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The notion of collecting useful biologic data without actually handling, or even seeing, an animal has appeal for many of us, especially we who find mammalian carnivores extremely difficult to capture. Such animals also are of concern and focus because many carnivore species and populations have been decimated, continue to be persecuted, or are the target of high profile restoration efforts. Clearly, this comprehensive guidebook regarding noninvasive survey methods for carnivores is both timely and valuable. These techniques may provide practical and ethical advantages by increasing safety for animal subjects and researchers, minimizing disturbance to animals, and, therefore, decreasing sampling bias while allowing larger sample sizes at a lower cost (Pauli et al., 2009). The one proviso we must acknowledge for readers of the Journal of Wildlife Diseases is that by “survey” these authors explicitly mean collecting data to identify the abundance and distribution of carnivores; “disease” is not listed in the index, though it is brought to readers’ attention in several chapters. Regardless, the innovative approaches to data collection presented here may have direct application for disease studies (see below), and at a minimum will provide a much better understanding of our colleagues’ approaches to collecting useful and comprehensive data sets on carnivore populations.

Chapter 1 (“Noninvasive Research and Carnivore Conservation”) briefly reviews and justifies the use of the label “noninvasive” for many of the methods presented, and places the use of these methods in context with the continued importance of other “hands-on” techniques for use in understanding and solving biologic problems. A brief history of noninvasive survey methods follows, along with the history, scope, and review of subsequent chapters.

Chapter 2 (“Designing Effective Noninvasive Carnivore Surveys”) describes how to assess occurrence, distribution, relative abundance, and abundance, and discusses considerations necessary for monitoring populations. Throughout the chapter, the authors make a strong argument to move away from measures of relative abundance and single-site surveys toward more quantitatively rigorous approaches such as occupancy modeling and capture-recapture techniques (see Chapter 11 for statistical details of these models). When describing occupancy models, the authors do an excellent job of explaining why it is important to separate detection probability from occupancy probability and how this leads to more reliable estimates of presence. Study design layouts are graphically displayed in eight figures to help the reader visualize how objectives, biology, and logistics influence the spatial sampling scheme. Statistical models of occupancy and population estimation are presented in a conceptually accessible fashion, with the reader referred to detailed presentations in the citations. The chapter concludes with 10 key points to be considered by all researchers designing surveys to detect, monitor, and estimate the size of carnivore populations. Although design issues are discussed in general terms here, the authors tactfully discuss the unique strengths and weaknesses of each survey method in the following chapters without unnecessary repetition.

Chapter 3 (“Natural Sign: Tracks and Scats”) provides a detailed review of the background, objectives, practical considerations, survey design issues, and future direction of the use of natural sign surveys to detect and monitor carnivores. This chapter follows naturally from the first two chapters, as it discusses the oldest, least biased, least technical, and most affordable noninvasive tech-
niques available for surveying carnivores. The authors recognize the inherent limitations of natural sign surveys and skillfully illustrate when this method is appropriate, the seasonal and geographic constraints of tracking, and the difficulty in identifying unique individuals and sometimes even species from tracks and scats. They highlight the importance of establishing appropriate survey objectives and developing a suitable study design to maximize the scientific value of collected data, while recognizing that continued advancements in survey design and genetic testing (covered in Chapter 9) will increase the effectiveness and power of natural sign surveys in the future.

Chapter 4 ("Track Stations") is a well-organized and comprehensive treatment of the use of a variety of track station methods for several carnivore species. Of particular use to readers is Table 4.1, which presents references to published studies that have used track station methods organized by study species. As in other chapters, the authors provide a frank discussion of strengths and weaknesses of methods. They include a thorough review of the use of track stations in addressing a variety of study objectives without unnecessarily duplicating material from previous chapters. Also presented are well-researched descriptions of the application of track station methods, from which even the most seasoned practitioner will discover new tools.

Chapter 5 ("Remote Cameras") provides a comprehensive review of the objectives, applications, practical considerations, survey designs, and future direction of the use of remote cameras in carnivore surveys. The authors effectively describe sampling design and provide pertinent references without needlessly duplicating information found in Chapter 2. Disease ecologists will be particularly interested in referenced studies that utilized remote cameras to document behavioral interactions of carnivores in order to examine the potential for disease transmission and the effectiveness of vaccine baits. A shortcoming of the chapter is the emphasis placed on remote camera technology at the time of writing. These technologies are rapidly improving and the discussion was dated by the time of publication.

Chapter 6 ("Hair Collection") is an exceptional summary of one of the most rapidly developing family of techniques for surveying wildlife. A real strength of the chapter is the frequent use of photographs and informative diagrams to enhance the reader’s understanding of the tools and techniques described. The chapter begins appropriately with descriptions of hair collection techniques, broadly divided into baited and unbaited approaches. The authors present a succinct table of published studies organized by study species and hair collection technique for quick reference, and several are discussed in more detail in the text. The authors also provide detailed descriptions of practical considerations involving the use of hair collection techniques.

Chapter 7 ("Scat Detection Dogs") offers a complete and easily understood overview of a novel, noninvasive survey technique. The authors thoroughly discuss the background, limitations, costs and application of this relatively new technique for surveying study populations. The authors’ discussion of the methodology is sufficient to permit a thoughtful analysis of the applicability of detector dogs for specific projects. The use of scat detector dogs may alleviate the constraints of other approaches by maintaining independence of collected samples and removing the bias associated with attractant-based survey methods (e.g., hair snare, cameras). Certainly, the potential to more completely survey a target population through the use of scat detector dogs is an exciting prospect for wildlife disease-related research objectives.

Chapter 8 ("Integrating Multiple Methods to Achieve Survey Objectives") discusses the advantages and limitations of employing multiple detection methods for surveying one or more target species. Initially, the authors clarify their terminology (e.g., "method" vs. "design") and discuss why multiple methods may be required for detection of multiple species or for single-species abundance estimation. Potential benefits of employing multiple methods are described in terms of efficiency and effectiveness, cost, data resolution, multiple target species, and objectives. Meeting assumptions of capture-recapture analysis is addressed from the perspective of adjusting for capture heterogeneity, but no discussion of the pitfalls associated with using different capture and recapture methods is presented. General survey design issues, method interaction or conflict, and occupancy studies are discussed with an emphasis on the importance of estimating detection probability. In their concluding thoughts, the authors suggest that improvements to existing survey methods and development of new techniques may ultimately diminish the need for integrating multiple methods. They also postulate that new statistical approaches that permit dependencies between species detections or detection devices will expand the applicability of multiple-method surveys. Throughout the chapter the reader is pointed to examples, including several case studies detailing the
authors' research, and more in-depth discussion of methods presented in other chapters within the volume. Overall, the reader is left with a thorough overview of the benefits, limitations, and considerations for employing multiple survey methods.

Chapter 9 ("Genetic and Endocrine Tools for Carnivore Surveys") begins with a very thorough review of modern genetics methodology as it applies to noninvasive techniques to address questions for carnivore biology, conservation, and management. The authors provide valuable information on several study objectives that could be approached using genetic sampling, related laboratory techniques, and sample collection and preservation (including important caveats and pitfalls). Also provided are valuable suggestions for choosing a laboratory to conduct analyses and instructions for shipping samples, though considerations for international shipments are not mentioned. The second section of this chapter offers a summary of questions that have been addressed recently using the endocrinology of wild populations. This section provides valuable information on what can be learned from endocrine testing of different types of samples and how to collect and store those samples. This portion of the chapter lacks the thoroughness of the discussion of genetics but provides information necessary to plan a field study that will involve endocrine testing of samples. Upon reading this chapter, a researcher should be well positioned to initiate an appropriate pilot study for his or her organism and study system, the importance of which is stressed several times.

Chapter 10 ("Attracting Animals to Detection Devices") is a well-researched review of a variety of wildlife attractants categorized as baits, lures, and natural attractants. The author provides a thorough description of the methods used to deploy a wide variety of attractants for carnivore surveys. An often overlooked consideration discussed by the author and of particular interest to disease ecologists is the issue of disease transmission when using baits, both for wildlife and for researchers. Also discussed are methods to evaluate the effectiveness of baits and lures. The author concludes with four extremely well-researched appendices, which include a comprehensive presentation of baits and lures used in carnivore surveys organized by target species, including references, and a select list of commercial suppliers of baits and scent lures, lure ingredients, and costs.

Chapter 11 ("Statistical Modeling and Inference from Carnivore Survey Data") begins with a discussion regarding the establishment of objectives and sampling considerations, much of which is applicable beyond the realm of carnivore surveys. The remainder is broken into two sections based on different sampling situations: those when an individual animal can be identified and those when it cannot. The chapter ends with an explicit treatment of statistical approaches for dealing with genetic and photographic sampling data and a review of applicable software packages. As the authors point out, covering even one methodologic topic in a single chapter is a challenge, and we commend them for their success in balancing breadth and depth to provide a well-written and understandable review of the statistical treatment of carnivore survey data. We also agree with the authors' approach of providing an overview of modeling strategies rather than writing a "step-by-step" guide to the use of statistical techniques. Readers would benefit from a strong statistical background in order to understand the details of occupancy and capture-recapture modeling, but it is not necessary for gleaning the chapter's most valuable points. Strengths of the chapter include abundant references, inclusion of both formulas and descriptive text, and effective use of illustrative examples. The chapter would have benefited from a clearer delineation of the occupancy and abundance sections. Although specific to analysis of carnivore surveys, the chapter should be valuable to a broad audience, because the conceptual issues addressed throughout are faced by researchers studying a variety of taxa.

Chapter 12 ("Synthesis and Future Research Needs") highlights the critical advances that have contributed most to the study of carnivores, compares strengths and weaknesses of techniques, and shares thoughts on where the field may be headed. The authors note that the rise of genetic methods, continuing advances in remote camera technology, novel device design, use of detection dogs, and biostatistical innovation signal major progress. Tables that present species-specific methodologic suitability and method comparisons are a quick way to evaluate the potential of various techniques. Continued innovation in established and new techniques will be essential to help understand landscape changes that are sure to come.

With respect to disease considerations, we also note that throughout the chapters that incorporate the use of scat as a noninvasive survey method, multiple authors briefly addressed the issue of the potential zoonotic risk factor from improper handling of samples. It would have been nice to see this strongly
emphasized because there is pathogenic risk to field or laboratory carnivore researchers handling fresh feces from a wide array of carnivores. Furthermore, the detection of fecal pathogens using opportunistically collected scat received a cursory mention, although it has vast potential in characterizing the epizootiologic patterns in populations and disease risk present in certain environments. This diagnostic tool is developing rapidly because fecal micro- and macroparasites may be very pertinent risks and limiting factors to carnivore populations. If characteristics such as species, sex, and relatedness can be determined from scat, linking these demographic parameters to pathogen presence and even intensity can yield interesting ecologic correlations that before were difficult to conduct without directly handling animals. Items used for remote detection (track stations and remote cameras) may be marked by either target or nontarget species with exudates or excrements. The proper disinfection of equipment that may act as fomites transporting pathogens from one project site to another was not mentioned but is important. Along these lines, the risk involved with congregating species and their excrements at bait stations could have been addressed. The use of cameras for wildlife disease studies, such as quantifying contact rates or vaccine delivery efficiency, was mentioned and should be emphasized. The authors also were insightful for mentioning the risk that the use of infected bait or nonendemic carcasses poses for native wildlife by serving as potential sources of pathogens. For example, we were pleased to see the mention of potentially infecting canids with the rickettsial organism that causes salmon-poisoning disease by using infected wild or hatchery fish. Finally, the authors made a clear and relevant point that dogs used for scat surveys need to be fully vaccinated and monitored in order to minimize risk to both dogs and wildlife.

Overall, this is an extremely valuable body of work, built on the firm foundation provided by Zielinski and Kucera (1995). It is clearly presented by leaders in the field of carnivore conservation, management, and research and thus timely and comprehensive. Even though many examples are North American, the techniques and consideration described are applicable worldwide and for a variety of taxa. We particularly liked the use of case studies at the close of most chapters as an informative means of providing specific detail for the survey methods addressed, though we note not all cite the published source. This is a very reasonably priced handbook for professionals of all sorts and could serve as a valuable text for a university seminar class on animal sampling and population assessment.

**LITERATURE CITED**
