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An Overview Of The Potential Effect Of Climate Change On American Pine Marten

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AN OVERVIEW OF THE POTENTIAL EFFECT OF CLIMATE CHANGE ON AMERICAN PINE MARTEN

by

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ABSTRACT

The impacts of climate change are only increasing, and yet not all those impacts have been studied on certain species. The American pine marten *Martes americana* (Turton, 1806) is one of the species potentially vulnerable to climate change. They are an important component of biodiversity as they hunt a variety of small mammals and feed on numerous plants. Martens are also important prey to many winged and terrestrial species. In Maine, they are an umbrella species that co-occur with eleven other species and their presence is also a good indicator of a healthy forest environment. I conducted a literature review to assess what information is available regarding the potential impacts of climate change on this species. I looked at basic biology as well as potential stressors for martens. Those stressors included climate change, heat, temperature, snow cover, snow depth, food availability, and forest disturbance. I observed trends in the literature based on the stressor terms and quantified how many studies had been published within a range of years. Fewer studies on marten stressors have been published in recent years and they are not currently a species of conservation concern. However, martens are reaching the southern edge of their geographical range in Maine and their stressors are important factors to study. Martens are habitat specialists and are sensitive to changes in canopy cover, the number and proximity of trees, and snow conditions. Climate change predictions indicate that snow cover may become less abundant and with forest disturbance becoming a regular occurrence, this species is running out of habitat to turn to. Although the diet and energetics of this species have been well studied, the impacts of heat, due to climate change, on prey availability and their reproduction costs are not well known. Further research on how heat is going to affect this species is needed.

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INTRODUCTION

Climate change is an ongoing crisis that has impacted countless biomes around the world. Climate change is a shift in weather patterns that has been attributed to greenhouse gas emissions from natural occurrences and human-dependent actions (Fawzy et al. 2020). Human activities have caused the average global temperature to increase by 1.0 °C. The average global temperature is predicted to increase by another 1.5 °C between 2030 and 2052 (Fawzy et al. 2020). Temperature increases have caused many environments to change and cause lower survival rates for many species. Thus, climate change has caused many plants and animal species to redistribute themselves (Pecl et al. 2017). Species are shifting more poleward or upwards in elevation at an average rate of 6.1 m per decade (Schloss et al. 2012). The ability to disperse in the face of climate change depends on the species and their habitat's ability to provide their preferred conditions with the effects of climate change present (Schloss et al. 2012). Since not all species respond to these environmental shifts at the same time it is affecting the habitat's overall composition with species interactions being disrupted (Pecl et al. 2017). These interactions and changes in ecosystems can cause unprecedented consequences. Thus, being able to understand the determinants of current range limits can be crucial to managing biodiversity (Siren et al. 2020).

Climate change is typically monitored through temperature, precipitation, sea-level rise, ocean acidification, and extreme weather conditions (Fawzy et al. 2020). There is an array of what could be considered a stressor: a potential threat to the organism, for a mammal in an environment dealing with climate change risks. Some climate dangers include droughts, floods, hurricanes, severe storms, heat waves, wildfires, cold spells, and

landslides. In 2018 alone there were 315 cases of natural disasters (Fawzy et al. 2020). Of these 315 cases, there were 16 cases of drought, 26 cases of extreme temperature, 127 cases of flooding, 13 cases of landslides, 95 cases of storms, and 10 cases of wildfires. Climate risks can eventually lead to loss of life due to health hazards as well as natural disasters, and excessive stress on ecosystems, especially with marine systems. Food and water availability are also highly affected. Thus, increased migration is expected due to extreme weather conditions and disasters (Fawzy et al. 2020).

Large carnivores are typically apex predators within a food web. Due to this, they are also known as sentinel species (Marneweck et al. 2022). Sentinel species respond to ecosystem changes in a timely, measurable, and explainable manner thus they reflect the condition of ecosystem-level processes. When large carnivores display changes in behavior and population growth it typically indicates a change at lower trophic levels. However, large carnivores are impacted directly by medium to large prey availability which makes it hard to note any changes in lower trophic-level species (Marneweck et al. 2022). Large carnivores may not respond to changes promptly, thus making small carnivores a better species to observe as they can be a global sentinel. Small carnivores can indicate how an ecosystem is structured, functions, and changes. Many small carnivores are already marked as sentinel species. They can indicate the biodiversity, climate change, landscape alterations, and bioaccumulation of an ecosystem (Marneweck et al. 2022).

Carnivores at their southernmost limits that require specific habitat features are particularly vulnerable to changes in their environment, especially to increasing temperatures (King et al. 2020). Canadian lynx (*Lynx canadensis* Kerr, 1792) and

Wolverines (*Gulo gulo,* Linnaeus, 1758) are cold-adapted species that are sensitive to climate change. Lynx rely on a certain depth of the snow as they use it for hunting cover (King et al. 2020). Wolverines use snow tunnels, fallen trees, and boulders with snow on them as denning sites. Snow dens may provide some thermal benefits and act as cover for the species (Fisher et al. 2022). In United States mountain landscapes, wolverines are found to den in sites under downed trees, boulders, and rock caves which they access through deep snow. In the Nearctic wolverines are confined to mountains, boreal, and arctic environments in which they require snow even into mid-May (Fisher et al. 2022). Similar to wolverines, Canadian lynx's habitat usage and distribution are based on snow conditions. Lynx occupancy will decrease with increasing temperatures and there is very little movement in the habitat between the winter and summer seasons (King et al. 2020). Both species are susceptible to further impacts of climate change. For the lynx, their summer movement is not as well-known and since they are habitat specialists and diet specialists it is important to note how increasing temperatures will affect their requirements. For wolverines, climate change predictions indicate a reduction in spring snow availability which is crucial for a suitable habitat for this species (Fisher et al. 2022). Further habitat disturbance via human activity puts this species at risk as well. There has been a lack of research on climate change impacts on snow in the Palearctic where wolverines also reside (Fisher et al. 2022).

Unlike the Canadian Lynx and Wolverine, Fishers [*Pekania* (*Martes*) *pennanti* Erxleben, 1777] are connected to old-growth forests and require greater than 30% canopy cover and large trees (Olson et al. 2014). They are found in Canada, the United States east coast, and southern Sierra Nevada as well as the northern parts of California. In the

U.S. they are found as far south as Kentucky (Olson et al. 2014). Fishers require precipitation and prefer mid-range minimum winter temperatures (Olson et al. 2014). Fishers avoid very dry habitats and deep snow. They are not adapted to walk through deep snow cover and doing so could be energetically costly. Fishers are predicted to move more north and eastward due to increasing temperatures. They have large dispersal distances they can travel but will be limited by snow (Olson et al. 2014).

American pine marten (*Martes americana,* Turton, 1806) are habitat specialists that live in mature coniferous forests (Buskirk and Powell 1994, Thompson and Harestad 1994). They require tall well-stocked forests, canopy cover, and suitable rest sites in trees or on the ground with plenty of debris as cover (Buskirk and Powell 1994, Thompson and Harestad 1994). They rely on snow cover for hunting, hiding from predators, and providing a subnivean rest site with thermoregulatory benefits (Hauptmann, 1979; Raine, 1983; Steventon, 1979). Marten is susceptible to further climate change impacts. In Maine, martens are a species of conservation interest since they have a significant impact on prey populations and are an indicator species for forest conditions. Martens co-occur with 11 other species, who are dependent on their presence. Some of those species are coyotes, raccoons, and short-tailed weasels (Mortelliti, Brehm, and Evans 2022). A 10%, 25%, and 50% decline in detection in the marten population correlated with an occupancy decrease in the eleven other species (Mortelliti, Brehm, and Evans 2022). In a 25% decline in the marten population with 10% habitat coverage, the bear, red squirrel, deer, snowshoe hare, and fisher remained. In a 25% habitat coverage, bear and red squirrel occupancy remained at the same level as the 10% coverage. Yet, species that increased habitat colonization in the absence of marten? were deer, snowshoe hare, fisher, coyote,

and short-tailed weasel. Marten, therefore, has an umbrella effect that allows for the monitoring of the other species it co-occurs with and is important in the forest ecosystem, as marten are both prey and predator species and an indicator of forest health (Mortelliti, Brehm, and Evans 2022).

Due to their preference for colder habitats and reliance on snow, martens are expected to move more poleward with climate change. Yet their potential to respond to climate change has not been fully characterized. Through a comprehensive literature review of the impacts of climate change on American pine marten, my thesis aims to determine how marten's habitat, movement, distribution, food availability, and energetics will be affected by heat and increasing temperatures in the summer season. My objective is to summarize what is known and identify gaps in knowledge regarding how climate change is affecting American pine marten, as it will help reveal the physical and habitat limitations of this species. These data can aid in predicting the species distribution and implementing further conservation efforts. I predict responses to heat and increasing temperatures, especially in the summer season, will be understudied.

METHODS

A literature review was conducted on certain terms related to *M. americana.* I searched for terms in Google Scholar such as “American pine marten”, “*Martes americana*”, “climate change”, “temperature”, “summer”, “heat”, “snow”, “distribution”, “habitat”, “forest disturbance”, “food availability”, and “conservation”. Other terms were initially searched for, but those selected were the ones most relevant to the study. I originally restricted the search for studies between 1980 to 2022. I thought those years would be the ones with more relevant information on the terms searched for, especially since climate change was a term that was not heavily researched until the 1970s. However, as I proceeded with my research relevant studies dating further back, such as ones in the 1930s were discovered and included. Thus, the range of years studied was from the 1930s to April 2022.

The stressors that were assessed are energy costs, the effects of climate change in the winter and summer, fragmentation of habitat, and food availability. For each stressor, I did a keyword search through the Web of Science. With each keyword, I quantified the number of papers through the Web of Science. The studies were then exported into an excel sheet. I sorted through each study to ensure it was relevant to the American marten. If the American marten was not the focus of the study the articles were removed. I summarized the number of articles published each year to identify if there have been changes in interest or concern regarding the specific stressor.

RESULTS

Quantitative number of studies

General Ecology

A total of 14 studies that included general ecology were found on Google Scholar and 316 studies on Web of Science. The 316 studies found through Web of Science included the studies found on Google Scholar. It should be noted that the only studies included in the content analysis (see Discussion) were the ones accessible through the University of Maine Library subscription service.

The total number of studies on the American pine marten has increased steadily since 1942 (Figure 1). There were not a lot of studies conducted on marten before 1994. However, there are fluctuations within the publication numbers. The greatest number of studies were published in 2017. After 2017, there is a downward trend with a decrease in published studies in 2022. The decrease in published studies in 2022 could be attributed to the literature review not being a full year's worth as the collection of literature stopped in April of 2022.

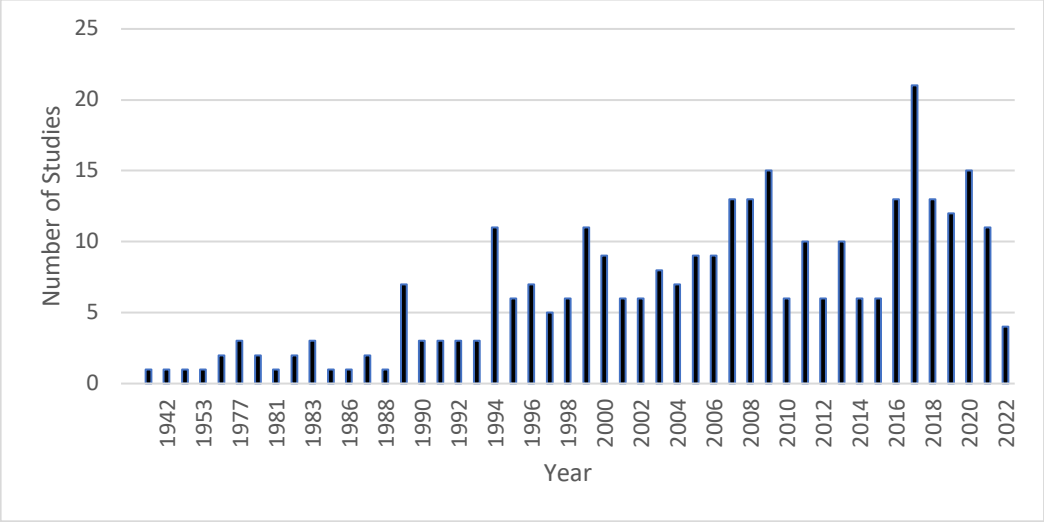

Figure 1. Number of studies on American pine marten published per year: A total of 316 studies were found about the American pine marten. The data reflects the years the studies were published and how many studies were published within a specific year. One study was missing the year of publication so there are only 315 studies included in this graph.

Climate Change

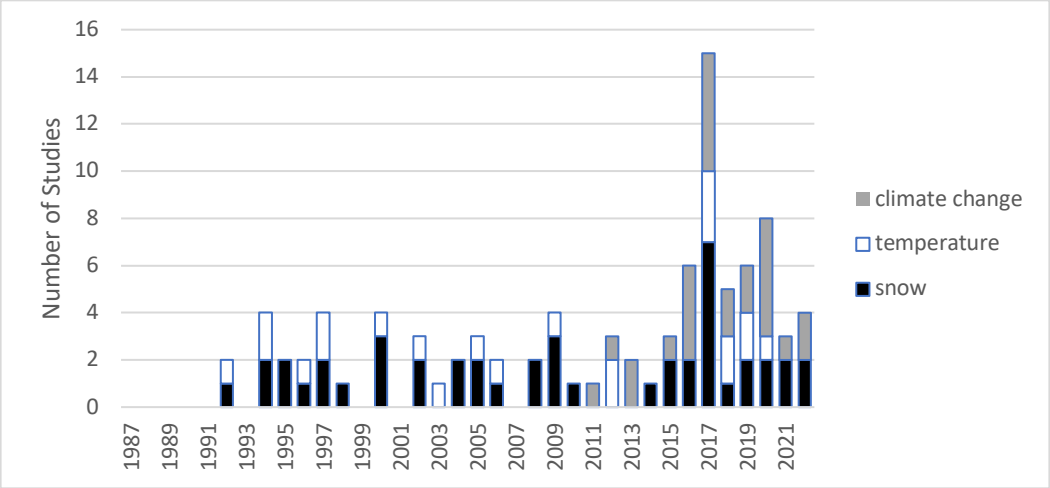

Figure 2. Number of studies on American pine marten and climate change, temperature, and snow published per year: There were 31 studies addressing climate change, 23 studies on temperature, and 47 studies on snow depth, cover, etc.

Studies on climate change, temperature, and snow cover showed similar trends (Figure 2). The years leading up to 2016/2017 fluctuate. Once the number of publications hits the year 2016 or 2017 there is a spike in studies published, but only within that year specifically. However, after 2016/2017 the number of studies published begin to decrease, as the relationship between climate change, temperature, and snow are well-studied and already known. There was one study on heat in the year 1994, no other studies have been published on this topic concerning the American pine marten.

Habitat, Food, and Conservation

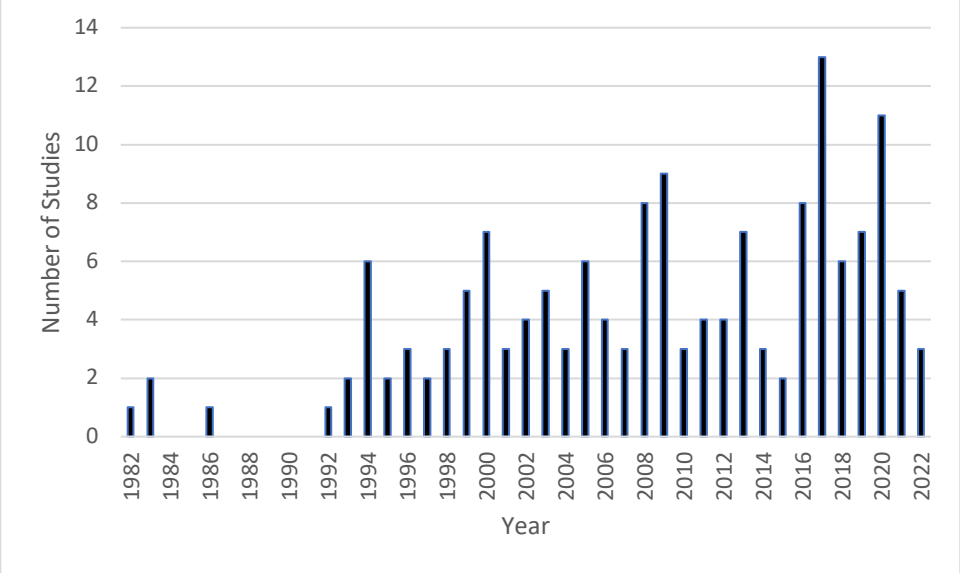

Figure 3. Number of studies on American pine marten and habitat published per year: There is a total of 156 studies.

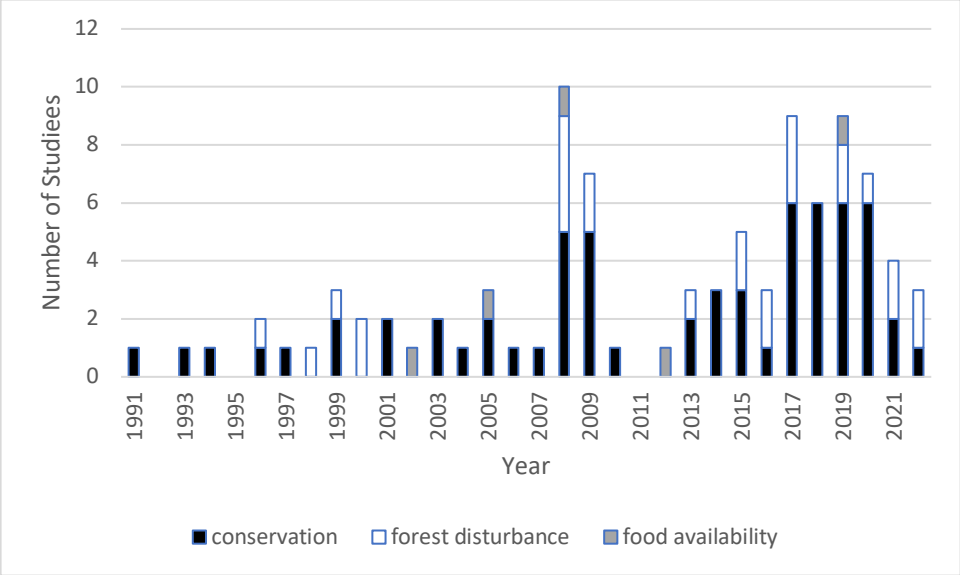

Figure 4. Number of studies found on forest disturbance, food availability, and conservation published per year: There is a total of 26 studies on forest disturbance, 5 studies on food availability, and 63 studies on marten conservation with 2 studies missing a publication year.

Studies on habitat display fluctuations with spikes in the years 1994, 2000, 2008, 2009, 2013, 2017, and 2020 (Figure 3). After these years, however, there is a downward trend of studies published regarding the American pine marten habitat. Forest disturbance publication numbers spiked between 2008 and 2017 with a decrease in studies published after those years (Figure 4). Habitat and forest disturbance are heavily studied topics for marten. Studies on food availability show a consistent production of one study within 2002, 2005, 2008, 2012, and 2019 with no studies published within the last three years (Figure 4). Studies on American pine marten conservation have a repetitive trend (Figure 4). There is a spike in studies published between 2008 and 2009, as well as between 2017 and 2020. After 2020 there is a decrease in studies published.

DISCUSSION AND CONCLUSION

Most studies on American pine marten, out of the search terms used, focused on habitat. A total of 316 studies were found and 156 of those were on habitat alone. There were a combined 101 studies on climate change, temperature, and snow. There were a combined 94 studies on forest disturbance, food availability, and conservation. The number of publications spiked sometime past the year 2015 with a decrease afterward. Overall, there was only one study, from 1994, found addressing heat, with no studies found on heat, temperature, and climate change in the summer season.

As climate change is estimated to further impact seasonal conditions and temperatures it is important to study their effects on species, especially with a lack of studies on heat, temperature, and climate change in the summer season. This lack of research makes stressors such as food availability important to study as increasing temperatures can harm or aid plant production and possibly reduce prey availability for martens. Forest disturbance should be continually studied as well since marten habitat and home ranges are still affected by further removal of preferred habitat features, especially since martens are habitat specialists. Many of these stressors if they go understudied can affect marten population numbers. Marten conservation lacks attention in many states where the marten resides. It is concerning that there is a decrease in studies published within the past two years. However, this could be due to global events such as the COVID-19 pandemic. The marten population is decreasing and without the stressors affecting them being studied and their conservation being advocated for, they may just fall victim to climate change and human activity impacts.

General Ecology

American martens are found in the boreal forest anywhere from Alaska, Canada, New England, the Great Lakes region, the Rocky Mountains, south along Northern California, and the Sierra Nevada (Helgen & Reid 2016). Habitat loss has pushed the species out of the southeastern areas (Peterson 1966). The home range of an individual male tends to be two to three times larger than the females (Clark, 1984; Burnett, 1981; Major et al., 1981; Francis and Stephenson, 1972; Hawley and Newby, 1957; Quick, 1953, 1956b; Newby and Hawley, 1954). Home ranges of male martens will overlap with other males as well as females. At a minimum, the males' range is 10 to 20 km^2 and only 3-6 km^2 for females (Wynne and Sherburne, 1984; Buskirk, 1983; Raine, 1982; Major et al., 1981; Mech and Rogers, 1977). Sexual competition between males forces them to keep a home range that includes two to six female adults (Clark, 1984; Powell, 1979). Home ranges are variable as martens may disperse within the fall after offspring have been weaned (Francis and Stephenson, 1972). Marten's dispersal depends on the available resources and population density (Francis and Stephenson, 1972).

American pine martens are typically found in mature coniferous forests with closed canopies, large trees, and a lot of woody debris (Buskirk and Powell 1994, Thompson and Harestad 1994). Martens prefer to have >30% canopy cover and use low overhead as cover (Burnett 1981). They do not like large openings in the canopy or in the patches of tree proximity as it can make them more vulnerable to predators. Marten activity is greater in summer than in winter with nocturnal activity greater in the winter (Marshall 1942) and diurnal activity in the summer (More 1978). Since martens do not hibernate in the winter, they search for suitable rest sites during this time. They mostly

reside in hollows in trees, large branches (Masters, 1980), hollow logs or stumps (Marshall, 1951 *b*), ground burrows, rock piles, and crevices (Mech and Rogers, 1977). Sometimes they can be found in subnivean resting sites under stumps, snags, and debris which may have some thermoregulatory benefits (Hauptmann, 1979; Raine, 1983; Steventon, 1979). Martens commonly use witches' brooms, a dense clump of branches, as resting sites (Spencer 1987).

American pine marten is referred to as a diet generalist since they are omnivores and have a wide range of what they can eat (Jensen et al. 2012). They tend to eat small mammals, such as voles which are their main food, snowshoe hares, tree squirrels, flying squirrels, chipmunks, shrews, and mice (More 1978; Worthen and Kilgore 1981). They even eat birds and their eggs, reptiles, amphibians, earthworms, insects, and fruits as well as berries. Martens at minimum need at least 80 kcal/day (More 1978; Worthen and Kilgore 1981). Reproduction occurs from June to August. Gestation is 220 to 276 days in total (Ashbrook and Hanson, 1930; Brassard and Bernard, 1939; Hamilton, 1943; Markley and Bassett, 1942; Ritchie, 1953). Once the reproductive cell has been fertilized it will remain in a cavity of the uterus where the fertilized cell will be carried over a period until growth proceeds. The growth will then occur for about 27 days which can vary based on the fertilization date (Jonkel and Weckwerth, 1963). Males do not assist with rearing the young (Clark, 1984). There is sexual dimorphism present, with males being larger, at about 3 weeks of growth, possibly due to competition against females (Brassard and Bernard, 1939; Markley and Bassett, 1942; Ritchie, 1953).

Stressors

American pine martens are diet generalist. They are omnivores and eat anything from small mammals to fruits. Marten will reside where the most prey is available, whether it is small mammal or mast crop prey (Jensen et al., 2012). Martens eat the mast production of plants such as beech, sugar maple, and mountain ash (Jensen et al., 2012). The amount of prey available for martens is dependent on how much food is available to their prey. Climate change can cause initial temperature warming and more availability of carbon dioxide which can aid in a plant's growth. Yet, more severe effects such as drought, flooding, and intense heat can cause less mast production. Less mast production implies less food availability for primary consumers, thus affecting the prey availability of marten and other carnivores (Jensen et al., 2012). Martens will respond by increasing movement which will ultimately affect their home range size and foraging behavior, and juvenile dispersal can lead to a higher probability of entrapment (Jensen et al., 2012). Martens will move dwellings within their home range based on prey availability during the season (Buskirk, 1983; Soutiere, 1979; Weckwerth and Hawley, 1962). Thus, they may begin to use their summer dwellings for the winter if they do not have the available resources (Jensen et al., 2012).

Forest fragmentation has become an issue within the martens' environments and affected their movement as well. Martens are forest-dependent mammals (Evans 2021). An increase in timber harvests has caused low fragmentation in a landscape with many dominant features still present (Hagris, Bissonette, & Turner 1999). Since martens are sensitive to fragmentation, they are expected to have a low population density in fragmented areas (Hagris, Bissonette, & Turner 1999). Martens avoid clear cuts and other

large openings, especially in the winter, but low fragmentation could be beneficial to them in the summer, as the clear cuts and openings can make prey more noticeable (Hagris, Bissonette, & Turner 1999). Martens responded negatively to low levels of habitat fragmentation. They were rarely detected in sites with more than 25% of the area being open even with the dominant landscape still present (Hagris, Bissonette, & Turner 1999). Thus, martens are not only sensitive to fragmentation but the size and proximity of open areas. Population density decreased with open patches lying more closely together and less than 100m wide patches were not enough to sustain martens (Hagris, Bissonette, & Turner 1999). Having frequent fragmented patches in their habitat makes it more difficult for martens to establish a suitable home range that provides them with a rest site, foraging opportunities, and cover from predators. The patches make them more vulnerable both to predators and weather conditions. They not only use denning sites as a home, but as a place to hide from temperatures that are too warm for them, they use them as cooling sites. If they are spending more time venturing from patch to patch in search of a more suitable home, then they are expending more energy and placing themselves in a position of exposure.

Martens prefer tall, well-stocked forests with trees greater than 12 m in height (Woollard 2021). However, with forest harvesting decreasing the availability of tall well-stocked forests, martens have been found to move to less isolated and smaller patches of forests (Woollard 2021). Martens avoided stunted forest growth and secondary succession forest patches. In their home range, martens avoided patches of these forest types, especially ones that are abundant with trees that had a height of fewer than 9 meters, implying there may be a risk with using this habitat site (Woollard 2021).

Martens need a lot of forage to sustain themselves since they have high metabolic needs (Woollard 2021). Therefore, increasing their movement rates can be harmful as they may not find enough forage to sustain themselves in moving from suboptimal habitats into a more sustainable one. With the continuous harvests, these clear-cuts will not have enough time to regenerate to provide martens with the environmental conditions they require, as tall well-stocked forests are an important habitat factor to them. Any partial harvest activities can diminish canopy cover, an essential component of marten's habitat as they use the canopy as a rest site (Evan & Mortelliti 2022). Forest disturbance always produces negative results, martens were less likely to occupy or colonize areas with more intense timber removal (Evan & Mortelliti 2022). The extinction rate proved to be higher in areas with repeated disturbance (Evan & Mortelliti 2022).

Martens rely on snow depth for thermal cover and to hunt prey. They will also stay under this cover to avoid predators (Bowman & Robitaille 1997). Martens use subnivean layers to rest, den, and forage (Bowman & Robitaille 1997). In Ontario, Canada martens show a preference for forests with a second growth cover type, where forage has regrown after a timber harvest. They prefer spruce-fir forests with downed logs as it provides more cover and makes it easier for martens to access the subnivean layer through the usage of downed logs from the tree (Bowman & Robitaille 1997). Martens are exposed to relatively low air temperatures throughout the year, which may cause an increased energy requirement (Worthen et al. 1981). In the winter martens typically rest in subnivean layers that are natural and contain woody debris. Martens will also rest under stumps (Hauptmann 1979; Raine 1983; Steventon 1979). However, martens cannot rest in subnivean layers that are completely snow, especially during the

coldest temperatures in the winter as they would lose heat and not be able to maintain their homeothermy (Hauptmann 1979; Raine 1983; Steventon 1979). The snow would melt and wet their fur (Buskirk 1989). If their fur were to get wet, then they would need to expend more energy to maintain a suitable thermoregulatory rate. Thus, to accommodate for the colder climates their metabolic heat production was elevated slightly, while their oxygen consumption will increase as the temperature decreases (Worthen et al. 1981).

With forest disturbance and climate-induced temperature changes worsening, martens are expanding to other regions in search of more suitable home ranges. In the United States locations that the marten inhabits, researchers have predicted that they will move more northward due to a decrease in snow depth (Siren et al., 2020). However, in Alaska moving north is not an option and instead, they are distributing themselves westward. In the past 60 years, Alaska's winter temperatures have increased by almost 4°C (Baltensperger, Morton, and Huettmann 2017). As discussed previously subnivean dens are vital to not only martens but also their main source of prey: voles. Since they are reliant on coarse woody debris to provide them with thermal cover and subnivean protection, martens may be confined to habitats that meet certain standards (Baltensperger, Morton, and Huettmann 2017). Originally the Kenai Lowlands in Southern Alaska were presumed to be a suboptimal habitat for martens as it has shallow snow cover, temperature inversions in the winter where cold air becomes trapped under a layer of warm air, active fire history, and smaller trees (Baltensperger, Morton, and Huettmann 2017). Yet, with forest disturbances and climate shifts, the Kenai Lowlands may have become more suitable than their current habitat

There is evidence of American pine martens undergoing physiological changes to better adapt to colder climates (Wereszczuk, 2021). The researchers saw an increase in pine marten body size over time, most likely attributed to more food availability (Wereszczuk, 2021). The body mass increase is accredited to warmer climates that allow berry bushes to grow more frequently and thus in the juvenile phase, they can consume more (Wereszczuk, 2021). However, these data spanned the last 117 years and if the martens have more recently developed larger body sizes, as of the 1960s and onwards, then they will not be as plastic to acclimating to a warmer climate (Wereszczuk, 2021). Yet, physiological adaptations can take centuries to occur, with climates and forests changing more rapidly, the martens do not have that time to evolve to match the current climate.

Future Research

Martens are listed as a species of least concern on the IUCN RedList but with a decreasing population trend (Helgen & Reid 2016). In many North American states, including Maine, the marten is still hunted and trapped. There was a period in which protective regulations were placed on the mammals, allowing a population increase. However, there is not a recent recording of their population number within many of the states where martens are. Unfortunately, no present actions have been taken to conserve the species, leaving the American pine marten vulnerable to further population decrease. Stressors related to global change leave martens even more vulnerable to a further population decrease. Many factors contribute to suitable habitat for the pine marten. To date, little research is available on the potential impacts of heat on the marten's habitat selection. However, it can be inferred that increased temperatures may

provide less preferable wintering sites if there is not enough snow cover and force them to increase their movements to find more habitable sites. However, in doing so they are making themselves more vulnerable to predators and having to forage more to maintain their high metabolic rates which may not be feasible. Martens are habitat specialists and require certain features such as tall well-stocked forests, coarse woody debris, and canopy cover for resting sites, but timber harvests are making these features less abundant. The lack of features is only further pushing martens out of their home range. Therefore, more research is needed on the potential impacts of raising temperatures, combined with forest disturbance, especially in the summer season, and how that affects marten habitat, movement, distribution, food availability, and energetics to inform conservation and management plans and ensure marten population numbers do not decrease further.

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APPENDICES

APPENDIX I- MODIFIED VERSION OF THE SPREADSHEET USED TO CREATE THE GRAPHS

Publication Type	Authors	Book Editors	Author Full Names	Article Title	Source Title	Publication Year
J	Powell, T; Ju		Powell, Todd; Jung, Th	Apparent Preda	CANADIAN FIEL	2007
J	WRIGHT, PL		WRIGHT, PL	INTERGRADATI	JOURNAL OF MA	1953
J	LEACH, DH		LEACH, DH	FORELIMB MYC	CANADIAN VETE	1977
J	LEACH, D		LEACH, D	FORELIMB MUS	CANADIAN JOUI	1977
J	RAINE, RM		RAINE, RM	RANGES OF JU	CANADIAN FIEL	1982
J	GRAHAM, M		GRAHAM, MA; GRAHA	HOLOCENE RE	AMERICAN MIDL	1990
J	Otto, RD		Otto, RD	Attempted preda	CANADIAN FIEL	1998
J	RAINE, RM		RAINE, RM	WINTER FOOD-	CANADIAN JOUI	1987
J	PARAGI, TF		PARAGI, TF; WHOLECI	MARTEN, MART	CANADIAN FIEL	1994
J	LEACH, D		LEACH, D	DESCRIPTIVE A	CANADIAN JOUI	1977
J	LEACH, DH;		LEACH, DH; DEKLEER	DESCRIPTIVE A	CANADIAN JOUI	1978
J	RAINE, RM		RAINE, RM	WINTER HABITA	CANADIAN JOUI	1983
J	MARSHALL,		MARSHALL, WH	NOTE ON MISS	JOURNAL OF MA	1952
J	MITTON, JB		MITTON, JB; RAPHAEL	GENETIC-VARIA	JOURNAL OF MA	1990
J	YOUNGMAN		YOUNGMAN, PM; SCHI	MARTES-NOBIL	JOURNAL OF MA	1991
J	NAGORSEN		NAGORSEN, DW; MOR	WINTER DIET C	CANADIAN JOUI	1989
J	Foresman, K		Foresman, KR; Pearsor	Activity patterns	CANADIAN FIEL	1999
J	Hughes, SS		Hughes, Susan S.	NOBLE MARTE	JOURNAL OF MA	2009
J	BELAN, I; LI		BELAN, I; LEHNER, PN	VOCALIZATION	JOURNAL OF MA	1978
J	BUSKIRK, S		BUSKIRK, SW; HARLO	TEMPERATURE	NATIONAL GEO	1988
J	JOLICOEUR		JOLICOEUR, P	DEGREE OF GE	GROWTH	1963
J	Enders, RK;		Enders, RK; Leckley, JF	Cyclic changes i	ANATOMICAL R	1941
J	Harlow, HJ; I		Harlow, HJ; Buskirk, SW	Amino acids in p	JOURNAL OF MA	1996
J	SOUTIERE,		SOUTIERE, EC; STEVE	SEASONAL PE	CANADIAN FIEL	1981
J	HOLMES, JC		HOLMES, JC	HELMINTH PAR	CANADIAN JOUI	1963
J	POOLE, BC		POOLE, BC; CHADEE,	HELMINTH-PAR	JOURNAL OF W	1983
J	BUSKIRK, S		BUSKIRK, SW; HARLO	BODY-FAT DYN	JOURNAL OF MA	1989
J	GIANNICO,		GIANNICO, GR; NAGO	GEOGRAPHIC A	CANADIAN JOUI	1989
J	CLARK, TW;		CLARK, TW; BEKOFF,	AMERICAN MAF	CANADIAN FIEL	1989
J	Zarnke, RL;		Zarnke, RL; Whitman, J	Prevalence of S	JOURNAL OF W	2004
J	TAYLOR, MI		TAYLOR, ME; ABREY,	MARTEN, MART	CANADIAN FIEL	1982
J	SLOUGH, B		SLOUGH, BG; ARCHIB	FOOD-HABITS (	CANADIAN FIEL	1989
J	Gosse, JW;		Gosse, JW; Hearn, BJ	Seasonal diets (	CANADIAN FIEL	2005
J	HOBSON, D		HOBSON, DP; PROULX	INITIAL POSTR	CANADIAN FIEL	1989
J	DOUGLASS		DOUGLASS, RJ; FISHE	HABITAT SELE	CANADIAN FIEL	1983
J	FISHER, R;		FISHER, R; GILBERT, I	HEART-RATE A	CANADIAN JOUI	1987
J	RILEY, MA		RILEY, MA	AN ANALYSIS (	JOURNAL OF MA	1985
J	BATEMAN, I		BATEMAN, MC	WINTER HABITA	CANADIAN FIEL	1986
J	White, KS; G		White, KS; Golden, HN;	Predation by Wo	CANADIAN FIEL	2002
J	SEVILLE, R		SEVILLE, RS; ADDISO	NONGASTROIN	JOURNAL OF W	1995
J	PROULX, G		PROULX, G; COOK, SF	ASSESSMENT /	CANADIAN JOUI	1989
J	Kelly, JR; Fu		Kelly, Jillian R.; Fuller, T	Records of Recc	CANADIAN FIEL	2009
C	HICKS, SA;	WILLISON, JHM;	HICKS, SA; CARR, SM	GENETIC-ANAL	SCIENCE AND T	1992
J	Wright, PL		Wright, PL	Delayed implant	ANATOMICAL RI	1942
J	Lynch, LM		Lynch, L. M.	Isolation by Plei	INTEGRATIVE A	2018
J	HOBERG, E		HOBERG, EP; AUBRY,	HELMINTH PAR	JOURNAL OF WI	1990
J	Grant, J; Ha		Grant, J; Hawley, A	Some observatio	ACTA THERIOL(	1996
J	Harding, LE		Harding, LE	Environmental c	BULLETIN OF EI	2004

AUTHORS BIOGRAPHY

Jordyn Morel is originally from Fall River, Massachusetts. She is the eldest of three children. She is the first in her family to attend college. She has a mother, Tiffany Morel, who is rooting for her success back home. Her siblings might be rooting for her as well, but it's hard to tell and depends on the day. She has taken many classes over her time here at the University of Maine, some of which she enjoyed and some not so much. She is majoring in Zoology as she has a profound love for animals, starting at the age of one if not younger. Before she entered college, she came in with the idea that she would be a veterinarian. However, after seeing her beloved cat passed, she realized that was something she wouldn't be able to handle. Thus, she turned to zoology, not to mention that wildlife is cool, from a respectful distance. She took advanced courses in middle school and high school to prep for college, but nothing could prepare her. In her junior year of college, she joined Dr. Levesque's lab where she was able to do her thesis research on the impacts of climate change on the American pine marten. She was not only excited to discuss her research, but it made her realize just how many species fly under the radar when it comes to studies being conducted on them and how there is a lack of research regarding climate change which is a very real and growing problem. After college she hopes to acquire a job as a wildlife rehabilitator, zookeeper, or in a shelter, even a farm, she's not picky. She eventually hopes to be able to train therapy animals, but she is okay to go with the flow and see where life takes her as well.