Chapter 12

GUIDELINES AND TECHNIQUES FOR STUDYING THE REPRODUCTIVE ECOLOGY OF WILD FISHERS (*PEKANIA PENNANTI*), AMERICAN MARTENS (*MARTES AMERICANA*), AND OTHER MEMBERS OF THE *MARTES* COMPLEX

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Abstract: Information on reproduction is essential to understanding population dynamics and developing conservation plans for wildlife. However, research on reproduction with species in the *Martes* Complex in wild settings can be challenging due to their low population densities, elusive behaviours, and tendency to hide young in cryptic den structures such as tree cavities or snow burrows. Answering basic questions about life history parameters in the *Martes* Complex involves specialized techniques that have been increasingly refined by researchers over the last half-century. We present a review of techniques and recommendations for researchers initiating a study of reproduction in a wild setting with a focus on the fisher (*Pekania pennanti*) and American marten (*Martes americana*). Specifically, we discuss details involved in studying reproduction through (1) assessment of teat condition at live captures, (2) assessment of reproductive organs of carcasses, (3) location and monitoring of reproductive dens using telemetry, (4) use of remote cameras at reproductive den structures, and (5) investigation of reproductive den chambers. We conclude by briefly summarizing available information on reproduction for members of the *Martes* Complex to highlight knowledge to date and encourage additional research.

INTRODUCTION

Reproduction plays an essential role in the long-term persistence of populations (Stearns 1992; Mills 2007). Thus, the study of a species' reproductive

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ecology and associated habitat needs is often a necessary step in the creation of an effective conservation plan (e.g., Wisdom et al. 2000; Burns et al. 2013). However, investigating reproduction of rare or elusive species in wild settings presents many challenges which require a combination of field experience, technological innovations, and creativity to overcome. The sharing of information about field techniques, including advantages, disadvantages, and recent advances of different methods, often occurs informally between biologists working on the same species, especially as researchers may have limited space to elaborate on methodology in publications. Over the last decade, there have been a number of studies focused on reproductive ecology within the *Martes* Complex and corresponding improvements in research techniques available to investigate reproduction in the wild. As many species in this Complex are of conservation concern in at least part of their geographic range, information on reproductive ecology is of great value. To foster continued advancement of research within the *Martes* Complex, we summarized and reviewed available techniques to study reproduction within this unique group of mammals; the resulting chapter includes a synthesis of research methods and insights from the authors' collective experience in working with some of these species for many years. Our hope is that researchers will continue to improve these techniques and adapt them as needed for different species and geographic areas.

The *Martes* Complex includes all species within the genus *Martes* in North America, Europe, and Asia, the recently renamed fisher (*Pekania* [formerly *Martes*] *pennanti*; Koepfli et al. 2008; Sato et al. 2012), tayra (*Eira barbara*), and wolverine (*Gulo gulo*) (Proulx and Aubry 2014). A number of field studies of reproductive ecology have focused on 2 North American species, the fisher and American marten (*Martes americana*). As a result, the information presented in this chapter relies heavily on examples from these 2 species; however, we included information on other species in the *Martes* Complex whenever possible. A new marten species, the Pacific marten (*M. caurina*), was recently recognized in western North America (Carr and Hicks 1997; Dawson and Cook 2012); but as most publications from this region predate the new classification, we refer only to *M. americana* in our examples.

Many members of the *Martes* Complex share similarities in morphology (e.g., long, slender bodies), physiology (e.g., delayed implantation), and habitat selection (e.g., tree cavities for reproductive dens); known exceptions to these patterns include wolverine denning in snow burrows (Magoun and Copeland 1998) and tayra not undergoing delayed implantation (Presley 2000). Even with some differences, we expect the methods and field experiences in studying one species will be

relevant, at least in part, to other species in the group. For researchers working on species with limited baseline data, techniques that have been successful with a related species should provide a good starting point. The reproductive period is a sensitive time for individual animals (Facka et al. 2016) and vital to the persistence of local populations, so it is important to find a balance between gathering valuable data and negatively impacting reproductive females. Our objectives were to: (1) provide guidelines for researchers planning a study of reproduction on species in the *Martes* Complex, (2) describe techniques to study reproductive ecology in the wild, (3) discuss potential effects of methods on study animals and ways to minimize impacts, (4) provide suggestions for adapting techniques to species with minimal baseline data, and (5) highlight research accomplishments and further research needs for individual species.

Many terms associated with reproduction in the *Martes* Complex are regionally well known and accepted among biologists. Yet, other terms have acquired slightly different meanings across time, studies, and species, which can make accurate ecological comparisons challenging. In Table 12.1, we briefly define key terms associated with reproduction in the *Martes* Complex based on previous publications and our own field research. The selection of terms and definitions reflect a North American flavour (for example, the words 'den' and 'denning' are specifically linked to reproduction, which is not necessarily the case elsewhere) and are presented as suggestions for consistency in the *Martes* Complex; however, where alternative terms are preferred or already in use, researchers can facilitate comparisons by clarifying the meaning of the terms used in their study (e.g., Birks et al. 2005).

GUIDELINES FOR STUDYING REPRODUCTION IN THE *MARTES* COMPLEX

Research questions, study design, and planning for field work

In this chapter, we concentrate on the logistical aspects of answering basic research questions associated with reproduction in the *Martes* Complex, but emphasize the importance of first developing sound research questions of ecological value, and then designing a study to address those questions using appropriate and ethical techniques. Once key questions are identified, the next steps are to identify the types of data needed to address those questions and the techniques to be used. In Table 12.2, we provide example research questions associated with reproduction in *Martes* Complex species to highlight the intersection between desired data and potential methods.

Table 12.1. Key terms relevant to fieldwork on reproduction in the *Martes* Complex based on previous publications and the authors' field research.

Term	Definition
Rest site	A daily refuge used by a male or female at any time during the year. Rest sites may provide thermal and/or physical protection for individuals and are typically used for sleeping, eating, and hiding from predators or inclement weather. (Zielinski et al. 2004; Larroque et al. 2015)
Reproductive den	A refuge used by a reproductive female with young that are still dependent and nursing. Dens provide thermal and physical protection for females and offspring during maternal activities and hidden refuges for kits/cubs while the female is away. Dens are typically used for longer periods than rest sites. (Weir et al. 2012)
Natal den	The first reproductive den used by a female in a given year and where parturition occurs. (Magoun and Copeland 1998; Ruggiero et al. 1998)
Maternal den	Any reproductive den used subsequent to a natal den. Maternal dens are used when kits/cubs are not yet weaned and have limited mobility. (Magoun and Copeland 1998; Ruggiero et al. 1998)
Maternal rest site	Rest structures used by females with young after reproductive dens, but prior to juvenile independence. These sites may be used for >1 day or >1 occasion and can provide shelter for young while the female forages. They differ from dens in that young are (presumably) weaned and mobile, but still dependent on the female. Sites used by wolverines for similar purposes are called rendezvous sites. (Persson et al. 2006; Green 2017)
Den structure	The physical structure in which a female conceals her young, such as a tree, snag (standing dead tree), snow bank, or hollow log. (Kleef and Tydeman 2009; Weir et al. 2012)
Den microsite	The discrete portion of the den structure within which a female houses her kits or cubs (e.g., cavity in tree, burrow in a snow bank)
Parturition date	Parturition is the act of a female giving birth to young. In studies of *Martes* Complex species in the wild, parturition is assumed to have occurred based on localized behaviour of females to an individual structure or site. (Arthur and Krohn 1991)
Litter size	True litter size is the actual number of offspring at birth per female in a given year. Estimated litter size is the measure obtained in wild settings and may vary by method and when the count is conducted. Counts of live offspring at reproductive dens typically occur 3–12 weeks after parturition. (Matthews et al. 2013b)
Kits, kittens, cubs	The offspring of fishers are typically called kits and young martens have been called kits and kittens. Wolverine offspring have been called cubs and kits, while young tayras have been called cubs. We use kit and cub interchangeably. (Powell 1993; Magoun and Copeland 1998; Kleef 2000; Presley 2000; May et al. 2012)

Table 12.2. Potential research questions related to reproductive ecology of fishers (*Pekania pennanti*), American martens (*Martes americana*), and other members of the *Martes* Complex, the types of data needed to address them, and available techniques.

Research questions	Types of data needed	Techniques
What proportion of adult females reproduce each year?	Number of females that had offspring relative to the number monitored during reproduction that were old enough to have offspring	-Teat assessment -Carcass assessment -VHF telemetry
When does mating occur?	Movements of males and females during period of receptivity Movements of males during denning season (fisher)	-VHF telemetry -GPS telemetry (some species) -Remote cameras (some species)
When does parturition occur?	Dates when females localize to 1 structure	-VHF telemetry
What is the average litter size?	Counts of copora lutea, unimplanted blastocysts, developing embryos, placental scars, dependent kits/cubs in den cavities, or mobile kits/cubs with females post den season	-Carcass assessment -VHF telemetry combined with remote cameras (at dens) or den cavity investigations
What are den attendance patterns for reproductive females?	Dates and times when the female is at the den with young, when she leaves, and when she returns Measures of abiotic factors potentially associated with attendance	-VHF telemetry -Remote cameras -Temperature loggers -Telemetry loggers
When do kits/cubs become mobile?	Photos or videos of kits or cubs at late dens and maternal rest sites or rendezvous sites	-VHF telemetry combined with remote cameras (at dens/rest sites)
What types of structures are used as reproductive dens?	Location of the den structure and microsite Field measurements and description of den structure and microsite	-VHF telemetry combined with den vegetation measurements -Den chamber investigations with den microsite measurements

As with any research project, many logistical details must be considered when planning fieldwork; a key concern in studying reproduction in *Martes* Complex species is that reproductive timelines (e.g., parturition dates) are largely dictated by the biology of the species. Advanced preparation is critical if animals are to be tracked using telemetry, but

also to collect carcasses in suitable condition at the appropriate times of year. As such, we recommend creating a reproductive timeline to ensure a successful research project. If live-capture or telemetry is part of the study design, researchers should carefully consider the time involved to obtain permits and transmitters, recruit skilled personnel for live-trapping, engage local veterinarians, and capture animals. While these suggestions may seem rudimentary, ensuring that a project timeline stays on track will help ensure that the window of opportunity to study reproduction is not lost and impacts are minimized.

Live-trapping and handling of animals

Studying reproductive ecology in the *Martes* Complex often requires capturing and handling individual animals to deploy Very High Frequency (VHF) transmitters for future relocation during the reproductive season (Arthur and Krohn 1991; Bull and Heater 2001; May et al. 2012). Capture and handling protocols should be designed in accordance with relevant permitting regulations and guidelines for the safe handling of wild mammals (e.g., Sikes et al. 2011; Proulx et al. 2012; Kollias and Abou-Madi 2014). Capture efforts for most species should be conducted in the late summer, autumn, or winter to avoid capturing females that are near parturition or with dependent young, although ideal timing may vary with species. Females trapped too close to parturition could lose young due to stress or restricted opportunity to find a suitable den. Females trapped once denning has begun could lose kits to exposure or malnutrition if separated for too long or may no longer be able to access offspring hidden in chambers with small entrances if a newly attached radio-collar inhibits movement. Anecdotal accounts, such as a wild-caught female fisher giving birth in captivity but failing to nurse kits (Leonard 1986), lactating female fishers abandoning dens after spring captures (Arthur and Krohn 1991), and the use of small natal den openings by female fishers (Figure 12.1; Green 2017) indicate that these are valid concerns. If parturition dates and weaning dates are known for the study species, researchers should avoid live-trapping during active gestation or while females are denning. If parturition dates or gestation periods are not known for a species, researchers should use data for closely related species, make adjustments as needed, and suspend trapping if lactating females are captured.

Many species in the *Martes* Complex have been captured in box or cage-type live traps; to reduce injuries (e.g., broken canines, damaged claws) and provide insulation in cold weather, box traps can be modified by attaching a plywood cubby box (a 61-cm-long box attached to the

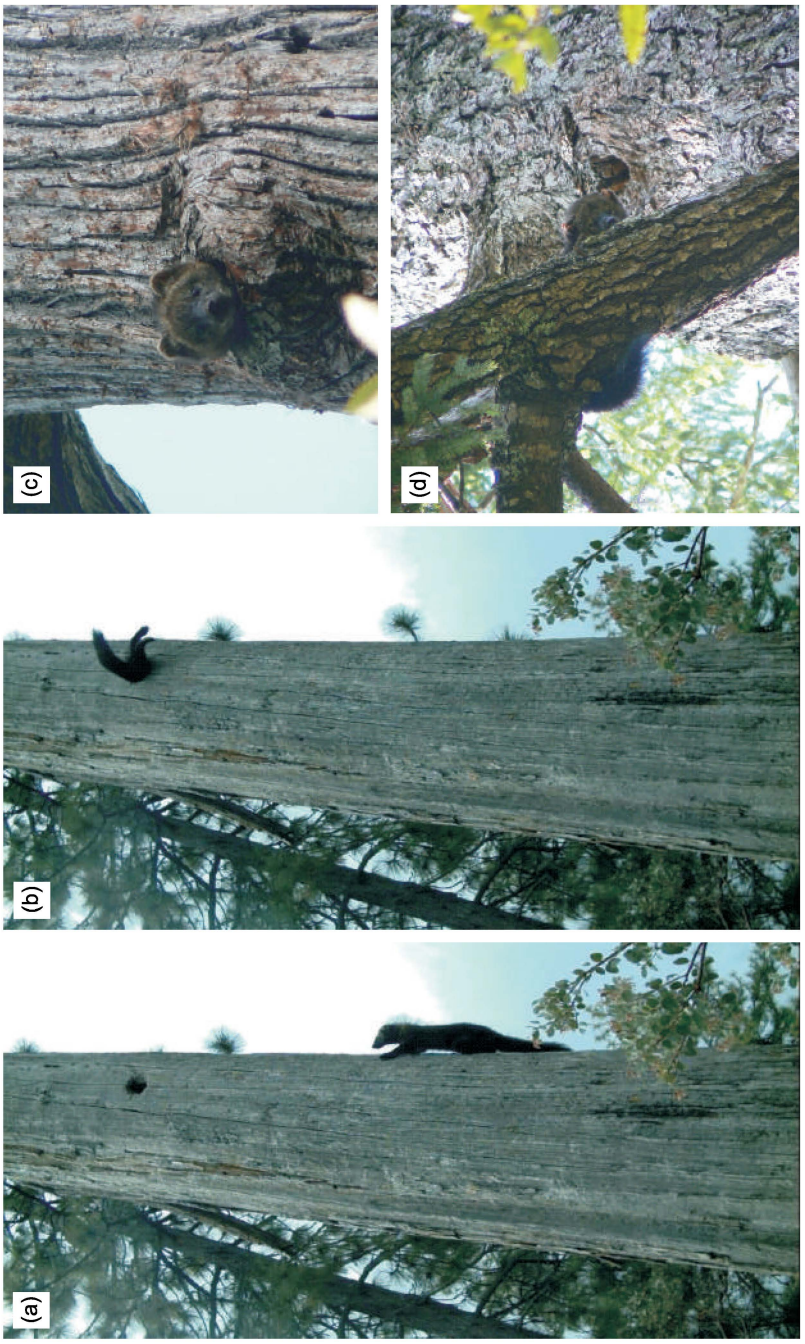

Figure 12.1. Entrances to fisher natal dens tend to be small relative to the body size of the species. Photos (a) and (b), taken by remote cameras, show a female climbing and entering a natal den in the southern Sierra Nevada, California (photo credit R. Green, USFS). Photo (c) shows a female peering out of a natal den cavity in Hoopa, California; (d) shows a male on a branch near a small natal den entrance (photo credit K. Rennie, Hoopa Tribal Forestry).

back end of live traps for protection from inclement weather and minimize stress; e.g., Seglund 1995) or covering the interior floor of the trap with plywood, burlap, or corrugated plastic (e.g., Mortenson and Moriarty 2015). Appropriate baits vary by species, but have included chicken (Mortensen and Moriarty 2015), venison (Sweitzer et al. 2015), as well as eggs and honey (Wereszczuk and Zalewski 2015). Traps should be physically checked daily once set; trap transmitters can be used to help inform researchers sooner about trap firing (Proulx et al. 2012), although these devices add cost and are subject to failure, so should not replace physical checks. Wolverines require more specialized methods for capture; the 2 primary options used are darting (Persson et al. 2006) or use of baited log-box traps (Copeland et al. 1995). Cubby boxes and log-box traps take time to construct, which should be considered in the project timeline. Fishers and American martens have been immobilized using a combination of ketamine and either diazepam or midazolam (Kreeger and Arnemo 2012; Mortenson and Moriarty 2015; Sweitzer et al. 2015); pine marten (*Martes martes*) and stone marten (*M. foina*) have been sedated with ketamine (Wereszczuk and Zalewski 2015) as well as Domitor and revived with Antisédan (Larrouqe et al. 2015); ketamine and xylazine or medetomidine have been used with wolverines (Persson et al. 2006). We recommend consulting with veterinarians and researchers familiar with the species of interest to obtain the current advice on dosages and safety issues.

Transmitters

Most members of the *Martes* Complex have long, thin bodies and frequently go in and out of tight spaces; this is particularly true during the breeding season when females of many species use tree cavities or other microsites with small entrances (e.g., Green 2017). Researchers must carefully consider how transmitters and radio-collars could affect reproduction. If collar-mounted transmitters are used, it is important to select a model with a size and shape that is compatible with the behaviour of the species of interest. For instance, if the transmitter and battery package is too large, it may prevent a female from entering a suitable microsite entrance or increase her risk of getting stuck in a tight place. We suggest researchers err on the side of caution in transmitter selection and consider collar profile, canister size, and flexibility of the antenna. For example, Holohil collars (model MI-2M, 31 grams, Holohil Systems Ltd., Carp, Ontario, Canada) were used on reproductive female fishers in California without obvious restrictions in movement or neck injuries (R. Green, personal observation).

Some researchers have opted to use transmitters implanted in the abdomen (Thompson et al. 2012). The benefit of using intraperitoneally-implanted transmitters is they should not hinder animals in tight spaces. For species like wolverines with a thick neck and relatively broad head, intraperitoneally-implanted transmitters may be the best option to reduce the risk of collars becoming too tight as animals grow or falling off too easily (Copeland 1996; Persson et al. 2006). Drawbacks to this method are that a veterinarian is generally required to surgically insert the implant, the transmitter stays in the abdominal cavity for the animal's lifespan if not removed (Thompson et al. 2012), and complications can result from surgery (Copeland 1996). Proulx and MacKenzie (2012) have explored the use of dorsal implants in the American badger (*Taxidea taxus*), a related species with similar concerns to wolverine in regards to collar fit (i.e., broad head and neck); further investigation is needed to determine if this is a suitable option for use with wolverines.

As global positioning system (GPS) collars decrease in size and fit individuals within the *Martes* Complex they may become an option to study reproduction. Presently, the size, shape, battery life, reliability, and price of available GPS collars do not make them a logical choice for most studies of female reproduction. GPS collars may also not be suitable for locating den structures as they are typically unable to obtain fixes while a female is in a den cavity, so confirmation and monitoring of reproductive den structures will still require VHF methods. As GPS collars improve for small carnivores they may provide valuable data on movement patterns of females away from dens, as well as males and females during the mating season.

TECHNIQUES FOR STUDYING REPRODUCTION IN THE *MARTES* COMPLEX

We focus on 5 of the most readily available and useful techniques currently available that apply broadly across species, but note that this list is not exhaustive. Researchers have developed many innovations to study reproduction that can be combined with other techniques to meet research goals with different species. For example, Kleef (2000) and Kleef and Tydeman (2009) used a unique method which involved placement of temperature loggers in known den cavities of pine martens to assess when parturition occurred (based on the time spent by a female in the den) and monitor activity patterns; using this method, they also found a relationship between activity patterns and age of kits. Cummins (2016) has developed a similar method for use with radio-collared female

fishers in which a telemetry data logger monitored activity patterns at dens. Some less-invasive techniques have also been used with pine martens to study faecal marking relative to reproduction (Barja et al. 2011), assess genetic relatedness, and estimate litter sizes using hair samples (O'Reilly et al. 2013). Methods for locating wolverine dens (e.g., snow-tracking, monitoring of former den sites) are not described in detail here, but references are available (e.g., May et al. 2012).

Technique 1: Assessment of female reproductive status at live captures

The use of nipple size as an index of reproduction offers an alternative to radio-telemetry (Paragi 1990; Mech et al. 1993; Brooks and McRoberts 1997; Frost et al. 1999). Females of the *Martes* Complex generally wean kits or cubs between 6 and 10 weeks after parturition (Powell 1993; Mead 1994; Inman et al. 2012). For the welfare of females and kits, however, live-trapping and capture during the whelping and rearing period are generally avoided to evaluate lactation; when trapping is resumed after weaning, lactation has ceased. Thus, expression of milk and teat palpitation is not a pertinent diagnostic. Teat size post-weaning has the potential to act as an indicator of reproduction. To our knowledge, measurements of teats to assess reproduction has only been well-documented with fishers, but the techniques involved have potential for use with most, if not all, species in the *Martes* Complex.

Paragi (1990) concluded that nipple sizes of current-year breeders and non-breeders were sufficiently distinct to assign reproductive status to unknown individuals in south-central Maine. His conclusion was based on live-trapped individuals and pelt measurements with small sample sizes (nulliparous [females that had not previously given birth] n 26, non-parous [females that had given birth, but not in the previous spring] n 1, parous [females that gave birth in the previous spring] n 7). The parous females were captured at 2 distinctly different times in the female reproductive cycle (4 captured in May and 3 between August and December). Frost et al. (1999) found nipple size to be a reliable index for captive and wild fishers in Maine and Massachusetts to distinguish current-year breeders from non-breeders, but found that former breeders may be misclassified as current breeders.

Matthews et al. (2013a) evaluated nipple size as an index of weaning success for wild fishers captured in California. Weaning success, defined as whether a female successfully weaned at least 1 kit, was used rather than the parturition of at least 1 kit (e.g., Paragi 1990); weaning success was chosen because it accounted for kits that died during whelping or rearing (e.g., Matthews et al. 2013b). The authors measured width and

height of all 4 nipples on captured fishers using digital calipers and 30-cm plastic rulers (Paragi 1990; Frost et al. 1999). Along with these 8 direct nipple measurements, the authors derived 16 additional nipple variables that were evaluated as potential predictors of weaning success (Matthews et al. 2013a). Nipple sizes (mm^2) were measured as diameter at base multiplied by height to the nearest one-hundredth of a millimetre. Matthews et al. (2013a) used a modified randomForest (RF) procedure to classify measured females into 1 of 3 reproductive classes and account for repeated measures of individual females sampled in multiple years. Reproductive classes were: non-breeder (females that did not exhibit denning behaviour), attempted breeder (females that exhibited denning behaviour but failed to exhibit behaviour until weaning), and current breeder (females that exhibited denning behaviour until weaning). A bootstrap sampling procedure was used to generate training and test data sets and a random subset of 12 of the 24 variables for the construction and error assessment for each of the 1,000 trees. Each training data set included all the observations of females measured only once and a randomly selected observation of each female measured in multiple years. In addition, each test data set included a randomly selected observation of each female measured in multiple years that was not included in the training data set. Their RF algorithm correctly classified reproductive class for 130 (89%) and 131 (90%) of the 146 observations using raw and weighted totals, with chance-corrected measures of prediction (Cohen's kappa statistic) = 0.80 and 0.81, respectively (Matthews et al. 2013a). Non-breeders were most accurately classified, followed closely by current breeders. Individuals that attempted to breed but did not successfully wean litters were least accurately classified.

Pros: This technique helps identify the proportion of the population that reproduces annually.

Cons: Although teat size and condition may indicate that a female bore and reared young for some period of time, this technique does not provide information on litter size or den location.

Considerations: Teat-size assessment is appropriate for researchers working with wide-ranging but easily live-trapped species, or in study areas where monitoring of reproductive dens using telemetry may be especially difficult due to rugged terrain or limited resources. Although field work and analysis has only been done with fishers, teat assessment is likely appropriate for use with other species in the *Martes* Complex, although additional data would be needed to generate a new RF algorithm.

Technique 2: Assessment of reproductive status and fecundity using carcasses

Examination of the reproductive tracts of carcasses from individuals in the *Martes* Complex can provide valuable data on reproduction in wild populations (e.g., Banci and Harestad 1988; Helldin 1999; Bakeev et al. 2003; Steklenev 2014). Carcasses can yield information on litter size and fecundity rates, which can be used to estimate recruitment rates and inform population estimates for conservation and management of *Martes* Complex species. Carcass-based methods are typically used to collect data on reproduction from harvested populations where large numbers of carcasses are regularly available; as such, these methods may not be appropriate for species or populations that are not harvested due to conservation concerns or other reasons. Reproductive estimates obtained from carcasses can be combined with other data (e.g., age or sex) and used to correlate changes in recruitment rates to harvest history, changes in habitat suitability, or fluctuations in prey populations (e.g., Hawley and Newby 1957; Weckwerth and Hawley 1962). Carcass-based methods can also be used for post-mortem assessment of radio-collared study animals if the carcass is sufficiently fresh. Data on male reproductive characteristics can also be obtained from carcasses (e.g., sexual maturity based on baculum measurements; Wright and Coulter 1967; Madsen and Rasmussen 1985; Strickland and Douglas 1987), but we focus here on examination of female reproductive tissues.

Four methods can be used to assess pregnancy rate and litter size using carcasses of females ≥1 year of age: counting corpora lutea (CL) in ovaries, counting un-implanted blastocysts (BCs) in uteri, counting implanted embryos (IEs) in uteri, and counting placental scars (PSs) on uterine tissue (Gilbert 1987). Each method represents a different part of the reproductive process and, thus, provides slightly different information. Corpora lutea form during ovulation, with individual CL representing a single ovum that was released (Gilbert 1987). As *Martes* Complex species are either known or suspected induced ovulators, CL counts reflect both copulation and ovulation rates. Serial sections of ovaries are typically prepared using a microtome, and sections are stained prior to microscopic examination (Strickland and Douglas 1987). Strickland and Douglas (1987) suggested CL counts yielded the best litter size estimates during delayed implantation, but they may over-estimate litter size or pregnancy rates if all released ova are not fertilized or if some fertilized ova never implant or are resorbed before parturition (Crowley et al. 1990).

After fertilization, embryos develop to the blastocyst stage at which point development arrests during the period of delayed implantation that

all *Martes* Complex species (except tayra) undergo (Mead 1994; Proulx and Aubry 2017, this volume). Implantation and further development of the embryo does not occur until 30 days or more before parturition (reviewed in Mead 1994). Prior to implantation, BCs can be flushed from the uterus with distilled water or 95% alcohol administered with a syringe (Gilbert 1987; Crowley et al. 1990) and counted using a dissecting microscope. Blastocyst counts represent the number of fertilized ova, but not all BCs may implant and develop to term. Thus, as with CL counts, BC counts may over-represent true litter sizes (Crowley et al. 1990). As BCs decay rapidly in poorly preserved specimens (Douglas and Strickland 1987; Strickland and Douglas 1987), BC counts may under-represent true litter sizes if carcasses are not fresh or were not frozen soon enough.

Implanted embryos can be counted on carcasses collected during active gestation (i.e., after implantation and prior to parturition). Because IEs can resorb after placentation (Gilbert 1987), IE counts are more reliable from carcasses collected close to parturition. Trapping seasons are often established to conclude before implantation occurs, so examination of IEs is most practical for post-mortem examination of study animals or animals hit by vehicles (e.g., Fournier-Chambrillon et al. 2010). Developmental state of IEs can help estimate implantation dates in some species (Gilbert 1987).

Placental scars form last in the reproductive process. *Martes* Complex species have endotheliochorial placentas (Gilbert 1987), which are characterized by a deep connection between fetal and maternal tissues. PSs form from hemosiderin-filled macrophages that concentrate at implantation sites (Mead 1994). Since PSs form as a result of parturition, PS counts may more accurately reflect true litter size and pregnancy rates. However, PSs persist for varying amounts of time and may only be detectable on fresh or properly preserved specimens (Gilbert 1987; Strickland and Douglas 1987; Elmeros and Hammershøj 2006). Some authors have suggested PSs are not evident or are difficult to detect in trapper-harvested carcasses (Strickland et al. 1982); others have not reported issues detecting them (Coulter 1966; Crowley et al. 1990). Crowley et al. (1990) found PSs were visible on fisher carcasses collected during December and closely matched pregnancy rates and litter sizes of fishers from independent field data. Mead (1994) stated that PSs should be present until implantation during the following reproductive cycle and suggested that failure to identify PSs could be due to use of improper techniques. PSs can be viewed via macroscopic analysis of longitudinally sectioned uteri; microscopic analysis of fixed and stained uteri may improve PS counts (Mead 1994; Fournier-Chambrillon et al.

2010). If PSs cannot be reliably detected, litter size and pregnancy rates may be under-estimated. On the other hand, PSs can form from embryos that were resorbed during later stages of placenta development (Mead 1994).

Choice of method depends in part on timing of carcass collection. IE counts are only useful for carcasses collected less than a month prior to parturition, while PSs may only be useful for several months following parturition (Gilbert 1987; Strickland and Douglas 1987; Elmeros and Hammershøj 2006). Corpora lutea counts are most frequently used with carcasses from trappers because they are reliably detected during delayed implantation. Staining uteri may improve detection of PSs longer after parturition and reduce count variability among observers (Fournier-Chambrillon et al. 2010); however, staining methods have not been evaluated for all species in the *Martes* Complex.

One of the most important considerations when using carcass-based methods are potential biases associated with each method. Because each of the methods discussed above reflects a different part of the reproductive-developmental process, choice of method may bias estimates of pregnancy rates and litter sizes. Studies comparing multiple methods have generally found that litter sizes estimated from CL are larger than those from BCs and that estimates from both CL and BCs are larger than those from PSs (Coulter 1966; Strickland et al. 1982; Douglas and Strickland 1987; Crowley et al. 1990). These results are consistent with expectations because not all ova become fertilized during copulation and BCs may not all implant or may be resorbed. Theoretically, PS counts should match litter size at parturition, but may underestimate true litter size due to poor detection as a result of postpartum regeneration of uterine tissue prior to carcass collection and/or poor carcass preservation (Coulter 1966; Strickland et al. 1982). Nonetheless, estimates from different methods are relatively similar (e.g., litter size estimates for fishers range from 2.5–3.9; reviewed in Powell 1993), suggesting that any of these methods may be useful for long-term monitoring as long as it can detect inter-annual changes in litter sizes.

Estimates of pregnancy rates from examination of ovarian or uterine tissues are similarly biased. Ovulation rates from CL counts are generally high and have been documented at ≥95% in fishers (Douglas and Strickland 1987), ≥75% in American martens (Strickland and Douglas 1987), 98% in pine martens (Helldin 1999) and 50–91% in sables (*Martes zibellina*; Bakeev et al. 2003). Parturition rates for fishers from PSs (e.g., 22–88%; Crowley et al. 1990) and field-based estimates (46–75%) are lower and more variable, suggesting CL may overestimate parturition rates. Estimates of ovulation rates from CL have been lower and more variable for American marten (e.g., 22–82%, Flynn and Schumacher 2009).

Variability in American marten and sable ovulation rates may reflect decreased reproductive output due to nutritional stress during prey population nadirs (Hawley and Newby 1957; Weckwerth and Hawley 1962; Zaleker and Poluzadov 1967; Thompson and Colgan 1987; Flynn and Schumacher 2009). Although CL counts appear to give accurate estimates of parturition rates for martens, they may over-estimate fisher parturition rates; this could ultimately influence fisher population models. Positively biased estimates of pregnancy rates could have implications for conservation or management if methods fail to detect changes in reproductive rates or lead to over-estimates of population size.

Pros: Carcasses may provide a wealth of data on reproduction where readily available from the fur harvest. Carcass-based methods typically provide larger sample sizes at a lower cost than other methods, such as intensive monitoring of radio-collared animals (e.g., Banci and Harestad 1988).

Cons: Carcasses may be unavailable in areas without harvest seasons or where species are not targeted for their pelts or are legally protected. Methods may produce biased estimates of litter size and parturition rates, which could affect population models and resulting management decisions. These techniques require laboratory facilities, equipment, and expertise that are not widely available, and carcass disposal adds costs where carcasses are classified as clinical waste.

Considerations: Obtaining carcasses through lethal trapping of wild animals may be illegal or inappropriate in populations of conservation concern and raises ethical considerations even in healthy populations in regards to numbers taken, timing of trapping, and traps used. Carcass condition can influence reliability of methods (Gilbert 1987; Mead 1994); carcasses should be used immediately or frozen to limit decomposition, and local regulations followed for disposal.

Technique 3: Monitoring reproduction using telemetry

Telemetry is an invaluable tool for studying reproduction in members of the *Martes* Complex (reviewed by Thompson et al. 2012); it can be used to determine reproductive success of individuals, determine the timing of parturition, facilitate estimates of litter size, and identify structures used as reproductive dens. Millspaugh and Marzluff (2001) provide a broad discussion of telemetry in wildlife research and considerations for study design. In this section, we focus on methods for using telemetry to monitor females in the *Martes* Complex during the reproductive season, and provide suggestions for field protocols that consider the species' ecology to avoid undue stress to study animals, meet logistical challenges, and collect useful data.

Triangulation and homing techniques have been used to study reproduction in many wildlife species, with early examples in the *Martes* Complex focused on fishers (Leonard 1986; Arthur and Krohn 1991), American martens (Ruggiero et al. 1998), and pine martens (Brainerd et al. 1995). Telemetry-based techniques have improved over time with advancements in receivers, transmitters, and increased understanding of reproductive ecology in different species. The techniques we describe here have been effective in studying fisher reproduction in mountainous parts of California (Matthews et al. 2013b; Sweitzer et al. 2015); adjustments may be needed for implementation with other species. Reproductive dens of some species (e.g., pine marten) have been located through chance observations and re-use of known dens (Kleef 2000; Birks et al. 2005); in most cases, however, telemetry will be needed to find dens, especially in remote areas. For this section, we assume the reader is familiar with triangulation, but has limited experience using homing techniques. We recommend 6 steps: (1) locate adult females prior to parturition, (2) recognize denning behaviour, (3) conduct "walk-ins", (4) identify den structures, (5) monitor active dens, and (6) recognize moves to maternal dens; repeat steps 3–5.

Step 1: Locate adult females prior to parturition. The daily pattern of behaviour of female fishers (Paragi et al. 1994), pine martens (Brainerd et al. 1995), wolverines (Copeland 1996), and presumably other *Martes* Complex species changes markedly once a female has given birth; so monitoring of movement patterns prior to parturition can help determine when females localize to natal dens. We suggest locating individual females via ground triangulations every 2 to 3 days in the weeks prior to estimated parturition dates, then using homing techniques (i.e., "walk-ins") when females are inactive (i.e., consistent signal with minimal or no fluctuation) to identify rest sites or potential natal dens. Identification of rest structures used by females prior to den initiation also helps to pinpoint when parturition occurs. In some studies, the protocol has been to wait until a female has localized for 2 to 3 days (based on triangulation) before hiking in to a potential den site (Paragi et al. 1996), while other studies recommend walk-ins as opportunities arise with inactive females; the latter may be necessary if field staff are limited and cannot obtain frequent locations. Regardless of the approach, efforts should be made to avoid disturbing individual animals too often (e.g., walk-ins ≥3 days in a row or ≥3 times in a week).

Step 2: Recognize denning behaviour. Reproductive dens found using telemetry are typically identified based on localized behaviour of individual females and repeated use of structures. For fishers, pine martens, and American martens, the act of localizing to an individual tree for days at a time is sufficiently different from the normal pattern of movement to

be distinctive (Henry and Ruggiero 1993; Zalewski 1997; Matthews et al. 2013b). Patterns of behaviour may be similar for other members of the *Martes* Complex, although this is not known for all species and may be less obvious in species with small home ranges or that frequently re-use the same sites for resting (e.g., stone marten). Frequent triangulations (≥3 times a week) may be sufficient to identify a change in the female's behaviour; once a female appears to localize, implement step 3.

Step 3: Conduct "walk-ins". Prior to using homing to locate a potential den, field workers should try to obtain a triangulation and monitor the activity of the female for 20–30 minutes. If the female appears inactive based on the steadiness of the transmitter signal, then the technician should hike towards the triangulated location (or most consistent signal if a triangulation is not possible), keeping the receiver and receiving antenna (e.g., yagi) available to check that the animal remains inactive, take additional bearings as needed, and continue towards the most consistent signal. In areas with steep or varied topography, changes in the transmitter signal can give the impression the animal has become active if direct line of sight between the receiver and transmitter is lost. When uncertainty arises, we suggest hiking until a prominent point is reached and a clear signal obtained to better assess the animal's activity level.

When approaching the transmitter closely, a signal can often be obtained without the antenna using only a coaxial cable attached to a receiver; this can be helpful with practice, but can also be misleading as signals may be audible from quite a distance. Obtaining a signal with only the receiver and no cable or antenna (a "box signal") is a more-reliable method to confirm close proximity to the transmitter. In California, technicians using a R-1000 receiver (Communications Specialists, Inc., Orange, CA) to track fishers fit with Holohil collars could generally obtain a box signal within a <50-m radius of tagged animals (R. Green, personal observation); the distance varies with equipment used, the structure (e.g., log compared to tall tree), and the microsite (e.g., cavity compared to a branch), but a box signal often indicates that a rest or den site is within the immediate field of view. If a box signal is obtained, the technician should reattach the coaxial cable and receiving antenna, turn down the volume and gain on the receiver, and quietly circle the area until the signal is associated with 1 structure. Visual cues, such as potential microsites (e.g., cavity openings, branch clusters), hairs or chewing at a cavity entrance, fresh scat, snow-tracks, or prey remains can be helpful, but unless the animal is observed the transmitter signal should be relied upon to identify the female's location.

In general, >2 visits to a structure (with the adult female present) are needed to identify a reproductive den; if kits are confirmed at the

site, then a single visit is sufficient. The following criteria were used to classify structures used by female fishers in California as reproductive dens and could be adapted for other research projects; during the reproductive period, a female had to be (1) relocated at the same site for ≥2 days in a row, (2) relocated at the same site for ≥2 days over the course of a week, and/or (3) kits confirmed at the site via remote camera, den investigation, or other visual observation or auditory cue. To minimize disturbance but maximize accurate identification of a reproductive den structure, a female might be located in a structure on day 1, confirmed in the area via triangulation on day 2, then located again at the structure on day 3 or 4 with a walk-in. If a species (e.g., wolverine) or individual animal is especially sensitive to human presence, the frequency and proximity of den visits should be adjusted accordingly.

Time of day may influence when females are inactive at dens. Pine martens and fishers have been located at dens in the morning more consistently than other times during daylight hours (Zalewski 2001; R. Green, unpublished data). This pattern of early morning den attendance tends to become less reliable as the season changes, daily temperatures increase, and kits grow larger (Kleef and Tydeman 2009). Species in seasonal environments that initiate natal dens in late winter or spring may show similar behavioural patterns, thus efforts to locate dens may be most productive in the morning (e.g., beginning 1 hour before sunrise), as temperatures may be coldest then during the early den season (Green 2017). For species living in warmer climates (e.g., tayra) or urban areas (e.g., stone marten), pilot studies may be needed to determine the best time of day to find females at dens.

Step 4: Identify den structures. If a single structure is identified using telemetry or the animal is seen, the location should be recorded using a GPS unit, basic information recorded on a datasheet (e.g., tree species), a drawing sketched and/or photo taken, and the site marked for future relocation; vegetation measurements should be taken at a later date when the site is not occupied. We recommend securing a piece of flagging near (~5 m) but not attached to the potential den structure; a more permanent marker (e.g., tree tag secured with a nail) may be desirable, but loud noises should be avoided while the target animal is present. If a technician cannot narrow the signal to 1 structure, coordinates should still be taken, flagging put up near possible structures, and notes taken; if the site is a den, the female will return and another attempt to identify the structure can be made. Field workers should acknowledge uncertainty if the telemetry signal is confusing to avoid incorrect identification of a structure; remote cameras may help identify the correct structure if the female keeps returning to the site.

Step 5: Monitor active dens. Once reproductive den structures are confirmed, occupancy can be monitored remotely using triangulations and single bearings towards the den for a few days followed by walk-ins every 4 to 6 days (depending on objectives). To verify presence of the female at the den during a walk-in, a technician should typically obtain a box signal and confirm with a bearing towards the structure, but not re-circle the structure each time; this approach balances the need to know where the female has her offspring while minimizing disturbance.

Step 6: Recognize moves to maternal dens, then repeat steps 3–5. Female fishers in California occasionally moved from the natal den after a relatively short time (2 weeks) and sometimes stayed in the same structure for the full denning season (3 months); however, on average females moved from natal to maternal dens after about 4 weeks and used 3.4 structures as dens each year (Green 2017). Kleef (2000) confirmed 2 pine martens using natal dens for 52 and 56 days each before litters were moved. Matthews et al. (2013b) reported female fishers moving kits a mean distance of 385 m and as far as 1,728 m to new dens; but occasionally females moved kits to nearby trees (e.g., 18 m). Unless another monitoring device is set up at a den tree, homing in on inactive females is the only way to determine whether a female moved her young and find the location of the new den. Locating and monitoring maternal dens is the same process as with natal dens; however, den-attendance patterns tend to be less predictable as kits age and females may spend more time away from the den (Kleef 2000; Cummins 2016), so perseverance with walk-ins at different times may be needed to find dens later in the season.

Pros: Telemetry allows researchers to identify den structures, estimate parturition dates, count litter sizes (with additional techniques), and obtain a reproductive history for individual animals.

Cons: Locating dens using telemetry brings humans into close proximity to sensitive areas, which could disturb denning females. Telemetry can involve extensive travel in a vehicle and a steep learning curve for new field workers. Radio-transmitters can fail or drop off, preventing tracking of individuals unless they stay at known dens where remote cameras can be deployed.

Considerations: Once field workers are proficient in this technique, their ability to identify den structures quickly and quietly will improve and disturbance will be minimized. Efficiency of revisits can be increased by marking a trail to a den with flagging and human scent can be minimized by not touching the den structure. Confirming that an adult female is not denning or determining that a female has failed in a denning attempt can present challenges. If an adult does not appear to

have localized once other females have started denning (especially females in areas where triangulation is difficult), periodic walk-ins can help verify whether or not she has young.

Technique 4: Den monitoring and counts of young using remote cameras

Remote cameras have become a valuable tool for wildlife research and management, allowing sites of interest to be monitored without human observers. When deployed at reproductive dens of species in the *Martes* Complex, remote cameras can be used to obtain litter-size estimates and observe denning behaviour of females and kits or cubs (Figures 12.1, 12.2). Litter size estimates can be obtained from image sequences of

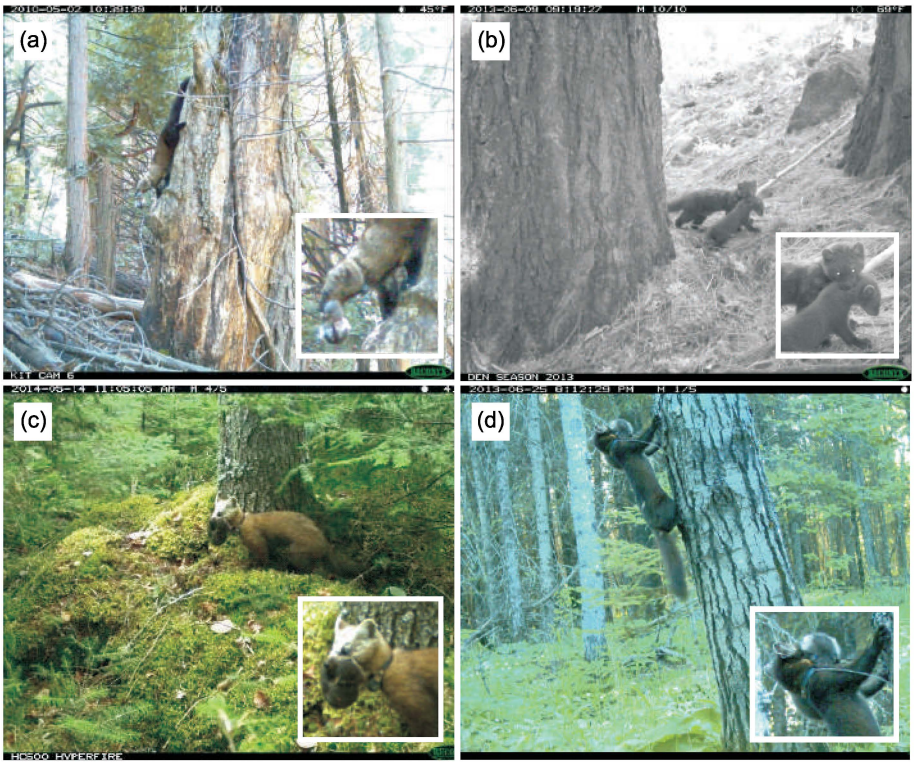

Figure 12.2. Photos taken by remote cameras that document females moving kits from reproductive dens. Photo (a) shows a female fisher moving a young kit (4 weeks old) from a natal den and (b) documents a female fisher carrying an older kit (10 weeks old) from a maternal den; both photos are from California (photo credit R. Green, USFS). From Minnesota, (c) shows an American marten female moving a young kit (2 weeks old) from a natal den in a burrow and (d) shows an older kit (6–8 weeks old) being moved (female's face is obscured; photo credit Minnesota DNR).

females moving young to new dens or from images of kits or cubs as they mature and become active outside the den (Figure 12.3). Behavioural data obtained from cameras can help determine how long a den is occupied, activity patterns of females and offspring, presence of males and occurrence of mating-related behaviours (primarily for fishers, which mate shortly after parturition), developmental stages of kits, documentation of prey brought back by the female, and presence of predators or other species at den sites (Aubry et al. 1997; Jones et al. 1997). In many cases, remote cameras provide behavioural data that cannot be obtained through direct observation; thus, combining remote cameras with telemetry and other techniques can provide a more complete understanding of reproductive ecology.

There are many different models of remote cameras available for use in wildlife research that offer a wide array of features and options for customization. Remote-camera systems rely on a sensor (typically infrared) to detect an animal and trigger the camera to record an image or video. Passive infrared (PIR) sensors are used in most modern remote camera systems and can detect heat or movement. PIR sensors monitor the amount of infrared energy in the camera's field of view and are triggered when acute changes in infrared energy exceed sensor thresholds. Animals radiate heat in the form of infrared energy, so presence or movement of animals changes the infrared energy level enough to trigger the sensor. However, small animals, animals moving quickly (e.g., females carrying young), or animals too far away may not activate the sensor; variation in infrared energy can also trigger the camera in the absence of an animal.

The first published studies using remote cameras to monitor reproductive dens of American martens and fishers took place during the mid-1990s (Aubry et al. 1997; Jones et al. 1997). Early remote-camera systems were limited by image-storage capacity, slower trigger and shutter speeds, multiple external components, and film development. Modern camera systems have many new features and improved image quality, although optimal specifications will depend on study objectives and budget constraints. Trigger speed and shutter speed vary among models, but can be as fast as <1 second and up to 2 frames per second, respectively. Trigger speed, sensor sensitivity, time delay between photos, and number of photos per trigger may influence whether an animal is captured in an image. Many cameras allow users to program settings; researchers should test cameras prior to deployment to select optimal settings for project needs. Some camera models have a video mode which has been used to detect *Martes* Complex species at stations not associated with reproductive dens (Proulx and Dickson 2014); this option may also prove useful in documenting behaviour and obtaining counts of older young at dens.

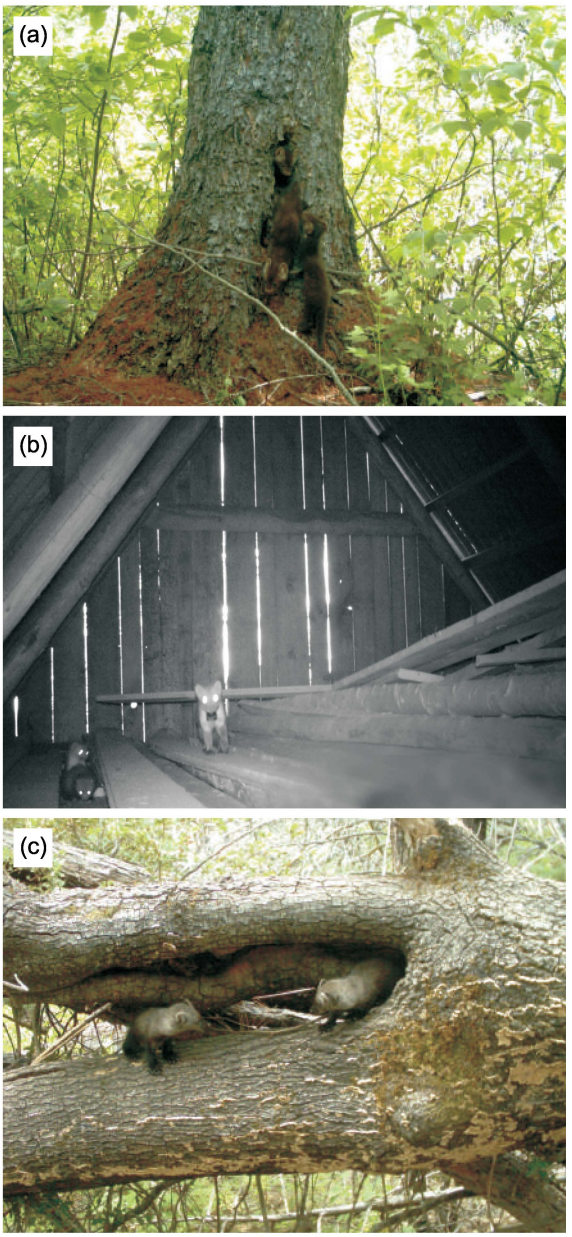

Figure 12.3. These photos, taken with remote cameras, demonstrate the views used to document litter size and kit behaviour at den and rest sites. The top photo (a) shows 3 semi-mobile American marten kits (6–8 weeks old) exiting a low tree cavity and playing at a maternal den in Minnesota (photo credit Minnesota DNR). Photo (b) shows a radio-collared female stone marten with 2 mobile kits in a village barn in Poland (photo credit MRI PAN). Photo (c) is of 2 fisher kits (age 3.5 months) at a maternal rest site in a hollow log.

Choice of camera features and deployment methods should be based in part on minimizing disruption to study animals. Image storage capacity, battery life, and the number of cameras placed at a site all influence the time required to set up cameras and the frequency of re-visits to den sites. Standard white-light flash camera systems may be disruptive when triggered at night, causing some mammal species to avoid (e.g., kinkajous [*Potos flavus*]; Schipper 2007) or become attracted to (e.g., felids; Kelly et al. 2012) camera sites. Cameras with infrared flashes reduce flash-related concerns, but with some reduction in image quality. Reconyx remote cameras (models PC800 and PC85, Holmen, WI) with lo-glow infrared technology were used at fisher dens and provided photos of sufficient quality to detect kits carried by the female (R. Green, unpublished data). When possible, we recommend using large size memory cards, long-life batteries, and infrared flashes to obtain useful photos while minimizing disturbance and the frequency of den visits.

Placing cameras at dens can potentially be disruptive to females, especially during early stages of the kits' lives; as such, designing protocols that minimize disturbance at dens should be a priority for researchers. If a primary objective is litter counts, then a fast trigger speed and the ability to take multiple photos without delay should be key considerations. In photos taken by remote cameras at fisher dens, females often moved very fast when carrying kits down tree boles (R. Green, unpublished data), so rapid trigger time and a continuous burst of photos were needed to obtain accurate counts of young. The ability to look at test photos during initial set up and view photos after the camera has been deployed for a few days can be essential to get cameras in optimal position; some cameras provide a viewer, while in other cases an additional device is needed to view photos. Thought should also be given to how camera data will be analysed and managed, because cameras can easily record thousands of images, and extracting litter count and behavioural data from such image sets can be extremely time consuming.

The best approach for deploying cameras at a particular den site depends on the type and number of cameras being used and site-specific factors such as the den structure and the location of travel routes to and from the den. If litter-size estimates are a primary goal, identifying and targeting the route used by the female to leave the den is critical. Ideal camera placement will depend on camera model and characteristics of the den structure, but some guidelines should be established for desired height above ground and distance from the den. The availability of trees suitable for camera attachment and dense vegetation can limit placement options. Cameras too far from den structures may not trigger, while cameras too close may not give a sufficient field of view to document kit

transfer. Variability should be expected with different dens and camera models, and experimentation will be necessary; however, a useful starting point is to use 2–3 cameras around and facing the den, each about 5 m from the den structure.

For species using cavities in trees, we suggest setting up the cameras to include the main trunk of the tree, a small area of ground, and any obvious alternate travel routes. If the cavity is very high in the tree (≥5 m), the camera is unlikely to obtain desired photos if pointed straight at the cavity; a better alternative is to focus the camera on the trunk below the cavity. Female fishers in California typically brought their kits down the main trunk of the den tree even if they had been using alternate routes when traveling alone (R. Green, personal observation), possibly because females choose the quickest and safest route when carrying a kit. An exception is if a small tree or log leaning against the tree creates a ramp to the ground; females may prefer that route when carrying young. When field workers check cameras at dens, they should view photos in the field to determine whether the female has been detected, identify the route(s) being used, and adjust camera positions accordingly.

Litter size estimates obtained from remote cameras may underrepresent true litter size and should be treated as minimum litter sizes. Females can move kits and avoid being photographed if they take routes out of the camera view, move too quickly to be detected, or move when the camera is malfunctioning due to disturbance or low batteries. Using multiple cameras at a den site does not ensure that all kits are photographed, although clues are often obtained to suggest a kit was missed (e.g., female returns after moving 1 kit, but is not seen leaving a second time).

Many cameras come with straps or adjustable bungee cords for camera attachment, but technicians should have extras to accommodate a variety of situations (e.g., large-diameter trees). Technicians may also consider using gloves or commercial products aimed at removing human scent from cameras. Minimizing human scent may reduce stress on study animals and keep non-target animals (e.g., black bears [*Ursus americanus*]) from investigating or damaging the camera. If possible, technicians should re-visit sites to check cameras when females are gone or after kits have been moved to a new den site. If cameras must be deployed or checked while a female is at the den, effort should be made to do so quickly and quietly. Attractants (e.g., bait, lure) should definitely not be used at reproductive dens. However, baited cameras at non-den locations can be set up after the denning season to detect females with mobile young (e.g., pine martens in Belgium; Van Den Berge and Gouwy 2011);

this method does not necessarily require use of telemetry and may yield late-season counts of young.
Pros: Remote cameras can help verify that a female has kits in a structure, obtain litter size estimates, and document behaviours related to reproduction in a format that can be shared by researchers or used for educational purposes. Remote cameras permit monitoring without human presence, and provide behavioural data that is challenging to obtain with other methods.
Cons: A disadvantage is the cost of purchasing cameras if they are not already available; camera cost depends on manufacturer and model, but can cost more than $500 USD per camera.
Considerations: Detection probability can be affected by camera model and size of the animal being detected (Hansen 2009). Using cheaper cameras may result in a trade-off with camera performance; it may be worthwhile to obtain fewer high-quality cameras and rotate them among different den sites. Researchers should note reactions of individual females to camera placement; if a female consistently moves to a new den after cameras are deployed, we suggest waiting 1–2 weeks before re-setting or not deploy them again if sufficient data has been obtained. At natal dens, we suggest waiting at least 1 to 2 weeks before deploying remote cameras to avoid prompting females to move kits to another den when they are very young and vulnerable.

Technique 5: Investigating den cavities

Many members of the *Martes* Complex are known to use tree cavities during reproduction; cavities can provide thermal protection for females and young during inclement weather, as well as physical protection from predators. However, these secure chambers also present challenges to researchers trying to obtain litter counts or study den microsites. Accessing active reproductive den chambers has the potential to be disruptive to reproductive females and hazardous to young, and requires a substantial amount of time, effort, and equipment; however, we believe that den chamber investigations can be done safely and successfully if appropriate planning, training, and precautions are taken. This section is based largely on the authors' experience climbing trees to investigate fisher reproductive dens in California, but other species in the *Martes* Complex may also use den chambers which can be accessed by the techniques (or modifications) described here. Wolverine dens are known exceptions to this trend; a brief description of the specialized challenges involved in their study is presented at the end of this section.

Fishers, and likely other arboreal species in the *Martes* Complex, often select tree cavities well above human eye level, in protected

(potentially deep) microsites with small openings as den chambers (Green 2017); specialized camera systems and tree-climbing techniques are often required to access these den chambers and count kits. For example, of 42 active fisher dens investigated on the Hoopa Valley Indian Reservation, all required climbing to reach the den entrance and a majority required special camera equipment to observe and count kits due to either the constricted opening, the depth, or convolutions within the chamber (S. Matthews, unpublished data). In British Columbia, Weir et al. (2012) reported mean heights of fisher den entrances at >5 m, while in the Netherlands, Wijsman (2012) noted that the entrances of pine marten dens were between 4 and 14 m high. These examples, combined with the presence of decay in many den structures (Weir et al. 2012), highlight the challenges of viewing reproductive den chambers.

Reproductive dens of species in the *Martes* Complex are most likely to be located by using telemetry to track potentially reproductive females (discussed in section Technique 3). If a den is to be investigated and the reproductive female is not carrying a transmitter, effort should be made to investigate the potential den when she is gone (e.g., remote cameras could confirm departure). Unless the cavity is obvious, an attempt should be made to identify the location of the den cavity using telemetry and visual cues at least 1 day prior to the den investigation. Field workers should verify that the female is using a structure 1–2 days before the investigation, then monitor the female from a distance on the morning of the examination. Researchers should wait until the transmitter signal indicates the female has left the den before hiking in to the site. Once at the den, someone should monitor the female's transmitter signal every 5–10 minutes throughout the process; if she appears to be returning to the den, the investigation should be discontinued and everyone should leave the site. The next day an effort should be made to ensure the female is in the vicinity of the den and did not abandon the litter or move to a new site.

Pole-mounted cameras can be used to inspect den cavities from the ground without the need for climbing, if the entrance is not too high and the cavity can accommodate the size and limitations of the camera. Micro-video cameras attached to poles transfer images either wirelessly or wired to a portable hand-held or pole-mounted monitor or other device. Lighting can be white or infrared, and cameras may be black and white or colour. Pole-mounted cameras are available commercially (e.g., Sandpiper Technologies, Inc., Manteca, CA) and home-made systems can be constructed using off-the-shelf components at a substantial cost savings (Waldstein 2012). The camera is mounted on a telescoping pole, which allows researchers to extend the camera up to a cavity and insert it in the opening. Some of the higher-end telescoping poles can reach a

height of up to 15 m; however, controlled placement of the camera into a cavity becomes increasingly difficult above 12 m due to ever increasing sway. Video output from the monitor to a video camera or other video capture/recording device allows for a more-detailed review of the data later. This system is useful for dens within reach of the telescoping pole with a cavity entrance large enough for the camera to fit easily, and interiors with an unobstructed view of the floor within the visual range of the camera (±2 m). Pole-mounted cameras are an excellent choice for relatively simple and shallow cavities (e.g., Wijsman 2012). They should be used with caution, however, in situations where the equipment could get stuck in the entrance, but the structure cannot be climbed safely to retrieve the camera. Home-made systems using a pulley mounted to a telescoping pole can allow viewing of the bottom of the cavity (Erb et al. 2014) and burrow probes or endoscopes can be used for accessing cavities near the ground (e.g., Jones et al. 1997).

Many dens require investigators to climb the den structure to adequately investigate cavities and count kits (Figure 12.4), although this may differ among tree species and regions. A wide variety of tree-climbing techniques can be used to access dens and it is beyond the scope of this chapter to describe them in sufficient detail to enable their use without further guidance and instruction. Proper training under the supervision of a qualified tree climber is often required, and experience is essential. All components of climbing systems should comply with standards developed by the American National Standards Institute, the European PPE Directive 89/686/EEC, or the Union Internationale des Associations d'Alpinisme, and must be used according to manufacturers' recommendations. The tree's structure, species, and height, as well as the terrain and distance from the nearest road, will determine the most efficient method to access cavities. Safety concerns will dictate which structures can be climbed safely. Climbing snags is not recommended, and many old and large trees have sections that are decayed and unstable. In some structures, potential reproductive cavities simply cannot be accessed safely. Every tree must be carefully inspected for safety concerns from the ground before attempting to climb it. Environmental hazards such as wind, rain, imminent lightning storms, and cold temperatures should be assessed and monitored, and technicians must ensure that adequate time is available to ascend and descend the tree safely.

A common method used by wildlife researchers is the Single Rope Technique (SRT; Jepson 2000; Coffey and Andersen 2013). This technique involves the use of mechanical ascenders or friction knots to climb a rope anchored to the base of a tree or a branch. Upon reaching the cavity,

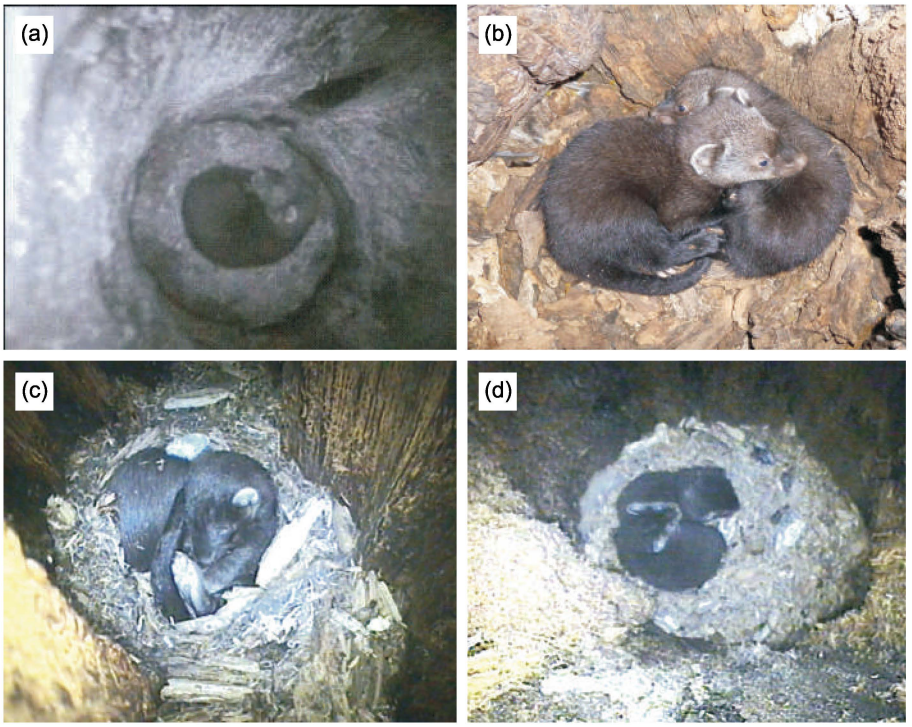

Figure 12.4. Images of kits obtained during den chamber investigations. Photo (a) of a young fisher kit inside a natal den in California was taken during den check with a camera inserted into the cavity (photo credit C. Thompson, USFS). Two older fisher kits (b) were photographed with a hand-held digital camera in a shallow maternal den cavity in California (photo credit R. Green, USFS). In Minnesota, photos of 2 fisher kits (c) and 2 American marten kits (d) were taken in den cavities using a modified telescoping pole (photo credit Minnesota DNR).

lanyards are used for positioning. If the cavity is above the climbing rope, the climber can detach from the rope and climb the tree using the 3-point climbing system and lanyards. Various types of descent devices and friction knots can be used to descend from the tree. Doubled Rope Techniques (DdRT) can also be used and are especially suitable for hardwoods or situations where a single branch suitable for climbing can be isolated for rope placement [https://www.fs.fed.us/treeclimbing/policy/2015_04_22NTCGweb.pdf]. In this method, the rope is draped over a branch, with one end connected to the climber's harness and then to the running end of the rope (i.e., working end of the rope used in tying knots) with a friction hitch that permits the climber to ascend and descend. One advantage of DdRT methods is the relatively small amount of equipment that must be carried to the site, but a disadvantage is that they are more strenuous. SRT systems allow the climber to ascend tall

trees more efficiently than DdRT. A weakness of both systems is that the safety of the supporting branch often must be evaluated from the ground. Both SRT and DdRT systems require installing a climbing rope in the tree prior to ascending. This can be accomplished using a throw line and weight bag, a crossbow fitted with a fishing reel, a Big Shot (Jepson 2000), a wrist rocket, or other methods to install a static climbing rope in the tree.

Den cavities can also be accessed using climbing spurs. Spurs often require the least amount of equipment (e.g., spurs, harness, and lanyards, along with safety equipment), which is helpful when access to the den involves a long hike. Spurs are not recommended for repeated climbs, however, as they can damage the tree. A rappel device (a metal piece of equipment connected to a climber's harness that applies friction to the rope to control the rate of descent) and a rope for rappelling out of the tree is usually the quickest way to descend from the tree cavity. Swedish tree-climbing ladders are another option, but are problematic if steep terrain and long distances are involved; they may also cause noise disturbance at the den. Extension ladders can be useful to access low cavities in snags or trees easily accessible from a road.

Once at the den-cavity entrance, a micro-video camera on a flexible probe can be used to view the interior of the den chamber, count the kits, estimate their ages, and observe other behaviours. A camera connected to a video monitor is placed into a cavity until the den chamber and kits are visible. As an example, the Peep-A-Roo Video System (Sandpiper Technologies Inc., Manteca, CA) uses a head-mounted video display to allow hands-free cavity exploration; many other commercially-made burrow probes, endoscopes, and miniature cameras are available, and home-made systems can be constructed from off-the-shelf components. These systems are capable of viewing the contents of deeper and more-obstructed cavities than are pole-mounted cameras. Cavities are usually dark and require some type of illumination to see the kits. White light generally offers superior resolution and the ability to view in colour, but may disturb the kits; infrared lighting, suitable for low-light conditions, is less intrusive and generally sufficient for a litter count. Also, the kits may be located off to the side of the vertical shaft, requiring a flexible probe. Den cavities can be quite deep, so long cables or long focal distances are often required. As examples, fisher den-cavity depths in California averaged 114 cm (deepest at 880 cm; S. Matthews, unpublished data); mean depth of fisher den cavities in British Columbia was 68 cm (± SD 31 cm; Weir et al. 2012); and mean depth of pine marten den cavities in the Netherlands was 22 cm (deepest at 33 cm; Kleef and Tydeman 2009).

For pole-mounted camera investigations and den climbs, the optimal timing of the inspection during the denning season will vary depending on the species, but waiting at least 2 weeks for pole-mounted investigation and 3--4 weeks minimum before climbing a den tree is probably appropriate for most species. Anecdotal evidence suggests that some females may move young to a new den after a tree has been climbed (York 1996), so waiting until kits are less vulnerable is an important consideration. Another option is to wait until the female has moved to her first maternal den. For some species where parturition date is not known, video or photos of kits taken during the den investigation may help to determine their age based on their eyes (open or closed), pelage colour, and throat-patch development (Kleef and Wijsman 2015). Kits may also be extracted for sexing and marking purposes (York 1996; Matthews et al. 2013b), but these techniques are beyond the scope of this chapter. We encourage researchers interested in these techniques to seek out further guidance on this topic. We caution that kit extraction involves additional risk to kits and climbers, and involves additional considerations and constraints.

Minimum estimates of birth rates and litter sizes for wolverines have been collected using radio-telemetry and observations of cubs. Adult females are typically radio-tracked weekly during the denning season (mid-February through April) by plane, and then ground-based telemetry is used to find dens (Magoun and Copeland 1998; Persson et al. 2006). Snow-tracking, visual observation with spotting scopes, capturing family groups, or a combination of these methods have been used to determine the presence and number of cubs between early May and early June (Persson et al. 2006).

Pros: These combined techniques offer the most accurate estimates of kit counts available; observing kits in a den cavity is the closest estimate of true litter size possible in the wild.

Cons: Specialized camera and tree-climbing equipment can be expensive. A basic climbing team consists of a climber and a second qualified person that can assist and perform a rescue if needed. Depending on travel time, the difficulty of the climb, and cavity access, climbing a single den structure and counting kits could be a 4–8 hour effort, especially in areas with very tall trees. Because the female cannot be present during den investigations, researchers can spend many hours in the field waiting for the female to leave. Consequently, both patience and multiple days of effort may be needed to collect data. Additional drawbacks include the possibility of getting cameras stuck in cavity entrances, dropping things into the den chamber, inadvertently modifying the cavity or structure, females moving young or abandoning litters due to disturbance, and potential risks to climbers.

Considerations: Human scent will be left on the tree and at the cavity after a climb; to minimize the scent, we suggest wearing sturdy gloves when climbing, and disposable scent-free gloves when working around the trunk on the ground or while at the den-cavity opening.

SUMMARY OF STUDIES OF REPRODUCTION IN THE *MARTES* COMPLEX

In this section, we summarize previous research on reproduction in the *Martes* Complex; species are arranged in phylogenetic order (see Koepfli et al. 2008). Our goals were to provide a summary of results from studies conducted on each species, and highlight areas where future research is needed. This section is not an exhaustive summary of all research on reproduction in the *Martes* Complex but, rather, a place to start when considering new research projects. We have attempted to find references on all species, but recognize that sources unavailable through English language databases may be underrepresented. We focused on determining whether the following have been studied: (1) reproduction in the wild, (2) reproduction in captivity, (3) reproductive habitat (e.g., dens), (4) age when females first give birth, (5) timing of mating, (6) parturition dates, and (7) litter sizes. Results from a sample of studies found in our review are highlighted in Table 12.3 and the text.

Pine marten (*Martes martes*)

A number of studies have described aspects of pine marten reproduction across portions of its range in the wild (e.g., Brainerd et al. 1995; Kleef and Tydeman 2009; Wijsman 2012) and in captivity (e.g., Ocetkiewicz 1973). Reproductive den structures have been documented in some areas, including use of trees with cavities, rock crevices, burrows, and human structures (Brainerd et al. 1995; Birks et al. 2005; Kleef and Tydeman 2009; Van Den Berge and Gouwy 2011; Stier 2012; Wijsman 2012). Concerns have arisen about reduced availability of trees suitable for natal dens as a result of forest management in western Europe (Birks et al. 2005); in Great Britain, den boxes have been used successfully to facilitate the reintroduction (or reoccupation) of pine martens (Croose et al. 2014). Mating has been documented in July (Amstislavsky and Ternovskaya 2000). In captivity, parturition occurred from early March to late April (Heptner et al. 1967; Ocetkiewicz 1973); the number of females reproducing annually may vary regionally and with the age of females (Grakov 1981). Data on litter sizes have been collected in various regions. Grakov (1981) combined data on litter size from 30 regions in Russia (n 1,184 litters); mean litter size was 3.5 (range 1–8). Similar litter sizes have been

Table 12.3. Summary of some reproductive parameters for *Martes* Complex species including examples of data collected in wild settings.

Martes Complex species	From review by Mead (1989)		Reproductive data of *Martes* Complex species from wild settings (example values)			
	Mating period	Gestation (days)	Parturition date range (den monitoring)	Mean litter size (counts of CL)	Mean litter size (counts at dens)	Reproductive dens (recorded locations)
Pine marten	July	230–270	20 Mar–30 Apr[1]	3.4–3.6[2]	2.8 (1–5)[1]	Belgium, Germany, Netherlands, Norway, Poland, Scotland, Sweden
Sable	June–July	253–297	Data needed	2.5–5.0[3]	Data needed	Data needed
American marten	July-Aug	259–276	4–30 Apr[4]	3.2 (2–6)[5]; 4.1[6]	2.9 (1–4)[7]	Canada: BC; USA: MN, OR, WA, WI, WY
Pacific marten			Data needed	Data needed	Data needed	Data needed
Japanese marten			Data needed	Data needed	Data needed	Data needed
Stone marten	July	236–274	Data needed	Data needed	Data needed	Luxembourg
Yellow-throated marten	Oct–Nov	172–190	Data needed	Data needed	Data needed	Data needed
Nilgiri marten			Data needed	Data needed	Data needed	Data needed
Wolverine	May–July	240–270	16 Feb–6 Mar[8]	3.2[9]; 4.1[10]	1.9 (1–4)[11]; 2 (2)[12]	Canada: BC, ON; Finland, Norway, Sweden, USA: AK, ID, MT, WY
Fisher	Mar–Apr	327–358	4–27 March[13]; 9 March–7 April[14]; 22 March–9 April[15]	3.4[16]; 3.7[17]	1.6 (1–3)[15]; 1.9 (1–3)[14]; 2.8 (2–4)[18]	Canada: BC, ON; USA: CA, MA, ME, MI, OR
Tayra	Apr	63–67	Data needed	Data needed	2 (1 record)[19]	Venezuela

Sources: [1]Wijsman 2012; [2]Helldin 1999; [3]Monakhov 2011; [4]Henry and Ruggiero 1993; [5]Flynn and Schumacher 2009; [6]Fortin and Cantin 2005; [7]Erb et al. 2014; [8]Magoun and Copeland 1998; [9]Banci and Harestad 1988; [10]Wright and Rausch 1955; [11]Persson et al. 2006; [12]Magoun and Copeland 1998; [13]York 1996; [14]Matthews et al. 2013b; [15]Sweitzer et al. 2015; [16]Douglas and Strickland 1987; [17]Crowley et al. 1990; [18]York 1996; [19]Sunquist et al. 1989.

observed in western Europe, but with a slightly lower mean of 2.7 kits (Baudvin et al. 1985; Ebersbach and Stubbe 1994; Kleef and Tydeman 2009; Stier 2012; Wijsman 2012). Litter size has also been estimated from counts of embryos, corpora lutea, and blastocysts (Grakov 1981; Krüger 1995; Helldin 1999; Broekhuizen and Müskens 2000; Stier 2012). A good deal of baseline data is available for the pine marten, but further study of habitat use by reproductive females is needed, particularly in areas where use of mature and managed forests could be compared.

Sable (*Martes zibellina*)

In Russia, some aspects of sable reproduction have been studied in the wild (Monakhov 2011); however, the species has also been commonly raised on fur farms, so much of the baseline data on reproductive parameters are from studies of captive animals (e.g., Korhonen et al. 2001; Bakeev et al. 2003; Kashtanov et al. 2008; Rozhnov et al. 2008; Kashtanov et al. 2014). Most studies of wild sables have been conducted in winter, therefore natal dens have rarely been investigated and only 1 record of a natal den could be located (Bakeev et al. 2003). Monakhov (2011) noted that sables use tree cavities, root wads, down wood, and rock piles for resting; he also noted that females may place reproductive dens in drier parts of the taiga, but did not provide details on the types of structures used. Mating takes place from the end of June into July and parturition occurs from 25 March to 3 May the following year (Bakeev et al. 2003). Females undergo delayed implantation with total gestation lasting 236–315 days (Amstislavsky and Ternovskaya 2000; Bakeev et al. 2003). In captivity, the litter size of sables varied with female age from 2.7 cubs in 1-year-old females to 3.7 in 7-year-old females (Bakeev et al. 2003; Svishcheva and Kashtanov 2011); a similar estimate of litter size was obtained from analysis of carcasses trapped by hunters (Bakeev et al. 2003). Excellent baseline data on reproduction from sables in captivity is available; however, data on reproductive parameters and den structures in the wild is lacking and could provide important insights into potential conservation issues.

American marten (*Martes americana*) and Pacific marten (*Martes caurina*)

In North America, studies of reproduction in American martens have been conducted in the wild (e.g., Raphael and Jones 1997; Ruggiero et al. 1998; Joyce 2013; Erb et al. 2014) and in captivity (e.g., Enders and Leekley 1941; Markley and Bassett 1942). Reproductive den structures have been identified and include live trees and snags with cavities, hollow logs, rock crevices, squirrel middens, and underground burrows

(Raphael and Jones 1997; Ruggiero et al. 1998; Erb et al. 2014). Females appear to mate for the first time at about 15 months of age (first parturition occurs at 2 years of age), although many may not mate successfully until around 27 months (parturition at 3 years of age; Markley and Bassett 1942). Mating has been documented from late June through early August (Markley and Bassett 1942; reviewed by Mead 1994), and copulation may take place on the ground or in trees (Ruggiero and Henry 1993). Parturition occurs from late March through mid-May (Strickland et al. 1982; Erb et al. 2014). Mean litter sizes of 2.8–3.7 have been reported from carcasses (Strickland and Douglas 1987; Flynn and Schumacher 2009) and captive American martens (Strickland and Douglas 1987); direct estimates of litter size from the wild are still rare (but see Bull and Heater 2001; Erb et al. 2014). Although baseline information on reproduction in American martens is widely available, additional research on geographic variation in reproductive parameters, habitats associated with reproduction (e.g., dens, microsites, foraging), and behaviours during kit rearing and mating is needed. The recent taxonomic distinction between the American and Pacific marten (Carr and Hicks 1997; Dawson and Cook 2012) may inspire future efforts to compare the reproductive ecology of these species.

Japanese marten (*Martes melampus*)

There appears to be very limited information available on reproduction in the Japanese marten from either wild or captive settings. Tatara (1994) provided a brief summary of breeding ecology and behaviour of this species from the Tsushima Islands. Evidence from this field study (e.g., testicular volume of wild-caught males, vulval enlargements and scratches on backs of wild-caught females, 2 observed copulations) suggests that mating occurs in late July through mid-August, although further study was recommended (Tatara 1994). Parturition occurs between mid-April and early May, although the extent of variation is not clear; the average litter size was estimated at 2 kits, although sample sizes for this parameter were limited (Tatara 1994). Research by Tatara (1994) appears to provide the best starting point for future studies of reproduction in the Japanese marten. Additional baseline data is needed on reproductive parameters (e.g., timing of mating and parturition) and habitat used during reproduction throughout the range of this species.

Stone marten (*Martes foina*)

Despite the relative abundance of stone martens in most of Europe, data on the reproductive ecology of this species is still relatively sparse.

A number of studies have been conducted on free-living stone martens, although largely in urban and rural areas near humans (e.g., Herr et al. 2010; Wereszczuk and Zalewski 2015); however, we found relatively few studies focused specifically on reproduction (e.g., Madsen and Rasmussen 1985; Lammertsma et al. 1994; Kleef 1998). Waechter (1975) and Skirnisson (1986) described natal dens where litter size estimates were obtained and female and kit activity was monitored. Many studies estimated reproductive parameters from carcasses obtained from trappers or collected as road mortalities (Madsen and Rasmussen 1985; Skirnisson 1986; Steklenev 2014). The mating season is restricted to the period from mid-June to mid-August, and parturition occurs in the subsequent year from mid-March to the end of April (Stubbe 1968; Canivenc et al. 1981; Madsen and Rasmussen 1985; Steklenev 2014). Information on number of offspring per female is limited to a few studies, mainly from central Europe, where the mean litter size was 2.8 cubs (Madsen and Rasmussen 1985; Krüger 1995). Additional baseline information about reproductive ecology is needed; investigations of reproduction in areas near humans (urban and rural) compared to more natural habitats might be of interest, especially due to the potential variation in diet and den selection.

Yellow-throated marten (*Martes flavigula*)

Although yellow-throated martens appear to be relatively widespread in northern India, southern China, and much of south-east Asia, little information on reproduction is available. Several yellow-throated martens have been fitted with radio-collars and tracked (e.g., Grassman et al. 2005), although not to reproductive dens. Yellow-throated martens have been documented using crevices in rocks, burrows, and hollow trees as resting sites (Wilson and Mittermeier 2009), so reproductive dens may be located in similar microsites. Mating is suspected to occur in August and parturition in April, with litter sizes of 2–5 (Wilson and Mittermeier 2009); however, little field data is available to support this information. According to records from 2 captive females at a zoo, copulations took place from 18 to 21 August and parturition occurred on 18 April of the following year; copulations also occurred from 25 to 29 October with parturition occurring on 27 March (Tumanov 2003); litter sizes were 2 and 1, respectively. In captivity, mating behaviours were also observed from November to February (Tumanov 2003). Proulx and Aubry (2017, this volume) note that *M. flavigula* is monogamous (unlike many members of the *Martes* Complex) and undergoes 2 estruses per year. Baseline research on all aspects of reproductive ecology is needed for this species.

Nilgiri marten (*Martes gwatkinsii*)

Based on literature searches, no information could be found on reproductive ecology of the Nilgiri marten, which occurs over a limited distribution in southern India (Wilson and Mittermeier 2009). Reproductive ecology of the Nilgiri marten may be similar to the closely related and more widespread yellow-throated marten, but information on reproduction in that species is also limited. Anecdotal evidence suggests that Nilgiri martens are arboreal and use cavities (Balakrishnan 2005; Wilson and Mittermeier 2009); denning behaviours might be similar to other arboreal martens, but this species also occurs in warmer climates so differences in the timing of mating and parturition may differ from many other species in the *Martes* Complex. As with *M. flavigula*, Proulx and Aubry (2017, this volume) note that *M. gwatkinsii* is monogamous. Baseline information on reproductive parameters and habitat needs, as well as other basic aspects of ecology, are much needed for this species.

Wolverine (*Gulo gulo*)

Studying almost any aspect of wolverine ecology is fraught with challenges due to this species' wide-ranging behaviour and tendency to live in remote areas. Regardless, a number of studies related to reproduction in wild settings, including location of reproductive dens, have been conducted in Scandinavia and parts of North America (Magoun and Copeland 1998; Persson et al. 2006; May et al. 2012). Reproductive dens of wolverines differ from most members of the *Martes* Complex in that they occur largely in snow drifts with tunnels that are often associated with boulders, logs, or talus but in some areas are simply composed of snow (Magoun and Copeland 1998). Female wolverines may incorporate boulders and logs into their dens where available to reduce work and increase structural integrity, but where structures are limited (e.g., tundra), they can create dens just in snow (K. Aubry, personal communication). A limited number of studies have occurred in captivity (e.g., Blomqvist 1995). Females are capable of giving birth at 2 years of age, but typically wait until ≥3 years (Banci and Harestad 1988; Persson et al. 2006). Precise information on mating is limited, but it appears to begin in May and continue through August, with a peak in June (Inman et al. 2012). Parturition has been documented from late January into April, with most births in February through mid-March (see Inman et al. 2012). Mean litter sizes from field studies in Scandanavia and North America range from 1.8 to 2.5 (Persson et al. 2006), although litters of up to 5 have been reported (Wilson and Mittermeier 2009). Good baseline data on reproductive parameters and dens are available

for the wolverine, but additional data on reproductive ecology (including timing of mating) and den requirements in new geographic areas would be of value. Continued research on the intersection of conservation, climate, and resource availability (e.g., dens, food) in relation to reproduction is also needed (Persson 2005; Copeland et al. 2010).

Fisher (*Pekania pennanti*)

Concern about fisher conservation in parts of North America, particularly on the west coast, have led to a number of broad ecological research projects that have focused to some extent on reproduction in wild settings (e.g., Aubry and Raley 2006; Matthews et al. 2013b; Erb et al. 2014; Sweitzer et al. 2015; Facka et al. 2016). Fisher reproduction has also been studied in captive research settings (Frost and Krohn 1997) and fur farms (Hall 1942). Natal and maternal dens have been located in cavities of large live trees and snags (Paragi et al. 1996; Weir et al. 2012; Matthews et al. 2013b; Erb et al. 2014). In some regions, hardwood species are commonly selected for reproductive dens (Weir et al. 2012, Green 2017), while in others conifers are used most often (Aubry and Raley 2006). Because all trees used as dens contain a large cavity, females may simply be selecting the most cavity-susceptible species available locally. Females can mate at 1 year of age, but not give birth until ≥2 years due to a period of delayed implantation lasting 10 months (Mead 1994). Mating occurs during a short window (1–2 weeks) during late March or April (soon after parturition for females that give birth) and parturition occurs in March and early April (Powell 1993); mean parturition dates from studies in the wild include 17 March (York 1996), 22 March (Matthews et al. 2013b), 28 March (Sweitzer et al. 2015), and 30 March (Green 2017). Litter size typically ranges from 1 to 4 (review in Powell 1993); mean litter sizes reported from reproductive dens using techniques from this chapter include 1.6 (Sweitzer et al. 2015), 1.9 (Matthews et al. 2013b), and 2.8 (York 1996). Much baseline information on reproduction exists for fishers, but data on reproductive parameters is still needed in parts of the range to investigate potential variation related to climate, forest management, diet, and body size. Further study of habitats used during reproduction at multiple spatial scales, and male movements during the breeding season would be of value.

Tayra (*Eira barbara*)

Tayra are reportedly common in parts of Central and South America (Presley 2000), however, little field research has been conducted on reproduction; we could find only 1 study that documented reproduction

in the wild. A radio-collared female tayra was tracked in Venezuela for 6 months from January to June (Sunquist et al. 1989); the female had 2 young in a den but the methods used to determine litter size and characteristics of the den were not described. The female localized in the vicinity of a den until the cubs were about 3 months old. Tayra reproduction has been studied to a limited extent in captive settings, including an investigation of the oestrus cycle (Poglayen-Neuwall et al. 1989) and a study of copulation, gestation, and parturition (Poglayen-Neuwall 1975). Females may first have young around 2 years of age and may produce an average of 1 to 3 young; unlike all other members of the *Martes* Complex, female tayras do not undergo delayed implantation and can enter oestrus several times during a year; thus, the timing of mating and parturition is variable (Vaughn 1974; Poglayen-Neuwall 1975). Tayras have bred and produced offspring in zoos; published reports describe pairing of females with males, females near parturition, and the development of young (Encke 1968; Vaughn 1974; Presley 2000). Baseline information on the reproductive ecology of tayras is lacking, especially information on den structures and reproductive parameters in the wild. Parturition dates may be hard to estimate for the tayra, so care should be taken if lactating females are captured; if transmitters are attached, we suggest using collars with slim profiles until more is known about den microsites.

CONCLUSIONS

We hope this review of some of the techniques and considerations involved in planning a study of reproduction in the *Martes* Complex will be useful to researchers new to this topic, as well as those with prior experience who are considering new methods. To some extent, techniques such as carcass examinations and field telemetry have not changed substantially in recent years, but advancements in our knowledge of reproductive ecology among the *Martes* Complex may provide new insights using these methods. Other techniques have undergone dramatic technological developments since they were first used, such as the increased trigger speeds, storage capacity, and photo quality of remote cameras; these advances have improved our ability to observe activities at reproductive dens with limited disturbance. With careful application, the methods described here can improve our baseline understanding of the reproductive ecology of some species, and provide new insights for well-studied species.

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