VIRGINIA DEPARTMENT OF WILDLIFE RESOURCES

2025-2029 BLACK BEAR MANGE MANAGEMENT PLAN

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Primary contributors to this plan include the following Virginia Department of Wildlife Resources Staff:

John Tracey, DVM
Nelson Lafon, MS
Katie Martin, MS
Carl Tugend, MS
Cale Godfrey, MS

Several other staff members from the wildlife division provided written feedback.

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Jen Riley, DVM; Blue Ridge Wildlife Center
Jon Cooper; VDWR Board Member
North Carolina Wildlife Resources Commission; Internal Bear Mange Committee lead by Colleen Olfenbuttel, MS and Miranda Turner, MS
Scott Carver, PhD; University of Georgia

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Executive Summary

Mange, a highly contagious skin disease caused by mites, affects many wild and domestic mammals. Sarcoptic mange caused by *Sarcoptes scabiei* is implicated most often in Virginia's bears. From 2014 to 2018, sporadic reports of bear mange in Virginia were primarily focused in the northern Shenandoah Valley (close to known distributions in West Virginia, Maryland, and Pennsylvania). Since 2020, reports have increased in frequency and geographic spread, with 27 counties having at least 3 cases and 33 counties having at least one case. There are many unknowns related to the occurrence and spread of mange in bears. Clinical signs can include itching, hair loss, thickened and dry skin, altered behavior, and poor body condition in severe cases. Research and experience has shown that many bears with mild to moderate cases can survive and clear symptoms of mange. There has been no clear evidence from other states with longer histories with sarcoptic mange that the disease limits bear populations over the long-term. However, localized population declines have been observed recently in some mange-affected areas of Virginia, particularly in counties with historically liberal harvest seasons.

With a primary goal of long-term population viability, Virginia Department of Wildlife Resources (VDWR) recognizes that it must utilize an adaptive management framework to address the imperfect knowledge about mange in bears. Informed by the 2023-2032 Virginia Bear Management Plan, goals for the management of bear mange in Virginia include:

1) implementing science-based surveillance and management techniques,
2) managing for resilient populations of black bears affected by sarcoptic mange,
3) identifying and addressing critical knowledge gaps, and
4) communicating effectively with constituents and fostering citizen science opportunities.

This management plan is structured around these four goals. Objectives developed to guide the attainment of each goal are followed by potential strategies that clarify approaches or actions that can be taken.

<u>Surveillance and Monitoring</u>

To date, the majority of VDWR's surveillance for sarcoptic mange has been from opportunistic investigations of bears with suspicious clinical signs reported by members of the public or hunting communities. Strategies going forward will continue to leverage public reports and citizen science to track the status of the disease, both in bears and wild canids. More active (and costly) surveillance methods are required to answer important epidemiological questions like prevalence/incidence rates of disease, impacts to

populations, and changing host: parasite dynamics. This plan includes objectives and strategies to address:

- standard data collection and response protocols,
- comprehensive statewide surveillance for mange in bears, and
- surveillance for mange in other wildlife species.

Management & Response

Control measures that are both cost-effective and likely to be helpful should be evaluated and implemented, but it is important to acknowledge that no "silver bullets" currently exist. Eradication of mange in free-ranging species with robust populations has not been successful and is not a practical, cost-effective goal. This plan includes objectives and strategies to address:

- removal of severely infested bears,
- transmission of mange, and
- bear population management in the face of mange.

Research

For over a decade, VDWR has participated in research efforts within Virginia and across multiple other affected states to better understand mange in bears. This plan includes objectives and strategies to address future research opportunities, limitations, and hurdles.

Communication & Outreach

Since 2014, when the current sarcoptic mange outbreak in bears began in Virginia, a central component of VDWR's efforts related to mange has been outreach and communication with the general public, interested hunters and landowners, and external partners and agencies within Virginia and regionally. This plan includes objectives and strategies to address:

- public awareness of mange,
- engagement of constituents in surveillance and management, and
- inter- and intra-agency understanding of mange.

Introduction

Mange is a highly contagious skin disease caused by microscopic mites affecting many wild and domestic mammals. At least four different mite species have been reported in bears (see Appendix 2); however, sarcoptic mange caused by the skin-burrowing mite *Sarcoptes scabiei* causes the most clinical disease in Virginia. This widespread mite species causes sarcoptic mange in a variety of mammalian hosts, including scabies in humans, and several host-adapted variants (e.g. canis, hominis, suis, etc.) are thought to exist. To date, current evidence from Virginia suggests that the mite and the host species (bears, wild canids) are genetically the same as those in other states in the region, including West Virginia, Maryland, and Pennsylvania. In the 1990's, sarcoptic mange emerged as a significant concern for bears in Pennsylvania and has radiated outward to other contiguous bear populations. From 2014 to 2018, sporadic cases of sarcoptic mange began to show up in the several of Virginia's northwestern mountain counties. Since 2020, reports have greatly increased in frequency and geographic spread, with at least 33 counties now with at least one case.

Currently, there are many unknowns related to the presence and spread of mange in bears, and research efforts are underway to understand these processes. Mites are easily transferred to a new host when an unaffected animal comes into direct physical contact with an infested individual. In addition, mites that fall off an infested host can persist in the environment under ideal conditions for up to two weeks and may infect a new animal that enters a contaminated site. Because bears are relatively solitary, the biggest risk for indirect environmental transmission likely occurs under conditions where they congregate, either naturally (e.g. dens, mating, scent-marking) or unnaturally (e.g. garbage cans, bait piles, bird feeders, and other food resources).

The clinical signs of mange are a result of damage to the host's skin by the burrowing mite, the immune reaction of the host, the physical skin trauma that occurs through scratching, and the secondary bacterial infections that subsequently develop. Clinical signs are variable but can include intense itching, mild to severe hair loss, thickened or dry skin covered by scabs or tan crusts, altered behavior (e.g. lethargy) and poor body condition in severe cases. Research primarily done in Pennsylvania has shown that many bears with mild to moderate cases survive and clear symptoms of mange (Tiffin et al 2024). Bears exhibiting signs of a late-stage mange infestation are often very noticeable to the public due to their poor skin and body condition, their inability to find sufficient resources (food or shelter) in their natural environments, and their propensity to inhabit residential areas or man-made structures.

Although mange is a cause of mortality in black bears, there has been no clear evidence from other states with longer histories of mange in bears that the disease limits populations over the long-term (personal conversations with bear and health teams in PA & WV). However, localized population declines have been observed recently in some mange-affected areas of Virginia, particularly in counties with historically liberal harvest seasons. A multitude of factors including increased harvest seasons to achieve publicly-desired population reductions, successive years of poor hard mast production (primarily red and white oaks), and increased winter temperatures, along with the expansion of mange in bears, have likely all contributed to declining trends in several of Virginia's bear management zones. Research projects with Virginia Tech are currently being conducted to provide information on survival, movements, transmission routes, and potential susceptibility of certain bear populations in Virginia.

VDWR takes sarcoptic mange seriously and is concerned about potential population-level impacts as well as individual bear welfare. For unknown reasons, mange appears to be demonstrating higher case rates and faster spread in Virginia than in some other states despite apparent similarities with regards to hosts, mites, and other disease dynamics. Long-term prospects are for the disease to likely remain endemic in areas already affected and for continued geographic expansion.

With a primary goal of long-term population viability, VDWR recognizes that it must manage this disease to the best of its abilities despite incomplete knowledge of disease processes, extrapolating from existing knowledge about bear biology and sarcoptic mange epidemiology in other species. VDWR is incorporating an adaptive management framework into its approach to wildlife disease management (including mange in bears and chronic wasting disease in deer) which facilitates learning from prior management decisions and allows flexibility to change disease management strategies based upon effectiveness,, emergence of new information, and public acceptance. Using an adaptive management framework, future bear management decisions may be influenced by new and ongoing research aimed at demonstrating how mange spreads on the landscape and evaluating the effectiveness of mange management actions in Virginia and elsewhere.

Goals

The 2023-2032 Virginia Bear Management Plan contains direction regarding surveillance and management of mange and other diseases in bears that informed the development of this mange management plan. The Population Viability goal includes objectives and strategies related to determining and addressing risk factors to long-term bear population viability. The Population and Carrying Capacity goal in the bear plan includes objectives and strategies for assessing and meeting bear population objectives in each zone across the state. The Bear Health and Welfare goal includes objectives and strategies for monitoring of diseases to determine impacts on the health and welfare of individual bears and on bear populations; implementing applicable management actions to reduce impacts of disease on bear health and populations; and, increasing public awareness regarding bear diseases that may impact the health of bears, humans, and/or other wild or domestic animals.

The goals of the VDWR, as they pertain to management of mange in bears, are as follows:

i. Implement science-based surveillance and management techniques and continually adapt as more is learned.
ii. Manage for resilient populations of black bears affected by sarcoptic mange to ensure sustained use and conservation of the resource.
iii. Identify critical knowledge gaps and address them through professional networks and research efforts.
iv. Communicate broadly and effectively with constituents and foster citizen science opportunities.

Section 1: Surveillance and Monitoring

<u>Overview</u>

Surveillance programs for wildlife diseases can utilize passive (opportunistic) or active (systematic) strategies (Mörner et al 2002, Artois et al 2009). To date, the majority of VDWR's surveillance for sarcoptic mange has been from the opportunistic investigations of suspect bears reported by members of the public or hunting communities. These reports are invaluable for tracking the general progression and trends of the disease, but are skewed by numerous factors, including the visibility of certain bears or their proximity to humans, variable human population densities, time of year, and even the willingness of the public to report to VDWR. Active surveillance methods are required to answer important epidemiological questions like prevalence/incidence rates, impacts to populations, and changing host:parasite dynamics. But due to the high costs and logistical hurdles of many active methods, they are infrequently employed over large geographic areas or long time periods. Going forward, a robust surveillance program for sarcoptic mange in bears and other affected hosts in Virginia will require integrating passive and active surveillance approaches that form a comprehensive, statewide mange reporting network, supplemented by targeted, short-term projects designed to answer specific questions, and longer-term, intensive monitoring of certain populations or metrics.

Objective 1: Standardize and objectify mange data collection and response protocols.

Strategy 1: Develop and implement a case severity grading system based on recognizable clinical signs.

Clinical signs of sarcoptic mange include alopecia, hyperkeratosis, erythema, and intense pruritus. These are often first noted on the head and face but can begin anywhere on the body. The skin then becomes thickened, fissured, and lichenified, providing opportunity for secondary bacterial and yeast infections. Immune system hypersensitivity responses to antigens in the mites and their by-products are likely responsible for the widespread skin pathology. The secondary infections and intense pruritus can then lead to further behavioral changes, thermoregulatory compromise, loss of body condition, and death. Severely affected individuals are often emaciated. (Niedringhaus et al 2019) (Appendix 3)

A case severity definition that can be applied objectively by trained individuals offers an opportunity to standardize case data and responses. Several researchers have created matrix scoring systems to grade case severity in bears based on 1) hair loss, 2) skin condition, and 3) body condition (Tiffin 2022, Francisco et al unpublished). Similarly, since 2014 VDWR has collected data on these variables as well as the behavioral status of suspected mange cases in bears. To standardize case severity of mange affected bears in Virginia and ensure consistent responses, VDWR will develop a scoring system using a combination of these variable as well as time of year. Within the scoring matrix, body condition will carry more weight than the other scoring variables as body condition appears to correlate more strongly with survival than any of the other factors (Tiffin 2022). While data on skin condition will continue to be assessed, determining pathology through photographs or observations from afar can be difficult; thus, skin condition will not be incorporated into a dispatch or euthanasia protocol, but only scored if an animal is handled.

Strategy 2: Establish consistent individual and geographical case definitions.

Although clinical signs (especially in severe cases) are highly suggestive of sarcoptic mange (Brewster et al 2013, Valldeperes et al 2019), there are other causes of alopecia and skin disease that can be misdiagnosed as sarcoptic mange (Appendix 3). There are other mite species that can live on bears (Appendix 2) so it is imperative that proper identification be obtained. *Ursicoptes americanus* mites appear to be more prevalent on bears than originally thought and co-infections with *S. scabiei* have been documented

(Broadhurst et al 2025). Definitive diagnosis of sarcoptic mange requires recovering *S.scabiei* mites from the skin of infested animals through skin scraping or skin biopsy procedures, then confirming the species through microscopic identification of characteristic mite morphology or molecularly via polymerase chain reaction (PCR). Mange can also be confirmed through histopathological examination of skin biopsies by a veterinary pathologist, but mite speciation may not always be possible with this method (Peltier et al 2018). Although microscopic examination is relatively quick and inexpensive, it requires training to perform correctly. Thus, only confident, trained VDWR staff or referral laboratories will be used to "confirm" a suspected case.

Utilizing the clinical signs and diagnostic procedures described above, the following case definitions will be established:

- Sarcoptic mange confirmed
    - Cases will only be considered confirmed if *S. scabiei* mites are verified through microscopic identification by trained individuals, PCR, or histologically.
    - Although subclinical cases of sarcoptic mange have not been witnessed in bears, it is theoretically possible that a case could be confirmed despite no clinical signs.
- Sarcoptic mange suspected, but unconfirmed
    - If quality photographs or game camera images are received that clearly exhibit clinical signs consistent with sarcoptic mange, then the case will be considered suspect.
    - Suspected cases *will be* counted and included in epidemiological and statistical analyses, consistent with previous VDWR case reporting.
- Sarcoptic mange possible
    - This case definition is reserved for reports that could be consistent with mange but exhibit a lack of confidence in the diagnosis. Some examples of possible cases include:
        - Poor quality or long-distance images provided by the public in which clinical signs may be evident but are difficult to discern.
        - A bear exhibiting symptoms that are consistent with numerous causes and no further diagnostics are able to be performed (ex: photos showing mild crusting of the ear tips or mild alopecia).
    - Possible cases *will not* be counted for epidemiological or statistical purposes.

Using confirmed cases, the opportunity exists to study the validity of using photos and observational tools for diagnosis, allowing for further refinement of the case definitions.

Spread of the disease will be tracked at the smallest geographic resolution as possible (ideally GPS location or address) and status of the disease will generally be reported at the county level, using the following designations:

- Mange affected county
  - A county that has had 3 confirmed and/or suspected cases in a single year or 5 confirmed and/or suspected cases in 3 years.
  - This is the designation that VDWR has employed since 2014 and will be retained for consistency purposes.
  - Previous experience has demonstrated that a single mange case in a location far from affected areas does not necessarily "seed" the disease in the bear population (see maps in Appendix 1).
- Mange emerging county
  - A county that is adjacent to a mange affected county *and* has had at least one confirmed or suspected case.
  - These counties are likely to see additional cases in the near future.
- Mange status unknown county
  - A county that does not meet either of the above definitions.
  - This designation would include counties with no confirmed detections as well as counties with single detections that are disjunct from mange effected or emerging counties.

Separating emerging from affected counties allows for varying levels of surveillance or management effort to be applied. As an example, response protocols could focus confirmatory diagnostic tools on emerging and unknown counties. While there are currently no differences in management strategies based on county mange status designations, future protocols might look different in affected vs emerging counties.

Strategy 3: Refine data collection and database management techniques focused on maintaining a usable, complete, long-term data set.

Since the emergence of mange in Virginia's bears, case data has been stored in several spreadsheets and Survey 123 datasets which contain inconsistencies in exactly what was collected and how it is stored. Much of the above discussion in Strategies 1 & 2 seeks to identify what data should be collected, but challenges still exist with how and where to store that data.

In order to accurately categorize and share Virginia's experience with other states and researchers, finding a comprehensive, consistent, long-term mange data solution should be a high priority for VDWR's wildlife health and bear teams.

Objective 2: Perform comprehensive statewide mange surveillance in bears using a combination of active and passive methods.

Strategy 1: Continue to leverage reports from the public to track the status of the disease.

As stated above, this technique has been the primary method for tracking disease progression within Virginia and despite inherent biases, is still a valuable surveillance tool.

Reporting mechanisms currently in place include:

- USDA-WS Virginia Wildlife Conflict Helpline (Tollfree, operates M-F, 8AM-4:30PM)
  - This is the primary route from which mange reports are currently received by VDWR. Reports from the Helpline are sent directly via email to the VDWR bear team and the local district wildlife biologist for assessment.
- VDWR Dispatch Center (Operates 24/7, primarily for law enforcement communication)
  - When the dispatch center receives a call for service that references a bear with mange, it is referred to the USDA-WS Helpline, local Conservation Police Officer (CPO), and/or District Wildlife Biologist for the area from which the call was received.
- Email Reporting (Wildlife health, General VDWR, Bear Mange)
  - There are several VDWR email boxes that have been used to report mange including the general VDWR information (wildlife@dwr.virginia.gov), wildlife health (wildlifehealth@dwr.virginia.gov), and bear mange reporting (bearmange@dwr.virginia.gov) email boxes.
  - These mailboxes are monitored by various staff and reports are directed to the appropriate local staff member. Email reporting is not intended for situations involving an emergency response.
  - The Bear Mange mailbox was set up primarily for the reporting of harvested mange bears during an open hunting season but frequently receives general reports of mange affected bears outside of hunting seasons.

Additional reporting Mechanisms in Progress:

- After-hours phone access to a conflict specialist.

    - Beginning in the fall of 2025, a human-wildlife conflict specialist will begin duties which include taking after- hours and weekend reports of mange affected bears.
    - Calls will continue to be directed to the USDA-WS Virginia Conflict Helpline where a voicemail can be left for the conflict specialist. The conflict specialist will have access to monitor these calls/voicemails during evenings and weekends and provide a response (when needed) for severely mange affected bears.
- Online Reporting Option
    - Expansion of an online disease reporting system interface is in development. This system is part of a broader effort to better capture disease incidents for all wildlife across Virginia.

Strategy 2: Engage interested constituents in citizen science.

Fostering engagement from interested constituents can add valuable data and build trust with VDWR. Listed below are some examples of citizen science projects VDWR is currently pursuing or plans to pursue.

- Hunter log and general public observation form
    - A general bear observation form was created and distributed to interested constituencies. This voluntary survey collects date, location (as precise as possible), and number of bears observed. Observations of both healthy bears and mange affected bears can be reported on the observation form.
    - A bear hunter-specific observation form was created and distributed prior to the beginning of the August bear chase season in 2025. This voluntary form asks participants to record bear observations along with hunt metrics such as hunt duration, use of hounds, weaponry, and harvest. Surveys such as these are helpful for gaining hunter effort data along with observations of healthy and mange affected animals.
- Tissue sampling of hunter-harvested bears
    - Annually, over 2,000 black bears are hunter-harvested in Virginia with the most recent 3-year average being 2,630 bears (2022-2024). While physical harvest check stations are no longer operated, hunter participation in sampling efforts for disease surveillance in other species (e.g. white-tailed deer) has remained a valuable tool through both voluntary and mandatory efforts.
    - Biological tissue samples such as muscle, hair, tooth, liver, and blood are all valuable samples that can be readily collected and stored from hunter-

harvested bears. Additionally, skin scrapes and/or skin biopsies could provide valuable information from both mange affected and non-affected bears.

- Genetic analyses, including landscape-level gene flow, toxin exposure (e.g. rodenticides), mange exposure (antibody presence), and mange mite or other parasite identification are a few of the analyses that could be run from the aforementioned samples. Additionally, sample banking, particularly of bears in current non-mange affected areas, will be critical for future comparisons and analyses. Future funding for genetic or other analytical work will be crucial to continue understanding mange and its impacts on black bears.
- Consistent metadata (e.g. harvest date and county) are available for hunter-harvested bears and ideally, hunters would willingly provide more specific harvest location information.
- VDWR staff will collaborate with bear hunters to identify practical sample collection methodologies.

Strategy 3: Utilize trail camera grid surveys to evaluate disease status and progression.

Due to the visible nature of mange, trail camera surveys utilizing randomized grids across bear home ranges may be a useful tool for monitoring disease presence and prevalence on the landscape. Camera grids have previously been used for active mange surveillance in other host species (Brewster et al 2017, Ringwaldt et al 2023). Pairing camera arrays with occupancy modeling frameworks (Appendix 7) could allow for the creation of mange detection heat maps, "severity" scoring, and the ability to analyze disease presence with covariates such as habitat (cover types, elevation, aspect), disturbance (distance to roads, human habitation), and site occupancy by other potential mange affected species (e.g. canids).

- Two large camera grids have been deployed as part of a bear spatially explicit mark-recapture population study in collaboration with Virginia Tech (Appendix 5) and images from these grids are currently being evaluated using occupancy modeling. Ideally, at the conclusion of this project, these pre-existing camera grids could be utilized for long-term monitoring and the refinement of statistical methods.
- An ~80 camera grid was deployed in several mange affected (endemic) counties along the northern part of the Blue Ridge in summer 2025. This camera grid will be utilized for a minimum of 2 field seasons (preferably 3) to determine occupancy, habitat use, and detection probability in this area which has demonstrated declining bear population trends in recent years.

Strategy 4: Continue to trap, collar, and study appropriate bears or mange cases, as funding and staff resources allow.

- Outside of defined research projects, opportunistic trapping of mange affected bears and monitoring with the use of GPS enabled collars can provide additional survival, movement, and reproductive data that will continue to build on project datasets. Opportunistic trapping events can occur at any time of year (although primarily outside of open hunting seasons due to drug withdrawal periods) affording opportunities to provide additional insight into disease progression and survival.
- Opportunistic trapping/collaring will most likely occur following public reporting of a mange affected bear. Thus, these trapping events may be more likely to occur in developed landscapes with more wildlife-urban interface as compared to existing research trapping efforts currently occurring in more rural settings (e.g. National Forest, Wildlife Management Areas). This will offer additional insights into the potential use of anthropomorphic food sources and developed areas by mange affected bears.
- The use of GPS collars to monitor female bears of reproductive age will be especially important to determine future fecundity rates which directly impact population dynamics. Modern GPS collars typically last 3 to 4 years in the field, allowing for long term monitoring over multiple reproductive cycles.
- Additional research needs are outlined in the research section below and include opportunities for continued monitoring of mange and non-mange affected bears across the state. However, it needs to be recognized that trapping and monitoring of collared bears requires funds and staff resources that will not always be available.

<u>Objective 3: Perform adequate surveillance for mange in other wildlife species.</u>

The early history of mange in North American wildlife is centered around wild canids and is discussed in Appendix 1. Although documentation of the early cases in Virginia's canids is lacking, it has likely existed for over half a century. Currently, red foxes (*Vulpes vulpes)* and coyotes (*Canis latrans*) are the sympatric hosts currently most affected in Virginia (Kelly & Sleeman 2003, VDWR anecdotal data). Other mammalian hosts in Virginia that have published records of sarcoptic mange elsewhere in North America include racoons, fishers, fox squirrels, house mice, feral swine, porcupines, and white-tailed deer (Niedringhaus et al 2019).

Genetic characterization has revealed that the mites found on both bears and canids in the mid-Atlantic region are genetically similar (Peltier et al 2017, Francisco unpublished). The role other hosts might currently play in the transmission and maintenance of the disease in bears is poorly understood, but despite the disease existing statewide in canids for decades, transmission to bears rarely, if ever occurred. Before the emergence of the sarcoptic mange in Virginia's bears in 2014, the disease was only confirmed in one bear (Appendix 1). More information about the disease in sympatric hosts that overlap with bears is needed to elucidate what role they play in the transmission and maintenance of the disease in bears.

Strategy 1: Centralize and standardize all potential reports of mange in Virginia's wildlife.

To track epizootics and spatiotemporal data of mange in wild canids and other wildlife species, VDWR will begin centralizing and standardizing data from public reports of suspected mange events. These reports could be solicited and obtained from the same reporting methodologies as discussed in the bear surveillance section above. VDWR currently receives suspected mange reports from a number of these outlets, but placing an emphasis on the collection of sufficient metadata and centralizing reports will be necessary to allow for review and potential statistical evaluation. Since witnessing mange in wild canids (especially red foxes) has been common for so long, undoubtedly many observations go unreported and constituent outreach will be necessary to encourage reporting.

Additionally, there are numerous partner organizations and constituent groups who interact with wildlife afflicted with mange, including VDWR licensed recreational trappers, VDWR permitted wildlife rehabilitators and nuisance wildlife control operators, USDA-Wildlife Services staff, and county animal control operators. All of these groups could be regularly surveyed to discover regional trends. Larger wildlife rehabilitation facilities often have excellent, databased clinical records that could be regularly filtered and obtained.

Strategy 2: Leverage trail camera grid surveys to evaluate mange status.

As discussed above in Objective 2, Strategy 3, standardized camera grids can be used to determine disease status and even estimate prevalence within several host species. Occupancy modeling is currently being performed utilizing images from two Virginia Tech research grids. Research grids for unrelated studies can even provide insight into specific locations and times. For example, photos from a large chronic wasting disease project in

Arkansas have been used to analyze mange in numerous species (Jorge personal communication).

Strategy 3: Continue to contribute to the genetic and biogeographical understanding of Sarcoptes in North America.

Researchers with the Southeastern Cooperative Wildlife Disease Study (SCWDS) continue to study the genetic relatedness of mites recovered from numerous host species, and VDWR will continue to collect and contribute specimens to these efforts. To accomplish this, VDWR staff will opportunistically collect skin biopsies or skin scrapes from clinically affected animals and will also work with willing participants from the groups mentioned above for assistance in procuring samples.

Section 2: Management and Response

Overview

Disease management in wild animal populations utilizes strategies geared towards three basic goals: 1) prevention of disease introduction, 2) control of disease, or 3) eradication of disease (Wobeser 2002). Since *S. scabiei* can infest a large number of mammals over a broad geographic range, several intervention and management strategies have been previously attempted, with varying degrees of success. It is likely this disease will continue to expand within Virginia's bears and regionally throughout contiguous populations, and limiting human assisted movement or acceleration of disease spread will be an important consideration moving forward. Control measures that are both cost-effective and likely to be helpful should be studied and implemented, but it is important to acknowledge that no "silver bullets" currently exist to prevent mange in free-ranging wildlife populations. Further, eradication of mange has not been successful in widespread free-ranging populations and is not a realistic goal. As stated in goal #3 of this plan, VDWR will have to consider effects of this disease as it strives to manage for consistent, resilient bear populations. Given what is currently known, VDWR attempts to respond in such a way that will be more helpful than harmful to bears over the long-term.

Disease prevention, reduction, or management protocols can focus on either the infectious agent (*S. scabiei*), the host (bears and other mammals), or the environment (Virginia's landscapes). Many actions were considered and are described below, even if their implementation is not recommended at this time. It is important for any plan to be adaptive in nature to incorporate new research or results from previous efforts. This is especially true for mange in bears, where substantial knowledge gaps create a significant need to extrapolate from previously attempted management actions with other species.

Additionally, population impacts of disease can lead to necessary adjustments in species population goals and management approaches. Mange in Virginia's black bears will be a persistent management consideration, but the short and long-term population impacts are still unclear. It is imperative that necessary population data be collected now, so that future population management actions can be appropriately modeled, followed, and reviewed.

<u>Objective 1: Implement appropriate, welfare focused interventional strategies.</u>

Strategy 1: Continue to opportunistically humanely dispatch or euthanize emaciated bears suffering from mange.

The reason for euthanizing emaciated, severely affected bears is two-fold. First, although natural recovery is possible for these individuals, bears exhibiting an advanced state of disease in poor body condition are less likely to recover (Tiffin 2022, Tiffin et al 2024). Second, these bears are often highly visible to the public and present justified animal welfare concerns. It has also been shown that these bears often have an extremely high mite burden (Francisco personal communication) so removal may also alleviate some transmission risk.

This recommendation is in line with how other agencies are approaching mange. A survey of 35 state and federal personnel with bear management responsibilities from 17 states was performed in 2023 by Fancisco et al at SCWDS (publication currently in review). When asked about responding to mange in wildlife (not just bears), 97% responded that severely affected animals should be euthanized, but 43% opposed the euthanasia of moderate cases and 80% opposed the euthanasia of mild cases.

The only published survival data of mange infected bears is from Pennsylvania, where 81% of bears recovered regardless of treatment protocol (Tiffin et al 2024). The survival rate of infected bears in Virginia (both in mange affected and mange emerging counties) is currently unknown, but this population parameter is one of the key questions that VDWR's current collaborative bear mange study with Virginia Tech hopes to answer (Appendix 5). Given the research from Pennsylvania and in the absence of Virginia-specific data, it seems prudent to give non-severely affected individuals a chance to recover.

Individual and population immunity is also poorly understood in bears. Similar to the disease in canids, individual immunity in bears is probably short-lived (Neidringhaus et al 2019), disease re-occurrence is common, and due to subsequent Type I hypersensitivity responses, secondary cases can even be more severe (Francisco et al in-review, Little et al 1998). Although no evidence exists for affected populations of any species developing complete resistance, populations do adapt over time. Often, when sarcoptic mange is introduced into a naïve population, a primary wave of emergence can have drastic population effects (Ferreyra et al 2022, Carver et al 2023), which are then followed by periodic or sporadic, localized epizootics. The long-term dynamics of this disease in bears have yet to be worked out, but actions that could slow or interfere with host:parasite evolution and population adaptation should be avoided.

Demonstrating the Department's application of adaptive management to the presence of mange in bears, VDWR is updating its Bear Mange Response Protocol for the fourth time since 2014. Over time, this protocol has evolved from early attempts to dispatch all affected individuals to now only removing severely affected animals for welfare reasons. As stated in the Objective 1, Strategy 1 of the surveillance section, a new, standardized scoring system will be used to determine if dispatch of a bear is appropriate based on body condition, hair loss, behavior, and time of year.

Similar to bears, VDWR commonly authorizes humane dispatch for other wildlife severely-affected by mange and will continue to do so as clinical disease progression for these species leads to emaciation and presents similar animal welfare concerns. Further, spillover from canids is thought to be responsible for sporadic cases of bear mange (Schmitt et al 1987), and consistent (as opposed to random) handling of severely-affected mange individuals of all species may lead to important discoveries regarding the transmission and occurrence of mange in free-ranging populations.

Dispatch of mange-affected bears may legally be performed by department staff, local law enforcement, licensed veterinarians, animal control officers, and when authorized, members of the public. In May 2025, the VDWR Board approved a new regulation (VA Administrative Code 4VAC15-40-310) to clarify that VDWR staff, and external partner agency staff designated by the Director, can give permission to the public to humanely dispatch animals, including for disease reasons. The public must notify VDWR first, and photos and verbal descriptions will be utilized by authorizing staff to complete mange scoring and dispatch protocols. Since *S. scabiei* poses a risk to domestic animals and humans, safe carcass handling and disposal language will be provided when dispatch is authorized (Appendix 6).

Pharmaceutical treatment for severe cases is occasionally brought up in place of humane dispatch. VDWR is not recommending widespread treatment of any mange cases at this time (discussed further in Appendix 4).

Objective 2: Reduce mange transmission and prevent human-assisted movement of mange mites.

Strategy 1: *Properly dispose of infectious carcasses.*

Proper carcass management in large-bodied species presents obvious challenges, but whenever possible, carcasses of bears that are humanely dispatched (either by VDWR personnel or the public) should be removed from the landscape or buried on-site. Proper disposal methods include deep burial, placement in lined landfills, incineration (in a commercial incinerator), and digestion. Safe carcass handling and disposal language will be provided to VDWR staff and those authorized to dispatch or who find dead specimens on their property.

Strategy 2: *Avoid the relocation of bears to new areas. If movement of a bear is necessary, follow proper diagnostic and biosecurity procedures to prevent the accidental translocation of mites.*

The VDWR stopped routinely relocating bears from conflict situations in 2001, and only does so today under rare, extreme circumstances. The following protocols will be used if a decision is made to relocate a bear:

- If possible the bear should be released in the county of origin. If this is not feasible, the bear can only be moved to a county with similar mange status. Bears from mange affected areas cannot be moved to mange unknown areas.
- If field conditions allow and staff possess the necessary equipment, a skin scrape evaluation performed under sedation/anesthesia should be performed. If this cannot be performed, then prophylactic treatment can be considered.

Limited bear movements may also occur due to the VDWR's orphan surrogacy and rehabilitation programs, which are conducted in collaboration with the Wildlife Center of Virginia (WCV). A brief description of these programs, including disease prevention and management measures is below:

Surrogacy Program

Orphaned neonate cubs are placed with surrogate sows as appropriate during the denning season as a first option for an “orphan” event. VDWR is currently in the process of expanding this program more broadly across the state, so that cubs can be placed locally. Following a basic health check, cubs are often placed the same day or within 48 hours of the orphaning event and often do not receive any additional care other than basic feeding. Any cubs needing medical attention prior to placement are housed at the WCV’s indoor intensive care unit (ICU).

Rehabilitation Program

Orphaned cubs which are not eligible for surrogate placement (outside of the denning season, no available surrogates) are housed at the WCV for a period ranging from 6 months to 1 year prior to release back to the wild. Most commonly, these bears are released as yearlings during the spring (April) and when feasible, in their county of origin. All yearlings must have 3 negative skin scrapes to be eligible for release. All equipment taken to the WCV for the releases (traps, carriers) are disinfected with a 10% bleach solution prior to and following release events.

Strategy 3: Continue to promote best management practices to ensure domestic canines are not involved in mite transmission.

There is little evidence to suggest that domestic dogs are a significant source of transmitting mites to new areas or other species. Still, because they (and other domestic animals) are capable of being infested, emphasizing common preventive measures is warranted. These strategies could be added to best management practices recommendations for hunting with hounds and recreating outdoors with pets. Many prophylactic preventive strategies for other parasitic diseases (heartworm, fleas, etc.) are also effective at preventing or limiting mange, and dog owners should consult with their veterinarians to adopt a protocol that minimizes risk. Dogs that are suspected of potentially being infested should be evaluated by a trained professional and appropriately treated before being further utilized for hunting or other outdoor activities.

Strategy 4: Limit the artificial congregation of bears.

Transmission of sarcoptic mange is driven by direct contact between individuals or indirectly through contact with recently contaminated environments. The amount of direct vs indirect transmission sustaining the disease in bears has been speculated but is difficult to research (Browne et al 2021). Mite survival off the host has been documented for up to 13 days under ideal laboratory conditions with mites taken from infected bears

(Niedringhaus et al 2019) and 19 days with mites taken off infected dogs (Arlian et al 1984), but the infectivity of these mites over time in unknown. Indirect transmission through shared environments, like denning sites, has been implicated in transmission in some species (Cypher et al 2017, Carver et al 2023).

Any practice that artificially congregates bears has the potential to increase both direct and indirect transmission and should be avoided whenever possible. Artificial congregation can occur due to point sources (bird feeders, baiting/feeding sites, mismanagement of trash, etc.) or at larger scales (agricultural operations, etc.). It has been illegal to feed or bait bears anywhere in the Commonwealth since 2003 (VA Administrative Code 4VAC15-40-282). Maintenance of the prohibition on baiting and feeding of bears, increased outreach on the importance of avoiding these practices, and training on proper enforcement of the regulation are important measures to minimize transmission risks. Supplemental feeding of bears in mange-affected populations in Virginia is occasionally proposed by constituents as a measure to help stressed individuals and bolster population recovery efforts. Although it is thought that widespread supplemental feeding of black bears has the potential to increase fecundity and artificially inflate population densities (Kirby et al 2017), the risks of mange transmission through artificial feeding outweigh any potential benefit.

Through participation in the BearWise program, VDWR provides outreach messaging and assistance to communities and constituents about living with bears and managing artificial attractants. Although this is done primarily to mitigate bear conflicts, any progress made in this realm also has the potential to alleviate mange transmission risk.

<u>Objective 3: Incorporate disease effects into bear population models and population management.</u>

Strategy 1: Adapt population models and indices to include non-hunting mortality, so that population management tools can be implemented in a timely, data-driven manner.

As with most wildlife species, no economically practical methods exist to accurately and precisely estimate black bear population size on an annual basis across the entire state of Virginia. Population estimation techniques that involve capturing and marking bears, conducting surveys (e.g., camera, hair snare, bait station), or genetic analysis are viable on smaller study areas but are generally cost prohibitive at the regional or statewide scale. Virginia, like many eastern states (Black Bear Management Jurisdictional Survey, 2023), utilizes population reconstruction to estimate a minimum bear population index by bear management zone and statewide. Population reconstruction modeling utilizes data from hunter-harvested animals which can be collected in a cost-efficient manner and provides the most economically responsible and sensitive annual population indices for bears at bear management zone and statewide scales.

Multiple eastern states have compared reconstructed bear population indices utilizing population reconstruction to integrated population models. The results indicate that integrated population models can enhance precision of the populations indices; however, overall trends and population index values were similar for both methods. In mange affected bear populations natural mortality rates as well as harvest rates are likely variable and may strongly influence population estimates using reconstruction. Integration of natural mortality rates into population reconstruction models is one mechanism to alleviate the impact of mange on population reconstruction models. In addition to investigating natural mortality rates in mange and non-mange affected areas, DWR is also investigating and evaluating alternative population monitoring indices (e.g., occupancy modeling, SECR) which may afford other cost-effective approaches to managing bears in Virginia (See Appendix 5 for further discussion of population models.).

Strategy 2: Adjust bear hunting seasons when necessary to reduce cumulative mortality and achieve bear population objectives.

Experience in Virginia suggests that bear mortality from mange is likely cumulative with other factors such as bear harvest through hunting and bear-vehicle collisions. Although direct effects of mange on bear populations are difficult to address, reducing female bear harvest mortality through hunting season adjustments is a primary tool within VDWR's control. Whenever bear populations decline below the levels established in objectives of the 2023-2032 Bear Management Plan, bear hunting season adjustments are considered. During the 2024-2025 hunting regulation review and amendment cycle, bear seasons were reduced in 24 counties primarily located in the northwestern portion of the state where sarcoptic mange is endemic.

Harvest reductions in areas where mange has already impacted populations are critical for the ability for those populations to rebuild but can also be used pre-emptively to bolster populations ahead of mange outbreaks. Using the Shenandoah Valley of Virginia as a case study, it does not seem beneficial to reduce bear populations ahead of mange as this only seems to exacerbate the impacts that mange may have on a population. Prior to mange (or significant reports of mange) in the northern Shenandoah Valley, bear population objectives for these bear management zones were modified to "reduce" (from stabilize) in

2017. To meet this objective a new 3-day early bear season was implemented in 2018, which allowed the use of all legal weapons (archery, muzzleloader, firearms) as well as hounds and would run for 3 days during the week prior to early archery season (generally the last week of September or first week of October). This season proved to be extremely popular with many bear hunters and effective at harvesting female bears. During this timeframe, reports of sarcoptic mange in this area began to increase, with significant increases in reports noted from 2019 through present day. The combination of the high female harvest (as prescribed to meet population objectives), poor mast years which occurred during these same timeframes, and the onset of sarcoptic mange, bear populations in the Shenandoah Valley have taken a significant decline. Population reconstruction and harvest graphics for bear management zones 5 and 9 are shown below as an example of this decline.

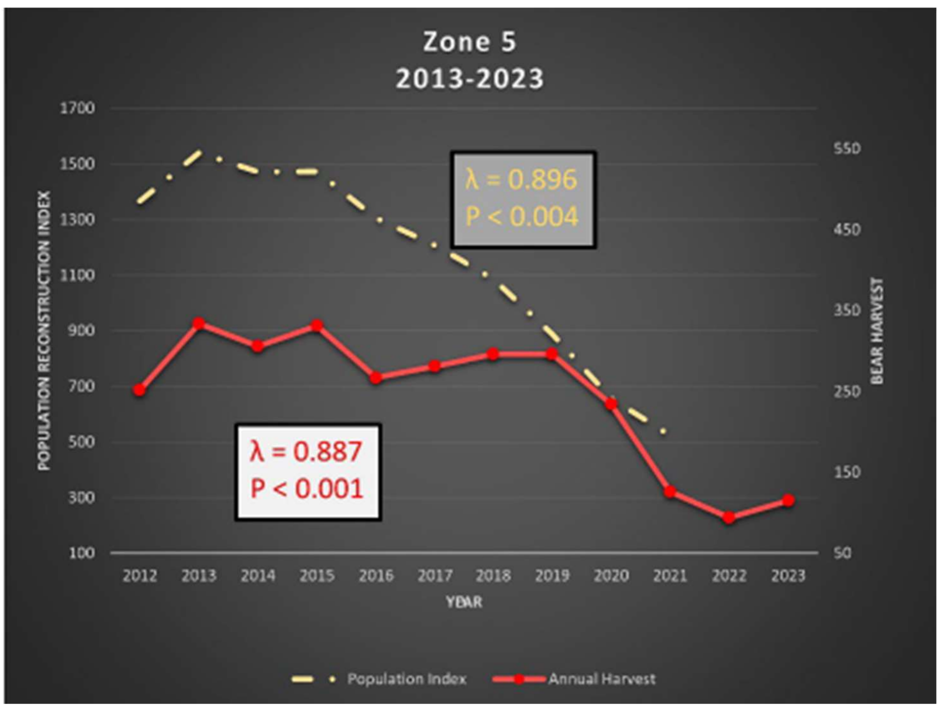

Figure X: Zone 5 population reconstruction and harvest, 2023.

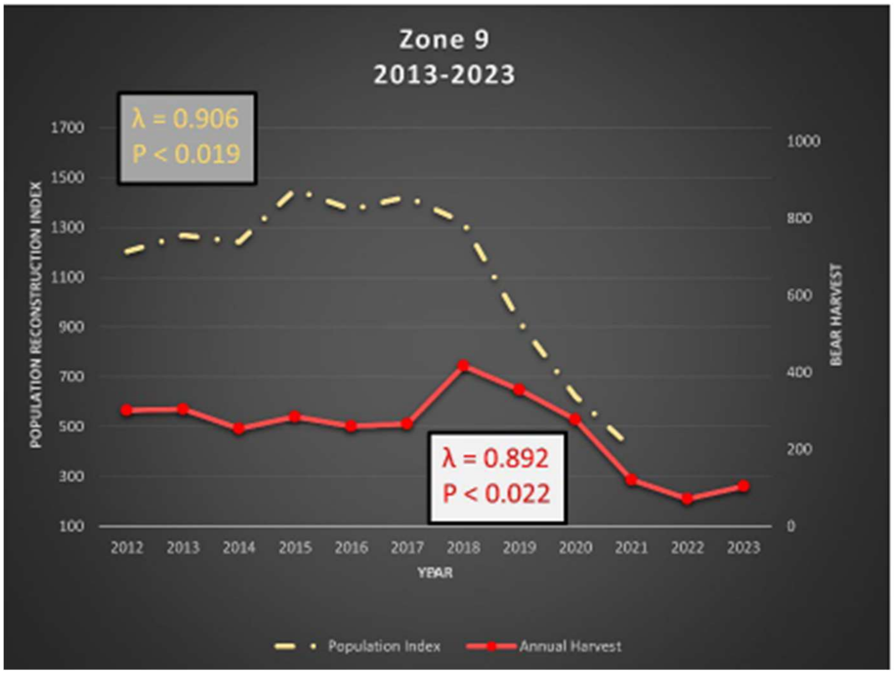

Figure X: Zone 9 population reconstruction and harvest, 2023.

<u>Additional management strategies evaluated but *not recommended* for widespread adoption at this time.</u>

Explanations for why certain strategies are not adopted are typically not laid out in management plans, but due to the interest of stakeholders regarding some of these items, a more detailed discussion and justification is warranted. Strategies that were evaluated by VDWR but which are not recommended at this time include aggressively targeting clinical bears for culling, widespread pharmaceutical treatment of clinical bears or populations, and establishment of disease management or containment areas. A thorough discussion about why these strategies were not adopted is in Appendix 4.

Section 3: Research

<u>Overview</u>

Since VDWR began detecting cases of mange in bears in northwest Virginia in 2014, staff have continued to expand knowledge of this disease and how it may impact the management of bears. This has been done by reviewing research conducted in other states and species, implementing research efforts in Virginia, and participating in regional, multistate studies.

Due to limited internal research capacity and funding, VDWR has relied heavily on crucial external partnerships to help study sarcoptic mange. In collaboration with the Wildlife Center of Virginia (WCV), the effectiveness of several treatment protocols was evaluated, specifically ivermectin and fluralaner. The results found that although anthelmintic treatment in combination with supportive care can clear mange infestations, even in severely affected individuals (Van Wick & Hashem 2019, Van Wick et al 2020), once released back into the wild most animals become reinfested, some more severely than when first admitted (Francisco et al in review). VDWR has also contributed diagnostic samples for several multi-state research projects led by the Southeastern Cooperative Wildlife Disease Study (SCWDS) at the University of Georgia, including studies on general mange surveillance, black bear mange toxicology, bear mange skin microbiome, and bear mange mite enumeration. Lastly, VDWR is currently partnering with Virginia Tech on a large two-part project, one part studying disease progression through spatial-temporal and physiological effects of sarcoptic mange in black bears, and another evaluating bear population density estimates in mange affected vs mange unaffected areas using spatially explicit capture-recapture (SECR). These partnerships and research efforts will help guide evidence-based management not only here in Virginia but in other states being impacted by mange in black bear populations. The specifics of all the past and current research projects VDWR has been or is involved in can be found in Appendix 5.

Still, there are critical questions about mange in bears that remain partially of fully unanswered and require further study. VDWR intends to be active in this realm, helping answer these questions and continuing to contribute knowledge from its experience to the scientific community.

<u>Objective 1: Identify future research opportunities, limitations, and hurdles.</u>

Strategy 1: Prioritize major knowledge gaps for future research endeavors.

With the expansion of sarcoptic mange throughout bear populations in the mid-Atlantic, VDWR has an opportunity to be a regional leader in helping address knowledge gaps. But with significant funding constraints, efforts should be focused on answering some of the most applicable questions. The following discussion highlights some of the most important research needed to effectively address disease and population management.

- *What short and long-term impacts does mange have on bear populations?*

As previously stated, this disease is very likely to remain in Virginia, and VDWR will need to manage bear populations accordingly. An understanding of survival/mortality rates is needed, both in endemic and emerging areas. If survival in Virginia's bears is not similar to that found in Pennsylvania's bears (Tiffin et al 2024), then attempts must be made to elucidate the reasons for the difference. In addition to understanding survival/mortality rates, sub-lethal impacts to fitness and reproductive physiology must also be quantified so that they can be integrated into population models. Ongoing collaborative projects with Virginia Tech will start providing insights into these variables, but VDWR must be prepared to continue investing towards additional research in this realm.

It is plausible that selective pressures applied by the disease may be changing the genetic structure and diversity of the population. Such changes cannot be determined without a baseline understanding of the genetic diversity prior to disease emergence. It has been hypothesized that genetic bottlenecking and lack of genetic diversity could be contributing to the current emergence of the disease (see Genetic Health Marker Testing project description above). The fields of population and landscape genetics are rapidly evolving with advancing technology and could lead to numerous future project opportunities. In anticipation of expanded opportunities for genetic research, VDWR plans to begin a more thorough collection and banking protocol of bear tissues for this work.

An understanding of the role of population immunity is also lacking. Individual immunity appears relatively short-lived (Niedringhaus et al 2019) but could still contribute to the overall dynamics as the disease becomes endemic. Some species exhibit initial severe waves of disease followed by sporadic epizootics driven by environmental factors, host densities, and population immunity. Whenever opportunity arises, VDWR will attempt to collect and bank serum that could be used for serosurveys as well as population exposure and immunity studies.

- *What epidemiological or ecological knowledge is missing regarding sarcoptic mange in black bears?*

Although sarcoptic mange is an ancient disease affecting >140 mammalian species, disease epidemiology can vary significantly between species and is poorly understood in bears. A thorough understanding of transmission in bears is still lacking, hindering development of effective intervention and control strategies.

Fundamental knowledge gaps exist for the roles of direct and indirect transmission, interspecies transmission, and effects of population density.

The solitary nature of bears has led some researchers to speculate that the bulk of transmission may be indirect (Browne 2022). However, mites have limited longevity in the environment, 13 days under ideal laboratory conditions (Niedringhaus 2019). Den contamination is frequently implicated for some species (wombats, foxes, etc.) but is probably only a concern in bears denning in family groups. Basic life history can be used to make some transmission assumptions (ex: more direct contact between bears during breeding seasons), but a more thorough, quantifiable understanding of contact rates and spatial overlap (both intraspecies and interspecies) at various times of the year could lead to the development of better transmission models and possibly targeted, strategic interventions or treatments. Integrating data from collared bears, environmental sampling, and wild canid surveillance will be needed to decipher and model the complex transmission pathways.

Some herding species exhibit a high degree of density dependent transmission, but frequency dependent (or density independent) transmission has been described in other species. At present, there is no evidence that transmission of sarcoptic mange in bears is density-dependent. However, a more thorough understanding of the role that density plays in mange transmission in bears would be very useful for bear managers to implement harvest management approaches that minimize disease occurrence and transmission within the bear population. Management of bear population density at the leading edge of an expanding mange outbreak is presently a significant challenge for managers. In addition to establishing case studies regarding management experiences in such scenarios, rigorous data collection on population changes and the potential variables driving those changes provides an opportunity for retrospective analysis and study that could provide valuable insight to other bear managers facing this management challenge.

- *What surveillance or management actions require further refinement or review?*

As discussed in the Management & Response section and Appendix 4 of the plan, widespread treatment of bears or other sympatric species is not a practical response given the current state of knowledge regarding management of mange in free-ranging wildlife, but investigating treatment options under a structured, experimental framework remains a viable strategy for advancing current knowledge on management of mange.

Prophylactic treatment (vaccination) against *S. scabiei* has been most explored in domestic rabbits, even showing some potential to reduce clinical signs, mite survival, and replication (Liu et al 2014, Shen et al 2023). But to date, there are not vaccines commercially available for use in any species. Varying levels of immune responses (especially hypersensitivity responses) exhibited by different host species add another layer of complexity that would need to be thoroughly explored before such treatment would be applicable to bears or any wildlife species. Additionally, the logistical hurdles and cost of administration to a wide-ranging wild population must also be considered. Oral vaccine programs do exist for certain diseases of wildlife affecting public health (ex: rabies) and endangered populations (ex: black-footed ferrets), but the feasibility of vaccine options for sarcoptic mange remain unknown and even if feasible, it would not be expected to be a tool available anytime soon.

An indirect enzyme linked immunosorbent assay (ELISA) is commercially available to detect Immunoglobulin G (IgG) antibodies in the serum of canids. Use of this assay in bears has been studied as both an accessory diagnostic tool and a method to evaluate population-level exposure (Peltier et al 2018, Niedringhaus et al 2020, Houck et al 2021). The detection of antibodies in serum can help confirm active disease but can also indicate prior exposure or prior disease and recovery. The temporal aspects of the humoral response in bears has not been quantified through artificial challenge studies, but serial testing post-treatment demonstrated rapidly declining titers, all falling below detectable limits within 14 weeks (Niedringhaus et al 2020). There is also likely significant variability of IgG titers due to individual immune response and level of infective dose. A study of North Carolina bears discovered an 18% seroconversion rate despite no known cases of sarcoptic mange in the state (Houck et al 2021), indicating that bears may be frequently exposed to *S. scabiei* through sympatric hosts or the environment. Further work is needed to determine whether this is true exposure or if assay cross-reactivity could be occurring to antigens from other mite species. This, combined with a better understanding of the immune response of bears, could elucidate future opportunities for serology to be used to study disease dynamics and exposure in populations; thus, VDWR will begin to bank serum samples as opportunity arises.

Strategy 2: Advocate for adequate funding for mange research and continue to build collaborative partnerships.

Dedicated funding sources for continued and new research will be critical in closing these knowledge gaps and making sound adaptive management decisions moving forward. As additional states experience mange in bears, regional/multi-state research projects are likely to develop (and currently are being developed). Dedicated funding needs to be in place so that Virginia can take advantage of these opportunities to partner with additional state agencies, research universities, and disease specialists on mange research and management. Partnerships with other state agencies and universities (both in state and out of state) will be critical to ensuring knowledge dissemination as research unfolds and new and emerging techniques or management strategies are developed.

Section 4: Communication and Outreach

<u>Overview</u>

Since 2014, when the current sarcoptic mange outbreak in bears began in Virginia, a central component of VDWR's efforts related to mange has been outreach and communication with the general public, interested hunters and landowners, and external partners and agencies (both within Virginia and regionally). Transparency and open communication with all interested parties is integral to creating and maintaining trust, and ultimately, for successful management of the disease. The enhancement and adaptation of current efforts in outreach and communication will reinforce public confidence in VDWR as the lead agency in Virginia with respect to mange in wildlife. Although beyond the scope of this management plan, the development of a comprehensive communications plan for mange in bears (and perhaps other animals) in Virginia could be useful. In lieu of a more formal communications plan, the measures outlined below represent a pragmatic approach given current circumstances and resources.

<u>Objective 1: Increase public awareness and transparency about mange in Virginia's bear population and VDWR's management of the disease</u>

Efforts should address questions such as, what is known and unknown about mange, why is this disease important to wildlife managers and the public, and what is being done (or not done) about mange to include why (or why not) those items are being done. Outcomes of successful public outreach will include better public understanding of sarcoptic mange, preventing misconceptions, and acknowledgement that the agency is committed to science-based management. Respondents to a recent survey of wildlife managers and researchers in the eastern U.S. emphasized that it is particularly important to educate residential homeowners and renters who may have limited understanding of mange as a natural disease of bears and other species (Francisco et al 2025, in review).

Strategy 1: Develop a centralized webpage with resources for multiple species susceptible to mange and with separate links to information specific to bears and other species.

Expanding website content to better reflect and address those mange topics which the public is most frequently searching will maximize page visits and educational effectiveness. This strategy will also help establish VDWR as the topical authority among segments of the public which may not normally consider VDWR as source of information on mange in wildlife. Many current mange-related queries pertain to topics not addressed fully by VDWR's existing online content. It will be important to address questions such as what is mange, how do pets get mange [from wildlife], is mange contagious, can humans get mange, and what does mange look like.

Website text including words and phrases likely to be relevant to users' questions is more likely to rank higher in search results and drive more traffic to VDWR online mange content. Content should generally be written at a 6th–8th grade level or lower. The language used matters: most users won't find (or find useful) content that uses significant amounts of jargon or scientific terms; consider what the visitor is going to be searching for and use common, straightforward terms and plain language. It may be beneficial to include frequently asked questions and answers regarding important aspects of mange (e.g., risks to humans and other animals, why we do not treat bears, why some bears have to be dispatched). Consider strategically leveraging images and video to enhance visibility in search results.

Strategy 2: Expand other outreach methods and opportunities, including updates to existing flyers and factsheets, social media, in-person or virtual presentations, community events, publication of articles in various media, etc.

Over the past few years, VDWR has expanded its outreach efforts regarding mange. The annual hunting and trapping digest now contains a full page of information on mange, reporting mange observations, and what to do if you harvest a bear with mange. In conjunction with staff in DWR's Outreach Division, bear program staff developed a new partnership with the Virginia Master Naturalist (VMN) program. Over the last 3 years, bear program and Outreach staff have trained VMN chapters across the state to provide formal presentations and tabling events on all things, including mange, related to bears. During training, staff provide information on mange and include materials that can be disseminated to the public. Currently 18 chapters are enrolled in the program, and over the last 3 years, they have provided information to an average of 15,500 constituents per year. DWR bear program staff also serve on a national level working group updating materials associated with BearWise to include specific information regarding mange in bears.

Strategy 3: Work with Virginia Tech researchers to maintain a public website for the ongoing Virginia Bear Mange Study to inform interested parties about research objectives and progress.

A website specific to the ongoing VA Bear Manage Study went public in April 2025, with information on study objectives, the study team, and progress updates (Virginia Bear Mange Study | Home).

Strategy 4: Provide periodic updates to bear hunters, landowners, and other organizations with an interest in bear mange, to include hot topics, regional news, research updates, opportunities for engagement, etc.

Frequent communication with interested stakeholders can build trust, maintain collaborative relationships, demonstrate VDWR's concern and commitment to management of mange, and ensure that correct information regarding mange is disseminated. As mange spreads, it is important that stakeholders in newly impacted areas hear from VDWR before misinformation becomes entrenched.

Strategy 5: Provide updates on mange research or management to the Board of Wildlife Resources' Wildlife and Boat Committee semiannually.

Objective 2: Engage constituents to maximize reporting of bears with mange, collection of data associated with the disease, and efficiency of implementing measures to reduce transmission or impacts of mange

Efforts should address what hunters and other publics can do to help, how their information or efforts contribute to management of mange, and how to reduce risk of mange to humans and domestic animals. Opportunities to become involved give concerned citizens some ownership and investment in management of mange in bears.

A recent survey of wildlife managers and researchers in the eastern US pointed to the importance of equipping wildlife rehabilitators to assist in mange outreach and management, given their public-facing roles with wildlife. Ideally, such outreach and communications would convey that mange occurs naturally in the wild and that many animals are able to recover from mild and moderate cases (Francisco et al. 2025, JWM in press).

Strategy 1: Provide up-to-date guidance regarding ways the public and hunters can assist with management of mange.

Following is abbreviated existing guidance from the current VDWR website, annual hunting and trapping laws digest, etc.:

- To help reduce the negative impact of mange in black bears, the public can minimize the congregation of bears (and other animals) by removing or securing potential attractants (e.g., discontinue feeding birds or other wildlife, secure garbage or compost containers) and help VDWR track the distribution of the disease by reporting all suspected cases of mange to the Department through the VA Wildlife Conflict Helpline (vawildlifeconflict@usda.gov or toll free 1-855-571-9003) or through an online platform under development. Per protocol, severely affected bears may be dispatched, either by staff or other officials or by citizens authorized by VDWR.
- Hunters should report any mange suspect bear observed during the bear hound training season to the VA Wildlife Conflict Helpline. During hunting season, if a hunter harvests a bear with signs of mange they must utilize their bear tag and report the bear at the time of harvest because this information remains a vital element of the Department's bear management program. The harvested bear should also be reported to bearmange@dwr.virginia.gov with the photo and confirmation number from reporting the harvest.
- Best management practices should be used when handling a mange infested bear, which should be minimized to avoid unnecessary exposure, to include wearing disposable gloves, disinfecting equipment or areas contacted by the bear, washing clothes worn when with the bear, and contacting a doctor or veterinarian regarding human or animal exposure, respectively.

Strategy 2: Provide opportunities for hunters and others to engage in citizen science that will advance understanding and management of mange in bears.

Following are ongoing opportunities for citizen engagement in collection of mange-related data:

- Bear observation form – Interested members of the public can report on numbers of healthy bears and bears with mange observed.
- Bear hunter log – Participating hunters can record useful metrics with regards to bear hunting (e.g., healthy and mange-affected bears seen, ran, and treed) in mange and non-mange areas.
- Hunter sampling – Participating bear hunters can collect samples, following clear and simple protocols, to support ongoing or new research/monitoring in Virginia and regionally (e.g., via SCWDS).
- Skin samples from other species affected by mange (e.g., canids) – In coordination with the furbearer program, recreational trappers, rehabbers, and commercial nuisance animal permittees can opportunistically obtain samples from mange affected-animals.

Objective 3: Ensure that staff across VDWR and partner agencies understand management of bear mange and can provide consistent messaging to constituents

Strategy 1: Ensure that public-facing staff across VDWR are equipped with sufficient information to assist with management of mange and provide consistent messaging to constituents.

To ensure consistency, competency, and efficiency across all operational levels, VDWR will provide information and training to all personnel involved in surveillance, diagnostics, field response, and public engagement activities.

Strategy 2: Continue to collaborate with external agencies and partners within and outside of Virginia regarding important research and management, including the human dimensions aspects of mange (e.g., public opinions, knowledge, successful messaging).

In 2022, Virginia hosted a multi-state meeting, attended by 22 states plus universities, to discuss the current state of knowledge of mange; this meeting initiated much of the research collaboration now occurring with other states in the region and with SCWDS. In 2023-24, VDWR participated in a multi-state survey of bear managers about effective management strategies and promoted a survey developed by SCWDS that assessed public and hunter perceptions of black bear mange management strategies, including euthanasia, treatment, and non-intervention. Within Virginia, partnerships could be enhanced with the establishment of an interagency committee to collaborate on multiple aspects of bear research and management, to include sarcoptic manage.

Conclusion

VDWR takes mange in black bears seriously, with a primary goal of long-term population viability for conservation and societal benefits. Implementing diverse strategies for surveillance and monitoring, management and response, research, and communications and outreach, mange must be managed to the best of our abilities despite incomplete knowledge of the disease. Incorporating an adaptive management framework facilitates learning from prior management decisions and flexibility to change disease management strategies based upon effectiveness, emergence of new information, and public acceptance. Future bear management decisions may be influenced by new and ongoing research aimed at demonstrating how mange spreads on the landscape and evaluating the effectiveness of mange management actions in Virginia and elsewhere.

Appendix 1: History of Mange in Bears and Other Wildlife in North America

S. scabiei is a generalist mite that has infected at least 148 mammalian hosts (including humans and many domestic animals) across the world (Escobar et al 2021). Although a single, heterogenous species, several genetic clades exist that seem to correlate closely with the type of infected host (canis, hominis, bovis, etc.). The first reports of mange in wildlife in North America came when mites from domestic dogs were used to infect coyotes and wolves in Montana in the early 1900's, which were subsequently released in an attempt to infect predator populations more widely (Chapter 107, 1905 Montana Legislative Code). Epizootics of sarcoptic mange were then reported in red foxes in Ohio (Olive & Riley 1948), Pennsylvania (Pryor 1956), and Wisconsin (Trainer & Hale 1969).

The first published record of a mange-causing mite in black bears involved a *Demodex* species identified in a sample from a partially alopecic bear sow captured in northern Wisconsin in 1975 (Manville et al 1978). However, this case presented milder clinical signs compared to later sarcoptic infestations. Sarcoptic mange specifically entered the record in 1984 in Oscoda County, Michigan, when a young bear with hair loss, crusty skin, and poor body condition was shot and diagnosed via skin scrapings (Schmitt et al 1987). This bear had been observed alongside another symptomatic young bear, and the following spring, an adult female, presumed to be their mother, was euthanized and confirmed with sarcoptic mange, signaling early spread in wild populations (Schmitt et al 1987). It is presumed that these cases were a spillover effect from sympatric hosts, and it does not appear that the disease spread further within the local bear population.

In 1991, an adult male bear with sarcoptic mange was documented in Indiana County, Pennsylvania. Three additional cases were reported the following year, and the disease began radiating outward to affect additional counties. Over a span of nearly 30 years, the disease had been confirmed in bears in 55 out of PA's 67 counties and spread into nearby states with contiguous populations, including West Virginia in 2003, Maryland in 2008, and New York in 2011 (Niedringhaus et al 2019) (see Figure 1). A cluster of cases in eastern Oklahoma, northwest Arkansas, and southwest Missouri has also emerged, with the first reports in those states occurring in 2016, 2018, and 2020, respectively (SCWDS unpublished data).

The first suspected bear mange case reported in Virginia was a bear cub in Rockingham County in late 2003, which included histopathological skin samples that were sent to SCWDS. Mange was confirmed but was suspected to be ursicoptic and not sarcoptic. Two additional suspected cases were reported in 2004. The first was a yearling from Augusta

County, which was also diagnosed with *U. americanus*. The second was an adult female bear from Rockingham County. This bear was captured, treated at WCV, ear-tagged, and released. *S. scabiei* mites were recovered from skin scraping at the time of intake, making this Virginia's first confirmed case of sarcoptic mange in bears. It is unclear whether this case was the result of opportunistic spillover from wild canids or regional spread from other bears. Regardless, no additional cases were reported to VDWR until 2014.

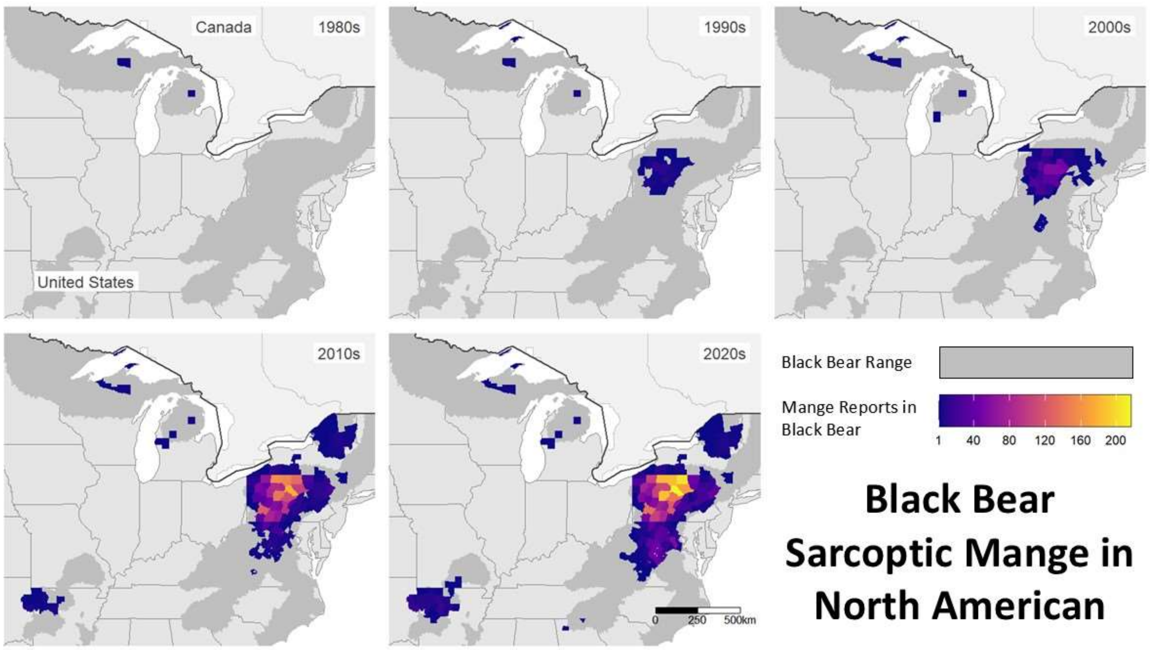

Figure 1. Heat map of the distribution of sarcoptic mange reports of black bears by decade in North America from the 1980's-2020's (SCWDS, unpublished data).

Beginning in 2014, DWR began receiving public reports of suspected mange in bears in northwestern Virginia counties. Table 1 shows the number of confirmed/suspected cases received by VDWR by year beginning in 2014. In 2020, the number of reports increased drastically. It is unknown to what degree this is reflective of expanded prevalence of the disease versus increased reporting by the public. In 2020, DWR released multiple outreach documents to the public asking constituents to report suspicious cases, and the onset of the SARS-CoV2 pandemic also led to a large uptick in the number of Virginians spending time outdoors. The graphs in Figure 2 show the serial geographic expansion of affected Virginia counties between 2014 and 2024.

Year	Reports	# Counties with Reports
2014	2	1
2015	2	1
2016	14	1
2017	12	5
2018	22	8
2019	29	12
2020	110	15
2021	121	19
2022	123	18
2023	162	23
2024	274	33

Table 1: Breakdown of bear mange reports (both confirmed and suspected) received by VDWR between 2014 and 2024.

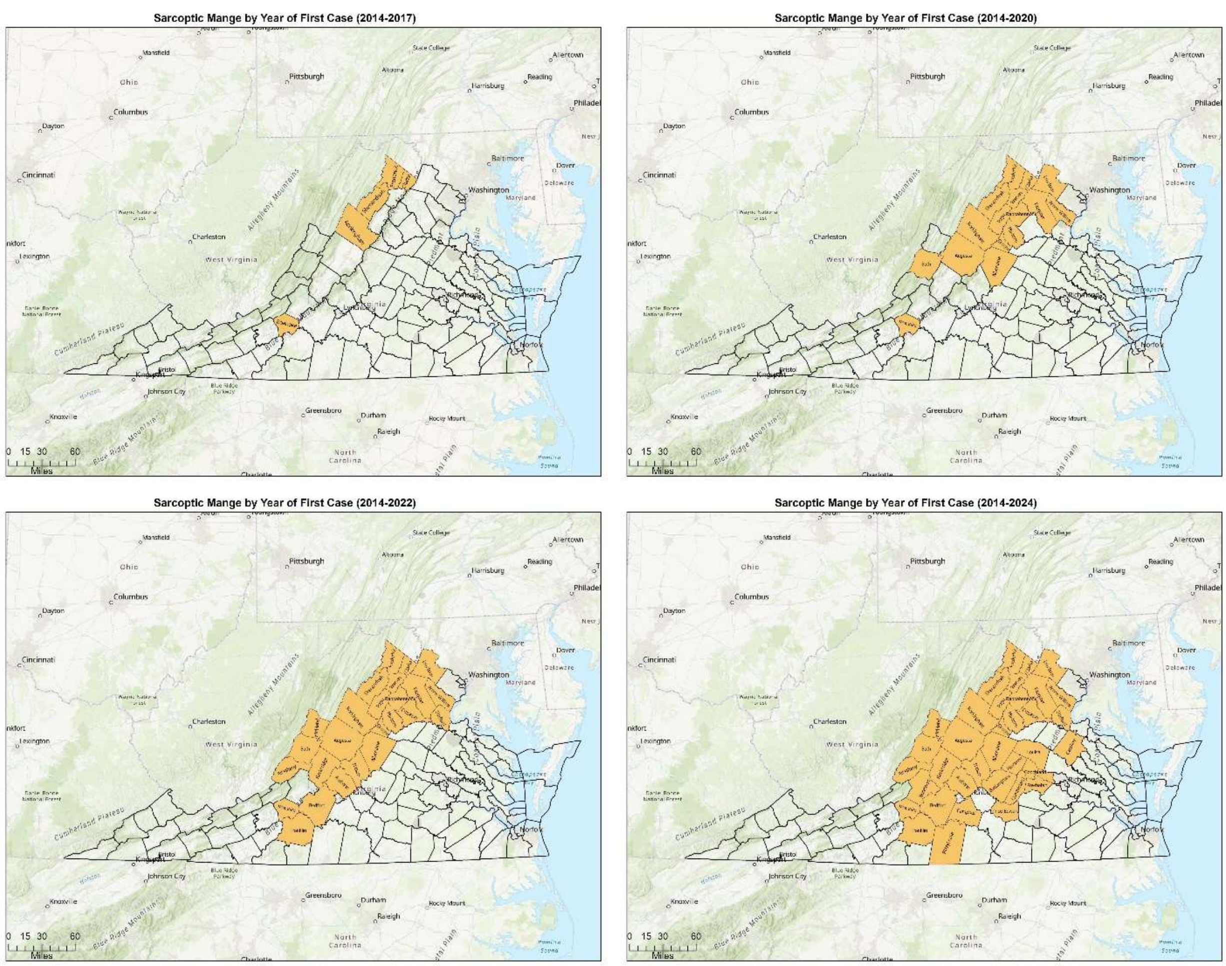

Figure 2. Graphs showing southern and eastward expansion of sarcoptic mange in bears from 2014-2024. All counties with at least one case are highlighted.

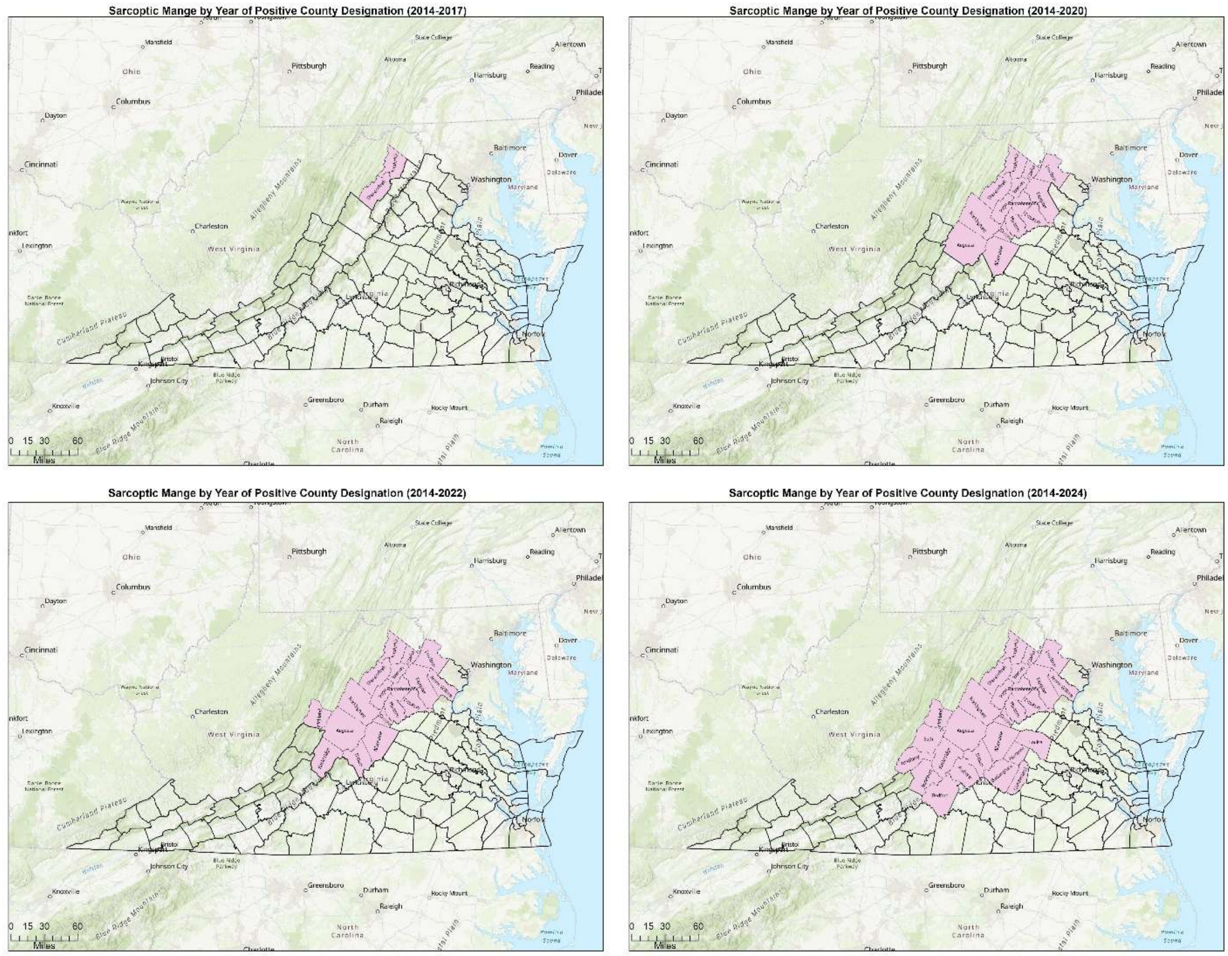

Figure 2. Graphs showing southern and eastward expansion of sarcoptic mange in bears from 2014-2024. All counties meeting "mange affected" status as described in Objective 1, Strategy 2 of the surveillance section.

Appendix 2: Mange Mites in Black Bears

Sarcoptes scabiei is a microscopic mite within the acarid subgroup of eight-legged arachnids. This tiny mite features a rounded, flattened body with short, sturdy legs equipped with claws and dorsal spines. These characteristic adaptations enable it to burrow efficiently into a host's skin. Female mites excavate tunnels up to 1 cm long in the epidermis. A single female may lay 3-4 eggs daily, totaling over 50 eggs, during a 4-6 week lifespan (Arlian & Morgan 2017). Eggs then hatch into larvae within 3-4 days, and these larvae migrate to the skin surface to mature into nymphs and adults, perpetuating the infestation through rapid reproduction. Its life cycle, which encompasses eggs, larvae, nymphs, and adults, unfolds entirely on or within the bear, completing in approximately two weeks under warm, humid conditions. This efficient cycle facilitates the mite's spread within and between hosts.

Sarcoptic mange has affected at least 148 mammalian species across 39 families, including being the causative agent of scabies in humans. Evolution across a broad geographic range has resulted in several host-adapted variants (e.g. canis, hominis, suis, etc.). In North American wildlife, sarcoptic mange has been reported in foxes, wolves, coyotes, white-tailed deer, fishers, raccoons, porcupines, feral swine, fox squirrels, swamp rabbits, house mice, and bighorn sheep (Niedringhaus et al 2019). Initial genetic analysis of mites from bears in Pennsylvania and nearby sympatric species utilizing ITS-2 and cox1 genes revealed that several mite genetic variants may be circulating (Peltier et al 2017), but subsequent genetic work performed at SCWDS using cox genes and whole mitochondrial sequencing has revealed that the mites indeed do genetically cluster regionally and across host species (Francisco et al unpublished data). Mites from bears and sympatric hosts in the mid-Atlantic region appear to be genetically related and most similar to a clade of North American mites of canine origin.

Transmission of *S. scabiei* most commonly occurs through direct contact of infected individuals, but indirect contact through contaminated environments can also play a role. Mite survival off the host has been documented for up to 13 days under ideal laboratory conditions with mites taken from infected bears (Niedringhaus et al 2019) and 19 days with mites taken off infected dogs (Arlian et al 1984), but the infectivity of these mites over time in unknown. Cool, humid environments appear to favor longer mite survival, with freezing temperatures and hot summer temperatures contributing to more rapid mite death (Niedringhaus et al 2019). Host life history and biology likely also contribute to the amount of direct vs indirect transmission within a population (Browne et al 2020), but the relative proportion of direct vs. indirect transmission in bears is not fully understood. July is currently the month during which VDWR receives the highest number of suspected reports followed by May, June, and August (see Table 2).

Some species exhibit a high degree of density dependent transmission (Fernández-Morán et al1997, Ferreyra et al 2022), but frequency dependent (or density independent) transmission has been described in other species (Niedringhaus et al 2019, Carver et al 2023). The relative effects of how density affects transmission in bears is also poorly understood and needs to be further studied. Finally, although spillover from sympatric canid hosts is hypothesized as the disease entry point into bear populations, their role in the maintenance and transmission of the disease in bear populations in not fully understood.

Month	**Cumulative Reports**
January	55
February	46
March	56
April	62
May	111
June	101
July	142
August	99
September	55
October	49
November	56
December	39
Total	**871**

Table 2: 2014-2024 cumulative suspect bear mange reports received by VDWR, by month.

Other mite species exist with the potential to cause clinical mange in bears, including demodectic mange caused by *Demodex ursi* and ursicoptic mange cause by *Ursicoptes americanus*.

- *Demodex* spp.: These cigar-shaped mites, natural inhabitants of hair follicles and sebaceous glands in mammals (e.g., dogs, cats, humans), cause demodectic mange or demodicosis. *Demodex ursi* causes demodectic mange specific to black bears. Their life cycle—egg, larva, protonymph, deutonymph, adult—occurs entirely within follicles, typically as harmless commensals, though disproportionate mite burdens may become problematic in immunocompromised individuals such as those stressed by malnutrition, injury, or disease. Reports of clinical outbreaks historically appear restricted to black bear populations in Florida, manifesting as localized hair loss (e.g., face, limbs) or, rarely, generalized alopecia with redness and scaling (Forrester et al 1993). The first documented case in black bears was reported from northern Wisconsin in 1975, when *Demodex* mites were recovered from scab tissue of a partially alopecic sow (Manville et al 1978). No confirmed records of demodectic mange exist from Virginia.

- *Ursicoptes americanus*: This host-specific mite causes ursicoptic (audycoptic) mange, burrowing near hair follicles in bears. Initially identified in a captive black bear from Kansas without clinical signs, its first association with disease came in July 1975 from an Idaho bear with severe generalized alopecia (90% head hair loss) and pronounced skin lesions on the neck, thorax, and forelimbs (Yunker et al 1980). The mite is similar to *S. scabiei*, aside from subtle morphology differences and its restriction to hair follicles like *D. ursi* (Yunker et al 1980). Clinically normal bears can harbor *U. americanus* with minimal or no clinical signs, though when signs appear, they are often less severe than those of sarcoptic mange; co-infestations with *S. scabiei* have been documented with overlapping clinical signs, complicating diagnosis (Broadhurst et al 2025). Although the prevalence of *U. americanus* on bears in Virginia is unknown, a recently published study noted that mites were found on 14.7% of bears handled at the Wildlife Center of Virginia between 2014 and 2023 (Broadhurst et al 2025).
- *Chorioptes* spp.: These surface-dwelling mites, common in livestock (e.g., cattle, sheep - dubbed "foot mange" or "leg mange"), feed on epidermal debris rather than burrowing. Chorioptic mange was first detected in a free-ranging Massachusetts black bear in 2019 linked to skin lesions (Niedringhaus et al 2021), but this was a unique case and remains rare in wildlife.

Appendix 3: Mange Pathogenesis and Other Causes of Skin Disease

Clinical signs of sarcoptic mange can vary from mild to severe. Subclinical infections have not been diagnosed in bears but have been noted in other species. Early lesions manifest as small, red, inflamed spots (2-3 cm wide), often starting on the ears, elbows, or abdomen and spreading as the infestation intensifies. Alopecia is noted and can range from localized (small patches) to generalized (extensive lesions) in severe cases. In more severe cases, the skin becomes chronically inflamed and malodorous, often with secondary bacterial and yeast infection. This inflammation and infection leads to a breakdown in epithelial barriers, and serum leaks from damaged tissues which dries into yellowish crusts or scabs. The skin becomes thickened and lichenified. In canids, the skin inflammation is mediated by type I hypersensitivity responses to the mites or foreign material deposited in the skin, and it is likely this also occurs in bears (Niedringhaus et al 2019). Chronic mange can appear as thickened, leathery skin exposed by alopecia. These extensive skin changes compromise the skin's essential functions, such as maintaining fluid balance and protecting against water loss. Energy depletion from constant scratching and immune response drains fat reserves, while lost insulation impairs thermoregulation. In severe cases, bears are often emaciated. As these signs progress into the advanced stages of the disease, there is an increased potential for starvation and death.

In comparison, ursicoptic mange can present subtly in normal bears with mild alopecia around the face and muzzle or escalate to more severe hair loss and crusty lesions in extreme cases, overlapping with sarcoptic mange signs and potentially complicating gross diagnosis, particularly when co-infestations occur (Broadhurst et al., 2025). This information reinforces the importance of careful sampling and diagnosis to distinguish it from other mites and assess co-morbidity.

Several other skin conditions can present clinical signs overlapping with sarcoptic mange in black bears. Accurate differentiation among these conditions requires thorough diagnostic evaluation, including skin scrapings, histopathology, fungal culture, and microscopic examinations, to ensure appropriate diagnosis.

- **Pelodera dermatitis:** Pelodera dermatitis, also known as rhabditic dermatitis, can also present clinical signs similar to mange in black bears. It is caused by the free-living nematode *Pelodera strongyloides*, typically found in moist, decomposing organic matter. Bears with Pelodera dermatitis may exhibit alopecia, redness, crusty and thickened skin lesions, inflammation, and severe pruritus (itchiness), which closely mimic the clinical presentation of sarcoptic mange. Lesions commonly occur in areas of prolonged contact with contaminated soil or bedding, such as limbs, abdomen, and ventral surfaces. Unlike sarcoptic mange, however, Pelodera dermatitis often involves superficial skin layers rather than deep burrowing mites (Fitzgerald et al 2008).
- ***Trichophyton sp.* (Ringworm)**: A study conducted between 2014 and 2019 in California documented generalized dermatophytosis in eight juvenile black bears. These bears, originating from different regions, presented with emaciation, alopecia, and exfoliative dermatitis, ultimately resulting in death or euthanasia. Histopathological examinations revealed generalized hyperkeratotic dermatitis, folliculitis, and furunculosis, with skin structures heavily colonized by fungal hyphae and arthrospores. Fungal cultures identified *Trichophyton equinum*, a zoophilic dermatophyte typically associated with equids and rarely reported in non-equid species. The study hypothesized that factors such as illness, malnutrition, age, or immunosuppression may have increased the bears' susceptibility to this generalized fungal infection (Clothier et al 2022).
- **Seasonal Shedding**: Seasonal shedding in black bears can mimic sarcoptic mange primarily through extensive hair loss, patchy coats, and a rough appearance, especially during late spring and early summer. During this normal physiological process, bears naturally lose their thick winter coats in irregular patches,

sometimes revealing dry, dull, or flaky underlying skin. This appearance can resemble the patchy alopecia and roughened skin typically associated with mange. However, unlike mange, seasonal shedding does not usually involve skin inflammation, crust formation, or abnormal weight loss. Additionally, bears undergoing seasonal shedding typically regrow healthy, uniform coats within weeks, whereas bears with mange may take longer to recover or continue to deteriorate without intervention.

- **Pantsless Bear Syndrome**: This hair loss phenomenon on the hind end of black bears has been observed in multiple southern states. The exact cause is unknown but may be attributable to chronically wet environments.
- **Allergic Dermatitis**: Allergic reactions to environmental irritants, insect bites, or plants can lead to generalized itching, hair loss, thickened skin, and crusting.
- **Ectoparasites (Ticks, Fleas, Lice)**: Severe infestations with ticks, lice, or fleas may cause significant hair loss, skin irritation, and dermatitis. Close examination typically reveals a heavy burden of visible parasites on the skin.
- **Nutritional Deficiencies or Starvation**: Poor nutritional status or starvation may result in generalized hair loss, dull coat, flaky skin, and overall poor condition.

Appendix 4: Management Strategies Not Recommended for Widespread Adoption

The following discussion intends to provide some context and justification for why these strategies were not recommended.

- *Aggressively targeting clinical individuals for selective or non-selective culling.*

  While this approach has not been tried in bears, there are published reports of its use in ruminant herds in Europe (Alasaad et al 2012, Espinosa et al 2020). The authors of these reports noted that this strategy was controversial, difficult to measure impacts, and never proven to be an effective strategy. Given public scrutiny of dispatching bears involved in significant human-bear conflict situations, application of an aggressive, targeted culling program is likely to draw considerable public interest and scrutiny. Although the opportunistic removal of severely affected individuals is recommended above, the distinction between such intervention for animal welfare purposes and the aggressive culling of bears for disease control is notable. For example, although much is still to be learned, bears that survive mange and reproduce subsequently may contribute to population level genetic resistance. Given these sociological and epidemiological factors, it would be inappropriate to initiate such a program in Virginia without a solid, scientific basis establishing the success of this approach. Further, aggressively finding, targeting, and dispatching individual bears using any methodology for capturing bears would be labor intensive and within free-ranging populations, likely to miss intended target animals.

- *Widespread pharmaceutical treatment of clinical individuals or populations*.

Treatment of mange in bears has generated a lot of interest and discussion. There are several effective treatment options available for domestic dogs and other domestic species (see end of this section). Research on treatment of bears has been limited to ivermectin and fluralaner (Van Wick & Hashem 2019, Tiffin et al 2024, & Francisco et al in-review). It has been shown that treatment of affected bears (sometimes even in severe cases) can contribute to recovery, but the picture is complicated by natural recovery rates as well as immune dysfunction leading to severe, subsequent re-infections. For instance, in Pennsylvania 88% of ivermectin treated bears recovered, but 74% of un-treated bears recovered naturally (Tiffin et al 2024). With this data in mind, the Pennsylvania Game Commission stopped the routine practice of treating clinically affected bears (DiSalvo personal communication). Fourteen adult bears held at the Wildlife Center of Virginia (WCV) were successfully treated with either fluralaner or ivermectin (Van Wick & Hashem 2019, Francisco et al in-review). Four were fitted with radio-collars before release and all died between 76 and 694 days post-release, 3 from severe mange cases and one from unknown causes found decomposing in a den. The ten additional bears successfully treated at WCV were ear-tagged before release; 1 was successfully harvested by a hunter, 1 is thought to have been harvested, 1 was hit by a vehicle, and 7 had unknown fates (Francisco et al in review). Due to these results, VDWR and WCV stopped the labor-intensive practice of capturing, transporting, holding, and treating bears.

Treatment at a landscape or population level presents another set of logistical and ethical hurdles, including effective dosing and administration, adverse effects on non-target species or the environment, potential drug residues in a consumed species, and the opportunity for the development of drug resistance (Moroni et al 2020). For these reasons, treatment is rarely used except in small, isolated populations (Cypher 2017, Oleaga 2019, Rudd et al 2020). A 2019 review of all known treatment programs in wildlife, including ivermectin placed in feed for ruminants in Europe and topical application of ivermectin to wombats in dens, found that although short-term successes were documented in some individuals, long-term post-treatment monitoring was often insufficient to demonstrate a statistical benefit to the population (Rowe et al 2019). This was emphasized in a subsequent response to the review, with the authors concluding that "pharmacological treatment of mange in wild animals mostly produces individual healing, but its effects on achieving control or eradication in a population are mostly inconclusive" (Moroni et al 2020).

Due to the logistical hurdles, potential consequences, and a lack of demonstrated effectiveness regarding whether treatment programs can benefit populations, VDWR does not intend to adopt widespread treatment protocols for any mange affected animals at this time, including bears. Appropriate outreach will be required to convey this approach to the public as treating of affected wildlife is something the public often expects (Francisco in review). Provided that adequate resources exist, there remains opportunity to study certain treatment protocols at small, controlled scales and to explore the development of tools that could be applied at a landscape level. However, it is critical that such research be conducted in a controlled manner that can generate statistically relevant data from which reliable results can be gained to advance the understanding of mange treatment on the landscape.

The following drug classes are most often used to treat sarcoptic mange:

Macrocyclic Lactones
Historically, mange has been treated with drugs like ivermectin or selamectin, often requiring multiple doses due to the mites' life cycle. These antiparasitic drugs fall under the umbrella class of macrocyclic lactones, and work by killing the mites responsible for the infestation. However, treatment with macrocyclic lactones typically requires multiple doses over several weeks. The most commonly used treatment option for sarcoptic mange is repeated injections of ivermectin, but its long-term effect on survival is difficult to monitor in free-ranging wildlife (Rowe et al, 2019, Moroni et al 2020).

Isoxazolines
Newer isoxazoline drugs, such as Sarolaner (Simparica®) and Fluralaner (Bravecto®), offer long-acting relief. Fluralaner, approved for dogs in 2014, is better studied and preferred, having shown some early promise in treating sarcoptic mange in black bears (Van Wick & Hashem 2019; Van Wick et al 2020). The drug, which is commonly used as a flea and tick preventative in domestic cats and dogs, operates by inhibiting ligand-gated chloride channels in the neurons of arthropods,

which includes mites. This mechanism makes it effective at eliminating mites without harming the mammalian host. A notable advantage of fluralaner, in comparison to ivermectin, is that a single dose can provide prolonged protection against parasites, potentially eliminating the need for repeated treatments in black bears.

- *Establishment of disease management or containment areas.*

  The establishment of disease management areas is frequently used to contain or slow the movement of infectious agents in populations. Extensive consideration was given to their implementation for sarcoptic mange management, but at this point, it is not recommended for the following reasons:
  - The disease has rapidly advanced in the population over the past 5 years, affecting new counties each year. As such, DMA designations would need to change frequently, complicating effective communications strategies for disseminating appropriate information.
  - There are currently no strategies recommended for implementation that require that "mange affected" areas have different management actions in place than in areas without mange detections, and thus no distinction is needed at this point. Should any such strategies choose to be adopted, DMAs could be established (with defined criteria) if needed.

Population management decisions can (and should) be made using the defined geographic criteria established the VDWR's Black Bear Management Plan (i.e., bear management zones).

Appendix 5: Past and Current VDWR Research Project Contributions

Treatment of Sarcoptic Mange in Bears – Between 2016 and 2023, 14 adult bears were transported to the Wildlife Center of Virginia for treatment and rehabilitation.

Timeline: 2016-2023

Funding Source(s): VDWR & WCV Operational Funds

Principal Investigator(s): Peach Van Wick, DVM, Karra Pierce, DVM

Co-Investigator(s): Megan Kirchgessner DVM/PhD, Katie Martin, MS, Raquel Francisco, DVM, MS, Jillian R. Broadhurst, Marcelo Jorge, PhD, Michael J. Yabsley, PhD, John Tracey, DVM

Collaborating Institutions: Wildlife Center of Virginia, University of Georgia (SCWDS), VDWR

Status: Concluded. Initial results exhibited great promise for complete clinical resolution of the disease with a single dose of fluralaner (Van Wick et Hashem 2019), but long-term follow-up utilizing GPS collars on four successfully treated bears found that reinfection with *S. scabiei* was common, leading to clinical disease often more severe than the original case (Francisco et al in-review).

Bear Mite Burden – This study evaluates the relationship between *Sarcoptes* mite burdens on different regions of a black bear's body and across disease severity categories. Samples from roughly 30 bears were categorized into severity groups (normal, mild, moderate, severe, recovering). Findings will guide diagnostic protocols by identifying the most reliable body region(s) for mite detection and offer insights into disease pathogenesis. The work directly supports management efforts to refine diagnostic sampling strategies.

Timeline: January 1, 2023 – December 31, 2023
Funding Source(s): Multistate Conservation Grant Program (MSCGP) – Wildlife Restoration Fund
Principal Investigator(s): Michael J. Yabsley, PhD
Co-Investigator(s): Jillian R. Broadhurst
Collaborating Institutions: University of Georgia (SCWDS), AGFC, WVDNR, VDWR, NYSDEC, MDC
Status: Ongoing (Sample Collection CLOSED)

Mange Toxicology – This project investigates toxin exposure in black bears with sarcoptic mange, particularly anticoagulant rodenticides and other environmental contaminants. Liver samples from bears across Arkansas, Virginia, and West Virginia are analyzed for toxicant burdens to determine whether toxin exposure correlates with increased mange susceptibility or severity. Preliminary findings suggest potential immunosuppressive effects of toxins, but further investigation is required to establish causation.

Timeline: January 1, 2023 – December 31, 2023
Funding Source(s): Multistate Conservation Grant Program (MSCGP) – Wildlife Restoration Fund
Principal Investigator(s): Michael J. Yabsley, PhD
Co-Investigator(s): Raquel Francisco, DVM, MS
Collaborating Institutions: University of Georgia (SCWDS), UC Davis 29 Toxicology Laboratory, MDC, AGFC, WVDNR, VDWR, NYSDEC
Status: Ongoing (Sample Collection CLOSED)

Bear Mange Microbiome Study – Partnership with the University of Arizona investigating how sarcoptic mange alters the skin microbiome (bacterial and fungal communities) of American black bears (*Ursus americanus*). The goal is to characterize dysbiosis associated with mange severity and explore secondary infections that may complicate recovery. The study aims to guide future therapeutic interventions by wildlife agencies and rehabilitation centers.

Timeline: 2023–2025
Funding Source(s): Morris Animal Foundation (MAF)
Principal Investigator(s): Raquel Francisco, MS, DVM
Co-Investigator(s): Leigh Combrink, PhD, Michael J. Yabsley, PhD, Natalie Rose Payne
Collaborating Institutions: University of Georgia (SCWDS), The University of Arizona School of Natural Resources and the Environment, VDWR, NYSDEC, AGFC
Status: Ongoing (Sample Collection CLOSED)

Genetic Health Marker Testing in Mange Bears – This study evaluates the diversity of the major histocompatibility complex (MHC) class II genes in black bear populations affected by sarcoptic mange. It tests the hypothesis that populations exhibiting lower MHC diversity are more susceptible to severe mange, potentially informing future conservation genetics efforts and bear management practices.

Timeline: 2023–2025
Funding Source(s): Morris Animal Foundation (MAF) 31
Principal Investigator(s): Raquel Francisco, MS, DVM
Co-Investigator(s): Erin Lipp, PhD, John Wares, PhD, Michael J. Yabsley, PhD, Bernardo Mesa, PhD, Marcela Kelly, PhD
Collaborating Institutions: University of Georgia (SCWDS), East Stroudsburg University of Pennsylvania, Virginia Polytechnic Institute and State University; AGFC, MDC, NCWRC, PGC, WVDNR, VDWR, NYSDEC
Status: Ongoing

Human Dimensions of Mange Management – This project assesses public and hunter perceptions of black bear mange management strategies, including euthanasia, treatment, and non-intervention. Surveys conducted across endemic, emerging, and low-prevalence states measure knowledge of mange, risk perceptions, trust in agencies, and support for management actions. Findings aim to inform communication strategies tailored to different stakeholder groups, facilitating greater public understanding and acceptance of wildlife disease management.

Timeline: January 1, 2023 – December 31, 2023

Funding Source(s): Multistate Conservation Grant Program (MSCGP) – Wildlife Restoration Fund
Principal Investigator(s): Michael J. Yabsley, PhD
Co-Investigator(s): Elizabeth Pienaar, PhD; Raquel Francisco, DVM, MS
Collaborating Institutions: University of Georgia (SCWDS); Georgia Department of Natural Resources (GADNR), WVDNR, VDWR
Status: Ongoing (Sample Collection CLOSED)

Population and Demographic Impacts of Sarcoptic Mange on VA Black Bears and Implications on Harvest Season Structure based on Predictive Densities in Mange and Non-Mange Affected Areas – This research assesses bear density/abundance between mange and non-mange affected areas by utilizing hair snare surveys combined with spatially explicit capture-recapture (SECR) based DNA extraction modeling in mange affected (endemic area and newly emerging mange area) and non-mange affected areas for a minimum of 3 years. Results will help understand if sarcoptic mange outbreaks have resulted in population declines by combining estimates of abundance (objective 1) with vital rate estimates to model the population growth rate of mange affected and non-mange affected areas. Vital rate data will be collected through utilization of GPS collared bears in both mange affected and non-mange affected areas. Estimates of stage specific survival and reproductive rates in both populations will provide critical metrics to pair with density estimates from objective 1. The study will use vital rate data (objective 2) to model population viability under a variety of mange and harvest impact scenarios to determine if, and by how much, harvest needs to be reduced or timing of seasons altered to prevent population declines. Additionally, the data will be used to investigate potential behavioral and physiological mechanisms by which mange causes declines in vital rates (e.g. denning behavior, reduced foraging, increased activity and space use).

Timeline: April 1, 2024 – on going
Funding Source(s): Virginia Department of Wildlife Resources
Principal Investigator(s): Brett Jemser and Marcella Kelly
Co-Investigator(s): Fang Chen, PhD Candidate; Madison Thurber, MS Candidate; Isabella Sciarrino, MS Candidate; Katie Martin, VDWR Bear Project Lead; John Tracey, VDWR Veterinarian; Carl Tugend, VDWR Bear Project Lead
Collaborating Institutions: University of Georgia (SCWDS); Virginia Tech University, VDWR
Status: Ongoing

Appendix 6: Human Health Considerations

Sarcoptic mange is a zoonotic disease, and humans can become infected by handling infested animals. Symptoms may include temporary skin irritation accompanied by red, itchy welts. However, these symptoms are often transient, and infection is usually self-limiting due to the host specificity of *S. scabiei*. True scabies in people is caused by the hominid variant of *S. scabiei*. Contact should be avoided, especially for people with poor immune function, including those receiving immunosuppressive treatments and young children, as symptoms may be prolonged in some cases. Accordingly, hunters should wear disposable gloves during skinning or field dressing and thoroughly wash hands. If a potentially infected animal is handled, skin exposure can be avoided by wearing full length sleeves and pants followed by appropriate clothing laundering.

Appendix 7: Population Monitoring Glossary

- **Population Reconstruction:** population analysis technique utilizing age at time of harvest and the backward addition of cohorts to estimate a minimum population size over time. Natural mortality is not generally taken into consideration but can be added to the model if known.
    - Pros: Data (harvest and age) is easily available and distributed across the state (and bear management zones). Costs of population reconstruction are also very low as the only input cost is generally the aging of harvested bear teeth by the laboratory. Current teeth aging costs for approximately 2500 bears per year in Virginia is $18,000 annually.:
    - Cons: The lag in population estimation indices behind harvest (for most precise estimates a 3-year lag is utilized) is problematic, particularly for populations with unstable trends. The estimates are also less accurate when the proportion of non-harvest mortality is substantial.
    - Integrated population models combine multiple data sources and often utilize Bayesian frameworks to increase the robustness of population estimates and account for uncertainty in these estimates. Integrated models often utilize age at time of harvest data from population reconstruction plus incorporate other data sources (often unique by state or area of interest) such as abundance estimates from mark-recapture, spatial data (movement data from collared animals), and non-harvest mortality. Integrated models are more costly to develop and run due to the additional input data required. Data availability varies from state to state, and even within states, depending on research and management objectives, budgets, and staffing levels.

- **Occupancy Modeling:** statistical modeling technique to study distribution and habitat use as well as detection probability of target species. This method utilizes non-invasive sampling from cameras deployed over a spatial array to determine detection/non-detection at each site thus allowing the ability to calculate the probability of a site being "occupied" by the target animal. Habitat characteristics, human influence (e.g. distance to roads), and seasonality can all be accounted for within occupancy modeling.
  - **Pros:** Non-invasive sampling method (cameras) which reduces costs and effort and provides valuable information on habitat use and probability of occupancy under different environmental conditions.
  - **Cons:** Labor intensive during camera deployment/recovery and does not provide density/abundance estimates, simply presence/absence of a site being occupied.
  - This methodology is being utilized (primarily due to the low input costs) to monitor bear populations in the northern Shenandoah Valley mange endemic area beginning in 2025. Camera arrays will be utilized for a minimum of 2 field seasons (preferably 3) to determine occupancy, habitat use, and detection probability in this area which has noted declining bear population trends in recent years.

- **Capture-Mark-Recapture**: utilizes marked individuals and recapture rates to estimate population size. Basic mark recapture models assume closed populations with no significant birth, death, immigration, or emigration throughout the study period, and are used in black bear population estimates by some states. Pennsylvania notably runs one of the largest mark-recapture efforts of any eastern state, tagging over 700 bears each year with the recaptures counted during their bear harvest season (# of tagged bears in the harvest each year). The most commonly utilized formula for mark-recapture is the Lincoln Peterson Formula (N = (M*C)/R where:
  - N= Population Size
  - M = number of animals initially marked
  - C = total # of animals captured in the 2nd capture event (capture effort or harvest)
  - R = number of recaptured marked animals in the 2nd capture event (capture effort or harvest)

While physical marks (ear tags) were the common method for marking bears for many years, advancements in genetics have now allowed for non-invasive sampling utilizing hair samples. Hair corrals (small wire enclosures) can collect hair samples as bears cross the wire which are then analyzed for DNA in the hair follicles to uniquely identify individual bears. These identified bears are considered “marked”.

  - Pros: Increased accuracy and precision of density estimates can be gained by using mark-recapture but are dependent on the size of the area sampled and the number of individuals captured. Mark-recapture is often used within defined boundaries (e.g., National Park, management unit, etc) rather than across a statewide scale.
  - Cons: Scaling mark-recapture efforts beyond a single management unit (county or zone or park for example) can be manpower intensive and expensive. Mark-recapture utilizing actual capture and tagging for black bears involves the cost of staff time, immobilization chemicals, tags, monitoring equipment, and traps. Trapping and tagging animals is also not without some risk and stress to the animal that occurs during the capture and handling event. The utilization of hair corrals for non-invasive mark-recapture are also manpower intensive and expensive to scale beyond single management units. Following the initial installation of hair corrals across a defined grid, hair must be collected (generally weekly) for a set amount of time (6-8 weeks). DNA extraction and genetic analysis costs vary but are not cheap, especially depending on the size of the area sampled and number of hair samples processed. Additionally, mark-recapture models provide a population estimate for that point in time (single year) and must be repeated to provide trends in populations. For smaller research units, efforts may be repeated yearly while for larger areas, every 5 to 10 years is more common.

- **Spatially Explicit Capture Recapture**: SECR utilizes the same principles as mark-recapture but includes spatial data such as the location of detection/capture, all detection points on the landscape, and animal home range size and movement histories. The most common method utilized with SECR models for black bear population estimation is hair sampling from noninvasive hair corrals or rub sites set up along a random grid. The use of spatial factors (forest cover, food availability, proximity to roads, agricultural lands, etc) allow modeling to incorporate the variation of density of bear populations across the landscape. Detection probability is also an integral part of SECR models which incorporates the variability of detection of individual animals within a population.
  - SECR with hair corrals is currently being utilized in Virginia as part of the Bear Mange Study across both the mange affected study area and the control area.

Hair corral grids (150 in year 1, 162 for years 2 and 3) were deployed in year 1 of the project and will run for 2 field seasons in the control area and 3 field seasons in the mange affected area.

- The pros and cons of SECR are similar to those noted above for basic mark-recapture. Pros include improved accuracy and precision of density estimates, especially for defined study areas, while cons include the high cost of scaling up this type of monitoring to a statewide or even bear management zone scale on a routine basis. As noted for mark-recapture estimates provided are for those single points in time (year(s) that data was collected) and additional collection will have to occur to continue to provide data for these efforts. While it would not be practical to apply SECR statewide yearly, some states rotate sample efforts across bear management units over multiple years, with a 5- or 10-year return interval often cited for rerunning sampling and analysis.

- **Additional Bear Monitoring Metrics:**
  - In conjunction with harvest data other metrics can be collected to aid in population assessment. None of the below metrics alone can provide population estimates but can contribute to integrated models or overall knowledge of bear status within a state or defined management unit.
    - Bear Vehicle Collision Data
    - Agricultural Damage/Depredation Permits
    - Bear Conflict Reports
    - Disease Reports
  - Virginia utilizes all the above metrics when assessing bear population objectives and biennial regulation amendments to bear harvest seasons. Data quality for each of these metrics often varies depending on how it was collected (e.g., citizen reports, staff reports, partner agency reports).

Glossary of Terms and Acronyms

Direct transmission: Disease transmission that occurs from direct contact between two individuals
Indirect transmission: Disease transmission between two individuals through a contaminated reservoir, fomite, or environment
Density-dependent transmission: Occurs when contact rates that drive disease transmission increase when the density of the population increases
Frequency-dependent transmission: Occurs when contact rates that drive disease transmission remain constant regardless of the density of the population
Sympatric hosts: Related species in the same geographic area that host the same parasitic species
Epizootic: A drastic or sudden increase in the number of cases of infectious disease in an animal population
Endemic: A baseline level of disease activity in an affected animal population
SCWDS: Southeastern Cooperative Wildlife Disease Study
WCV: Wildlife Center of Virginia

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