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Human Dimensions of Timber Rattlesnake (Crotalus horridus) Management in Connecticut

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Human Dimensions of Timber Rattlesnake (*Crotalus horridus*) Management in Connecticut

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Introductory Pages

Chapter 1: Introduction

As the global human population grows, humans and wildlife are increasingly sharing space and resources (DeStefano & DeGraaf, 2003; Vitousek, 1997). Much of the eastern United States (US) is defined as wildland-urban interface, in which developed areas and infrastructure are adjacent to or intermixed with natural, undeveloped areas (Martinuzzi et al., 2015). In these urban and exurban areas that exist near natural habitat, human-wildlife encounters have become increasingly common (DeStefano & DeGraaf, 2003; Kretser, Curtis, Francis, Pendall, & Knuth, 2009; Organ & Ellingwood, 2000; Warren, 1997), and residents seek assistance with and information about wildlife (Lindsey & Adams, 2006). This is particularly relevant to the northeastern US, which contains dense human populations intermixed with forested natural habitat. In fact, New England states represent four of the top five states with the greatest proportion of area considered wildland-urban interface (Martinuzzi et al., 2015).

Characteristics and frequency of wildlife encounters that result from adjoining human and wildlife habitat have implications for local wildlife management strategies. Human interactions with wildlife can have lasting impacts (Kansky, Kidd, & Knight, 2016) that shape attitudes and reinforce currently held perceptions about a species (Morzillo, de Beurs, & Martin-Mikle, 2014; Siemer, Hart, Decker, & Shanahan, 2009). Humans have directly contributed to species' declines in the northeastern US (Foster, Motzkin, Bernardos, & Cardoza, 2002), and human factors such as attitudes, behaviors, and support for wildlife management can all affect the success or failure of certain wildlife conservation initiatives (Bangs et al., 1998; Liordos, Kontsiotis, Anastasiadou, & Karavasias, 2017; Olson, MacGowan, Hamilton, Currylow, & Williams, 2015).

Consideration of human factors in wildlife management strategies has led to a growing body of research evaluating human perceptions of and interactions with wildlife. One research conclusion involves the conceptual linkage among human values, value orientations, attitudes, behavioral intentions, and behaviors (Dietsch, Teel, & Manfredo, 2016; Fulton, Manfredo, & Lipscomb, 1996; Teel & Manfredo, 2010). These linkages may be particularly important for management of species that are unpopular and/or perceived to be dangerous. As such, it can be difficult for managers to build public enthusiasm or support for conservation of little-liked species (Batt, 2009; Gunnthorsdottir, 2001; Kellert & Berry, 1980; Liordos et al., 2017; Tisdell, Wilson, & Swarna Nantha, 2006). For example, snakes have long inspired fear or dread in humans (Öhman & Mineka, 2003; Pandey, Subedi Pandey, Devkota, & Goode, 2016) and consistently ranked below other species in studies on attitudes or support for management related to certain taxa (Batt, 2009; Gunnthorsdottir, 2001; Kellert & Berry, 1980). Despite the importance of human factors when considering snake management, reptiles are underrepresented in published natural resources research (Bonnet, Shine, & Lourdais, 2002; Christoffel & Lepczyk, 2012), including human dimensions studies.

One snake species that has suffered detrimental effects due to anthropogenic presence is the timber rattlesnake (*Crotalus horridus*). The extent of timber rattlesnake range in the northeast has decreased drastically over the past four decades (Brown, 1992; Martin, Brown, Possardt, & Sealy, 2008). Historically, this species ranged throughout New England, including southern Maine and northern Vermont (Palmer, 1946; Tyning, 1992). Today, timber rattlesnakes are extirpated from Maine and Rhode Island, and listed as endangered in the remaining New England states where they occur in small, isolated populations (Breish, 1992). Factors influencing the decline of northeastern rattlesnake populations have included historical bounties

offered by local governments, habitat loss, roadway mortalities, and poaching (Brown, 1992; Fritsch II, 1992; Martin et al., 2008). Other actions contributing to declines may include intentional killings (Olson et al., 2015; Pandey et al., 2016) and intentional roadway mortalities (Ashley, Kosloski, & Petrie, 2007; Beckmann & Shine, 2012; Crawford & Andrews, 2016; Langley, Lipps, & Theis, 1989; Sealy, 2002) despite protected status in New England.

Current management efforts for timber rattlesnakes in New England vary by state (Breish, 1992), and include: habitat protection, outreach and education, and anti-poaching strategies (Blodgett, Talmage, & Andrews, 2015; Fritsch II, 1992). For example, in Connecticut, the state occasionally employs a conservation officer to monitor rattlesnake habitat (J. Dickson, Connecticut Department of Energy and Environmental Protection [DEEP], 2015, personal communication). In addition, a Turn-in-Poachers (TIP) hotline exists to report potential wildlife poaching activity (J. Dickson, DEEP, 2015, personal communication). However, it is unknown if these efforts have any effect on timber rattlesnake poaching.

Objectives. The overall goal of this study was to address a gap in our knowledge about the human dimensions of timber rattlesnake management in the northeast by quantifying and evaluating human factors related to timber rattlesnakes among residents near one of Connecticut's timber rattlesnake populations. In Chapter 2, I approached this issue through a traditional human dimensions lens to evaluate attitudes toward timber rattlesnakes. I used results from a mail survey to quantify attitudes and identify potential factors influencing attitudes. I also explored the connections between attitudes toward rattlesnakes, behaviors toward rattlesnakes, situational factors, and wildlife value orientations. In Chapter 3, I took a spatial approach to social survey data analysis. I mapped the spatial distribution of attitudes toward timber rattlesnakes, identified significant clustering of attitudes, and explored connections with

landscape variables. In Chapter 4, I evaluated the potential for management strategies that rely on effort at the individual resident level. To do this, I mailed an informational outreach packet, providing information on the species, what to do in an unexpected encounter, and information on how to recognize and report potential rattlesnake poaching activity to the TIP hotline. I used a follow-up survey to evaluate decreases in concern about encountering a rattlesnake and increases in knowledge and willingness to call the TIP hotline. In the final chapter, I provide general conclusions on the human dimensions of timber rattlesnake management in a particular part of Connecticut and management recommendations.

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Chapter 2: Resident Attitudes Toward Timber Rattlesnakes (*Crotalus horridus*) in Central Connecticut

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Abstract

Timber rattlesnakes are endangered in Connecticut, and occur in two populations in the northwest and central regions of the state. Factors contributing to rattlesnake declines include habitat loss and fragmentation, roadway mortalities, poaching, and intentional killings. Challenges to creating effective rattlesnake management strategies exist because there is currently little information about human factors that may impact management. Objectives of this research were to evaluate: 1) attitudes toward timber rattlesnakes and factors influencing attitudes, and 2) behavioral intentions toward timber rattlesnakes, including support for management. A mail survey instrument was used to collect data from residents who live near the rattlesnake population in central Connecticut (n = 593). Results suggested that two main variables define resident attitudes toward rattlesnakes: existence value of the species and perceived threats from the species. Rattlesnake-related factors and situational factors appeared to contribute more heavily to attitudes toward rattlesnakes than general wildlife values. Attitudes significantly predicted behavioral intentions toward rattlesnakes and support for various rattlesnake management strategies. Resident support for particular rattlesnake management strategies was also strongly related to attitudes toward the species. Results will aid wildlife managers in their ability to incorporate human factors into rattlesnake management and public outreach strategies.

Key words: attitudes, human dimensions, wildlife management, timber rattlesnakes, Connecticut

Introduction

As human development expands into previously natural areas, people are encountering wildlife near their homes more frequently (DeStefano & DeGraaf, 2003; Kretser, Curtis, Francis, Pendall, & Knuth, 2009; McCance et al., 2017; Organ & Ellingwood, 2000; Steffen, Broadgate, Deutsch, Gaffney, & Ludwig, 2015; Vitousek, 1997; Warren, 1997). In the eastern United States (US), dense human populations live in close proximity to large wildlife populations (Martinuzzi et al., 2015; Organ & Ellingwood, 2000). Recently, managers have turned their attention toward conflict mitigation strategies for wildlife that live near human communities (McCance et al., 2017; Messmer, 2000). Current wildlife management is in an "impact management" period, in which wildlife professionals are managing for both wildlife populations and for human-wildlife interactions (McCance et al., 2017).

An emphasis on human-wildlife conflict mitigation is particularly suitable for the wildland-urban interface, where human structures or communities are intermixed with natural areas (McCance et al., 2017; Radeloff et al., 2005). This land classification is prevalent throughout the eastern US, with Connecticut containing the greatest proportion of wildland-urban interface area (Martinuzzi et al., 2015). This intermixing of habitat for numerous wildlife species and human residential areas increases the chance for human-wildlife interactions and the potential for conflict (DeStefano & DeGraaf, 2003; Johnston, 2001; Morzillo, de Beurs, & Martin-Mikle, 2014; Radeloff et al., 2005). In these areas, a feedback loop can occur when residents with positive or negative attitudes toward wildlife create landscape characteristics that attract or discourage animals, respectively, leading to human-wildlife interactions that enforce original attitudes (Belaire, Whelan, & Minor, 2014; Morzillo et al., 2014).

In this study, we focus on the timber rattlesnake (*Crotalus horridus*), one species affected by human interactions in the wildland urban interface. Habitat loss, illegal collection, road mortalities, and intentional killings have caused northeastern timber rattlesnake populations to become increasingly rare and fragmented (Fritsch II, 1992; Martin, Brown, Possardt, & Sealy, 2008; Olson, MacGowan, Hamilton, Currylow, & Williams, 2015). Timber rattlesnake ecology and life history strategies make this species particularly sensitive to human impact, and loss of reproductive-age individuals can greatly affect population numbers (Brown, Jones, & Stechert, 1994). Timber rattlesnakes are now extinct in Maine and Rhode Island, and listed as endangered in the remaining New England states. Connecticut is home to two isolated timber rattlesnake populations, one in the central part of the state and one in the northwest corner (Fritsch II, 1992; J. Dickson, Connecticut Department of Energy and Environmental Protection [CT DEEP], November 2015, personal communication).

This study addresses a gap in our knowledge of human perceptions of predator species, and specifically a gap in knowledge of how humans in a northeastern region of the US perceive and interact with a venomous snake species. Research on the human dimensions of venomous snakes is currently rare, and this is the first such study to be conducted in New England. Our research builds upon previous studies on the connection between human factors, such as value orientations, attitudes, and behaviors, related to a herptile species (Christoffel 2007; Hartel et al., 2015; Perry-Hill et al., 2014; Reimer et al., 2014). We used a social survey instrument to collect data from Connecticut residents adjacent to a rattlesnake population and explore connections between attitudes, behavioral intentions (including support for management actions), species-specific variables, variables related to general wildlife orientations, and social-demographic variables. Our objectives were to evaluate: (1) factors influencing resident attitudes toward

timber rattlesnakes, and (2) resident behavioral intentions toward timber rattlesnakes, including support for potential management actions.

Conceptual Background

Past research suggests that the general public more readily supports conservation of charismatic species or "model organisms", over less popular species and those that are not conventionally cute (e.g., lacking humanoid physical characteristics), such as herpetofauna (Batt, 2009; de Pinho, Grilo, Boone, Galvin, & Snodgrass, 2014; George, Slagle, Wilson, Moeller, & Bruskotter, 2016; Gunnthorsdottir, 2001; Kellert, Black, Rush, & Bath, 1996; Knight, 2008; Liordos, Kontsiotis, Anastasiadou, & Karavasias, 2017; Tisdell, Wilson, & Swarna Nantha, 2006). For example, snakes often elicit fear or disgust from humans (Davey et al., 1998; Öhman & Mineka, 2003). These fear reactions are enabled by media related to wildlife that portrays wild animals as dangerous or unpleasant (e.g., films, such as "Jaws" and "Anaconda"), which can contribute to myths about the species and elevate perceptions of risk (Harrison & Cantor, 1999; Prokop, Fančovičová, & Kubiatko, 2009).

Several factors contribute to attitudes toward herpetofauna species, including cultural values, wildlife values, knowledge level, past experiences, personal norms, fear level, and sociodemographics (Ceríaco, 2012; Christoffel, 2007; Hartel et al., 2015; Öhman & Mineka, 2003; Raymond & Schneider, 2014; Zinn & Pierce, 2002). For example, respondents familiar with eastern hellbenders (*Cryptobranchus alleganiensis*) held more positive attitudes toward hellbenders than respondents who were unaware of this species' existence (Reimer et al., 2014). Also for eastern hellbenders, species-specific attitudes were better indicators of behaviors toward

that species than general wildlife beliefs (Perry-Hill et al., 2014). For box turtles (*Terrapene carolina carolina*), positive attitudes were significantly predicted by mutualistic wildlife value orientations (Hartel et al., 2015). Christoffel (2007) found that both previous knowledge of rattlesnakes and the belief that one lived near rattlesnake habitat contributed to positive attitudes.

Despite the above studies, herpetofauna are still largely underrepresented in the natural resources management literature (Bonnet, Naulleau, & Shine, 1999; Christoffel & Lepczyk, 2012; Grodsky, Iglay, Sorenson, & Moorman, 2015). Complicating this further, because of the fear-based emotional reactions that can be triggered by an unexpected snake encounter (Hudenko, 2012; Öhman & Mineka, 2003), research conclusions regarding human interactions with non-snake reptile species (e.g., turtles, lizards) may not apply to snake management. Therefore, species-specific research is especially important for wildlife that may be perceived negatively, such as venomous snakes (Christoffel & Lepczyk, 2012; Pandey et al., 2016). Region-specific research is also necessary because perceptions of a venomous snake species may vary regionally, as attitudes are impacted by familiarity and level of experience (Christoffel, 2007; Kretser, Curtis, Francis, et al., 2009; Pinheiro, Rodrigues, & Borges-Nojosa, 2016; Reimer et al., 2014).

A human-rattlesnake encounter that ends in snake mortality can result from a combination of negative attitudes and an exaggerated risk perception, as well as a range of split-second emotions (Figure 1; Christoffel, 2007). The outcome of the encounter may also be influenced by factors specific to situational context, such as years lived near rattlesnake habitat, presence of young children, and the presence of pets (Hayman, Harvey, Mazzotti, Israel, & Woodward, 2014; Zinn & Pierce, 2002). For example, an individual who feels generally positive toward wildlife, including venomous snakes, still may engage in behaviors that lead to a negative

outcome for a rattlesnake encounter experienced near their home, exhibiting a cognitive dissonance (Heberlein, 2012). In this study, we expected that attitudes influence behavioral intentions toward timber rattlesnakes, and are better predicted by rattlesnake-specific variables (e.g., knowledge and awareness of timber rattlesnakes) and situational factors (e.g., presence of children and pets), than wildlife value orientations (Fulton, Manfredo, & Lipscomb, 1996).

Methods

Study Context and Location

The focus of this study was on a rattlesnake population in central Connecticut (Figure 2), and included portions of two Connecticut towns. Of the two isolated rattlesnake populations in Connecticut, this one is believed to be more heavily affected by humans (J. Dickson, CT DEEP, November 2015, personal communication). The study area is defined by human development (15% of land cover) intermixed with forested patches (71% of land cover; Data source: Landsat TM imagery; CLEAR, 2006). Considered wildland-urban interface, a majority of the land cover is medium housing density intermix (35%), low density intermix (27%), and uninhabited vegetation (25%) (Martinuzzi et al., 2015). The central part of the study area consists of forestland (area = 13.7 km^2) that serves as the center of rattlesnake activity for this population.

This region was predominately rural until the early 1980's when development increased with the growth of the finance industry in a nearby city (Winslow, 1987). Recently this area experienced an above average turnover of residents (B. DiLoreto, GRI, ABRIM, January 2017, personal communication). Past outreach efforts included, from 1980's-2008, an annual letter

mailed to selected addresses by CT DEEP informing residents of timber rattlesnake presence in the area. The impact of that effort has not been studied, and it is unknown whether more recent incoming residents are aware of rattlesnake presence.

We focused our study on residents most likely to have come in contact with a timber rattlesnake, per the recommendations of McCleery, Ditton, Sell, & Lopez (2006). Therefore, we defined the study area conservatively as a 4-km radius circle (total area= 50.3 km^2) centered on a central point of rattlesnake activity and based on the straight-line distance that an adult timber rattlesnake may move from the den site during summer foraging and mating activities (about one to three km; Tyning, 2005). Individuals familiar with this rattlesnake population confirmed that our study area included areas most likely to experience a rattlesnake encounter (D. Fraser, Siena College, March 2016, personal communication).

Data Collection

We used a mail survey instrument to collect data from a randomly selected group of households (n = 1,500) from our study area. The study population was defined as the total number of residences within the study area (approximately 3,600), and the sampling unit was the individual household. Sample size was based on the desired number of completed surveys and a desired sampling error $\alpha = 0.05$ (95% confidence interval; Sheskin, 1985). We acquired addresses in an Address Based Sample (ABS) from Marketing Systems Group (Horsham, PA), which creates sampling frames from US Postal Service delivery sequence files. Seasonal homes and PO boxes were excluded from the sample unless they were the resident's only way to receive

mail. The University of Connecticut Institutional Review Board (IRB Protocol # H15-237) granted permission for use of human subjects.

Corresponding to the rattlesnake activity season, surveys were mailed in June 2016. Multiple mailings were used in an effort to increase response rate (Dillman, Smyth, & Christian, 2008). Survey questions were pre-tested with a focus group to confirm clarity and inclusion of all major rattlesnake issues and concerns. We used a modified version of Dillman's Tailored Design Method with the following chronology: (1) a pre-notice postcard introducing the project and the researchers, (2) questionnaire with a cover letter and return envelope with postage included, (3) reminder postcard, and (4) second mailing of questionnaire packet with a cover letter to those who did not return the survey after the first mailing (Dillman et al., 2008). A non-response follow-up survey was completed using door-to-door canvassing during Fall 2016, and focused on ten key items from the original survey. Non-response surveys were completed for 10% of non-respondents to the original survey (n = 91 non-response surveys completed), selected randomly from a list of non-respondents.

Independent variables

Experiences related to timber rattlesnakes

Past research suggests that timber rattlesnake experiences relate to more favorable attitudes toward the species (Ballouard et al., 2013; Christoffel, 2007; Hartel et al., 2015). To evaluate experiences, we presented participants with a list of possible rattlesnake-related experiences (adapted from Christoffel 2007) ranging from indirect (i.e., been to an educational program that included information on timber rattlesnakes, read or heard a news story about a rattlesnake in Connecticut) to direct exposure to rattlesnakes (i.e., was in a vehicle that ran over a

rattlesnake, have a friend or neighbor or family member who was bitten by a rattlesnake). Responses were coded as 1 (yes, has experienced) or 0 (no, has not experienced) and summed to derive an *Experience* variable.

Awareness of timber rattlesnakes

To measure respondents' awareness of timber rattlesnakes in the area (*Awareness*), we asked the following question: "Before receiving this survey, were you aware of the potential presence of rattlesnakes in your neighborhood?" (yes = 1; no = 0).

Knowledge

Similar attitudinal research has found that greater knowledge of a species is associated with greater attitude scale scores related to the species (Bath, Olszanska, & Okarma, 2008; Christoffel, 2007; Ericsson & Heberlein, 2003; Glikman et al., 2012). We derived the *EcoRole* score to represent our respondents' knowledge of timber rattlesnake role in the ecosystem, based on indicated level of agreement (5 = strongly agree, 4 = somewhat agree, 3 = unsure, 2 = somewhat disagree, 1 =strongly disagree) to eight statements about timber rattlesnake ecology and life history. We used exploratory factor analysis (principal component analysis [PCA], using varimax rotation) to construct scale scores based on items that factored together. We used Cronbach's alpha (α; Cortina, 1993) to measure internal reliability of statements that factored together, and derived scale scores for each respondent by summing the values of corresponding statements. PCA resulted in four statements that reliably factored together, which were used to create a scale score for *EcoRole* (n = 591; α = 0.714): (a) rattlesnakes help to control local rodent populations, (b) rattlesnakes can help reduce the spread of Lyme disease, (c) rattlesnakes are

important to the Connecticut ecosystem, (d) removing one adult female rattlesnake from the population can greatly affect future population numbers. We derived the *EcoRole* score for each respondent by summing the response values for each of the four statements (possible values between 4 and 20). Higher scores indicated greater knowledge about timber rattlesnakes' place in the ecosystem.

We also evaluated awareness of current threats to rattlesnake populations (*ThreatKnow*), by asking respondent to indicate which of the following actions they believe may contribute to the overall decline of rattlesnake populations in Connecticut: (a) the removal of rattlesnakes from the wild to be sold for profit (poaching), (b) intentional killings by humans, (c) road mortalities, (d) disease, (e) habitat loss, and (f) urban development. We derived a scale score for each respondent by summing the total number of threats selected, as these are all considered current threats to Connecticut rattlesnakes.

Social Acceptance Capacity and Risk Perception

To evaluate social acceptance capacity (*IdealPop*) for timber rattlesnakes near homes, we asked participants to select their ideal rattlesnake population in their local area: (a) healthy and abundant population, frequent sightings, (b) small and isolated population, occasional sightings, (c) population risks extinction, sightings are rare, or (d) no rattlesnakes (Christoffel, 2007). To evaluate risk perception (*RiskPer*), we asked participants, "To what extent do you believe that you personally are at risk from rattlesnakes near your home?" (1 = great risk; 2 = some risk; 3 = slight risk; 4 = no risk; 9 = unsure; Christoffel (2007).

Wildlife Value Orientations (Mutualism and Domination)

Wildlife value orientations reflect amalgamated beliefs around wildlife, and can be represented as mutualism versus domination value orientations (Manfredo, Teel, & Henry, 2009). Past research suggests that snakes can evoke strong human emotions can evoke (Hudenko, 2012; Öhman & Mineka, 2003), suggesting that attitudes might be better predicted by species-specific variables and situational factors than general wildlife value orientations (Hayman et al., 2014). We asked participants to rank their level of agreement (5= strongly agree, 4= somewhat agree, 3= unsure, 2= somewhat disagree, 1= strongly disagree) with 14 statements that represented either a mutualism based-belief (i.e., social affiliation and caring; *Mutualism*) or a domination based-belief (i.e., appropriate use and hunting; *Domination*; Dietsch & Teel, 2012; Teel & Manfredo, 2010). Statements used to measure *Mutualism* were: (a) animals should have rights similar to the rights of humans, (b) I view all living things as part of one big family, (c) I feel a strong emotional bond with animals, (d) I care about animals as much as I do other people, (e) we should strive for a world where humans and wildlife can live side by side without fear, (f) I value the sense of companionship I receive from animals, and (g) wildlife are like my family and I want to protect them. Statements used to measure *Domination* were: (a) humans should manage wild animal populations so that humans benefit, (b) we should strive for a world where there is an abundance of wildlife for hunting and fishing, (c) hunting does not respect the lives of animals, (d) the needs of humans should take priority over wildlife protection, (e) wildlife are on the earth primarily for people to use, (f) hunting is cruel and inhumane to the animals, and (g) people who want to hunt should be provided the opportunity to do so. Remaining statements that did not factor well were removed from further analysis.

We used PCA and Cronbach's alpha to confirm that responses to the WVO statements grouped into mutualism or domination components (social affiliation and caring statements: n =

579; α = 0.834; hunting statements: n = 579; α = 0.835; appropriate use of wildlife statements: n = 579; α = 0.629). We derived *Domination* and *Mutualism* value orientation scores for each respondent by computing the means of responses (ranging from 1-5) to corresponding belief statements.

Socioeconomics and Situational Factors

Past research suggests that specific situational factors are connected to attitudes and behaviors related to wildlife (Hayman et al., 2014; Karlsson & Sjöström, 2007; Morzillo, Mertig, Hollister, Garner, & Liu, 2010; Zinn & Pierce, 2002). These factors can also be referred to as sociodemographic variables; however, in this study, we refer to them as situational variables to convey their potential in influencing the outcome of a human-rattlesnake encounter. To evaluate residential tenure (*ResTenure*), we asked participants to indicate the number of years they had resided at their current address. For the number of children in the household (*Children*), we asked participants to indicate the number and ages of children under the age of 18 currently living at that address, and who regularly visit that address. We converted integer values to a binomial format based on the presence (coded as 1) or absence (coded as 0) of children. For the presence of outdoor pets (*Pets*) and respondents' gender (*Sex*), we used binomial responses (*Pets:* yes = 1, no = 0; *Sex:* female = 1, male = 2). For respondents' age (*Age*), we subtracted the integer value of year born from 2016 to identify age in years. To evaluate respondents' education level (*Education*), we asked participants to indicate the highest level of formal education completed, from the following response options: (a) less than high school, (b) high school graduate or equivalent, (c) vocational or trade school, (d) some college, (e) college degree (2-year or certificate), (f) college degree (bachelor's degree), or (g) graduate or professional degree.

Dependent variables

Attitudes toward rattlesnakes

Human attitudes, behaviors, and conservation support related to individual wildlife species can be shaped by a variety of factors related to that species (Christoffel, 2007; Fulton et al., 1996; Glikman, Vaske, Bath, Ciucci, & Boitani, 2012; Hartel et al., 2015; Hayman et al., 2014). We hypothesized that rattlesnake-specific variables and situational factors would better predict attitudes toward rattlesnakes than general values, such as wildlife value orientations (Hayman, Harvey, Mazzotti, Israel, & Woodward, 2014; Perry-Hill et al., 2014). To evaluate attitudes, we asked study participants to indicate level of agreement, on a 5-point Likert scale (5= strongly agree, 4= somewhat agree, 3= unsure, 2= somewhat disagree, 1=strongly disagree), with 12 belief statements about rattlesnakes (modified from Christoffel, 2007, and Riley, 1998). We used PCA to construct scale scores based on items that factored together and derived attitude scale scores for each respondent by summing the values of corresponding statements.

PCA resulted in two attitude variables: *Coexistence* and *Concerns*. *Coexistence* followed a general theme of mutual coexistence between humans and rattlesnakes, and included eight statements (n = 591; α = 0.915): (a) I am personally interested in rattlesnakes, (b) I would enjoy seeing a rattlesnake in the wild, (c) even if I never seen one, I enjoy just knowing that rattlesnakes exist, (d) if I knew that a rattlesnake lived near my home, it would decrease my enjoyment of living there, (e) I take pride in knowing that a rattlesnake lives near my home, (f) I would be less likely to have a rattlesnake relocated from my property if I knew that it may not survive as a result, (g) rattlesnakes pose an unacceptable threat to pets, and (h) rattlesnakes pose

an unacceptable threat to children. Individual score values for this attitude variable were between 8 and 40; higher scores indicated a more favorable attitude toward rattlesnakes.

Four statement items were used to create *Concerns* (n = 591; α = 0.769), which followed a theme of rattlesnakes as a cause for concern: (a) rattlesnakes reduce the property values in my area, (b) rattlesnakes pose a threat to people by their presence, and (c) rattlesnakes should be eliminated from Connecticut, and (d) rattlesnakes have just as much right to live as any other animal. Individual score values for this attitude variable were between 4 and 20, with a higher score indicating a less favorable attitude toward rattlesnakes (e.g., more concerns about rattlesnake presence). From this point on, we will use "greater scale scores" to refer to respondent scores for each attitude variable that indicate more favorable attitudes toward coexistence with rattlesnakes and less concern about rattlesnake presence.

Behaviors and Behavioral Intentions

Past research suggests that behavioral measures can improve attitudinal research studies related to wildlife (McCleery et al., 2006). We measured reported behaviors (*Behavior*) toward timber rattlesnakes using a three-part question. First, we identified respondents who had ever encountered a rattlesnake on their property ("Have you encountered a snake you believed was a timber rattlesnake on your property?"). Then, we asked respondents who indicated an encounter to select their behavior in the most recent encounter, given the following options: (a) contacted someone for assistance, (b) avoided it and took no further action, (c) relocated it or attempted to relocate it, (d) killed or attempted to kill it, or (e) other.

We hypothesized that behavioral intentions toward timber rattlesnakes would be predicted by species-specific attitudes (as in Perry-Hill et al., 2014). To measure behavioral

intentions (*BehaviorInt*), we adapted Christoffel (2007) and Peyton, Bull, Reis, & Visser's (2001) bear sensitivity index used to measure human intolerance for bear interactions. We asked respondents to select the behavior in which they would most likely engage given seven hypothetical snake encounter scenarios: (a) rattlesnake on your property, (b) unidentified snake on your property, (c) rattlesnake crossing a road near your home, (d) rattlesnake threatens a pet in your neighborhood, (e) rattlesnake threatens a child in your neighborhood, (f) rattlesnake on a trail near your home, (g) neighbor asks you for assistance with a rattlesnake on their property. Response options were limited to: (a) do nothing, (b) call local snake volunteer, (c) call CT DEEP, (d) call animal control or police, (e) attempt to move snake, or (f) kill snake. We then asked those who selected item (f) for any of the scenarios to indicate the main reason for doing so.

To evaluate intended support of rattlesnake management strategies, we measured support for specific timber rattlesnake management actions (*SupportMan*) based on responses to the question: "To what extent do you support each of the following management strategies for rattlesnakes in Connecticut?". Participants were asked to respond to eight current or potential rattlesnake management strategies: (a) increased public education and outreach about rattlesnakes, (b) relocating rattlesnakes off of a property, at the landowner's request, (c) government money spent to protect rattlesnakes, (d) government money spent to protect rattlesnake habitat, (e) private funds (from donations) spent to protect rattlesnakes, (f), private funds (from donations) spent to protect rattlesnake habitat, (g) laws that prohibit killing rattlesnakes, and (h) laws protecting rattlesnakes that restrict a landowner's right to develop private property. Responses were presented and coded using Likert-scale format (5 = strongly support; 4 = somewhat support; 3 = unsure; 2 = somewhat against; 1 = strongly against).

Statistical analysis

Statistical analyses were completed using SPSS (version 24.0; SPSS, Inc., version 24.0; Chicago, Illinois) or RStudio (Version 1.0.136). We used univariate, bivariate, and multivariate methods to analyze responses to survey questions (Sokal & Rohlf, 1995). Chi-square (χ^2), ANOVA, and Pearson's *r* were used to compare sample means and test bivariate relationships among all variables (Sokal & Rohlf, 1995). Effect size (Gliner, Vaske, & Morgan, 2001) was used to assess the strength of the relationships between variables, as appropriate. We used a linear regression model with 14 independent variables (*Experience, Awareness, EcoRole, ThreatKnow, RiskPer, IdealPop, Mutualism, Domination, ResTenure, Children, Pets, Sex, Age,* and *Education*), to identify influencing factors for each attitude variable (*Coexistence* and *Concerns*).

Results

Sample characteristics

We received 595 completed surveys (39.7% response rate). Two surveys received after completion of the non-response follow-up survey were removed from analysis (*n*= 593). Fifty four percent of respondents were female, and the mean respondent age was 56 years old (SD = 13.8; range: 19-94; Table 2). According to American Community Survey data (2011-2015), our gender ratio is representative of the area. However, given that the median age for applicable census tracts is 44 years old, with 78% of population reported as 18 years or older (ACS, 2015), and the mean respondent age from our non-response survey was 51 years old, our average age is

likely higher than the actual average adult age. Our average respondent had lived at their current address for 20 years, and 31% of our respondents had lived at their current address for less than 10 years. For the highest level of education obtained among our respondents, 32% reported a bachelor's degree and 41% reported a graduate or professional degree. Amount of formal education completed was greater for our respondents than the average resident, as sixty-three percent of residents in the three applicable census tracts have attained a bachelor's degree or greater (ACS, 2015). Among non-respondents, the most common reason for not responding to the mail survey was that the respondent never received or did not recall receiving the survey (*n*= 36; 40%).

Bivariate Relationships among Independent Variables

Bivariate analysis revealed relationships between sociodemographic variables, such as *Children* and *Age* (*F* =258.187, *p*-value = 0.000), as well as and *ResTenure with Children* (*F* = 207.320, *p*-value = 0.000), *Age* (*r* = 0.7464, p-value =0.000, *eta* = .806), *Education* (*r* = -0.2657, *p*-value =0.000, *eta* = .286), and *Experience* (*r* = 0.1870, *p*-value = 0.0000, *eta* = .399). A negative relationship existed between *Domination* and *Mutualism* (*r* = -0.5235, *p*-value = 0.000, *eta* = .663), as well as *Domination* and *Sex*, with male respondents more likely to have higher *Domination* scale scores than females (*F* = 51.689, *p*-value = 0.000). A direct relationship existed between *EcoRole* and *ThreatKnow* (*r* = 0.3293, *p*–value = 0.000, *eta* = .388), whereas inverse relationships existed between *RiskPer* and *Awareness* (*F* = 7.452, *p*-value = 0.007), and *RiskPer* and *Experience* (*r* = -.2304, *p*-value = 0.0000, *eta* = .287).

Distribution of Attitude Scores

For the *Coexistence* attitude variable, the average scale score was 24.05 (SD = ±8.59). Scale scores followed a normal distribution, with a kurtosis value of -0.987. For the *Concerns* attitude variable, the average scale score was 8.70 (SD= ±3.53). The distribution of the scores for the *Concerns* variable were skewed toward lower values (scores < 12), indicating more favorable attitudes, with a kurtosis value of 0.390.

Variables influencing Attitudes

Regression analysis revealed that those with greater *Coexistence* scale scores (more favorable to coexistence with rattlesnakes) were more likely to have more experiences related to rattlesnakes (*Experience*), greater knowledge of rattlesnake role in the ecosystem (*EcoRole*), a lower sense of risk perception (*RiskPer*), a desire for more abundant rattlesnake populations (*IdealPop*), mutualistic wildlife value orientations (*Mutualism*), and were male (*Sex*; Table 3). Regression analysis revealed that those with greater *Concerns* scale scores (less concern about rattlesnake presence) were more likely to have greater knowledge of rattlesnake role in the ecosystem (*EcoRole*) and greater knowledge of current threats to rattlesnakes (*ThreatKnow*), a lower sense of risk perception (*RiskPer*), a desire for more abundant rattlesnake populations (*IdealPop*), high mutualism wildlife values (*Mutualism*), and low domination wildlife values (*Domination*). Factors influencing *Concerns* and *Coexistence* scores were largely consistent. Exceptions included gender and experience for *Coexistence*, and knowledge of current threats to rattlesnake population for *Concerns*.

Behaviors and Behavioral Intentions

Twenty-five percent of survey respondents (n = 146) indicated they had encountered a snake believed to be a rattlesnake on their property. Of those respondents, 80% indicated that they either contacted someone for assistance or, avoided it and took no further action (*Behavior*). Seven respondents indicated that they either killed or relocated the snake (or attempted to do so).

Respondents with greater attitude scales scores (*Coexistence* and *Concerns)* were more likely to report that they would do nothing in response to most snake encounter scenarios. Respondents with lower attitude scale scores were more likely to report that they would kill the snake or call animal control or police. Of the 74 respondents who indicated that they would kill the snake in response to at least one scenario, 80% indicated that they chose that option because of safety concerns. We used listwise deletion to remove respondents who indicated they would attempt to move the snake from these analyses because results were inconsistent for the small number of respondents who chose this option.

Among survey respondents, the most supported management actions were increased public education and outreach about rattlesnakes (61% strongly support) and relocating rattlesnakes off of a property, at the landowner's request (52% strongly support). The least supported management action was laws protecting rattlesnakes that restrict a landowner's right to develop private property (14.5% strongly support). We found that support for timber rattlesnake management strategies was more likely among those who had greater attitude scale scores (*Coexistence* and *Concerns*).

Discussion

Increasing urbanization and cultural value shifts have been connected to changes in the way that humans perceive and interact with wildlife (Manfredo, Teel, & Bright, 2003). Specifically, researchers have documented a gradual shift away from wildlife values that consider wildlife solely in terms of human use and benefits, and toward mutualistic and protection-directed value orientation (Manfredo, Teel, Sullivan, & Dietsch, 2017; Manfredo et al., 2009; Manfredo et al., 2003). This shift may indicate greater support for conservation and protection of non-game species, that is, species that cannot directly benefit humans through consumptive use. In this study, we explored the relationship between human attitudes and behavioral intentions toward a local timber rattlesnake population and factors associated with those attitudes. Our results suggest a greater proportion of respondents had favorable attitudes toward rattlesnakes than outright adverse attitudes and about half our respondents acknowledged rattlesnake existence value.

According to the cognitive hierarchy of human behavior, wildlife value orientations impact attitudes, which impact behaviors toward wildlife (Fulton et al., 1996). However, emotions and situational context can also influence behavior in a wildlife encounter scenario (Hudenko, 2012; Perry-Hill et al., 2014). Our results support previous research suggesting that behaviors and attitudes toward timber rattlesnakes would be more heavily influenced by interacting species-specific and situational variables, than general wildlife values (Christoffel, 2007; Hartel et al., 2015; Kretser, Curtis, & Knuth, 2009; Reimer et al., 2014). Attitudes toward timber rattlesnakes predicted behavioral intentions in response to an unexpected timber rattlesnake encounter (Table 4). Yet, although wildlife value orientations were among factors contributing to attitudes, they did not contribute strongly to the linear regression results. Instead, our results suggested that in an unplanned timber rattlesnake encounter, an individual's response

(behavior, as driven by attitudes) may be more likely guided by knowledge of rattlesnake role in the ecosystem, past experiences related to the species, and risk perception regarding rattlesnakes. This provides support for the correspondence or specificity principle, suggesting that an individual's behaviors and behavioral intentions (i.e., indicated support for management actions) will exhibit the strongest correlation with attitudes specific to that object, as opposed to more general attitudes or values (Ajzen & Fishbein, 1977; Heberlein, 2012; Whittaker, Vaske, & Manfredo, 2006)

Further support for the above conclusion is demonstrated by individual chi-square tests on behavioral intentions in various snake-encounter scenarios and expected influencing variables (Table 4). *Coexistence* influenced reported behavioral intentions in all encounter scenarios but one ("you see a rattlesnake on the trail near your home"). Knowledge of timber rattlesnake role in the ecosystem and risk perception were factors contributing to all eight scenarios, whereas mutualism and domination scores contributed to behavioral intentions in one and two scenarios, respectively (Table 4). While each of the hypothetical rattlesnake encounter scenarios included contextual location details (e.g., near your home, on your property, in your neighborhood), two of the scenarios included additional context ("a rattlesnake threatens a pet in your neighborhood" and "a rattlesnake threatens a child in your neighborhood"). Although these two scenarios have low probability of occurrence, they were useful in gaining a better understanding of behavioral intentions in situations where emotions may heavily influence behaviors. We found that presence of children in the household (*Children*) did contribute to respondents' behavioral intentions in the hypothetical scenario of a rattlesnake threatening a child.

Although behavioral intentions do not always predict actual behaviors, they are generally considered to be valid proxies (Fulton et al., 1996) and our results provided support for this

theory. Approximately 70% of the respondents who had encountered a rattlesnake reported actual behaviors that aligned with their reported behavioral intentions in the hypothetical scenario of finding a rattlesnake on their property (*n* =89). Elsewhere in the study, 65% of respondents who reported encounters in 2016 also reported actual behaviors that corresponded with intended behaviors (*n* = 13; author unpublished data, 2017). It is worth noting, however, that most reported intended behaviors were passive (e.g., do nothing or call someone for assistance).

In response to the eight hypothetical encounter scenarios, some respondents (*n*= 75) indicated that they would kill the snake. Elsewhere on the survey, these respondents indicated their general emotions regarding timber rattlesnakes as unhappy, anxious, and frightened (author unpublished data). Additionally, average attitude scale scores for those individuals indicated less favorable attitudes toward rattlesnakes (mean *Coexistence* score= 16.82, mean *Concerns* score= 11.95). Several individuals indicated that they would kill a rattlesnake if they saw one crossing a road near their home (*n*= 12). These results support past conclusions that snake roadway mortalities are sometimes intentional (Ashley, Kosloski, & Petrie, 2007; Beckmann & Shine, 2012; Crawford & Andrews, 2016; Langley, Lipps, & Theis, 1989). Exclusive from behavioral intentions, timber rattlesnakes have been found to cross roadways more slowly than other snake species and have a tendency to immobilize in response to a vehicle, which may increase the threat of roadway mortalities (Andrews & Gibbons, 2005). Therefore, combined ecological and human stressors justify management actions to prevent roadway mortalities, a major threat to Connecticut rattlesnakes (D. Fraser, Siena College, March 2016, personal communication).

Our findings indicate that greater knowledge of the rattlesnake's role in the ecosystem, lower risk perception, and more rattlesnake-related experiences are connected to favorable

attitudes and non-harmful behaviors toward timber rattlesnakes. These results suggest that outreach and education strategies that provide information and direct experiences with snakes may have a beneficial influence on rattlesnake management in this area. Previous researchers have made similar conclusions regarding the beneficial impacts of a planned, guided snake encounter (Christoffel, 2007; Lo, Chow, & Cheung, 2012; Morgan & Gramann, 1989; Skupien, Andrews, & Larson, 2016). In the past, outreach programs that provide direct experiences (i.e., facilitating interactions between humans and rattlesnakes in an educational setting) have partnered with organizations, such as schools, zoos, and nature centers.

When seeking to address environmental behaviors, a common error is to rely entirely on a *cognitive fix*, (i.e., providing information and educational material in an attempt to change attitudes), when a *structural fix* (i.e., putting structures or systems in place that encourage a behavior change) can be more effective (Heberlein, 2012). Our results highlight the importance of a structural fix during an unexpected timber rattlesnake encounter that results in a beneficial outcome for both the rattlesnake and the human. According to Heberlein (2012), attitudes that are tied to direct experiences are stronger, harder to change, and more likely to be connected to behavior. Kansky, Kidd, & Knight (2016) examined tolerance for human-wildlife conflict and found that personally meaningful events with wildlife influence perceptions of intangible benefits from wildlife, which can influence tolerance of a species. This conclusion is consistent with findings by Siemer, Hart, Decker, & Shanahan (2009), that positive experiences can influence concern about human-bear interactions. However, a discrepancy can exist between people's expectations of a wildlife encounter, whether positive or negative, and the actual experience (McCance et al., 2017). For example, an individual may expect a rattlesnake encounter to have a negative outcome and if those expectations are not met, the experience may

be remembered in a neutral or even positive light. Based on evidence of a growing demand for assistance with and information about wildlife (Lindsey & Adams, 2006), accurate rattlesnake information provided from a trained professional or volunteer may be beneficial in the event of a rattlesnake encounter.

This research added to our understanding of human perceptions and interactions with a species that is sometimes perceived as dangerous. This knowledge of the factors that impact human attitudes and behaviors toward timber rattlesnakes can guide wildlife managers in creating management strategies that better incorporate human complexity. Our study area has been suggested as a success story in terms of human-rattlesnake coexistence (D. Fraser, Siena College, March 2016, personal communication). While we found that attitudes toward timber rattlesnakes appear to be generally positive or neutral, human-caused rattlesnake mortalities are still a concern in this area from a management standpoint. Methods used in our study may be transferrable to other locations and species, as well as future research regarding the human dimensions of reptile conservation in the northeast.

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Table 2.1. Dependent and independent variables for identifying: respondents' attitudes toward rattlesnakes (♦), support for management strategies (^), sociodemographic variables (^^), reported behaviors and behavioral intentions toward rattlesnakes (†), actual experiences with rattlesnakes (††), awareness and knowledge of rattlesnakes (*), risk perceptions and social acceptance (**), and wildlife value orientations (***).

Variable creation	Variable
To what extent do you agree or disagree with the following statements about rattlesnakes in Connecticut?	*Coexistence*♦ *Concerns*♦
Have you encountered a snake you believed was a rattlesnake on your property? What did you do when you encountered the snake?	*Behavior*†
Please select the one action that you would most likely take, regarding the snake, in each of the following scenarios.	*BehaviorInt*†
To what extent do you support each of the following management strategies for rattlesnakes in Connecticut?	*SuportMan*†
Please indicate whether each statement [about rattlesnake experiences] applies to you.	*Experience*††
Before receiving this survey, were you aware of the potential presence of rattlesnakes in your neighborhood?	*Awareness**
To what extent do you agree or disagree with the following statements about rattlesnakes in Connecticut?	*EcoRole**
To the best of your knowledge, which of the following factors may contribute to the overall decline of rattlesnake populations in Connecticut?	*ThreatKnow**
To what extent do you believe that you are personally at risk from rattlesnakes near your home?	*RiskPer***
Please select the scenario that best represents, in your opinion, the ideal rattlesnake population in your local area.	*IdealPop***
To what extent to you agree or disagree with each of the following statements [about wildlife]?	*Mutualism** *Domination****
Approximately how many years have you lived at your current address?	*ResTenure*^^
For the address where you received the survey, please indicate the number of children under the age of 18 currently living there. [Changed to a binary variable based on presence/absence children under the age of 12.]	*Children*^^
Do you have a pet that spends time outside?	*Pets*^^
Are you male or female?	*Sex*^^
In what year were you born?	*Age*^^
What is the highest level of formal education that you have completed?	*Education*^^

Table 2.2. Sample characteristics for variables expected to influence respondents' attitudes toward timber rattlesnakes in their area.

Variable	*n*	Descriptive results
Demographics		
Age (Mean ± SD)	572	56.03 ± 13.76
Female (%)	588	53.6
Residential tenure (Mean ± SD)	580	20.41 ± 14.14
Children (< 18 years old) present (%)	556	40.6
Outdoor pet present (%)	589	52.8
Education (%)	583	
Less than high school		0.7
High school grad. or equivalent		7
Vocational or trade school		2.6
Some college		8.1
College degree (2-year or certificate)		8.9
College degree (Bachelor's)		31.6
Graduate or professional degree		41.2
General relationship with wildlife (scale 1 to 5)	591	
Mutualism score (Mean ± SD)		3.61 ± 0.83
Domination score (Mean ± SD)		2.63 ± 0.67
Coexistence attitude Score (Mean ± SD; scale 8 to 40)	591	24.05 ± 8.59
Concerns attitude score (Mean ± SD; scale 4 to 20)	591	8.70 ± 3.53
Aware of timber rattlesnakes in area (%)	564	93.3
Knowledge of timber rattlesnakes (Mean ± SD; scale 4 to 20)	591	15.12 ± 2.65
Knowledge of current threats to CT timber rattlesnakes (Mean ± SD; scale 0 to 6)	591	2.93 ± 1.71
Encountered timber rattlesnake on property (%)	587	24.9
Experiences related to timber rattlesnakes (Mean ± SD; scale 0 to 7)	592	2.34 ± 1.42
Ideal timber rattlesnake population (%)	580	
No rattlesnakes		11.4
Population risks extinction, sightings are rare		10.7
Small and isolated population, occasional sightings		64.1
Healthy and abundant populations, frequent sightings		13.8
Risk perception toward timber rattlesnakes (%)	585	
I am at great risk		1.9
I am at some risk		13.2
I am at a slight risk		44.4
I am at no risk		34.4
Unsure		6.2

Table 2.3. Regression model for attitudes toward timber rattlesnakes in Connecticut, as defined by the *Coexistence* and the *Concerns* attitude variables[a, b] (*n* = 591)

	Coexistence attitude variable[b]			*Concerns* attitude variable[c]		
Variable	Standardized Coefficients *β*	*t*	*Eta*	Standardized Coefficients *β*	*t*	*Eta*
Domination score	-0.055	-0.144		0.39	2.275*	0.431
Mutualism score	1.42	3.711*	0.574	-0.424	-2.449*	0.622
Awareness of timber rattlesnakes	1.704	1.626		-0.726	-1.531	
Experiences related to timber rattlesnakes	0.631	3.324*	0.215	-0.094	-1.091	
Knowledge of timber rattlesnake role in the ecosystem	1.172	10.634*	0.612	-0.399	-8.009*	0.58
Risk perception	2.948	8.196*	0.383	-1.295	-7.959*	0.39
Ideal population of timber rattlesnakes	3.383	9.830*	0.548	-1.196	-7.684*	0.485
Knowledge of threats to timber rattlesnakes	0.118	0.722		-0.197	-2.675*	0.382
Residential tenure	0.012	0.427		-0.013	-1.022	
Children present	-0.024	-0.037		-0.208	-0.718	
Outdoor pet present	-0.688	-1.296		0.144	0.601	
Gender	-1.242	-2.389*	0.156	-0.067	-0.272	
Age	-0.014	-0.469		0.014	1.008	
Education	-0.124	-0.767		0.063	0.862	

[a] Standardized coefficients reported. An (*) denotes $p < 0.05$.

[b] $R^2 = 0.568$, Adjusted $R^2 = .556$, $F = 46.874$, $p < 0.001$

[c] $R^2 = 0.478$, Adjusted $R^2 = .463$, $F = 32.791$, $p < 0.001$

Table 2.4. Bivariate analysis for reported behavioral intentions for timber rattlesnake encounter scenarios [a]

		You find a rattlesnake on your property	*You find an unidentified snake on your property*	*You see a rattlesnake crossing a road near your home*	*A rattlesnake threatens a pet in your neighbor-hood*	*A rattlesnake threatens a child in your neighbor-hood*	*You see a rattlesnake on a trail near your home*	*Your neighbor asks you for assistance with a rattlesnake on their property*
Attitude	χ^2	326.711*	283.363*	259.683*	322.479*	237.711*	187.776	230.104*
	Cramer's *V*	0.375	0.355	0.338	0.378	0.327		0.319
Knowledge	χ^2	267.232*	146.251*	179.436*	158.154*	123.001*	289.360*	215.610*
	Cramer's *V*	0.339	0.255	0.281	0.265	0.235	0.352	0.309
Experience	χ^2	41.465*	30.546	35.239	33.963	45.526*	30.305	40.092
	Cramer's *V*	0.133				0.143		
Risk Perception	χ^2	42.426*	35.912*	44.048*	38.201*	27.9*	41.318*	30.341*
	Cramer's *V*	0.135	0.127	0.139	0.13	0.112	0.133	0.116
Ideal Population	χ^2	82.478*	45.092*	60.402*	69.413*	45.897*	56.553*	48.515*
	Cramer's *V*	0.218	0.164	0.189	0.203	0.167	0.181	0.17
Mutualism	χ^2	578.459*	500.554	518.858	443.598	469.892	474.025	507.423
	Cramer's *V*	0.504						
Domination	χ^2	265.265*	304.663	271.258*	227.401	245.76	198.445	249.095
	Cramer's *V*	0.341		0.35				
Residential Tenure	χ^2	305.775	416.036*	356.171*	339.717*	304.638	341.377*	313.642
	Cramer's *V*		0.435	0.4	0.392		0.386	
Outdoor Pet	*F*	0.001	0.089	0.534	0.286	3.562	0.073	0.136
Children	*F*	5.380*	0.503	0.24	0.923	6.7*	0.131	7.030*
	Eta	0.099				0.113		0.115

An asterisk (*) indicates significance at the 95% confidence level ($\alpha = 0.05$ level).

[a]Behavior response options: Do nothing, call local rattlesnake volunteer, call CT DEEP, call Animal Control or Police, or kill snake (Attempt to move snake option was removed because of low number of respondents

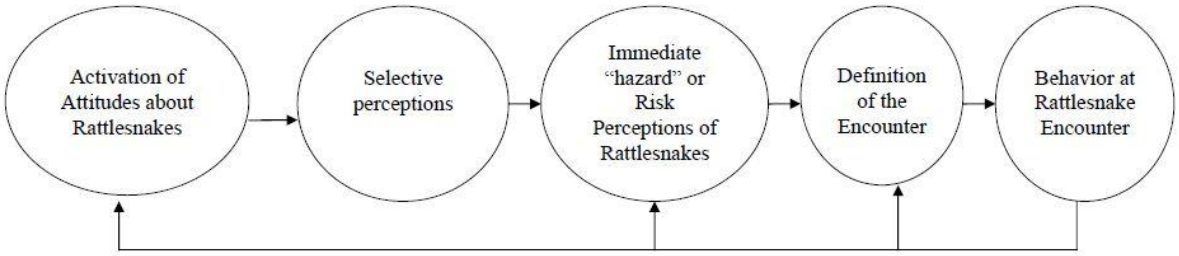

Figure 2.1. Conceptual model of human behavior toward rattlesnakes in an unplanned encounter (Christoffel, 2007)

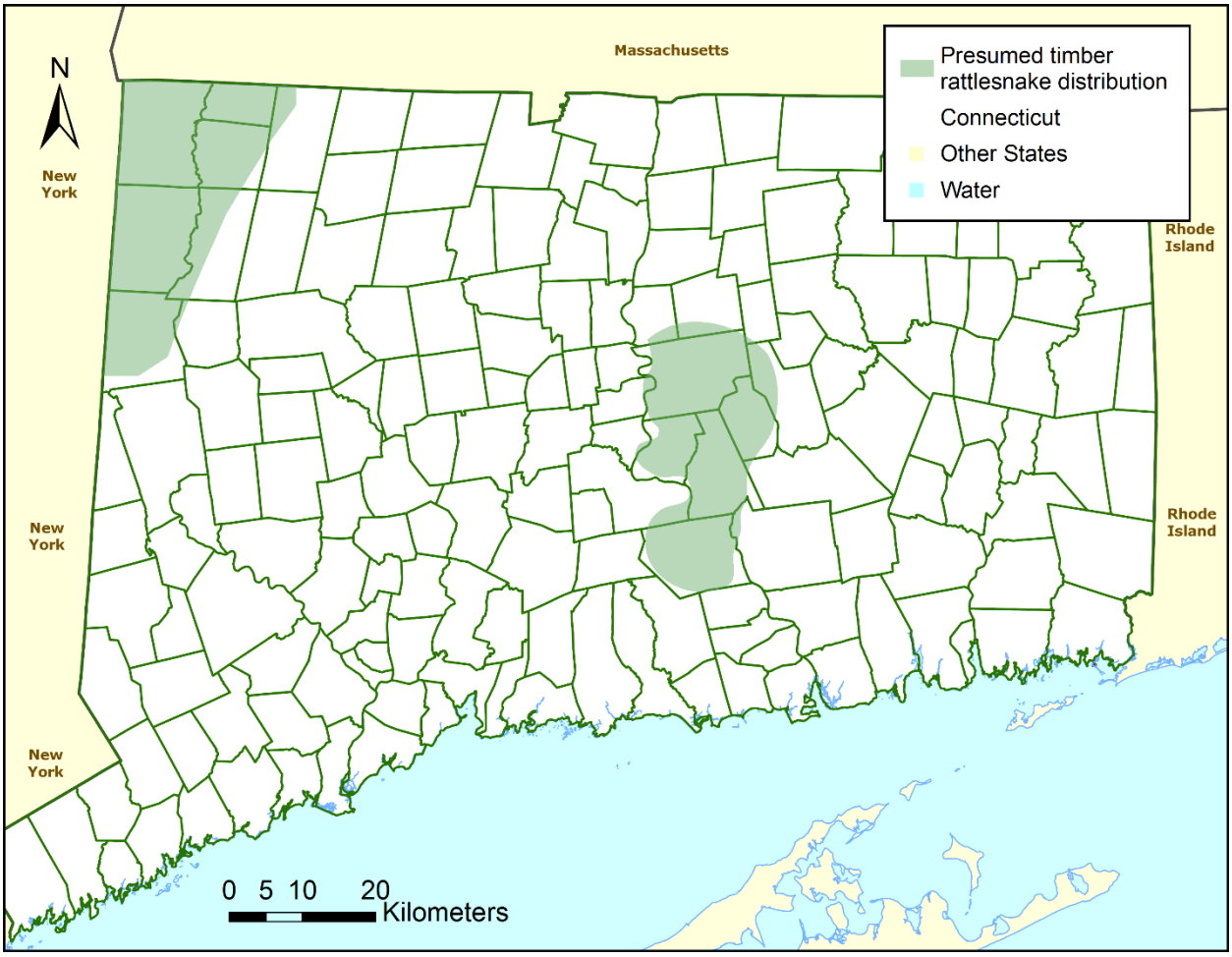

Figure 2.2. General estimated timber rattlesnake (*Crotalus horridus*) distribution in Connecticut (CT DEEP, 2015).

Chapter 3: Spatial Distribution of Attitudes Toward Timber Rattlesnakes (*Crotalus horridus*) in Central Connecticut

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Abstract

The largely exurban landscape of Connecticut can create unique challenges for wildlife management due to high densities of people and wildlife living in close proximity. This is particularly true for species sometimes perceived as uncharismatic or dangerous, such as the timber rattlesnake (*Crotalus horridus*). Timber rattlesnakes are endangered in Connecticut, and factors contributing to rattlesnake declines include habitat loss, roadway mortalities, poaching, and intentional killings. Challenges to creating effective rattlesnake management exist because there is currently little information about human attitudes toward rattlesnakes and local human encounters with the species. Objectives of this research were to evaluate: 1) the spatial patterns of attitudes toward timber rattlesnakes, in relation to rattlesnake habitat, and 2) the relationship between attitudes and landscape characteristics. A mail survey ($n = 593$) was used to collect data from residents who live near a rattlesnake population in central Connecticut. The main attitude variable that emerged focused on existence value of the species. Spatial analyses revealed significant clustering of this variable across the study area landscape, but a lack of a strong connection to landscape variables applied in analysis. Additional research is necessary to determine the underlying causes of attitude clusters, but knowledge of attitude cluster locations will aid wildlife managers in creating localized management and targeted outreach strategies aimed at reducing rattlesnake mortalities across their geographic range.

Key Words: timber rattlesnakes, Connecticut, mail survey, attitudes, hotspot analysis

Introduction

As the world becomes increasingly urbanized, humans and wildlife often share common space and resources (DeStefano & DeGraaf, 2003; Vitousek, 1997). This is particularly true in landscapes defined as wildland-urban interface (WUI), in which human development is adjacent to or intermingled with natural, undeveloped areas (Bar-Massada, Radeloff, & Stewart, 2014; Radeloff et al., 2005). Within these landscapes, potential for human-wildlife encounters and conflict exists because anthropogenic areas are intermixed with wildlife habitat (Carr & Burgeuess, 2004; Decker & Gavin, 1987; DeStefano & DeGraaf, 2003; Kretser, Curtis, & Knuth, 2009; Organ & Ellingwood, 2000; Warren, 1997).

Contributing to this conflict are human-wildlife encounters when wildlife include developed areas within their habitat (Dunning, Danielson, & Pulliam, 1992; Evans, Rittenhouse, Hawley, & Rego, 2017; Way, Ortega, & Strauss, 2004). In such instances, habitat may include residential yards, which can be landscaped in a way that actually attracts wildlife closer to humans (Belaire, Westphal, & Minor, 2016; Morzillo & Schwartz, 2011). Conflict may even arise from the mere presence of certain species and, therefore, the potential for an undesired encounter (e.g., low or no tolerance for the presence of particular species; Evans, 2014; Morzillo, de Beurs, & Martin-Mikle, 2014). Recent research suggests that residents of WUI and urban landscapes are increasingly seeking out information about wildlife or assistance with actual wildlife encounters (Lindsey & Adams, 2006; McCance et al., 2017). These trends highlight the importance of landscape-level research on human-wildlife interactions and its application to wildlife management and conflict mitigation in WUI areas (Chapron et al., 2014; McCance et al., 2017; Messmer, 2000).

Much of the current literature on human-wildlife conflict at the landscape level focuses on mammalian carnivore species that utilize large tracts of land (i.e., Gompper, 2002; Kretser et al., 2009; Naughton-Treves, Grossberg, & Treves, 2003; Siemer, Hart, Decker, & Shanahan, 2009; Treves et al., 2004). For example, Riley & Decker (2000) used the results of a mail survey to compare perceptions of current cougar population trends in Montana with actual cougar densities in each region. Similarly, Piédallu et al. (2016) evaluated county-specific factors that influence attitudes toward brown bears in the Pyrenees. Elsewhere, Morzillo, Mertig, Garner, & Liu (2007) found clustering in attitudes regarding management techniques for black bear populations in eastern Texas. Morzillo & Schwartz (2011) identified clusters of rodent control product usage affiliated with low-density development areas near open space. Carter, Riley, Shortridge, Shrestha, & Liu (2013) identified linkages between clusters of attitudes toward tigers in Nepal and socioeconomic factors, such as social caste status and level of education attained. Elsewhere, Sponarski, Semeniuk, Glikman, Bath, & Musiani (2013) examined the variation in rural residents' perceptions of wolves in Canada, in an effort to dispel the misconception of homogeneity in rural residents' attitudes. Treves et al. (2004) created human-wolf conflict predictive maps to compare affected and unaffected towns and determine influencing landscape variables. Most recently, Behr, Ozgul, & Cozzi (2017) used social survey data and a habitat suitability map to identify areas that were both ecologically and socially suitable for wolves in Switzerland.

Fewer studies have focused on variations in the spatial distribution of human dimensions data in association with wildlife across small spatial scales, such as the town or neighborhood level. Meanwhile, human decision-making regarding wildlife and influencing factors such as attitudes and beliefs (Fulton, Manfredo, & Lipscomb, 1996) can exhibit variation across different

spatial scales (Harris et al., 2012; Morzillo et al., 2016). Therefore, understanding of small-scale integrated ecological and social data can be particularly useful for effective management of a species with a relatively small home range. Ultimately, small-scale decisions can influence the success of certain management actions, which may not transfer effectively across different scales (Bright, Manfredo, & Fulton, 2000; Liordos, Kontsiotis, Anastasiadou, & Karavasias, 2017; Liordos, Kontsiotis, Georgari, Baltzi, & Baltzi, 2017).

Our research contributes to gaps in knowledge about the spatial distribution of human attitudes toward wildlife, particularly for a small spatial scale and for attitudes toward a herpetofauna species -- both currently understudied topics. Specifically, we focused on human attitudes toward a local timber rattlesnake (*Crotalus horridus*) population, a herpetofauna species that utilizes relatively small patches of the landscape compared to other predator species. Our objectives were to: (1) evaluate the spatial patterns of attitudes toward timber rattlesnakes, and (2) evaluate the relationship between attitudes toward rattlesnakes and landscape characteristics. To address our objectives, we used social survey data to describe patterns in the spatial distribution of human attitudes toward rattlesnakes, and explored relationships among attitudes and landscape variables (distance from the state forest and property parcel size). Predicting specific areas where conflict may occur can allow for more efficient resource allocation for species and habitat management (Carter et al., 2013; Treves et al., 2004). This research will help guide management strategies that factor in the spatial heterogeneity that exists in human attitudes and the landscape of focus.

Methods

Background Context and Study Area

Timber rattlesnake populations in the northeastern US have drastically decreased since colonial times largely due to anthropogenic activities (Brown, Jones, & Stechert, 1994; Fritsch II, 1992). Much of the decline in the late 20th century may be attributed to government bounties on dead rattlesnakes, a practice that continued into the early 1970's in several New England states (Blodgett, Talmage, & Andrews, 2015; Martin, Brown, Possardt, & Sealy, 2008). Other contributing factors include habitat loss, disease, roadway mortalities, poaching, and intentional human killings (Clark, Marchand, Clifford, Stechert, & Stephens, 2011; Martin et al., 2008). Furthermore, timber rattlesnake ecology and life history strategies (e.g., long-lived, slow to reach reproductive age) make them particularly susceptible to human impacts. For instance, population turnover is slow and the loss of adult individuals can greatly influence overall population numbers (Brown, 1991; Brown et al., 1994; Martin et al., 2008). In Connecticut, our focus for this study, timber rattlesnakes have been reduced to only two isolated populations, one in the northwest corner and one in the center of the state (Fritsch II, 1992; Martin et al., 2008).

Our study area included two towns in central Connecticut where there are a number of human-rattlesnake encounters annually as individual rattlesnakes venture across roadways and private properties during summer foraging and mating activates (J. Dickson, Connecticut Department of Energy and Environmental Protection [DEEP], November 2015, personal communication). The area is generally classified as WUI, with 62% of the area classified as the intermix category (Mockrin & Radeloff, 2017). This focal region was predominantly rural until the early 1980's, during which the rate of development began to increase rapidly in association with the expanding finance industry in a nearby city (Winslow, 1987). Much of the residential

development since 1985 has been clustered in areas adjacent to timber rattlesnake habitat (CLEAR, 2006). The two towns within our study area experienced a 121% and 169% increase in housing units from 1970-2010 (Data source: 1980 Census of Population and 2010 Census of Population and Housing; United States Census Bureau). Accompanying changes in land cover proportions from 1985-2006 show large increases in developed and turf/grass land cover and large decreases in agricultural land cover, with smaller decreases in deciduous and coniferous forests (<10% each), suggesting a conversion from agricultural lands to developed areas (CLEAR, 2006). Land ownership is a mix of state forest, town- and state-owned public lands, with interspersed residential areas.

We defined our study area and study population based on the estimated range of the central Connecticut timber rattlesnake population, and all human residences that occurred within that estimated range. The study extent was demarcated by a 4-km radius circle (total area = 50.3 km^2). This radius length was based on previous research that found timber rattlesnakes in Massachusetts moved a maximum straight-line distance of about one to three km from a den site during their summer foraging and mating activities (Tyning, 2005). We confirmed that our study extent included residences most likely to experience rattlesnake encounters, based on long-term recording of human-rattlesnake encounter locations (D. Fraser, Siena College, April 2016, personal communication). This sampling design allowed us to focus on residents with "accessible" attitudes; i.e., those who are most likely to have experienced an encounter with a timber rattlesnake (McCleery, Ditton, Sell, & Lopez 2006).

Data Collection

We used a mail survey to collect data from a sample of residents in our study area. We acquired a random sample of households (n = 1,500) from Marketing Systems Group (Horsham, PA), which uses postal delivery routes to construct samples. The sampling frame was defined as the list of residences within the specified study area (see previous section; approximately 3,600 households total), and the sampling unit was the individual household. Sample size was based on the desired number of completed surveys and desired sampling error of $\alpha = 0.05$ (95% confidence interval; Sheskin, 1985).

We used a modified version of Dillman's Tailored Design Method for mail surveys in an effort to increase response rate (Dillman, Smyth, & Christian, 2008). Survey materials were mailed in June 2016, in the following order: (1) a pre-notice postcard introducing the project and the researchers, (2) a survey booklet with a cover letter, (3) a reminder postcard, and (4) a second mailing of survey booklet with a cover letter to those who did not send back the survey after the first mailing (Dillman et al., 2008). A non-response follow-up survey was completed using door-to-door canvassing between September and October 2016. The follow-up survey focused on the reason for non-response and ten key items from the original survey. We randomly selected and surveyed 10% of our total non-respondents (n = 91 completed non-response surveys).

Variables

Attitudes toward timber rattlesnakes (dependent variable)

Human attitudes toward rattlesnakes can be influenced by a variety of factors and can affect behaviors in a human-rattlesnake encounter (Christoffel, 2007; Fulton et al., 1996). Conceptually, attitudes toward herpetofauna are derived from an array of socio-psychological

and experiential variables (Ceríaco, 2012; Christoffel, 2007; Hartel, Carlton, & Prokopy, 2015; Öhman & Mineka, 2003; Raymond & Schneider, 2014; Zinn & Pierce, 2002). Therefore, we hypothesized that such variables may also contribute to attitudes toward rattlesnakes, as has been found regarding other species (Carter et al., 2013; Kretser et al., 2009; Morzillo et al., 2007b). To define our dependent variable, attitudes toward timber rattlesnakes were quantified by asking study participants to indicate level of agreement, on a 5-point Likert scale (5= strongly agree, 4= somewhat agree, 3= unsure, 2= somewhat disagree, 1=strongly disagree), to twelve attitude-based belief statements about rattlesnakes (modified from Christoffel 2007). We used principal component analysis (PCA) with varimax rotation to assign statements to components based on the items that factored together in construction of scale scores. We used Cronbach's alpha (α; Cortina, 1993) to measure internal reliability of the combinations of these statements. An attitude scale score for each study participant was derived by summing the values of responses to each statement item. Eight statement items were used to create a scale score for the attitude variable (n = 591; α = 0.915): (a) I am personally interested in rattlesnakes, (b) I would enjoy seeing a rattlesnake in the wild, (c) even if I never see one, I enjoy just knowing that rattlesnakes exist, (d) if I knew that a rattlesnake lived near my home, it would decrease my enjoyment of living there, (e) I take pride in knowing that rattlesnakes live near my home, (f) I would be less likely to have a rattlesnake relocated from my property if I knew that it may not survive as a result, (g) rattlesnakes pose an unacceptable threat to pets, and (h) rattlesnakes pose an unacceptable threat to children. Individual values for this attitude variable ranged between 8-40, with a higher score indicating a more favorable attitude. A positive attitude toward timber rattlesnakes, as defined by the belief statements that formed this variable, represented the general theme of agreeable human-rattlesnake coexistence. All statistical analyses were completed in SPSS (SPSS, Inc.,

version 24.0; Chicago, Illinois). Alpha values were defined at the 95% confidence interval ($\alpha = 0.05$) for all analyses.

Landscape Variables

Proximity to rattlesnake habitat and property parcel size may influence respondents' attitudes toward timber rattlesnakes, due to increased familiarity and personal experiences (Christoffel, 2007; Morzillo et al., 2007b; Siemer et al., 2009). We hypothesized that attitudes toward timber rattlesnakes would be influenced by landscape factors, such as parcel size and proximity to rattlesnake habitat. Some mammalian research has linked proximity to habitat with more negative attitudes (e.g., wolves, Ericsson & Heberlein, 2003; Karlsson & Sjöström, 2007; Williams, Ericsson, & Heberlein, 2002; prairie dogs, Zinn & Andelt, 1999) and less support for certain management strategies (Morzillo et al., 2007b). However, we expected that proximity to rattlesnake habitat may be linked to more favorable attitudes based on increased familiarity and personal experiences, and a more reasonable perception of risk. For example, Reimer et al. (2014) found that increased familiarity with the eastern hellbender contributed to favorable attitudes toward the species. Elsewhere, and Christoffel (2007) found that the belief that one lived near rattlesnake habitat contributed to positive attitudes toward the species. Additionally, parcel size has been found to be associated with landowner behaviors regarding property maintenance; specifically large parcels were found to have a large proportion of natural landscape and woodland areas (Nassauer et al., 2014). Larger parcels also may include a larger proportion of potential wildlife habitat.

We evaluated relationships between the attitude variable and two landscape variables: 1) distance of the residence from the state forest (rattlesnake habitat) and, 2) property parcel size. We used the Near tool in ArcMap (ArcGIS, version 10.3.1) to calculate the distance from each respondent's address to the closest edge of the polygon that represented the area covered by the state forest within our study area (i.e., location of rattlesnake foraging area and den sites). To calculate parcel area, we used a spatial join to connect a parcel data polygon layer (total number of matched parcels = 573) to the attitude scores point layer. We then calculated the area of each parcel in meters squared (m^2). We used SPSS to calculate the Spearman's ranked correlation between attitudes, distance from state forest (m), and property parcel area (m^2) (Sokal & Rohlf, 1995), in order to identify any relationship between attitudes and these landscape variables. We used this nonparametric correlation test because the landscape variable data were not normally distributed.

Spatial analysis

We hypothesized that the spatial distribution of attitudes toward timber rattlesnakes would exhibit a non-random pattern. Past research suggests clustering in attitudes exists related to wildlife. For example, Carter et al. (2013) found that clusters of positive or negative attitudes toward tigers were connected to sociodemographic and cultural variables. We used ArcMap to evaluate the spatial distribution of attitudes following methods adapted from Carter et al. (2013) and Morzillo & Schwartz (2011). First, we defined the distance at which the maximum autocorrelation of attitude variable scores occurs. This is the distance from a single point, at which nearby points are most similar in value. To identify this distance, we set the ArcMap

Incremental Spatial Autocorrelation tool to run 20 iterations, at 50 m increments, starting at 650 m. The use of a defined distance band interval allowed us to account for the tendency of households in exurban and suburban areas to be clustered into neighborhoods, and conduct the analysis at scale that is relevant to our attitude variable (Morzillo & Schwartz, 2011). The maximum spatial autocorrelation for the attitude variable occurred at 1,100 m (z-score = 3.292, p < 0.000). We calculated the global Moran's *I* statistic, with an assumption of randomness, to determine spatial autocorrelation (Fixed Distance Band method; distance band= 1,100 m; Moran, 1950; Morzillo & Schwartz, 2011). Results of the Moran's *I* test indicated that values for the attitude variable were significantly clustered among respondents in our study area (*I*= 0.0316, *z* score= 4.849, *P*< 0.0001).

Once the Moran's *I* statistic confirmed clustered data, we used a Getis-Ord (Gi*) Hotspot Analysis (Getis & Ord, 1992) to identify significant clustering of high or low values of the attitude variable. Gi* is a local statistic used to identify locations of clusters and whether they are of high values or low values It is recommended that *G(d)* statistics be used in conjunction with *I(d)* statistics (Getis & Ord, 1992).

We also evaluated spatial distribution of attitudes in terms of proximity to where human-rattlesnake encounters are most likely to actually occur. In Connecticut, there are no recent formal population studies or long-term monitoring of individual snake movements. Therefore, we used data from three sources to estimate where rattlesnakes are moving outside of the central forested area and encountering people: a list of addresses compiled by DEEP, our mail survey results, and 2016 reported rattlesnake encounters (Unpublished data, D. Fraser, 2016). First, we compiled data points from a list of "high-priority" street addresses, based on human-rattlesnake encounters, once used by DEEP to mail letters alerting residents of rattlesnake presence. Second,

we included locations of all survey respondents who indicated a confirmed rattlesnake encounter on their property (*n*= 118), based on responses to a survey question regarding rattlesnake encounters: *Have you encountered a snake you believed was a rattlesnake on your property?*, and *Was this snake confirmed to be a rattlesnake?*. Finally, the third source of data points were from a list of all reported rattlesnake encounters on private property in 2016 (*n*= 6, after removing duplicate points with the survey results encounter data). This information was compiled by a local individual who organizes volunteers to respond to calls from residents about rattlesnake encounters. We used the ArcMap Integrate and Collect Events tools to aggregate and display encounter events that occurred within a certain distance (75 m) of each other, based upon the general spacing of housing units in this area. We then compared the compiled group of encounter events to attitude hotspot locations (described above) to visually assess where humans encountered rattlesnakes, and associated human attitudes and behaviors toward rattlesnakes. GIS layers representing all state protected land (Data source: DEEP, www.ct.gov/deep, 2010, "Connecticut DEEP Property") and protected open space patches (Data source: DEEP, www.ct.gov/deep, 2011, "Protected Open Space") were clipped to the study area to assess gaps in protected land where rattlesnakes are moving and encountering humans.

Results

Sample characteristics

We received completed surveys from 595 residents (39.7% response rate). Two surveys received after completion of the non-response follow-up survey were removed from analysis (*n* =

593). Approximately 54% of respondents were female; average age was 56 years old (Table 1). The gender ratio of respondents is representative of the area (American Community Survey [ACS], 2015). However, given that the median age for applicable census tracts is 44 years old, with 78% of population reported as 18 years or older (ACS, 2015), and the mean respondent age from our non-response survey was 51 years old, our average age is likely higher than the actual average adult age. Respondents have lived at their current address for 20 years, on average; 31% of respondents have lived at their current address for less than 10 years. Our study area appeared to be experiencing an above average turnover of residents, as indicated by home sales (B. DiLoreto, GRI, ABRIM, January 2017, personal communication). Among respondents, the reported highest level of education obtained was a bachelor's degree (32%) and a graduate or professional degree (41%). Amount of formal education completed was slightly greater for our respondents than the average resident, as sixty-three percent of residents in the three applicable census tracts have attained a bachelor's degree or greater (ACS, 2015). Among those who completed non-response surveys (n = 91), the most common response for non-response was never having received or did not recall receiving the survey (40%).

Attitudes Toward Timber Rattlesnakes

The average scale score of the attitude variable was 24.05 (SD = ±8.59; range = 8-40). The distribution of attitudes scores was normal, with a kurtosis value of -0.987. There was an inverse relationship between the attitude variable and distance of the respondent's property from the closest perimeter of the state forest (Spearman's rho= -0.105, $p < 0.05$; Table 2). However, a scatter plot of these two variables showed no discernable relationship. Therefore, our results do

not support our hypothesis that attitudes toward timber rattlesnakes are influenced by the landscape variables (i.e., distance from a state forest and property parcel size) considered in this analysis.

Spatial Distribution of Attitudes

Results supported our hypothesis of a non-random distribution of attitudes toward timber rattlesnakes. Local Gi* statistic values showed three significant clusters of attitudes toward rattlesnakes ($p < 0.05$). We identified one cluster of more favorable attitudes (i.e., high attitude variable scores; hereafter "positive attitude hotspot") in the northwest region of our study area and two clusters of unfavorable attitudes (i.e., low attitude variable scores; hereafter "negative attitude hotspot) in the west and southeast regions of our study area. Results from aggregating human-rattlesnake encounter locations suggested that most reported encounters occurred in the north-northwest portion of our study area.

Discussion

Human-wildlife conflict is at the forefront of wildlife management in areas where human development is intermixed with natural areas (McCance et al., 2017). Researchers are increasingly taking a landscape approach to mitigate such conflicts (i.e., Kretser et al., 2009; Kretser, Sullivan, & Knuth, 2008; Treves et al., 2004). However, to date, use of this approach has largely focused on charismatic megafauna with extensive home range areas. We applied this technique toward human conflict with a species of small body size occupying a relatively small

area adjacent to human residential areas, in order to evaluate spatial patterns of attitudes toward timber rattlesnakes. Results indicated spatial clustering of attitudes toward timber rattlesnakes within our study area; specifically we identified one hotspot of more favorable attitudes toward timber rattlesnakes and two hotspots of less favorable attitudes. The first part of this discussion is structured around three potential reasons for clustering of attitudes: (1) similarity in shared information and perceptions related to rattlesnakes, (2) similarity in terms of experiences, awareness levels, and/or knowledge levels related to timber rattlesnakes, or (3) similarity in residential tenure. In exploring these ideas, we grouped study participants by attitude hotspot location: residents within the more favorable attitudes cluster (favorable hotspot), residents within the less favorable attitude clusters (adverse hotspot), and those not in an attitude hotspot.

First, it is possible that neighbors are sharing information and perceptions with each other about the local rattlesnake population. Researchers have suggested that more negative attitudes toward wolves from residents proximate to wolf territories in Sweden may be connected to indirect experiences related to wolves, such as media and discussions with friends, rather than direct experiences (Karlsson & Sjöström, 2007). Indirect experiences related to rattlesnakes may also be influencing attitudes as a result of social contagion, the spread of ideas or behaviors due to peer influence. Social contagion effects have been researched extensively regarding lawn and property manipulation (i.e., landscaping); landscaping decision-making may be partially influenced by other individuals, such as a trusted member of one's social network (Turner, Jarden, & Jefferson, 2016), as well as by group factors, such as cultural and social norms (Heberlein, 2012; Nassauer, Wang, & Dayrell, 2009). In addition to contributing to mimicry of physical property characteristics (Belaire et al., 2016; Grove et al., 2006; Hunter & Brown, 2012; Nassauer et al., 2009), social norms may impact environmental behaviors, such as reductions in

energy consumption, in what has been called a "norm-to-conform" phenomena (Ayres, Raseman, & Shih, 2013; Costa & Kahn, 2013). It is possible that a small-scale social contagion effect is occurring within our study area when it comes to transfer of information about rattlesnakes.

Many of the locations identified within the favorable attitude cluster overlap with streets that were targeted for mailed rattlesnake information (1980's-2008). Thus, it is possible that residents who received rattlesnake information at that time either shared or discussed it with neighbors. While some anecdotal evidence does indicate that residents in this area are discussing rattlesnakes with neighbors, friends, and family (author unpublished data), there was no difference in how respondents in each hotspot category responded to the following survey question: "were you aware of the potential presence of rattlesnakes in your neighborhood when you moved into your home at this address?" (response options: "yes, from real estate agent or property deed", "yes, from builder/contractor/developer", "yes, from another source", "no"). However, 49% of *all* respondents chose the response option, "yes, from another source". Many of these respondents included a write-in answer indicating that they learned about rattlesnakes from neighbors or general word-of-mouth. Additional information regarding precisely how and from whom residents are learning about this timber rattlesnakes may benefit management in this area.

Second, residents within positive and negative attitude clusters may share a similar level of rattlesnake experiences, level of awareness of rattlesnake presence, and/or knowledge related to timber rattlesnakes. Familiarity (i.e., awareness and knowledge of rattlesnakes) and positive direct experiences with a species have been shown to impact attitudes toward that species and support for particular management strategies (Ballouard, Provost, Barré, & Bonnet, 2012; Christoffel, 2007; Hartel et al., 2015; Reimer et al., 2014). Using the same groupings as above

(favorable hotspot, adverse hotspot, no hotspot), we compared levels of awareness and rattlesnake encounters among the groups. Similar to the findings of Christoffel (2007), we found that a greater proportion of residents within the adverse attitude hotspots (as compared to favorable hotspots) indicated they were unaware of rattlesnakes in the area when they moved into their current address (Table 3). A greater proportion of residents in the adverse attitude hotspot also indicated that they were unaware of the potential presence of rattlesnakes in their neighborhood before receiving the mail survey (Table 3). Likewise, a greater proportion of people in favorable hotspots reported encountering a rattlesnake on their property compared to respondents in adverse hotspots (Table 3). It is possible that residents who live closer to the forested patch (e.g., rattlesnake habitat) have encountered a higher proportion of timber rattlesnakes, and hold more favorable attitudes toward the species. Although our results did not provide evidence that the residence distance from the forest affects attitudes, this may be because residents did not appear to encounter rattlesnakes equally around the entire forest perimeter (more encounters occurred on the north-northwest edges of the forest).

Finally, it is possible that residents in these clusters have lived at their current address for a similar length of time. Morzillo, Mertig, Garner, & Liu (2007a) found that residents who were newer to their current address held more favorable attitudes toward black bears in eastern Texas. Elsewhere, Reimer et al. (2014) found that increased familiarity with a species contributed to more positive attitudes toward that species. In 1985, timber rattlesnakes became a state-listed protected species in Connecticut and rattlesnake presence was required to be noted in property deeds in certain areas. Consequently, it has been suggested that residents who moved to this area prior to 1985 may not have been notified of rattlesnake presence (T. Mocko, 2017, personal communication). However, our survey results suggested that a greater proportion of respondents

with lesser residential tenure (≤ 10 years) indicated that they were *not* aware of the potential presence of timber rattlesnakes when they moved to their current address, versus residents of greater residential tenure. Although clustering of residential tenure did occur among our respondents (Moran's *I*= 0.034, *z* score= 2.234, *p*-value = 0.0255), the cluster locations (two of newer residents; two of older residents) did not overlap with the attitude hotspots. Elsewhere in the project (see Chapter 2) residential tenure was not found to influence attitudes toward rattlesnakes (linear regression model; R^2=0.581; author unpublished data). However, relationships existed between residential tenure and behavioral intentions toward rattlesnakes in certain encounter scenarios (e.g., a rattlesnake threatening a pet in the neighborhood, and finding a rattlesnake on a trail near home; see Chapter 2).

Our analysis provides some insight into *why* attitudes toward wildlife cluster in certain areas, but additional in-depth analysis (i.e., interviews) of residents in the favorable attitude clusters is needed to further evaluate why residents in that cluster appear to be more tolerant. However, simply knowing *where* favorable versus adverse attitudes exist may be a necessary first step to help managers target certain areas for outreach actions, particularly at the neighborhood scale. Results of the above exploratory analyses suggested that residents within the adverse attitude clusters may be less aware of the presence of timber rattlesnakes (Table 3). For instance, some residents indicated learning about rattlesnakes in the area for the first time from our survey, and therefore possibly formed an attitude at that moment as influenced by the provision of information in the survey itself (Heberlein, 2012). Providing rattlesnake information or other customized outreach within these adverse hotspots could help mitigate desired management outcomes. In the past, the Connecticut DEEP Wildlife Division has mailed letters to certain locations in our study area to inform residents of the presence of timber rattlesnakes and

provide phone numbers to call in the event of a rattlesnake encounter. However, this management action was discontinued in 2008 for financial reasons. Thinking forward, our results show very specific areas that may most benefit from mailed information about recommended behaviors in the event of an unexpected rattlesnake encounter. In instances of adverse attitude clusters, intent may not be to change attitudes within these adverse attitude clusters, but rather influence human behavior (Heberlein, 2012). Mailed information that provides phone numbers to call in the event of an encounter simply makes it easier for residents – even those adverse to rattlesnakes - to choose a behavior that is congruent to species management goals. Additionally, it seems that information about the presence of timber rattlesnakes may not be reaching some of the new residents in this area. Wildlife managers can collaborate with town offices and local real estate agencies to better inform potential homebuyers in certain areas of the presence of endangered species and related legal expectations.

Our results also may help guide management strategies at the landscape scale by identifying areas where timber rattlesnakes are most at risk to human impacts. For a little-liked species, habitat connectivity and landscape matrix quality may be thought of in social terms, as well as physical terms (Behr et al., 2017); areas of more favorable attitudes could be relatively safer for rattlesnake movement than areas of adverse attitudes. In our study, we identified one area where clustered favorable attitudes intersect with an area of a high proportion of rattlesnake encounters. This location may be suitable for conservation strategies at the level of the private property, such as promoting benign or beneficial landowner behaviors toward rattlesnakes, and land protection in an attempt to connect fragmented patches of protected land that currently exists in this area.

There is evidence to suggest local support for rattlesnake conservation strategies that target private land. Approximately 27% of overall survey respondents (n = 152) indicated an interest in learning about how they can become involved with rattlesnake conservation in Connecticut. These residents could be engaged in conservation actions at the spatial scale at which rattlesnake movements are occurring. In this highly fragmented study area, rattlesnakes are utilizing residential lawns for movement and foraging habitat, which is not likely to change as development continues into the future. Small-scale landscape characteristics of individual yards may either attract (i.e., stonewalls) or deter (i.e., fences) timber rattlesnakes. Taking this into account, managers could encourage private property landscaping in a way that decreases the probability of attracting timber rattlesnakes to areas where they are more likely to encounter humans (e.g., adjacent to a house or building). If residents are interested in improving rattlesnake habitat connectivity via their property, opportunities exist for rattlesnake-friendly landscaping along the perimeter of yards and further away from the houses or other structures. This may work particularly well for the large property parcels that are prominent in this area. Future research could evaluate relationships among human factors and landscape variables in the same spatial scale as rattlesnake movements (i.e., presence of basking rocks, proportion of shaded areas).

Our research results illustrate the utility of evaluating the spatial distribution of human factors. In an exurban landscape where humans and rattlesnakes occupy the same spaces, knowledge of factors that impact human-rattlesnake interactions can help guide wildlife managers in creating more effective management strategies at both the neighborhood and landscape level.

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Table 3.1. Descriptive statistics for all survey respondents (*n*= 593).

Variable	Categories	Descriptive Results
Sex (% Female)		53.6
Age (Years)	Mean (SD)	56 (±13.8); range = 19-94
Education (%)	Less than high school	0.7
	High school graduate or equivalent	7.0
	Vocational or trade school	2.6
	Some college	8.1
	College degree (2-year or certificate)	8.9
	College degree (Bachelor's)	31.6
	Graduate or professional degree	41.2
Residential Tenure (years)	Mean (SD)	20 (±14.1); range = 0.08-70
Children	% households with children <18 years	40.5
Pets	% households with an outdoor pet	52.8

Table 3.2. Spearman's Ranked Correlation test among attitude variable and two landscape variables (distance to nearest perimeter of forest parcel (n = 578) and property parcel area (m^2 ; n = 573).

			Distance from Forest	Property Parcel Area (m^2)	Attitude Variable
Spearman's rho	Distance from Forest	Correlation Coefficient	1	-.151*	-.105*
	Property Parcel Area (m^2)	Correlation Coefficient	-.151*	1	0.041
	Attitude Variable	Correlation Coefficient	-.105*	0.041	1

An asterisk (*) indicates significance at the 95% confidence level ($\alpha = 0.05$).

Table 3.3. Variation in responses between respondents in the favorable (n = 116) versus adverse attitude toward rattlesnakes hotspots (n = 79).

	Chi-Square		Favorable Hotspot (%)	Adverse Hotspot (%)
Before receiving this survey, were you aware of the potential presence of rattlesnakes in your neighborhood?	8.285 *	No	6.0	19.5
		Yes	94.0	80.5
Were you aware of the potential presence of rattlesnakes in your neighborhood when you moved into your home at this address?	9.983 *	No	28.3	47.6
		Yes, from real estate agent or property deed	17.9	4.8
		Yes, from builder/ contractor/ developer	7.5	4.8
		Yes, from other source	46.2	42.9
Have you encountered a snake you believed was a rattlesnake on your property?	4.35 *	No	81.9	92.4
		Yes	18.1	7.6

An asterisk (*) indicates significance at the 95% confidence level ($\alpha = 0.05$).

Chapter 4: Management of a Venomous Snake in New England: Support among Connecticut residents for timber rattlesnake (*Crotalus horridus*) management strategies

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Abstract

The management of a species that is unpopular and often perceived as dangerous among humans can create unique challenges for wildlife professionals. This is particularly true in exurban areas, where human residences are often intermixed with wildlife habitat, intensifying the potential for human-wildlife interaction. In this study, objectives were to 1) evaluate resident support for regional rattlesnake management strategies implemented at the state or town level, and 2) explore the potential for two local timber rattlesnake management strategies: a) mailed informational outreach, and b) use of an anonymous hotline to report potential poaching activity. We used two separate mail surveys (n =593; n = 385) and a mailed outreach effort to collect data from residents near a Connecticut rattlesnake population in order to examine human factors related to support for timber rattlesnake management strategies. Results indicated that greater support for management is related to more favorable attitudes toward timber rattlesnakes. More passive management strategies, such as increased outreach and education, were the most strongly supported among study participants. Results from the mailed informational outreach effort and a follow-up survey showed that local residents appear generally amenable to receiving information about timber rattlesnakes; the majority indicated a willingness to use an anonymous hotline to report potential rattlesnake poaching activity. This study will guide local wildlife managers in creating future timber rattlesnake management strategies for this area, in an attempt to manage for persistent timber rattlesnake populations.

Key words: timber rattlesnake, mail survey, management, outreach, poaching

Introduction

Predator populations are declining worldwide, concurrent with global human population growth (Ceballos & Ehrlich, 2002; Morrison, Sechrest, Dinerstein, Wilcove, & Lamoreux, 2007; Ripple et al., 2014). Predator species are integral in shaping the structure of ecosystems, through prey-predator interactions and cascading top-down effects of predation (Berger, Stacey, Bellis, & Johnson, 2001; Terborgh et al., 2001). Regional losses of predator species can have dramatic effects on ecosystems, including increased prey populations, degradation of vegetation, or an alternative predator filling the ecological niche the lost species held (Berger et al., 2001; Gompper, 2002; Miller et al., 2001; B. J. Miller, Harlow, Harlow, Biggins, & Ripple, 2012). In addition to ecological impacts, changing predator populations have social impacts and implications for local human communities (Bangs et al., 1998; Gompper, 2002; Kellert, 1985). There has been extensive research on human-carnivore conflict and strategies to facilitate coexistence between humans and predators (e.g., Chapron et al., 2014; Hill, 2015; Karlsson & Sjöström, 2007; Kellert, 1985; Treves et al., 2004; Treves & Karanth, 2003). However, much of that research has focused on large charismatic megafauna (e.g., wolves, tigers, grizzly bears), with less emphasis on human interactions with smaller carnivorous species.

Timber rattlesnakes are among the few remaining apex predators in New England forests. Rattlesnake prey consists primarily of small mammals, such as white-footed mice (*Peromyscus leucopus*), deer mice (*P. maniculatus*), and eastern chipmunks (*Tamias striatus*) (Clark, 2002; Martin, Brown, Possardt, & Sealy, 2008). In addition to being important food sources, these rodent species are primarily responsible for infecting black-legged tick (*Ixodes scapularis*) larvae and nymphs with pathogens that cause tick-borne illnesses, such as Human babeosis or Lyme

disease (Hersh, Tibbetts, Ostfeld, & Keesing, 2012; F. Keesing et al., 2009). Timber rattlesnake consumption of these rodent vectors may contribute to a reduced number of pathways for transmission of Lyme disease to humans (Kabay, Caruso, & Lips, 2013). Maintaining an ecosystem's predator-prey balance and biodiversity may positively affect human health by reducing the spread of harmful pathogens (Keesing & Ostfeld, 2015).

Despite the important ecological role of this predator, timber rattlesnake populations have decreased in much of the Northeastern United States (US). Historically, the range of this species included all six New England states, and extended into Ontario (Martin et al., 2008; Palmer, 1946). Habitat loss and human impacts (including government-paid bounties, illegal collection, road mortalities, and intentional killings) have resulted in rattlesnake populations in the northeast becoming increasingly rare and fragmented (Brown, 1992; Fritsch II, 1992; Martin et al., 2008; Olson, MacGowan, Hamilton, Currylow, & Williams, 2015). Today, rattlesnakes are extinct in Maine and Rhode Island, and listed as endangered in the remaining four New England states. In New Hampshire, there is one known population that includes an estimated few dozen individuals (Clark, Marchand, Clifford, Stechert, & Stephens, 2011). Vermont and Connecticut each contain two isolated populations, and Massachusetts has four small populations (Bauder, Blodgett, Briggs, & Jenkins, 2011; Clark et al., 2011; Fritsch II, 1992; Tyning, 2005). In addition to anthropogenic impacts, northeastern rattlesnake populations are susceptible to disease due to lack of genetic diversity and changing climate (Clark et al., 2011).

Once population declines became apparent in the late 1970's, the timber rattlesnake became a state-protected species in five northeastern states in a span of thirteen years: Massachusetts (1979; endangered), New York (1983; threatened), New Hampshire (1987; endangered), Vermont (1987; endangered), and Connecticut (1992; endangered; Blodgett,

Talmage, & Andrews, 2015; Breish, 1992; Martin et al., 2008). Current management strategies vary by state, and include protection of land known to contain rattlesnake habitat, enhancement of the quality of and connectivity of habitat patches, and outreach to nearby residents (Blodgett et al., 2015; Breish, 1992; Fritsch II, 1992). However, a lack of information about human attitudes and encounters with timber rattlesnakes in these states make development and enforcement of such strategies difficult.

Conceptual background and context

Strategies exist for considering human factors (i.e., behaviors related to wildlife and support for management) when addressing management strategies for unpopular species that occur in close proximity to developed areas (Dickman, 2010; Gunnthorsdottir, 2001; Liordos, Kontsiotis, Anastasiadou, & Karavasias, 2017; Perry-Hill et al., 2014). One strategy involves the dissemination of positive and accurate information (e.g., through outreach and educational programming), in an attempt to influence human perceptions and behaviors in ways that lead to beneficial impacts for species management (Ballouard et al., 2013; Morgan & Gramann, 1989; Skupien, Andrews, & Larson, 2016). For example, results of a recent research study using an agent-based model suggested that resident education on safe garbage disposal, aversive bear conditioning, and how to contact wildlife authorities could reduce the number of human-bear conflicts in a residential area (Marley et al., 2017).

Extensive research exists on the various approaches to environmental education and subsequent changes in attitude or behaviors, and it is beyond the scope of this study to conduct a thorough literature review. However, generally, researchers have concluded that education that

provides direct experiences can be more effective than "classroom-style" approaches, which simply provide information (Christoffel, 2007; Morgan & Gramann, 1989). For an animal that can inspire strong emotional reactions in humans, modeling (i.e., seeing a professional safely handle a snake) or direct contact opportunities may be particularly beneficial (Morgan, 1992; Skupien, et al. 2016). For example, Ballouard, Provost, Barré, & Bonnet (2012) found an improvement in children's attitudes toward snakes following a field trip that provided an opportunity for non-venomous snake handling.

Experiential education is an approach that incorporates these direct experiences and immerses the learner in the situation or the reality of the focus (i.e., wildlife conflict), and requires the learner to recall and build upon early parts of the program through critical thinking and reflection (Kolb, 1984; Sponarski, Vaske, Bath, & Loeffler, 2016). Recently, a comprehensive experiential education program on living with coyotes in Nova Scotia was found to have a positive effect on attitudes related to coyotes (Sponarski, Vaske, Bath, & Loeffler, 2016). Elsewhere, an assessment of five years of bear education initiatives in Ecuador (including some experiential education techniques) showed some increases in behavioral intentions to reduce bear conflict (Espinosa & Jacobson, 2012). Moreover, the principles of interpretation also can be useful when utilizing direct experiences for more effective changes in behaviors and attitudes. Interpretation is a way of communicating ideas that aims to create meaningful personal connections and experiences, rather than simply providing factual information (Tilden, 1977). The main principles of interpretation relate to connecting to an individual's personality or actual experiences, provoking emotional reactions and revelations, and treating communication as an art form (Tilden, 1977).

Despite the extensive research on techniques for influencing environmental behaviors and attitudes, it can still be difficult to assess education programs and determine if the subsequent reported perception changes are ephemeral (e.g., immediately following the presentation of information) or long-term changes in behavioral outcomes. Therefore, to determine actual success of outreach programs, there is a need for better quantitative assessment and definition of success indicators (Christoffel, 2007; Gore et al., 2006). Gore, Knuth, Curtis, & Shanahan (2006) reviewed six programs that addressed human-bear conflict and taught proper bear-aversion techniques, and proposed a stronger set of program evaluation variables and performance indicators. Additionally, responses to outreach initiatives may vary depending on the target species and the study area, thus, there is opportunity for targeted outreach paired with an understanding of the factors influencing species-specific attitudes and behaviors (Christoffel, 2007; Teel et al., 2010).

A second management strategy that incorporates human factors is a citizen-based approach – in our case, to address rattlesnake poaching. Researchers suggest that local residents could potentially be motivated to aid in combating poaching (Green, 2016; McSkimming & Berg, 2008). A commercial market for live reptiles, including rattlesnakes, exists (Auliya et al., 2016; Fitzgerald & Painter, 2000) and illegal collection of timber rattlesnakes in New England is a major threat to the persistence of regional populations (J. Dickson, B. Hess, Connecticut Department of Energy and Environmental Protection [DEEP], 2015, personal communication; Blodgett et al., 2015; Brown, Jones, & Stechert, 1994). The life history strategies of northern timber rattlesnake populations make them susceptible to human collection (Brown, 1991; Martin et al., 2008); a single knowledgeable collector could devastate a population (Brown et al., 1994; Fitzgerald & Painter, 2000). Anti-poaching measures in Connecticut include a Turn-in-Poachers

(TIP) anonymous hotline to alert DEEP conservation officers to suspicious activity; some towns also utilize a conservation officer and trail cameras to monitor rattlesnake den sites. However, the effectiveness of these approaches has not been measured and, more broadly, few studies have focused on implementing a community-based citizen approach to anti-poaching (McSkimming & Berg, 2008).

In this study, we addressed two knowledge gaps at both the local species and broader wildlife science levels: lack of information about human interactions with timber rattlesnakes in New England, and perceptions of potential management strategies for this species. Our objective was to evaluate resident support for broad, regional "top-down" rattlesnake management strategies implemented at the state or town level that are enforced by wildlife professionals and local authorities. We then assessed the potential for two local management strategies that focus on effort at the level of the individual: (a) the use of the TIP hotline for reporting potential rattlesnake poaching activity, and (b) an informational outreach effort to promote coexistence with rattlesnakes.

Methods

Study Context and Location

We used two separate mail surveys to collect data from Connecticut residents adjacent to a known timber rattlesnake population. Our focus was on the rattlesnake population in central Connecticut (Figure 1), the range of which included portions of two Connecticut towns. We focused on this location because this rattlesnake population is believed to be more affected by

humans than the northwestern Connecticut population (J. Dickson, DEEP, November 2015, personal communication). Historically a rural area, rapid development began in the early 1980's and paralleled growth of the finance industry in a nearby city (Winslow, 1987). Much of this development took place near areas that contain the local rattlesnake denning and foraging habitat (Fritsch II, 1992).

The region is defined by intermixed human development and deciduous forest; the majority of land cover is classified as wildland urban interface (i.e., contains at least 6.17 housing units/ km^2; Radeloff, Hammer, & Stewart, 2005). The central part of the study area consists of forestland (area = 13.7 km^2) that serves as the center of rattlesnake activity for this population. This forestland is surrounded by residential development, streets, and a state highway. Land cover features include deciduous forest (63%), developed area (14.8%), coniferous forest (7.6%), turf and grass (6%), forested wetland (2.2%), agricultural fields (2%), and barren land (1.5%) (Data source: Landsat TM imagery, as classified by UConn Center for Land Use Education and Research (CLEAR); CLEAR, 2006). This area appeared to be experiencing an above average turnover of residents (B. DiLoreto, GRI, ABRIM, January 2017, personal communication). Although noted on some property deeds, incoming residents may be unaware of the timber rattlesnake presence and safe response behaviors during an unexpected encounter. A previous outreach effort was concentrated in the northwest region of our study area and largely consisted of mailed information and informal conversations. However, there has not been a concentrated effort regarding in-person rattlesnake educational programs (D. Fraser [Siena College], 2016, personal communication; J. Dickson [DEEP], 2017, personal communication).

We targeted residents with "accessible" attitudes, that is, those who are most likely to have come in to contact with a timber rattlesnake (Fazio, 1990; McCleery, Ditton, Sell, & Lopez, 2006). Therefore, we defined the study area conservatively as a 4-km radius circle (total area= 50.3 km^2) centered on known rattlesnake denning areas and with a radius extending the straight-line distance that an adult timber rattlesnake moves from the den site during summer foraging and mating activities (about one to three km; Tyning, 2005). Individuals familiar with this rattlesnake population confirmed that our study area included areas most likely to experience a rattlesnake encounter (D. Fraser, Siena College, March 2016, personal communication). Data collection involved a three-part process, described as follows.

Data Collection Part I: Attitudes toward Rattlesnakes Survey

First, we used a mail survey instrument to quantify human attitudes and behaviors toward timber rattlesnakes in this area and related variables (hereafter "Attitudes Survey"). The total number of residences within the study area (approximately 3,600 households) defined the study population, and the individual household defined the sampling unit. Sample size was based on the desired number of completed surveys and a desired sampling error of ±5% (Sheskin, 1985). We acquired addresses in an Address Based Sample (ABS) from Marketing Systems Group (Horsham, PA), which creates sampling frames from the US Postal Service delivery sequence files. Seasonal homes and PO boxes were not included in the sample, unless they were the resident's only way to receive mail. Survey questions were pre-tested with a focus group consisting of residents of the study area towns to confirm question clarity and inclusion of all major rattlesnake issues and concerns.

Surveys (n = 1,500) were mailed in June 2016. In an effort to increase response rate, we used a modified version of Dillman's Tailored Design Method for mail surveys, with the following chronology: (1) pre-notice postcard introducing the project and the researchers, (2) survey with cover letter, (3) reminder postcard, and (4) second mailing of survey packet with cover letter to those who did not send back the survey after the first mailing (Dillman et al., 2008). A non-response follow-up survey was completed using door-to-door canvassing during Fall 2016, and focused on ten key items from the original survey. Non-response surveys were completed for 10% of non-respondents to the original survey (n = 91), selected randomly from a list of non-respondents. Variables defined using the results of this survey were as follows.

Attitudes toward rattlesnakes (Coexistence)

Human attitudes toward a certain species can be shaped by factors that may also affect behaviors toward that species and support for potential management strategies (Christoffel, 2007; Glikman, Vaske, Bath, Ciucci, & Boitani, 2012; Hayman, Harvey, Mazzotti, Israel, & Woodward, 2014). Species that are thought to be ugly or dangerous are often considered low priority by the general public - if considered at all (Batt, 2009; Gunnthorsdottir, 2001; Tisdell, Wilson, & Swarna Nantha, 2006). Public apathy and outright aggression toward unpopular species can be major barriers to conservation planning (Bangs et al., 1998; Olson et al., 2015). For example, negative attitudes toward snakes may be directly contributing to intentional killings by humans and even intentional roadway mortalities (Ashley, Kosloski, & Petrie, 2007; Beckmann & Shine, 2012; Crawford & Andrews, 2016; Langley, Lipps, & Theis, 1989; Pandey, Subedi Pandey, Devkota, & Goode, 2016; Sealy, 2002). In this study, we expected that human

attitudes toward timber rattlesnakes would predict support for timber rattlesnake management strategies and willingness to report potential rattlesnake poaching.

To evaluate attitudes toward timber rattlesnakes, we asked study participants to indicate level of agreement, on a 5-point Likert scale (5= strongly agree, 4= somewhat agree, 3= unsure, 2= somewhat disagree, 1=strongly disagree), to twelve attitude-based belief statements about rattlesnakes (modified from Christoffel, 2007 and Riley, 1998). We used exploratory factor analysis (principal component analysis [PCA] with varimax rotation) to group statements that factored together for construction of scale scores, and Cronbach's alpha (α; Cortina, 1993) to measure internal reliability of statements that factored together. We derived attitude scale scores for each respondent by summing the values corresponding to items for each group of statements.

Eight statement items were used to create a scale score for our attitude variable (n = 591; α = 0.915). This variable defines a respondent's attitudes toward rattlesnakes based on their responses to statements that generally follow a theme of mutual coexistence between humans and rattlesnakes (*Coexistence*): (a) I am personally interested in rattlesnakes, (b) I would enjoy seeing a rattlesnake in the wild, (c) even if I never see one, I enjoy just knowing that rattlesnakes exist, (d) if I knew that a rattlesnake lived near my home, it would decrease my enjoyment of living there, (e) I take pride in knowing that a rattlesnake lives near my home, (f) I would be less likely to have a rattlesnake relocated from my property if I knew that it may not survive as a result, (g) rattlesnakes pose an unacceptable threat to pets, and (h) rattlesnakes pose an unacceptable threat to children. Individual score values for this attitude variable were between 8 and 40, with a higher score indicating greater perceived mutual coexistence.

Support for Rattlesnake Management

Past research suggests that a local community's lack of support for certain wildlife management strategies (i.e., attempted reintroductions, culling, euthanizations) can impact the effectiveness of these strategies (Clark, Huber, & Servheen, 2002; Doddridge, 2001; Liordos, Kontsiotis, Georgari, Baltzi, & Baltzi, 2017; Teel & Manfredo, 2010). Local support may be particularly important for amphibian and reptile management, as people generally indicate less support for conservation of uncharismatic species (Batt, 2009; Gunnthorsdottir, 2001; Liordos, Kontsiotis, Anastasiadou, et al., 2017; Tisdell et al., 2006). Because of the relationship among attitudes, behavioral intentions, and behaviors (Fulton, Manfredo, & Lipscomb, 1996), we hypothesized that residents' level of support for rattlesnake management strategies would be influenced by attitudes toward timber rattlesnakes. To evaluate support for potential regional timber rattlesnake management actions we asked participants: "To what extent do you support each of the following management strategies for rattlesnakes in Connecticut?". We provided eight current or potential rattlesnake management strategies (Table 1). Respondents were instructed to choose one response for each management strategy listed, from the following options: strongly support (5), somewhat support (4), unsure (3), somewhat against (2), and strongly against (1).

PCA resulted in seven of the eight management strategy statements factoring together (α= .887). The remaining statement was removed ("relocating rattlesnakes off of a property, at the landowner's request").

Willingness to Report Potential Poaching Activity

For a citizen to notify law enforcement of a wildlife crime, they must be (a) knowledgeable enough about wildlife regulations to know a crime is occurring, (b) motivated to

report the crime, and (c) aware of how to report the crime (Green, 2016; McSkimming & Berg, 2008). In Connecticut, the TIP hotline is an anonymous phone line managed by DEEP that residents can call to report poaching or potential poaching activity. We were interested in assessing awareness of this hotline, previous use of this hotline, and, most importantly, willingness to call the TIP hotline to report activity that may indicate rattlesnake poaching (*TIP1*). We expected that survey respondents' willingness to call the TIP line to report suspicious activity near rattlesnake habitat would be predicted by positive attitudes toward timber rattlesnakes (Fulton et al., 1996). In our survey, we described the TIP hotline ("as part of the TIP program, CT DEEP offers a toll-free, 24-hour phone line that people can anonymously call to provide information about illegal poaching activities") and provided examples of suspicious activity that may indicate rattlesnake poaching ("examples of suspicious activity that may indicate rattlesnake poaching are a person carrying a snake hook/ stick and bag, or a person who asks you or your neighbors about rattlesnake locations"). Then, we used a two-part question to assess willingness to report potential poaching activity to the TIP hotline: (a) "if you were to witness this type of suspicious activity from a stranger in your neighborhood, would you call the TIP hotline to report it?" and (b) "are you likely to report suspicious activity if the person is someone you know (such as a friend or neighbor)?". Respondents were give three response options (2= yes, 1 = unsure, 0= no,).

Knowledge of Timber Rattlesnake Role in the Ecosystem

We derived a variable to represent respondents' knowledge of the timber rattlesnake's role in the ecosystem, from indicated levels of agreement (5= strongly agree, 4= somewhat agree, 3= unsure, 2= somewhat disagree, 1=strongly disagree) to eight statements about timber

rattlesnake ecology and life history (Brown, 1991; Martin et al., 2008). We used PCA and Cronbach's alpha (α) to derive the *EcoRole* scale score by summing the response values for the four statements that factored together (n = 591; α = 0.714): (a) rattlesnakes help to control local rodent populations, (b) rattlesnakes can help reduce the spread of Lyme disease, (c) rattlesnakes are important to the Connecticut ecosystem, (d) removing one adult female rattlesnake from the population can greatly affect future population numbers. Higher values indicated greater knowledge of the rattlesnake's ecological role in this area.

Data Collection Part II: Rattlesnake Information Packet

Fear and safety concerns are common human sentiments when it comes to venomous snake species (Christoffel, 2007; Öhman & Mineka, 2003). Increased knowledge and familiarity of a species has been shown to be connected with more favorable perceptions of that species (Christoffel, 2007; Reimer et al., 2014; Vaske & Donnelly, 2007). From the 1980s to 2008, DEEP annually mailed a letter to select addresses in our study area containing information about timber rattlesnake presence and phone numbers for assistance in the event of an encounter. However, that effort was discontinued, and outcomes were never evaluated.

As a first step in our assessment, we assembled a timber rattlesnake information packet that included four items: (a) cover letter explaining the purpose and the contents of the packet, (b) CT DEEP *Snakes in Connecticut* color brochure, with details on identification of Connecticut snakes, (c) CT DEEP Timber Rattlesnake Fact Sheet, and (d) *Connecticut Rattlesnake Response Program* refrigerator magnet, which included the phone numbers of five local volunteers and state employees who respond to requests for assistance with rattlesnake encounters in the area,

and the phone number of the CT TIP hotline (Figure 2). Information packets were mailed between July and September 2016 to each study participant who completed and returned the Attitudes Survey (n = 590) and a group of randomly selected non-respondents (n = 122). By providing accurate information about the species and resources for assistance in the event of an encounter, it was not our intent to change attitudes, but rather to provide accessible information to residents in response to an unexpected encounter.

Data Collection Part III: Outreach Survey

To test our hypothesis (see above), we used a follow-up mail survey to collect data on our study participants' attentiveness to the rattlesnake information packet (hereafter "Outreach Survey"). This survey was shorter than the Attitudes Survey and focused on retention and actual use of the information packet. In February 2017, we mailed Outreach Surveys to those participants who completed and returned the Attitudes Survey and subsequently received the rattlesnake information packet (n = 589; one respondent requested removal from the study). Survey mailing followed the same four-step process as the Attitudes Survey (see above). Questions on the survey addressed whether the landowner remembered receiving the information packet, whether the information was used, any changes in level of concern or knowledge regarding rattlesnakes, and descriptions of any encounters with rattlesnakes in 2016. Variables defined using the results of this survey were as follows.

Updated Willingness to Report Poaching

Lack of knowledge about wildlife laws and how to report a violation (particularly among those in non-rural areas or non-hunters and non-anglers) can be barriers to poaching prosecutions (Green, 2016). Therefore, we evaluated whether residents would be more likely to report potential rattlesnake poaching activity after being provided with timber rattlesnake information and TIP hotline instructions (*TIP2*). We repeated the same question from the Attitudes Survey to re-assess willingness to report rattlesnake poaching in the Outreach Survey (i.e., two-part question focused on reporting potential poaching activity), with the following response options: very likely (5), somewhat likely (4), unsure (3), somewhat unlikely (2), very unlikely (1). For comparisons with responses about the TIP hotline from the Attitudes Survey, we collapsed responses from the Attitudes Survey: "very likely" and "somewhat likely" responses to "yes" (2) and "somewhat unlikely" and "very unlikely" responses to "no" (0). Unsure responses remained the same (1).

Reported Change in Concern and knowledge

Elevated levels of concern and risk perception regarding rattlesnake presence can contribute to detrimental behaviors toward the species and lower acceptance for species presence (Christoffel, 2007; Riley & Decker, 2000). Past research suggests that educational programming about an unpopular or unfamiliar species can contribute to more favorable attitudes (Reimer et al., 2014; Skupien et al., 2016). Elsewhere, Gunnthorsdottir (2001) suggested a framing effect, such that unpopular species were seen as slightly more attractive when described as endangered. Therefore, we hypothesized that concern about encountering a rattlesnake (*ConcernChange*) would decrease after receiving the rattlesnake information packet, which described this species' endangered status, non-aggressive demeanor, and the availability of volunteers to assist in an

encounter. We also hypothesized that respondents would self-report that knowledge about timber rattlesnakes had increased (*KnowledgeChange).* We used a multi-part question to evaluate these expectations: "For each of the following items below, please tell us whether and how receiving the previous survey and the information packet affected you personally, (a) your level of concern about encountering a rattlesnake, and (b) your level of knowledge about timber rattlesnakes. Response options were limited to: increased (2), decreased (1), no change (0), and unsure (9).

Statistical analysis

Statistical analyses were completed in either SPSS (version 24.0; SPSS, Inc., version 24.0; Chicago, Illinois) or RStudio (Version 1.0.136). We used Pearson's *r* and the Spearman's ranked correlation coefficient to explore bivariate relationships between the variables described above (Sokal & Rohlf, 1969). Effect size (Gliner, Vaske, & Morgan, 2001) was used to assess the strength of the relationships between variables, as appropriate.

We used a potential for conflict index (PCI_2) analysis (Manfredo, Vaske, & Teel, 2003; Vaske, Beaman, Barreto, & Shelby, 2010) to assess the potential for conflict among residents regarding various timber rattlesnake management strategies. The potential for conflict index is used to visualize the level of variation among responses regarding support or acceptability of an action, on a multi-point scale (Manfredo et al., 2003). The greatest potential for conflict occurs when responses are equally divided between the most extreme options (e.g., strongly agree and strongly disagree), while the least potential for conflict would result when there is full consensus on an option. We used Microsoft Excel to construct a PCI_2 analysis on the results of responses to survey question: "To what extent do you support each of the following management strategies for rattlesnakes in Connecticut?" (5= strongly support, 4= somewhat support, 3= unsure, 2=

somewhat against, 1= strongly against). Responses were recoded to center on zero (strongly support = 2, somewhat support= 1, somewhat against= -1, strongly against = -2), and we ran the analysis with the neutral value (unsure = 0) removed and at a power of one (Vaske et al., 2010). We then split our dataset into two groups: respondents with attitude scores below 23 (less favorable attitudes toward human-rattlesnake coexistence) and those with attitude scores above 25 (favorable attitudes toward human-rattlesnake coexistence), based upon the midpoint neutral attitude score value of 24, and a one point buffer on either side. We ran the PCI_2 again to compare the potential for conflict within each group.

Results

Sample characteristics

We received completed Attitudes Surveys back from 595 residents (39.7% response rate). We excluded two responses from the analysis because they were returned after non-response follow-up was completed (final *n*= 593). Approximately 53.6% of our respondents were female. Respondents were, on average, 56 years old (SD: ±13.8; range: 19 to 94). According to recent census data, our gender ratio is representative of the study area (American Community Survey (ACS) Data, 2011-2015). However, given that the median age for applicable census tracts is 44 years old, with 78% of population reported as 18 years or older (ACS, 2015), and the mean respondent age from our non-response survey was 51 years old, our average age is likely higher than the actual average adult age. Our average respondent had lived at their current address for 20 years; 31% of our respondents have lived at their current address for less than 10 years.

Regarding the highest level of education attained among our respondents, 32% reported having obtained a bachelor's degree and 41% reported having obtained a graduate or professional degree. According to recent census data, approximately 63% of residents in the three census tracts that make up our study area have attained a bachelor's degree or greater (ACS Data, 2011-2015). Among non-respondents (n = 91), the most common reason given (40%) for non-response was never having received the survey or did not recall receiving the survey.

We received completed Outreach Surveys from 386 respondents (65%). One survey was returned after the start of data analysis, and was not included in analysis (n = 385). Eleven surveys were returned with ID numbers removed and were not included in analysis that involved matching the Outreach Survey responses with responses from the earlier survey. Assuming the same individual completed both the Attitudes and Outreach surveys for each household, approximately 54% of the Outreach Survey respondents were female and the mean respondent age was 57 (SD: ±13.3). The average Outreach Survey respondent had lived at their current address for approximately 21 years. From this point forward, when a percentage and a sample size (n) are reported, the n refers to the total number of people who answered that particular survey question.

Attitudes and Support for Rattlesnake Management Strategies

For the attitude variable (*Coexistence*), the average scale score was 24.05 (SD: ±8.59; possible range = 8-40). Distribution of the scores was normal, with a kurtosis value of -0.987. For the households that also completed the Outreach survey, the mean attitude score was 25.00 (SD: ±8.51).

On the Attitudes Survey, the most supported management actions were increased public education and outreach about rattlesnakes, and relocating rattlesnakes off of a property at the landowner's request (Table 1). The use of private funds from donations to protect rattlesnakes was generally supported by more respondents than the use of government money. The least supported management action was laws protecting rattlesnakes that restrict a landowner's right to develop private property.

The results of bivariate analysis suggest a strong positive relationship between attitudes toward rattlesnakes and support for each management strategy (Table 2). However, responses to one strategy ("relocating rattlesnakes off of a private property, at the landowner's request") did not follow this overall trend, which is apparent in the correlation with attitudes (Table 2; Figure 4). PCI_2 results suggest the greatest potential for conflict among all our study participants is in relation to laws protecting rattlesnakes that restrict a landowner's right to develop private property ($PCI_2 = 0.34$; $n = 579$). The least potential for conflict related to increased public education and outreach about rattlesnakes ($PCI_2 = 0.06$; $n = 577$). When study participants were further segmented by attitude scores (attitude scores < 23 and attitude scores > 25), the greatest potential for conflict was suggested among respondents with less favorable attitudes toward rattlesnakes (attitude score < 23) regarding laws that prohibit killing rattlesnakes ($PCI_2 = 0.31$; $n = 249$; Figure 3). As a group, respondents with attitudes that favored mutual rattlesnake-human coexistence (attitude scores > 25) did not suggest great potential for conflict (all $PCI_2 \leq 0.25$).

Likelihood of Reporting Potential Poaching to TIP Hotline

On the Attitudes Survey, 11% of respondents indicated awareness of the TIP hotline before receiving the survey ($n = 580$). The majority of survey respondents indicated that they

would report activity near rattlesnake habitat (Table 3). However, fewer indicated they would report someone familiar, as opposed to a stranger (Table 3). On the Outreach Survey, a greater proportion of respondents indicated that they would report potential poaching activity and a smaller proportion reported being unsure (Table 3).

Bivariate results suggested that those with greater attitude scale scores were more likely to indicate that they would report potential rattlesnake poaching activity to the Connecticut TIP hotline, when the suspect is a stranger (r = .433, $p < 0.05$, *eta* = .520). If the suspect in question is someone that the respondent knows personally (i.e. friend or family member), however, the relationship between attitudes and the likelihood of reporting potential poaching activity was not as strong (r = .224, $p < 0.05$, *eta* = .227). We also found a direct relationship between responses on the Attitudes Survey and the Outreach Survey on the likelihood of reporting potential poaching activity if the suspect is a stranger (Spearman's rho = .444), and if the suspect is familiar (Spearman's rho = .352; Figure 5). Ninety-four percent of respondents who indicated they would report suspicious activity from a stranger in the Attitudes Survey also indicated they would report suspicious activity from a stranger in the Outreach Survey (Figure 5).

Informational Outreach Effort

From the Outreach Survey, approximately 54% of respondents to the respective question (n = 351) indicated that they still had the *Snakes in Connecticut* brochure in their possession; 85% (respondent n = 344) indicated that they had referred to that item and found it very useful or somewhat useful (Table 4). Approximately 49% of respondents (n = 349) indicated that they still had the *Connecticut Rattlesnake Response Program* refrigerator magnet in their possession; 62.5% (respondent n = 323) had referred to that item and found it very useful or somewhat

useful. Approximately 35% of respondents to the respective question (n = 350) indicated that they still had the Timber Rattlesnake Fact Sheet in their possession; 81% (respondent n =329) reported that they had referred to that item and found it very useful or somewhat useful.

When asked to describe how the Information Packet components were used, (selected) responses included the following:

> *I looked up a snake that we saw near our house.*
>
> *Everyone in household read info and magnet is on fridge.*
>
> *I enjoyed learning more about the rattlesnake. I do not really like snakes, so never had spent any time learning about them.*
>
> *Identified rattlesnakes crossing* [road name removed] *in early September (successfully!)*

On the Outreach Survey, and after receiving the rattlesnake information packet, 21% of respondents to the respective question (n = 381) indicated that they feel more positively, 6% indicated that they feel more negatively, and 71% indicated that there was no change in their feelings about living near one of Connecticut's rattlesnake populations. Nine percent of respondents indicated that level of concern about encountering a rattlesnake increased, 12% indicated that concern decreased, and 77% reported no change in concern (n =384; Table 5). Selected additional feedback included:

> *Very little concern before or after.*
>
> *I didn't realize they were so close.*
>
> *I have a small dog, so I am always concerned.*

Wasn't a concern before and still isn't.

Seventy-two percent of respondents reported that their level of knowledge about timber rattlesnakes increased, and 26% reported no change in level of knowledge (n = 383; Table 5). Selected additional feedback included:

Always good to know more.

Knew some information before I was sent info packet.

Slight improvement in knowledge about them.

Less fear of being "attacked".

Approximately 67% of respondents to the respective question (n = 370) indicated that the Attitudes Survey and the rattlesnake information packet increased their awareness of factors that affect rattlesnake populations in Connecticut. Several respondents indicated it was particularly interesting to learn that rattlesnake poaching was impacting Connecticut rattlesnake populations.

Discussion

Local resident support for management of an endangered species has the potential to impact the effectiveness and outcome of certain wildlife management actions (Clark et al., 2002; Doddridge, 2001; Liordos, Kontsiotis, Georgari, et al., 2017; Teel & Manfredo, 2010). In this study, we highlighted factors that are likely to influence resident support for management of timber rattlesnakes in Connecticut and explored potential management strategies. We used data from two mail surveys to evaluate support for broad "top-down" rattlesnake management

strategies, and then assessed the potential for two local management actions that focus on effort at the level of the individual: (a) an informational outreach effort to promote coexistence with rattlesnakes, and (b) the use of the TIP hotline for reporting potential poaching. We frame this discussion around the implications for support of rattlesnake management by residents who live among the rattlesnake population, utility of a mailed informational outreach effort, and approaches to combat timber rattlesnake poaching.

We found that our respondents were generally supportive of most Connecticut timber rattlesnake management strategies, with more than half indicating support for all but two of the listed management strategies. Attitudes toward rattlesnakes predicted the likelihood of reported support for all but one of the management strategies. As the anomaly, respondents with favorable attitudes toward rattlesnakes were more likely to be *against* relocating rattlesnakes off of private property (Figure 4). This irregularity may be because relocation could be considered slightly invasive toward the snake in question (Brown, Bishop, & Brooks, 2009; Nowak, Hare, & McNally, 2002). These residents may also be aware that short-distance translocation is not always effective, as the snake may return to the original location (Brown et al., 2009; Harvey, Lentini, Cedar, & Weatherhead, 2014; Nowak et al., 2002). However, results of research focused on short-distance translocation of rattlesnakes have varied, and this management technique does appear to mitigate the immediate threat to the snake from potential conflict with humans (Harvey et al., 2014).

The least-supported management actions included government money spent to protect rattlesnakes and laws protecting rattlesnakes that restrict a landowner's right to develop private property. The latter also resulted in the greatest PCI_2 value, indicating that a focus on management actions that restrict private property owners may lead to more volatile public

discourse and possibly resentment toward both wildlife managers and rattlesnakes. Elsewhere on the Outreach Survey, we found that almost half (47%) of respondents indicated that both state and federal funding are appropriate funding sources for rattlesnakes; state funding was the next most popular choice (20% of respondents indicating it as an appropriate funding source). Collectively, our results support past research conclusions on the positive relationship between greater attitude scale scores related to a species and greater support of management for that species (Liordos, Kontsiotis, Anastasiadou, et al., 2017).

When considering resident support for timber rattlesnake management strategies, it is important to frame the situation in terms of what is being asked of the stakeholder (i.e., burden), and understand that individuals may consider required burden in decision-making about the situation and resulting behavior. For example, wildlife managers may ask a resident to do nothing if they encounter a rattlesnake on their property. Inadvertently, managers may actually be demanding *more* of that resident by asking them to coexist with a rattlesnake on their lawn (as oppose to relocating the rattlesnake). Applying such logic to our survey results, the most supported management strategies and those with the least potential for conflict were those in which residents were least burdened and did not have to change their behavior (i.e., increased education and outreach).

Educational outreach is one approach to addressing apathetic or adverse attitudes toward a species that may contribute to lack of support for management. Wildlife education is increasingly focused on as a way to influence attitudes, particularly toward unpopular species (Adams & Thomas, 1986; Ballouard et al., 2012; Skupien et al., 2016). Past research has compared the effectiveness of providing information (e.g., classroom based, mailed information) as a means to increase knowledge and influence attitudes toward a species and impact of real-life

wildlife encounters (e.g., field excursions, direct encounters, hands-on programs) in an attempt to influence attitudes by providing a positive wildlife experience (Ballouard et al., 2012; Christoffel, 2007; Morgan & Gramann, 1989; Skupien et al., 2016). Greater knowledge about a species has been shown to directly relate to more favorable attitudes and support for management (eastern massasauga and timber rattlesnakes, Christoffel, 2007; wolves, Glikman et al., 2012; eastern hellbenders, Reimer et al., 2014; desert tortoises, Vaske & Donnelly, 2007). Despite such findings, Heberlein (2012) warns of the fallacy of thinking that simply "educating the public" (a *cognitive fix*) will lead to attitude and behavior change. Instead, researchers have found that a combination of direct, hands-on experiences and factual information may be the most effective way to influence attitudes, particularly if the experiences are repeated (Ballouard et al., 2012; Christoffel, 2007; Morgan & Gramann, 1989; Skupien et al., 2016). As such, the principles of interpretation may be particularly useful in influencing human attitudes and behaviors related to venomous snakes in this area because this form of communication does not rely upon cognitive fixes and instead incorporates story-telling, appeals to emotion, and direct personal experiences (Tilden, 1977). Instead, communication and messaging that directly appeals to the salient beliefs connected with the desired behavior can also be effective in influencing actual behavior change (Brown, Ham, & Hughes, 2010; Hughes, Ham, & Brown, 2009). Aside from in-person programs, providing factual information still may be effective when paired with a *structural fix*, i.e., an approach that influences human behavior by changing the context of the situation (Heberlein, 2012).

Our results support that pairing timber rattlesnake information with a refrigerator magnet containing phone numbers for assistance in the event of an encounter seemed to be a well-received and potentially effective tool for this area. Elsewhere in our study (see Chapter 3),

results of a spatial analysis indicated that a cluster of residents with greater knowledge of the rattlesnake's role in the ecosystem overlapped with some of the streets where previous rattlesnake-related outreach (i.e., mailed information and informal conversations) was conducted. Furthermore, a cluster of residences with lower knowledge of the rattlesnake's role in the ecosystem was identified in the southeast region of our study area, a location that has not historically been a focus for formal rattlesnake outreach. In the Outreach Survey, a high proportion of our study participants (72%; n = 383) reported that their knowledge about timber rattlesnakes increased after receiving the mailed Rattlesnake Information Packet, and comments from many of our respondents reflected pleasure with receiving the information. Although we expected that the information and the inclusion of phone numbers to call in the event of an unexpected rattlesnake encounter may ease existing concern about rattlesnakes, most respondents (77%; n = 384) reported no change in their level of concern. However, of those respondents, several indicated that they had little or no concern about rattlesnake encounters before or after receiving the survey and information. Additionally, 12.5% of respondents reported that their level of concern about encountering rattlesnakes decreased, and 9.1% (n = 384) reported that concern increased after receiving the information. Of respondents who reported increased concern, several commented that they were not previously aware of rattlesnakes in their area, which could explain the increased concern.

Spreading awareness of the local availability of a free Rattlesnake Response Program may change the context of an unexpected rattlesnake encounter for some residents. Elsewhere in this study, we found that favorable attitudes toward timber rattlesnakes were related to number of personal experiences with timber rattlesnakes. Therefore, increasing the likelihood of a positive outcome (for both human and rattlesnake) in an unexpected rattlesnake encounter may

beneficially impact timber rattlesnake conservation in this area. Investigation of actual behavioral measures will assist understanding of long-term effects of this outreach tool and the rattlesnake response program.

We also highlight changes in concern and knowledge in the seven-month time period between the Attitudes Survey and the Outreach Survey and note that other events may have occurred that affected people's attitudes related to venomous snakes (i.e., media reports about venomous snake bites in other parts of the country). For example, from February 2016 to April 2017, local and national media outlets sporadically covered a news story about a potential timber rattlesnake population recovery plan in Massachusetts that involved introducing rattlesnakes to a remote island in the Quabbin reservoir. A survey question on the Outreach Survey addressed the potential for outside sources of information on rattlesnakes ("During the past year, did you receive any additional rattlesnake information other than what we sent you last summer?"). However, approximately 3% (n = 385) of survey respondents answered "yes" to this question, and subsequent write-in responses (n = 9) indicated local rattlesnake response volunteers, friends, and online sources as the alternate sources of information.

Finally, concerns about poaching have contributed to a sense of secrecy among wildlife managers and researchers when it comes to certain animal locations (Lindenmayer & Scheele, 2017), and a hesitancy to use informational signs that may alert poachers to rattlesnake locations (Brown, 1992). While this secrecy may contribute to agency mistrust through limitation of free and open flow of information between wildlife managers and the general public, the chance of endangered wildlife locations being discovered by poachers is generally considered a greater risk (Lindenmayer & Scheele, 2017; Meijaard & Nijman, 2014).

One approach to combat poaching that does not require sharing sensitive location information is encouraging local human communities to act as a "neighborhood watch" (McSkimming & Berg, 2008). Our results suggest a willingness among the majority of survey respondents to report potential rattlesnake poaching activity. For this approach, it is important to understand and consider residents' motivations for reporting potential poaching as a means to guide and promote desired behavior. Past research on motivations for reporting fish poaching to a TIP hotline found that the main motivations were (a) preventing loss to resource, (b) preventing the loss of local economic benefits, (c) preventing the loss to stream access, and (d) protecting angler safety (McSkimming & Berg, 2008). Elsewhere on our Attitudes Survey, we asked survey respondents who indicated that they would report suspicious activity that may indicate rattlesnake poaching to the TIP hotline (n = 402) to also indicate their main motivation for doing so. The majority of respondents indicated that their main motivation was a value for the existence of rattlesnakes in the area (46%; n = 396), similar to McSkimming & Berg's (2008) findings on "preventing loss to resource" as a popular motivation. The next most common motivation reported was an interest in reducing crime in the community (30%; n = 396). Contrary to McSkimming & Berg (2008), protecting the safety of outdoor recreationalists and protecting the privilege of public land access were reported less frequently as motivators. In our study, only three respondents indicated that a possible financial reward would be their main motivation. A lack of awareness of rattlesnake poaching and of the TIP hotline may be also be major barriers to this strategy. On the Attitudes Survey, only 23% of study participants (n = 587) indicated that they were aware of the removal of rattlesnakes from the wild as a factor that contributed to the overall decline of Connecticut rattlesnake populations, and only 11% (n = 580) indicated an awareness of the Connecticut TIP hotline. Given that those with greater attitude

scale scores were more likely to indicate willingness to report poaching, there is opportunity for attitudes that favor human-rattlesnake coexistence and local interest in this timber rattlesnake population to serve as motivations for reporting potential poaching activity.

Management Recommendations

For this particular population of timber rattlesnakes, we believe that mailed outreach information could be a particularly effective management strategy. While outreach and educational programs that feature actual direct encounters with wildlife can be very effective (Ballouard, Provost, Barré, & Bonnet, 2012; Christoffel, 2007), only a small proportion of survey respondents indicated interest in attending such a program. On the Attitudes Survey, 17% of respondents (n = 593) indicated an interest in informational workshops or presentations about amphibians and reptiles in their area, and on the Outreach Survey, only 25% of respondents (n = 384) indicated an interest in attending a short educational program about timber rattlesnakes. It is important to note that we did not mention the potential presence of live snakes in these survey questions, which may have resulted in a greater proportion indicating a willingness to attend such a program. Regardless, previous research has found that participants of species-specific educational programs reported greater interest in the species in question than non-participants (Christoffel, 2007). However, while the abundance of literature on the beneficial impacts of modeling, direct experiences, and interpretive programs cannot be ignored, conclusive recommendations for in-person educational programming is beyond the scope of our data.

Alternatively, in the event of limited financial resources, mailing information about timber rattlesnakes to select households on an annual or even biennial basis may have an

equivalent impact. Other studies have suggested that the education of humans near and directly adjacent to bear habitat on bear management strategies can be an effective way to reduce the probability of a bear becoming a conflict bear (i.e., becoming conditioned to human food; Marley et al., 2017). This conclusion could be applicable to our study area in terms of targeting residents adjacent to rattlesnake habitat.

New residents to the area could also be targeted, as it is currently unclear how incoming residents learn about the presence of this species. Since the timber rattlesnake became a state-listed species in 1985, strategies for informing new residents have evolved from simply noting potential timber rattlesnake presence in the property deed, obligating developers to divulge this information to potential home buyers and include it in plot plans and subdivision maps (T. Mocko, town environmental planner, 2016, personal communication). Therefore, residents in the area prior to 1985 may not have been informed about potential rattlesnake presence, whereas new residents are theoretically informed by real estate agents and builders/developers. However, our Attitudes Survey results showed that new residents (residential tenure less than 10 years) were actually less likely to indicate that they were aware of rattlesnake presence before moving into their current address. Of those who indicated that they were aware of rattlesnake presence before they moved in to their current address, only 4% indicated builders/developers/contractors as the source of that information. Thus, it seems that newer residents to this area may not be receiving information about timber rattlesnakes.

Elsewhere in this study (see Chapter 3), we hypothesized that residents are sharing information related to timber rattlesnakes with their neighbors and, on the Outreach Survey, several respondents commented that they shared some or all components of the Rattlesnake Information Packet with friends, family, and neighbors. Therefore, mailing these resources to

select homes on a regular basis may aid in the outward dissemination of information throughout this community, particularly if long-term residents are sharing information with new neighbors about how to respond in the event of an unexpected rattlesnake encounter. Additional research is needed to evaluate the long-term impacts of this and other management actions.

In conclusion, the human residents around this rattlesnake population appear to be amenable to supporting management actions for their local timber rattlesnake population. In fact, approximately 27% of overall survey respondents (n = 571) indicated an interest in learning about how they personally can become involved with rattlesnake conservation in Connecticut. Further actions targeting this community to engage them directly in rattlesnake management could be effective.

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Table 4.1. Frequencies of responses to Attitudes Survey questions regarding resident support for various timber rattlesnake management strategies in Connecticut

To what extent do you support each of the following management strategies for rattlesnakes in Connecticut?	Strongly support	Somewhat support	Unsure	Somewhat against	Strongly against
Increased public education and outreach about rattlesnakes. (*n* = 577)	61.4%	30.8%	5.4%	1.4%	1.0%
Relocating rattlesnakes off of a property, at the landowner's request. (*n* = 579)	51.6%	34.2%	8.8%	3.3%	2.1%
Government money spent to protect rattlesnakes. (*n* = 578)	16.6%	30.6%	26.6%	16.1%	10.0%
Government money spent to protect rattlesnake habitat. (*n* = 579)	24.4%	35.2%	19.7%	11.6%	9.2%
Private funds (from donations) spent to protect rattlesnakes. (*n* = 580)	43.6%	35.5%	12.2%	3.8%	4.8%
Private funds (from donations) spent to protect rattlesnake habitat. (*n* = 580)	45.3%	35.5%	10.9%	3.6%	4.7%
Laws that prohibit killing rattlesnakes. (*n* = 579)	37.0%	26.6%	18.7%	8.8%	9.0%
Laws protecting rattlesnakes that restrict a landowner's right to develop private property. (*n* = 579)	14.5%	19.2%	28.2%	17.8%	20.4%

Table 4.2. Correlation between support for various rattlesnake management strategies and *Coexistence* attitude variable.

	Pearson's *r*	*eta*
To what extent do you support each of the following management strategies for rattlesnakes in Connecticut?		
Increased public education and outreach about rattlesnakes. (*n* = 577)	0.414*	0.531
Relocating rattlesnakes off of a property, at the landowner's request. *(n = 579)*	-0.250*	0.369
Government money spent to protect rattlesnakes. *(n = 578)*	0.519*	0.584
Government money spent to protect rattlesnake habitat. *(n = 579)*	0.572*	0.638
Private funds (from donations) spent to protect rattlesnakes. *(n = 580)*	0.518*	0.605
Private funds (from donations) spent to protect rattlesnake habitat. *(n = 580)*	0.507*	0.590
Laws that prohibit killing rattlesnakes. *(n = 579)*	0.576*	0.633
Laws protecting rattlesnakes that restrict a landowner's right to develop private property. *(n = 579)*	0.494*	0.545

An asterisk (*) indicates significance at the 95% confidence level ($\alpha = 0.05$ level).

Table 4.3. Frequencies of survey responses to questions on the Attitudes Survey (mailed June 2016) and the Follow-up Survey (mailed February 2017) regarding willingness to report potential rattlesnake poaching activity to the Connecticut TIP hotline.

	Yes	No	Unsure
Attitudes Survey			
If you were to witness this type of suspicious activity from a stranger in your neighborhood, would you call the TIP hotline to report it? (n = 582)	69.1%	7.4%	23.5%
Are you likely to report suspicious activity if the person is someone you know (such as a friend or neighbor)? (n = 397)[1]	54.4%	9.1%	36.5%
Outreach Survey[2]			
How likely are you to report potential poaching activity if the suspect is a stranger? (n = 373)	84.7%	6.7%	8.6%
How likely are you to report potential poaching activity if the suspect is someone you know? (n = 369)	69.4%	11.1%	19.5%

[1]In the Attitudes Survey, if the respondent answered *no* or *unsure* to the first question, they were instructed to skip the second question.

[2]Responses to these questions were recoded (*very likely* and *somewhat likely* converted to *Yes*, and *somewhat unlikely* and *very unlikely* to *No).*

Table 4.4. Frequencies of survey responses to Follow-up Survey questions (mailed February 2017) regarding the usefulness of each component of the Rattlesnake Information Packet (mailed July 2016).

After receiving the information packet, did you refer to each of the following components and, if so, how useful did you find each one?	I *did* refer to this component and found it to be:			I *did not* refer to this component
	Very useful	*Somewhat useful*	*Not useful*	
Snakes in Connecticut brochure (*n* = 344)	49.4%	36.0%	1.2%	13.4%
Connecticut Rattlesnake Response Program Magnet *(n = 323)*	35.9%	26.6%	11.1%	26.3%
Timber Rattlesnake Fact Sheet *(n = 329)*	43.5%	37.1%	2.1%	17.3%

Table 4.5. Frequencies of survey responses to Follow-up Survey questions regarding the changes in concern and knowledge about rattlesnakes.

For each of the following items below, please tell us whether and how receiving the previous survey and the information packet affected you personally.	Increased	Decreased	No Change	Unsure
Your level of concern about encountering a rattlesnake (*n* = 384)	9.1%	12.5%	77.3%	1.0%
Your level of knowledge about timber rattlesnakes (*n* = 383)	71.8%	0.0%	26.4%	1.8%

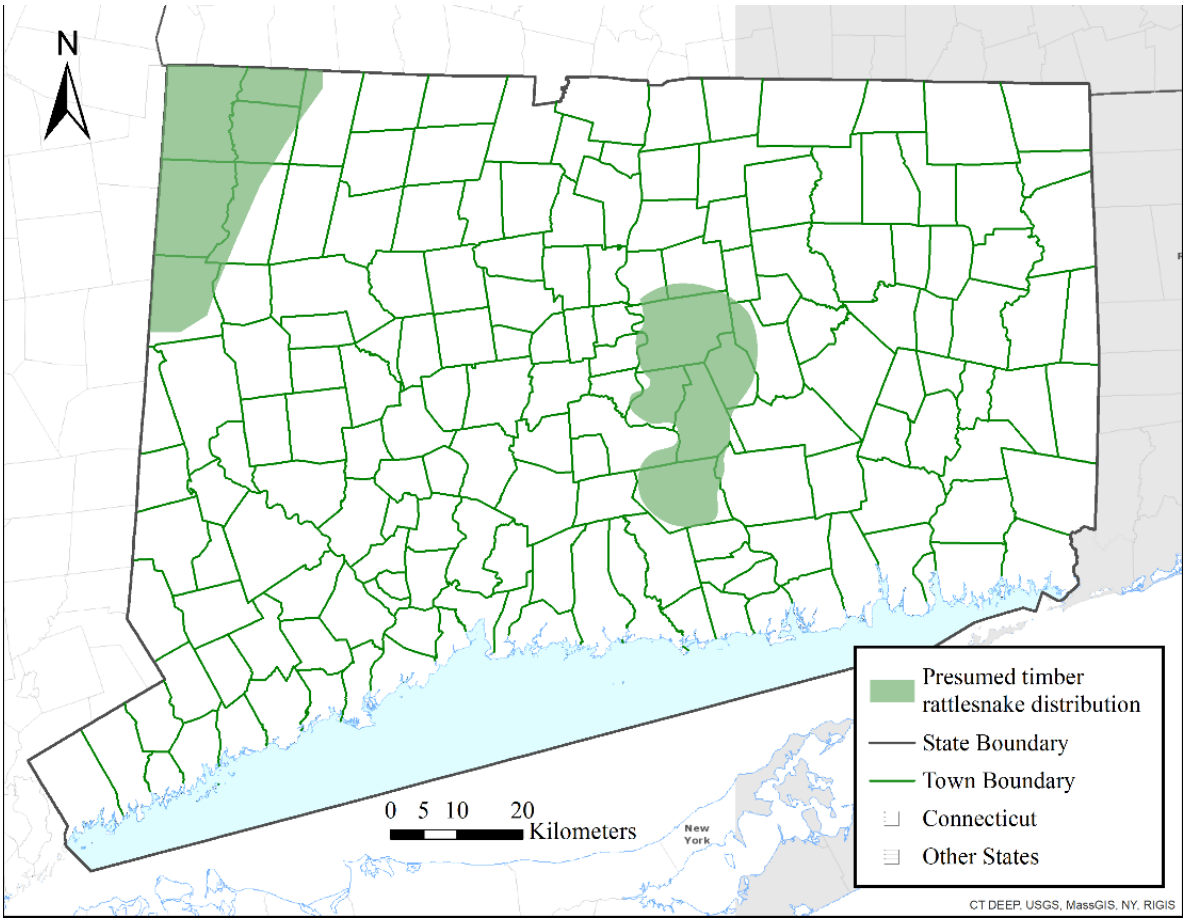

Figure 4.1. General estimated timber rattlesnake distribution in the state of Connecticut (CT DEEP, 2015).

Figure 4.2. Connecticut Rattlesnake Response Program refrigerator magnet, included in the Rattlesnake Information Packet, mailed July 2016.

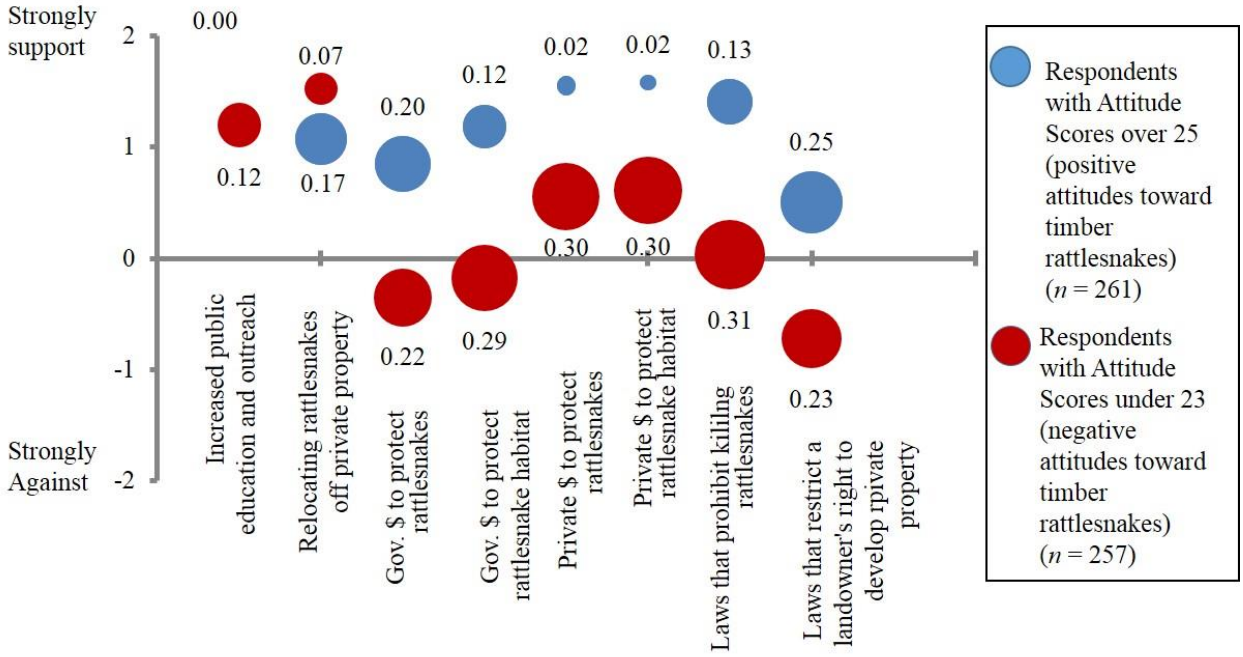

Figure 4.3. Potential for Conflict Index (PCI_2) results, showing the potential for conflict around various timber rattlesnake management strategies. Respondents are grouped by their attitudes toward timber rattlesnakes. Blue circles illustrate support among those with more favorable attitudes toward timber rattlesnakes. Red circles showing support among those with more adverse attitudes toward timber rattlesnakes. Larger circles represent greater potential for conflict.

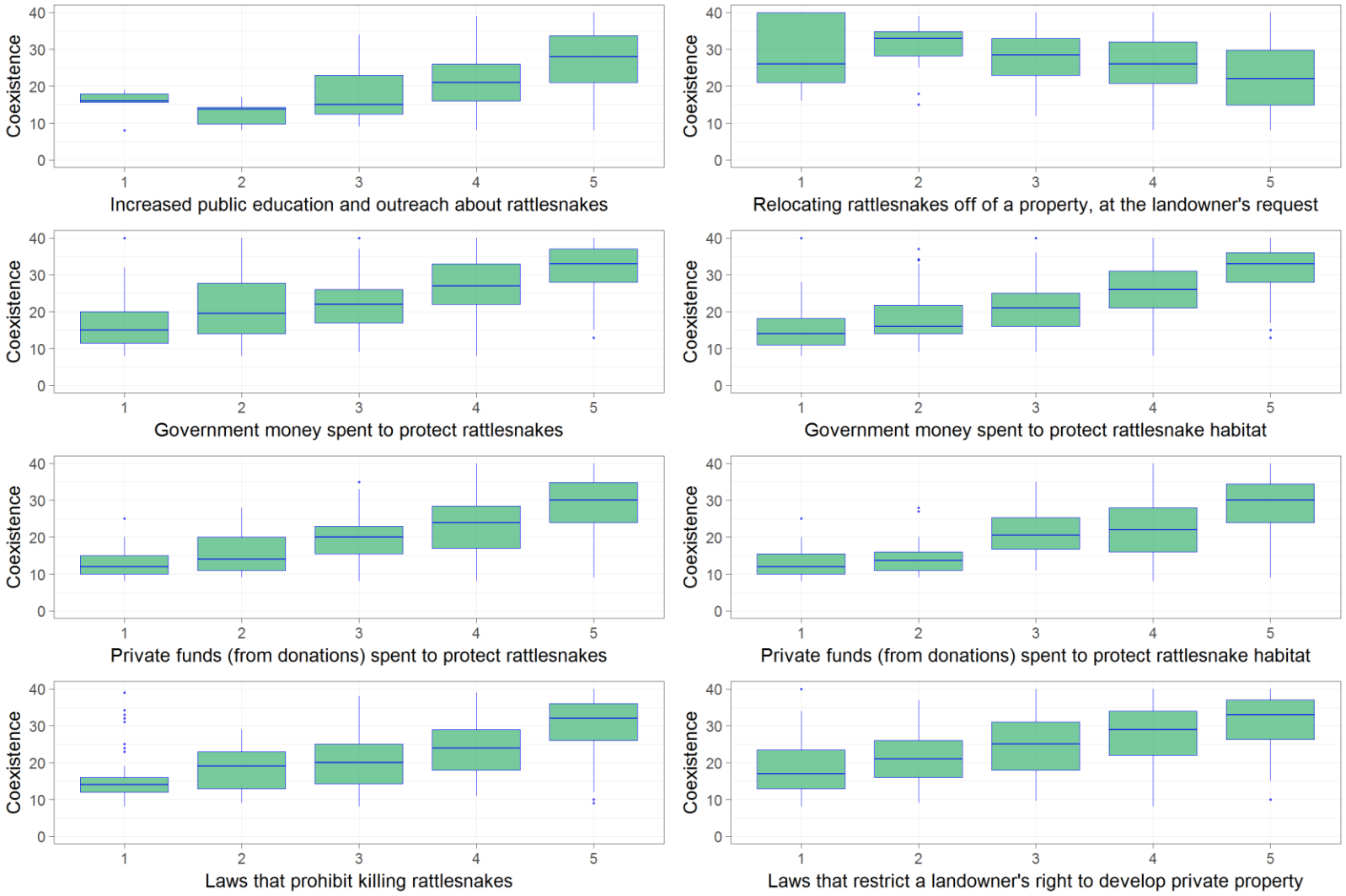

Figure 4.4. Boxplots of indicated level of agreement (5= Strongly agree, 4= Somewhat agree, 3= Unsure, 2= Somewhat disagree, 1= Strongly disagree) for each rattlesnake management strategy, as compared to scale-score representing attitudes toward rattlesnakes (*Coexistence).*

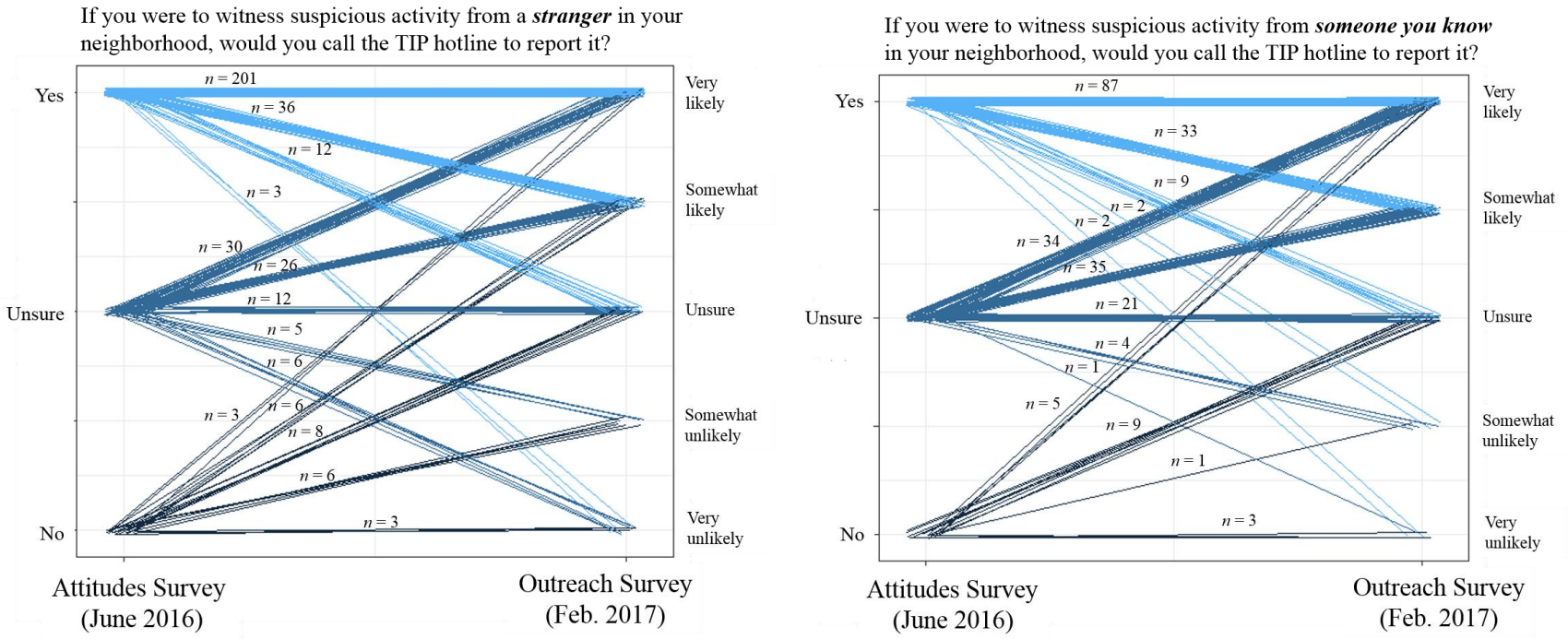

Figure 4.5. Survey respondent changes in answers to the questions regarding use of the TIP hotline to report potential rattlesnake poaching activity, from the Attitudes Survey to the Outreach Survey (mailed eight months apart).

Chapter 5: Conclusion

The goal of this research study was to evaluate human factors that may impact timber rattlesnake persistence in central Connecticut. I used data from two mail surveys and informational outreach to describe attitudes and behaviors toward rattlesnakes, map the spatial distribution of attitudes in relation to rattlesnake habitat, and evaluate the utility of mailed information in reducing concern about rattlesnake encounters and promoting non-detrimental behaviors toward rattlesnakes. My research findings have implications for *who* residents in this area are, in terms of perceptions about rattlesnakes, *where* wildlife managers should target management efforts, and *how* and *what* information should be distributed about rattlesnakes in this area.

My results provided quantitative support for the idea that residents in this area demonstrate attitudes supporting general coexistence with timber rattlesnakes. Results of Chapter 2 suggest that attitudes toward rattlesnakes in this area were more neutral or favorable, rather than outright hostile. Attitudes were best predicted by variables directly related to rattlesnakes in the area, such as risk perception, stakeholder acceptance capacity, experiences related to rattlesnakes, and knowledge of rattlesnake role in the ecosystem. Results also suggested that attitudes toward timber rattlesnakes may be better predicted by species-specific variables than general wildlife value orientations. Behavioral intentions toward timber rattlesnakes, including support for most management strategies, were influenced by attitudes toward the species. These findings indicate that many residents of this area may be interested in cooperating with wildlife managers in pursuit of timber rattlesnake management strategies. Managers could work to ensure that residents in this area with more neutral or negative attitudes are well-informed regarding timber rattlesnake ecology, life history, and status.

Results of Chapter 3 suggest that attitudes toward timber rattlesnakes spatially exist in three significant clusters. Underlying causes of attitude clusters may include social contagion effects or similarity in level of familiarity or experiences related to rattlesnakes. Wildlife managers can use knowledge of these cluster locations to create targeted management strategies, which may be particularly beneficial given limited resources. Informational outreach related to timber rattlesnakes may be effective management for some neighborhoods, while residents in other areas may be amenable to private property conservation actions. Furthermore, I found some evidence that some residents who exhibit attitudes scale scores suggesting coexistence with the species may have experienced more encounters with timber rattlesnakes. Additional research can provide further information on linkages between attitudes toward rattlesnakes, distance lived from rattlesnake habitat, and actual experiences with rattlesnakes.

In Chapter 4, I evaluated support for rattlesnake management strategies in this area and assessed the utility of providing information about rattlesnakes to residents. While in-person programs have been found to have great benefits for species management, a small proportion of study participants indicated a willingness to attend such programs. However, study participants were receptive to mailed information. This may be a simple, cost-effective way to increase knowledge of this species. Such outreach may include information on responding to an unexpected rattlesnake encounter and who to call for assistance, if necessary (i.e., requesting a volunteer to relocate the snake off of private property). I suggest that such outreach information be clear in communicating desired behaviors of residents. For example, leaving the snake alone may be the desired behavior in many situations, yet leaving a snake in a roadway may actually contribute to mortality. Results also suggested that participants were generally unaware of the TIP hotline. Given this information, many participants indicated that they would call it to report

potential rattlesnake poaching activity. Utilizing willing residents in this area as a type of community watch may help deter rattlesnake poaching.

This research contributed to our knowledge of human dimensions of timber rattlesnake management in Connecticut. I intend for my results to guide wildlife managers in creating management strategies that help reduce rattlesnake mortalities and aid in maintaining timber rattlesnake populations in Connecticut.