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Trends in Human-wildlife Interactions as Related to Land Use and Human Density in Massachusetts

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TRENDS IN HUMAN-WILDLIFE INTERACTIONS AS RELATED TO LAND USE AND HUMAN DENSITY IN MASSACHUSETTS

A Thesis Presented

by

MICHAEL ALLEN HUGUENIN

Submitted to the Graduate School of the
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ABSTRACT

TRENDS IN HUMAN-WILDLIFE INTERACTIONS AS RELATED TO LAND USE AND HUMAN DENSITY IN MASSACHUSETTS

FEBRUARY 2015

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We conducted a study of human-wildlife interactions in Massachusetts, USA between April 2010 and May 2012. Our objectives were to (1) compile and summarize public-generated reports on human-wildlife interactions across Massachusetts; (2) evaluate reports based on species, public concerns, and seasonal distribution; and (3) evaluate public perceptions of human-wildlife interactions. We collected unsolicited reports of human-wildlife interaction submitted to the Massachusetts Division of Fisheries and Wildlife (MDFW) through phone calls, emails, and face-to-face communications from the public. We received 2,730 reports from 332 of 351 towns in Massachusetts regarding 76 different wildlife species ranging from moose (*Alces alces*) to honey bees (*Apis mellifera*). Coyotes (*Canis latrans*) (328, 12%), bears (*Ursus americanus*) (307, 11%), and foxes (*Vulpes vulpes* and *Urocyon cinereoargenteus*) (284, 10%) were the most common species reported. Property disturbance/damage was the most common report type (934, 35%), concern for the welfare of wildlife was the most common concern type (539, 24%), and the most common report and concern pairing (referred to as perception type) was reports of young/injured wildlife with a concern for the welfare of wildlife (279, 13%). We tested for differences in reporting rates of human-wildlife interactions among seasons (spring, summer, fall, and winter) and among 5 urban-suburban development categories (low, medium-low, medium, medium-high, high). The distribution of total animal report records were greater than expected for spring and for summer and less than expected for fall and for winter. The distribution of total animal report records were less than expected for low and medium-low development categories, and greater than expected for medium, medium-high, and high development categories. We then conducted multiple regression analyses to examine how total reports of human-wildlife interactions, as well as reports of human and species-specific interactions (coyotes, foxes, bears, fishers (*Martes pennanti)*, and birds of prey) related to median home value and landscape composition and configuration. Total reports and reports of coyote, fox, and fisher were correlated with our model.

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CHAPTER 1

HUMAN-WILDLIFE INTERACTIONS AS REPORTED BY THE PUBLIC IN MASSACHUSETTS

1.1 Introduction

Interactions between humans and wildlife occur in various forms and at varying degrees throughout the world. Interactions range from being very positive and gratifying to completely negative, which are alternatively referred to as conflicts. Conover (2002) defined wildlife conflicts as an action by humans (e.g., conversion of wildlife habitat) or wildlife (e.g., depredation or property damage) that has a negative impact on the other. Many people are aware of human impacts on threatened and endangered species (Vitousek et al. 1997, Lotze and Milewski 2004), but some may not consider human activity with regards to more abundant species. In reality, the actions of humans can have a profound effect on wildlife regardless of the species' population status. For example, altering or eliminating habitat and providing artificial food sources can change the distribution and behavior of common or abundant species. According to Vogel (1989), species composition, density, and behavior of deer in Montana changed in some areas where housing density increased. Vogel (1989) also suggested that this may not be a direct result of housing density, but of the tendency to develop houses on more fertile land. Therefore, some species may adapt (by decreasing home range size) in order to continue utilizing more productive habitats, which can translate into a negative interaction with humans through unwanted encounters, depredation, and property damage.

Some adjustments in wildlife behavior may not always result in negative interactions with humans, but the behavioral changes may pose problems for the (localized) wildlife population itself. For instance, species that tend to be more diurnal in rural settings can become crepuscular or fully nocturnal in response to human daytime activity (particularly in urban and suburban settings), which could have a considerable impact on diet and reproduction (Ditchkoff et al. 2006). In fact, temporal adjustments by large predators, such as coyotes and bobcats (Latin names presented in Table 2) living in urban ecosystems, have been reported by McClennen et al. (2001), Tigas et al. (2002), and Riley et al. (2003). Temporal adjustments by large predators are examples of not only the impact that human-dominated landscapes can have on wildlife behavior, but the adaptability of these species.

The adaptability of certain wildlife species coupled with an ever-growing and changing human population has set the stage for many human-wildlife interactions in both urban and rural settings. Massachusetts has a very diverse and dynamic landscape and is the third most densely human populated state in the country (U.S. Census Bureau 2010). Massachusetts is composed of large, densely populated cities, juxtaposed by growing suburban developments, contrasted by rural communities with much lower human population densities. In general, a gradient exists across Massachusetts, from high human densities and development in the east (the city of Boston and its surrounding suburbs) to lower human densities and development toward the west. In addition, smaller but similar sub-gradients emanate from other population centers located throughout the state like the cities of Worcester, Springfield, and Pittsfield. Human-wildlife interactions occur across these urban-rural gradients and sub-gradients. Some of these interactions are reported by the public to wildlife organizations and management agencies. In general, reports of interactions fluctuate based on location, time of year, distribution and behavior of the particular wildlife species, and the level of interaction at which an individual from the public is willing to tolerate.

The concept known as wildlife acceptance capacity (WAC; Decker and Purdy 1988) is defined as the maximum wildlife population in an area that is acceptable to people. WAC has since been referred to as wildlife stakeholder acceptance capacity (Riley and Decker 2000, Decker et al. 2001) and was previously introduced as social carrying capacity (Hendee et al. 1978). In contrast, biological carrying capacity (BCC) is a concept commonly defined by seasonal variation, wildlife behavior, and the availability of food, water, habitat, and other resources (Caughley 1977). In most areas of North America, WAC rarely coincides with that of BCC, and this is particularly true in many parts of Massachusetts. As Decker and Purdy (1988) described it, WAC can be thought of as a number that likely is more unstable than BCC within a given time and place due to the factors that impact it. Wildlife acceptance capacity is mainly defined by a particular constituency for an individual species at any place and time. In many cases involving abundant or overabundant animals (McShea et al. 1997), WAC is likely much more conservative than BCC (i.e., far fewer animals are tolerated by humans than the environment can typically support).

Understanding the factors that contribute to human-wildlife interactions and conflicts are essential for management. To that end, human dimensions specialists often conduct surveys, focus groups, or interviews to gather information on a variety of human-wildlife issues (Connelly et al. 2012). The subjects involved in these studies can be random samples of the public or targeted audiences or stakeholder groups. Another, and perhaps under-utilized, source of information, however, involves unsolicited responses of the public; i.e., individuals who volunteer information, contact a wildlife agency, or are otherwise motivated to take the initiative to make an inquiry or report some information regarding an interaction with wildlife. Most if not all state wildlife agencies receive unsolicited inquiries on a daily basis, and many agencies keep track of this information. The Massachusetts Division of Fisheries and Wildlife (MDFW) has been doing so for the past several decades.

Massachusetts, with its high human population, extensive infrastructure, well developed urban-rural gradients and sub-gradients, and evolving public attitudes about wildlife conservation and management, serves not only as an example of an urban-suburban environment but perhaps as a model for future conditions in other states and regions of the country. For these reasons, we thought it would be interesting and important to summarize and analyze the information on human-wildlife interactions (both positive and negative) that individual residents thought were important enough to warrant contacting MDFW. Our objectives were to (1) compile and summarize public-generated reports on human-wildlife interactions across Massachusetts; (2) evaluate these reports based on species, public concerns, seasonal distribution, and other report characteristics; and (3) evaluate the relationship between reports of human-wildlife interactions and the concerns associated with those reports. Our scope of inference was limited to those reports submitted by the public to MDFW and did not expand to the general public as a whole.

1.2 Study Area

Our study was conducted throughout the Commonwealth of Massachusetts (2,428,113 ha) (Fig. 1). We divided our study area into 351 sampling units, which follow the boundaries of the 351 cities and towns that comprise Massachusetts. Data were collected by Massachusetts Division of Fisheries and Wildlife (MDFW) staff at the MDFW field headquarters (Westborough, MA) and at the 5 MDFW district offices which are located throughout the state (Bourne, Ayer, West Boylston, Belchertown, and Dalton) (Fig. 1).

Human population density in Massachusetts during this study was 329 people/km^2 (ranging from 2.2 people/km^2 to 7,228.7 people/km^2 of town) (U.S. Census Bureau 2010), and road density averaged 2.7 linear km/km^2 (ranging from 0.37 km/km^2 to 13.7 km/km^2). According the landuse2005 layer in MassGIS (2012), Massachusetts has over 1.2 million ha of forest (ranging from 3.2 to 17,139 ha/town).

1.3 Methods

We summarized and examined reports of wildlife and human-wildlife interactions in Massachusetts, USA between April 2010 and May 2012. All reports analyzed for this study came via incoming unsolicited telephone calls, emails, and face-to-face communications from the public to MDFW staff. Data were collected on a standardized animal report data form modified from a previously used form by MDFW (Fig. 2). The modified animal report data form was developed in 2009 and was tested for one year prior to use in this study. The form was designed primarily to ensure data collected were not subjective. We accomplished this by providing a list of standard options from which to select for report type and concern type. We also trained staff on the use of the form prior to beginning data collection and periodically collected completed data sheets to ensure proper data collection. The animal report data form was also designed to collect a more robust dataset and to streamline data entry.

Data collectors were required to record the date of the report, species being reported, town the incident occurred in, incident or type of report, concern type associated with that incident, and the response given by the recorder. We recorded all reports regardless of species, and recorded the species reported without validating the individual identity of the actual species. We recorded data at the town level because of the concern that more specific data would not be provided consistently (e.g., some callers would be reluctant to give their street address). Also, when provided, we recorded the date of the incident. When the date of the incident was not provided, we recorded the date the report was submitted.

The section of the data sheet titled “Type of Report / Event” included the 26 most common and relevant reports, ranging from general reports to human attack. Before collecting these data we established 5 major categories for analysis and collapsed the 26 potential report types into: (1) general; (2) young/injured wildlife; (3) property disturbance/damage; (4) depredation; and (5) public safety (Table 1). The section titled “Caller’s Concern” was broken down as follows: (1) no concern; (2) concern for welfare of wildlife; (3) concern for property; (4) concern for pet/livestock safety; (5) concern for human health and safety; and (6) concern for human health and safety (children) (the latter two were combined into one category for analysis purposes). The “Caller’s Concern” section was meant to be filled out in concert with “Type of Report / Event”. A mark was placed in all applicable boxes for report type and concern type. Given that each record was a unique human-wildlife interaction, there were many possible combinations of report types, concern types and the combination report types as they relate to concern types.

We also developed a variable termed “perception type”. Specifically, perception type was the relationship between concern type(s) and the coinciding report type(s) for each record. Perception type was meant to provide insight into how an individual’s level of concern related to the interaction they experienced (e.g., a report type of general sighting with a concern for human health and safety; this combination may indicate that the individual’s perception of the interaction is positively skewed in that their level of concern was heightened in relation to a report type that may not warrant such an inflated concern).

We organized most species by individual type, but grouped other species when appropriate. Species were grouped in such circumstances where the detailed information required to distinguish one species from another was not consistently collected (e.g., squirrel, fox, duck, bird, etc).

Our analysis consisted of summarizing report type, concern type, perception type, species, and taxa. We summarized species and taxa by report type, concern type and perception type. Further, we summarized total reports, species, report type, concern type, and perception type by season (winter, spring, summer, and fall). Lastly, we performed a chi-squared test for goodness of fit to test for significant differences between expected number of records and observed number of records for each of the 4 seasons. Expected records were calculated as total records multiplied by the relative length of each season.

We tested the null hypothesis that the observed number of total records was not significantly different from expected ($\alpha < 0.05$) with the expected value based on the null hypothesis that records of human-wildlife interactions would have an equal chance of being reported regardless of season.

1.4 Results

We recorded 2,730 records in 332 of a possible 351 units (towns) (Fig. 3). Ninety-six percent (2,632) of all reports contained a town, 99% (2,708) contained a species, 98% (2,670) contained a report type, 82% (2,243) contained a concern type, and 81% (2,202) contained a perception type (a report type with a corresponding concern type).

We recorded 13 unique combinations of report types, with property disturbance/damage (934, 35%), young/injured wildlife (588, 22%), and general reports (577, 22%) being the most common (Table 2). We recorded 17 unique combinations of concern types, with concern for the welfare of wildlife (539, 24%), concern for public safety (502, 22%), and concern for property (329, 15%) being the most common concern types reported (Table 3). Of the 100 unique combinations of perception types recorded, the most common were reports of young/injured wildlife paired with a concern for the welfare of wildlife (279, 13%), reports of property disturbance/damage paired with a concern for public safety (245, 11%), and reports of property disturbance/damage paired with a concern for property (215, 10%).

Seventy-six species were recorded during this study; 34 mammals, 23 birds, 9 reptiles, 6 invertebrates, 3 fish, and 1 amphibian. Overall, the most common species were coyotes (328, 12%), bears (307, 11%), and both red foxes and gray foxes (284, 10%) (Table 4). We recorded 2,647 (97%) records of species containing a report type, 2,226 (82%) containing a concern type, and 2,185 (80%) records of species containing a perception type. We ranked the top 25 species by the top 8 report types (Table 5), by the top 8 concern types (Table 6), and by the top 5 perception types (Table 7). In each case, coyotes, foxes, and bears were among the top 3 species. Of the 2,647 records of species containing a report type, 1,920 (72%) were mammals, 625 (24%) were birds, 73 (3%) were reptiles, 15 (0.5%) were invertebrates, 6 (0.2%) were amphibians, and 5 (0.2%) were fish.

Among mammal reports, property disturbance/damage was the most common report type (779, 41%) followed by general reports (398, 21%) and young/injured wildlife (298, 16%). Reports of mammals regarding public safety was ranked 6th (64, 3%). Reports of birds mostly involved young/injured wildlife (275, 44%), property disturbance/damage (126, 20%), and general reports (123, 20%). The remaining 16% of bird reports were made up of 7 unique report types. Of the 73 reptile reports, 29 (40%) were general reports and 23 (32%) were reports of property disturbance/damage. Most reptile reports involved snakes (43, 59%), and turtles (including snapping turtles) (29, 40%) with one report of an alligator (general report type). The majority of snakes reported were categorized as general (19, 44%) and property disturbance/damage (14, 33%). Forty percent (6) of all reports of invertebrates involved bees and 3 (20%) were of jellyfish.

Total reports by season were 37% (1,008) in spring, 38% (1,028) in summer, 13% (357) in fall, and 12% (326) in winter. During summer and spring, bears ranked highest

(277, 14%) followed by foxes (248, 12%) and coyotes (207, 10%). During fall and winter, however, coyotes ranked highest (118, 17%) followed by birds of prey (44, 7%) and deer (39, 6%) (Fig. 4). Also, species diversity was greater during summer (60) and spring (54) than during fall (48) and winter (36).

We ranked the top 8 report types (Fig. 5), the top 8 concern types (Fig. 6), and the top 15 perception types (Fig. 7) by season. Property disturbance/damage was the highest ranked report type for spring (402, 40%), summer (331, 32%), and fall (114, 32%) and general report was the highest ranked report type for winter (90, 28%). Of the 934 reports of property disturbance/damage, 43% (402) were in spring, 35% (331) were in summer, 12% (114) were in fall, and 9% (84) were in winter. Concern for welfare of wildlife was the highest ranked concern type for summer (227, 26%) and fall (71, 25%), concern for public safety was the highest ranked concern type for spring (215, 26%), and no concern was the highest ranked concern type for winter (67, 25%). Of the 539 records of concern for welfare of wildlife, 42% (227) were in summer, 32% (173) were in spring, 13% (71) were in fall, and 12% (64) were in winter. Reports of young/injured wildlife paired with a concern for the welfare of wildlife was the highest ranked perception type for summer (123, 15%), property disturbance/damage paired with concern for human safety was the highest ranked perception type for spring (109, 14%), and general reports paired with no concern was the highest ranked perception type for both fall (40, 14%) and winter (43, 17%). Of the 279 reports of young/injured wildlife paired with concern for the welfare of wildlife, 44% (123) were in summer, 30% (84) were in spring, 13% (37) were in fall, and 12% (33) were in winter.

Data were collected for a total of 756 days. Collection days for each season were as follows: spring (212), summer (184), fall (182), and winter (178). The distribution of total animal report records were significantly greater than expected for spring ($\chi^2 (1) = 111.01$, $P < 0.001$) and for summer ($\chi^2 (1) = 284.22$, $P < 0.001$) and significantly less than expected for fall ($\chi^2 (1) = 176.14$, $P < 0.001$) and for winter ($\chi^2 (1) = 215.03$, $P < 0.001$) (Table 8).

1.5 Discussion

Our results show a wide diversity in reported interactions between humans and wildlife in Massachusetts. Reports to MDFW offices ranged from large mammalian predators to amphibians. Reports included both positive and negative reports ranging from general sightings to human attack, and from no concern to concern for public safety. With regard to the summaries provided in this study, it is important to consider that reports of interactions do not necessarily reflect actual interactions whether positive or negative. According to a public survey study conducted in the Northeast United States in 2012, the top 5 wildlife species that had caused Massachusetts respondents problems were deer, raccoons, skunks, squirrels, and coyotes (Duda et al. 2012). In contrast, our study showed that major predators clearly generated the highest report volume (coyotes, bears, foxes, birds of prey, and fishers) compared to other species. Perhaps this is the case because major predators in Massachusetts evoke more emotions (e.g., fear or anger) in people, driving them to seek out professional advice and assistance, or maybe they are actually involved in more human-wildlife interactions. After all, the most common report type was reports of property disturbance/damage (e.g., denning or nesting on property, feeding on personal property, seen using residential areas, etc.) with coyotes, bears, and foxes as the top 3 species. Reports of young/injured wildlife (the next most common report type) were associated with several of the other top ranked species (e.g., birds of prey, waterfowl, deer, and rabbits).

Bobcats and mountain lions ranked in the top 25 species reported, but with a much lower report volume than coyotes, bear, and foxes. Mountain lion reports are interesting because no single mountain lion has been confirmed by MDFW staff in Massachusetts in decades. The most dominant associated report type for mountain lions was of general sighting and most dominant concern type was of no concern, which follows the same general trend as bobcats. We suspect that most reports of mountain lions in Massachusetts are mistakenly identified bobcats. Bobcat population size obviously plays a big role in the frequency of reports, as bobcat behavior likely does. The behavior of bobcats as a shy and elusive species in Massachusetts also likely contributes to the associated report of general sighting and no concern. Bobcats may be less likely to exploit resources closely associated with humans, which results in fewer interactions. We also believe that the novelty and rarity of these sightings sets these reports (for both bobcat and mountain lion) apart from those predators most commonly reported, with respect to the associated report type and concern type. The enjoyment or novelty of seeing something rare may outweigh the perception of a potential negative interaction.

The perception type most reported was of young/injured wildlife paired with concern for welfare of wildlife. In general, relationships between report type and concern type were not highly skewed (e.g., most reports of young/injured wildlife had an associated concern for the welfare of wildlife). The highest ranked perception type that showed a skewed relationship between the type of report and type of concern was the combination of report of property disturbance/damage with a concern for public safety. That being said, this perception category was the most common for the top three ranked species (coyotes, foxes, and bears). It seems understandable that predatory species would dominate such a perception category given that some people may have more of a tendency to fear them, particularly when the animal is on their property and causing damage.

We found a clear seasonal trend in human-wildlife interaction reports to MDFW. We received 2-3 times as many reports in either summer or spring than that of winter or fall. We also received a higher diversity of species in summer and spring compared to fall and winter. Part of the reason interactions and species are reported less can certainly be attributed to the fact that some species are not here (migratory birds) or are simply not wondering the landscape as much in late fall and winter (bears). We certainly saw this trend maintained for many of the highest ranked species, particularly for coyote, bear, and fox. Lukasik and Alexander (2011) found similar results with regards to coyote conflicts in Calgary. In contrast to this, Poessel et al. (2013) found that reports of coyote conflicts were highest in the winter months in the Denver metropolitan area of Colorado. They hypothesize that this trend may be the result of food availability, territorial aggression toward other canids during the breeding season, or perhaps that human activity during the winter months was more likely to coincide with crepuscular coyote activity patters. We believe our findings that reports of coyote, fox, and bear disturbing/damaging property mostly during the summer and spring suggest that interactions with humans are due to (1) the highly visible young-rearing months; (2) a higher frequency of outdoor human activity during warmer months; or (3) more daytime activity during these months and in certain regions by these species.

Given the definition of wildlife acceptance capacity (WAC) provided by Decker and Purdy (1988), human experience, education level, cultural background, location of residence, and property values may be a few of the social factors that define WAC. In other words, human perception of and experience with or exposure to wildlife may influence acceptance levels. For example, the results of a public survey conducted in Massachusetts shows that those who had problems with wildlife indicated a higher level of concern about conflicts compared to those who did not have problems with wildlife (Duda et al. 2012). Metropolitan residents who saw themselves at risk of having a deer-vehicle collision or contracting Lyme disease were more likely to prefer a decrease in the deer population than those that did not have the same experiences (Stout et al. 1993). In the rural Pine Barrens of Wisconsin, Clendenning et al. (2005) found that permanent residents placed more importance on managing for hunting opportunities than did seasonal residents, but found no difference in attitudes toward endangered species protection and wilderness values.

Aside from human perception, landscape composition and configuration may contribute to human-wildlife interactions. Krester et al. (2008) showed that housing density in northern New York was an important indicator of concentrations of reported human-wildlife interactions, such that higher concentrations of interactions occur at intermediate levels of development. Certain wildlife species may adjust behavior based on habitat and resource availability. Buroch-Mordo et al. (2008) showed high spatial clustering of black bear-human conflicts for land cover type and by conflict type in Colorado.

There are likely countless variables required to fully explain human-wildlife interactions in Massachusetts, including both human demographic data and spatial data. It seems that further analyses that include a combination of demographic and landscape variables may prove useful in revealing patterns in reported human-wildlife conflicts.

TABLES

Table 1.1 The "Original Report Types" column represents each of the report types available for selection from the Animal Report Data Form used by the Massachusetts Division of Fisheries and Wildlife to collect unsolicited reports from the public regarding wildlife interactions. The original report types were then placed into 5 condensed categories ("Condensed Report Types") for analysis purposes.

Original Report Types	Condensed Report Types
Seeking general info	General
Report illegal activity	
Animal sighting or vocalization	
Feeding on naturally available food sources	
Using other/recreational/natural areas	
Young wildlife	Young/injured wildlife
Vehicle collision/roadkill	
Exhibiting signs of disease/injury	
Mortality from disease/injury	
Other or unknown mortality	
Feeding on personal property	Property disturbance/damage
Flooding (beaver)	
Denning/nesting on, in, or under property	
Using residential, business, school area	
Other property damage (public or private)	
Crop damage (agricultural)	Depredation
Missing pet/livestock	
Aggression toward pet	
Attack on livestock - witnessed	
Attack on livestock - not witnessed	
Attack on pets - witnessed	
Attack on pets - not witnessed	
Found inside home, business, school, etc.	Public safety
Approaching humans/pets on leash	
Aggression toward humans	
Human attack	

Table 1.2 List of each report type and combination of report types along with the total number of records recorded for each report type submitted by the public to the Massachusetts Division of Fisheries and Wildlife between April 2010 and May 2012. The list is sorted from highest to lowest based on total records.

Report Type	Total	% of total
Property disturbance/damage	934	35
Young / injured wildlife	588	22
General	577	22
Young / injured wildlife and property disturbance / damage	190	7
Depredation	139	5
Public Safety	96	4
Property disturbance/damage and public safety	72	3
Property disturbance/damage and depredation	35	1
Young/injured wildlife, prop. disturbance/damage, public safety	12	<1
Young/injured wildlife and public safety	12	<1
Depredation and public safety	9	<1
Property disturbance/damage, depredation, and public safety	4	<1
Young/injured wildlife, prop. disturbance/damage, depredation	2	<1
Total	2670	100

Table 1.3 List of each concern type and total number of records recorded for each concern type submitted by the public to the Massachusetts Division of Fisheries and Wildlife between April 2010 and May 2012. The list is sorted from highest to lowest based on total records.

Concern Type	Total	% of total
Welfare of wildlife	539	24
Public safety	502	22
Property	329	15
No concern	282	13
Pets/livestock and public safety	176	8
Pets/livestock	171	8
Property and public safety	86	4
Welfare of Wildlife and public safety	84	4
Welfare of wildlife and pets/livestock	16	1
Property and pets/livestock	15	1
Welfare of wildlife and property	13	1
Property, pets/livestock, and public safety	11	<1
Welfare of wildlife, pets/livestock, and public safety	7	<1
Welfare of wildlife, property, and public safety	4	<1
Welfare of wildlife, property, pets/livestock, and public safety	4	<1
Welfare of wildlife, property, and pets/livestock	3	<1
No concern and welfare of wildlife	1	<1
Grand Total	2239	100

Table 1.4 List of each species and total number of records for that species submitted by the public to the Massachusetts Division of Fisheries and Wildlife between April 2010 and May 2012. The list is sorted from high to low by total records then alphabetically by common name.

Species	Total	Species	Total
Coyote (*Canis latrans*)	328	Heron (*Ardea herodias*)	9
Bear (*Ursus americanus*)	307	Mouse (*Muridae* or *Cricetidae*)	9
Fox (*Vulpes vulpes* or *Urocyon cinereoargenteus*)	284	Porcupine (*Hystricomorph hystricidae*)	9
Bird of Prey (*Acciptridae*, *Cathartidae* or, *Falconidae*)	123	River Otter (*Lontra canadensis*)	8
Fisher (*Martes pennanti*)	123	Muskrat (*Ondatra zibethicus*)	7
Raccoon (*Procyon lotor*)	116	Amphibian (unknown species)	6
Beaver (*Castor canadensis*)	109	Bees (Vespidae or Apidae)	6
Woodchuck (*Marmota monax*)	106	Pheasant (*Phasianus colchicus*)	6
Canada Goose (*Branta canadensis*)	101	Pigeon (*Columba livia*)	6
Deer (*Odocoileus virginianus*)	98	Weasel (*Mustela frenata* or *Mustela erminea*)	4
Turkey (*Meleagris gallopavo*)	91	Animal (unknown species)	3
Waterfowl (Antidae)	77	Fish (unknown species)	3
Squirrel (*Sciurus carolinensis* or *Sciurus vulgaris*)	73	Jellyfish (unknown species)	3
Bird (unknown species)	72	Mink (*Mustela vison*)	3
Bobcat (*Lynx rufus*)	71	Raven (*Corvus corax*)	3
Skunk (*Mephitis mephitis*)	63	Asian Long-horned Beetle (*Anoplophora glabripennis*)	2
Bats (Chiroptera)	52	Beetle (unknown species)	2
Mountain Lion (*Puma concolor*)	52	Cat (*Felis domesticus*)	2
Eagle (*Haliaeetus leucocephalus*)	48	Copperhead (*Agkistrdon contortrix*)	2
Swan (*Cygnus olor*)	43	Cormorant(*Phalacrocorax auritus*)	2
Rabbit (*Sylvilagus floridanus* or *Sylvilagus transitionalis*)	38	Grouse (*Bonasa umbellus*)	2
Moose (*Alces alces*)	37	Peacock (unknown species)	2
Snake (unknown species)	37	Rattlesnake (*Crotalus horridus*)	2
Crow (*Corvus brachyrhnchos* or *Corvus ossifiragus*)	21	Wild Boar (*Sus scrofa*)	2
Turtle (unknown species)	20	Alligator (*Alligator mississippiensis*)	1
Opossum (*Didelphis virginiana*)	18	Badger (*Taxidea taxus*)	1
Woodpecker (Picidae)	17	Box Turtle (*Terrapene carolina*)	1
Flying Squirrel (*Glaucomys volans*)	13	Chicken (*Gallus gallus domesticus*)	1
Wolf (*Canis lupus*)	13	Darter (Percidae)	1
Snapping Turtle (*Chelydra serpentina*)	12	Domestic Geese (*Anser anser domesticus*)	1
Chipmunk (*Tamias striatus*)	11	Emu (*Dromaius novaehollandiae*)	1
Gull (unknown species)	11	Insect (unknown species)	1

Kingfisher (*Ceryle alcyon*)	1	Shrew (Soricidae)	1
Mole (Talpidae)	1	Snow Geese (*Chen caerulescens*)	1
Quail (*Colinus virginianus*)	1	Spider (unknown species)	1
Rat (*Rattus norvegicus*)	1	Spotted turtle (*Clemmys guttata*)	1
Rodent (unknown species)	1	Sturgeon (*Acipenser oxyrhynchus*)	1
Sea turtle (unknown species)	1	Vole (*Microtus pennsylvanicus* or *Microtus pinetorum*)	1
		Grand Total	2708

Table 1.5 Top 25 species by the top 8 report types and the total number of records recorded for each of the species by each of the report types submitted by the public to the Massachusetts Division of Fisheries and Wildlife between April 2010 and May 2012. The list is sorted from highest to lowest based on the total number of records for each species (percentages in parentheses) that also had a report type associated with it. Percentages based on number of records within each report type by the total for that species.

Species	Total records	Property disturb/ damage	Young / injured	General	Pets/livestock & Public safety	Depredation	Public Safety	Property disturb/ damage & public safety	Property disturb/ damage& depredation
Coyote	316	119 (37)	34 (11)	47 (15)	25 (8)	44 (14)	20 (6)	8 (3)	9 (3)
Bear	301	139 (46)	22 (7)	78 (26)	14 (5)	20 (7)	7 (2)	10 (3)	5 (2)
Fox	278	126 (45)	42 (15)	25 (9)	54 (19)	11 (4)	8 (3)	1 (<1)	3 (1)
Bird of Prey	121	11 (9)	63 (52)	14 (12)	11 (9)	4 (3)	8 (7)	5 (4)	3 (2)
Fisher	118	53 (45)	9 (8)	32 (27)	1 (1)	17 (14)	2 (2)	1 (1)	2 (2)
Raccoon	115	52 (45)	30 (26)	3 (3)	11 (10)	0 (0)	5 (4)	7 (6)	1 (1)
Beaver	108	72 (67)	4 (4)	27 (25)	1 (1)	0 (0)	1 (1)	1 (1)	2 (2)
Woodchuck	103	78 (77)	6 (6)	3 (3)	7 (7)	6 (6)	1 (1)	0 (0)	2 (2)
Canada goose	98	27 (28)	48 (49)	10 (10)	2 (2)	7 (7)	2 (2)	1 (1)	1 (1)
Deer	97	13 (13)	53 (55)	8 (8)	7 (7)	12 (12)	2 (2)	1 (1)	1 (1)
Turkey	91	30 (33)	16 (18)	10 (11)	7 (8)	1 (1)	12 (13)	14 (15)	1 (1)
Waterfowl	76	21 (28)	37 (49)	16 (21)	2 (3)	0 (0)	0 (0)	0 (0)	0 (0)
Squirrel	72	21 (29)	25 (35)	11 (15)	5 (7)	0 (0)	2 (3)	8 (11)	0 (0)
Bird	71	10 (14)	46 (65)	7 (10)	4 (6)	2 (3)	1 (1)	1 (1)	0 (0)
Bobcat	70	8 (11)	10 (14)	43 (61)	5 (7)	4 (6)	0 (0)	0 (0)	0 (0)
Skunk	63	37 (59)	11 (17)	7 (11)	6 (10)	0 (0)	0 (0)	0 (0)	2 (3)
Mt. Lion	52	5 (10)	1 (2)	41 (79)	2 (4)	2 (4)	0 (0)	1 (2)	0 (0)
Bats	50	11 (22)	6 (12)	17 (34)	1 (2)	0 (0)	10 (20)	3 (6)	0 (0)
Eagle	48	1 (2)	5 (10)	42 (88)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Rabbit	37	5 (14)	17 (46)	5 (14)	9 (24)	0 (0)	0 (0)	0 (0)	0 (0)
Snake	37	13 (35)	1 (3)	17 (46)	0 (0)	0 (0)	4 (11)	1 (3)	0 (0)

Moose	36	4 (11)	10 (28)	21 (58)	0 (0)	0 (0)	1 (3)	0 (0)	0 (0)
Swan	36	2 (6)	21 (58)	9 (25)	2 (6)	0 (0)	2 (6)	0 (0)	0 (0)
Crow	21	3 (14)	13 (62)	1 (5)	2 (10)	1 (5)	0 (0)	0 (0)	1 (5)
Opossum	18	6 (33)	8 (44)	2 (11)	1 (6)	0 (0)	1 (6)	0 (0)	0 (0)

Table 1.6 Top 25 species by the top 8 concern types and the total number of records recorded for each species by each of the concern types submitted by the public to the Massachusetts Division of Fisheries and Wildlife between April 2010 and May 2012. The list is sorted from high to low based on the total number of records for each species (percentages in parentheses) with an associated concern type. Percentages based on number of records within each report type by the total for that species.

Species	Total records	Welfare of wildlife	Public safety	Property	None	Pets/livestock & public safety	Pets/ livestock	Property & public safety	Welfare of wildlife & public safety
Coyote	292	15 (5)	82 (28)	13 (4)	28 (10)	81 (28)	50 (17)	9 (3)	7 (2)
Fox	248	19 (8)	107 (43)	9 (4)	12 (5)	30 (12)	29 (12)	4 (2)	24 (10)
Bear	231	24 (10)	80 (35)	34 (15)	29 (13)	9 (4)	10 (4)	23 (10)	11 (5)
Fisher	109	0 (0)	30 (28)	2 (2)	19 (17)	19 (17)	32 (29)	2 (2)	2 (2)
Raccoon	104	19 (18)	36 (35)	18 (17)	4 (4)	3 (3)	3 (3)	6 (6)	9 (9)
Bird of Prey	99	53 (54)	8 (8)	2 (2)	11 (11)	6 (6)	13 (13)	0 (0)	3 (3)
Woodchuck	94	8 (9)	13 (14)	51 (54)	2 (2)	3 (3)	4 (4)	9 (10)	2 (2)
Beaver	80	7 (9)	3 (4)	53 (66)	4 (5)	0 (0)	2 (3)	7 (9)	1 (1)
Turkey	79	24 (30)	20 (25)	18 (23)	2 (3)	3 (4)	0 (0)	5 (6)	3 (4)
Deer	76	43 (57)	3 (4)	12 (16)	9 (12)	2 (3)	1 (1)	1 (1)	3 (4)
Canada Goose	75	49 (65)	4 (5)	13 (17)	4 (5)	0 (0)	1 (1)	3 (4)	0 (0)
Squirrel	62	25 (40)	6 (10)	22 (35)	4 (6)	0 (0)	0 (0)	1 (2)	3 (5)
Waterfowl	61	48 (79)	1 (2)	3 (5)	7 (11)	0 (0)	0 (0)	0 (0)	0 (0)
Bobcat	60	3 (5)	11 (18)	3 (5)	32 (53)	0 (0)	5 (8)	0 (0)	0 (0)
Bird	55	39 (71)	3 (5)	7 (13)	3 (5)	1 (2)	1 (2)	1 (2)	0 (0)
Skunk	51	6 (12)	18 (35)	10 (20)	2 (4)	0 (0)	1 (2)	7 (14)	4 (8)
Bats	49	20 (41)	20 (41)	1 (2)	1 (2)	1 (2)	0 (0)	3 (6)	3 (6)
Eagle	36	6 (17)	0 (0)	0 (0)	30 (83)	0 (0)	0 (0)	0 (0)	0 (0)
Rabbit	34	25 (74)	1 (3)	5 (15)	3 (9)	0 (0)	0 (0)	0 (0)	0 (0)
Swan	33	27 (82)	3 (9)	2 (6)	1 (3)	0 (0)	0 (0)	0 (0)	0 (0)
Snake	30	2 (7)	16 (53)	0 (0)	6 (20)	4 (13)	0 (0)	0 (0)	2 (7)
Mt. Lion	29	1 (3)	4 (14)	1 (3)	15 (52)	3 (10)	5 (17)	0 (0)	0 (0)
Moose	25	4 (16)	2 (8)	2 (8)	14 (56)	1 (4)	1 (4)	0 (0)	1 (4)

Turtle	20	15 (75)	0 (0)	3 (15)	1 (5)	0 (0)	0 (0)	0 (0)	0 (0)

Table 1.7 List of the top 25 species by the top 5 perception types and the total number of records recorded for each species by each perception type submitted by the public to the Massachusetts Division of Fisheries and Wildlife between April 2010 and May 2012. Perception type is formatted as report type:concern type. The list is sorted from highest to lowest based on the total number of records for each species (percentages in parentheses) that also had a perception type associated with it. Percentages based on number of records within each report type by the total for that species.

Species	Total records	Young/injured wildlife: Welfare of wildlife	Property disturb/damage: Public safety	Property disturb/damage: Property	General: None	Young/injured wildlife: None
Coyote	284	6 (2)	36 (13)	5 (2)	13 (5)	12 (4)
Fox	245	9 (4)	64 (26)	6 (2)	4 (2)	9 (4)
Bear	227	6 (3)	49 (22)	19 (8)	17 (7)	6 (3)
Fisher	104	0 (0)	17 (16)	0 (0)	11 (11)	6 (6)
Raccoon	103	10 (10)	19 (18)	9 (9)	0 (0)	3 (3)
Bird of Prey	98	32 (33)	0 (0)	1 (1)	4 (4)	11 (11)
Woodchuck	91	3 (3)	10 (11)	45 (49)	0 (0)	2 (2)
Beaver	79	0 (0)	2 (3)	42 (53)	2 (3)	2 (3)
Turkey	79	9 (11)	4 (5)	14 (18)	1 (1)	1 (1)
Deer	75	26 (35)	0 (0)	4 (5)	1 (1)	9 (12)
Canada Goose	72	32 (44)	3 (4)	7 (10)	3 (4)	8 (11)
Squirrel	62	15 (24)	2 (3)	13 (21)	2 (3)	1 (2)
Bobcat	60	2 (3)	2 (3)	0 (0)	22 (37)	7 (12)
Waterfowl	60	27 (45)	1 (2)	3 (5)	3 (5)	2 (3)
Bird	55	32 (58)	1 (2)	5 (9)	2 (4)	2 (4)
Skunk	51	4 (8)	13 (25)	9 (18)	0 (0)	0 (0)
Bats	48	2 (4)	5 (10)	1 (2)	1 (2)	2 (4)
Eagle	36	3 (8)	0 (0)	0 (0)	30 (83)	1 (3)
Rabbit	34	15 (44)	0 (0)	4 (12)	3 (9)	0 (0)
Snake	30	0 (0)	7 (23)	0 (0)	6 (20)	0 (0)
Mt. Lion	29	0 (0)	1 (3)	1(3)	15 (52)	0 (0)
Swan	29	15 (52)	0 (0)	1 (3)	1 (3)	1 (3)

Moose	24	1 (4)	0 (0)	2 (8)	11 (46)	3 (13)
Turtle	17	5 (29)	0 (0)	0 (0)	1 (6)	0 (0)
Crow	16	3 (19)	0 (0)	0 (0)	0 (0)	2 (13)

Table 1.8 Total records submitted by the public to the Massachusetts Division of Fisheries and Wildlife between April 2010 and May 2012 relative to seasonal variation over the same time period. Expected records are calculated by multiplying proportion of total days for each season by $n = 2719$. The p value represents whether observed records are significantly different from expected records for each season ($\alpha < 0.05$).

Season	Total days	Proportion of total days	Expected records	Observed records	Proportion observed	p value
Fall	182	0.241	655	357	0.131	< 0.001
Spring	212	0.280	762	1008	0.371	< 0.001
Summer	184	0.243	662	1028	0.378	< 0.001
Winter	178	0.235	640	326	0.120	< 0.001
Total	756	1.000	2719	2719	1.000	

FIGURES

Figure 1.1 Study area is the state of Massachusetts. Reports from the public of human-wildlife interaction data were collected at Massachusetts Division of Fisheries and Wildlife district offices and field headquarters from April 2010 to May 2012.

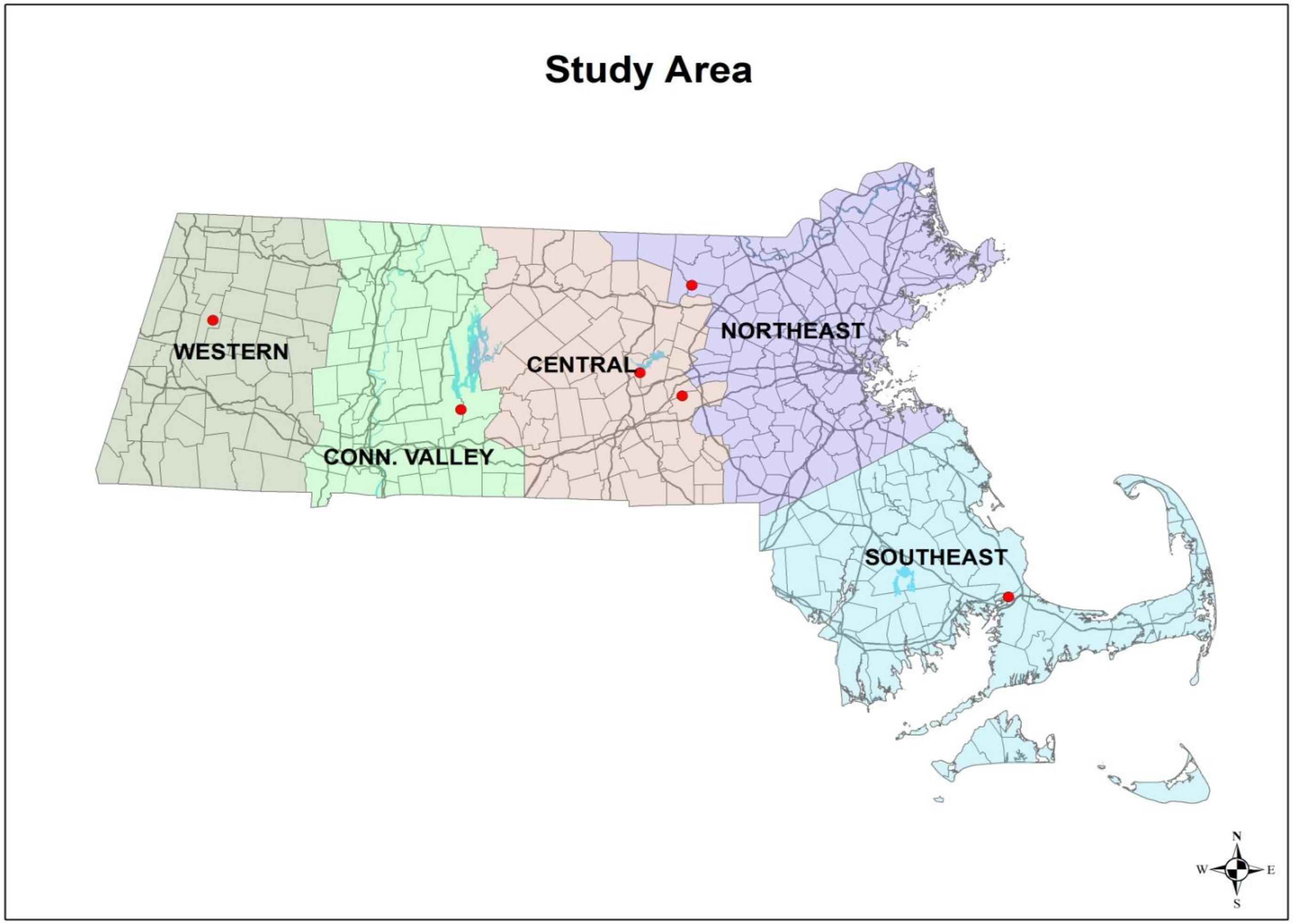
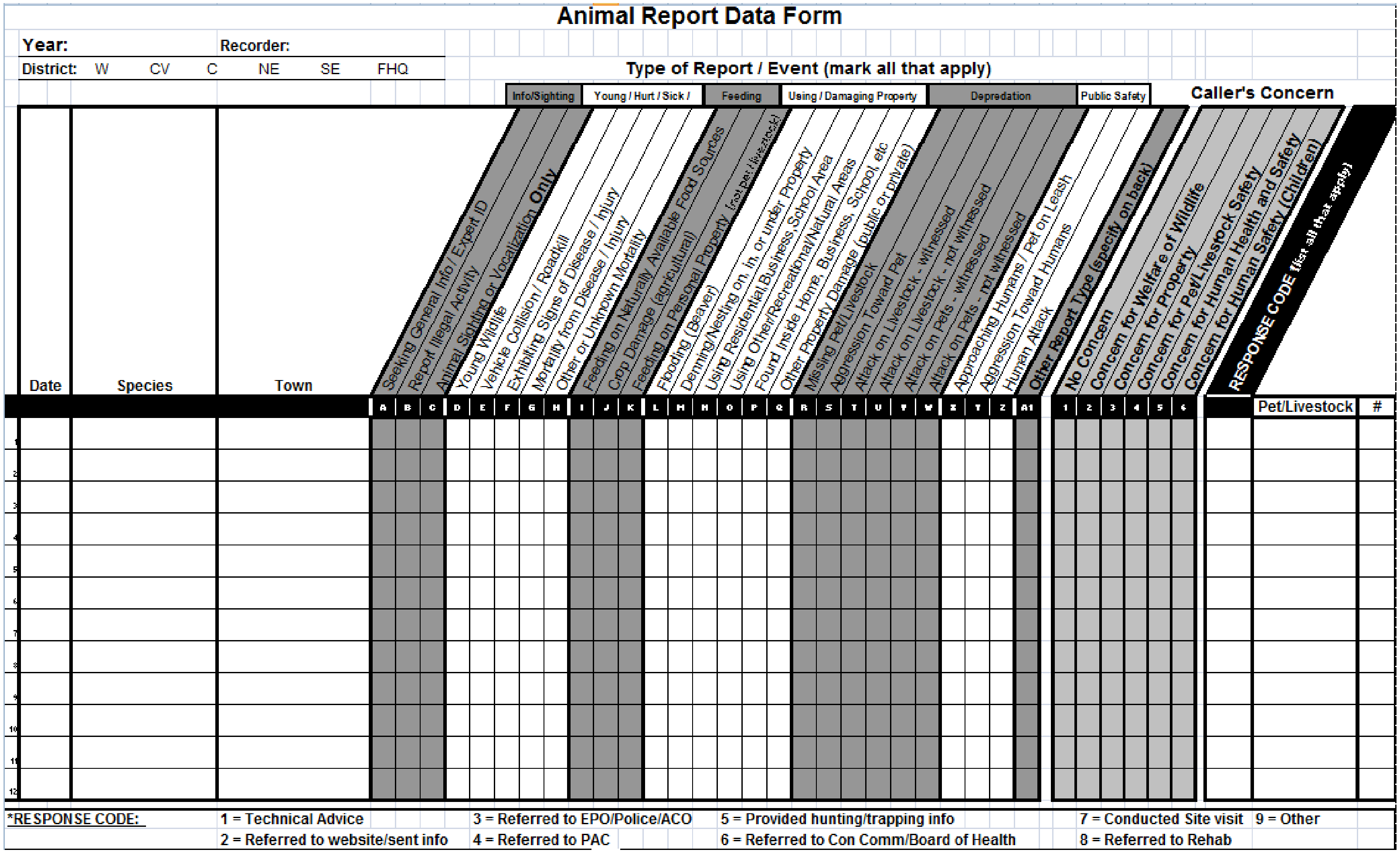


Figure 1.2 Animal report form. Unsolicited reports from the public of wildlife interactions collected by the Massachusetts Division of Fisheries and Wildlife. The form is broken down by date, species, town, type of report, and concern type. All other data collected on this form was considered supplemental and not used to analyze data for this study.



Animal Report Data Form

Year: Recorder:

District: W CV C NE SE FHQ

Type of Report / Event (mark all that apply)

Caller's Concern

Date | Species | Town

Info/Sighting:
- A Seeking General Info / Expert ID
- B Report Illegal Activity
- C Animal Sighting or Vocalization **Only**

Young / Hurt / Sick /:
- D Young Wildlife
- E Vehicle Collision / Roadkill
- F Exhibiting Signs of Disease / Injury
- G Mortality from Disease / Injury
- H Other or Unknown Mortality

Feeding:
- I Feeding on Naturally Available Food Sources
- J Crop Damage (agricultural)
- K Feeding on Personal Property (not pet / livestock)

Using / Damaging Property:
- L Flooding (Beaver)
- M Denning/Nesting on, in, or under Property
- N Using Residential Business, School Area
- O Using Other/Recreational/Natural Areas
- P Found Inside Home, Business, School, etc
- Q Other Property Damage (public or private)

Depredation:
- R Missing Pet/Livestock
- S Aggression Toward Pet
- T Attack on Livestock - witnessed
- U Attack on Livestock - not witnessed
- V Attack on Pets - witnessed
- W Attack on Pets - not witnessed

Public Safety:
- X Approaching Humans / Pet on Leash
- Y Aggression Toward Humans
- Z Human Attack

- A1 Other Report Type (specify on back)

Caller's Concern:
- 1 No Concern
- 2 Concern for Welfare of Wildlife
- 3 Concern for Property
- 4 Concern for Pet/Livestock Safety
- 5 Concern for Human Health and Safety
- 6 Concern for Human Safety (Children)

RESPONSE CODE (list all that apply) | Pet/Livestock | #

1
2
3
4
5
6
7
8
9
10
11
12

*RESPONSE CODE:
1 = Technical Advice
2 = Referred to website/sent info
3 = Referred to EPO/Police/ACO
4 = Referred to PAC
5 = Provided hunting/trapping info
6 = Referred to Con Comm/Board of Health
7 = Conducted Site visit
8 = Referred to Rehab
9 = Other

Figure 1.3 Density (reports per square kilometer of town/sample unit) of total unsolicited reports from the public of wildlife interactions in Massachusetts from April 2010 to May 2012 as collected by the Massachusetts Division of Fisheries and Wildlife.

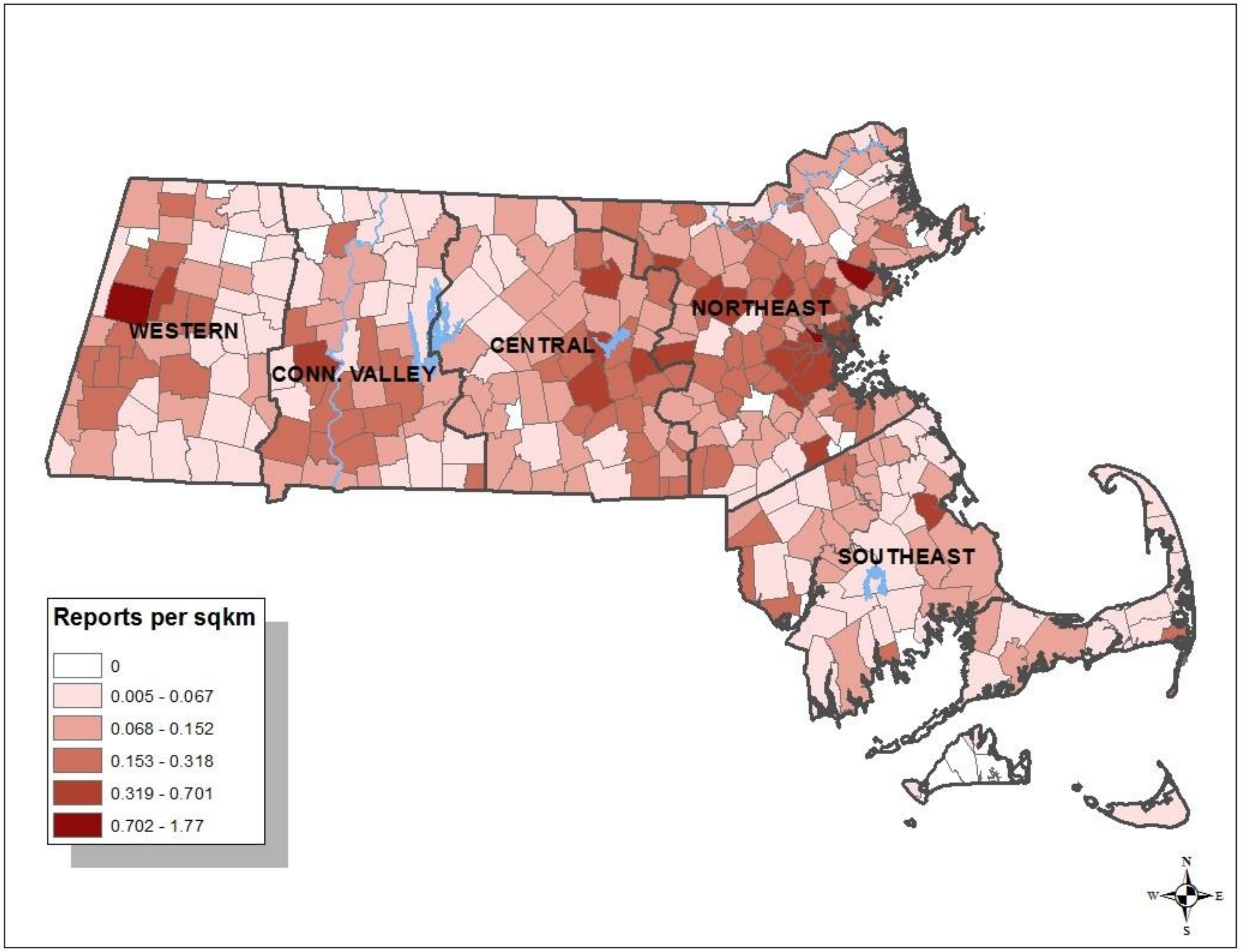


Figure 1.4 Top 25 ranked species reported by the public to the Massachusetts Division of Fisheries and Wildlife from April 2010 to May 2012 presented seasonally.

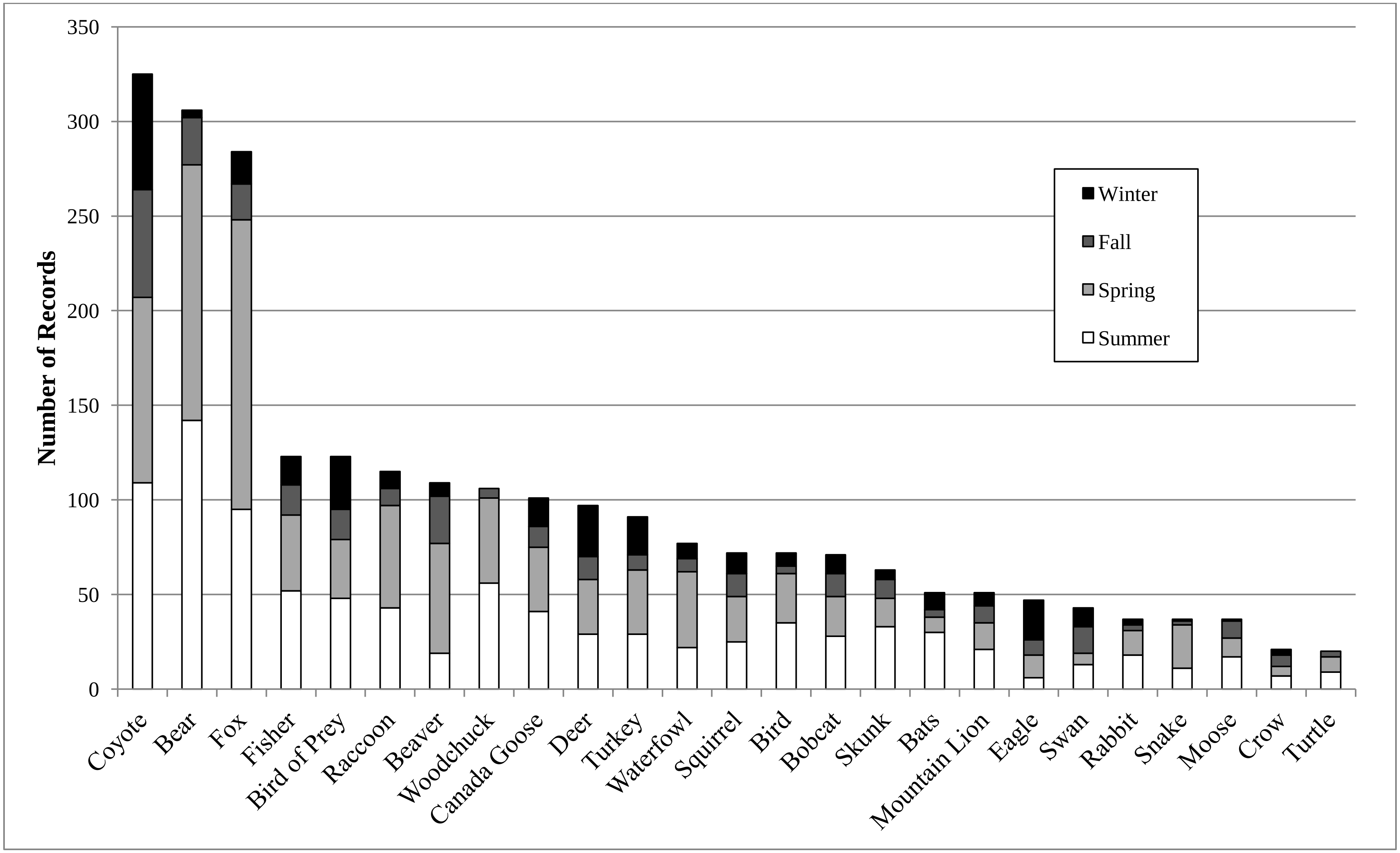


Figure 1.5 Top 8 ranked report types reported by the public to the Massachusetts Division of Fisheries and Wildlife from April 2010 to May 2012 presented seasonally.

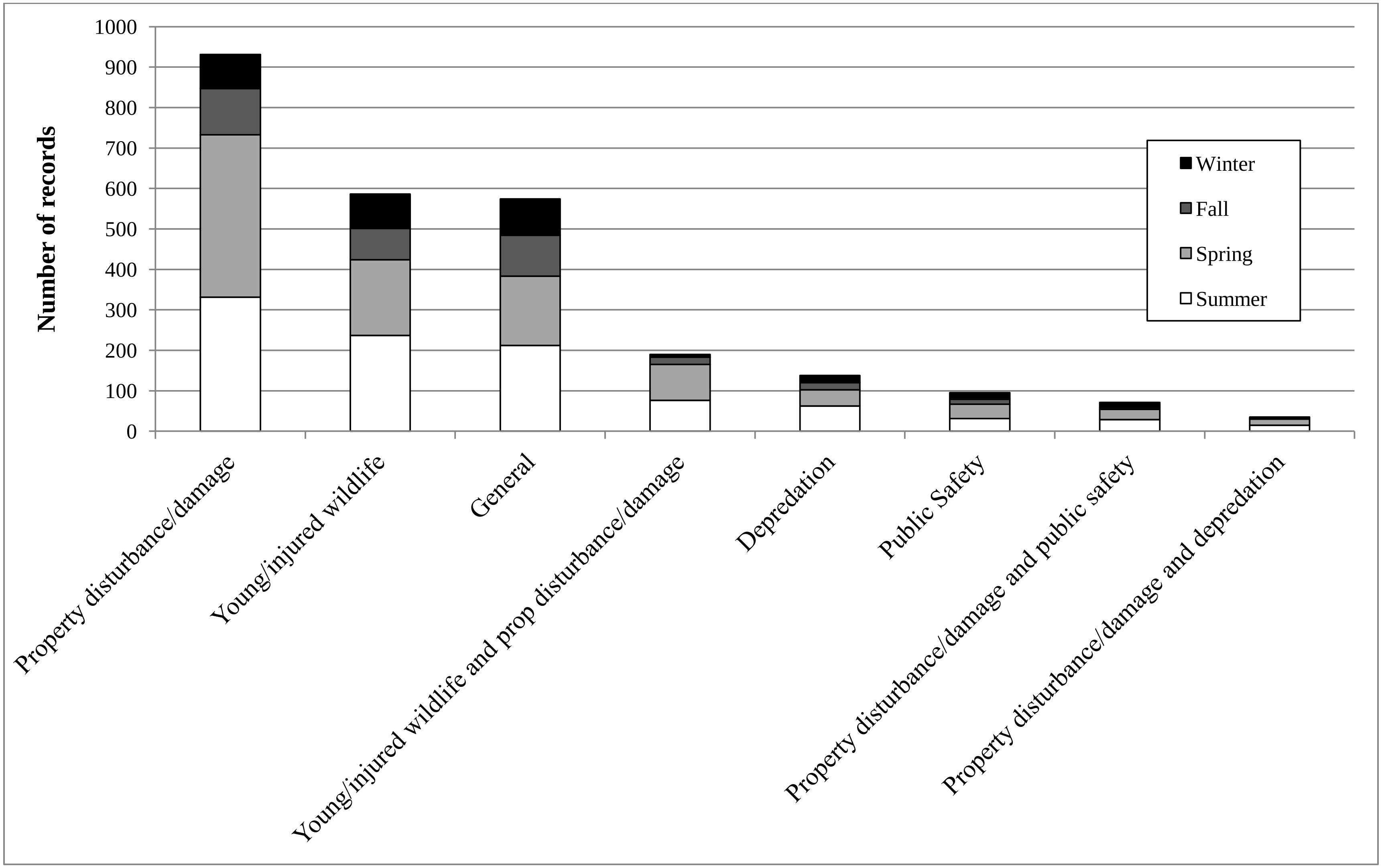


Figure 1.6 Top 8 ranked concern types reported by the public to the Massachusetts Division of Fisheries and Wildlife from April 2010 to May 2012 presented seasonally.

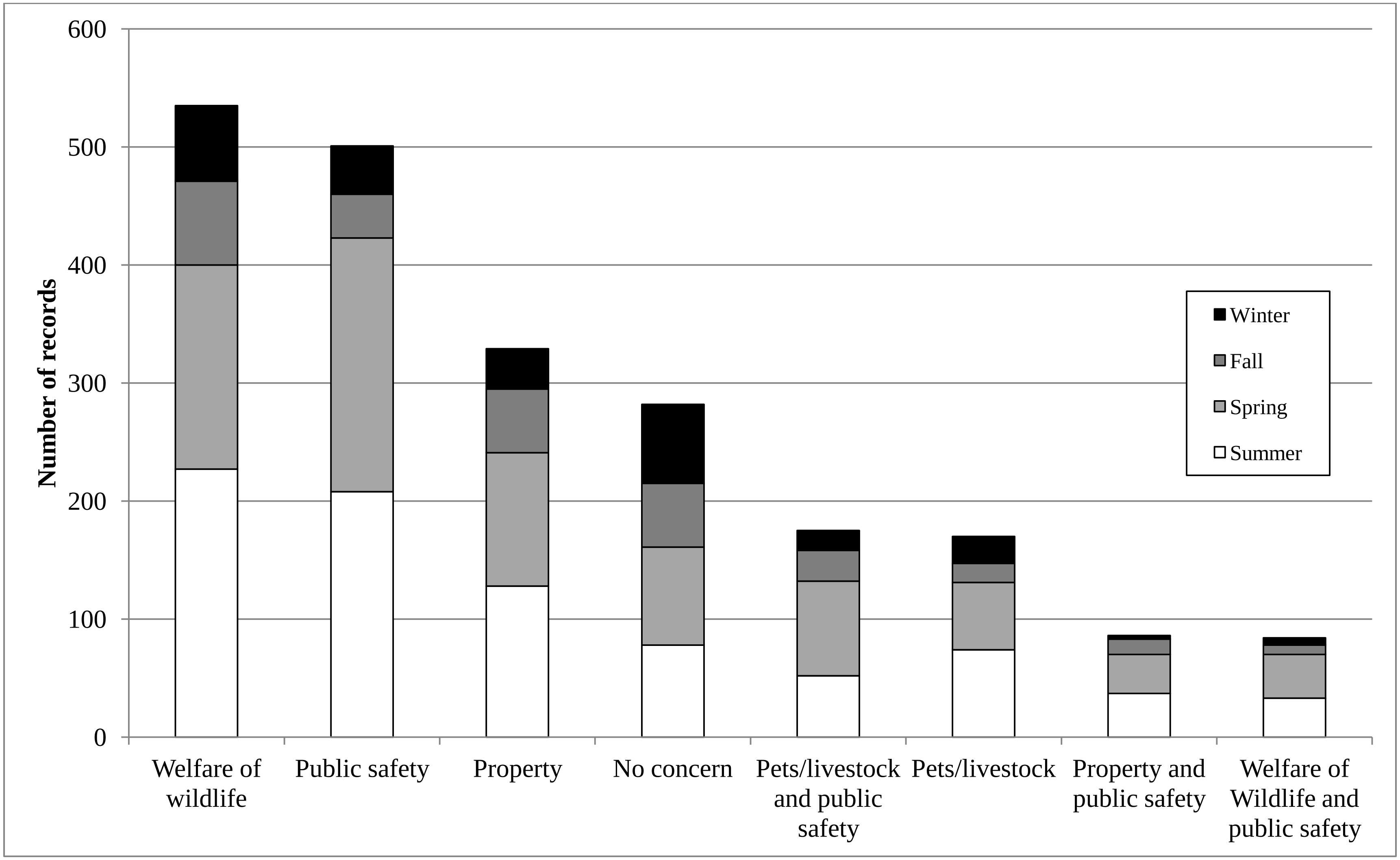
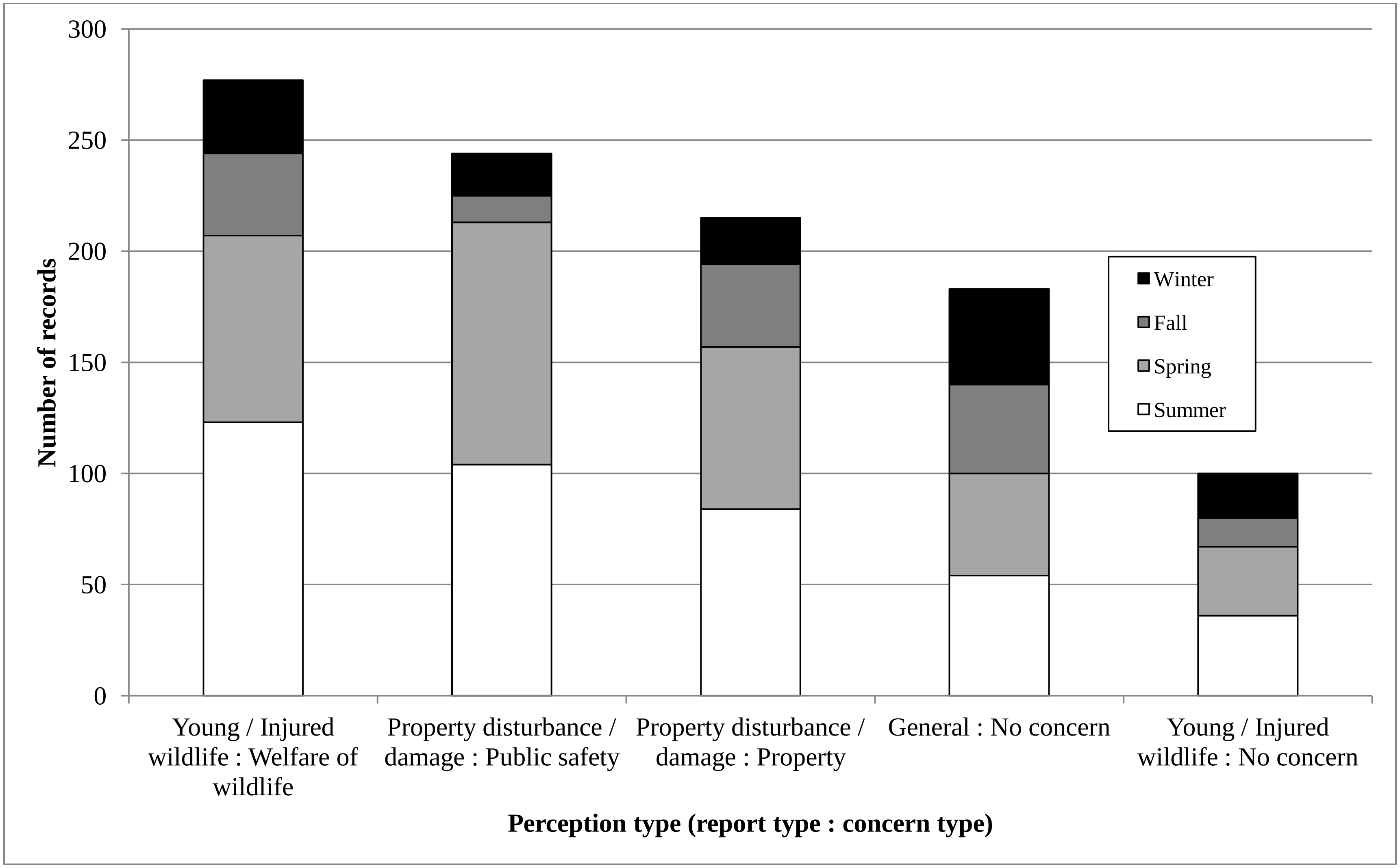


Figure 1.7 Top 5 ranked perception types reported by the public to the Massachusetts Division of Fisheries and Wildlife from April 2010 to May 2012 presented seasonally.



CHAPTER 2

LANDSCAPE CHARACTERISTICS AS AN INDICATOR OF HUMAN-WILDLIFE INTERACTIONS IN MASSACHUSETTS

2.1 Introduction

Humans have been manipulating the landscape throughout history, particularly modern history (Whitney 1994). As a result, some wildlife populations have suffered and some have benefitted (DeStefano and Johnson 2005). Regardless of the cause, the landscape has always and will continue to change, and many wildlife populations will respond, either positively or negatively, to that change. The state of Massachusetts, USA, consists of a diverse landscape, from dynamic beachscapes to mountainous rural settings to densely populated urban centers, and interactions and conflicts between humans and wildlife occur across this entire spectrum (DeGraaf and Yamasaki 2001, Foster et al. 2002, Huguenin and DeStefano 2014).

All wildlife species utilize the landscape in unique ways. Some populations require intact, less human dominated habitats while others can persist and even thrive in more human manipulated and human dominated environments (DeStefano and DeGraaf 2003, DeStefano and Johnson 2005). In either case, all wildlife species exploit the landscape to take advantage of available resources for both sustenance and protection. The behavior of wildlife and humans is such that interactions between them have the potential to occur among any species and along any landscape regardless of the composition and configuration of that landscape. That being said, we hypothesized that we could determine, and thus possibly predict, the type and frequency of human-wildlife interactions based on several key landscape characteristics. Specifically, we can begin to describe patterns of reports of human-wildlife interactions in a varied landscape across an urban-to-rural gradient by examining the frequency of reports of human-wildlife interactions against metrics that describe the characteristics of the urban-suburban landscape. Such characteristics include human population density and median home value, and broad landscape variables that describe both potential wildlife habitat and human development.

The Massachusetts Division of Fisheries and Wildlife (MDFW) is the state agency charged with managing and conserving wildlife in the state of Massachusetts, USA. MDFW has been collecting reports of wildlife and human-wildlife interactions from the public for several decades. All reports analyzed for this study were unsolicited from the public to MDFW staff during 2010-2012. Understanding the influence that human development and landscape variables have on reports of human-wildlife interactions can inform a more proactive educational strategy, and can assist with decisions regarding more direct management such as, managing and protecting habitat.

We examined reports from the public collected by MDFW that included human-wildlife interactions in general, as well as reports of interactions between humans and specific wildlife species across the state of Massachusetts. Our scope of inference was limited to those reports submitted by individuals to MDFW and did not expand beyond that to the general public as a whole. We focused on the spatial aspects of these reports and utilized both landscape composition and configuration variables and broad human dimension variables. We choose variables that were ecologically relevant, quantifiable, and that could inform management decisions as they relate to MDFW. Specifically, the objectives of this study were to investigate patterns in reports of human-wildlife interactions as they relate to levels of development and to investigate the relationship between reports and urban, suburban, and rural landscape composition and configuration variables.

2.2 Study Area

We conducted our study throughout the state of Massachusetts (2,428,113 ha) (Fig. 1). We divided the study area into 351 sampling units, which followed the boundaries of the 351 cities and towns that comprise Massachusetts. We only used towns from which data were collected, which was particularly relevant for species with limited population distribution (e.g., bears (*Ursus amercanus*)). Data were collected by MDFW staff at the field headquarters (Westborough, MA) and at the 5 district offices located throughout Massachusetts (Bourne, Ayer, West Boylston, Belchertown, and Dalton) (Fig. 1).

We used Massachusetts Geographic Information Systems (MassGIS) data to quantify spatial data. We reclassified the MassGIS LANDUSE2005 layer from 33 cover types to 7 cover types. Cover types represented throughout the study area were made up of forest, open, wetland, open water, agriculture, residential, and urban/industrial/commercial (Table 1).

Human population density in Massachusetts during this study was 329 people/km^2 (ranging from 2.2 people/km^2 to 7,228.7 people/km^2 of town) (U.S. Census Bureau 2010), and road density averaged 2.7 linear km/km^2 (ranging from 0.37 km/km^2 to 13.7

km/km^2). According the LANDUSE2005 layer in MassGIS, Massachusetts has over 1.2 million ha of forest (ranging from 3.2 to 17,139 ha/town).

2.3 Methods

We analyzed reports of wildlife and human-wildlife interactions in Massachusetts between April 2010 and May 2012. All reports analyzed for this study came via incoming, unsolicited telephone calls, emails, and face-to-face communications from the public to MDFW staff. Data were collected on a standardized animal report data form (Fig. 2). The animal report data form was designed specifically to ensure data collected were not subjective. We accomplished this by providing standard options to select from for both report type and concern type.

Data collectors underwent training and periodic evaluation to ensure consistency of data collection. Collectors were required to record the date of the report, the species being reported, the town the interaction occurred in, the report type, the concern type, and response given by the MDFW staff member. Specifically, the data collector first recorded the date, wildlife species, town of the interaction, and then selected the appropriate type of report or event that prompted the call. This main section of the data sheet was titled “Type of Report / Event” and included the 26 most common and relevant reports, ranging from sighting to human attack (in addition to “Other” for any events that did not fit into one of the 26 categories). The 26 types or events were grouped into 5 major categories for analysis: (1) general; (2) young/injured wildlife; (3) property disturbance/damage; (4) depredation; and (5) public safety (Table 2). After completing the report type section, the data collector would select the appropriate type of concern (titled “Caller’s Concern”) associated with the report type being reported. The Caller’s Concern section was broken down as follows: (1) no concern; (2) concern for welfare of wildlife; (3) concern for property; (4) concern for pet/livestock safety; (5) concern for human health and safety, and (6) concern for human health and safety (children) (the latter two were combined into one category for analysis purposes). The “Caller’s Concern” section was meant to be filled out in concert with “Type of Report / Event”. A mark was placed in all applicable boxes for report type and concern type. Given that each record was a unique human-wildlife interaction, there were many possible unique combinations of report types or concern types.

We used land cover data from the MassGIS LANDUSE2005 layer to calculate each habitat variable. Specifically, ArcMap 10 was used to reclassify 33 land use classes into 7 classes and to convert feature classes to raster (Table 1). We then clipped each of the 7 land cover classes for each sample unit and analyzed them using FRAGSTATS 4.1 (McGarigal et al. 2012). Three FRAGSTATS metrics were used to generate each landscape variables; percentage of landscape (PLAND), percentage of like adjacencies (PLADJ), and edge density (ED) (Table 3).

We used Program R 2.11.1 (R Core Team 2010) to analyze records of human-wildlife interactions in Massachusetts. We first analyzed the number of reports by level of development within each sample unit (town). Each town was placed into 1 of 5 categories characterized by level of development: (1) low (<10% developed); (2) medium-low (≥10 but < 25%); (3) medium (≥25 but <50%); (4) medium-high (≥50 but <75%); and (5) high (≥75%). Development was based on percent of area classified as urban and residential. Urban and residential classifications were derived from the

MassGIS LANDUSE2005 layer in ArcMap 10. We used FRAGSTATS 4.1 to compute percent of urban and percent of residential.

We performed a chi-squared test for goodness of fit to test for differences between expected number of records and observed number of records for each of the 5 development categories. Expected records were calculated as total records multiplied by the relative area in each category of development. We tested the null hypothesis that the observed number of total records was not different from expected ($\alpha < 0.05$) with the expected value based on the null hypothesis that records of human-wildlife interactions would have an equal chance of being reported regardless of location.

Following our chi-squared test for goodness of fit for development categories, we evaluated 6 dependent variables separately and their relationship with several independent variables throughout the entire study area. Dependent variables included total reports of human-wildlife interactions, and reports of human-wildlife interactions with respect to the 5 most frequently reported species (coyotes, bears, foxes, various birds of prey, and fisher). Independent variables included 2 human demographic variables: (1) human population density and (2) median home value, and 18 landscape variables: (1) percentage of landscape - forest (plandforest); (2) percentage of landscape - open (plandopen); (3) percentage of landscape - agriculture (plandag); (4) percentage of landscape - wetland (plandwet); (5) percentage of landscape - residential (plandres); (6) percentage of landscape - urban (plandurban); (7) percentage of like adjacencies - forest (pladjforest); (8) percentage of like adjacencies - open; (9) percentage of like adjacencies - agriculture (pladjag); (10) percentage of like adjacencies - wetland (pladjwet); (11) percentage of like adjacencies - residential (pladjres); (12) percentage of like adjacencies

- urban (pladjurban); (13) edge density - forest (edforest); (14) edge density - open; (15) edge density - agriculture (edag); (16) edge density - wetland (edwet); (17) edge density - residential (edres); and (18) edge density - urban (edurban) (Table 2).

Dependent variables were examined for normality and subsequently log transformed for each variable to better meet the assumptions of our model. We conducted a Shapiro-wilk normality test ($\alpha < 0.05$) to ensure the data were normally distributed. Following the normality test, we conducted a linear regression to closely examine the bivariate relationship between each dependent variable and each independent variable. We then developed a model and used multiple regression to test whether the independent variables were significantly correlated with the dependent variables ($\alpha < 0.05$). Prior to conducting the multiple regression analysis, we examined the multicollinearity of the independent variables using a Pearson correlation coefficient of ≤ 0.3. Variables were retained based on both the correlation coefficient (≤ 0.3) and on ecological significance. Given that some variables used in the model ranked above the correlation coefficient criteria, we later calculated the variance inflation factor of the final model to examine the level of correlation amongst the independent variables using a variance inflation factor criteria of <5. Lastly, we used the Breusch-Pagan test to test for heteroscedasticity in the model.

2.4 Results

We collected 2,730 reports between May 2010 and June 2012. We recorded 78 species within 332 of 351 (95%) units (towns) throughout the study (Fig. 3). Of the 2,730 reports, only those that could be identified to town were used for our analysis

(2,632, 96%). The mean number of reports/km^2 of unit was 0.15 (1.77 – 0.01, SD = 0.17). Percent of forest per unit averaged 56.4% (95.5% – 0.4%, SD = 21.2%), percent of residential area per unit averaged 21.5% (77.6% - 1.0%, SD = 15.7%), and percent of urban area per unit averaged 6.6% (52.9% - 0.1%, SD=7.5%).

Data were collected over an area of 20,956 km^2. The total area for each of the 5 development categories were as follows: low (6,366 km^2), medium-low (7,078 km^2), medium (5,859 km^2), medium-high (1,331 km^2), and high (319 km^2). In general, total animal reports were highest in the medium development category and lowest at the low and high categories. In contrast, reports were lowest in low development areas and highest in high developed areas when they were normalized by the area of each development category (Fig. 4). Specifically, total animal reports were less than expected for the low development category (χ^2 (1) = 227.5, $P \leq 0.001$), and for the medium-low development category (χ^2 (1) = 50.6, $P \leq 0.001$). Total animal reports were greater than expected for the medium development category (χ^2 (1) = 109.5, $P \leq 0.001$), for the medium-high development category (χ^2 (1) = 283.3, $P \leq 0.001$), and for the high development category (χ^2 (1) = 128.3, $P \leq 0.001$) (Table 4).

Based on the Pearson correlation coefficient (<0.3) and the ecological significance for all variables, 6 independent variables for each of the final multiple regression models were retained: median home value, plandforest, plandopen, plandwet, plandag, and edforest. Plandforest and human population density were highly correlated. We chose plandforest because it was a more ecologically significant variable. Also, human population density may be an interesting variable, but the complexities associated with human populations may cloud the data and make a meaningful interpretation difficult particularly without a higher degree of supporting human demographic data. Based on examination of the residuals plots generated from our regression analysis, the Shapiro-wilk normality test, and the Breusch-Pagan test, we determined that the assumptions of the model were not violated. We also examined the variance inflation factor (VIF) for the independent variables, and determined that multicollinearity did not inflate the final result of each model.

Analysis of the linear relationship between total reports of human-wildlife interactions in Massachusetts and the 6 independent variables revealed a significant correlation ($F_{6,\,325} = 22.9$, $P \leq 0.001$, Adjusted r-squared = 0.285). Specifically, reports of human-wildlife interactions were significantly (negatively) correlated with plandforest, plandwet, and median home value. However, the relationship between reports of human-wildlife interactions and plandag, plandopen, and edforest were not correlated within the model (Table 5).

Analysis of the linear relationship between reports of human-wildlife interactions for each of the 5 species and the independent variables showed mixed results. The final model for reports of human-wildlife interactions showed correlation for coyote ($F_{6,140} = 15.5$, $P \leq 0.001$, Adjusted r-squared = 0.37), fox ($F_{6,128} = 7.1$, $P \leq 0.001$, Adjusted r-squared = 0.21), and fisher ($F_{8,78} = 5.5$, $P \leq 0.001$, Adjusted r-squared = 0.29). Regarding reports of human-coyote interactions, only plandforest was a significant predictor ($P \leq 0.001$) with a negative correlation. Regarding reports of human-fox interactions, plandforest ($P = 0.044$) and plandwet ($P = 0.037$) were significant predictors and were negatively correlated with reports, and plandopen ($P = 0.029$) was a significant predictor, with a positive correlation. None of the independent variables were significant predictors for reports of human-fisher interactions. The final model was not significant for bear ($F_{6,102}$ = 2.2, *P* = 0.051, Adjusted r-squared = 0.06) or bird of prey ($F_{6,69}$ = 2.0, *P* = 0.079, Adjusted r-squared = 0.07). However, plandforest (*P* = 0.047) was positively correlated with human-bird of prey interactions (Table 6).

2.5 Discussion

It is important to note that reports of human-wildlife interactions or conflicts are not necessarily a measure of actual interactions or conflicts. Rather, voluntary reports from the public to conservation agencies should be considered more of a measure of public sentiment, tolerance level, and perception toward specific interactions with specific species. They provide different data and a different perspective than, say, mailed questionnaires to a random sample of homeowners. Voluntary, self-initiated reports from the public are another source of information for wildlife managers to consider.

Regardless of the method of data collection on human-wildlife interactions, interpretations of issues associated with interactions (particularly negative interactions) needs to be considered and evaluated carefully. Interpretations of interactions can vary among individuals, and what one person sees as a negative interaction or a potential health or safety issue can be very different from how their neighbor sees it. For example, Howe et al. (2010) pointed out that the trend in actual human-bear conflicts did not reflect trends in reports of human-bear complaints. They suggested that reporting rate may have increased due to a change in the perception of risk, or due to a reduced tolerance for bears. The fact that reports may not necessarily reflect actual interactions is an important distinction with regard to not only developing effective management strategies, but also with regard to our focus for this study.

Specifically, our focus involved the evaluation of data related to interactions between humans and wildlife as reported by the public to the Massachusetts Division of Fisheries and Wildlife. Therefore, our scope of inference included only those reports received and did not encompass the general public as a whole.

In our study, areas of high report density coincided with some of the major metropolitan cities in Massachusetts. In general, towns surrounding those cities also showed high report densities. Report density decreased as distance from metropolitan areas increased; however, cities or towns did not always meet this simple assumption. For instance, some towns with low levels of development had higher report densities than other towns with higher levels of development. These towns were either anomalies or, more likely, connected by several other variables that do not fit easily into such general categories, such as how accustomed individuals in the town were to interactions with certain wildlife species, or possibly due to the influx of expanding wildlife and/or human populations into a town. Another potential variable driving reports of interactions in certain towns may be the availability of alternative options for dealing with human-wildlife interactions. The public have many resources for which to report and obtain assistance for interactions with wildlife such as, pest control companies, local and national non-profit wildlife organizations (Audubon Society, Humane Society, etc.), local animal control officers, police departments, etc. Organizations such as these may be the only known source for the public to turn to, or may be the preferred source for some from the public to use. Report volume to MDFW is affected by the use and availability of alternative sources. That said we assume that the proportion of the local population utilizing alternative sources to report human-wildlife interactions is consistent across the state.

Many studies that address species diversity refer to the intermediate disturbance hypothesis (IDH) (Grime 1973, Connell 1978). Intermediate disturbance hypothesis generally states that biodiversity is greatest where disturbance is intermediate. We considered this hypothesis with regard to frequency of reports of human-wildlife interactions. After all, where development is low, human population density is generally low, and where development is high, wildlife resources are generally low. Both of these scenarios lend themselves to less of a chance for human-wildlife interactions. Therefore, it seems that intermediate levels of development may experience higher reports of interactions. A study in northern New York revealed that higher concentrations of interactions between humans and wildlife occurred at intermediate levels of development, indicating that housing density is a predictor for human-wildlife interactions (Krester et al. 2008). We analyzed the number of records of human-wildlife interactions within five categories of development (low, medium-low, medium, medium-high, and high development). Our study showed that the number of records (relative to the proportion of area for each development category) does not actually fit into this hypothesis. In contrast, records are highest within the high development category and lowest in the low development category (Fig 4).

Analyzing the relationship human development has with human-wildlife interactions may help reveal conflict trends in Massachusetts. Further, it may also be useful to examine how habitat-based landscape variables can predict interactions between humans and wildlife. Possell et al. (2013) found that conflicts between humans and coyotes in the Denver, Colorado metropolitan area were greater in open space and development land cover types (in contrast to natural and agricultural land cover) and in suburban housing areas (in contrast to urban, exurban, and rural areas). Buroch-Mordo et al. (2008) showed high spatial clustering of black bear-human conflicts by land cover type and by conflict type in Colorado.

We were also able to show that reports of human-wildlife interactions were different from expected within the above mentioned 5 categories of structural development throughout Massachusetts. Specifically, reports were lower than expected in towns typically considered rural (low and medium-low development), and greater than expected in towns typically considered suburban and urban (medium, medium-high, and high development). These results suggested that reports of human-wildlife interactions were influenced by variables that defined and connected the towns that make up each level of development. It is possible that wildlife population densities were lower in areas where fewer interactions were reported, or that human behavior is such that interest in reporting interactions is lower in those areas. It also seems likely that wildlife population densities and interest in reporting are not necessarily lower in rural areas, but that the landscape is composed and configured in a way that may influence how certain species utilize it. In fact, wildlife populations and species diversity may likely be lower in urban centers (Boston, MA) yet reports were relatively high in those areas. One might think that high levels of human population density would yield higher reports of human-wildlife interactions except that wildlife population density is not consistent among towns, which could certainly affect reporting rate. High levels of reports coupled with low wildlife populations and high human density may be a function of high resource overlap between humans and wildlife and/or low tolerance levels for the presence of wildlife.

Many species will take advantage of anthropogenic resources when they have the opportunity (DeStefano and Johnson 2005). Trophic dynamics are often altered, particularly in urban areas (Faeth et al. 2005). Anthropogenic influences and urbanization can affect the spatial dynamics in species such as coyotes (Atwood et al. 2004). Gehrt et al. (2009) revealed that, in the metropolitan area of Chicago, Illinois, where natural land cover dominated other land cover categories; urban land use was positively correlated with coyote home range size. These results suggest that coyotes increased home range size in order to take advantage of fragmented habitat. It seems possible that in areas where development is higher, wildlife species will utilize resources that humans also utilize, which may increase potential for interactions. Variable selection for this study was partially based on the idea that an increase in the potential for interactions could be related to wildlife behavior in the presence of higher human population density and/or the landscape characteristics within each town. We also considered variables based on the summaries provided by Huguenin and DeStefano (2014).

Huguenin and DeStefano (2014) showed that of 2,730 total records collected by MDFW between May 2010 and June 2012 in Massachusetts, one third (919) were reports of coyotes, bears, and foxes, and more than one third (934) were reports of property disturbance/damage. Summaries of these data provide insight into the structure of human-wildlife interactions in Massachusetts. These summaries were used to inform our study to further investigate some of the variables that drive trends of human-wildlife interactions.

Our study showed that total reports of human-wildlife interactions were negatively correlated with median home value. The analysis also showed that reports of human-wildlife interactions were negatively correlated with percentage of landscape classified as forest and wetland, but were not correlated with edge density of forest, percentage of landscape classified as agriculture, or open.

Negative correlation with median home value was surprising because we expected that residents in areas with higher valued homes may be more likely to report interactions because properties with more value would invoke a higher interest in protecting that property. That said the negative relationship may be due to the fact that individuals with higher valued homes would have the means to resolve issues with wildlife through a private contractor rather than by calling a state agency. A negative correlation between total reports with forest and wetland indicates that in areas where the percentage of forest and wetland decreased (and median home value decreased), total reports of interactions increased. In other words, the model indicated that reports increased where 2 key resources (cover and wetlands) decreased. Perhaps wildlife species are more visible in these areas or they utilize more anthropogenic resources, increasing the chances of an interaction.

Upon investigating the linear relationships of the 5 most reported species, we were only able to reveal a similar trend (as described above) for foxes, except that percentage of open was also significantly (positively) correlated with fox reports. The fox model indicated that as forest and wetland decreased and open increased, reports of fox-human interactions increased, which is consistent with the habitat preference of red foxes (likely the more commonly reported of the two fox species). Percentage of forest consistently showed a negative relationship in all scenarios where the model was significant (total reports, coyote reports, fox reports, and fisher reports). Interestingly, median home value was only a significant correlate for total reports. Perhaps this should not be a surprise given that a large proportion of reports of property damage involved many species other than coyote, fox, fisher, bear, and bird of prey, such as woodchuck (*Marmota monax*), beaver (*Castor canadensis*), raccoon (*Procyon lotor*), and skunk (*Mephitis mephitis*) (Huguenin and DeStefano 2014). In fact, according to Huguenin and DeStefano (2014), the report category in which the top 5 species dominated most heavily (in proportion to the other species reported) was reports of depredation. Median home value may not be a good predictor for these species because, although they are involved in many reports of property damage, they simply do not dominate this category as heavily as some others. Perhaps homes with free ranging livestock or outdoor pets would be a more adequate predictor.

Both bear and bird of prey reports showed no significant correlation with the model. It may be that these species are not discriminate of human demographics or of landscape variables. The majority of reports involving birds of prey were of young, injured, or dead individuals. Reports of these species are not typically those of negative interactions, but of concern for the animal’s well being. Uncovering predictors for this type of trend may require measuring more in-depth human demographic variables such as past experience with wildlife, education level, level of understanding of wildlife behavior, etc. Also, this trend may not be a priority as far as management of interactions is concerned. Certainly, birds of prey are involved in negative interactions with humans, but more data are required to adequately investigate this trend using the model as it is constructed.

Bears were typically reported as negative interactions yet still no significant correlation was found among landscape variables. Perhaps a bear in a backyard may drive a resident to report it or seek advice regardless of demographics and regardless of the surrounding landscape. That idea, coupled with the fact that bears can be found readily in both rural and suburban environments within their range, may explain the lack of trends uncovered in this study. Also, bear populations in Massachusetts are limited to the central and western part of the state. Only occasionally do lone individuals range to the eastern part of the state where the vast majority of suburban and urban areas in Massachusetts exist.

We believe that our models were adequate predictors for total reports and for certain species, particularly for coyote, fox, and fisher. It is also clear that reports of interactions between humans and wildlife are driven heavily by variables not quantified in this study, such as human behavior, personal experience and background, animal behavior, etc. Human behavior, background, and experience may influence how someone perceives the interaction and decides whether it warrants reporting it or seeking assistance. Also, alternative conflict resolution options may play a role in report frequency. In other words, people utilize alternate options to resolve negative interactions or to report interactions with species such as foxes, fisher, birds of prey, and even coyotes. For instance, they may simply contact a pest control company, the municipal animal control officer, the local police department, other wildlife organizations, or attempt to resolve the issue on their own. That being said, we were able to uncover significant correlations between certain species and our landscape and human demographic variables.

Wildlife utilize the landscape based on resource availability from both natural and anthropogenic resources. Our study was meant to investigate, broadly, the basic land use patterns and to investigate whether conflicts relate to those patterns. We believe understanding how development, landscape structure, and median home value relate to human-wildlife conflicts is an important step in managing those conflicts. A deeper investigation into the myriad demographic and social variables that likely drive a great deal of human-wildlife interactions is imperative, particularly for developing long-term management solutions. Managing wildlife alone is limiting with regard to reports of human-wildlife interactions, and the field of wildlife management may benefit from a more integrated approach by incorporating the social sciences with wildlife management. Developing an integrated approach can assist in accomplishing a more long-term solution by helping biologists understand how human perception and tolerance levels fluctuate and by potentially changing human behavior (Buroch-Mordo et al. 2009, White and Ward 2010).

It is not only important to manage and understand the dynamics of human-wildlife conflicts for the sake of humans, but also for the sake of what should be considered an important natural resource in that of wildlife. DeStefano and Deblinger (2005) presented a model of how wildlife populations can shift from a resource to a pest by using the change in beaver (*Castor canadensis*) populations in the late 1990's in Massachusetts as a case study. Following a ban in 1996 on body-gripping traps in Massachusetts, beaver harvest declined greatly and populations grew exponentially. Complaints regarding beavers more than doubled during this period of population growth causing many people to believe beavers to be nothing more than pests. They referred to this phenomenon as the resource to pest model. Although maybe not as dramatically, the resource to pest model applies to several species. Additionally, we believe that it is important to distinguish between reports of interactions and actual interactions and not attempt to manage reports of interactions using the same techniques as is used to manage actual interactions or conflicts as one is not necessarily representative of the other (Howe et al. 2010). Regardless of this distinction, research and management is still imperative in order to prevent species from becoming widely regarded as pests rather valuable natural resources.

Understanding the variables that drive trends can help inform managers of the dynamics of reports of human-wildlife interactions, which can help focus proactive education and other management strategies. A study conducted by supports the idea that proactive education can influence human behavior, but direct management of the species may still be required to avoid certain interactions that lead to actual conflicts. Espinosa and Jacobson's (2012) study revealed that education regarding the protection of the Andean bear (*Tremarctos ornatus*) in Ecuador had influenced residents to take action other than shooting when they simply saw an adult bear or cub. Although, Espinosa and Jacobson (2012) also showed that education had no influence on residents when focused on protecting crops or cattle from bears.

Many management techniques use a reactive approach which focuses on resolving negative interactions based on the type of interaction that occurred or the type of damage caused by wildlife. However, the problem often remains even after the reduction in damage, suggesting that social factors are important drivers of conflict (Dickman 2010). Also, the individual's perception of an interaction with wildlife is often overlooked when developing resolutions for those interactions. In general, the public's perception of human-wildlife interactions may be quite different from that assumed by managers. Some from the public may interpret behaviors as aggressive or abnormal due to misinformation or a lack of knowledge or experience rather than due to actual aggressive or abnormal behavior. Therefore perception should be quantified and considered when developing long-term management solutions. Skewed perceptions of risk likely cause many individuals to report negative interactions even when none have occurred making it difficult for managers to focus resolutions.

As mentioned earlier, it is important to consider that reports of interactions, as defined or interpreted by a caller, may not reflect actual interactions (Howe et al. 2010). For example, the momentary presence of a coyote in the neighborhood may be interpreted as threatening, but the animal's behavior may indicate that it is merely passing through, or even trying to avoid an interaction with humans. Therefore, implementation of management techniques designed to reduce actual negative interactions based solely on reports submitted by the public may be misguided. Rather, data collected for this study should be used to aid in the development of proactive management strategies designed to not only reduce actual negative interactions, but mainly to educate the public. Information and education can change attitudes of residents to help prevent or lessen unwanted interactions (Merkle et al. 2011). Proactive management should be a part of the solution to increase tolerance for wildlife and to increase the public’s appreciation for the value of all wildlife species.

TABLES

Table 2.1 List of original MassGIS LANDUSE2005 classifications for Massachusetts along with the categories they were reclassified as.

Reclassification of Landuse Class	Original Landuse Classification
Forest	Forest
	Forested Wetland
	Brushland/successional
Open	Open land
	Transitional
	Powerline/utility
	Golf course
	Cemetery
Wetland	Non-forested wetland
	Saltwater wetland
	Cranberry bog
Open water	Water
Agriculture	Cropland
	Pasture
	Orchard
	Nursery
Residential	Participation recreation
	Water-based recreation
	Saltwater sandy beach
	Multi-family residential
	High density residential
	Medium density residential
	Low density residential
	Very low density residential
Urban/industrial/commercial	Mining
	Spectator recreation
	Commercial
	Industrial
	Transportation
	Waste disposal
	Marina
	Urban public/institutional
	Junkyard

Table 2.2 List of original report types used to collect reports of human wildlife interactions along with the list of condensed report types which the original report types were categorized into for data analysis purposes.

Condensed Report Types	Original Report Types
General	Seeking general info
	Report illegal activity
	Animal sighting or vocalization
	Feeding on naturally available food sources
	Using other/recreational/natural areas
Young/injured wildlife	Young wildlife
	Vehicle collision/roadkill
	Exhibiting signs of disease/injury
	Mortality from disease/injury
	Other or unknown mortality
Property disturbance/damage	Feeding on personal property
	Flooding (beaver)
	Denning/nesting on, in, or under property
	Using residential, business, school area
	Other property damage (public or private)
Depredation	Crop damage (agricultural)
	Missing pet/livestock
	Aggression toward pet
	Attack on livestock - witnessed
	Attack on livestock - not witnessed
	Attack on pets - witnessed
	Attack on pets - not witnessed
Public safety	Approaching humans/pets on leash
	Aggression toward humans
	Human attack

Table 2.3 List and description of the FRAGSTATS metrics used to generate 18 landscape variables used as independent variables to compare against reports of human-wildlife interactions in Massachusetts.

FRAGSTATS Metric	Variable	Units	Description
Percentage of landscape (PLNAD)	Percentage of landscape - forest (plandforest) Percentage of landscape - open (plandopen) Percentage of landscape - agriculture (plandag) Percentage of landscape - wetland (plandwet) Percentage of landscape - residential (plandres) Percentage of landscape - urban (plandurban)	Percent	The sum of areas (m^2) of all patches of the corresponding patch type, divided by total landscape area (m^2), multiplied by 100 (to convert to a percentage).
Percentage of like adjacencies (PLADJ)	Percentage of like adjacencies - forest (pladjforest) Percentage of like adjacencies - open (pladjopen) Percentage of like adjacencies - agriculture (pladjag) Percentage of like adjacencies - wetland (pladjwet) Percentage of like adjacencies - residential (pladjres) Percentage of like adjacencies - urban (pladjurban)	Percent	The percentage of cell adjacencies involving cover that are like adjacencies.
Edge density (ED)	Edge density - forest (edforest) Edge density - open (edopen) Edge density - agriculture (edag) Edge density - wetland (edwet) Edge density - residential (edres) Edge density - urban (edurban)	m/ha	Sum of the lengths (m) of all cover edge in the landscape, divided by total landscape area (m^2), converted to ha.

Table 2.4 Total records relative to categories of development in Massachusetts, April 2010-May 2012. Expected records are calculated by multiplying proportion of total area (square kilometers) for each development level by *n* = 2632. The p value represents whether observed records are significantly different from expected records for each season ($\alpha < 0.05$).

Development	Total area (sq. km)	Proportion of total area	Expected records	Observed records	Proportion observed	p value
Low	6366	0.304	790	435	0.165	< 0.001
Medium-low	7078	0.338	895	722	0.274	< 0.001
Medium	5858	0.280	737	978	0.372	< 0.001
Medium-high	1331	0.064	158	363	0.138	< 0.001
High	318	0.015	53	134	0.051	<0.001
Total	20955	1.000	2632	2632	1.000	

Table 2.5 The standardized coefficients (beta) and p-value for each of the independent variables as they relate to total reports of human-wildlife interactions. Variables are ranked by relative importance based on the beta value. Negative symbols represent a negative relationship between the independent variable and dependent variable. No symbol indicates a positive relationship. Significance is indicated by a star (*). Total reports was significantly correlated with the model.

Independent Variables	Beta	P-value
Plandforest	-0.468	<0.001 *
Plandwet	-0.238	<0.001 *
Median home value	-0.106	0.044 *
Edforest	0.099	0.062
Plandopen	0.083	0.149
Plandag	-0.023	0.633

Table 2.6 The standardized coefficients (beta) and p-values for each of the independent variables as they relate to reports of human-coyote, fox, fisher, bear, and bird of prey interactions. Variables are ranked by relative importance based on the beta value. Negative symbols represent a negative relationship between the independent variable and dependent variable. No symbol indicates a positive relationship. Significance is indicated by a star (*).

Species	Independent Variables	Beta	P-value
Coyote *	Plandforest	-0.543	<0.001 *
	Plandwet	-0.102	0.141
	Plandopen	0.102	0.177
	Plandag	-0.060	0.409
	Edforest	0.015	0.838
	Median home value	0.014	0.845
Fox *	Plandopen	0.216	0.029 *
	Plandforest	-0.215	0.044 *
	Plandwet	-0.173	0.037 *
	Edforest	0.138	0.185
	Plandag	-0.085	0.296
	Median home value	0.049	0.599
Fisher *	Plandforest	-0.408	<0.001 *
	Edforest	-0.138	0.202
	Plandag	-0.135	0.165
	Plandopen	0.101	0.343
	Median home value	0.095	0.352
	Plandwet	-0.088	0.385
Bear	Plandopen	0.274	0.052
	Plandag	0.178	0.072
	Edforest	0.035	0.827
	Plandwet	0.024	0.822
	Plandforest	0.017	0.920
	Median home value	-0.004	0.961
Bird of Prey	Plandforest	-0.269	0.047 *
	Edforest	0.193	0.168
	Plandwet	-0.176	0.137
	Plandag	0.170	0.152
	Plandopen	-0.023	0.864
	Median home value	0.087	0.520

FIGURES

Figure 2.1 Study area is the state of Massachusetts. Data were collected at the Massachusetts Division of Fisheries and Wildlife district offices and field headquarters.

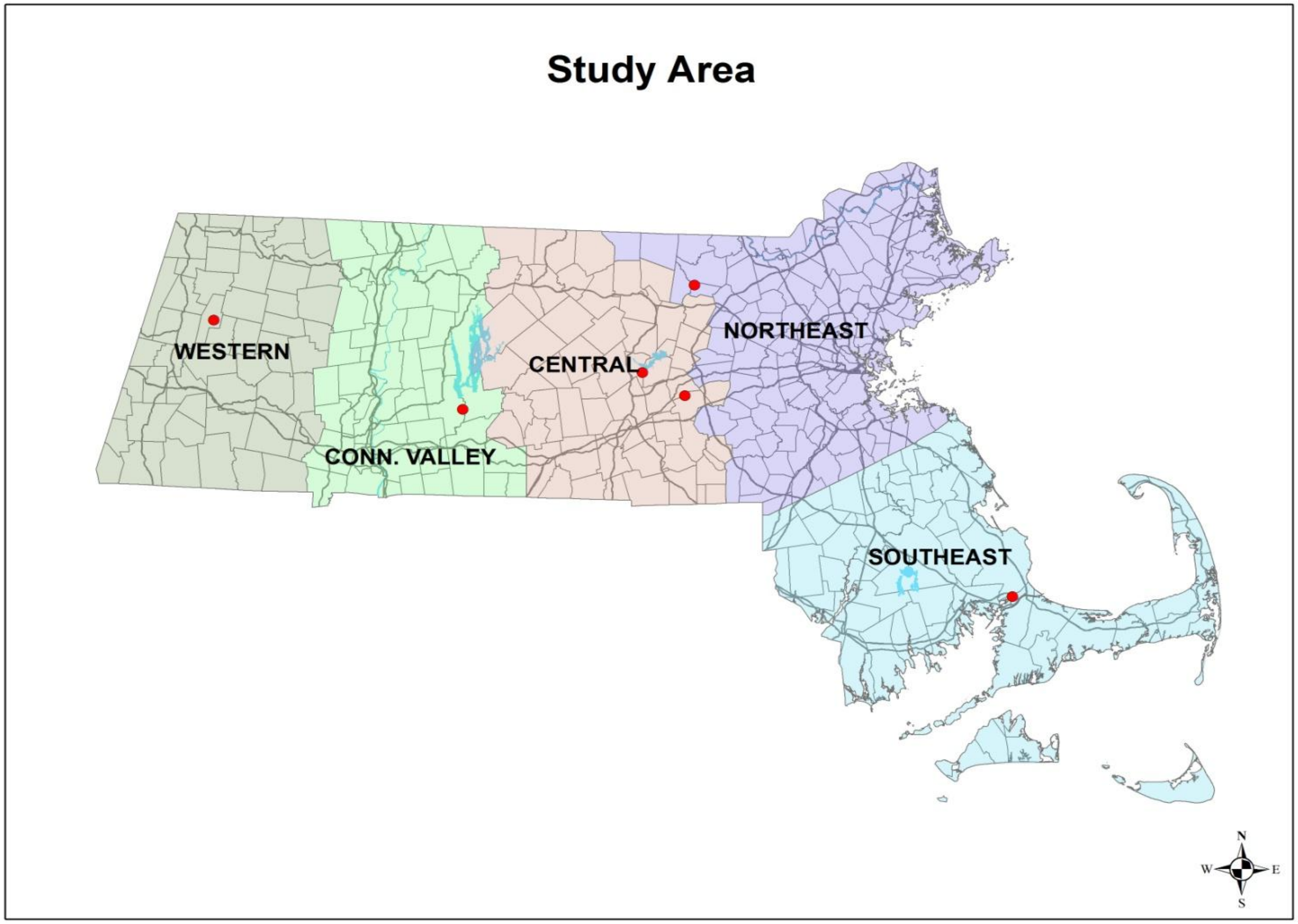
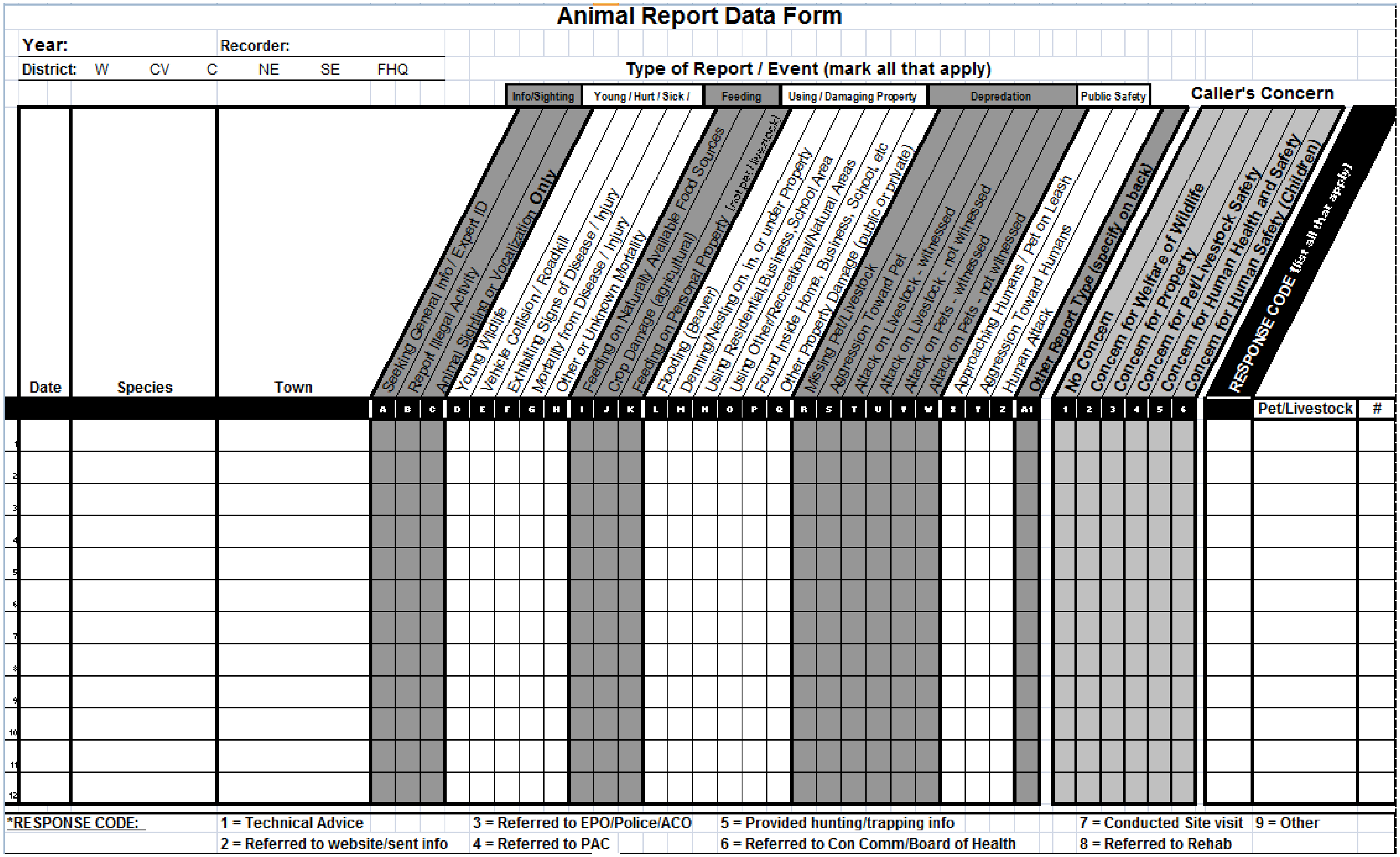


Figure 2.2 Animal report form. All data for this study were collected on this form. The form is broken down by date, species, town, type of report, and concern type. All other data collected on this form was considered supplemental and not used to analyze data for this study.



Animal Report Data Form

Year:

Recorder:

District: W CV C NE SE FHQ

Type of Report / Event (mark all that apply)

				Info/Sighting			Young / Hurt / Sick /					Feeding			Using / Damaging Property						Depredation						Public Safety				Caller's Concern								
	Date	Species	Town	Seeking General Info / Expert ID	Report Illegal Activity	Animal Sighting or Vocalization Only	Young Wildlife	Vehicle Collision / Roadkill	Exhibiting Signs of Disease / Injury	Mortality from Disease / Injury	Other or Unknown Mortality	Feeding on Naturally Available Food Sources	Crop Damage (agricultural)	Feeding on Personal Property (not pet / livestock)	Flooding (Beaver)	Denning/Nesting on, in, or under Property	Using Residential Business,School Area	Using Other/Recreational/Natural Areas	Found Inside Home, Business, School, etc	Other Property Damage (public or private)	Missing Pet/Livestock	Aggression Toward Pet	Attack on Livestock - witnessed	Attack on Livestock - not witnessed	Attack on Pets - witnessed	Attack on Pets - not witnessed	Approaching Humans / Pet on Leash	Aggression Toward Humans	Human Attack	Other Report Type (specify on back)	No Concern	Concern for Welfare of Wildlife	Concern for Property	Concern for Pet/Livestock Safety	Concern for Human Health and Safety	Concern for Human Safety (Children)	RESPONSE CODE (list all that apply)		
				A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A1	1	2	3	4	5	6		Pet/Livestock	#
1																																							
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*RESPONSE CODE:
1 = Technical Advice
2 = Referred to website/sent info
3 = Referred to EPO/Police/ACO
4 = Referred to PAC
5 = Provided hunting/trapping info
6 = Referred to Con Comm/Board of Health
7 = Conducted Site visit
8 = Referred to Rehab
9 = Other

Figure 2.3 Density (reports per square kilometer of town/sample unit) of total reports in Massachusetts from April 2010 to May 2012.

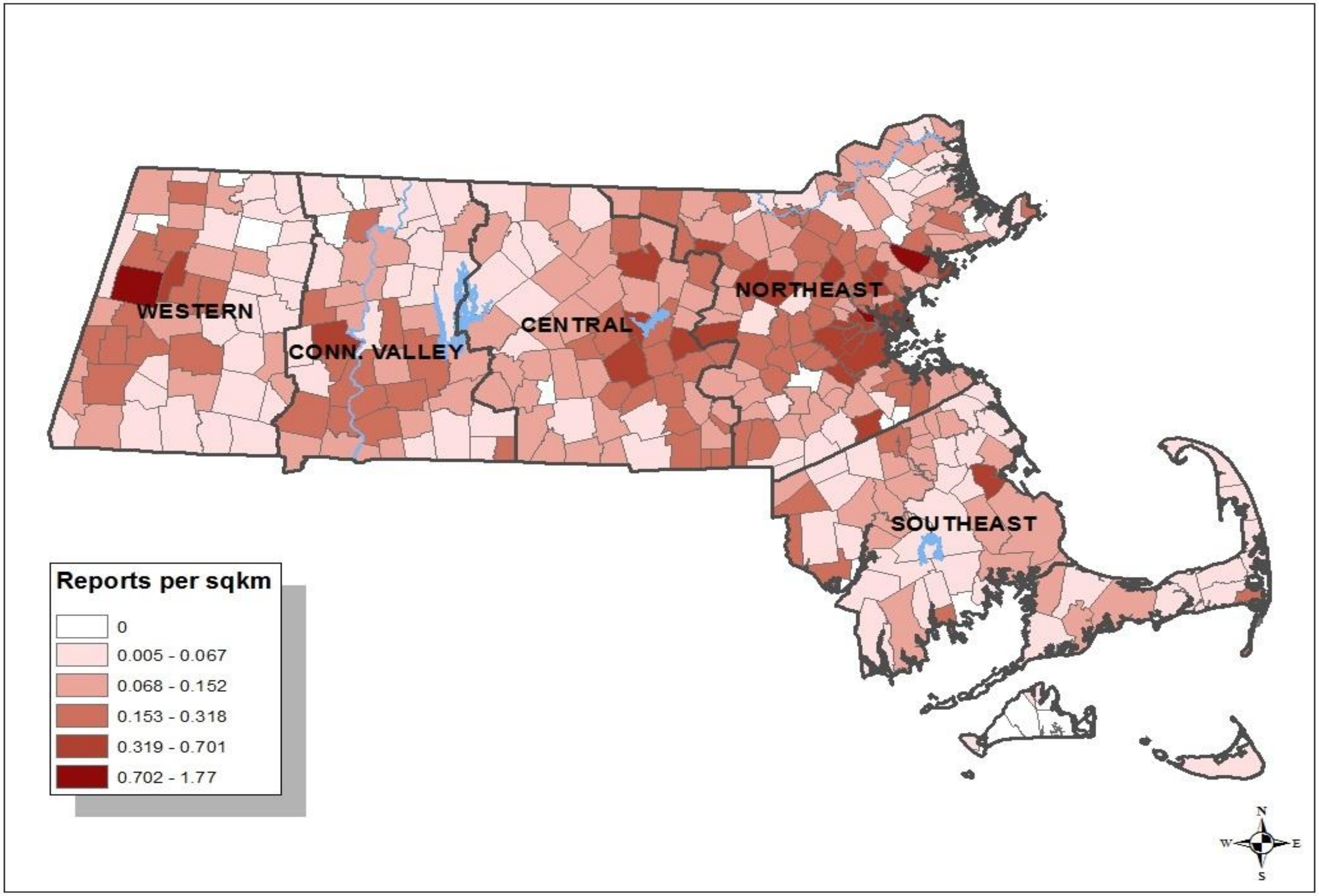
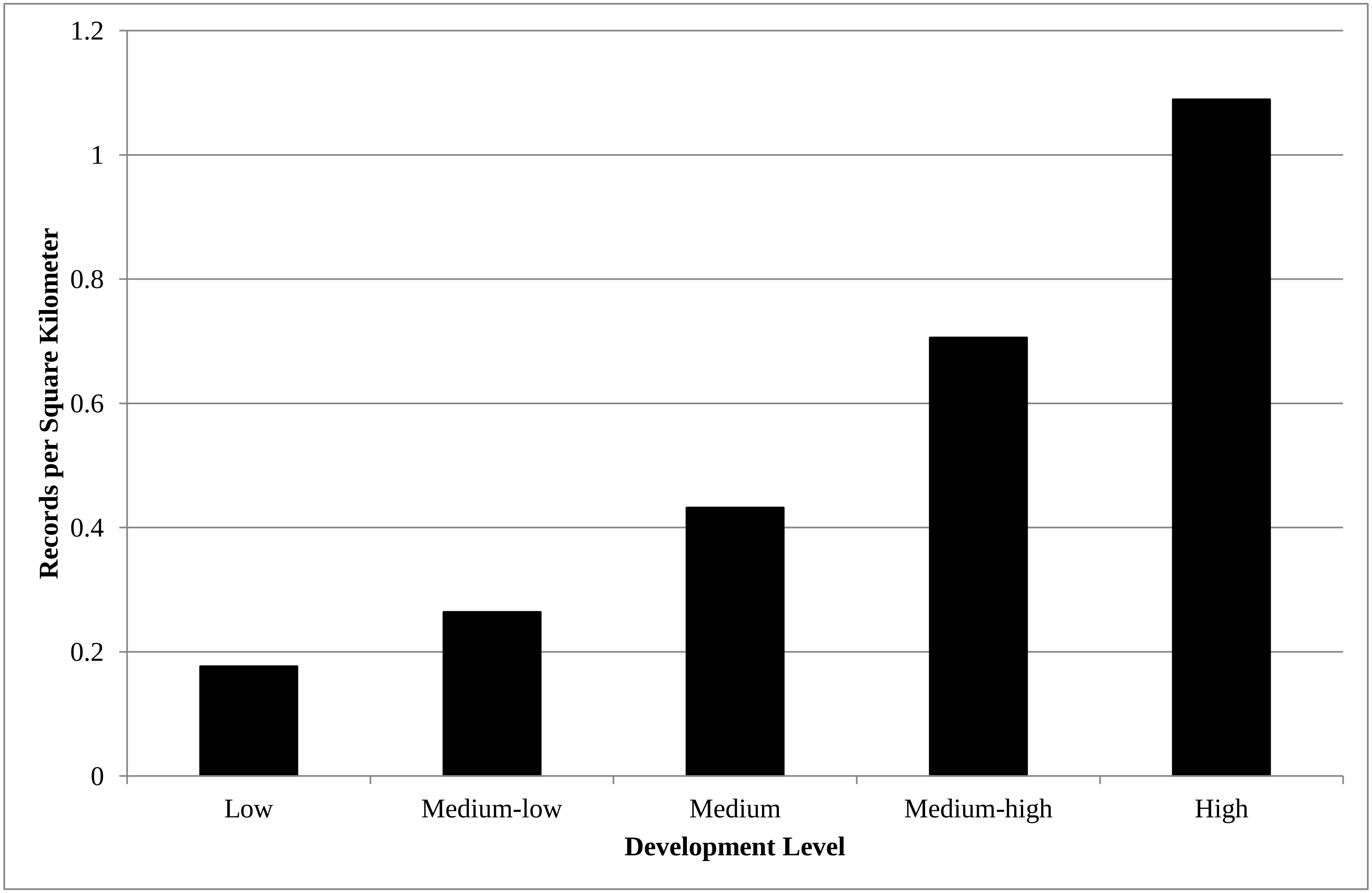


Figure 2.4 Records of reports of human-wildlife interactions in Massachusetts by development level. Proportion of records are calculated as total records within each development level multiplied by the proportion of total area (square km) within that development level.



BIBLIOGRAPHY

Atwood, T. C., H. P. Weeks, T. M. Gehring. 2004. Spatial ecology of coyotes along a suburban-to-rural gradient. Journal of Wildlife Management 68:1000-1009.

Baruch-Mordo, S. 2008. Spatiotemporal distribution of black bear-human conflicts in Colorado, USA. Journal of Wildlife Management 72:1853-1862.

Baruch-Mordo, S., K. R. Wilson, J. Broderick, S. W. Breck. 2009. A tool box half full: How social science can help solve human-wildlife conflict. Human Dimensions of Wildlife 14:219-223.

Caughley, G. 1977. Analysis of vertebrate populations. Thompson Press (India) Limited, New Delhi, India.

Clendenning, G., D.R. Field, and K.J. Kapp. 2005. A comparison of seasonal homeowners and permanent residents on their attitudes toward wildlife management on public lands. Human Dimensions of Wildlife 10:3-17.

Conover, M. 2002. Resolving human-wildlife conflicts: the science of wildlife damage management. CRC Press, Limited Licensing Company, Corporate Boulevard, Boca Raton, Florida, USA.

Decker, D. J., T. L. Brown, and W. F. Siemer. 2001. Human dimensions of wildlife management in North America. The Wildlife Society, Bethesda, Maryland, USA.

Decker, D.J., and T.L. Brown. 1982. Fruit growers' vs. other farmers' attitudes toward deer in New York. Wildlife Society Bulletin 10:150-155.

Decker, D.J., G.F. Matfield, and T.L. Brown. 1983. Influence of deer damage on farmers' perceptions of deer population trends: important implications for managers. Proceedings of the Eastern Wildlife Damage Control Conference 1:191-194.

Decker, D.J., and K.G. Purdy. 1988. Toward a concept of wildlife acceptance capacity in wildlife management. Wildlife Society Bulletin 16:58-62.

DeGraaf, R. M., and M. Yamasaki. 2001. New England wildlife: habitat, natural history, and distribution. University Press of New England, Hanover, New Hampshire, USA.

DeStefano, S., and R. D. Deblinger. 2005. Wildlife as valuable natural resources vs. intolerable pests: a suburban wildlife management model. Urban Ecosystems 8:179-190.

DeStefano, S., and R. M. DeGraaf. 2003. Exploring the ecology of suburban wildlife. Frontiers in Ecology and the Environment 1:95-101.

DeStefano, S., and E. A. Johnson. 2005. Species that benefit from sprawl. Pages 206-235 *in* E. A. Johnson and M. W. Klemens, editors. Nature in fragments: the legacy of sprawl. Columbia University Press, New York, USA.

Dickman, A. J. 2010. Complexities of conflict: the importance of considering social factors for effectively resolving human-wildlife conflict. Animal Conservation 13:458-466.

Ditchkoff, S.S., S.T. Saafeld, and C.J. Gibson. 2006. Animal behavior in urban ecosystems: Modification due to human-induced stress. Urban Ecosystems 9:5-12.

Duda, M.D., M. Jones, T. Beppler, S.J. Bissell, A. Criscione, P. Doherty, A. Ritchie, C.L. Schilli, T. Winegord, A. Lanier. 2012. Public attitudes toward and expectations regarding management of wildlife in the northeast United States. Responsive Management, Harrisonburg, Virginia, USA.

Espinosa, S., and S. K. Jacobson. 2012. Human-wildlife conflict and environmental education: evaluating a community program to protect the Andean bear in Ecuador. Journal of Environmental Education 43:55-65.

Faeth, S. H., P. S. Warren, E. Shochat, and W. A. Marussich. 2005. Trophic dynamics in urban communities. BioScience 55:399-407.

Foster, D. R., G. Motzkin, D. Bernardos, and J. Cardoza. 2002. Wildlife dynamics in the changing New England landscape. Journal of Biogeography 29:1337-1357.

Gehrt, S. D., C. Anchor, and L. A. White. 2009. Home range and landscape use of coyotes in a metropolitan landscape: conflict or coexistence? Journal of Mammology 90:1045-1057.

Hendee, J.C., G.H. Stankey, and R. C. Lucas. 1978. Wilderness management. U.S. Forest Service, U.S. Department of Agriculture, Miscellaneous Publication 1365, Washington D.C., USA.

Howe, E. J., M. E. Obbard, R. Black, and L. L. Wall. 2010. Do public complaints reflect trends in human-bear conflict? Ursus 21:131-142.

Huguenin, M. A., and S. DeStefano. 2014. Human-wildlife interactions as reported by the public in Massachusetts. Human-wildlife Interactions in prep.

Kretser, H. E., P. J. Sullivan, and B. A. Knuth. 2008. Housing density as an indicator of spatial patterns of reported human-wildlife interactions in northern New York. Landscape and Urban Planning 84:282-292.

Lukasik, V.M., and S.M. Alexander. 2011. Human-coyote interactions in Calgary, Alberta. Human Dimensions of Wildlife 16:114-127.

Lotze, H.K., and I. Milewski. 2004. Two centuries of multiple human impacts and successive changes in a north atlantic food web. Ecological Applications 14:1428-1447.

McClennen, N, R.R. Wigglesworth, S.H. Anderson. 2001. The effect of suburban and agricultural development on the activity patterns of coyotes (*Canis latrans*). American Midland Naturalist 146:27-36.

McGarigal, K., S. A. Cushman, and E. Ene. 2012. FRAGSTATS v4: Spatial pattern analysis program for categorical and continuous maps. Computer software program produced by the authors at the University of Massachusetts, Amherst. Available at the following web site: http://www.umass.edu/landeco/research/fragstats/fragstats.html.

McShea, W.J., H.B. Uderwood, J.H. Rappole. 1997. The science of overabundance: deer ecology and population management. Smithsonian Institution Scholarly Press, Washington D.C., USA.

Merkle, J. A., P. R. Krausman, and M. M. Booth. 2011. Behavioral and attitudinal change of residents exposed to human-bear interactions. Ursus 22:74-83.

Office of Geographic Information Systems (MassGIS). 2012. MassGIS homepage. http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/. Accessed 8 July 2012.

Possel, S. A., S. W. Breck, T.L. Teel, S. Shwiff, K. R. Crooks, and L. Angeloni. 2013. Patterns of human-coyote conflicts in the Denver metropolitan area. Journal of Wildlife Management 77:297-305.

R Core Team. 2010. R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

Riley, S.J., and D.J. Decker. 2000. Wildlife stakeholder acceptance capacity for cougars in Montana. Wildlife Society Bulletin 28:931-939.

Riley, S.P.D., R.M. Sauvajot, T.K. Fuller, E.C. York, D.A. Kamradt, C. Bromley, R.K. Wayne. 2003. Effects of urbanization and habitat fragmentation on bobcats and coyotes in southern California. Conservation Biology 17:566-576.

Stout, R.J., R.C. Stedman, D.J. Decker, and B.A. Knuth. 1993. Perceptions of risk from deer related vehicle accidents: implications for public preferences for deer herd size. Wildlife Society Bulletin 21:237-249.

Tigas, L.A., D.H. Van Vuran, and R.M. Sauvajot. 2002. Behavioral responses of bobcats and coyotes to habitat fragmentation and corridors in an urban environment. Biological Conservation 108:299-306.

United States Census Bureau. 2010. http://www.census.gov/. Accessed 2009. Vitousek, P.M., H.A. Mooney, J. Lubchenco, and J.M. Melillo. 1997. Human domination of earth's ecosystems. Science 277:494-499.

Vogel, W.D. 1989. Responses of deer to density and distribution of housing in Montana. Wildlife Society Bulletin 17:406-413.

White, P. C. L., and A. I. Ward. 2010. Interdisciplinary approaches for the management of existing and emerging human-wildlife conflicts. Wildlife Research 37:623-629.

Whitney, G. 1994. From coastal wilderness to fruited plain: a history of environmental change in temperate North America 1500 to the present. Cambridge University Press, Cambridge, England.