requirements?	
	How long has this CDDHT been operational? Has this handler worked with this dog previously? Has the dog had previous successful finds on other species?	
	Is the CDDHT used to working in the specific study environment? Depending on study requirements, have they been trained to do the length of searches asked of them?	
Environment	Please provide a record of the temperature, humidity, wind speed, vegetation density, and precipitation before and during any searches.	
Search	Overall, how was the search conducted? Please include information regarding the use of a lead, search distance, and search time.	

References

- Beebe, S.C., Howell, T.J. and Bennett, P.C. (2016) 'Using Scent Detection Dogs in Conservation Settings: A Review of Scientific Literature Regarding Their Selection', Frontiers in Veterinary Science, 3. Available at: https://doi.org/10.3389/fvets.2016.00096.
- Bennett, E.M. (2015) 'Observations from the Use of Dogs to Undertake Carcass Searches at Wind Facilities in Australia', in Wind and Wildlife. Dordrecht: Springer Netherlands, pp. 113–123. Available at: https://doi.org/10.1007/978-94-017-9490-9_7.
- Bennett, E.M., Hauser, C.E. and Moore, J.L. (2020) 'Evaluating conservation dogs in the search for rare species', Conservation Biology, 34(2), pp. 314–325. Available at: https://doi.org/10.1111/cobi.13431.
- Boroski, B.B. and Oliver, L. (2018) 'Striving for Best Standards and Practices: Recommendations for Optimizing Assessment and Performance of Ecological Scent Detection Dogs', in Using Detection Dogs to Monitor Aquatic Ecosystem Health and Protect Aquatic Resources. Cham: Springer International Publishing, pp. 287–302. Available at: https://doi.org/10.1007/978-3-319-77356-8_8.
- Browne, C.M., Stafford, K.J. and Fordham, R.A. (2006) 'The use of scent-detection dogs', Irish Veterinary Journal, 59(2).
- Centre for the Protection of National Infrastructure (2018) Key points to consider when specifying, procuring and implementing detection dog services.
- DeMatteo, K.E., Davenport, B. and Wilson, L.E. (2019) 'Back to the basics with conservation detection dogs: fundamentals for success', Wildlife Biology, 2019(1). Available at: https://doi.org/10.2981/wlb.00584.
- Domínguez del Valle, J., Cervantes Peralta, F. and Jaquero Arjona, M.I. (2020) 'Factors affecting carcass detection at wind farms using dogs and human searchers', Journal of Applied Ecology. Edited by A. McKenzie, 57(10), pp. 1926–1935. Available at: https://doi.org/10.1111/1365-2664.13714.
- Duggan, J.M., Heske, E.J., Schooley, R.L., Hurt, A. and Whitelaw, A. (2011) 'Comparing detection dog and livetrapping surveys for a cryptic rodent', The Journal of Wildlife Management, 75(5), pp. 1209–1217. Available at: https://doi.org/10.1002/jwmg.150.
- Elliker, K.R., Sommerville, B.A., Broom, D.M., Neal, D.E., Armstrong, S. and Williams, H.C. (2014) 'Key considerations for the experimental training and evaluation of cancer odour detection dogs: lessons learnt from a double-blind, controlled trial of prostate cancer detection', BMC Urology, 14(1), p. 22. Available at: https://doi.org/10.1186/1471-2490-14-22.
- Gadbois, S. and Reeve, C. (2016) 'The semiotic canine: scent processing dogs as research assistants in biomedical and environmental research', Dog Behavior, 2(3), pp. 26–32.
- Glen, A.S., Russell, J.C., Veltman, C.J. and Fewster, R.M. (2018) 'I smell a rat! Estimating effective sweep width for searches using wildlife-detector dogs', Wildlife Research, 45(6), p. 500. Available at: https://doi.org/10.1071/WR18021.
- Glen, A.S. and Veltman, C.J. (2018) 'Search strategies for conservation detection dogs', Wildlife Biology, 2018(1), pp. 1–9. Available at: https://doi.org/10.2981/wlb.00393.
- Goodwin, K.M., Engel, R.E. and Weaver, D.K. (2010) 'Trained Dogs Outperform Human Surveyors in the Detection of Rare Spotted Knapweed (Centaurea stoebe)', Invasive Plant Science and Management, 3(2), pp. 113–121. Available at: https://doi.org/10.1614/IPSM-D-09-00025.1.

- Grimm-Seyfarth, A., Harms, W. and Berger, A. (2021) 'Detection dogs in nature conservation: A database on their world-wide deployment with a review on breeds used and their performance compared to other methods', Methods in Ecology and Evolution. Edited by D. Fisher, 12(4), pp. 568–579. Available at: https://doi.org/10.1111/2041-210X.13560.
- Grimm-Seyfarth, A. and Klenke, R. (2018) 'How to detect elusive species? Detection dogs in nature conservation', in Proceedings of the 5th European Congress of Conservation Biology. Jyväskylä: Jyvaskyla University Open Science Centre. Available at: https://doi.org/10.17011/conference/eccb2018/108096.
- Hayes, J.E., McGreevy, P.D., Forbes, S.L., Laing, G. and Stuetz, R.M. (2018) 'Critical review of dog detection and the influences of physiology, training, and analytical methodologies', Talanta, 185, pp. 499–512. Available at: https://doi.org/10.1016/j.talanta.2018.04.010.
- Helton, W.S. (2009) Canine Ergonomics : The Science of Working Dogs. Boca Raton, FL: CRC Press.
- Hollerbach, L., Heurich, M., Reiners, T.E. and Nowak, C. (2018) 'Detection dogs allow for systematic non-invasive collection of DNA samples from Eurasian lynx', Mammalian Biology, 90, pp. 42–46. Available at: https://doi.org/10.1016/j.mambio.2018.02.003.
- Jamieson, L.T.J., Baxter, G.S. and Murray, P.J. (2017) 'Identifying suitable detection dogs', Applied Animal Behaviour Science, 195, pp. 1–7. Available at: https://doi.org/10.1016/j.applanim.2017.06.010.
- Jamieson, L.T.J., Baxter, G.S. and Murray, P.J. (2018a) 'Who's a Good Handler? Important Skills and Personality Profiles of Wildlife Detection Dog Handlers', Animals, 8(12). Available at: https://doi.org/10.3390/ani8120222.
- Jamieson, L.T.J., Baxter, G.S. and Murray, P.J. (2018b) 'You Are Not My Handler! Impact of Changing Handlers on Dogs' Behaviours and Detection Performance', Animals, 8(10), p. 176. Available at: https://doi.org/10.3390/ani8100176.
- Johnen, D., Heuwieser, W. and Fischer-Tenhagen, C. (2017) 'An approach to identify bias in scent detection dog testing', Applied Animal Behaviour Science, 189, pp. 1–12.
- Kerley, L.L. (2010) 'Using dogs for tiger conservation and research', Integrative Zoology, 5(4), pp. 390–396. Available at: https://doi.org/10.1111/j.1749-4877.2010.00217.x.
- Kokocińska-Kusiak, A., Woszczyło, M., Zybala, M., Maciocha, J., Barłowska, K. and Dzięcioł, M. (2021) 'Canine Olfaction: Physiology, Behavior, and Possibilities for Practical Applications', Animals, 11(8), p. 2463. Available at: https://doi.org/10.3390/ani11082463.
- Kretser, H., Glennon, M., Whitelaw, A., Hurt, A., Pilgrim, K. and Schwartz, M. (2016) 'Scat-detection dogs survey low density moose in New York', Alces. 52: 55-66., 52, pp. 55–66.
- Lazarowski, L., Krichbaum, S., DeGreeff, L.E., Simon, A., Singletary, M., Angle, C. and Waggoner, L.P. (2020) 'Methodological Considerations in Canine Olfactory Detection Research', Frontiers in Veterinary Science, 7. Available at: https://doi.org/10.3389/fvets.2020.00408.
- Lazarowski, L., Rogers, B., Waggoner, L.P. and Katz, J.S. (2019) 'When the nose knows: ontogenetic changes in detection dogs'(Canis familiaris) responsiveness to social and olfactory cues', Animal Behaviour, 153, pp. 61–68.
- Lit, L., Schweitzer, J.B. and Oberbauer, A.M. (2011) 'Handler beliefs affect scent detection dog outcomes', Animal Cognition, 14(3), pp. 387–394. Available at: https://doi.org/10.1007/s10071-010-0373-2.
- MacKay, P., Smith, D.A., Long, R.A. and Parker, M. (2008) 'Scat detection dogs', Noninvasive survey methods for carnivores, pp. 183–222.

- Matthew, E.E., Verster, R. and Weldon, C. (2021) 'A case study in canine detection of giant bullfrog scent', Journal of Vertebrate Biology, 69(3), pp. 20041–20043.
- McKeague, B., Chapman, S., Cripps, R., González-Solís, J., Hartman, J., Johnson, K., Kerrigan, P., McClelland, G.T.W., Militão, T., Smith, H. and Finlay, C. (2024) 'Recommendations for the use of conservation detection dogs in seabird research: a thematic analysis', Seabird [Preprint], (36).
- McKeague, B., Finlay, C. and Rooney, N. (2024) 'Conservation detection dogs: A critical review of efficacy and methodology', Ecology and Evolution.
- Merriam-Webster.com Dictionary (2023) Efficacy, Merriam-Webster. Available at: https://www.merriam-webster.com/dictionary/efficacy (Accessed: 24 July 2023).
- Monaghan, T.F., Agudelo, C.W., Rahman, S.N., Wein, A.J., Lazar, J.M., Everaert, K. and Dmochowski, R.R. (2021) 'Blinding in Clinical Trials: Seeing the Big Picture', Medicina, 57(7), p. 647. Available at: https://doi.org/10.3390/medicina57070647.
- Mosconi, F., Campanaro, A., Carpaneto, G.M., Chiari, S., Hardersen, S., Mancini, E., Maurizi, E., Sabatelli, S., Zauli, A., Mason, F. and Audisio, P. (2017) 'Training of a dog for the monitoring of Osmoderma eremita', Nature Conservation, 20, pp. 237–264. Available at: https://doi.org/10.3897/natureconservation.20.12688.
- de Oliveira, M.L., Norris, D., Ramírez, J.F.M., Peres, P.H. de F., Galetti, M. and Duarte, J.M.B. (2012) 'Dogs can detect scat samples more efficiently than humans: an experiment in a continuous Atlantic Forest remnant', Zoologia (Curitiba) [Preprint]. Available at: https://doi.org/10.1590/S1984-46702012000200012.
- Osterkamp, T. (2020) Detector Dogs and Scent Movement. Boca Raton, FL : CRC Press, [2020]: CRC Press. Available at: https://doi.org/10.4324/9780429020704.
- Richards, N.L. (2018) 'Looking Ahead: Future Directions and Considerations for Using Detection Dogs in Aquatic Environments and Ecosystems', in Using Detection Dogs to Monitor Aquatic Ecosystem Health and Protect Aquatic Resources. Cham: Springer International Publishing, pp. 303–317. Available at: https://doi.org/10.1007/978-3-319-77356-8_9.
- Richards, N.L., Hartman, J., Parker, M., Wendt, L. and Salisbury, C. (2021) 'The Role of Conservation Dog Detection and Ecological Monitoring in Supporting Environmental Forensics and Enforcement Initiatives', in Wildlife Biodiversity Conservation. Cham: Springer International Publishing, pp. 287–322. Available at: https://doi.org/10.1007/978-3-030-64682-0_11.
- Stanhope, K. and Sloan, V. (2019) 'Proposed Method for Testing and Accreditation of Great Crested Newt Detection Dogs', CIEEM In Practice, (105), pp. 36–40.
- Wasser, S.K., Davenport, B., Ramage, E.R., Hunt, K.E., Parker, M., Clarke, C. and Stenhouse, G. (2004) 'Scat detection dogs in wildlife research and management: application to grizzly and black bears in the Yellowhead Ecosystem, Alberta, Canada', Canadian Journal of Zoology, 82(3), pp. 475–492. Available at: https://doi.org/10.1139/z04-020.
- Woollett, D.A. (Smith), Hurt, A. and Richards, N.L. (2013) 'The current and future roles of free-ranging detection dogs in conservation efforts', in Free-Ranging Dogs and Wildlife Conservation. Oxford University Press, pp. 239–264. Available at: https://doi.org/10.1093/acprof:osobl/9780199663217.003.0010.