WESTERN COLORADO UNIVERSITY

The Thesis Committee for the Graduate Program in MS in Ecology

Certifies that this is the approved version of the following thesis:

REDUCING HUMAN-BEAR CONFLICTS: RESEARCHING AND ANALYZING FACTORS INFLUENCING CONFLICTS IN THE GUNNISON VALLEY

by

Cassandra Mendoza, B.S.

APPROVED BY

_____
Jessica Young, Thesis Advisor

_____
Jennie DeMarco, Program Director

_____
John Hausdoerffer, Dean, School of Environment
And Sustainability

5/4/21
Date

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Thesis

Presented to the Faculty of MS in Ecology

Western Colorado University

in Partial Fulfillment of the for the Degree of

Master of Science

Western Colorado University

Gunnison, Colorado

2021

Acknowledgements

I would like to acknowledge everyone who has assisted in the development of my project for my MS degree and supported my mental health along the way:

Bruno, The Trusty Service Dog, who was there with me every step of the way and basically earned his own master's degree!

Dr. Jessica Young, Advisor, Western Colorado University

Brandon Diamond, Area Wildlife Manager, Colorado Parks, and Wildlife

Dr. Phil Crossley, Professor of Geospatial Analysis, Western Colorado University

Dr. Kevin Alexander, Associate VP of Academic Affairs, Western Colorado University

Austin Kassner, Undergraduate Intern and one cool dude, Western Colorado University

Jason Kibler, Streets and Alleys, City of Gunnison

Erica Boucher, City Clerk, City of Gunnison

Dr. Sally Thode, Master of Environmental Management Professor, Western Colorado University

Neil Lassettre Ph.D., my cousin who was able to help me out of my rut at the end of the year.

Pierre Yves-Parent and Greg Chase for constant conversation in all things bear and constant motivation to tell me I am almost there.

My Parents, Brother, & Lauren for always reminding me not to quit and being supportive throughout all my challenges.

Dr. Anthony Miccoli for being the philosophical voice of reason for the importance of my work and why I should keep going.

The Mountaineer Field House 2020-2021 Staff for always being patient and dealing with my breakdowns and constant conversations with myself at work while I worked on this project and managed the team at the same time.

Abstract

Human-wildlife conflicts are increasing as population growth, habitat conversion, and climate change accelerate challenges for species that interface with urban and rural communities. In the Gunnison Valley, like many areas throughout the west, such conflicts are increasing between black bears and city residents. Black bears are adaptable mammals and exhibit different behaviors in response to selective pressures (e.g., temperature and precipitation changes, food availability, access to water, etc.). For example, warmer temperatures in early spring cause black bears to emerge from hibernation sooner when their traditional sources of food may be scarce. To help the City of Gunnison coexist with black bears, I did three things for my master's project: 1) I gathered existing Colorado Parks and Wildlife (CPW) black bear conflict data looking for conflicts within the City of Gunnison and gathered regional harvest data and compiled, mapped, and analyzed these data to determine conflict hotspots and possible correlation of conflict with temperature and precipitation, and human use of the landscape; 2) I reviewed existing climate models for the Gunnison region and identified predicted changes of abiotic and biotic factors associated with black bear foraging needs and hibernation behaviors; 3) Using the information that I gathered and analyzed, I consulted with individuals from the City of Gunnison, the citizens of the region, and CPW to create a human-black bear conflict management plan designed to reduce local human-black bear conflict with varying levels of implementation strategies.

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Introduction

During the last several decades in Colorado, an increasing number of human-black bear encounters and conflicts in residential neighborhoods, campgrounds, wilderness, and agricultural properties have generated media headlines, alarmed citizens, and caused concerns with local governments and state legislature (Masterson 2016). With the rapid expansion of human development and associated changes in land use in Colorado, American black bears (*Ursus americanus)* have learned to forage on a variety of widely available human-provided ("*see after: anthropogenic*") food (Lischka et al. 2019). When natural bear foods are limited by weather events such as late freeze or prolonged drought, many bears turn to these alternative foods creating a "perfect storm" of increasing human-black bear interactions and conflicts (Johnson et al. 2018) threatening the co-existence of the human population and a robust bear population. Human development and climate change and their combined effects are likely to be most pronounced along the human development-wildland interface where changes in both natural and anthropogenic conditions interact to affect wildlife (Laufenberg et al. 2018). Climate change affects wildlife by shifting long-term averages of climate variables (e.g., warmer overall temperatures and changes in precipitation patterns) and increasing the frequency and intensity of extreme climatic events (e.g., droughts, floods, historic snowfalls, etc.), which can have substantial effects on animal behavior, physiology, distributions, and population dynamics (Laufenberg et al. 2018).

Earth's climate is now changing faster than at any point in the history of modern civilization, primarily as a result of human activities (Pierre-Louis 2018). Many studies conducted by researchers around the world have documented increase in the temperature at Earth's surface, as well as in the atmosphere and oceans (Rusoke 2017). Global climate change is creating a trend

consistent with a warming world including high temperature extremes and heavy precipitation events increasing, glaciers and snow cover shrinking, and sea ice retreating (USNPS 2018). Such climate change affects species and ecosystems, with observed effects including shifts in species distributions, changes in life - history, effects on demographic rates, and reductions in population sizes (Rusoke 2017, Johnson *et al.* 2018). Climate change is a major evolutionary driver, and anthropogenically accelerated climate changes will drive substantial evolutionary changes in species (Mawdsley et al. 2009). Climate variability and change affects species and ecosystems in several ways including birds laying eggs and plant blooming earlier (Paniw et al. 2020). These changes in a variety of ecosystems, including in the Gunnison Valley, are being detected at a faster rate than anticipated (Rusoke 2017, Anderson & Wadgymar 2020).

The Gunnison Valley is surrounded by plateaus and some of Colorado's highest mountains and its climate is highly variable from drought to years with heavy snow (Lynn 2019). Current climate data for Gunnison County show that the period of 1988 to 2018 had an average of 50.8 centimeters of precipitation (PRISM Climate Group 2020) with higher elevations receiving the most precipitation. Climate data for Gunnison County show that the years from 1988 to 2018 had an average annual temperature of 4°C with an average maximum temperature of 10.7°C and average minimum temperature of -2.77°C (PRISM Climate Group 2020). The 2018 year in the Gunnison Valley was an example of increased climate variability with being the fifth warmest year recorded during the past 125 years and one of the driest (HPRCC 2019, NASA 2020) with an average temperature of 4.94°C and average precipitation of 38.45 centimeters (PRISM Climate Group 2020). Climate modeling for the Gunnison Basin predicts that the average annual temperature of the Upper Gunnison Basin is projected to increase 3°C with average summer temperatures increasing by 4°C by 2050 (HPRCC 2019). Models also predict shifts in the timing

and available of precipitation with more rain and less snowpack which is likely to have an impact on the timing and availability of forage for wildlife (Nelson 2019). Such shifts in precipitation and temperature are likely to influence local black bear ecological and behavioral responses and could cause them to increasingly seek anthropogenic food sources given changes in phenology.

Phenology is the timing of events over the annual cycle of plants and animals and influenced by changing temperature, moisture, and sunlight levels. Climate change induces earlier flowering times for some plant species (Panetta et al, 2020) which can affect the availability of berries and other bear food. For example, early flowering can increase fruit losses from frost damage (Iler et al. 2019). Frost damage to flower buds contributes to plant population declines, but there is also evidence that increased drought risk during longer growing seasons also strongly contributes to adverse effects on survival (Iler et al. 2019). Panetta et al. (2020) conducted a 25 year in situ climate manipulation study to identify mechanistic links between climate change and the local extinction of many widespread mountain plant species. They found that climate warming causes precipitous declines in plant population sizes due to reducing fecundity and survival across multiple life stages and purges belowground seed banks limiting the potential for the future recovery of mountain plant species. These changes in phenology due to climate change can impact the availability of natural food sources for local black bears.

Black bears are omnivorous, opportunistic feeders that can live up to 20 to 30 years depending on hunting harvest rates and the availability of a wide variety of naturally available food (Armstrong et al. 2011). Black bears eat vegetation such as berries, acorns, seeds, grasses, and forbs (Armstrong et al. 2011). They also eat insects and scavenge on carcasses (CPW 2015). The diets of black bears vary geographically depending on where and when these natural sources are available to bears (Baldwin & Bender 2009). Colorado black bears primarily eat trees and shrubs

that provide fruits and nuts as their primary natural food source. Throughout the forest communities' trees and shrubs of the peak black bear's interest are serviceberry, chokecherry, pin cherry, squaw apple, mountain ash, buffaloberry, currant, Gambel's oak and pinon (Lewis et al. 2015). Food-related factors influencing black bear movements are important for understanding the origins of bear conflicts (Merkle et al. 2013). The timing and availability of these critical bear food sources in the Gunnison Valley may lead to increased human-black bear conflict in changing climate conditions (drought, severe winters) and be exacerbated by increased human density (e.g., housing density, trash disposal practices etc.) and/or recreational use of the landscape (e.g. trail use etc.).

Black bears gain weight in the fall and lose up to 30% of their weight during the winter period of inactivity. Movements and activity of black bears vary in response to food supply. Black bears will travel long distances to exploit concentrated food sources (Kirby et al. 2016). Daily activity generally increases from den emergence until late summer or early fall when natural food availability is greatest. Activity declines until bears enter dens, which varies from October to December (Baldwin & Bender 2009). Black bears are corpuscular or most active at dusk and dawn. When localized natural food failure occurs, black bears become increasingly mobile and persistent in search for anthropogenic food sources including trash, fruit trees, pet food, bird feeders, livestock, and agricultural products (Wilbur et al. 2018).

There are two periods of the year (immediately post hibernation and during preparation for hibernation) that black bears seek concentrated food sources and may travel to areas in search of anthropogenic food sources. For black bears, hibernation is an important life-history strategy that is influenced by changing patterns of climate (Johnson et al. 2019). Hibernation is a state of inactivity that enables animals to conserve energy during seasonal food shortage or severe

weather, a need that may decline in response to changing environmental conditions. The long-term trend of warmer winter weather has been associated with earlier emergence from hibernation (Johnson et al. 2016). For hibernators sensitive to temperature, trends in warmer weather are correlated to shorter durations of hibernation. Temperature was found to have twice the magnitude of effect of either natural or human food availability in decreasing the overall length of hibernation. Additionally, disparate patterns in the snowpack could create trophic mismatches for bears that emerge prior to the onset of spring food resources (Johnson et al. 2016).

Reduced hibernation in bears will likely result in increased conflicts in the urban-wildland interface as bear increase their use of human developments, especially when natural foods are scarce (Schwieterman 2019). By 2050, Colorado climate models project that the average temperature will have increase by 2.5 to 5°C under medium-low emissions scenarios and by 3.5 to 6.5°C under high emission scenarios (Panetta et al. 2018). Assuming that the relationship between temperature and hibernation length is consistent, where a 1°C increase in the winter minimum temperature is associated with a 6-day reduction in black bear hibernation; by 2050, the average length of bear hibernation could decline by 15 to 39 days (Johnson et al. 2016). Given the increasing availabilities of human foods on the landscape, coupled with shifts in bear forage availability and hibernation behaviors, I predict that bears will increase their attempt to use anthropogenic food resources in the future leading to increase conflict in the Gunnison Valley. Limited research suggests that black bears foraging on anthropogenic food sources may also hibernate for shorter periods or even forgo hibernation altogether (Beckman & Berger 2003) which could increase the length and intensity of seasonal conflict in the Gunnison Valley.

Conflict & Conflict Mitigation

There are three distinct categories of human-bear conflict incidents: nuisance bears, depredating bears, and dangerous bears. Nuisance bears pose an immediate threat property and potentially damage property, but do not threaten public safety (CPW 2015). Nuisance bears involved in two incidents are destroyed in the state of Colorado. Depredating bears are bears that have killed cattle, sheep, horses, alternative livestock, or other hoofed livestock (CPW 2015). Any bear that kills cattle, sheep, horses, alternative livestock, or other hoofed livestock will be destroyed or translocated in Colorado. Dangerous bears are those that pose an immediate threat to human health and safety. Colorado Parks and Wildlife personnel will capture, ear tag, and translocate a bear if it is deemed dangerous because of its location and not its behavior. However, bears exhibiting behaviors considered to be a danger to people are killed.

One step taken to mitigate human-black bear conflict in some counties in the state of Colorado are changes in harvest. Regulated public harvest is the primary management tool used by CPW and other wildlife management agencies to regulate wildlife populations, including black bear. Harvest of black bears can be compatible with increasing, stable, or decreasing bear populations, depending on population management objectives and harvest regulations. Bear inventory efforts in Colorado involve extrapolating information about known bear densities in small geographic areas and applying them to larger areas. From “hair snag” samples the current conservative estimate of black bears in the state of Colorado is at approximately 10,000 to 12,000 bears. Using this information, CPW wildlife managers estimate that the bear population has been stable since 2011. Given the challenges and uncertainty in estimating bear population sizes, the number of hunting licenses has historically been conservative; however, recent increases in human-black

bear conflicts in Colorado have resulted in additional bear harvest licenses in most bear management areas (CPW 2015).

Management of human behavior is as important as management of bears. Research and observation offer conclusive evidence that human behavior, primarily carelessness with trash, bird feeders, pet food, and other bear attractants, increases the likelihood of human-bear conflicts in Colorado and throughout black bear range (Alldredge et al. 2015). Mitigation of human-bear conflicts involves integration of many management options, and no single option is best for every circumstance and varies by community and location. Local communities need to identify the correlates and causation of conflicts by understanding the locations and correlates of past conflicts and determine measures that can reduce future conflicts. Identifying areas with high conflict rates is critical for being able to predict the circumstances of future conflicts. Using this understanding to create bear conflict management plans and effective educational programs is a critical step to protecting both bears and the communities in bear habitat. Such plans include public education, waste ordinances, law and ordinance enforcement, exclusionary methods, capture and release, adverse conditioning, repellents, damage compensation programs, supplemental and diversionary feeding, depredation permits, and population management (Lackey et al. 2018). All methods have their advantages and disadvantages but education and cooperation between wildlife agencies and local municipalities are paramount in preventing conflicts.

The City of Gunnison ordinance 5.40.040 Section D (1997, 2014) states that “the municipality is a wildlife sanctuary for the refuge of all wildlife and citizens are urged to protect native wild animals”. Within the context of this existing ordinance, there is potential to fully realize the

city's intention to be a wildlife sanctuary for black bears through policy and planning, education, partnerships, and city infrastructure to truly support the coexistence of human and bear.

To aid the City of Gunnison in realizing their goal of promoting coexistence with black bear, I

- gathered existing Colorado Parks and Wildlife (CPW) black bear conflict data looking for conflicts within the City of Gunnison, and regional harvest data, then compiled, mapped, and analyzed these data to determine locations associated with bear harvest, conflict hotspots, and possible trends associated with precipitation, temperature, and human use of the landscape.
- reviewed existing climate models and predictions for the Gunnison region and created a list of predicted changes of abiotic and biotic factors associated with black bear foraging needs and hibernation behaviors.
- collaborated with the City of Gunnison, the citizens of the region, and CPW to create a well-researched, scientifically supported human-black bear draft conflict management plan (Appendix I) designed to reduce local human-black bear conflict with varying levels of implementation strategies contingent on environmental conditions predicted to increase conflict.

Methodology

Conflict Report Analysis. I gathered and transcribed the conflict reports from paper to a digital format by hand and created a spreadsheet to begin my analysis. These reports included conflict reports, mandatory hunting reports, and trap release reports. Mandatory hunting reports require the hunter to take their kill to Colorado Parks and Wildlife for review and processing. I collected a total of 885 reports spanning from years 1988 to 2018. These reports were utilized for my analysis due to them being the only primary and fairly consistent way to analyze conflicts within the valley. Each report notes location in a predetermined Data Analysis Unit (DAU, the geographic area that includes all the seasonal ranges of a specific herd) and by Public Land Survey System (PLSS) coordinates as a primary way to document location distribution. I used the PLSS coordinates to protect confidentiality of the reporter rather than the exact address locations. Those PLSS coordinates were then converted to latitude and longitude using Earthpoint R code. These coordinates were double checked manually on a Gunnison Public Lands USDA map. I created a database for data analysis including fields for the following:

- Year
- Report Type (Conflict/Mandatory/Trap & Release)
- ID (Generated)
- Date of Conflict/Kill
- DAU (Data Analysis Unit)
- Conflict Type
- Food Source Type
- Property Damage Type
- Complaint History
- Sex
- Age
- Female Breeding Status

- GMU (Game Management Unit, subsections of DAU)
- Township of Conflict/Kill
- Range of Conflict/Kill
- Section of Conflict/Kill
- ¼ Section of Conflict/Kill
- ¼ ¼ Section of Conflict/Kill
- Drainage of Conflict/Kill
- Seal # of Harvest Bear (if applicable)
- Address of Conflict Report
- Trap & Release (if applicable)
- Location of Trap & Release (if applicable)
- PLSS coordinates translated into Latitude and Longitude

Spatial Analysis. I then mapped the location of each conflict (N = 647) and created a geodatabase with a separate feature dataset for each year's conflicts. I used this geodatabase to examine conflict hotspots and as a baseline for monitoring how changes in human management and education influences future conflicts. The analyses that follow are based on the 2004-2018 conflict reports, as the 1988 to 2003 were only mandatory hunting reports that were not indicative of conflicts. However, I also transcribed those reports per Colorado Parks and Wildlife request.

Key Conflict factors. I compiled data for the Gunnison Valley on vegetative biomes, recreation, restaurants, major water sources, and populated areas to try and determine if those variables are correlated to human-wildlife conflict incidents. I compared locations of conflict points to vegetative biomes to further understand the land the bears are utilizing. This was done with the 'extract values to points' tool to extract the NLCD vegetation classification and append to the conflict location points.

To investigate possible correlation between the suspected conflict factors (listed above) and the locations of the reported conflicts, I applied regression modeling, optimized hotspot analysis and the 'Near' analysis tool which measures the distance from each conflict point to the nearest specified feature and adds a distance attribute to the input data.

I used the compiled conflict data to identify and map temporal and spatial "hotspots" and explored correlations between more dense conflict areas and other possibly associated variables with those hot spots (e.g., housing density, recreation trails, distance to water, etc.). I then mapped hotspots for all 647 conflict reports as well as each year of conflict reports separately using the kernel density tool.

Climate data and Future Conflict Trends Predictions. Informed by my review of the literature, I hypothesized that there would be a correlation between the precipitation/snowpack trends and greater conflict frequency after dryer winters in which natural food sources could be more limited. To investigate this, I compiled data from PRISM, SNOTEL, and the Gunnison County Electric Association and then implemented several different raster analysis processes to reclassify and combine the different data sets and correlate annual conflicts with the precipitation from the previous winter, focusing on two years with dryer, then wetter than normal precipitation. Unfortunately, data limitations from both the conflict reports and scale and longevity of sourced climate data prevented testing this hypothesis.

Results

Conflict Report Analysis. After performing the above analyses, I found several intriguing results for understanding local human – bear conflict. The root cause of conflict throughout the valley is the attraction to sources of human food or waste that are easily accessible by bears. Reports were classified by categories to identify possible attractants expected, the most significant source of conflict throughout the valley is related to anthropogenic food sources. Bears were reported causing property damage in 517 of the conflict reports with 85% of those being directly attributable to a food source (Figure 1). The most significant food source

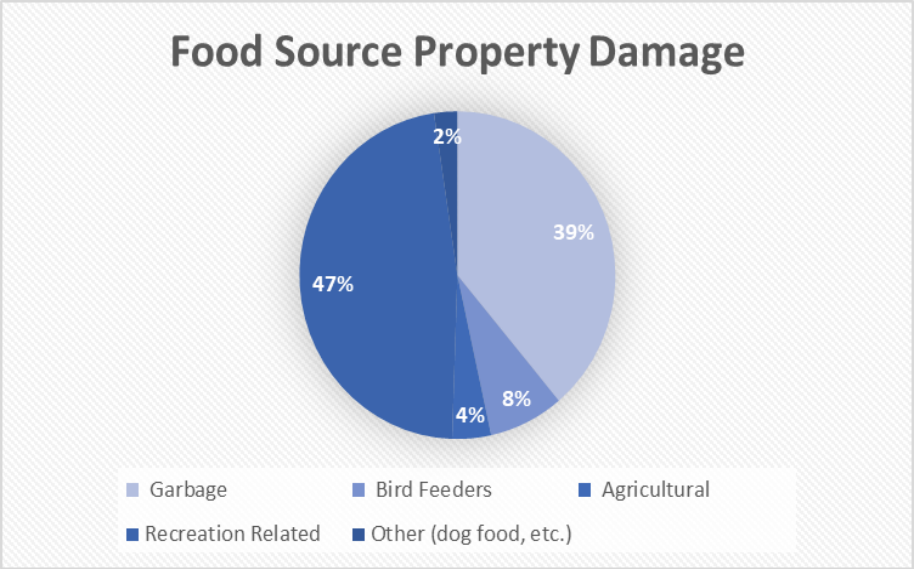


Figure 1: Conflict data summary for food source related property damage seen throughout 2004 to 2018. (n=647) with main factors including recreation related (47%), garbage (39%), bird feeder (8%), agricultural (4%), other (2%).

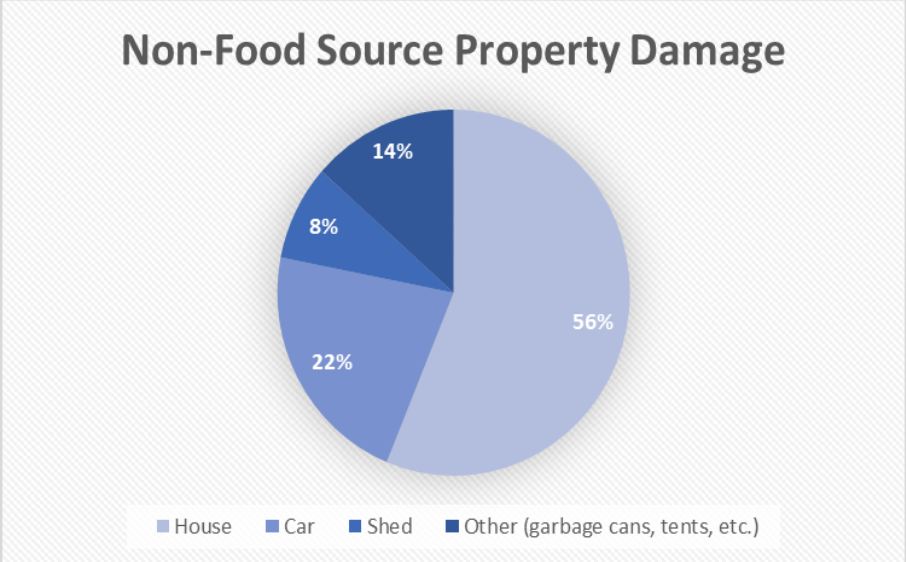


Figure 2: Conflict data summary for property damage seen throughout 2004 to 2018 (n=517out of 647) with main factors including house (56%), car (22%), other (14%), shed (8%).

identified was garbage. 56% percent of the property damage reported was associated with houses (Figure 2).

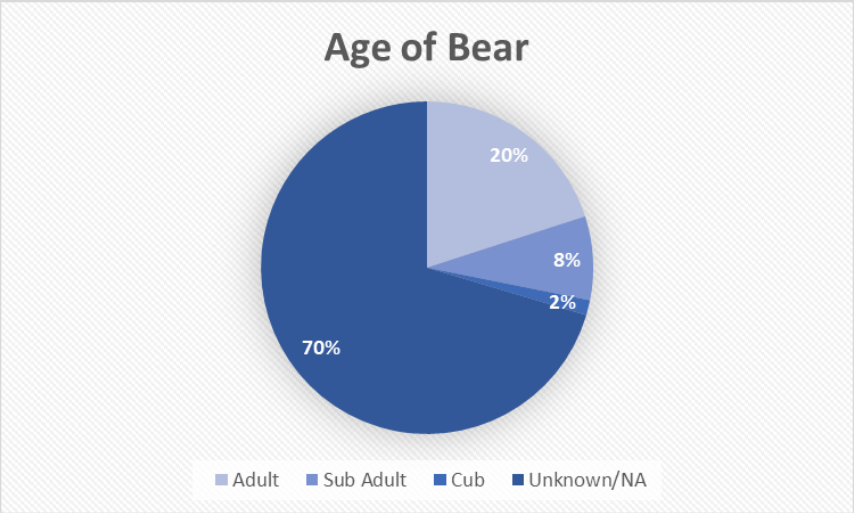


Figure 3: Conflict data summary for age of bears that were involved in conflicts from 1988 to 2018. N=624 with ages from unknown (70%), adult (20%), sub-adult (8%), and cub (2%).

While the exact age of conflict bears is typically unknown, reporting parties sometimes mentioned mothers with cubs, or made comments specific to "yearling" or "young bears" (Figure 3).

Throughout the data set, there appears to be a disproportionate number of "first-time" (a person that has never called in before) conflict reports in comparison to subsequent reports from the same location (Figure 4). There are likely a variety of explanations for this, and certainly inherent biases associated with voluntary conflict reporting. Bears in the valley may exhibit strong nomadic tendencies, continuously moving between high reward food sources. Or it may suggest that education and law enforcement actually help mitigate future conflict.

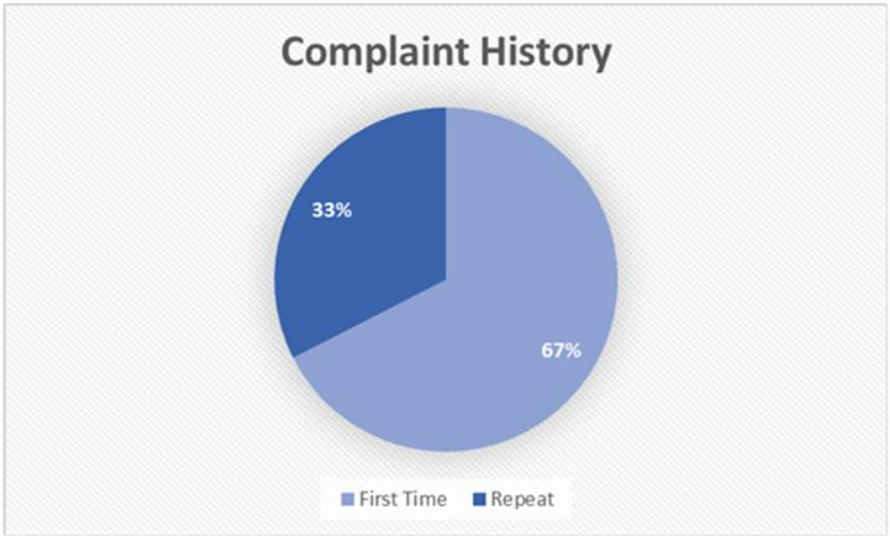


Figure 4: Complaint history for conflict reports within 2004 to 2018.

Spatial Analysis. After running the conflict reports through the variety of spatial analysis tools including regression modeling, optimized hotspot analysis and the near tool, the results produced lacked utility due to the restrictions associated with maintaining the confidentiality of residential addresses as well as many of the reports not including specific addresses or having out-of-region addresses. In order for results to be meaningfully interpreted, the Near tool and other proximity measures require more precise locations than the conflict reports provided.

Key Factors. The literature shows that in other locations, conflicts are correlated with access to food sources. The rate of interaction between humans and black bears is highly correlated to the quality and abundance of natural food sources. Through the analysis I determined that the highest conflict potential is during the fall months (August to October) (Figure 5 & Table 1) where the prior summer was recorded as extremely dry and where the prior winter produced minimal snowpack for the upcoming spring and would account for reporting spikes in 2007, 2012, and 2016 (Figure 5). It is suggested that a large number of conflicts happened in the valley at times of below average precipitation during winter months (October to April) and it was found statistically significant; however, explained a low amount of the variation in annual conflicts reported observed ($p=0.03$, $r2=0.03$). I found that above average temperatures throughout the spring/summer (May to September) to have more of an impact towards conflict than precipitation ($p=0.0001$, $r2=0.17$).

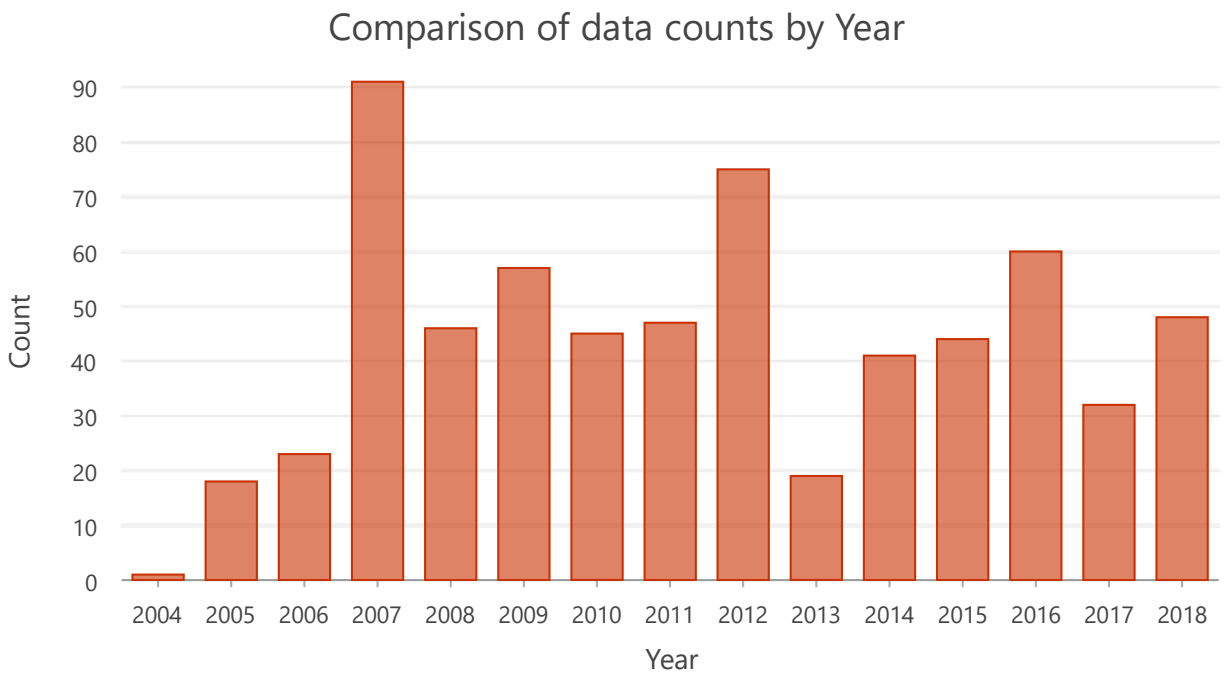


Figure 5: Annual number of conflicts reported from 2004-2018.

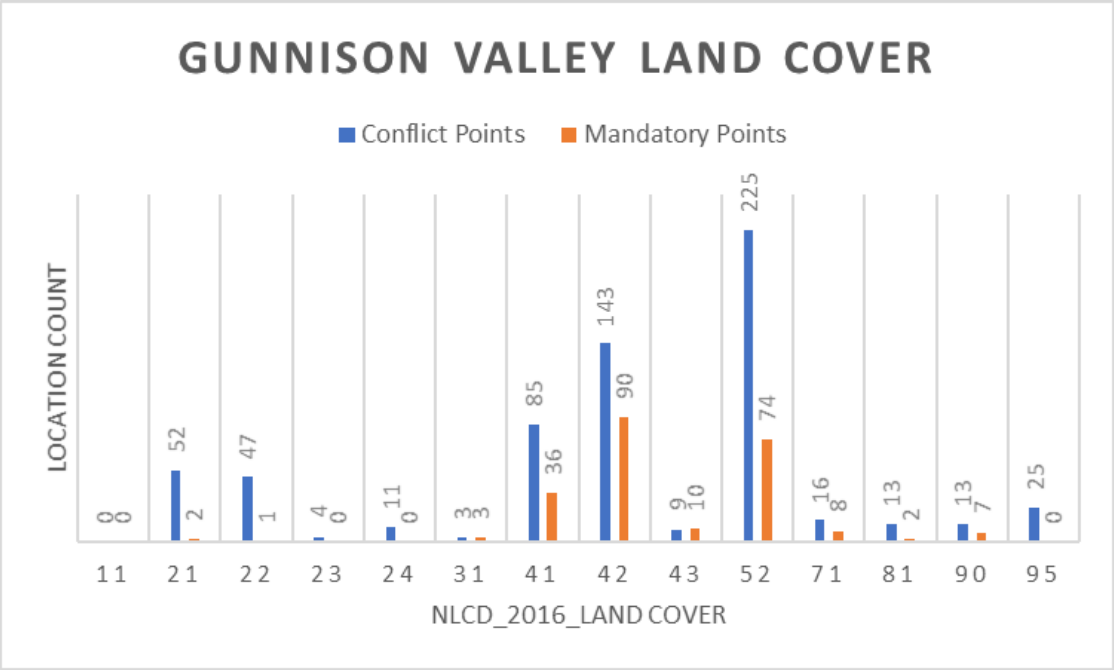
Winter Water Period	Conflict Year Analyzed	# of Conflicts	Total Winter Precipitation (Oct-Apr) (PRISM)(mm)	Average Spring/Summer Temperature (May-Sept) (PRISM)(°C)	# of Conflicts (and percent of annual total) That Occurred in Fall Months (Aug-October)
2003/2004	2004	1	324.09	11.86	1 (100%)
2004/2005	2005	18	266.54	12.40	18 (100%)
2005/2006	2006	23	284.92	12.44	21 (91%)
2006/2007	2007	91	254.53	13.06	58 (64%)
2007/2008	2008	46	418.7	12.08	32 (70%)
2008/2009	2009	57	292.65	12.14	55 (96%)
2009/2010	2010	45	251.96	12.56	17 (38%)
2010/2011	2011	47	362.42	12.40	25 (53%)
2011/2012	2012	75	172.36	13.70	64 (85%)
2012/2013	2013	19	199.36	13.00	12 (63%)
2013/2014	2014	41	286.02	12.40	41 (100%)
2014/2015	2015	44	217.19	12.38	38 (86%)
2015/2016	2016	60	334.05	12.44	26 (43%)
2016/2017	2017	32	390.03	12.72	32 (100%)
2017/2018	2018	48	215.21	14.14	28 (58%)

Table 1: Data for number of record conflicts within each year and average winter precipitation (mm) and spring/summer temperature (°C) for corresponding conflict year from PRISM.

Rates of conflicts are also positively correlated with the presence of non-residents and visitors. Those who provided addresses outside of the valley (non-permanent residents and visitors) were more likely to report a conflict (n=425 reports) compared to residents with addresses within the

valley (n=222). This was seen on the number of reports taken during peak visitor seasons (summer and fall) in the valley and the number of reports taken for people with addresses that do not occur within our valley.

Key Factors Spatial Analysis. After analyzing the land cover of the Gunnison Valley and comparing it to locations of conflict points as well as points from mandatory kill reports, it was determined most conflicts/mandatory kills occurred in shrub/scrub habitat. This is the natural habitat of black bears which contains native food sources from shrubs such as Serviceberry, Elderberry, and Gambel's Oak. Twenty six percent of conflict/mandatory kill points occurred in evergreen forests, which is also natural habitat for local black bears for rest and movement (Figure 6). These land covers (Figure 7) are also those preferred for residential development and associated with such locally. Following the habitat analyses, I explored the degree to which conflicts were associated with municipalities through a subsequent hotspot analysis.



11	Open Water	42	Evergreen Forest
12	Perennial Snow/Ice	43	Mixed Forest
21	Developed, Open Space	52	Shrub/Scrub
22	Developed, Low Intensity	71	Herbaceous
23	Developed, Medium Intensity	81	Hay/Pasture
24	Developed, High Intensity	82	Cultivated Crops
31	Barren Land	90	Woody Wetlands
41	Deciduous Forest	95	Emergent Herbaceous Wetlands

Figure 6: Bars represent the number of conflicts (Conflict Points [blue bars]; n=647) and mandatory kills (Mandatory Points [orange bars]; n=238) occurring from 2004-2018 which were located in each biome (NLCD 2016 Landcover [see reference table below main figure for biome corresponding to numeral in x-axis]).

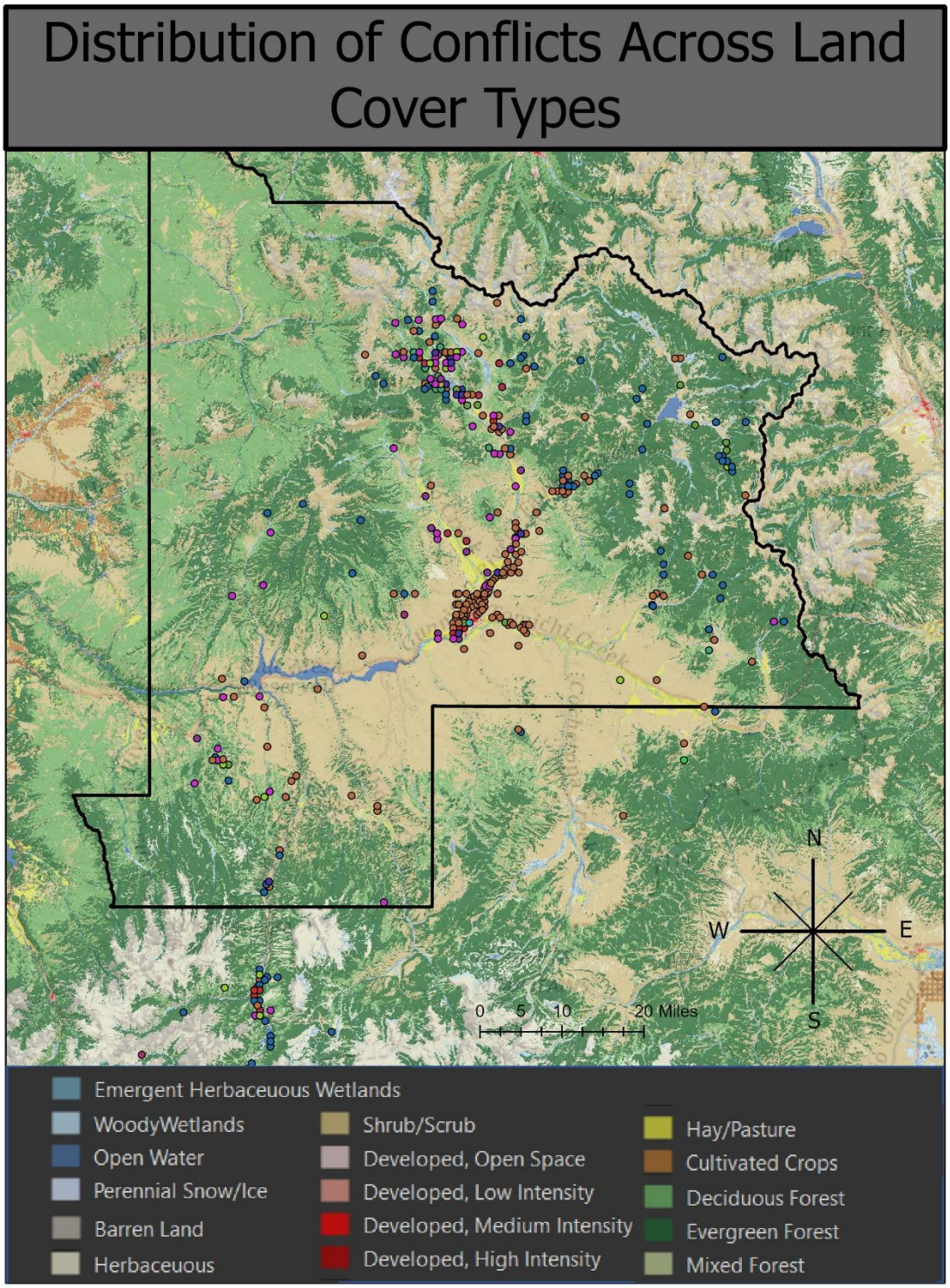


Figure 7: Gunnison Valley Land Cover. Mandatory kill and conflict points from 2004-2018 are overlayed in color associated with land cover.

Hotspot Analysis. After mapping all 647 conflict points by year (Figure 8), I performed a hotspot analysis with the kernel density tool (Figure 9). I performed the kernel density analysis to identify severity of conflicts within different areas in the valley. The kernel density analysis was performed on each individual year as well as the total conflict points combined. Each kernel density analysis produced a raster layer that I chose to symbolize with graduated colors to identify more or less dense conflict zones. The results showed that the densest hotspot zones were located in Crested Butte, Lake City, and the Dos Rios/Arrowhead neighborhoods. Somewhat dense conflict reporting zones included Crested Butte South, and Taylor Reservoir, and the surrounding areas. The City of Gunnison, Almont, were hot spots as well, but had less conflicts reported than some of the other municipalities or neighborhoods.

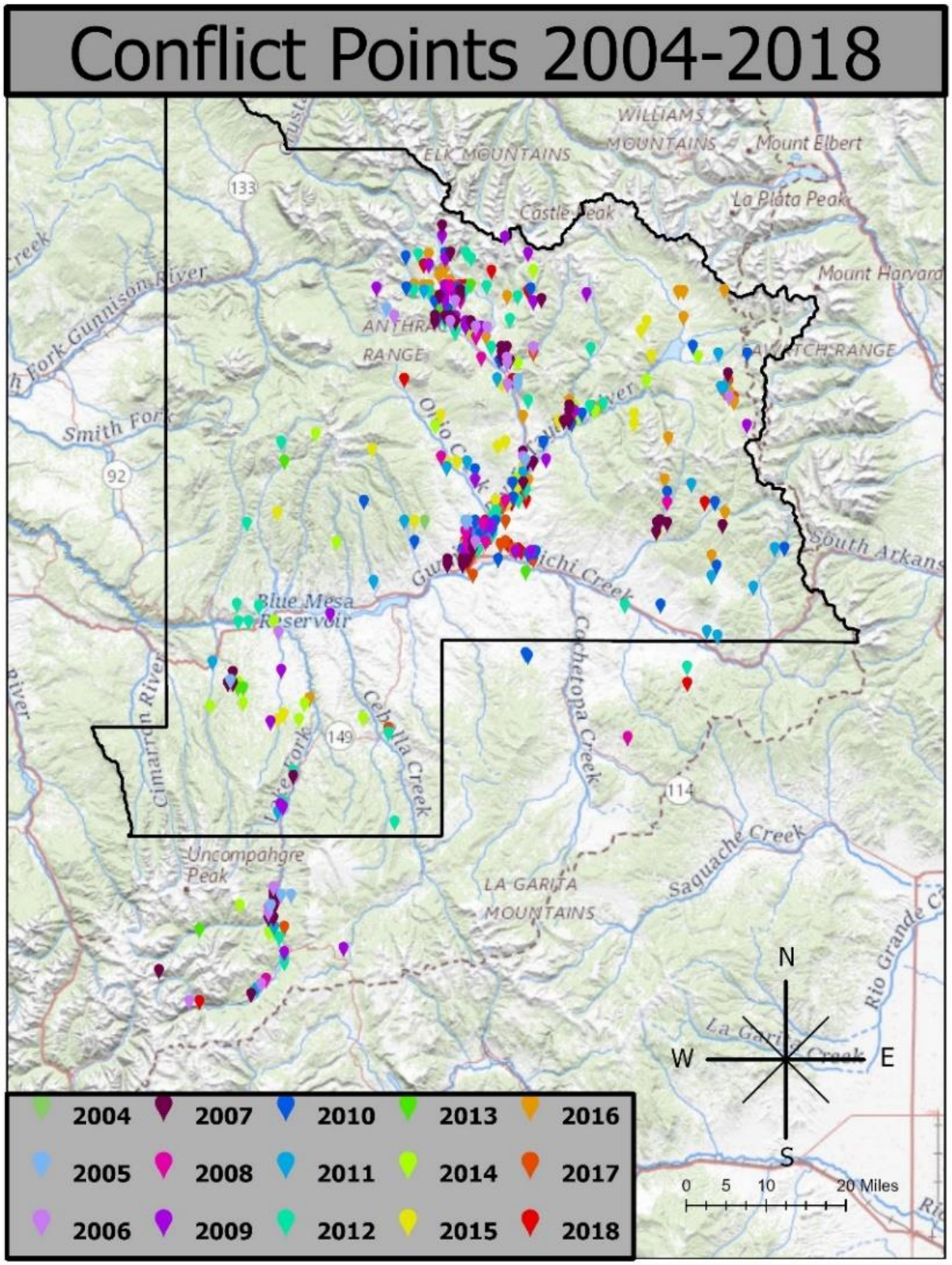


Figure 8: Conflict report locations by year (2004-2018) (n=647).

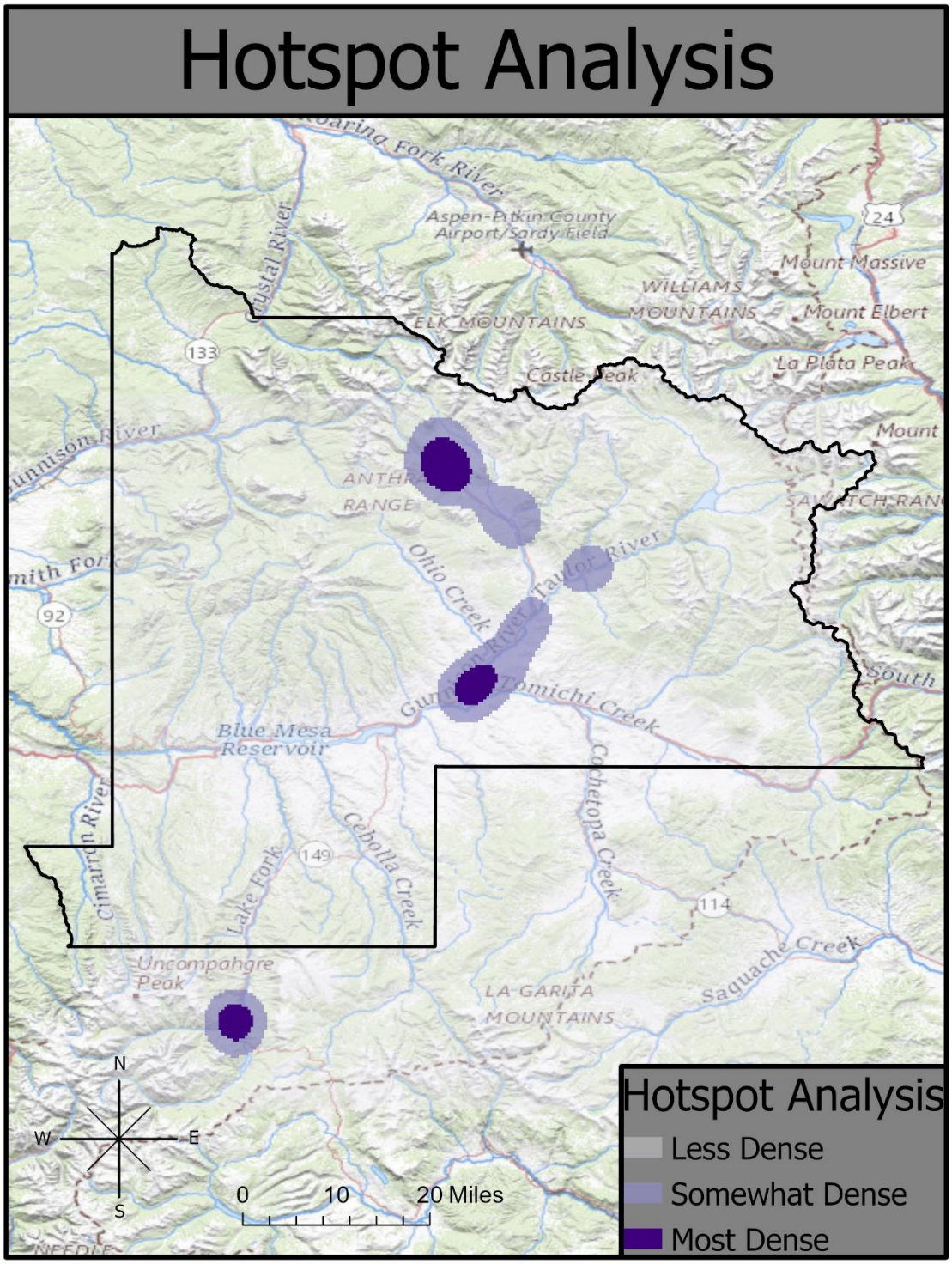


Figure 9: Map of the kernel density results of total conflict points identifying key hotspots throughout the valley.

Discussion

The City of Gunnison passed an ordinance in 1997, reviewed in 2014, designating the City as a wildlife sanctuary, which will provide refuge for all wildlife, and encouraged citizens to protect native wild animals (Ordinance 5.40.040 Section D). The definition of wildlife sanctuary is an area where wild animals and plants are protected, but such is more challenging when considering bears which can cause property and agricultural damage. For such, coexistence is a goal in which bears are encouraged to stay in their natural habitat and human property is preserved. Colorado Parks and Wildlife received 647 reports of bear conflicts from citizens in the Gunnison Valley during the period of 2004-2018 and local social media suggests that there are many unreported conflicts within the City of Gunnison. The aspirations of the City are challenged in a valley with increased tourism, changes in the nature of home ownership and in a time of climate change, all of which may be causing human-black bear conflicts rather than coexistence. Climate change affects wildlife by shifting animal behavioral patterns such as length and timing of bear hibernation (Johnson et al. 2017), creating a mismatch of when bears need increased food sources and when those sources are available (Lichska et al. 2019), and drawing bears to food in urban locations. I used climate predictions for the Gunnison Basin of increased average temperature and changes in precipitation timing to investigate correlations between temperature and precipitation trends and the frequency and location of bear conflicts. Though my in-depth analysis came out as inconclusive and was not possible with the reporting data and accessible local climate data due to a mismatch between national and local data. I was able to find a correlation that conflict was more likely to occur in times of low winter precipitation and high summer temperatures based on correlations between number of reports and annual total

precipitation amounts suggesting the need for more management of food sources and citizen education during such conditions.

Management of food sources sought by bears requires management strategies for trash, bird feeders, and other bear delicacies, such as dog food, that await them in yards. I found that 85% of conflict reports associated with property damage were directly attributed to food sources with the most significant culprit being garbage. My research shows that bear locations associated with mandatory kills and conflict reporting are in the shrub/scrub habitat, a source of bear food such as berries from serviceberry and other shrubs. When weather conditions interrupt natural food resources (Merkle et al. 2013) near town, bears have no choice but to explore for food alternatives prior to hibernation, and I found that highest potential for conflict in the Gunnison Valley was from August to October. Knowing the sources of food attracting bears, the timing of increased conflicts, and the predictions associated with increase of conflicts due to climate change helps with creating education campaigns and delivering them during key months to reduce conflict.

One significant challenge in such a campaign is the composition of the valley's community is changing with 63% of the residences owned by part time residents from outside the valley (One Valley One Prosperity Report 2016) who may have less familiarity with wildlife co-existence. I found that individuals who had primary addresses outside of the valley were almost twice as likely to report a conflict compared to those whose primary addresses were within the valley. Reaching a part-time and resident population takes careful planning and effort. The cost of failure is not only to the bears who are killed or who may be relocated to novel habits where they have little familiarity of the area, den sites, and food sources (Alldredge et al. 2015), it is also a cost to homeowners. I found bears damaged property in 517 of the 647 complaints with damages

to the home occurring 56% of the time. Finally, the cost is one in which the City's intent to become a wildlife sanctuary is unrealized and instead we become a place that diminishes the very wildlife that draws so many to the valley.

What can we do to promote wildlife coexistence? Conflict Mitigation Planning and Education.

Factors contributing to wildlife conflicts such as recreation, garbage disposal, and increased residential expansion into rural areas can lead to opportunities for simple changes to reduce conflicts. Reducing impacts due to climate change is more challenging (Higgins and Kousky 2016), yet individual actions matter for both. I utilized the data, analyses, and maps to provide a draft black bear conflict mitigation plan to the City of Gunnison to reduce conflicts and promote coexistence (Appendix I). I reviewed 15 conflict mitigation plans from two different countries and several states to understand and model the draft plan. Researched plans provided different perspectives from conflicts in urban and in rural locations. The development of my proposed Gunnison's human-black bear conflict management plan benefitted from both urban and rural perspectives because of our remote location, large second homeowner contingent, and significant tourist population. Each of these conflict mitigation plans provide possible techniques to mitigate conflict and suggest the importance of developing a mitigation plan based on local observations and data. The plans have a goal of minimizing human-bear conflicts through strategies such as identifying attractants, promoting proper food and other attractant storage on both public and private property, creating information and education programs, forming multiple governmental and private partnerships, and improving methods of conflict response and reporting.

In addition to the development of this conflict management plan and after consulting with Frank McGee of the Colorado Springs CPW office, I built an educational website and mobile app to pilot increasing public reporting and local responses to bear conflict. The website and mobile app

were modeled from the internal system the Colorado Parks and Wildlife currently use for conflict reporting. Both website (https://gunnisonconflict.squarespace.com/) and mobile application (https://www.appsheet.com/start/15c9a0cf-20ef-4756-a486-ffd0ba354b89) are in beta format, so are not currently available to the public.

The website and app could be integrated into the current Colorado Parks and Wildlife reporting system; however, such has been suggested to be preceded by a pilot determining the utility of the website and app locally. Colorado Parks and Wildlife has interest in partnering with the City of Gunnison to pilot the use of the reporting and educational tools developed, and such could be beneficial to other Colorado communities with the potential for significant wildlife conflicts. The link for both website and Google Form base of mobile application could be house within the City of Gunnison website under the wildlife conservation tab and on the Colorado Parks and Wildlife website within the local CPW office page as well as on their local Facebook. The creation of the website and app will be an integral part in addressing the some of the key issues I found within this project. The website and app will be able to allow the user to give there address if they please or give a more precise location than the conflict point locations were throughout this study. This will allow more precise insight into conflicts throughout the valley.

Creating a human-black bear conflict management plan for the Gunnison Valley and avenues to educate and enhance the utility of reporting is a key step in Gunnison truly becoming a wildlife sanctuary. Some key recommendations highlighted in the plan include creation of ordinances around waste disposal and wildlife attractants, development of a 'Bear Smart' community engagement group to increase education and an increase community engagement in reporting efforts and conflict mitigation. To further understand human-bear conflicts throughout the valley, it would be helpful and informative to conduct a similar study a few years down the road to see if

the recommended actions laid out in the draft management plan have reduced conflicts. A method of possible assessment to analyze outcomes from the management plan would be to model such a study after the Durango bear project (Johnson et al. 2018).

Gunnison's wildlife ordinance is truly aspirational, but it is also inspirational. With dedicated effort toward co-existence and implementation of the results through education and planning, the City of Gunnison can become a wildlife sanctuary for black bears.

Literature Cited

Alldredge, M. W., Walsh, D. P., Sweanor, L. L., Davies, R. B., & Trujillo, A. (2015). Evaluation of translocation of black bears involved in human–bear conflicts in South-central Colorado. *Wildlife Society Bulletin*, *39*(2), 334–340. https://doi.org/10.1002/wsb.526

Armstrong, D. M., Fitzgerald, J. P., & Meaney, C. A. (2011). *Mammals of Colorado* (2nd ed.). Denver Museum of Nature & Science and University Press of Colorado.

Association of Fish and Wildlife Agencies. (2018, March 15). *Human-Black Bear Conflict A Review of the Most Common Management Practices*. https://www.fishwildlife.org/application/files/7315/2243/9066/DRAFT_AFWA_Human_bear_conflict_management_3-15-2018_R.pdf

Baldwin, R. A., & Bender, L. C. (2009). Foods and nutritional components of diets of black bear in Rocky Mountain National Park, Colorado. *Canadian Journal of Zoology*, *87*(11), 1000–1008. https://doi.org/10.1139/Z09-088

Baruch-Mordo, S., Breck, S. W., Wilson, K. R., & Theobald, D. M. (2008). Spatiotemporal Distribution of Black Bear-Human Conflicts in Colorado, USA. *The Journal of Wildlife Management*, *72*(8), 1853–1862. https://doi.org/10.2193/2007-442

Baruch-Mordo, S., Wilson, K. R., Lewis, D. L., Broderick, J., Mao, J. S., & Breck, S. W. (2014). Stochasticity in Natural Forage Production Affects Use of Urban Areas by Black Bears: Implications to Management of Human-Bear Conflicts. *PLoS ONE*, *9*(1). https://doi.org/10.1371/journal.pone.0085122

Beckmann, J. P., & Berger, J. (2003). Rapid ecological and behavioural changes in carnivores: The responses of black bears (Ursus americanus) to altered food. *Journal of Zoology*, *261*(2), 207–212. https://doi.org/10.1017/S0952836903004126

Belant, J. L., Simek, S. L., & West, B. C. (2017). *Human-Wildlife Conflicts Monograph*. 80.

Boonman-Berson, S., Turnhout, E., & Carolan, M. (2016). Common sensing: Human-black bear cohabitation practices in Colorado. *Geoforum*, *74*, 192–201. https://doi.org/10.1016/j.geoforum.2016.06.010

Colorado Parks and Wildife. (2015). *CPW-Human-Bear-Conflict-Report.pdf*. Colorado Parks and Wildlife. https://cpw.state.co.us/Documents/Education/LivingWithWildlife/CPW-Human-Bear-Conflict-Report.pdf#search=black%20bear

Comunnity Builders Task Force. (2017). *OVPP Final Strategy Report*. http://cms5.revize.com/revize/gunnisonco/Comm%20Dev/OVPP%20Final%20Strategy%20Report.pdf

Iler, A. M., Compagnoni, A., Inouye, D. W., Williams, J. L., CaraDonna, P. J., Anderson, A., & Miller, T. E. X. (2019). Reproductive losses due to climate change-induced earlier flowering are not the primary threat to plant population viability in a perennial herb. Journal of Ecology, 107(4), 1931–1943. https://doi.org/10.1111/1365-2745.13146

Inouye, D. W. (2019). Effects of climate change on alpine plants and their pollinators. *Annals of the New York Academy of Sciences*, *n/a*(n/a). https://doi.org/10.1111/nyas.14104

Johnson, H.E., Breck, S. W., Baruch-Mordo, S., Lewis, D. L., Lackey, C. W., Wilson, K. R., Broderick, J., Mao, J. S., & Beckmann, J. P. (2015). Shifting perceptions of risk and reward: Dynamic selection for human development by black bears in the western United States. *Biological Conservation*, *187*, 164–172. https://doi.org/10.1016/j.biocon.2015.04.014

Johnson, Heather E. (2016, June). Black Bear Exploitation of Urban Environments: Finding Management Solutions and Assessing Regional Population Effects. https://cpw.state.co.us/Documents/Research/Mammals/Publications/Johnson-Durango-Bear-Progress-Report.pdf

Johnson, Heather E., Lewis, D. L., Lischka, S. A., & Breck, S. W. (2018). Assessing ecological and social outcomes of a bear-proofing experiment. *The Journal of Wildlife Management*, *82*(6), 1102–1114. https://doi.org/10.1002/jwmg.21472

Johnson, Heather E., Lewis, D. L., Verzuh, T. L., Wallace, C. F., Much, R. M., Willmarth, L. K., & Breck, S. W. (2018). Human development and climate affect hibernation in a large carnivore with implications for human–carnivore conflicts. *Journal of Applied Ecology*, *55*(2), 663–672. https://doi.org/10.1111/1365-2664.13021

Kirby, R., Alldredge, M. W., & Pauli, J. N. (2016). The diet of black bears tracks the human footprint across a rapidly developing landscape. *Biological Conservation*, *200*, 51–59. https://doi.org/10.1016/j.biocon.2016.05.012

Lackey, C. W., Breck, S. W., Wakeling, B. F., & White, B. (2018). *HUMAN–BLACK BEAR CONFLICTS*. 76

Laufenberg, J. S., Johnson, H. E., Doherty, P. F., & Breck, S. W. (2018). Compounding effects of human development and a natural food shortage on a black bear population along a human development-wildland interface. *Biological Conservation*, *224*, 188–198. https://doi.org/10.1016/j.biocon.2018.05.004

Lewis, D. L., Baruch-Mordo, S., Wilson, K. R., Breck, S. W., Mao, J. S., & Broderick, J. (2015). Foraging ecology of black bears in urban environments: Guidance for human-bear conflict mitigation. *Ecosphere*, *6*(8), art141. https://doi.org/10.1890/ES15-00137.1

Lischka, S. A., Teel, T. L., Johnson, H. E., & Crooks, K. R. (2019). Understanding and managing human tolerance for a large carnivore in a residential system. *Biological Conservation*, *238*, 108189. https://doi.org/10.1016/j.biocon.2019.07.034

Lynn, J. (2019). *King of the Hill? How Biotic Interactions Affect Biogeographical Pattern and Species Responses to Climate Change*. 148.

Masterson, L. (2016). *Living with Bears Handbook* (2nd ed.). PixyJack Press.

Mawdsley, J. R., O'Malley, R., & Ojima, D. S. (2009). A Review of Climate-Change Adaptation Strategies for Wildlife Management and Biodiversity Conservation. *Conservation Biology*, *23*(5), 1080–1089. https://doi.org/10.1111/j.1523-1739.2009.01264.x

Mazur, R., & Seher, V. (2008). Socially learned foraging behaviour in wild black bears, Ursus americanus. *Animal Behaviour*, *75*(4), 1503–1508. https://doi.org/10.1016/j.anbehav.2007.10.027

Merkle, J. A., Robinson, H. S., Krausman, P. R., & Alaback, P. (2013). Food availability and foraging near human developments by black bears. *Journal of Mammalogy*, *94*(2), 378–385. https://doi.org/10.1644/12-MAMM-A-002.1

Ministry of Enviornmental Services. (2015, September 21). *Strategy for preventing and managing human wildlife conflicts in Ontario*. Ontario.Ca. https://www.ontario.ca/page/strategy-preventing-and-managing-human-wildlife-conflicts-ontario

Multi-Resolution Land Characteristics Consortium, & USGS. (2016). NLCD 2016 Land Cover (CONUS) | Multi-Resolution Land Characteristics (MRLC) Consortium. Retrieved April 23, 2021, from https://www.mrlc.gov/data/nlcd-2016-land-cover-conus

NASA. (2020, December 20). *Climate Change Evidence: How Do We Know?* Climate Change: Vital Signs of the Planet. https://climate.nasa.gov/evidence

Nelson, A. S. (2019). *The effects of climate change and biodiversity loss on mutualisms*. 141.

Oregon State University, Northwest Alliance for Computational Science & Engineering, & USDA Risk Management Agency. (2020). *Time Series Values for Individual Locations*. PRISM Climate Group. Retrieved April 29, 2020, from http://www.prism.oregonstate.edu/explorer/

Paniw, M., Childs, D. Z., Armitage, K. B., Blumstein, D. T., Martin, J. G. A., Oli, M. K., & Ozgul, A. (2020). Assessing seasonal demographic covariation to understand environmental-change impacts on a hibernating mammal. *Ecology Letters*, *23*(4), 588–597. https://doi.org/10.1111/ele.13459

Panetta, A. M., Stanton, M. L., & Harte, J. (2018). Climate warming drives local extinction: Evidence from observation and experimentation. *Science Advances*, *4*(2), eaaq1819. https://doi.org/10.1126/sciadv.aaq1819

Pierre-Louis, K. (2018, May 4). As Winter Warms, Bears Can't Sleep. And They're Getting Into Trouble. *The New York Times*. https://www.nytimes.com/2018/05/04/climate/bears-not-hibernating.html

Regional Climate Centers, N., & ACIS. (2019). *High Plains Regional Climate Center—CLIMOD*. Retrieved November 17, 2019, from http://climod.unl.edu/

Responding to Environmental Change—Bears (U.S. National Park Service). (2019). Retrieved September 10, 2019, from https://www.nps.gov/subjects/bears/environmentalchange.htm

Rusoke, T. (2017). Climate Change and Its Effects on Wildlife Resources. *Nkumba University, Entebbe Uganda*.

Schwieterman, G. D. (2019). Is droning on making life unbearable? *Conservation Physiology*, *7*(1), coz034. https://doi.org/10.1093/conphys/coz034

Wilbur, R. C., Lischka, S. A., Young, J. R., & Johnson, H. E. (2018). Experience, attitudes, and demographic factors influence the probability of reporting human–black bear interactions. *Wildlife Society Bulletin*, *42*(1), 22–31. https://doi.org/10.1002/wsb.854

Appendix I: Draft Human – Black Bear Conflict Mitigation Management Plan. Please note that figures and appendices mentioned below are those associated with the management plan only.

CITY OF GUNNISON

Human-Bear Conflict Management and Education Plan

April 2021

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Appendix A: Bear Conflict Matrix

Appendix B: Review of Human-Bear Conflict Management Plans

1. BACKGROUND

The City of Gunnison passed an ordinance in 1999 designating the City as a wildlife sanctuary including providing refuge for all wildlife and encouraging citizens to protect native wild live animals (Ordinance 5.40.040 Section D). Despite this effort and others in local municipalities, Colorado Parks and Wildlife received 647 reports of bear conflicts from citizens in the Gunnison Valley during the period of 2004-2018 and local social media suggests that there are many unreported conflicts occurring within the City of Gunnison. The aspirations of the City are challenged in a valley with increased tourism, changes in the nature of home ownership and in a time of climate change, all of which may be contributing to human-black bear conflicts rather than coexistence. During the last several decades in Colorado, an increasing number of human-black bear encounters and conflicts in residential neighborhoods, campgrounds, wilderness, and agricultural properties have generated media headlines, alarmed citizens, and caused concerns with local governments and the state legislature (Masterson 2016). Human development has rapidly expanded in Colorado removing natural sources of black bear food while encouraging bears to increasingly forage on widely available human (anthropogenic) food. In addition, when natural food sources are reduced due to freezing or prolonged drought, bears turn toward human sources increasing human black-bear conflict (AFWA 2018). The challenge for communities like Gunnison is finding a way to overcome these issues and co-exist with a healthy, perpetual bear population. This draft black-bear conflict management plan is intended to aid in reducing conflict between City of Gunnison residents and black bears and promoting knowledge and co-existence to aid the City in realizing its goal of becoming a wildlife sanctuary.

1.1 BIOLOGY & ECOLOGY OF BLACK BEARS

American Black Bears, *Ursus americanus*, are considered widely abundant throughout the United States and Colorado. An estimated black bear population of 300,000 is growing and expanding in the U.S. Currently, only nine out the fifty states do not have a black bear population. Overall, black bear populations vary from state to state, with the lowest amount (5-10) in Rhode Island and the highest population (24,000 – 31,000) being in Wisconsin. The current black bear population in Colorado is estimated to be 10,000 to 12,000 and is distributed mostly throughout the west-southwestern part of the state (Masterson 2016). While no specific population estimate is available for the Gunnison Basin, local wildlife managers consider the black bear population stable to increasing.

Scientists recognize sixteen different subspecies of black bears, which occupy a wide variety of habitats. Black bears are commonly found in juniper woods, chaparral, oak

forests, hickory forests, bays, swamps, Flatwoods, hardwood forests, meadows, and more (ANT 2019). They are highly arboreal (tree-dwelling) and spend much of their lives in the trees. Black bears climb trees to forage for food, escape threats, sleep, or rest. Older bears tend to spend more time on the ground. In Colorado, the largest populations of black bears live in areas of Gambel's oak and aspen, or in association with natural fruit sources such as chokecherry and serviceberry. Some bears never leave oak brush zones while many exploit aspen dominated communities; however, high elevation spruce-fir forests are not generally considered productive bear habitats. Black bears prefer areas with cover, such as along river courses with thick vegetation and trees. Preferred habitats have dense vegetation and hard to access terrain which helps keep bears isolated from people. However, when natural food sources (acorns, nuts, berries) in those habitats are scarce, bears must seek out novel sources of food. The west side of Gunnison is a primary conflict zone based on the river corridor and other unique characteristics for that corridor.

Black bears are omnivorous, opportunistic feeders that can live 20 to 30 years depending on hunting harvest rates and the availability and quality of natural food (Armstrong et al. 2011). Black bears eat vegetation and mast including grasses, forbs, berries, acorns, and seeds. They also eat insects, scavenge carcasses (CPW 2015) and may opportunistically prey on wild ungulates as well as domestic animals. The diets of black bears vary geographically, depending on where and when natural foods are available (Baldwin & Bender 2009). Colorado black bears often select trees and shrubs that provide high-calorie mast. In the Gunnison valley, trees and shrubs of importance include serviceberry, chokecherry, pin cherry, squaw apple, mountain ash, buffaloberry, currant, Gambel's oak, and pinyon juniper (Klett et al. 2018). The annual phenology and abundance of these food sources are often correlated to the level of annual human-black bear conflict. Changing climate conditions (drought, severe winters), increased human density (e.g., housing density, trash disposal practices, etc.), and increasing human use of the landscape (e.g., camping, trail use, etc.), are also likely to influence future levels of human-black bear conflict.

Typical adult black bears stand 0.9 meters (3ft) tall at the shoulder, and their length from tip to tail is about 1.9 meters (~6ft) (Oldam 2020). Black bears are sexually dimorphic with adult males being larger than adult females. A large adult male can exceed 272 kg (600lb), where large adult females rarely exceed 90 kg (200lb) (NWF 2020).

Breeding season for black bears occurs during summer, the peak being from mid-June to mid-July but can extend until September (Boonman-Berson et al. 2016). Both males and females practice multiple mating. Females exhibit delayed implantation stalling any nutritional investment until after critical fall foraging to insure they gain enough fat reserves for both mother and cubs (Brown 2009). If a fall food shortage

results in a reduction in fat reserves, the egg is spontaneously aborted and absorbed with little energy cost to the female, allowing her to breed the following summer if nutritional resources are more favorable. Cubs are born in the den, typically in January, and litter sizes range from one to five cubs. Cubs stay with their mother for about a year and a half (Kirby et al. 2017).

Behavior varies among individual bears, even within the same population. Black bears are typically shy, solitary animals but do congregate around food sources, pair up or compete during mating season, and travel in family groups until about two years of age (Mazur & Seher 2008). Bears may exhibit aggressive behavior when they are habituated to human presence; however, a bear may also show aggressive behavior when it is focused on a food resource and has had no prior interactions with humans. Habituated or otherwise aggressive bears present a potential threat to human safety (Pritchett 2012).

1.2 HIBERNATION AND INFLUENCE ON CONFLICT

For many species, including black bears, hibernation is influenced by changing climate (Johnson et al. 2019). Hibernation is a state of inactivity that enables animals to conserve energy during a seasonal food shortage or severe weather. During this time, body temperatures are maintained near 34.5 degrees (C). . Black bears gain weight in the fall and lose up to 30% of their weight during hibernation. Despite the weight loss, most bears emerge in spring from dens in relatively good condition. Movements and activity of black bears vary in response to the food supply. Black bears will travel long distances to exploit concentrated food sources (Kirby et al. 2016). Daily activity generally increases from den emergence until late summer or early fall when natural food availability is highest. Activity then declines until bears enter dens, which occurs from October to December (Baldwin & Bender 2009). Black bears tend to be corpuscular, or most active at dusk and dawn. However, high levels of nocturnal activity are common for bears in urban environments as animals attempt to avoid humans while exploiting high calorie food resources. Bears that are active during daytime hours within city limits are of greater concern to wildlife managers based on their apparent high degree of habituation to people.

Limited research suggests that black bears subsidized by anthropogenic food sources may also hibernate for shorter periods or even forgo hibernation altogether (Beckman & Berger 2003), presumably as their dependence on seasonal native foods declines. Johnson et al. (2017) speculated that warming climate conditions would reduce bear hibernation and the length of their hibernation period. Reduced hibernation in bears is likely to increase conflict in the urban-wildland interface as bears increase their use of human developments, especially during years when natural foods are scarce

(Schwieterman 2019). For hibernators sensitive to temperature, trends in warmer weather are likely to reduce hibernation duration, while disparate patterns in the snowpack could create trophic mismatches for bears that emerge prior to spring food resources becoming available (Johnson et al. 2016). Temperature was found to have twice the magnitude of effect of either natural or human food availability in decreasing the overall length of hibernation. By 2050, Colorado climate models project that the average temperature will have increased by 2.5 to 5°C under medium-low emissions scenarios and by 3.5 to 6.5°C under high emission scenarios (Panetta et al. 2018). Assuming that the relationship between temperature and hibernation length is consistent, where a 1°C increase in the winter minimum temperature is associated with a 6-day reduction in black bear hibernation, by 2050, the average length of bear hibernation could decrease by 15 to 39 days (Johnson et al. 2016). Early emergence, prior to natural food resources becoming available, may leave bears no choice but to seek out anthropogenic food sources such as unsecured trash. Given the increasing human use and development across the landscape, coupled with potential shifts in natural bear forage availability and hibernation behavior, it is quite likely that bears will increase their pursuit of anthropogenic food in the future, leading to a concurrent increase in human/bear conflicts across the Gunnison Valley.

1.3 HUMAN – BLACK BEAR CONFLICT REPORTING

As mentioned above, when localized natural food failure occurs, black bears become increasingly mobile and persistent in searching for anthropogenic food sources, including trash, fruit trees, pet food, bird feeders, livestock, and agricultural products (Wilbur et al. 2018). Both human and black bear behavior underlie the likelihood of human-black bear conflicts.

In the Gunnison Valley, wildlife conflicts are typically reported to local law enforcement agencies or Colorado Parks and Wildlife (CPW). If a report is made to Colorado Parks and Wildlife relative to black bears or mountain lions, a conflict report is filled out and documented within the agency. These reports can range from sightings to aggressive or dangerous behavior. Currently, many reports are "nuisance" (causing trouble or annoyance) or sightings. CPW has recently transitioned from hard copy reporting forms to a internal mobile app that is not accessible to the general public. Residential conflicts center around high-calorie human food sources, primarily trash, birdseed, pet food, fruit trees, landfills, and other organic food sources (Ditmer et al. 2015). Black bears have an extremely keen sense of smell and excellent memories. Once they have learned about a reliable food source, they will often return (Lewis et al. 2015), especially as they prepare to go into hibernation.

In addition to those who report conflicts to Colorado Parks and Wildlife, I have seen significant public use of local social media pages informing others about sightings or conflicts throughout the valley. While such social media reports can be useful, there is the potential to create a platform that increases reporting and simultaneously provides education for coexistence solutions. The deployment of such solutions takes the concerted efforts of citizens, municipalities, and agencies working from a common plan.

2. BLACK BEARS OF THE CITY OF GUNNISON

For developing such a plan for the City of Gunnison, I have considered methods that have been used previously to mitigate bear conflict throughout different locations and create and implement techniques that will help fill needed gaps in knowledge and management within the City of Gunnison. I have analyzed current and previous management techniques utilized by Colorado Parks and Wildlife as well as research from key literature on human-wildlife conflicts.

2.1 CURRENT CPW MANAGEMENT METHODS

Colorado Parks and Wildlife designates three distinct categories of bears involved in human conflicts: nuisance bears, depredating bears, and dangerous bears. Nuisance bears pose an immediate threat to property or potentially damage property but do not threaten public safety (CPW 2015). Any bear involved in two nuisance incidents after being captured, marked, or translocated will be destroyed in the state of Colorado. Depredating bears are bears that have killed cattle, sheep, horses, alternative livestock, or other hoofed livestock (CPW 2015). CPW attempts to educate and collaborate with livestock owners on ways to minimize the potential for bear depredation; however, any bear that kills cattle, sheep, horses, alternative livestock, or other hoofed livestock may be destroyed or translocated. Dangerous bears pose an immediate threat to human health and safety (CPW 2015). Colorado Parks and Wildlife personnel will capture, ear tag, and translocate a bear if deemed dangerous because of its location and not its behavior. However, bears exhibiting behaviors deemed dangerous to people may be killed.

One way wildlife managers attempt to influence black bear-human conflict is through changes in hunter harvest objectives. Regulated hunter harvest is the primary management tool used by CPW and other wildlife management agencies to regulate wildlife populations, including black bears. Harvest of black bears can be compatible with increasing, stable, or decreasing bear populations, depending on population management objectives and harvest regulations. Recent bear population estimation efforts in Colorado have consisted of quantifying a known bear density for a small geographic area and extrapolating those results to a larger area. Infographics can be

made from this information to help public, city managers, and wildlife managers to understand and follow the correct protocol for incidents (Appendix A). According to Colorado Parks and Wildlife, the current conservative estimate of black bears in Colorado is approximately 10,000 to 12,000 bears and is stable. Given the challenges and uncertainty in estimating bear population sizes, the number of hunting licenses has historically been conservative; however, increased human-black bear conflicts in Colorado have resulted in additional bear harvest licenses in most bear management areas (CPW 2015). An inherent limitation with using hunter harvest to reduce conflict is that hunters may not hunt conflict prone bears. Reducing the number of wild bears influences the overall population but may not sufficiently promote wildlife co-existence.

Management of conflict prone human behavior is as important as the management of bears. Research and observation offer conclusive evidence that human behavior, primarily carelessness with trash, bird feeders, pet food, and other bear attractants, does increase the likelihood of human-bear conflicts in Colorado and throughout black bear range (Alldredge et al. 2015). Mitigation of human-bear conflicts involves integrating many management options; no single option is best for every circumstance and will vary by community and location. Identifying the correlations and causation of local conflicts thorough review and research of past conflicts is an essential first step. Predicting the circumstances of future conflicts and identifying areas with high conflict rates is also critical. Successful bear conflict management plans and programs are an equally important step and must incorporate comprehensive education and attractant management programs. Plans may address public education, law and ordinance enforcement, exclusionary methods, capture and release, adverse conditioning, repellents, damage compensation programs, depredation permits, privatized conflict management, and population management (Lackey et al. 2017). All methods have their advantages and disadvantages, but education and cooperation between wildlife agencies and local municipalities are paramount in preventing conflicts. Four examples of successful plans are summarized and cited in Appendix B.

One important component to explore for wildlife conflict mitigation plans is how to inform citizens about when to report/and when not to report a wildlife conflict. In Colorado, there are conflict issues that involve many species. The first step generally is to contact the local Colorado Parks and Wildlife office. They suggest before calling to read relevant articles to learn ways to reduce the potential conflict with wildlife. People are encouraged not to call if the conflict is a "nuisance" in nature. Nuisance wildlife issues that cannot be resolved are encouraged to check for pest control companies in

the area and read pertinent articles on preventing conflict to aid citizens in resolving complaints. However, if wildlife conflict poses an immediate danger for the animal or people, citizens are encouraged to contact the local Colorado Parks and Wildlife office or law enforcement agency.

2.2 LOCAL CONFLICT PATTERNS AND ANALYSES

To investigate the source of human-bear conflicts throughout the Gunnison Valley we need to first evaluate the number of conflicts, causes, and locations by summarizing CPW reporting information. I compiled and mapped a total of 647 conflict reports from 2004 to 2018 as seen in Figure 1.

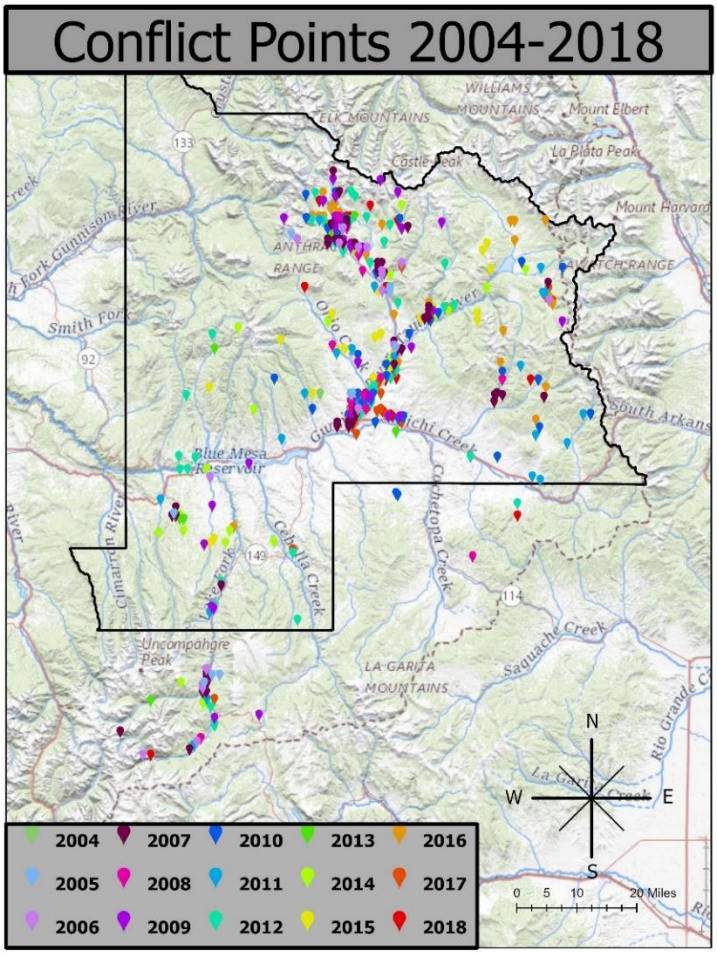

Figure 1: Conflict points through years 2004 to 2018 in Gunnison County with focus on game management units 54,55,66,67, and 551.

As expected, the most significant source of conflict throughout the valley is anthropogenic food sources. Bears were reported causing property damage in 517 of the conflict reports with 85% of those being directly attributable to a food source.

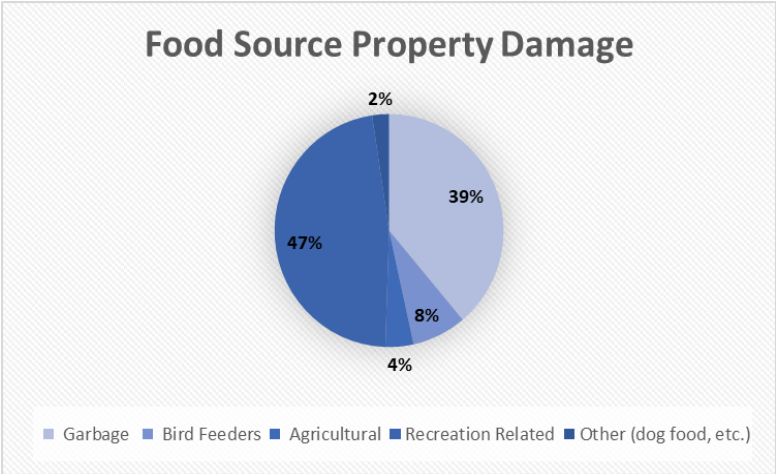

Figure 2: Conflict data summary for food source property damage seen throughout 1988 to 2018. N=647 with main factors including recreation related (47%), garbage (39%), bird feeders (8%), agricultural (4%), and other (2%).

The most significant food source identified was garbage (Figure 2). 56% percent of the property damage reported was associated with houses (Figure 3).

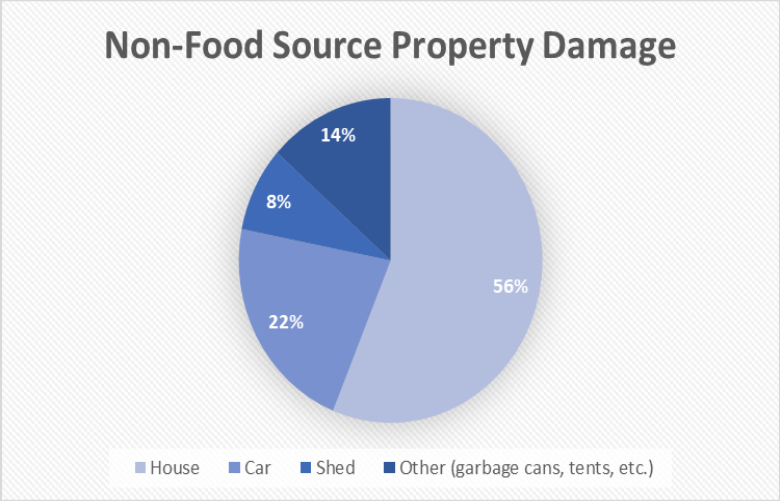

Figure 3: Conflict data summary for property damage that did not involve a food source for year 1988 to 2018. N=647 with main damages to houses (56%), cars (22%), sheds (14%), and other (8%).

While the exact age of conflict bears is typically unknown, reporting parties sometimes mentioned mothers with cubs, or made comments specific to "yearling" or "young bears" (Figure 4). Throughout the data set, there appears to be a disproportionate number of "first-time" conflict reports in comparison to subsequent reports from the same location. There are likely a variety of explanations for this, and certainly inherent biases associated with voluntary conflict reporting. Bears in the valley may exhibit strong nomadic tendencies, continuously moving between high reward food sources. Or it may suggest that education and law enforcement actually help mitigate future conflict.

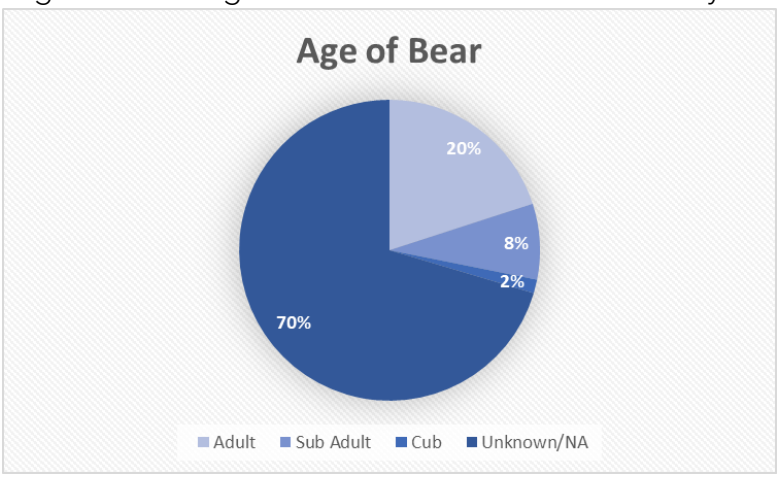

Figure 4: Conflict data summary for age of bears that were involved in conflicts from 1988 to 2018. N=624 with ages from unknown (70%), adult (20%), sub-adult (8%), and cub (2%).

Our hotspot analysis indicates 6 significant conflict clusters as shown in Figure 5.

- Crested Butte
- Crested Butte South
- Lake City (Hinsdale County)
- Almont
- Ohio City
- City of Gunnison
- West side of city limits in the City of Gunnison (Dios Rios & Arrowhead communities)

Typically, the rate of interaction between humans and black bears is highly correlated to the quality and abundance of natural food sources. Through my analysis we have determined that the highest conflict potential is during the fall months (August to October) in years where the prior summer was recorded as extremely dry and where the prior winter produced minimal snowpack for the upcoming spring. 65-70% of conflicts happened in our area at times of below average precipitation and above average temperature.

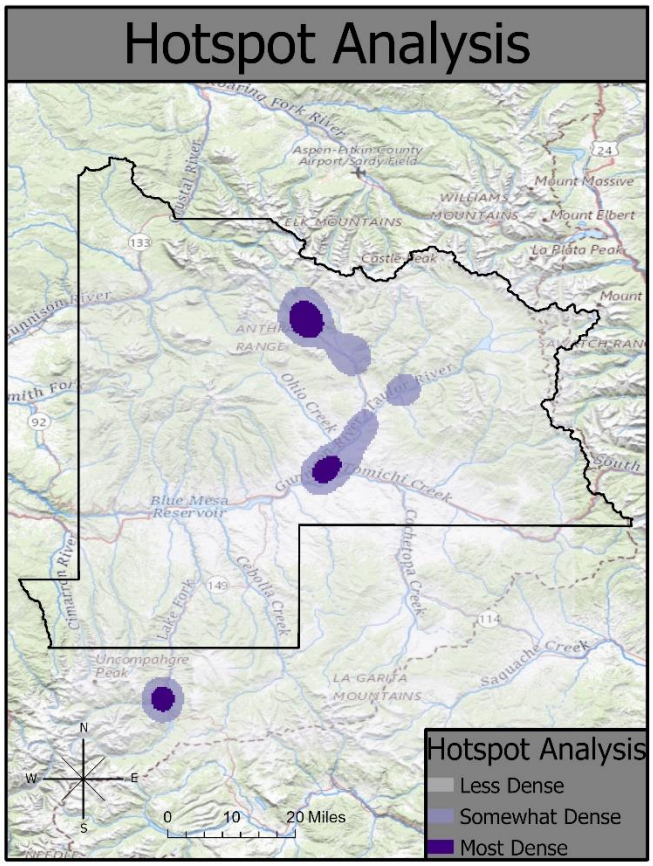

Figure 5: Map of the kernel density results of total conflict points identifying key hotspots throughout the valley.

Rates of conflicts are also positively correlated with the presence of non-residents and visitors. Non-permanent residents and visitors were more likely to report a conflict (n=425 reports). There could be an aversion from year-round residents to report a conflict in fear for the bear or consequences towards themselves (n=222). This was seen on the number of reports taken during peak visitor seasons (summer and fall) in the valley and the number of reports taken for people with addresses that are do not occur within our valley. The fact that in the Gunnison Basin, temperature, precipitation, and human settlement density are all correlated with elevation adds complexity to the analysis and increases the likelihood of conflict during dry times.

3. RECOMMENDED ACTIONS

Avoiding, minimizing, and mitigating for conflict helps community members co-exist with wildlife, while promoting the intrinsic value and quality of life that nature provides. Per current Gunnison City ordinance (Ordinance 5.40.040 Sect. D), "our municipality is a wildlife sanctuary for the refuge of all wildlife and citizens are urged to protect native wild animals". Within the context of existing ordinance, there is potential to codify the intent of creating a wildlife sanctuary for black bears through policy, planning, education, and partnerships. This is not to suggest that dangerous bears be tolerated within city limits, or that highly habituated bears causing property damage should receive sanctuary. Rather, it is the recognition that black bears will continue to interact with the City of Gunnison and its residents, therefore planning for bear conflict mitigation is a pragmatic course of action, especially in the southwest and west side of town.

I respectfully request that city council members examine management plans and ordinances developed in other communities where bear conflicts necessitated community action. The recommendations presented to the city council and land managers below are derived from a review of plans from all over North America, including the resort municipality of Whistler, Canada, the state of Wisconsin, and local communities including Crested Butte. I have attempted to adapt them to Gunnison with included consultation from City workers and residents. Recommended actions are broken down into four sections: Planning & Policy, Public Education, Partnerships, and Infrastructure. I have determined through our research that these four categories are key areas for reducing the number of human-bear conflicts in each community. All areas involve a high level of stakeholder collaboration.

3.1 PLANNING & POLICY

3.1.1 Work towards development of a 'Bear Smart' Community Engagement Group to facilitate community engagement and education and to assist the city and Colorado Parks and Wildlife with policy development. This group might consist of city managers, state and federal land managers, members of local NGO's and including the non-profits and business community, and other interested parties. This group would help facilitate the development and/or revision of city ordinances and community outreach required to reduce human-bear conflicts.

3.1.2 Collaborate with the Bear Smart Community Engagement Group to create initiatives that reduce bear habituation and safety issues (e,g, the Durango Bear Project designated bear management ordinances within their heaviest conflict zones identified by the City of Durango and Bear Smart Durango

(https://www.denverpost.com/2017/04/02/colorado-black-bear-management/).

3.1.3 Promote City-led collaboration with county and state officials to review, amend, create, and implement garbage disposal & wildlife attractant ordinances; consider adding fines for existing ordinances of relevance (See Appendix B section 1 for reference language). Review and require community guidelines to include bear smart (http://www.bearsmart.com/managingattractants) recommendations. Areas of consideration include waste disposal and storage, wildlife attractants, event protocols, etc.

3.1.4 Ensure that municipal planners consider bear movement corridors (use Figures 4 & 5 for general reference), waste management sites, key vegetative space, and public outdoor space when creating new developments to reduce human-bear conflicts.

3.1.5 Support conflict data collection and analysis that will allow stakeholders to better identify conflict patterns to identify better solutions. Supporting and encouraging members of the community to utilize a community reporting website and/or app. (We developed an example website (https://gunnisonconflict.squarespace.com/) and mobile application (https://www.appsheet.com/start/15c9a0cf-20ef-4756-a486-ffd0ba354b89) in beta format not currently available to the public.)

3.2 PUBLIC EDUCATION

3.2.1 Recruit a Bear Smart volunteer ambassador to implement a Bear Smart Program in collaboration with the Bear Smart Community Engagement Group. The activities include but are not limited to giving presentations throughout the local school district, updating the City Council on conflict activity and reports, attending, and presenting information at community events, and other on-going education for residents. Create of public education and communication programs by the Bear Smart Community Engagement group to be accessible for all regardless of income or language.

3.2.2 Keep city websites updated to reflect current information regarding conflicts and post relevant bear smart tips on social media channels (City of Gunnison and Gunnison 911 Center Facebook & Twitter). Ensure all content is in alignment with best bear management practices. Consider partnering with CPW on a website and app (see 3.1.5) pilot trial.

3.2.3 Increase educational signage to remind full time, part time residents, and visitors that they are in bear country. Increase partnership with Chamber of

Commerce and with the visitor desks at the USFS and BLM to provide best practices and relevant, recent information.

3.2.4 Provide information and access on all accessible outlets to a community reporting website to have up to date information. Work with local radio stations to provide information on recent conflict activity and needed actions for community members who do not have access or use other outlets. Deploy community-based reporting systems including proposed website and mobile app to be managed by the Bear Smart Community Engagement Group.

3.3 PARTNERSHIPS

3.3.1 Encourage local schools and daycare facilities to collaborate and incorporate Bear Smart activities and practices on school properties.

3.3.2 Monitor and encourage proactive bear management at nearby campgrounds (e.g., City of Gunnison's Gunnison Mountain Park Campground, BLM/Gunnison County's Hartman's sites) as well as city parks and other city property including the placement of updated metal bear food lockers.

3.3.3 Explore and develop partnerships with local businesses to enhance outreach and education for both full and part time residents and visitors.

3.4 INFRASTRUCTURE

3.4.1 Work with Western Colorado University and Colorado Parks and Wildlife to design and conduct a public perception survey aimed at gauging the public's understanding of bear issues within city limits, and their willingness to work toward "bear-proofing" our community.

3.4.2 Explore grant opportunities for purchasing of bear proof trash containers.

3.4.3 Collaborate with waste management businesses to develop and encourage the implementation of bear-proof waste management systems to be accessible for both residential and commercial use. Focus initially on areas west and southwest of town with the highest level of annual conflict.

3.4.4 Design future parks and recreation areas in a manner which reduces human-bear conflict and increase educational signage promoting the city's status as a Wildlife Sanctuary community.

4. CONCLUSION

Understanding the sources and nature of human-bear conflict locally helps the community create targeted actions to reduce conflict. Communities that have successfully reduced conflict with bears are typically those that have an active and

engaged group, which meets regularly, develops action plans, and modifies plans as necessary in consultation with elected officials and wildlife managers. Forecasted increases in human population and visitation rates, as well as more frequent drought and increased temperatures will necessitate public education that is targeted and ongoing. The City of Gunnison has the opportunity to educate the local population and improve waste management policies, waste removal systems, communication methods, and reporting methods to encourage people to make Gunnison a truly Bear Smart community. Filling the gaps in collecting more data and education with the task of creating and implementing a community reporting website and mobile application will be a vital part for not only the community but for managers as well. In most situations, people and wildlife can coexist.

5. REFERENCES

Alldredge, M. W., Walsh, D. P., Sweanor, L. L., Davies, R. B., & Trujillo, A. (2015). Evaluation of translocation of black bears involved in human–bear conflicts in South-central Colorado. Wildlife Society Bulletin, 39(2), 334–340. https://doi.org/10.1002/wsb.526

Armstrong, D. M., Fitzgerald, J. P., & Meaney, C. A. (2011). Mammals of Colorado (2nd ed.). Denver Museum of Nature & Science and University Press of Colorado.

Association of Fish and Wildlife Agencies. (2018, March 15). Human-Black Bear Conflict A Review of the Most Common Management Practices. https://www.fishwildlife.org/application/files/7315/2243/9066/DRAFT_AFWA_Human_bear_conflict_management_3-15-2018_R.pdf

Baldwin, R. A., & Bender, L. C. (2009). Foods and nutritional components of diets of black bear in Rocky Mountain National Park, Colorado. Canadian Journal of Zoology, 87(11), 1000–1008. https://doi.org/10.1139/Z09-088

Baruch‐Mordo, S., Breck, S. W., Wilson, K. R., & Theobald, D. M. (2008). Spatiotemporal Distribution of Black Bear-Human Conflicts in Colorado, USA. The Journal of Wildlife Management, 72(8), 1853–1862. https://doi.org/10.2193/2007-442

Baruch-Mordo, S., Wilson, K. R., Lewis, D. L., Broderick, J., Mao, J. S., & Breck, S. W. (2014). Stochasticity in Natural Forage Production Affects Use of Urban Areas by Black Bears: Implications to Management of Human-Bear Conflicts. PLoS ONE, 9(1). https://doi.org/10.1371/journal.pone.0085122

Beckmann, J. P., & Berger, J. (2003). Rapid ecological and behavioural changes in carnivores: The responses of black bears (Ursus americanus) to altered food. Journal of Zoology, 261(2), 207–212. https://doi.org/10.1017/S0952836903004126

Belant, J. L., Simek, S. L., & West, B. C. (2017). Human-Wildlife Conflicts Monograph. 80.

Boonman-Berson, S., Turnhout, E., & Carolan, M. (2016). Common sensing: Human-black bear cohabitation practices in Colorado. Geoforum, 74, 192–201. https://doi.org/10.1016/j.geoforum.2016.06.010

Brown, G. (2009). The Bear Almanac: A comprehensive Guide to the Bears of the World (2nd ed.). Lyons Press.

Colorado Parks and Wildife. (2015). CPW-Human-Bear-Conflict-Report.pdf. Colorado Parks and Wildlife. https://cpw.state.co.us/Documents/Education/LivingWithWildlife/CPW-Human-Bear-Conflict-Report.pdf#search=black%20bear

Comunnity Builders Task Force. (2017). OVPP Final Strategy Report. http://cms5.revize.com/revize/gunnisonco/Comm%20Dev/OVPP%20Final%20Strategy%20Report.pdf

Ditmer, M. A., Burk, T. E., & Garshelis, D. L. (2015). Do innate food preferences and learning affect crop raiding by American black bears? Ursus, 26(1), 40–52. https://doi.org/10.2192/URSUS-D-14-00028.1

Gunnison Climate Working Group. (2011, December 31). Gunnison Basin Climate Vulnerability Assessment Report. https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/Colorado/Documents/Climate/Upper%20Gunnison/Gunnison%20Basin%20Climate%20Vulnerability%20Assessment/GunnisonBasinClimateVulnerabilityAssessmentReport.pdf

Johnson, H.E., Breck, S. W., Baruch-Mordo, S., Lewis, D. L., Lackey, C. W., Wilson, K. R., Broderick, J., Mao, J. S., & Beckmann, J. P. (2015). Shifting perceptions of risk and reward: Dynamic selection for human development by black bears in the western United States. Biological Conservation, 187, 164–172. https://doi.org/10.1016/j.biocon.2015.04.014

Johnson, Heather E. (2016, June). Black Bear Exploitation of Urban Environments: Finding Management Solutions and Assessing Regional Population Effects. https://cpw.state.co.us/Documents/Research/Mammals/Publications/Johnson-Durango-Bear-Progress-Report.pdf

Johnson, Heather E., Lewis, D. L., Lischka, S. A., & Breck, S. W. (2018). Assessing ecological and social outcomes of a bear-proofing experiment. The Journal of Wildlife Management, 82(6), 1102–1114. https://doi.org/10.1002/jwmg.21472

Johnson, Heather E., Lewis, D. L., Verzuh, T. L., Wallace, C. F., Much, R. M., Willmarth, L. K., & Breck, S. W. (2018). Human development and climate affect hibernation in a large carnivore with implications for human–carnivore conflicts. Journal of Applied Ecology, 55(2), 663–672. https://doi.org/10.1111/1365-2664.13021

Kirby, R., Alldredge, M., & Pauli, J. (2017). Environmental, not individual, factors drive markers of biological aging in black bears. Evolutionary Ecology, 31(4), 571–584. https://doi.org/10.1007/s10682-017-9885-4

Kirby, R., Alldredge, M. W., & Pauli, J. N. (2016). The diet of black bears tracks the human footprint across a rapidly developing landscape. Biological Conservation, 200, 51–59. https://doi.org/10.1016/j.biocon.2016.05.012

Laufenberg, J. S., Johnson, H. E., Doherty, P. F., & Breck, S. W. (2018). Compounding effects of human development and a natural food shortage on a black bear population along a human development-wildland interface. Biological Conservation, 224, 188–198. https://doi.org/10.1016/j.biocon.2018.05.004

Lewis, D. L., Baruch-Mordo, S., Wilson, K. R., Breck, S. W., Mao, J. S., & Broderick, J. (2015). Foraging ecology of black bears in urban environments: Guidance for human-bear conflict mitigation. Ecosphere, 6(8), art141. https://doi.org/10.1890/ES15-00137.1

Lischka, S. A., Teel, T. L., Johnson, H. E., & Crooks, K. R. (2019). Understanding and managing human tolerance for a large carnivore in a residential system. Biological Conservation, 238, 108189. https://doi.org/10.1016/j.biocon.2019.07.034

Lynn, J. (2019). King of the Hill? How Biotic Interactions Affect Biogeographical Pattern and Species Responses to Climate Change. 148.

Masterson, L. (2016). Living with Bears Handbook (2nd ed.). PixyJack Press.

Mawdsley, J. R., O'Malley, R., & Ojima, D. S. (2009). A Review of Climate-Change Adaptation Strategies for Wildlife Management and Biodiversity Conservation. Conservation Biology, 23(5), 1080–1089. https://doi.org/10.1111/j.1523-1739.2009.01264.x

Mazur, R., & Seher, V. (2008). Socially learned foraging behaviour in wild black bears, Ursus americanus. Animal Behaviour, 75(4), 1503–1508. https://doi.org/10.1016/j.anbehav.2007.10.027

Merkle, J. A., Robinson, H. S., Krausman, P. R., & Alaback, P. (2013). Food availability and foraging near human developments by black bears. Journal of Mammalogy, 94(2), 378–385. https://doi.org/10.1644/12-MAMM-A-002.1

Ministry of Enviornmental Services. (2015, September 21). Strategy for preventing and managing human wildlife conflicts in Ontario. Ontario.Ca. https://www.ontario.ca/page/strategy-preventing-and-managing-human-wildlife-conflicts-ontario

Nelson, A. S. (2019). The effects of climate change and biodiversity loss on mutualisms. 141.

New York State Department of Enviornmental Conservation. (2011). New York State Black Bear Response Manual. Department of Convservation - New York State. https://www.dec.ny.gov/docs/wildlife_pdf/bearsopm.pdf

Oregon State University, Northwest Alliance for Computational Science & Engineering, & USDA Risk Management Agency. (2020). Time Series Values for Individual Locations. PRISM Climate Group. Retrieved April 29, 2020, from http://www.prism.oregonstate.edu/explorer/

Panetta, A. M., Stanton, M. L., & Harte, J. (2018). Climate warming drives local extinction: Evidence from observation and experimentation. Science Advances, 4(2), eaaq1819. https://doi.org/10.1126/sciadv.aaq1819

Pierre-Louis, K. (2018, May 4). As Winter Warms, Bears Can't Sleep. And They're Getting Into Trouble. The New York Times. https://www.nytimes.com/2018/05/04/climate/bears-not-hibernating.html

Pritchett, L. (2012). Great Colorado Bear Stories. Riverbend.

Ray, A. J. (2004). Linking Climate to Multi-Purpose Reservoir Management: Adaptive Capacity and Needs for Climate Information in the Gunnison Basin, Colorado. ProQuest Dissertations Publishing, 346.

Regional Climate Centers, N., & ACIS. (2019). High Plains Regional Climate Center—CLIMOD. Retrieved November 17, 2019, from http://climod.unl.edu/

Resort Municipality of Whistler. (2016). *Human-Bear Conflict Management Plan* (p. 15).

Responding to Environmental Change—Bears (U.S. National Park Service). (2019). Retrieved September 10, 2019, from https://www.nps.gov/subjects/bears/environmentalchange.htm

Rogers, L. (1986). Effects of Mast and Berry Crop Failures on Survival, Growth, and Reproductive Success of Black Bears. 8.

Rusoke, T. (2017). Climate Change and Its Effects on Wildlife Resources. Nkumba University, Entebbe Uganda.

Schwieterman, G. D. (2019). Is droning on making life unbearable? Conservation Physiology, 7(1), coz034. https://doi.org/10.1093/conphys/coz034

Swanson, C. (2019). Bear-resistant trash cans mandated on Colorado Springs' west side—With a loophole. Colorado Springs Gazette. Retrieved October 15, 2019, from https://gazette.com/news/bear-resistant-trash-cans-mandated-on-colorado-springs-west-side/article_3dbedddc-ea0a-11e9-b955-877e6767ef0a.html

US Census Bureau. (2019). US Census Bureau—Quick facts—Colorado. US Census Bureau. https://www.census.gov/quickfacts/fact/table/CO,US/PST045219

Valdez Bear Working Group. (2013). Bear-Management-Plan. City of Valdez Alaska. https://www.valdezak.gov/DocumentCenter/View/1154/Bear-Management-Plan-PDF?bidId=

Wenum, E., & Jones, K. (2011). Northwest Montana – FWP Region 1 Black Bear & Lion Conflict Management (Project 5152; p. 18). Montana Fish, Wildlife, & Parks.

White, P. C. L., & Ward, A. I. (2010). Interdisciplinary approaches for the management of existing and emerging human–Wildlife conflicts. Wildlife Research, 37(8), 623. https://doi.org/10.1071/WR10191

Wilbur, R. C., Lischka, S. A., Young, J. R., & Johnson, H. E. (2018). Experience, attitudes, and demographic factors influence the probability of reporting human–black bear interactions. Wildlife Society Bulletin, 42(1), 22–31. https://doi.org/10.1002/wsb.854

Appendix A: Matrix created by the Ministry of Environment of British Columbia. A system to deal with bear conflicts and the type of attractants and habitat created in April 2016.

		Bear Behavior/Level of Conflict					
		Level 1 Wary of human (leaves on approach)	**Level 2** Habituated (indifferent to presense of humans)	**Level 3** Assertive behavior or causes proerty damage (including livestock, pets)	**Level 4** Follows/bluff charges humans (threating) or is fed by humans	**Level 5** Causes huamn injury (defensive/surprise attack), Enters unoccupied building	**Level 6** Predatory or non-defensive attack, Enters occupied buildlings
Habitat Type and Feeding Source	**Level A** Bear is feeding on natural foods in natural area or continuous bear habitat	Manage	Manage	Manage with option to remove	Manage with option to remove	Manage with option to remove	Destroy
	Level B Bear is feeding on natural foods in area adjacent to continuous bear habitat	Manage	Manage	Manage with option to remove	Remove from population	Remove from population	Destroy
	Level C Bear is feeding on natural foods in sub-urban or residential area with immediate escape route	Manage	Manage	Manage with option to remove	Remove from population	Remove from population	Destroy
	Level D Bear occasionally feeding on non-natural foods in remote area (camps, etc.)	Manage	Manage with option to remove	Manage with option to remove	Remove from population	Remove from population	Destroy
	Level E Bear is frequently feeding on non-natural foods in residential area with immediate escape route	Manage with option to remove	Manage with option to remove	Remove from population	Remove from population	Destroy	Destroy
	Level F Bear is frequently feeding on non-natural foods in confined/urban areas with no immediate escape route or enters an occupied building	Manage with option to remove	Remove from population	Destroy	Destroy	Destroy	Destroy

Appendix B: Review of Human Bear Conflict Management Plans

Crested Butte Bear Management (https://library.municode.com/co/crested_butte)

The Town of Crested Butte provides a local model for black bear management. In 2007-2008 Division 3 in Article 5 of the Municipal Code was created and focused on Wildlife Protection. This Division includes nine different ordinances that residents are required to follow and officers to enforce. Residents are required to have an approved wildlife-resistant refuse container or dumpster. If the resident does not have a wildlife resistant container, they must store their refuse container within a building, house, or garage.

Wildlife-resistant refuse containers and dumpsters must be kept closed and locked when refuse is not being deposited. Residents must keep refuse containers inside until the day of scheduled collection from 6:00 am to 6:00 pm. Restaurant waste grease must be deposited in a wildlife proof commercial grease container. Wildlife-resistant containers may be placed no earlier than 6:00 pm on the day preceding the day of the scheduled collection. After pickup, all refuse containers, except wildlife-resistant refuse containers, must be resecured inside a home, garage, business, or wildlife-resistant enclosure by 6:00 pm on scheduled pick-up day. No person shall leave or store any refuse, food product, pet food, or grain in a manner that would lure, attract, or entice wildlife. Bird feeders are permitted except between April 15 and November 15 during critical bear forage periods, all feeders must be suspended on a cable or other device, making them inaccessible to bears, and the area below the feeder must be kept free from accumulation of seed debris. All construction sites must have a designated container that receives refuse edible by wildlife. This container should either be wildlife-resistant or a container that is emptied at the end of each workday.

Enforcement officers may issue a warning notice, citation requiring the purchase of a wildlife-resistant refuse container or summons and complaint to any person in violation. Enforcement officers have the right to inspect property regarding any wildlife concern or potential wildlife attractant. Any person's violations will receive a fine in amounts not to exceed $100 for the first offense, $200 for the second offense, and $300 for the third offense. Any additional offense after will not exceed $1,000, and each day that such violation continues to exist shall be deemed a separate offense. Crested Butte has created a Bear Smart organization that provides education materials through the city website for Crested Butte Area residents and visitors.

Resort Municipality of Whistler Canada Human-Bear Conflict Management Plan (https://www.whistler.ca/sites/default/files/2017/Mar/related/22452/2016_human-bear_conflict_management_plan.pdf)

Resort Municipality of Whistler has been engaged in proactive initiatives to reduces and prevent human-bear conflicts since the early 1990's. Whistler formed a black bear task team in 1997 to produce the original black bear management plan. From there a black bear biologist performed a bear hazard assessment in 2005. With the combined information they provided reports and strong community support to have Whistler become a Bear Smart Community. This document outlines what they have achieved since their previous bear management plan and what they can still approve upon with recommended actions. They place a great deal of focus on management of attractants, large turnover of residents and the ongoing need for public education and the large amount of newcomers that have no idea that bears exist in Whistler and do not know the waste management system especially if they do not have a vehicle.

Framework for Enhanced Black Bear Management in Ontario (https://docs.ontario.ca/documents/3087/274504.pdf)

Black bears are highly valued in Ontario's wildlife heritage. The goal of Ontario's black bear management program is to ensure sustainable black bear populations across the landscape. Ontario has established public awareness programs (e.g., Bear Wise) and partnering with stakeholders to develop educational programs highlighting bear biology and management for use by tourist outfitters and clients. They also created programs to raise public awareness of the need to report bears in the protection of property and impacts of climate change on bear populations and habitat. Their plan for human-bear conflict reduction is implementing the provincial Bear Wise program with the goal of reporting, response, prevention, and education and awareness.

Wisconsin Black Bear Management Plan (https://dnr.wi.gov/topic/WildlifeHabitat/documents/bearplan.pdf)

The program goal for black bear management in Wisconsin is to maintain a healthy and sustainable black bear population that fulfills the numerous ecological, social, and cultural benefits of bears while minimizing bear-human conflicts to promote and maintain a positive public image of black bears (Wisconsin DNR Bear Advisory Committee 2019). Wisconsin emphases their efforts on five main objectives: 1) ensure a healthy and sustainable black bear population in Wisconsin, 2) maintain high levels of hunter satisfaction, 3) address human-bear conflict issues, 4) identify appropriate communication strategies and outreach tools to increase public understanding, and 5) identify important needs and conduct research as necessary to address issues impacting black bears and hunting opportunity. Wisconsin's management plan

focuses heavily on the hunting of black bear and hunter satisfaction. Hunting is a main focal point regarding addressing and reducing human-bear conflicts along with the creation of the Wildlife Damage Abatement and Claims Program to assist in addressing agricultural damage. Looking closely into addressing human-bear conflicts, Wisconsin focuses on emphasizing their current tools for management including translocation, lethal control, liquid scents added to shooting permits, trap monitors, and proactive shooting permits. Future tools to be implemented include press release and social media postings, provide more training to DNR staff, creation of another black bear management plan, toll free black bear complaint reporting hotlines, increased staff for USDA-Wildlife services to respond to conflicts. Much of the human-bear conflict sections focus on agricultural damage rather than public or private property damage.