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Multispecies Mesocarnivore Monitoring:

USDA Forest Service Multiregional Monitoring Approach

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Abstract

Small- to mid-sized forest carnivores, also known as mesocarnivores, are an important part of the animal community within national forests. Many forest mesocarnivores are of conservation concern and are listed as threatened or endangered under the Endangered Species Act (ESA), have been petitioned for listing under the ESA multiple times, or have designations within the Forest Service that warrant consideration in decisions about planning, projects, or restoration. Mesocarnivores also receive heightened public attention and, as a result, are frequently the center of lawsuits brought against the Forest Service. However, there is no current monitoring framework in place to provide meaningful information about these species across larger scales. In addition, they are difficult to detect, occur in low densities, and have large home ranges.

We propose an approach for monitoring fisher (*Pekania pennanti*), Canada lynx (*Lynx canadensis*), American marten (*Martes americana*), Pacific marten (*M. caurina*), montane red fox (*Vulpes vulpes* sspp.), and wolverine (*Gulo gulo*) across the western United States. This approach was developed with close collaboration between the Forest Service Rocky Mountain Research Station and the National Forest System (NFS), and focuses on answering three basic monitoring questions: (1) Is a species present? (2) Are multiple individuals of a single sex present? and (3) Are multiple individuals, including both sexes, present? To answer these questions we designed a goal efficient monitoring (GEM) framework with four occupancy states related to a rare species population. We developed a Bayesian multistate dynamic occupancy model to analyze this information over time and estimate the probability that a population is likely to remain in one of these four occupancy states or transition to a different state. This document elucidates the process that led to the decision to use this framework and outlines the conceptual basis for GEM. A practitioner's guide with detailed GEM implementation instructions will follow in a subsequent publication.

Keywords: fisher, lynx, marten, montane red fox, wolverine, multispecies monitoring, forest carnivore, multistate model

Cover photos

From left, wolverine (photo: Jeff Copeland, The Wolverine Foundation, used with permission), lynx (photo: Milo Bircham, USDA Forest Service), and fisher (Michael Schwartz, USDA Forest Service).

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Chapter 1: The Need for Mesocarnivore Monitoring

This chapter describes the rationale for undertaking the monitoring effort and provides a brief overview of the monitoring plan.

Rationale

The western United States is home to a diverse mesocarnivore community. Mesocarnivores, small to mid-sized (typically <15 kilograms) carnivores, are ecologically important species. Many of these species have undergone significant distributional changes in the United States since European settlement began in the 19th century (Prugh et al. 2009; Roemer 2009). As a result, many mesocarnivore species are of conservation concern, as well as the focus of public interest and litigation.

Long-term monitoring of mesocarnivores is important to the USDA Forest Service for many reasons. For example, monitoring plays a key role in assessing land management plans (i.e., Forest Plans), informing species conservation assessments, and conforming to species-specific monitoring requirements and agreements.

The Forest Service is required by the National Forest Management Act of 1976 (NFMA) to provide for the diversity of plant and animal communities on National Forest System (NFS) land, including mesocarnivores and the habitats that support them. The Forest Service ensures diversity primarily through implementation of Forest Plans developed under current or historical planning regulations: the 2012 Planning Rule (FR 2012a; USFS 2012) and 1982 Planning Rule (FR 1982), respectively. Monitoring is essential to testing relevant assumptions, tracking conditions over time, and measuring the management effectiveness of Forest Plans. Monitoring information is important for evaluating whether a change in management direction is needed. While the Forest Service generally monitors ecological conditions such as vegetation structure and composition (USFS 2012, 2015), direct monitoring of wildlife populations can also be essential (Schultz et al. 2013). This is especially true for some mesocarnivores, such as those that were identified as management indicator species under the historical planning rule, those that may be identified as focal species under the current planning rule, or those for which there is conservation concern but precise habitat needs are unknown. Management indicator species are species whose population changes are "believed to indicate effects of management activities on other species of selected major biological communities or on water quality" (CFR 2012). Focal species provide information about the effectiveness of the Forest Plan "in providing the ecological conditions necessary to maintain the diversity of plant and animal communities and the persistence of native species in the plan area" (FR 2012a).

The 2012 Planning Rule establishes a two-tiered monitoring approach for all Forest Plans, regardless of which planning rule originally guided the plan. One tier is for plan-level monitoring, and the other is for broader-scale questions that are best answered at larger geographic scales than a single plan area. Mesocarnivores with large home ranges, low population densities, and elevated conservation status across large landscapes are an excellent fit for broader-scale monitoring strategies.

Mesocarnivore monitoring data can also help the Forest Service and others accurately evaluate species conservation status. Status designations include regional forester's sensitive species and species of conservation concern (USFS 2012); species petitioned, proposed, or listed by the U.S. Fish and Wildlife Service (USFWS) as threated or endangered under the Federal Endangered Species Act (ESA) of 1973; and species evaluated by States for natural heritage rankings or wildlife action plans. Unbiased designations are important because the Forest Service ultimately must address species with elevated conservation status in project planning or land management planning efforts.

Species monitoring, alone or in concert with habitat monitoring, may also be necessary to carry out specific commitments. For example, Canada lynx (hereafter, lynx) have unique monitoring requirements associated with the Northern Rockies Lynx Management Direction (hereafter Lynx Management Direction) (USFS 2007) and accompanying Biological Opinion (USFWS 2007). The Lynx Management Direction amended several Forest Plans to aid the recovery of lynx populations, and was predicated on certain assumptions that require monitoring. For example, it is important to validate over time which areas are occupied by lynx, so that the Lynx Management Direction can effectively promote species recovery.

This document will focus on mesocarnivores in the Northern Region (Region 1) and Intermountain Region (Region 4) as example regions that have supported the development of the monitoring plan and will provide the first implementation of this approach. We recognize that the mesocarnivore species of interest will vary by region, but the challenges associated with monitoring these mesocarnivores will be similar across all regions. Therefore, the approach also provides a basis for more general mesocarnivore monitoring. In the western United States, other NFS Regions where this approach would be applicable include the Rocky Mountain Region (Region 2), Pacific Southwest Region (Region 5), and Pacific Northwest Region (Region 6).

Regions 1 and 4 and the Forest Service's Rocky Mountain Research Station (RMRS) have worked collaboratively to identify three primary mesocarnivore species for monitoring. Primary species are species that have been identified in broad-scale monitoring priorities for mesocarnivores, have relevant designations under the 1982 or 2012 Planning Rules (Appendix A), and have been petitioned for listing under the ESA multiple times (Appendix B). Within this monitoring structure,

primary species will be the focus of surveys specifically designed to detect their population states with a priori statistical power. Other species not listed as being "primary" will be detected opportunistically within sampling designs associated with the primary species.

Primary Species

1. Fisher (*Pekania pennanti*)
2. Canada lynx (*Lynx canadensis*)
3. Wolverine (*Gulo gulo*)

Additionally, we identified two secondary mesocarnivore species for opportunistic monitoring in conjunction with primary species monitoring. Secondary species are species with relevant designations under the 1982 or 2012 Planning Rules (Appendix A) or native mesocarnivores where major gaps in knowledge about distribution exist.

Secondary Species

4. American marten (*Martes americana*)
5. Pacific marten (*Martes caurina*)
6. Montane red fox (*Vulpes vulpes* sspp.)

Monitoring mesocarnivores is complicated by two overarching problems: (1) gaps in knowledge about the basic distribution and habitat requirements of mesocarnivores on Forest Service and other land ownerships; and (2) the lack of an appropriate, multiscale framework that can resolve short-term and long-term trend information about mesocarnivores while addressing the uncertainty related to general low detectability and low abundance of mesocarnivores. We hope that by having a well-articulated plan that meets the Forest Service needs, we can better engage with our partners to identify how to best work together on mesocarnivore monitoring in both the Rocky Mountain region and across the western United States.

Approach

This section outlines the details of how we in the Rocky Mountain region will accomplish the mesocarnivore monitoring strategy.

Leadership and Partnerships

The three primary species have large distributions and home range sizes. Patterns and trends will become clear, depending on species, at scales that range from hundreds to tens of thousands of square kilometers. We recognize that at these large scales, the most efficient and biologically relevant approach to mesocarnivore monitoring is a multiregional approach. Therefore, this strategy has been developed as a collaborative, multiregional effort led by RMRS in Missoula, Montana, the Northern Region (Region 1), and the Intermountain Region (Region 4). We also recognize that at these scales, monitoring should involve many jurisdictions, including Federal, State, tribal, and large private landowners, which means that it is best accomplished as a cooperative partnership. Therefore, the ultimate goal of this monitoring strategy is to facilitate a larger, collaborative, multipartner, western United States-wide monitoring effort, with leadership shared across all partners.

Monitoring Questions

To meet the Forest Service's planning and management needs and to most effectively and efficiently monitor mesocarnivores, we propose the following multispecies, multiregional mesocarnivore monitoring strategy. The strategy will address:

1. Gaps in knowledge about the distribution of mesocarnivores in the Rocky Mountain region;
2. Uncertainty related to low detectability, low abundance, and large home range sizes of mesocarnivores;
3. Simple, straightforward monitoring questions, that when repeated over time, will provide the Forest Service with appropriate information to determine both planning-scale (e.g., national forest) and broad-scale (e.g., region) distribution, population status, and trends of mesocarnivores; and
4. Monitoring to support forest plans, regional broader-scale monitoring programs, and the Lynx Management Direction.

This plan uses a series of tiered monitoring questions that will maximize information efficiency so that, as each subsequent question is asked, it will answer all previous questions. The plan will address three questions about each of the primary species. Answers to these questions, when aggregated over time, will provide trend estimates that reflect the probability that an area remains occupied by either individuals or a reproducing population. These questions are:

1. Is the species present?
2. Are multiple individuals of a single sex present?
3. Are multiple individuals, including both sexes, present?

Not all of these questions will be answered in every location for every species. Rather, the plan allows for flexibility such that only appropriate questions for each area and species are addressed. Most past monitoring plans for carnivores are repeated grid-based surveys, where the landscape is divided into large (e.g., 5 km × 5 km) cells and selected cells are surveyed on a repeated basis (e.g., Kindberg et al. 2011; Proctor et al. 2010; Zielinski et al. 2013). Though this approach is effective, it is also expensive. Additionally, not all areas on the landscape have the same knowledge gaps or the same information needs. Thus, we need goal efficient monitoring (GEM), that is, the right survey design for the right location and knowledge level.

Monitoring Area

Broadly stated, the monitoring area is defined by the ranges, both current and historical, of the primary species of interest. As such, it incorporates areas managed and owned by many entities. Here, however, we will concentrate on Forest Service-administered lands in the Northern Region (Region 1) and Intermountain Region (Region 4), where implementation will begin (hereafter Monitoring Area) (fig. 1). Some

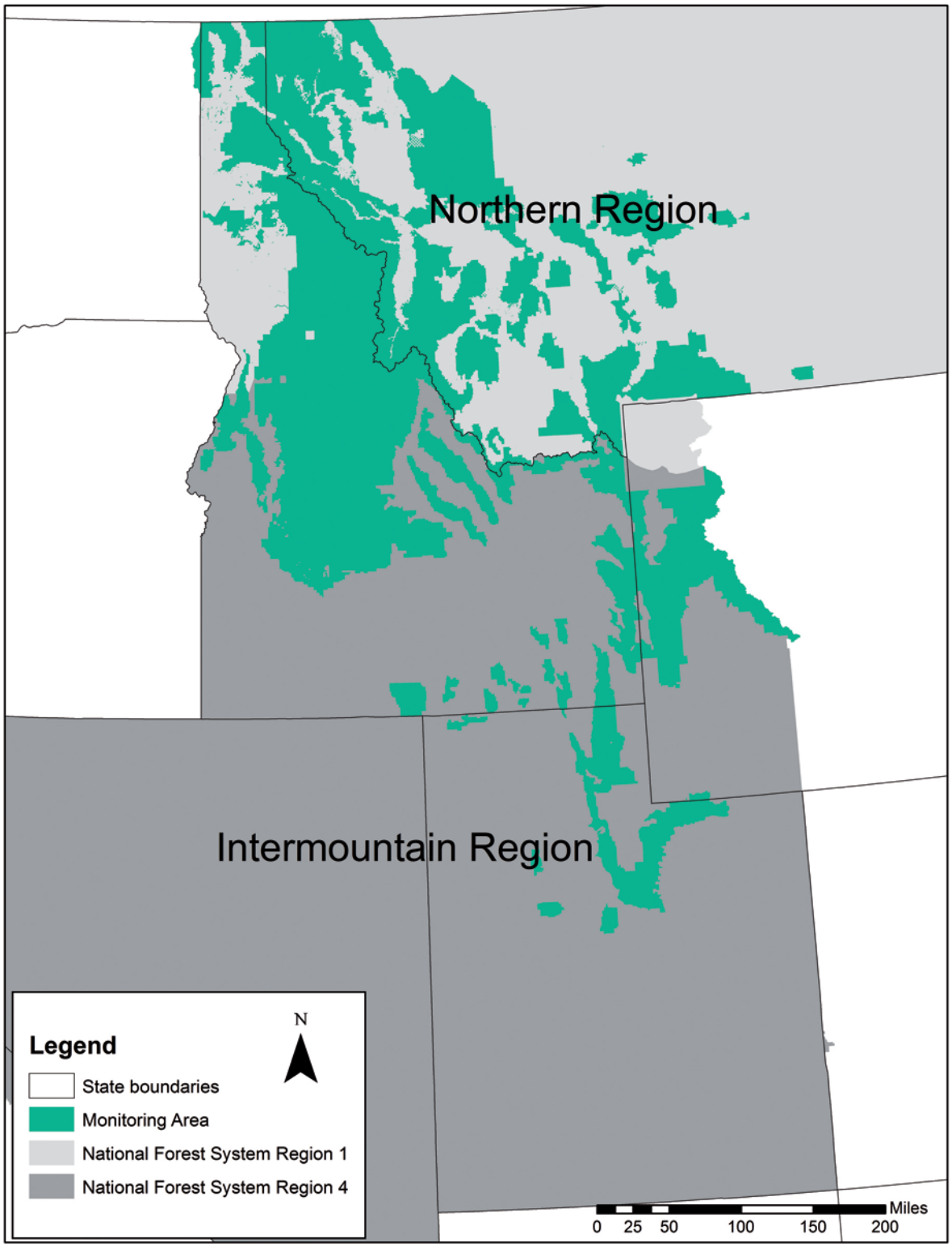


Figure 1—The Monitoring Area (shown in dark green) and the Forest Service participating regions (Northern Region and Intermountain Region).

national forests and national grasslands in Regions 1 and 4 do not contain habitat associated with any of the primary species and therefore are not included in the Monitoring Area.

Statistical Approach

This monitoring strategy will use a multistate approach to address the monitoring questions for the primary species. The states each correspond to a monitoring question and are hierarchically structured so that information at one state provides information at all of the states below that state. This approach will be aided by the use of Bayesian statistics, which are revolutionizing the way managers can track animal populations (Betram et al. 2015; Gelman et al. 2014). Bayesian statistics provide multiple advantages for problems where information is scarce, because they can accomplish the following: (1) incorporate knowledge from previous efforts, (2) fill in missing data with previous efforts or from other species in the community, (3) combine multiple streams of data, (4) share information between species to inform estimates of rare species, and (5) quantify uncertainty from processes on the landscape as well as from sampling. Due to the difficulties in collecting data for these rare species, it is imperative that statistical analyses take full advantage of available information. Thus, the advantages conferred by Bayesian statistics are essential to a large-scale mesocarnivore monitoring strategy.

Importantly, a Bayesian structure allows the Forest Service to be flexible concerning when and where the agency asks the three monitoring questions. These monitoring questions will change over time as levels of information and Forest needs change. To be both efficient and effective, the Forest Service must ask the right question in the right place and at the right time by using the most efficient and robust sampling design. Formally designing the monitoring within a multistate, Bayesian structure makes this possible. Refer to Chapter 4 for a more detailed description of this approach.

Timeline

Monitoring will be implemented with a pilot phase and a long-term implementation phase. The pilot phase began in 2017 and will run through 2020. This approach has worked well for other Forest Service mesocarnivore monitoring efforts. For example, the Southern Sierra Nevada Fisher Monitoring Program in the Pacific Southwest Region (Region 5) used a pilot phase to reduce uncertainty, which allowed the Forest Service to reduce effort and take advantage of new technology in the current implementation phase (ongoing) (Truex et al. 2016). The timeline of the implementation phase is tentative and will depend on a variety of factors, including funding. Figure 2 shows an overview of the focus of each phase of monitoring. A practitioner's guide with detailed GEM implementation instructions will follow in a subsequent publication.

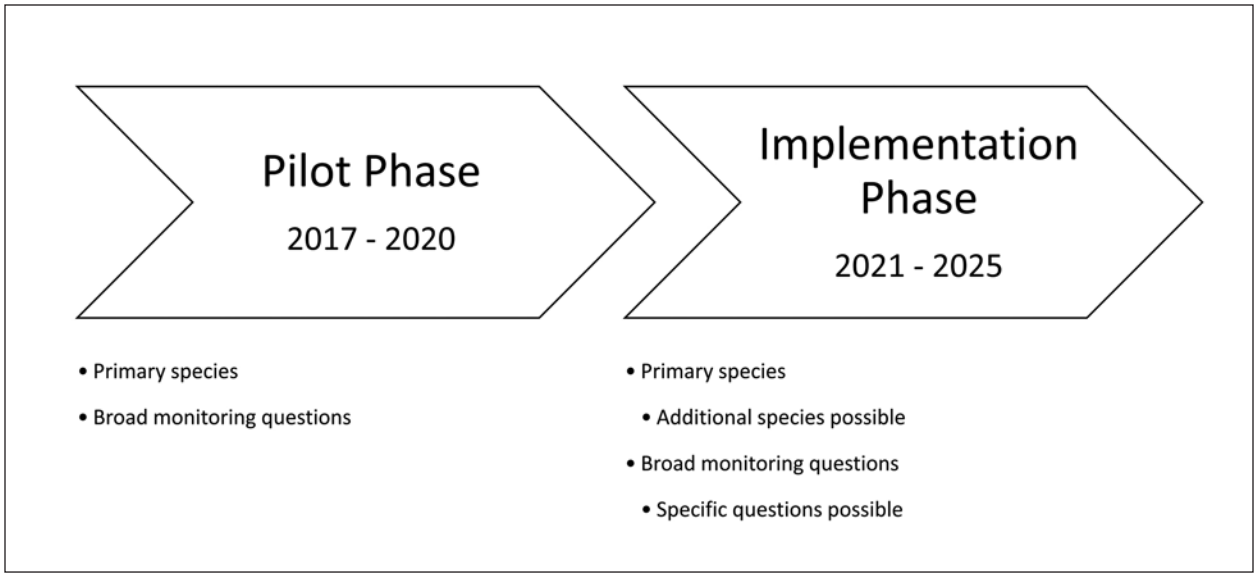


Figure 2—The focus of Pilot Phase and Implementation Phase of the monitoring effort.

Funding

The effort is currently funded through fiscal year 2018 by the Northern Region (Region 1) Resource Information Management (RIM) Board and the Intermountain Region (Region 4). Funding will continue to be sought from these sources, as well from partners and other sources.

Document Organization

The remainder of this document provides the details of how this strategy will be accomplished. Chapter 2 includes background information on each species, including life history information and why the species was selected. Chapter 3 outlines the process of developing the monitoring questions and determining where the Forest Service will ask each of the monitoring questions for each primary species. Chapter 4 describes in detail the GEM framework, including the statistical and field approaches used to obtain information for monitoring questions.

Chapter 2: Background Information on Mesocarnivore Species

This chapter contains background information on the primary species (fishers, lynx, and wolverines) and secondary species (martens and montane red fox) considered in this plan. It includes why each species was selected, the specific legal and regulatory framework that dictates management of the species, life history information, and the benefits of monitoring the species.

Primary Species Background

Fisher

Fishers were selected as a primary species because of their small population size and because they are disjunct and genetically distinct from other fisher populations. In fact, the USFWS designated northern Rocky Mountain fishers as a distinct population segment (DPS) in 2011. A DPS is a discrete population segment that is considered to be significant to the species as a whole (FR 2010b). The range of the northern Rocky Mountain DPS includes parts of east-central Idaho, southern Montana, and northwest Wyoming (FR 2011). Fishers in this DPS represent a distinct lineage that survived what was presumed to be extirpation by the 1960s (Schwartz 2007; Schwartz et al. 2012; Vinkey et al. 2006). As a result, they have been identified as a management indicator species, regional forester's sensitive species, or proposed species of conservation concern on multiple forests within the Monitoring Area. The species was not listed after the petition in 2009 partially in response to results of a survey effort by the RMRS and partners, funded by the Northern Region (Region 1), to document fisher range in the northern Rocky Mountain region from 2004 through 2011. Relatively little is known about their current distribution or status throughout the northern Rocky Mountains.

Regulatory and Legal Status

Federal Endangered Species Act

Fishers in the northern Rocky Mountain region were petitioned both to be considered to be a DPS and to be listed under the ESA in 2009 (FR 2010a). In 2011, the USFWS determined that the listing of the northern Rocky Mountain DPS as petitioned in 2009 was not warranted (FR 2011) but concluded that this area did constitute a valid DPS. Fishers in the DPS were again petitioned for listing under the ESA in 2013 (FR 2016a). In 2016, the USFWS determined that listing may be warranted due to factors B (overutilization) and E (other manmade factors) (FR 2016a). Most recently, the USFWS found in 2017 (FR 2017) that the species is neither in danger of extinction now nor likely to become so in the foreseeable future due to climate change, development, poisoning,

forestry, fire, trapping, or predation; thus, the species is not warranted for listing at this time under the ESA. Our monitoring approach will provide information helpful to determining whether listing is warranted. Appendix B outlines these petitions and decisions.

Forest Service

Fishers are considered a regional forester's sensitive species in Regions 1 and 4 (USFS 2011, 2016). Fishers have been proposed as a species of conservation concern on the Nez Perce-Clearwater National Forest (USFS 2013b).

Life History

Habitat Requirements

Fishers occupy forested landscapes that contain complex vertical (trees and snags) and horizontal (downed logs or debris) structure and dense canopies (Lofroth et al. 2010). These forests are typically found in low- to mid-elevation mixed-conifer or mixed-hardwood forests (Sauder and Rachlow 2014). These features, and thus fishers, are not necessarily exclusive to old-growth forests (Raley et al. 2012). At a home range scale, fishers in the northern Rocky Mountain region require large trees—the average maximum diameter at breast height [d.b.h.] in used stands was 107 cm—with cavities (Schwartz et al. 2013) and areas where vegetation heterogeneity is high (Sauder and Rachlow 2015). Females need cavities for reproduction and show a strong selection for such structures within their home range throughout the western United States (Paragi et al. 1996; Raley et al. 2012; Schwartz et al. 2013). Average female home-range size in the northern Rocky Mountains is approximately 25 km^2 and average male home-range size is substantially larger (Schwartz et al. 2006). Fishers exhibit seasonal habitat use in the northern Rocky Mountains. They favor old-growth subalpine fir (*Abies lasiocarpa*) and grand fir (*Abies grandis*) habitats in summer, but switch to using both young and old-growth forest types in the winter (Jones and Garton 1994). Fishers also avoid open and nonforested areas (Raley et al. 2012) and in the northern Rocky Mountains avoid stands of ponderosa pine (*Pinus ponderosa*) and lodgepole pine (*Pinus contorta*), probably due to the lack of large-diameter trees or complex understory structure, or a combination thereof (Schwartz et al. 2013).

Reproduction

Female fishers reproduce when they are 2 years old. Mating occurs in late spring. Females give birth to one to four kits the next year between mid-March and early April, following delayed implantation and a gestation period of approximately 36 days. Fishers mate again within approximately 10 days of giving birth. Parental care continues for approximately 10 months after birth. Kits are weaned at around 10 weeks. At 4 months, juveniles become mobile and able to travel with their mother. At 7 months, juveniles are somewhat independent, but stay within their mother's home range. Juveniles disperse at approximately 10 months (Lofroth et al. 2010).

Historical Distribution

There is limited information on the historical distribution of fishers in the Rocky Mountains. Fishers may have historically occurred in east-central Idaho, southern Montana, northwest Wyoming, and northeastern Washington (Gibilisco 1994). By the early 1900s, populations of fisher in the United States had declined significantly because of unregulated harvest, poisoning, and habitat loss (Vinkey 2003). Fishers were probably extirpated from Montana by 1929 and considered extinct or extremely rare in Idaho by the 1950s (Vinkey 2003). In response, there were several reintroductions in north-central Idaho and western Montana in the early 1960s (Vinkey 2003; Vinkey et al. 2006). However, a novel mitochondrial haplotype was identified in 2006 in Montana and north-central Idaho, suggesting that the species may not have been extirpated before the reintroductions, as previously thought (Schwartz 2007; Schwartz et al. 2012; Vinkey et al. 2006).

Current Distribution and Population Status

Currently fishers are present in northwestern Montana and central Idaho (Olson et al. 2014), but their exact distribution remains uncertain.

Benefits of Monitoring Fishers

Monitoring fishers will provide the following benefits for the Forest Service:

1. Improve understanding of current fisher distribution to inform project-level and planning-level NEPA analysis;
2. Improve understanding of long-term trends in fishers and identification of potential drivers of this trend;
3. Support Forest Plan monitoring programs, particularly on forests where fishers are considered a management indicator species, sensitive species, species of conservation concern, or focal species;
4. Support regional broader-scale monitoring programs; and
5. Provide information that can inform future ESA listing decisions. If fishers are petitioned or listed under the ESA in the future, knowledge of current distribution on Forest Service lands will equip the Forest Service with the information necessary to comply with ESA.

Canada Lynx

Lynx are one of the most high-profile mesocarnivores that occur on Forest Service lands in the Rocky Mountain region. They were selected as a primary species because of management concerns, their protection under the ESA, and ongoing litigation concerns related to proposed management actions. Not only are lynx the center of many legal challenges brought against the Forest Service, but because of their status as threatened under the ESA (since 2000) (FR 2000), they are addressed in almost every Forest Service planning document in the Monitoring Area. Lynx habitat in the Rocky Mountain region is patchily distributed (Squires et al. 2013).

Although some of the current distribution of lynx is described (Squires et al. 2013), there is still no clear regionwide understanding of the status of lynx populations, and changes in distribution or populations cannot be tracked without a long-term monitoring structure. In addition, there are legal requirements from the Lynx Management Direction Biological Opinion to monitor "unoccupied habitat," as defined by the 2006 amendment to the Lynx Conservation Agreement (USFS and USFWS 2006), on seven national forests within the Monitoring Area. These surveys are expensive and time consuming, and have not been conducted in a coordinated manner in the past to provide a comprehensive look at unoccupied lynx habitat. Therefore, monitoring lynx can provide the Forest Service with multiple benefits, most importantly compliance with regulatory and planning guidance including the Lynx Management Direction, and help inform management decisions both within and outside the Forest Service.

Regulatory and Legal Status

Federal Endangered Species Act

Lynx are listed as threatened under the ESA (FR 2000). Prior to listing, lynx were petitioned for listing in 1994 and determined to be not warranted for listing (FR 1997). However, a 1997 court order remanded that decision and required the USFWS to reconsider the decision. The species remained a candidate under the ESA from May 27, 1997 (FR 1997) until it was listed on March 24, 2000 as threatened under the ESA (FR 2000). In October 2017, the USFWS released a species status assessment for the lynx (USFWS 2017b). A subsequent review of that assessment in November 2017 concluded that the lynx may no longer warrant protection under the ESA, and should be considered for delisting (USFWS 2017b). However, a formal delisting proposal has not yet been issued. Appendix B outlines these petitions and decisions.

Forest Service

Because lynx are listed as threatened under the ESA, they do not have additional status within the Forest Service.

Life History

Habitat Requirements

At a landscape scale lynx require habitats that support dense populations of snowshoe hares (*Lepus americanus*) (Mowat et al. 2000). In the Rocky Mountain region, lynx habitat includes mature conifer and spruce-fir (*Picea–Abies*) forests, often in areas dominated by alpine fir, Engelmann spruce (*Picea engelmannii*), or lodgepole pine (Aubry et al. 2000; Squires et al. 2010), but such resources are often patchily distributed (Squires et al. 2013). Lynx select home ranges at mid-elevations (between 1,425 and 1,998 meters) in areas of high canopy cover and low topographic roughness with little open grassland (Squires et al. 2013). Females require mature spruce-fir forests with high cover, woody debris, and large-diameter trees for den sites, although studies have suggested that structure may play a more important role than forest age (Mowat et al. 2000; Squires et al. 2008). Dens are typically in

drainage-like areas away from forest edges in sheltered areas. Females appear to show low fidelity to den sites (Squires et al. 2007). Female home-range size is approximately 90 km^2 and male home-range size is 220 km^2 (Squires and Laurion 2000). Lynx generally exhibit seasonal shifts in vegetation preference, favoring mature, multistory forests in the winter—primarily spruce-fir forests—and a wider mixture of mature and young forests in the summer (Squires et al. 2013).

Reproduction

Female lynx typically reproduce when they are 2 years old, although they have been known to breed at 1 year of age when snowshoe hares are abundant. Lynx breed in March and April. This period is followed by a 60- to 70-day gestation period. Females give birth from late April to mid-June (Mowat et al. 2000). Maternal care continues for approximately 12 months and kittens begin to disperse in April and May. Throughout their range, lynx reproduction is closely tied to snowshoe hare abundance (Mowat et al. 2000).

Historical Distribution

Lynx historically occurred throughout the northern Rocky Mountains in Idaho, Montana, Wyoming, and Colorado (McKelvey et al. 2000). In the 1960s and 1970s, lynx populations in the Rocky Mountain region followed an expansion pattern that closely tracked population eruptions in Canada with a 2-year time lag (McKelvey et al. 2000).

Current Distribution and Population Status

Northern portions of Montana and a small part of northern Idaho are thought to support the largest lynx population in the western United States (USFWS 2017b). Lynx distribution in the Rocky Mountains has declined since the early 1990s. In addition to persistent populations in the Clearwater Drainage and Purcell Range in western Montana (Squires et al. 2013), lynx were located previously in both the Garnet Range of Montana, and in the Greater Yellowstone Area of Montana, Idaho, and Wyoming, where reproduction was also documented (Squires and Laurion 2000). Recent surveys have failed to detect lynx in the Greater Yellowstone Area (USFWS 2017). Currently, there are no estimates of population status, although there have been efforts in the past to look at population growth in northern portions of the Rocky Mountains, including in the Clearwater Drainage (where populations were declining between 1999 and 2007) and the Purcell Mountains (where populations were increasing between 2003 and 2007) (USFWS 2017).

Benefits of Monitoring Lynx

Monitoring lynx will provide the following benefits for the Forest Service:

1. Achieve compliance with Lynx Management Direction Biological Opinion term and condition 3 to monitor lynx unoccupied habitat (Appendix C), as defined by the 2006 amendment to the Lynx Conservation Agreement (USFS and USFWS 2006);

2. Improve understanding of current lynx distribution and trend information that can be used to inform project-level to planning-level NEPA analysis; and
3. Support regional broader-scale monitoring programs that can inform future ESA decisions and provide the Forest Service with the information necessary to efficiently comply with ESA regulations, including recovery goals should a recovery plan be established.

Wolverine

Wolverines were selected as a primary species because of small populations and the potential for wolverine to be listed under the ESA. Wolverines are considered a regional forester's sensitive species in the Northern Region (Region 1) (USFS 2011). In addition, national forests within the Monitoring Area are incorporating wolverine monitoring questions into their revised forest plan monitoring requirements (e.g., Bridger-Teton [USFS 2016a]). Wolverines have been petitioned for listing under the ESA twice (1994 and 2000), and are currently proposed as threatened (FR 2016b).

The range of wolverines in the United States has contracted significantly since the 1900s (McKelvey et al. 2014). However, the Rocky Mountain region is one of the few places in the contiguous United States where wolverines persist in a manner similar to their historical distribution (Aubry et al. 2007). They are an elusive species, such that even when present, they are difficult to detect because of low densities, and the harsh terrain that they inhabit, which often occurs in areas with difficult access (e.g., designated wilderness). As a result, relatively little is known about current population trends.

Regulatory and Legal Status

Federal Endangered Species Act

Currently wolverines are proposed as threatened under the ESA (FR 2016b). Wolverines were petitioned for listing under the ESA in 1994 (FR 1995) and 2000 (FR 2003). The decision to list has been challenged multiple times. Appendix B outlines these petitions and decisions. Most recently, the February 4, 2013, proposed rule to list the species as threatened was reopened for public comment and closed on November 17, 2016 (FR 2016b). A final listing decision is expected in 2018.

Forest Service

Wolverines are considered a regional forester's sensitive species in the Northern Region (Region 1) (USFS 2011).

Life History

Habitat Requirements

At a landscape scale, wolverines require persistent spring snow cover (Aubry et al. 2007; Copeland et al. 2010; Inman et al. 2013). Unlike most of the wolverine distribution in the western United States, wolverines in

the Rocky Mountain region do not appear to be closely associated with alpine vegetation (Aubry et al. 2007). Thus, wolverines may be more closely associated with the climatic conditions that produce persistent spring snow cover in the Rocky Mountain region, which is essential for their denning (Copeland et al. 2010; Magoun and Copeland 1998). Wolverines den in structures that are either buried by snow (e.g., trees, boulders) or make dens within the snow itself (Magoun and Copeland 1998). At a home range scale, wolverines need habitat that supports prey populations, including alpine and avalanche environments (Krebs et al. 2007). Female home-range size in the Rocky Mountain region is between 300 and 400 km^2 and male home-range size is between 797 and 1,582 km^2 (Copeland 1996; Inman et al. 2012a). Wolverines exhibit seasonal shifts, often using low elevation forests in winter and mid-elevation forests in summer (Krebs et al. 2007).

Reproduction

Female wolverines can reproduce when they are 2 years old, although average age of reproduction across their range is thought to be 3 years old (Inman et al. 2007). Wolverines breed between May and July. Breeding is followed by a period of delayed implantation and a gestation period of approximately 30 to 40 days. Females give birth to one to two kits the following spring, usually between early February and mid-March (Inman et al. 2012b). Wolverines abandon their natal dens with weaned kits by late April or early May (Magoun and Copeland 1998) and move kits to secondary (maternal) den sites. Parental care continues for approximately 5 months (Copeland 1996).

Historical Distribution

Wolverines were extirpated or driven to extremely low numbers in the lower 48 States by the 1900s (McKelvey et al. 2014). Previously, their range primarily included the western mountains of the United States and the Great Lakes region (Aubry et al. 2007). In the Rocky Mountain region, their range included Idaho, Montana, Wyoming, Utah, and Colorado. Evidence suggests that they were absent from Colorado and Utah by the 1920s, but persisting and increasing in the other States after the 1900s (Aubry et al. 2007).

Current Distribution and Population Status

Wolverines now reoccupy much of their historical range in the Rocky Mountain region, including in Idaho, Montana, Wyoming, and Washington (McKelvey et al. 2014). More recently, wolverines were detected in 2014 and 2016 in Utah. In 2014 a wolverine was detected in the Uinta Mountains of Utah and in 2016 a wolverine was struck by a car in Rich County, Utah, near Bear Lake (Utah Division of Wildlife Resources 2016). Before those detections, the last detections in Utah were in 1979 (Utah Division of Wildlife Resources 2016). Genetic evidence indicates that the individuals that currently occupy these areas are descended from recent migrants from the north in Canada (McKelvey et al. 2014).

The most recent analyses of wolverine populations in the Rocky Mountain region suggest that populations are small and may have undergone recent reductions. Schwartz et al. (2009) estimated the effective population size, or the approximate number of breeders in a population, in Montana, Idaho, and Wyoming as 35 (95 percent confidence interval [CI]: 28–52). The majority of wolverines in the Rocky Mountain region persist within this area and this small effective population size is therefore of concern (Schwartz et al. 2009). Based on predictive habitat modeling, Inman et al. (2013) concluded that the western United States could support approximately 644 wolverines (95 percent CI: 506–1881) and estimated that the current population, as of 2013, was approximately 318 wolverines (95 percent CI: 249–926).

Benefits of Monitoring Wolverines

Monitoring wolverines will provide the following benefits for the Forest Service:

1. Improve understanding of current wolverine distribution and trend information that can be used to inform project-level and planning-level NEPA analysis;
2. Support regional broader-scale monitoring programs; and
3. Provide information that can inform future ESA decisions.

Secondary Species Background

American Marten and Pacific Marten

Currently, two species of martens are recognized in the United States, American martens (*Martes americana*) and the western martens (*Martes caurina*) (Dawson and Cook 2012). Historically, they have sometimes been treated as subspecies, but current genetic information indicates they are separate species (Dawson and Cook; Schwartz et al. 2012). The taxonomic revision is recognized by the American Society of Mammalogists. Both species occur in the northern U.S. Rocky Mountains and form a narrow hybrid zone at their junction (Dawson and Cook 2012; Small et al. 2003). It is unknown whether the hybrids produce viable offspring.

American martens were identified as a management indicator species on multiple national forests within the Monitoring Area, but with the new distinction, some might be more appropriately identified as Pacific marten. Martens were selected as a secondary species because of management concerns in some local areas and their potential to provide information about the community of carnivores in a Bayesian context. Due to the power of "borrowing strength," which is increased precision and accuracy when multiple estimates use a common distribution in a Bayesian framework, information on marten occurrence patterns may be valuable for predicting abundance or occupancy of rare species (Iknayan et al. 2014).

Regulatory and Legal Status

Federal Endangered Species Act

Martens in the Rocky Mountain region are not protected under the ESA. However, a closely related subspecies, the Humboldt martens (*M. caurina humboldtensis*), was petitioned for listing in 2010 (FR 2012b; called *M. americana humboldtensis* in the Federal Register). The USFWS withdrew Humboldt martens from listing consideration in 2014 (FR 2015b), although this decision was partially overturned in 2017 (Center for Biological Diversity et al. v. U.S. Fish and Wildlife Service 2017).

Forest Service

Martens are considered a management indicator species on five national forests in the Monitoring Area: Bitterroot (USFS 1987a), Clearwater (USFS 1987b), Flathead (USFS 1986b), Custer-Gallatin (USFS 1986a), and Salmon-Challis (USFS 1988).

Life History

Habitat Requirements

Martens use a wide variety of forest types across their range. They are a forest obligate species that require dense canopy cover, woody debris that provides structure, and large trees for resting and denning sites (Cheveau et al. 2013; Thompson et al. 2012). Martens avoid open areas and, as a result, can be sensitive to forest harvest practices (e.g., Cushman et al. [2011]; Moriarty et al. [2016]; Potvin et al. [2000]) and recreation (Slauson et al. 2017). Mature and old mixed-hardwood and conifer forests appear to be important, although not exclusively used, throughout their range (Thompson et al. 2012).

Reproduction

Female martens typically reproduce when they are 2 years old. Martens breed in July and August. Breeding is followed by a period of delayed implantation and a gestation period of approximately 27 days. Females give birth from late March to April to one to five kits. Martens abandon their natal dens when kits are 7 to 13 weeks old and move kits to secondary (maternal) den sites. Parental care continues through late summer (Buskirk and Ruggiero 1994).

Historical Distribution

Martens in the United States are not as widely distributed as they were before European settlement (Buskirk and Ruggiero 1994). In the Rocky Mountain region, however, martens are generally widespread and distribution is presumed to be similar to their historical distribution (Buskirk and Ruggiero 1994).

Current Distribution and Population Status

Martens are currently thought to be widespread throughout the Rocky Mountain region (see map in Schwartz et al. 2012). Although local areas have reported some changes in populations, including a

dramatic decrease reported in the Bitterroot National Forest as of 2013 from track surveys (USFS 2013a), populations are generally thought to be stable and distribution unchanged.

Benefits of Monitoring Martens

Monitoring martens will provide the following benefits for the Forest Service:

1. Improve understanding of current marten distribution and populations that can be used to inform forest-plan requirements for monitoring martens as a management indicator species;
2. Support regional broader-scale monitoring programs; and
3. Provide information that can be used to inform rare species modeling.

Montane Red Fox

Montane red foxes (*Vulpes vulpes* sspp.) were selected as a secondary species because little is known about the subspecies' overall current distribution. Montane red foxes are part of the Nearctic genetic clade, one of two major genetic clades of native North American red foxes (*Vulpes vulpes*). The Nearctic clade is descended from populations that were isolated in the southern refugium during the last glacial maximum and currently occupies montane regions of the western United States and portions of southeastern Canada (see figure 1 in Aubry et al. 2009: 2675). Montane red foxes are a group of subspecies, several of which are of conservation concern, that have differentiated into subspecies in the western mountains of the United States. The Rocky Mountain red fox (*Vulpes vulpes macroura*) is the subspecies present in the Northern Region (Region 1) and Intermountain Region (Region 4), but does not have any conservation status currently. The Sierra Nevada red fox (*Vulpes vulpes necator*), which inhabits high elevation areas of the Sierra Nevada (Perrine et al. 2007), is considered endangered under the California Endangered Species Act (California Department of Fish and Wildlife 2018). A related valley subspecies, the Sacramento Valley red fox (*Vulpes vulpes patwin*) (Sacks et al. 2010), has a small genetic effective population size, causing concern, yet little is known about its contemporary abundance, demographic trajectory, or habitat use (Sacks et al. 2017). The Cascade red fox (*Vulpes vulpes cascadensis*), which occupies the crest and eastern slopes of the Cascade Mountains (Aubry 1983), is also considered a Washington State candidate species (Washington Department of Fish and Wildlife 2013) and a Washington Natural Heritage critically imperiled species (Washington Department of Natural Resources 2017). Because several subspecies are of conservation concern and little is known about the Rocky Mountain red fox, a proactive approach to understanding distribution of montane red foxes is likely to benefit the Forest Service by providing useful baseline information.

Regulatory and Legal Status

Federal Endangered Species Act

Montane red foxes in the Rocky Mountain region are not protected under the ESA. A closely related subspecies, the Sierra Nevada red fox, was found warranted but precluded by other priorities for listing by the USFWS in 2015 (FR 2015a).

Forest Service

Montane red foxes are not specifically addressed in any Forest Service directive in the Monitoring Area. See Chapter 1 for a summary of general Forest Service requirements that pertain to wildlife and monitoring of wildlife.

Life History

Habitat Requirements

Montane red foxes occur in cooler, high elevation forests of the mountains in the western United States (Aubry et al. 2009). Little is known about their specific habitat requirements. A closely related subspecies, the Sierra Nevada red fox, occurs at elevations above 400 meters (Sacks et al. 2010; Statham et al. 2012).

Reproduction

Although little is known about the reproduction of montane red foxes, it is likely that it is similar to that of lowland red foxes (*Vulpes vulpes*). Red foxes are monogamous and breed from late winter to early spring. Similar to other related subspecies, montane red foxes may use a variety of den types, including a sheltered den in a structure, rock piles, or earthen dens (Aubry 1983).

Historical Distribution

Prior to the last glaciation (Wisconsin glaciation), montane red foxes were distributed in mountain regions throughout the western United States. At that time, the tree line was 1,000 meters lower in the northwestern United States (Aubry et al. 2009).

Current Distribution and Population Status

Little is known about the current distribution and population status of montane red foxes, although museum specimens indicate that the species was present in locations throughout the Rocky Mountain region approximately 80 to 100 years ago (Aubry et al. 2009).

Benefits of Monitoring Montane Red Foxes

Monitoring montane red foxes will provide the following benefits for the Forest Service:

1. Improve understanding of current montane red fox distribution and populations that are currently largely unknown; and
2. Support regional broader-scale monitoring programs and provide baseline information on conservation status.

Chapter 3: Monitoring Questions for Primary Species

This chapter contains a description of the monitoring questions for the primary species. It describes how those questions were developed and how they correspond to different states of a rare species population.

Monitoring Questions

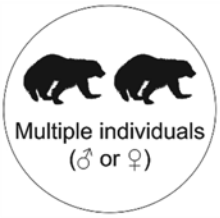
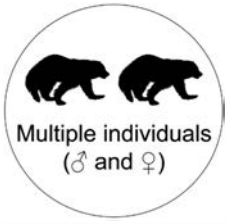
We worked extensively with multiple parties across the Forest Service and potential external partners to gain a broad understanding of the information needs for the primary species. This process was started with a series of semistructured interviews conducted between June and August 2016 with Forest Service and potential external partners, including additional Federal agencies, State agencies, tribal governments, and nonprofit organizations. We ultimately focused this plan on meeting Forest Service information needs, although the information from this strategy is broadly usable to track the status of the primary species in the Rocky Mountain region.

These efforts identified three important monitoring questions for the primary species:

1. Is the species present?
2. Are multiple individuals of a single sex present?
3. Are multiple individuals, including both sexes, present?

The questions are tiered, such that answering any higher-tier question will provide an answer for that question and any questions below. The tiers are defined based on the amount of information they provide about the population. Thus, the first-tier question, "Is a species present?" provides the least amount of population-level information. Each of these questions corresponds to a different state of a population (table 1, fig. 3).

Table 1—Possible population states for the primary species. Wolverine is used as an example species to illustrate the states.

Category	Not present	Present		
		Single individual	Multiple individuals	
Population state				

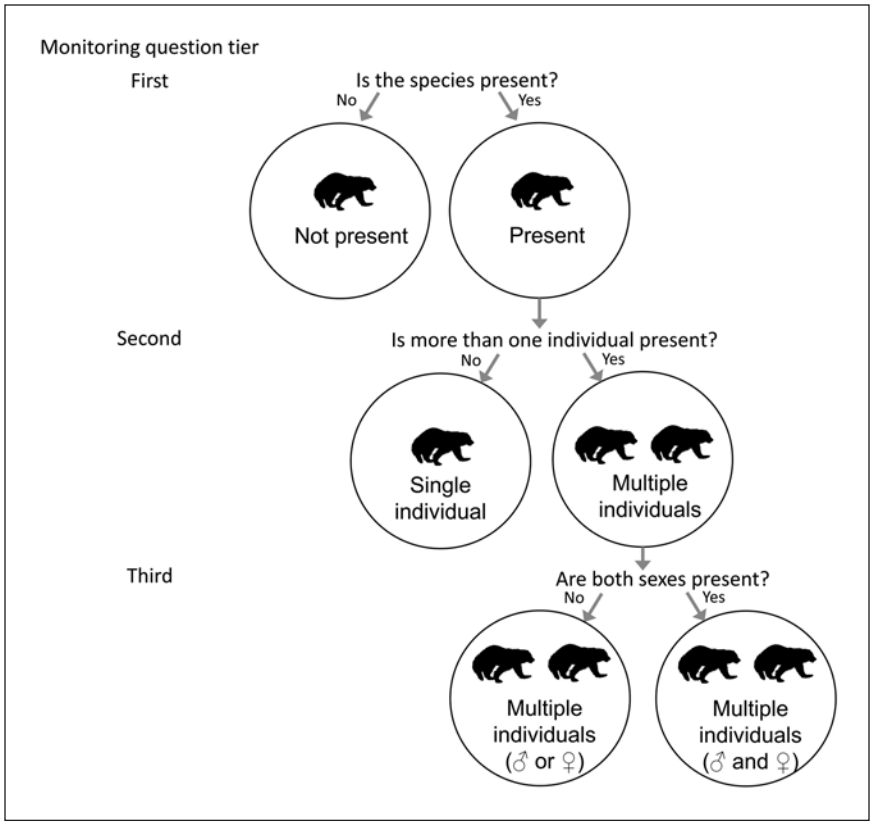


Figure 3—Monitoring questions, with tier indicated, and the population state for which the questions provide answers. Wolverines are used as an example species to illustrate the states.

To define which tier of question was appropriate for each primary species on each of the national forests, we conducted in-person meetings with the national forests in Regions 1 and 4 between July and October 2017 and sent follow-up questionnaires to document the results of these meetings. Appendix D contains these questionnaires from the national forests that responded. We used national forests as an initial primary mapping unit because the laws and policies that guide the Forest Service are based on the national forest scale or larger. In addition, we reviewed past survey information for the primary species on Forest Service lands within the Monitoring Area as documented in

- Forest Service Forest Plan Monitoring Reports,
- Forest Service Survey Reports,
- Conference monitoring publication,
- Existing databases within the Forest Service and publicly available data sources, and
- Personal communication with Forest Service employees.

Figures 4 through 6 show the highest-tier monitoring question for each of the primary species on a national forest scale. Figure 7 is a summary of the total number of questions for each primary species.

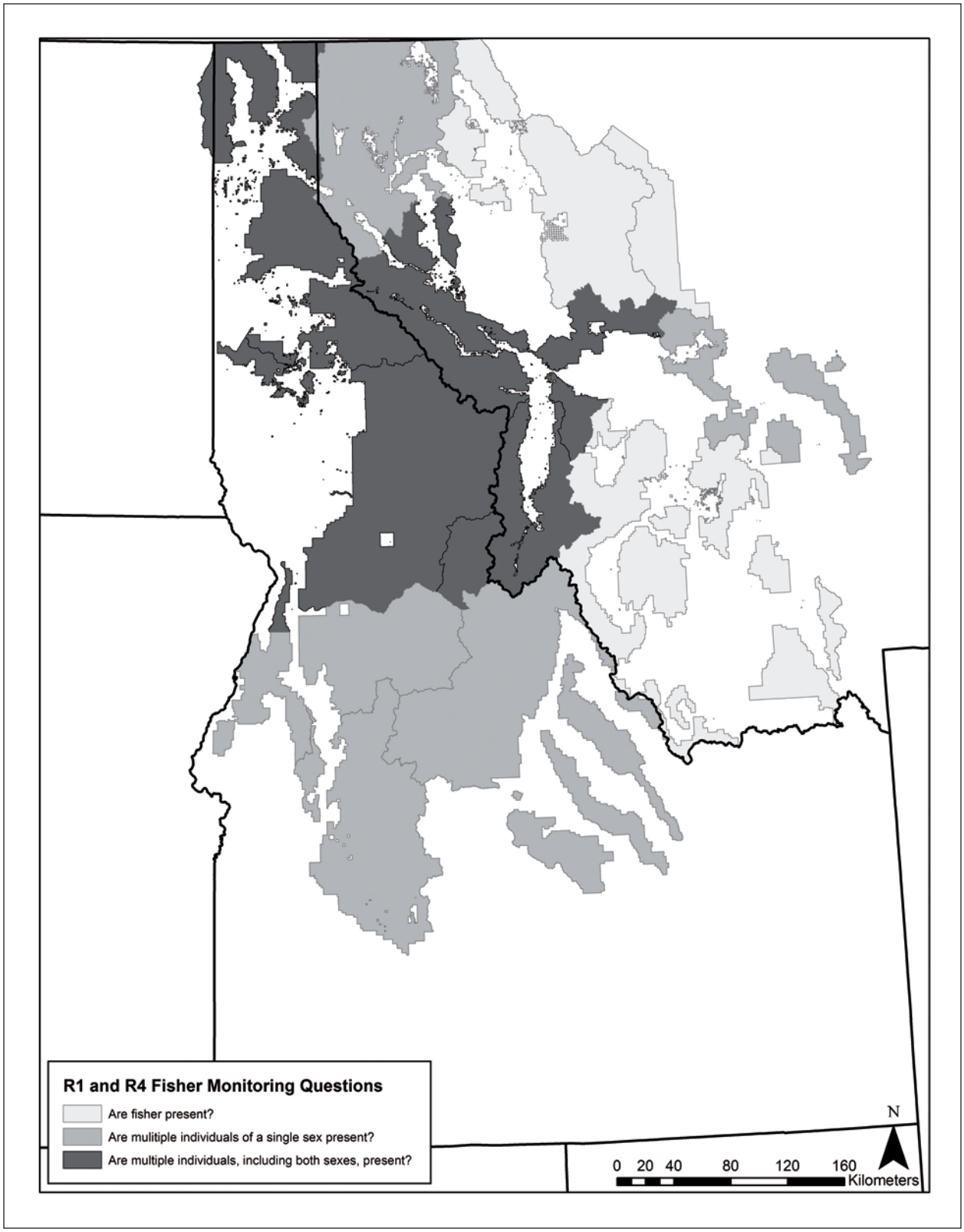


Figure 4—Phase 1 monitoring questions for fishers in the Monitoring Area.

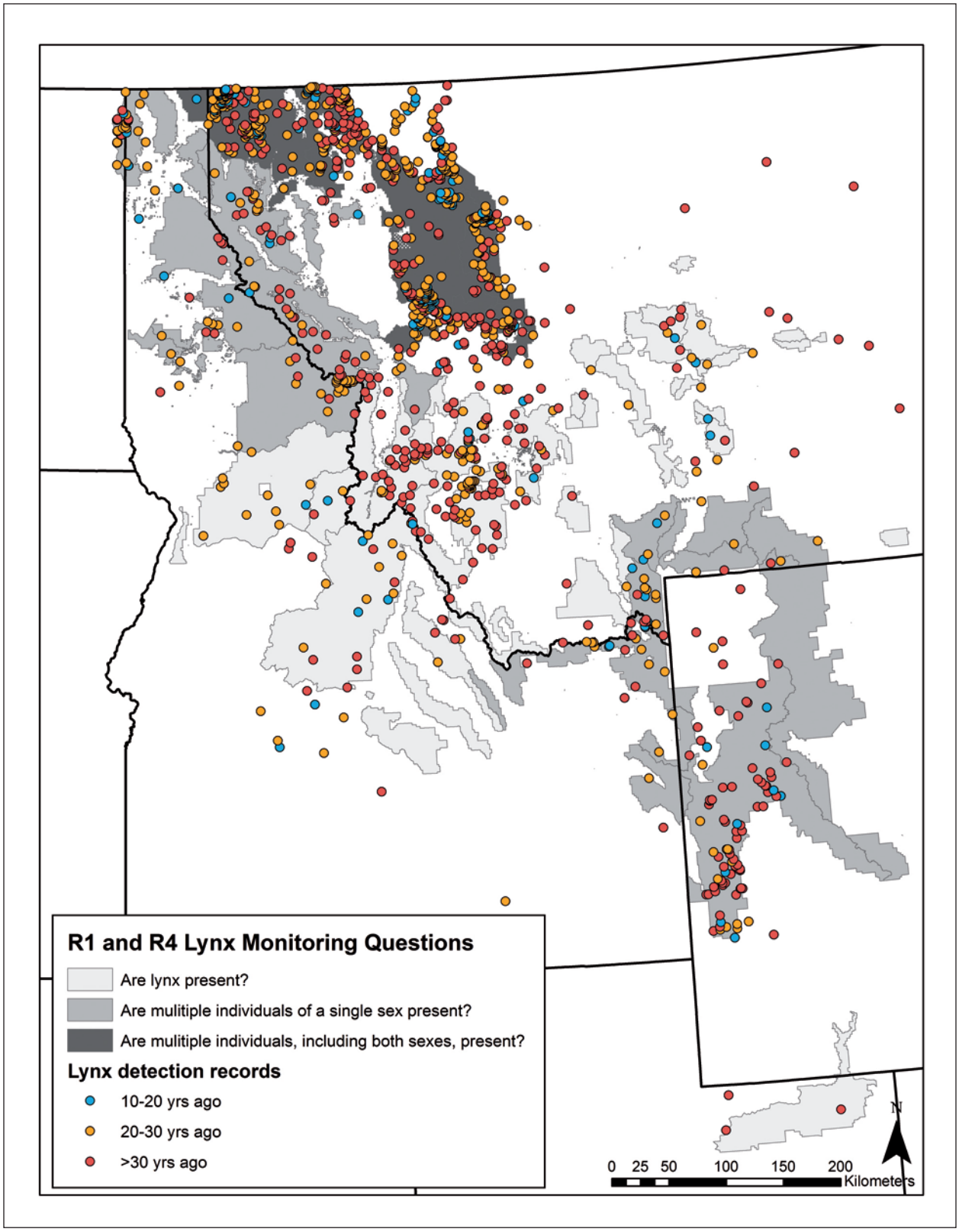


Figure 5—Phase 1 monitoring questions for lynx in the Monitoring Area.

Figure 6—Phase 1 monitoring questions for wolverines in the Monitoring Area.

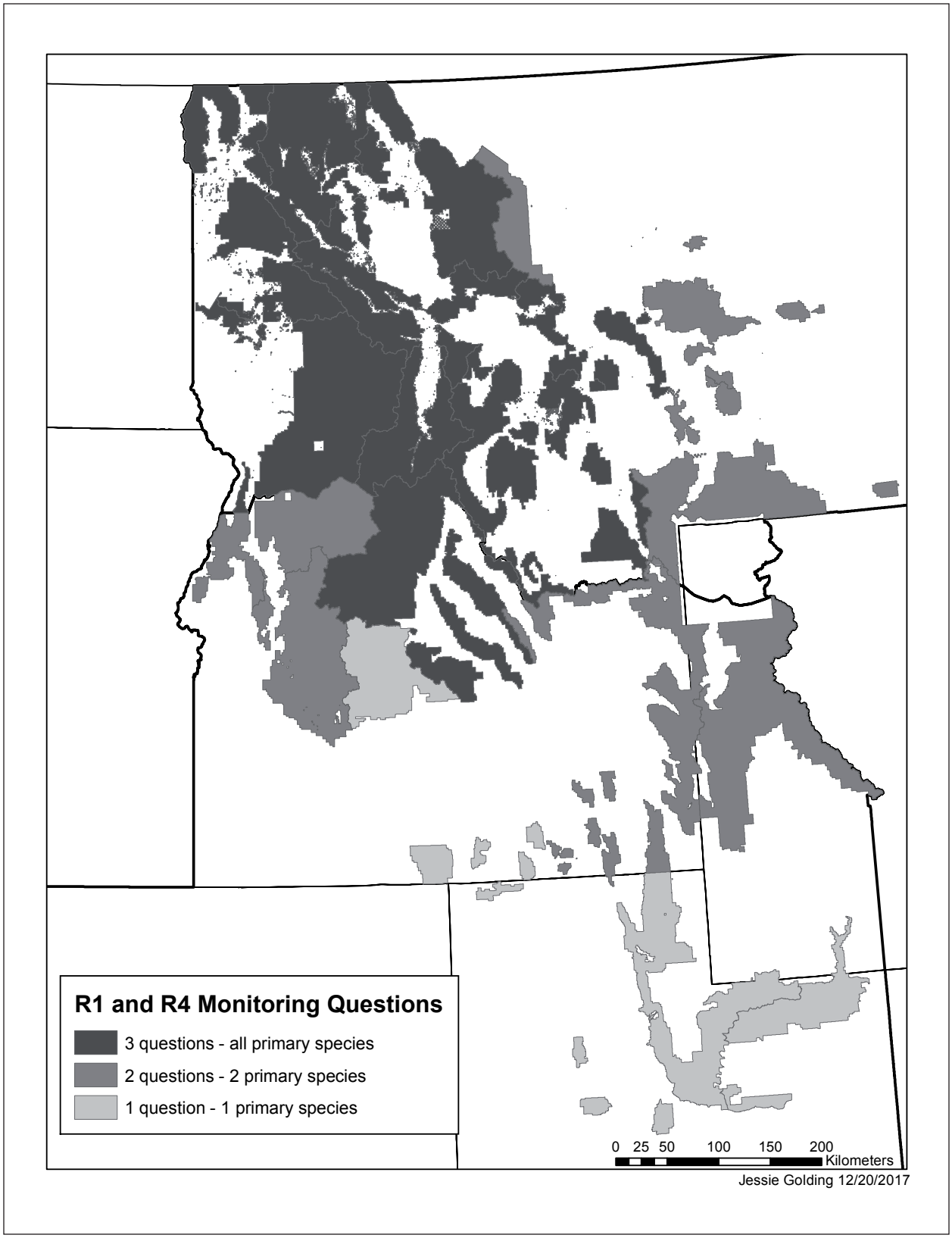


Figure 7—Summary of the number of Phase 1 monitoring questions for primary species on a forest.

Chapter 4: Goal Efficient Monitoring

This chapter describes the monitoring strategy: goal efficient monitoring. It includes the rationale for the approach, the statistical approach, recommended survey methods to collect the data necessary for each question, and an outline of how the monitoring information will be used.

Rationale

There are two main challenges to monitoring rare species. The first is that rare organisms are difficult to locate and surveys therefore tend to be expensive to implement. The second is, given the difficulties associated with rarity, a monitoring plan that is targeted to meet the needs of decisionmakers often does not scale appropriately to provide biologically relevant information about the species. Because of these challenges, effective long-term monitoring strategies for rare species are scarce. However, monitoring rare species is important because the status and trend of rare species affect legal, management, and societal decisions. In addition, there are legal mandates, such as the monitoring required for lynx under the Lynx Management Direction Biological Opinion (USFWS 2007), to monitor rare species. Finally, monitoring may be the only source of information for rare species. Thus, we need an approach that robustly addresses the monitoring questions identified in Chapter 3 and that overcomes the existing challenges of rare species monitoring.

Rare Species Challenges

Rare species are often difficult to detect, either because of low densities, secretive behavior, or lack of knowledge about when and where to find an organism. As a result, land and wildlife managers who need information about rare species are often faced with a tradeoff between selecting "omnibus" survey methods (Sauer et al. 2003), defined as methods capable of detecting multiple species, or targeted survey methods to get specific information on a species of interest. Information constraints typically limit the utility of omnibus methods for rare species (Manley et al. 2004). Because omnibus sampling approaches are, by definition, not specifically designed to collect sufficient data for any particular species, rare species occurrences may simply be too scarce to provide meaningful monitoring data.

Recent statistical advances such as Bayesian multispecies models allow improved analyses of rare species data when collected during multispecies surveys (Iknayan et al. 2014). These advances in analytical capability can partially alleviate this problem, but the problem remains. There are, however, undeniable cost efficiencies associated with omnibus approaches; if one cares about monitoring more than one species, using omnibus approaches is generally more efficient than conducting multiple

independent surveys each targeted at an individual species (Manley et al. 2004). Further, individual species surveys cannot take advantage of efficiencies afforded by the use of Bayesian multispecies models; large sample sizes are needed to detect trends in rare species using traditional frequentist statistical analyses (e.g., Ellis et al. 2014). Thus, the ideal rare species monitoring plans must contain elements of both omnibus and targeted surveys.

The key to efficiency in designing rare species surveys is to design the most cost-effective mixture of omnibus and targeted sampling approaches, such that all of the targeted species are adequately sampled. For rare carnivores, existing survey methods, including tracking to obtain genetic samples, remote cameras, or noninvasive hair snare methods, represent a mixture of omnibus and targeted efficiencies. These methods are inherently multispecies and therefore omnibus. However, they are also somewhat targeted in that they are better at detecting certain species. For example, small baited enclosures (cubbies) are effective for sampling mustelids, but other animals use these traps as well (Kendall and McKelvey 2008).

Monitoring Design Challenge

Most large-scale, long-term monitoring programs for wildlife are "surveillance" monitoring programs, a term defined by Nichols and Williams (2006), suggesting a generalized design. For instance, the Breeding Bird Survey (BBS) is a broad-scale survey that has been conducted from 1966 to the present across the United States to evaluate patterns of over 400 North American bird species (Sauer et al. 2017); data for all species are gleaned from a single omnibus sampling design. Surveillance monitoring often contains sophisticated statistical design elements and will provide reliable data for broad-scale trends, but there is little effort to ensure the scales are pertinent to specific management areas (e.g., watersheds) or that rare species are adequately sampled (Manley et al. 2004).

Because surveillance monitoring is not targeted at answering specific questions for specific species, inferences tend to be weak and relative, and as such there is strong incentive to retain design and methods across time to produce more reliable indices. Consequently, surveillance monitoring designs are not responsive to current needs; design changes tend to be limited to localized increases in sampling density (densification) within a broader invariant design. Nichols and Williams (2006) noted that this type of surveillance monitoring efforts fails to address pertinent management questions and it is not designed to do so. They proposed instead that monitoring should emulate scientific studies and that a "targeted" approach to monitoring may be more appropriate (see also Holthausen et al. 2005). In a scientific study, a question is clearly posed with a matching sampling design to generate information that can be tested, with high confidence, and produce direct answers with adequate reliability.

Nichols and Williams' (2006) approach solves the problem of data production at suboptimal scales and with inadequate power by surveillance monitoring, but creates its own problems. Targeted questions are continuously fluctuating. Societal needs and priorities are constantly changing, and the acquisition of knowledge creates new questions. As an example that is simple but pertinent to rare carnivores, one often enters a particular land area in a state of ignorance: Whether the organism is present, or not, is unknown. So the first targeted question is: Does this area contain at least one organism? A monitoring approach can be designed to answer this question.

Assuming that an organism has been found, the next series of questions is likely to revolve around its population status: Were there more than one, were there both females and males, and were the females reproductive? The necessary targeted information, and therefore the optimal targeted design, is different if the question is one of occurrence versus detecting individual males and females. Note also that though represented here as a linear chain of increasing information, the progression could easily vary: Reproductive females may be found in one survey but fail to be detected in subsequent surveys. Due to the vagaries of small population dynamics, populations may shrink or vanish.

When we look across broader spatial extents, it is clear that both the local needs and information levels will be in a constant state of flux. Thus, there exists a conundrum for any broad-scale monitoring effort seeking to maintain continuity across space and time. Efficiency demands that the targeted goals and therefore efficient designs change across space and time. This contrasts with integrative needs of a broader survey, its continuity, and the ability to use and compare data collected in one place and time to inform data collected in different places and during either previous or subsequent times. In short, although Nichols and Williams (2006) lay out a compelling argument concerning why targeted monitoring is advantageous in a particular place and time, they do not offer a coherent approach to integrate these disparate efforts into a long-term, broad-scale monitoring effort.

Goal Efficient Monitoring Approach

To address these challenges and provide the relevant management information from the monitoring questions presented in Chapter 3, we propose a new approach using a flexible framework we call goal efficient monitoring (GEM). GEM is a long-term monitoring framework that allows local flexibility and the ability to efficiently use data from seemingly disparate targeted local efforts that aggregate into a coherent whole. It is based on the ideas of focusing on states of a rare population rather than abundance, as was suggested by MacKenzie et al. (2005). It has four main components that make it uniquely able to solve rare species monitoring problems:

1. Tiered monitoring questions that address the finest-scale local needs but can scale up appropriately because of their tiered nature;

2. Monitoring questions that correspond to well-defined and discernable population states of interest;
3. A well-developed understanding of the processes of transitioning between or staying within a population state; and
4. Defined maximum scale at which each state is relevant.

In the context of multispecies mesocarnivore monitoring, this approach has the additional benefit of including sufficient elements of omnibus sampling to take advantage of efficiencies afforded through Bayesian multispecies surveys (Iknayan et al. 2014).

The tiered monitoring questions for this plan were developed to meet local information needs but can provide relevant information, even if questions differ, across a larger area. For example, forest resource managers may want to know whether a rare species population on their forest has the potential to be a reproducing population, so they would ask the third-tier question: Are multiple individuals of a single sex present or are both sexes present? If the managers on the neighboring forest have only a question about whether the species is present, both efforts can be combined to determine species presence across the region because the third-tier question always answers the second- and first-tier questions.

For the population states presented (table 1), we assumed, for the sake of clarity, that transitions follow a linear progression and that a population must transition through each state in a predictable manner. This is not strictly the case, and allowing transitions that jump states (e.g., both sexes present transitioning to not present) is acceptable within the modeling framework. The vast majority of transitions, however, will probably be those shown in figure 8: either remaining within a state or transitioning into an adjacent state.

By tracking state transitions, answers to the tiered GEM questions, when aggregated over time, will provide monitoring trend estimates. For example, if upward transitions exceed downward transitions regionally,

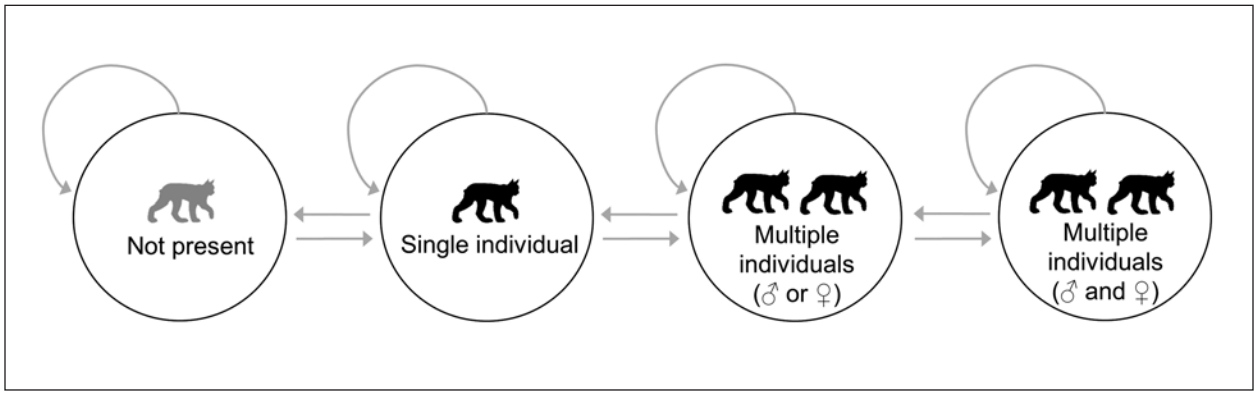


Figure 8—The four potential states (represented as circles) and the process of transitioning between the states (straight arrows) or staying within a state (curved arrows). Lynx are used as an example species to illustrate the states.

this will indicate an expanding population. One of the most powerful parts of GEM is that monitoring states over time gives us context to understand the biological importance of the current state. In fact, we find that the biological importance of the population state is best understood with knowledge of the previous transition or maintenance of a state (table 2).

Within the GEM context, information on transitions or remaining within a state comes from repeatedly asking the tiered questions over time. Because the questions asked change with knowledge of the population state, surveys are conducted in a manner that always addresses the current information need. Thus, one has to constantly cycle through the questions, allowing for repeats of cycles as well as progression through the monitoring questions. Appendix E provides a hypothetical example of what a progression through 4 years of GEM would look like for the three primary species on the Bitterroot National Forest in the Northern Region (Region 1).

The maximum scale at which the states for this plan (table 1) are relevant is based on the utility of knowing that a population exists in the highest state. That is, once the population becomes large enough that knowing there are multiple individuals of both sexes is trivial, the state-based approach ceases to be useful. At these higher population levels, meaningful information on population change takes the form of changes in numbers or in demographic parameters. In this effort we have chosen to delineate areas where population state will be estimated to areas no

Table 2—Biological importance (inference that can be drawn from observation) of states based on observation and previous transition. Most likely importance in bold (if multiple possibilities shown). Wolverine is used as an example species to illustrate the states.

		Not Present	Present		
	Direction of previous transition	Not present	Single individual	Multiple individuals (♂ or ♀)	Multiple individuals (♂ and ♀)
Biological importance	→	NA	**Disperser passing through** Disperser colonizing	Dispersers passing through **Dispersers colonizing**	**New reproducing population established**
	←	**Local extinction** (either from population or unsuccessful colonization event)	**Last individual left from a population** Last individual left from an unsuccessful colonization event	**Remaining individuals of a population** (that is no longer reproducing)	NA
	↻	**Area not optimal/suitable for species**	**Disperser colonizing**	**Dispersers colonized**	**Existing reproducing population persisting**

larger than the equivalent of 50 home ranges of the species of interest. In most cases the actual population that inhabits these spaces will be much smaller than this theoretical carrying capacity.

Statistical Approach

We propose a multistate model to analyze the data in the GEM framework. The GEM analysis builds on the multistate dynamic occupancy models of Royle (2004), Royle and Link (2005), Nichols et al. (2007), MacKenzie et al. (2009), and Kéry and Schaub (2012). Figure 9 shows a schematic of the states and the associated statistical transition probabilities. Table 3a summarizes those probabilities and table 3b shows the probabilities associated with observing each state.

The GEM multistate dynamic occupancy model will be most useful in a Bayesian hierarchical framework because these models can estimate transition or staying probabilities, even those with missing data, while explicitly dealing with observational uncertainty and imperfect detection (Dorazio 2016). Bayesian frameworks also allow for the incorporation of prior information (Dorazio 2016), meaning that surveys that were accomplished in the past can be used to inform estimates and design of surveys in the future. With the repeated asking of questions over time, Bayesian analysis provides a considerable advantage over traditional estimation methods. The previous survey efforts inform not only the next monitoring question, but also the information that the model has available to use for predictions. In fact, the estimation of all three of these questions can be accomplished in the single GEM model. Finally, Bayesian multispecies models may allow new insight into rare species by using information from the community of species that are detected by using omnibus survey methods (Iknayan et al. 2014). These advantages are essential for a large-scale, rare mesocarnivore monitoring program.

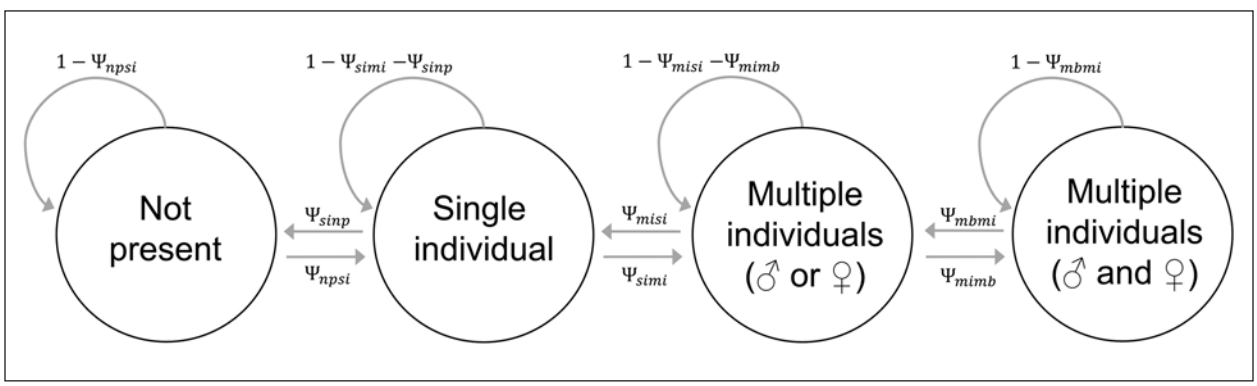


Figure 9—The four potential states (represented as circles) and the statistical transition probabilities (Ψ) between the states. Curved arrows represent the probability of not transitioning (1-Ψ) and the straight arrows represent the probability of transitioning (Ψ). Subscripts are as follows: np = not present; si = single individual; mi = multiple individuals (single sex); mb = multiple individuals (both sexes). Combined subscripts indicate a transition in the order that the subscripts appear (e.g., npsi = not present transitioning to single individual).

Table 3a—The transition probabilities (ψ) between the states. Subscripts are as follows: np = not present; si = single individual; mi = multiple individuals (single sex); mb = multiple individuals (both sexes). Combined subscripts indicate a transition in the order that the subscripts appear (e.g., npsi = not present transitioning to single individual).

		True state at time $t+1$			
		Not present	Single individual	Multiple individuals (single sex)	Multiple individuals (both sexes)
True state at time t	Not present	$1-\Psi_{npsi}$	Ψ_{npsi}	0	0
	Single individual	Ψ_{sinp}	$1-\Psi_{simi}-\Psi_{sinp}$	Ψ_{simi}	0
	Multiple individuals (single sex)	0	Ψ_{misi}	$1-\Psi_{misi}-\Psi_{mimb}$	Ψ_{mimb}
	Multiple individuals (both sexes)	0	0	Ψ_{mbmi}	$1-\Psi_{mbmi}$

Table 3b—The probability of detecting (p) the states. Subscripts are as follows: np = not present; si = single individual; mi = multiple individuals; mb = multiple individuals (both sexes).

		Observation at time t			
		Not observed	Single individual observed	Multiple individuals (single sex) observed	Multiple individuals (both sexes)
True state at time t	Not present	1	0	0	0
	Single individual	$1-p_{si}$	p_{si}	0	0
	Multiple individuals (single sex)	$1-p_{si}-p_{mi}$	p_{si}	p_{mi}	0
	Multiple individuals (both sexes)	$1-p_{si}-p_{mi}-p_{mb}$	p_{si}	p_{mi}	p_{mb}

Recommended Survey Methods

In the GEM framework three types of information are required: detection/nondetection information, individual identification, and sex determination. Genetic sampling by noninvasive survey methods can provide all three of those pieces of information. In addition, identification reliability is high with genetic methods, which is particularly important for rare species. Therefore, for this strategy we recommend the use of three noninvasive survey methods to collect genetic samples: snow tracking (Squires et al. 2004), multispecies bait station, and targeted bait station (fisher – Schwartz et al. 2006; lynx – McKelvey et al. 1999).

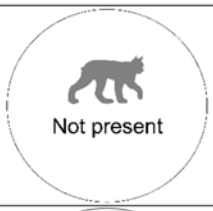
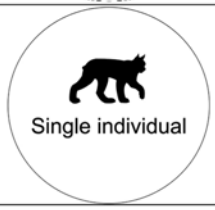
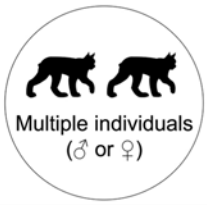
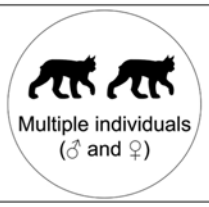
Snow tracking should be used as the primary lynx detection method as it has proven to be the most reliable for winter surveys (Squires et al. 2012). Snow tracking should be used in combination with multispecies bait station setups, as multispecies bait stations are more efficient for detecting a broad suite of species. Both snow track surveys (McKelvey et al. 2006) and bait stations allow the collection of genetic samples,

which enable verification of species and individual identification. We recommend the use of remote cameras at a portion of the multispecies and targeted bait stations to (1) provide multispecies omnibus survey information; (2) understand the interaction between animals and the bait station setup; and (3) obtain photos, videos, or both for promotional or educational materials. Table 4 provides an overview of how each survey method can be used to detect each state and what detection is needed to confirm presence of the state.

Implementation

National forests will have the ability to decide to participate in the survey effort. Ideally, national forests will work with the monitoring coordinator to design and implement multispecies surveys for the primary species. The monitoring coordinator will provide survey design assistance, including maps and survey locations. The coordinator will work closely with the national forests to ensure that the surveys maximize the potential to meet the needs of the forest and provide useful information in this framework. The monitoring coordinator will play an essential role in design, data storage, consistency, communication, and collaboration, all of which will help ensure the success of the effort.

Table 4—Detection method for each state. Lynx is used as an example species to illustrate the states.

	State	Detection methods	Detection needed to confirm state
Not present		Camera station Gun brush Camera Scat detecting dogs eDNA	NA
Present		Gun brush Backtrack Scat detecting dogs	Genetic identification (individual)
		Gun brush Backtrack Scat detecting dogs	Genetic identification (individual and sex)
		Gun brush Backtrack Scat detecting dogs	Genetic identification (individual and sex)

Thresholds and Triggers

Monitoring is most effective when data generated from the efforts are tied to thresholds or triggers (Nie and Schultz 2012; Schultz et al. 2013). Thresholds are predetermined signals that have been identified due to biological or management relevance. Triggers are predetermined signals that, when detected, require an action (Block et al. 2001). We encourage the development of thresholds and triggers as this monitoring plan is implemented. Similarly, triggers may be set to require committing to additional monitoring should populations of the target species diminish in occupancy by a certain percentage. Overall thresholds and triggers can help efficiently direct monitoring efforts by explicitly linking monitoring to the biology of the species or management (Schwartz et al. 2015).

Centralized Database

The approach described in this chapter can be accomplished only through centralized data storage. If the information collected to answer these monitoring questions is not stored in a central database, the information gained through repeating the questions over time could be lost. In a Bayesian system the power to identify current conditions depends on prior data collection, so access to these data represents an integral part of the statistical design. The central database will be maintained through RMRS and at a minimum will include monitoring location information, date, species detection information (including the method used to identify the species), and individual identification or genetic information (if applicable). Monitoring information will also be compatible with and stored in the Forest Service corporate wildlife database, NRM Wildlife, so that it is accessible to NFS employees. We will work with partners to ensure data formats are compatible with existing local databases, but data sharing will not occur without additional arrangements. This is especially important for rare species where location data may be sensitive.

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Appendix A: Regulatory and Legal Status of Primary and Secondary Species

Forest Service Regions mentioned are as follows: Region 1 = Northern; Region 2 = Rocky Mountain; Region 3 = Southwestern; Region 4 = Intermountain; Region 5 = Pacific Southwest; Region 6 = Pacific Northwest; Region 9 = Eastern.

Species: Fisher

Status: Regional forester's sensitive species
Scale: USDA FS Region
USDA FS location: Region 1, Region 4
Status: Proposed species of conservation concern
Scale: National forest
USDA FS location: Nez Perce-Clearwater National Forest

Species: Lynx

Status: ESA threatened
Scale: Species' known range
USDA FS location: Region 1, Region 2, Region 3, Region 4, Region 9

Species: Wolverine

Status: Regional forester's sensitive species
Scale: USDA FS Region
USDA FS location: Region 1

Status: ESA proposed threatened
Scale: Species' known range
USDA FS location: Region 1, Region 4, Region 5

Species: Marten (American and Pacific)

Status: Management indicator species
Scale: National forest
USDA FS location: Bitterroot National Forest, Clearwater National Forest, Custer-Gallatin National Forest, Flathead National Forest, Salmon-Challis National Forest

Species: Montane red fox

Status: None
Scale: Not applicable
USDA FS location: Not applicable

Appendix B: History of ESA Listing Petitions and Decisions for Primary Species

Species: Fisher

Date: February 24, 2009
Action: Petition for a rule to designate fishers in the northern Rocky Mountain region as a Distinct Population Segment (DPS) and add them to the list of endangered or threatened wildlife protected by the Endangered Species Act (ESA)

Date: April 9, 2009
Action: Response to 2009 petition stating that emergency listing was not warranted and a 90-day review would commence in 2011

Date: June 30, 2011
Action: 12-month finding that listing of the fisher in the northern Rocky Mountain region was not warranted

Date: September 23, 2013
Action: Petition for a rule to add the northern Rocky Mountain fisher DPS to the list of endangered or threatened wildlife protected by the ESA

Date: October 31, 2013
Action: Response to 2013 petition stating that emergency listing was not warranted

Date: January 12, 2016
Action: 90-day finding that listing of the northern Rocky Mountain fisher DPS may be warranted under the ESA based on factors B (overutilization) and E (other factors)

Date: October 5, 2017
Action: 12-month finding that listing of the northern Rocky Mountain fisher DPS as threatened or endangered under the ESA is not warranted

Species: Lynx

Date: August 23, 1994
Action: Petition for a rule to add Canada lynx to the list of endangered or threatened wildlife protected by the ESA

Date: August 26, 1994
Action: 90-day finding that listing of Canada lynx may be warranted

Date: December 27, 1994
Action: 12-month finding that listing of Canada lynx was not warranted

Date: March 27, 1997
Action: Court order remanded the 1994 Canada lynx 12-month finding back to the USFWS for reconsideration

Species: Lynx (continued)

Date: May 27, 1997
Action: 12-month finding that listing of Canada lynx was warranted but precluded and would be added to the list of candidate species

Date: July 8, 1998
Action: Proposed rule to list the lynx as threatened under the ESA

Date: March 24, 2000
Action: Canada lynx in the contiguous United States considered a DPS and listed as a threatened species under the ESA based on factor D of the ESA (inadequacy of existing regulatory mechanisms)

Date: November 13, 2017
Action: USFWS published a 5-year review and recommendation to proceed with proposed rule to remove the Canada lynx DPS from the threatened and endangered species list

Species: Wolverine

Date: August 3, 1994
Action: Petition for a rule to add wolverine in the contiguous United States to the list of endangered or threatened wildlife protected by the ESA

Date: April 19, 1995
Action: August 3, 1994 petition did not present substantial information indicating that listing was warranted

Date: July 4, 2000
Action: Petition for a rule to add wolverine in the contiguous United States to the list of endangered or threatened wildlife protected by the ESA and designate critical habitat

Date: October 21, 2003
Action: 90-day finding that the July 4, 2000 petition did not present substantial scientific and commercial information indicating that listing was warranted

Date: September 29, 2006
Action: Ruled that the 90-day finding was in error and ordered U.S. Fish and Wildlife Service (USFWS) to make a 12-month finding for the wolverine

Date: April 6, 2007
Action: Extended deadline for 12-month finding to February 28, 2008

Date: June 5, 2007
Action: Notice of status review initiation

Date: March 11, 2008
Action: 12-month finding that wolverine did not constitute a DPS and therefore was not a listable entity under the ESA

Date: July 8, 2008
Action: Complaint challenging 12-month finding

Species: Wolverine (continued)

Date: March 6, 2009
Action: Settlement from the July 8, 2008 challenge where the USFWS agreed to submit a new 12-month finding to the Federal Register by December 1, 2010

Date: April 15, 2010
Action: Initiation of status review for wolverine

Date: December 14, 2010
Action: 12-month finding that wolverine constitutes a DPS and was warranted for listing under the ESA but precluded by other higher priorities

Date: April 13, 2012
Action: Challenge of 12-month finding

Date: September 20, 2012
Action: Court granted stay to USFWS

Date: February 4, 2013
Action: Proposed rule to list wolverine as threatened

Date: October 31, 2013
Action: Reopened rule for public comment

Date: February 5, 2014
Action: 6-month extension of final determination

Date: August 13, 2014
Action: Withdrawal of rule to list "based on our conclusion that the factors affecting the DPS as identified in the proposed rule were not as significant as believed at the time of the proposed rule's publication in 2013"

Date: August 13, 2014
Action: Challenge of withdrawal

Date: April 4, 2016
Action: USFWS ordered to reconsider the rule

Date: October 18, 2016
Action: Reopened comment period on February 4, 2013 rule (comment period closed November 17, 2016)

Appendix C: Northern Rockies Lynx Management Direction 2006: Occupied and Unoccupied Lynx Habitat

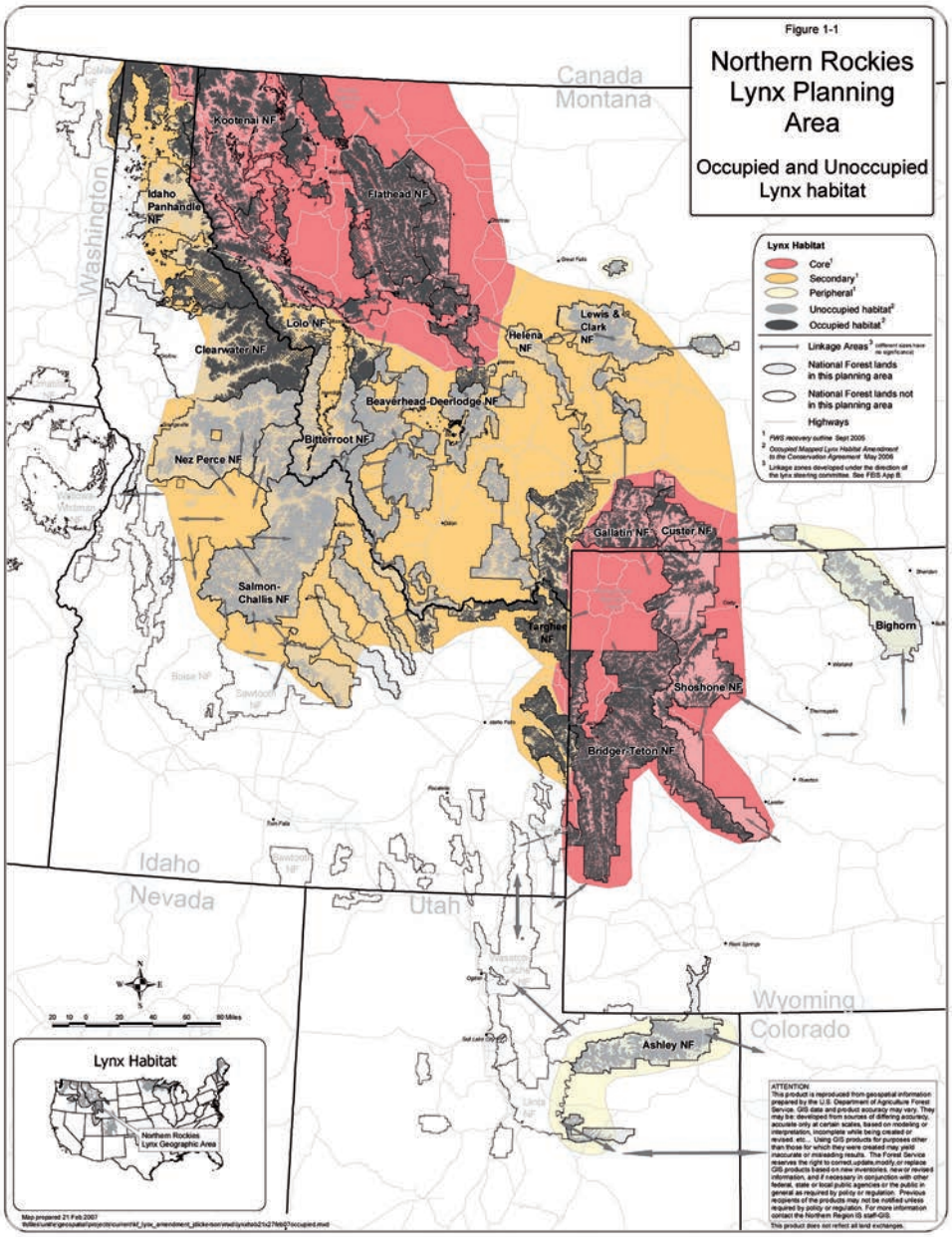

Figure C1—Lynx habitat in the northern Rocky Mountains. Figure source: USFS and USFWS (2006).

Reference

USDA Forest Service (USFS and USFWS). 2006. Canada Lynx Conservation Agreement. USFS Agreement #00-MU-11015600-013. Missoula, MT: U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior, U.S. Fish and Wildlife Service. 13 p.

Appendix D—Mesocarnivore Information Needs in the Northern Region (Region 1) and the Intermountain Region (Region 4)

Staff from RMRS, Region 1, and Region 4 held meetings in July, August, and September 2017 with each national forest, including forest biologists and ecological staff officers on each national forest, to determine the information needs of the forest, namely where the national forest wanted to ask each of the monitoring questions for the primary species. The information provided here are the follow-up questionnaires that were sent to the national forests in the Northern Region (Region 1) and Intermountain Region (Region 4) after these meetings. Not all questionnaires were returned, so only those that were returned are presented.

Received 08/25/2017

Multispecies Mesocarnivore Monitoring

Bitterroot National Forest Participation

Region

R1	R2	R4	R5	R6
☒	☐	☐	☐	☐

Forest Name

Bitterroot National Forest

Forest Information Needs

Species of Interest (check all that apply)

Fisher	Lynx	Wolverine	Marten	Montane Red Fox
☒	☒	☒	☒	☒

Species questions (check all that apply)

Fisher	Lynx	Wolverine	Marten	Montane Red Fox
☒ Is the species present?	☒ Is the species present?	☐ Is the species present?	☐ Is the species present?	☒ Is the species present?
☒ Are multiple individuals, including females, present?	☐ Are multiple individuals, including females, present?	☒ Are multiple individuals, including females, present?	☐ Are multiple individuals, including females, present?	☒ Are multiple individuals, including females, present?
☒ Is there a reproducing population present?	☐ Is there a reproducing population present?	☒ Is there a reproducing population present?	☐ Is there a reproducing population present?	☒ Is there a reproducing population present?

If you have additional questions, describe

Winter 2017/2018

	Yes	No
Survey planned for winter 2017/2018?	☒	☐

If yes, describe project or plan survey is associated with (if multiple please describe)	*We will attempt to maintain our 4 year average level of monitoring involving around 50-60 bait/carnivore stations in conjunction with established track survey protocols in the Sapphire Mountains, the north and south 1/3s of the Bitterroot Mountains in Ravalli County and the Upper Selway River watershed including the motorized corridor and sampling areas along trails in the Selway Wilderness. See note below about collaborating with the MPG Ranch in order to boost the quantity and extent of monitoring activity.*

If yes, provide shapefile of proposed survey locations to Jessie Golding (jgolding@fs.fed.us).

Will include shapefiles asap

Target Species (check all that apply)

Fisher	Lynx	Wolverine	Marten	Other
☒	☒	☒	☐	☒

If other, describe	*Mountain Red Fox if advisable….*

Survey Method (check all that apply)

Camera	Hair Snare (DNA)	Snow Track	Combination	Other
☒	☒	☒	☒	☒

If other, describe	

Program Participation

	Yes	No
Available to participate in monitoring program (check all that apply)	☒ Winter 2017/2018	☐ Winter 2017/2018
	☒ Winter 2018/2019	☐ Winter 2018/2019

Comments	

Resources to contribute (check all that apply)

Personnel Time	Housing	Snowmobile	Equipment	Other
☒	☒	☒	☒	☒

If other, describe	*1) We will continue to collaborate with Kylie Paul (formerly with Defenders of Wildlife) who is currently employed as biologist with the MPG Ranch research facility outside of Stevensville. Kylie plans to maintain her role in organizing the volunteer effort for carnivore monitoring in the Bitterroot Valley in cooperation with the Forest. She has recruited over 100 volunteers in the two previous years of the project. (also item 2 below* *2) We collect and store all of our own carrion or other bait needed for the season* 3) The Forest collects and stores all the carrion and other bait needed for the season's work. We also cooperate with Kylie in supplying bait for the monitoring stations 4) We are attempting to secure supplemental funding to help maintain the program at its current robust level

Received 08/25/2017

Multispecies Mesocarnivore Monitoring

Flathead National Forest Participation

Region

R1	R2	R4	R5	R6
☒	☐	☐	☐	☐

Forest Name

Flathead National Forest

Forest Information Needs

Species of Interest (check all that apply)

Fisher	Lynx	Wolverine	Marten	Montane Red Fox
☒	☒	☒	☒	☒

Species questions (check all that apply) Strata 1 – Swan drainage; North, Middle, and South Forks of the Flathead

Fisher	Lynx	Wolverine	Marten	Montane Red Fox
☒ Is the species present?	☐ Is the species present?	☐ Is the species present?	☐ Is the species present?	☒ Is the species present?
☐ Are multiple individuals, including females, present?	☐ Are multiple individuals, including females, present?	☒ Are multiple individuals, including females, present?	☐ Are multiple individuals, including females, present?	☐ Are multiple individuals, including females, present?
☐ Is there a reproducing population present?	☒ Is there a reproducing population present?	☒ Is there a reproducing population present?	☐ Is there a reproducing population present?	☐ Is there a reproducing population present?

Species questions (check all that apply) Strata 2 – Salish Range (Island Unit of SLRD + bulk of TLRD)

Fisher	Lynx	Wolverine	Marten	Montane Red Fox
☒ Is the species present?	☐ Is the species present?	☐ Is the species present?	☐ Is the species present?	☒ Is the species present?
☐ Are multiple individuals, including females, present?	☐ Are multiple individuals, including females, present?	☒ Are multiple individuals, including females, present?	☐ Are multiple individuals, including females, present?	☐ Are multiple individuals, including females, present?
☐ Is there a reproducing population present?	☒ Is there a reproducing population present?	☒ Is there a reproducing population present?	☐ Is there a reproducing population present?	☐ Is there a reproducing population present?

If you have additional questions, describe

Note that the questions differ by strata on Flathead NF.

Winter 2017/2018

	Yes	No
Survey planned for winter 2017/2018?	☒	☐

If yes, describe project or plan survey is associated with (if multiple please describe)	*Flathead National Forest's current and upcoming revised Long Range Management Plan* *Northwest Crown of the Continent* *Southwest Crown of the Continent*

If yes, provide shapefile of proposed survey locations to Jessie Golding (jgolding@fs.fed.us).

Will include shapefiles asap

Target Species (check all that apply)

Fisher	Lynx	Wolverine	Marten	Other
☒	☒	☒	☒	☐

If other, describe	

Survey Method (check all that apply)

Camera	Hair Snare (DNA)	Snow Track	Combination	Other
☒	☒	☐	☒	☒

If other, describe	*Backtracking for DNA if track of a target species is detected.* *Not all bait stations have remote camera sets.*

Program Participation

	Yes	No
Available to participate in monitoring program (check all that apply)	☒ Winter 2017/2018	☐ Winter 2017/2018
	☒ Winter 2018/2019	☐ Winter 2018/2019

Comments	*Our goal for 2017/2018 is to sample 10 to 30 grid cells, with a focus on Wilderness and some areas of higher likelihood for fishers.* *For both winters, there is uncertainty as to whether any appropriated funding will be available for this effort beyond salaries for permanent employees. It is relatively certain we will not have funding for the two full tech crews that would be needed to survey 60 grid cells.* *We could use help funding the crew as well as purchasing things like lure, cameras, camera cards, gun brushes, and desiccant. Help with map-making would also be appreciated.*

Resources to contribute (check all that apply)

Personnel Time	Housing	Snowmobile	Equipment	Other
☒	☐	☒	☒	☒

If other, describe	*FNF has a rich dataset of forest carnivore monitoring, particularly from 2013 to 2017, and years of experience working with the protocol, logistics, and planning. We also have (finally!) a good set of snowmobiles and trailer. We have only ~$3000 remaining in our agreement with Swan Valley Connections for the workforce, but we may be able to use get commitments for Wilderness cabins and use volunteers to accomplish some of the work.*

Received 08/21/2017

Multispecies Mesocarnivore Monitoring

Helena-Lewis and Clark National Forest Participation

Region

R1	R2	R4	R5	R6
☒	☐	☐	☐	☐

Forest Name

Helena-Lewis and Clark National Forest

Forest Information Needs

Species of Interest (check all that apply)

Fisher	Lynx	Wolverine	Marten	Montane Red Fox
☒	☒	☒	☒	☐

Species questions (check all that apply)

Fisher	Lynx	Wolverine	Marten	Montane Red Fox
☒ Is the species present?	☒ Is the species present?	☒ Is the species present?	☒ Is the species present?	☐ Is the species present?
☐ Are multiple individuals, including females, present?	☒ Are multiple individuals, including females, present?	☒ Are multiple individuals, including females, present?	☐ Are multiple individuals, including females, present?	☐ Are multiple individuals, including females, present?
☐ Is there a reproducing population present?	☒ Is there a reproducing population present?	☒ Is there a reproducing population present?	☐ Is there a reproducing population present?	☐ Is there a reproducing population present?

If you have additional questions, describe

Winter 2017/2018

	Yes	No
Survey planned for winter 2017/2018?	☐	☒

If yes, describe project or plan survey is associated with (if multiple please describe)

If yes, provide shapefile of proposed survey locations to Jessie Golding (jgolding@fs.fed.us).

Target Species (check all that apply)

Fisher	Lynx	Wolverine	Marten	Other
☐	☐	☐	☐	☐

If other, describe	

Survey Method (check all that apply)

Camera	Hair Snare (DNA)	Snow Track	Combination	Other
☐	☐	☐	☐	☐

If other, describe	

Program Participation

	Yes	No
Available to participate in monitoring program (check all that apply)	☒ Winter 2017/2018	☐ Winter 2017/2018
	☒ Winter 2018/2019	☐ Winter 2018/2019

Comments	*Our ability to participate will be funding dependent.*

Resources to contribute (check all that apply)

Personnel Time	Housing	Snowmobile	Equipment	Other
☒	☒	☒	☒	☐

If other, describe	*The availability of resources will depend on the funding and availability at the time of need (e.g. snowmobiles) and how this will fit with other Forest priorities. Ideally, we would have some personnel and equipment/snowmobile to assist.*

Received 08/25/2017

Multispecies Mesocarnivore Monitoring

Kootenai National Forest Participation

Region

R1	R2	R4	R5	R6
☒	☐	☐	☐	☐

Forest Name

Kootenai National Forest

Forest Information Needs

Species of Interest (check all that apply)

Fisher	Lynx	Wolverine	Marten	Montane Red Fox
☒	☒	☒	☒	☐

Species questions (check all that apply)

Fisher	Lynx	Wolverine	Marten	Montane Red Fox
☒ Is the species present?	☒ Is the species present?	☐ Is the species present?	☐ Is the species present?	☒ Is the species present?
☒ Are multiple individuals, including females, present?	☐ Are multiple individuals, including females, present?	☒ Are multiple individuals, including females, present?	☐ Are multiple individuals, including females, present?	☐ Are multiple individuals, including females, present?
☐ Is there a reproducing population present?	☒ Is there a reproducing population present?	☐ Is there a reproducing population present?	☒ Is there a reproducing population present?	☐ Is there a reproducing population present?

If you have additional questions, describe

Winter 2017/2018

	Yes	No
Survey planned for winter 2017/2018?	☒	☐

If yes, describe project or plan survey is associated with (if multiple please describe)	*Contingent on other work priorities and staff availability Cabinet Ranger District personnel will place and run approximately 8 remote camera/hair snare sets (4 cameras which each run 2 months at a set) from December 2017 to March 2018. Our current protocol is consistent with that used by the Multistate Wolverine Survey in 2017/18 and for over a decade on the Ranger District. The exact locations of sets and methodology could be coordinated with RMRS, with the caveat that some effort be focused on existing or proposed future project areas for vegetation management.*

If yes, provide shapefile of proposed survey locations to Jessie Golding (jgolding@fs.fed.us).

Exact sampling sites still to be determined.

Target Species (check all that apply)

Fisher	Lynx	Wolverine	Marten	Other
☒	☒	☒	☒	☒

If other, describe	*Wolf, mountain lion, bobcat.*

Survey Method (check all that apply)

Camera	Hair Snare (DNA)	Snow Track	Combination	Other
☒	☒	☐	☒	☒

If other, describe	

Program Participation

	Yes	No
Available to participate in monitoring program (check all that apply)	☒ Winter 2017/2018	☐ Winter 2017/2018
	☒ Winter 2018/2019	☐ Winter 2018/2019

Comments	*At least one district may have snowmobiles available. Additionally, at least one work center may be available for lodging, although there are costs associated with plowing, etc. Plus, it would require reservations because other groups use our work center as well. We'd all need to discuss further to see if it'll work for the your crews. We are unable to provide much personnel time. At best, we may be able to spare our district bios to assist for a couple days each. There may be opportunities to use volunteers from some of our local non-governmental organizations (Yaak Valley Forest Council, Friends of Scotchman Peaks Wilderness, etc). We'd need more info on what the workload and expectations are in order to better understand how we may be able to assist.*

Resources to contribute (check all that apply)

Personnel Time	Housing	Snowmobile	Equipment	Other
☒	☒	☒	☐	☐

If other, describe	

Appendix E: Example Multispecies Mesocarnivore Monitoring Form

The following is a hypothetical example of monitoring on the Bitterroot National Forest over a 4-year period with the GEM monitoring approach for fishers, lynx, and wolverines. It does not reflect any real monitoring or species occurrence data and is not intended to be a representation of what is present on the Bitterroot National Forest.

For all maps, habitat is grouped by areas of ≥0.25 value from Olson et al. (2014) and areas within 2 km of those patches (half of a small fisher home range [16 km^2] radius). Only groups ≥16 km^2 are included.

The 15 km × 15 km (225 km^2) grid cells selected were based on cells with ≥25 percent or more wolverine habitat.

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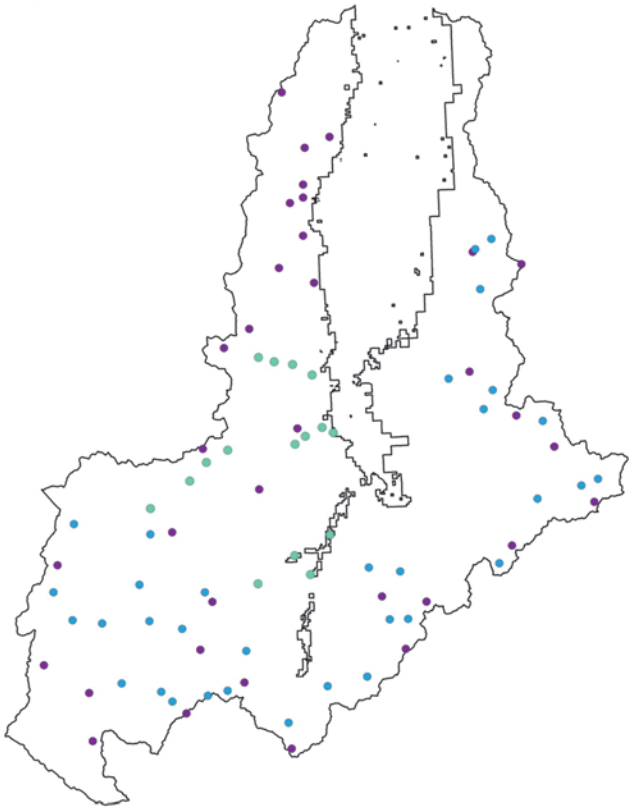
USDA Forest Service (USFS). 2014. Lynx monitoring protocol in unoccupied lynx habitat. Unpublished report on file with: U.S. Department of Agriculture, Forest Service, Northern Region, Missoula, MT. 2 p.

Winter 2017–2018 Survey Plan



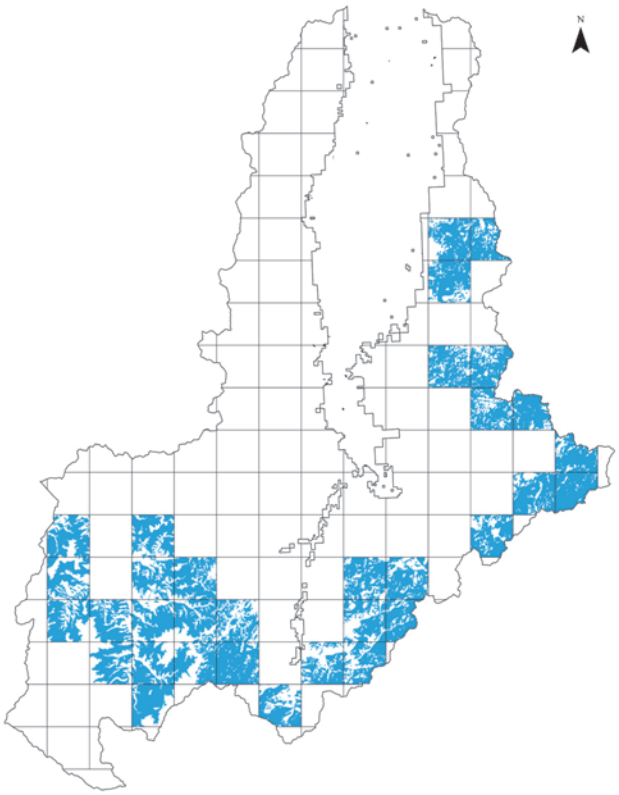
Survey details

Symbol	Species	Question	Certainty	Target state	Number of sites	Method
	Fisher	Are multiple individuals of a single sex present?	95%	Multiple individuals (♂ or ♀)	16	Hair snare: 16 Visit repeats: 3
	Lynx	Are lynx present?	95%	Not present	33	Snow track: 33 Track repeats: 3
	Wolverine	Are multiple individuals, including both sexes, present?	95%	Multiple individuals (♂ + ♀)	30	Hair snare: 30 Visit repeats: 2

Fisher Details

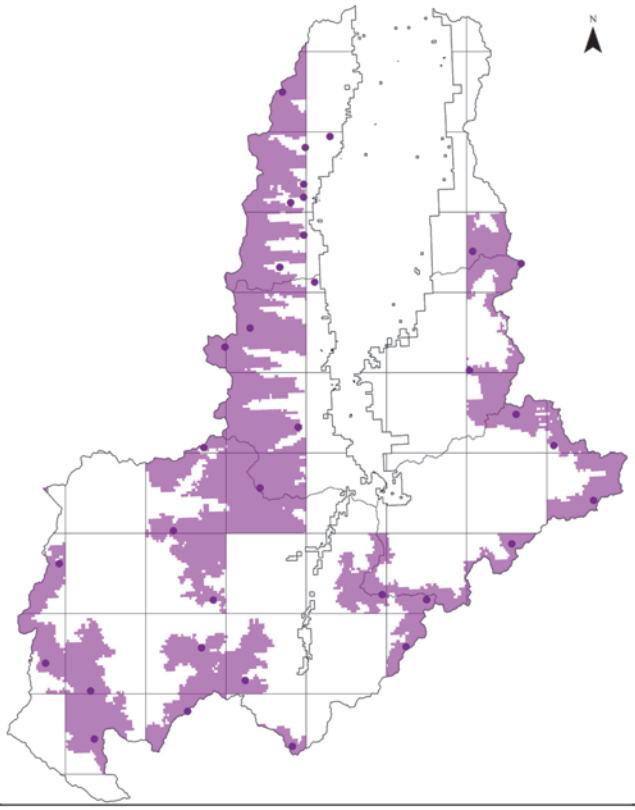
Survey details						
Symbol	**Meaning**	**Method**	**Repeats**	**Frequency**	**Target information**	**Notes**
	Fisher survey location	Hair snare	3	~3 weeks	Individual identification	Fisher hair snare boxes per Schwartz et al. (2007) protocol preferred, but multispecies bait station may be used.
	Fisher habitat	Olson et al. 2014				Habitat grouped by areas of 0.25 value or above from Olson et al. (2014) and areas within 2 km of those patches (half of a small fisher home range [16km^2] radius). Groups that are not at least 16km^2 removed.

Lynx Details



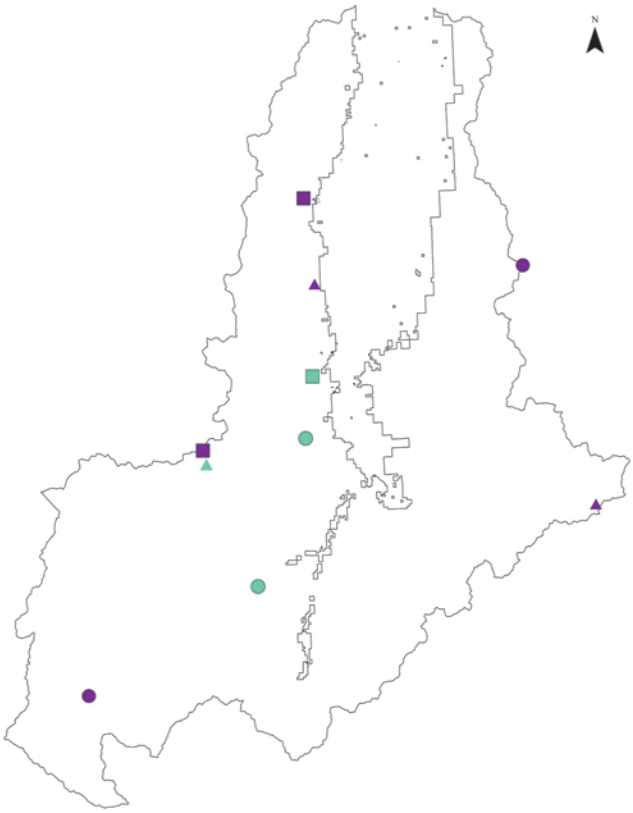
Survey details						
Symbol	Meaning	Method	Repeats	Frequency	Target Information	Notes
	Lynx survey cell	Snow track	3	Snow dependent	Species identification	Snow tracking according to Squires et al. 2004 protocol and USFS 2014 Lynx Monitoring Protocol in Unoccupied Lynx Habitat.
	Lynx habitat	USFS and USFWS 2006				Habitat raster from 2006 amendment to the Lynx Conservation Agreement (Figure 1-1) (USFS and USFWS 2006).
	Lynx grid cell	Squires et al. 2004				8 km x 8 km (64 km^2) grid cell based on lynx home range size (Squires et al. 2004).

Wolverine Details

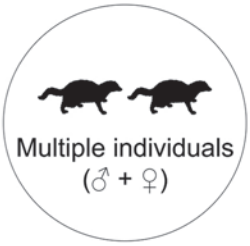
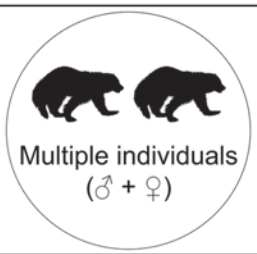


Survey details						
Symbol	Meaning	Method	Repeats	Frequency	Target information	Notes
	Wolverine survey location	Hair snare	3	~3 weeks	Individual identification Sex identification	Multispecies bait station with camera.
	Wolverine habitat	Copeland et al. 2010				15 km x 15 km (225 km^2) grid cells selected based on cells with 25% or more wolverine habitat.
	Wolverine grid cell					15 km x 15 km (225 km^2) grid cells based on wolverine home range size.

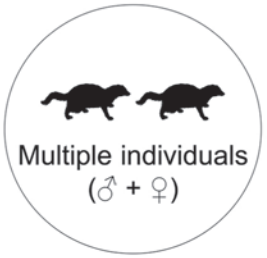
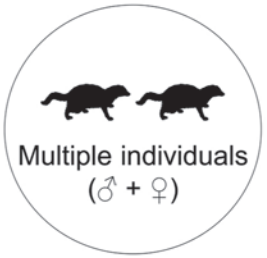
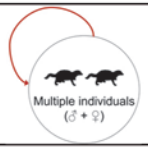
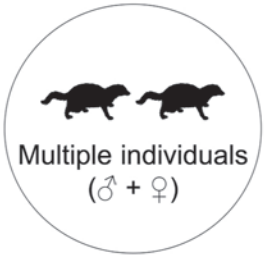
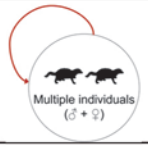
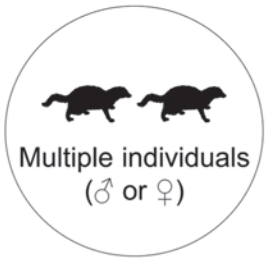
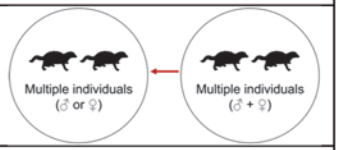
Example Winter 2017–2018 Survey Results



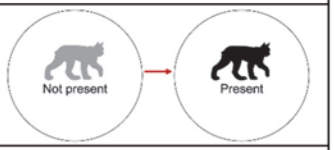
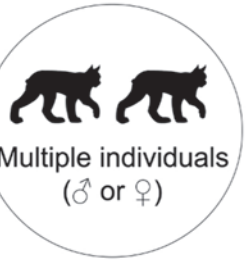
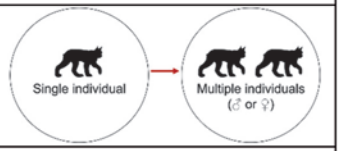
Survey result details

Symbol	Meaning	Species	Question	# Detections	State
	Species identification Female identification Male identification	Fisher	Are multiple individuals of a single sex present?	4	 Multiple individuals (♂ + ♀)
	NA	Lynx	Are lynx present	0	Not present
	Species identification Female identification Male identification	Wolverine	Are multiple individuals, including both sexes, present?	6	 Multiple individuals (♂ + ♀)

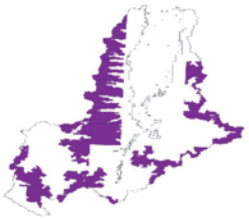
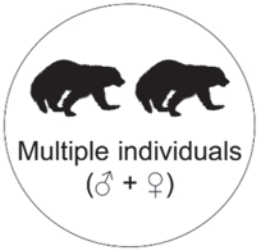
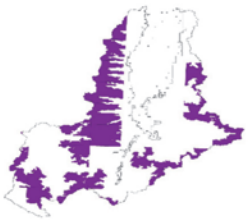
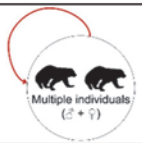
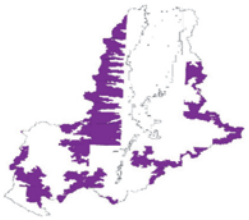
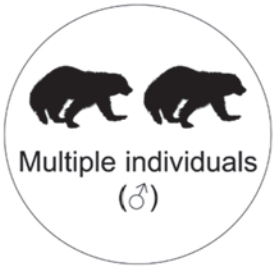
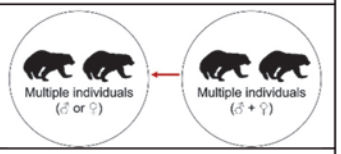
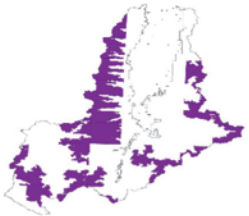
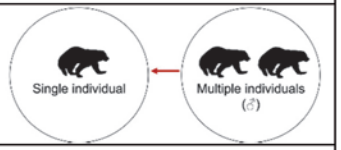
Example Cumulative Fisher Results 2017–2020

Year	Monitoring question	Possible states (existing knowledge)	Sampled area	Detected state (survey)	Possible states (after survey)	Knowledge accumulation or monitoring	Possible or known transitions
2017	Are multiple individuals of a single sex present?	Single individual Multiple individuals (♂ or ♀) Multiple individuals (♂ + ♀)			Multiple individuals (♂ + ♀)	Monitoring	2017–2018
2018	Are multiple individuals, including both sexes, present?	Multiple individuals (♂ or ♀) Multiple individuals (♂ + ♀)			Multiple individuals (♂ + ♀)	Monitoring	 2018–2019
2019	Are multiple individuals, including both sexes, present?	Multiple individuals (♂ or ♀) Multiple individuals (♂ + ♀)			Multiple individuals (♂ + ♀)	Monitoring	 2019–2020
2020	Are multiple individuals, including both sexes, present?	Multiple individuals (♂ or ♀) Multiple individuals (♂ + ♀)			Multiple individuals (♂)	Monitoring	

Example Cumulative Lynx Results 2017–2020

Year	Monitoring question	Possible states (existing knowledge)	Sampled area	Detected state (survey)	Possible states (after survey)	Knowledge accumulation or monitoring	Possible or known transitions
2017	Are lynx present?	Present Not present			Not Present	Knowledge accumulation	2017–2018
2018	Are lynx present?	Present Not present			Present	Monitoring	 2018–2019
2019	Are multiple individuals of a single sex present?	Single individual Multiple individuals (♂ or ♀) Multiple individuals (♂ + ♀)			Single individual	Knowledge accumulation	Stayed as single individual Multiple individuals (single sex) to single individual 2019–2020
2020	Are multiple individuals of a single sex present?	Single individual Multiple individuals (♂ or ♀)			Multiple individuals (♂ or ♀)	Monitoring	

Example Cumulative Wolverine Results 2017–2020

Year	Monitoring question	Possible states (existing knowledge)	Sampled area	Detected state (survey)	Possible states (after survey)	Knowledge accumulation or monitoring	Possible or known transitions
2017	Are multiple individuals, including both sexes, present?	Single individual Multiple individuals (♂ or ♀) Multiple individuals (♂ + ♀)			Multiple individuals (♂ + ♀)	Monitoring	2017–2018
2018	Are multiple individuals, including both sexes, present?	Multiple individuals (♂ or ♀) Multiple individuals (♂ + ♀)			Multiple individuals (♂ + ♀)	Monitoring	 2018–2019
2019	Are multiple individuals, including both sexes, present?	Multiple individuals (♂ or ♀) Multiple individuals (♂ + ♀)			Multiple individuals (♂)	Knowledge accumulation	 2019–2020
2020	Are multiple individuals, including both sexes, present?	Single individual Multiple individuals (♂ or ♀) Multiple individuals (♂ + ♀)			Single individual	Monitoring	

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