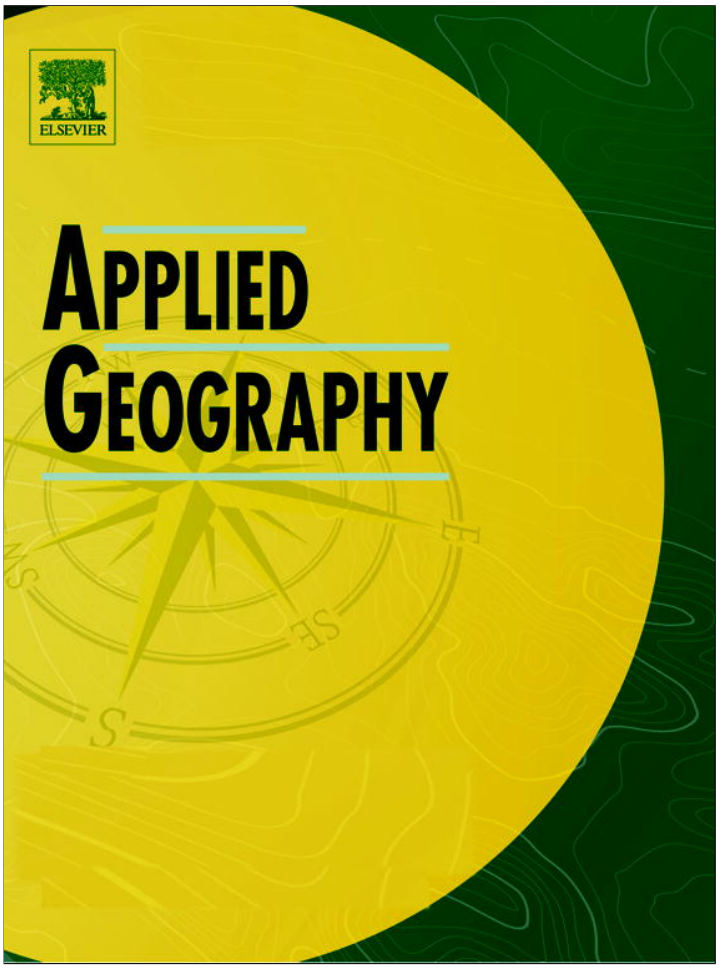
Provided for non-commercial research and education use.
Not for reproduction, distribution or commercial use.




(This is a sample cover image for this issue. The actual cover is not yet available at this time.)

This article appeared in a journal published by Elsevier. The attached copy is furnished to the author for internal non-commercial research and education use, including for instruction at the authors institution and sharing with colleagues.

Other uses, including reproduction and distribution, or selling or licensing copies, or posting to personal, institutional or third party websites are prohibited.

In most cases authors are permitted to post their version of the article (e.g. in Word or Tex form) to their personal website or institutional repository. Authors requiring further information regarding Elsevier's archiving and manuscript policies are encouraged to visit:

http://www.elsevier.com/copyright

Author's personal copy

Applied Geography 35 (2012) 414–421

Contents lists available at SciVerse ScienceDirect

Applied Geography

journal homepage: www.elsevier.com/locate/apgeog

# Scampering in the city: Examining attitudes toward black-tailed prairie dogs in Denver, Colorado

Lauren K. Morse [a], Rebecca L. Powell [a,b,*], Paul C. Sutton [a,c]

[a] Department of Geography, Division of Natural Sciences and Mathematics, University of Denver, 2050 E. Iliff Avenue, Denver, CO 80208, United States
[b] Center for Energy, Environment, & Sustainability, Wake Forest University, 1834 Wake Forest Rd., Winston-Salem, NC 27109, United States
[c] Barbara Hardy Institute & School of Natural and Built Environments, University of South Australia, Adelaide, Australia

*Keywords:*
Urban wildlife
Human–wildlife conflict
Attitude
Prairie dogs
Remote sensing

A B S T R A C T

The conservation of prairie dogs in the Western United States is contentious, as prairie dogs are often considered pests. This research addresses the ecological and social outlook for prairie dog colonies in Denver, Colorado. Remote sensing analysis was applied to identify potential locations for colony reintroduction. To assess the social outlook, knowledge and attitudinal surveys were distributed to residents living near existing colonies and potential colony sites. Statistical analysis of responses provided insight into relationships amongst ecological knowledge, access to educational literature, demographics, and attitudes toward prairie dogs. Results indicated that women view prairie dogs more favorably than men; ecological knowledge was strongly associated with favorableness toward prairie dogs; and residents living near existing colonies were more favorable toward prairie dogs. We conclude that prairie dogs have the potential to be sustained in Denver. This study may help wildlife managers in targeting neighborhood-level education efforts to specific demographics and (mis) conceptions.

© 2012 Elsevier Ltd. All rights reserved.

## Introduction

Cities are burgeoning in both extent and population (Potere, Schneider, Angel, & Civco, 2009). Edge cities and suburbs further contribute to an increasing dominance of the built environment (Garreau, 1992; Wolch, 2007). As concrete structures and asphalt thoroughfares annex the countryside, humans frequently come into contact and conflict with wildlife inhabiting the urban fringe. While some generalist species are more-or-less accepted as part of the urban landscape, many species seem entirely incongruous with contemporary conceptions of the metropolis. While the values placed on urban wildlife in general are shaped by the broader conditions of society (Manfredo, Teel, & Bright, 2003), most American cities are: "…culturally fragmented arenas in which values and attitudes towards nature in general (and wildlife in particular) are bound to be highly variable…" (Wolch, West, & Gaines, 1995, p. 737). Urban open space may be physically suitable for wildlife populations; yet, if residents do not support the wildlife, survival may be threatened. The outlook for urban wildlife thus depends upon both ecological and social factors.

Human-wildlife interactions in metropolitan settings are often contentious. Metropolitan environments largely remain hostile to many vertebrate species; it is especially difficult for mammals to thrive in an urban structure that limits their movement (Garden, McAlpine, Peterson, Jones, & Possingham, 2006). Nonetheless, even lacking corridors and habitat, shadow animal populations manage to survive in the city (Wolch, 2002). However, successful urban animal populations face another challenge—the fissure between urban residents' perception of wilderness and the actual impacts of urban wildlife (Messmer, 2000; Wolch et al., 1995). While wild species may be perceived as charismatic—even iconic—from a distance, their local presence can generate intense conflict over concerns related to human safety and economic losses. Annually, over sixty percent of urban American households experience conflict with wildlife (Messmer, 2000). Human–wildlife conflicts are challenging to resolve because they are often caused by human behavior and expectations (i.e., that wild animals behave "appropriately" around humans); these expectations are difficult to change without extensive education or enforced regulations (Savard, Clergeau, & Mennechez, 2000). Often, repeated animal intrusions become increasingly threatening, and the offending

* Corresponding author. Current address: Center for Energy, Environment, & Sustainability, Wake Forest University, 1834 Wake Forest Rd., Winston-Salem, NC 27109, United States. Tel.: +1 336 758 3541.
*E-mail addresses:* powellr@wfu.edu (R.L. Powell), paul.sutton@unisa.edu.au (P.C. Sutton).

0143-6228/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.apgeog.2012.09.005

Author's personal copy



animal may be killed in the interest of public safety. For example, each year, United States government agents kill an estimated 90,000 "problem" coyotes—a species that is increasingly thriving in suburbs and urban residential neighborhoods (Stark, 2009).

The dichotomy between wilderness and urbanization is even more evident for native wildlife species that have been designated as pests. A pest designation emerges from the widespread perception of harms. The threat may be real or perceived (Messmer, 2000); either way, the stakeholder *perceives it as real*. A pest designation may also perpetuate the association of harms and obscures benefits derived from a particular species. With a pest species, direct management such as culling or translocation is generally preferred by the public. Pest species are purposefully excluded from local landscapes; however, the ostracized animals may migrate to open space, find new marginal habitat, adapt to the altered landscape, or perish for lack of habitat (Wolch et al., 1995).

Despite such conflicts, urban wildlife can provide myriad benefits for urban residents and visitors (Wolch, 2006). A majority of Americans engage in non-consumptive wildlife recreation each year, select wildlife species are perceived as an amenity by urban homebuyers, and supporting urban wildlife fits in well with the rise in sustainability ethos (Wolch, 2007; Wolch et al., 1995). Urban wildlife species may promote a city's identity; for example, salmon are designated as a critical species to the entire metropolitan area of Seattle (Wolch, 2002). The fish attract tourists, and also serves as a source of urban pride, which has resulted in the successful promotion of local habitat restoration (Wolch, 2002). Urban wildlife can create opportunities for ecological education and a tangible connection to local environments. Natural open spaces also lower stress and reduce crime in nearby urban areas (James et al., 2009). Recognizing the benefits of urban wildlife, many communities are working to incorporate wildlife into their built environments (Wolch, 2006). Community-based efforts combined with regional policies will be critical in mitigating the impacts of rapid development on wildlife (Garden et al., 2006; Ricketts & Imhoff, 2003).

The City and County of Denver, Colorado, U.S.A, provides an example of an urban area that is protecting a historically unpopular species (in this case, prairie dogs) due to esthetic and practical benefits that result from the animals' presence. Denver's black-tailed prairie dogs (*Cynomys ludovicianus*, hereafter referred to as "prairie dogs") currently experience severe ecological and social limitations to their distribution. However, the Denver Parks & Recreation Department is actively supporting current prairie dog colonies and in the process of identifying potential relocation sites. One of the driving motivations for supporting urban prairie dog populations is to maintain a source of prey for local predators—both for esthetic purposes, such as supporting local populations of golden eagles, ferruginous hawks, and red-tailed hawks, as well as for practical purposes, such as providing alternative food sources to coyotes, which are increasingly a threat to urban pets (DeLaup, personal communication, Feb. 2010; Hoogland, 2006).

An estimated five billion prairie dogs inhabited North America prior to the 1800s (Forrest, 2005). The natural habitat of these burrowing rodents consists of short grass and mixed grass prairie, and ecologists consider prairie dogs to be a keystone species in these biomes (Kotliar, Miller, Reading, & Clark, 2006; Slobodchikoff, Perla, & Verdolin, 2009). Their colonies were historically home to many imperiled species, including black-footed ferrets and burrowing owls (Lomolino & Smith, 2004). Ecologists estimate that prairie dog colonies currently cover only 1–2% of their original range as a result of extermination, habitat loss and fragmentation, recreational shooting, and outbreaks of sylvatic plague (*Yersinia pestis*) (Fox-Parrish & Jurin, 2008; Hoogland, 1995). Dwindling prairie poses another significant challenge to the species' long-term survival. Rapid urban expansion, in addition to agricultural conversion, transforms prairie ecosystems and makes prairie dog colonies vulnerable to extermination (Magle & Crooks, 2007, 2009). The Denver–Aurora metropolitan area's population alone has increased by 15% between 2000 and 2008 (U.S. Census Bureau, 2009). Prairie dogs are further limited in their urban habitat due to their need for stable colony sites. Unlike most urban wildlife (specifically birds and mammals), they are tied to a specific colony (with the exception of migrating juvenile males).

These colonies can be hot spots for conflict between residents and other stakeholders. Prairie dogs lack institutional protection; they are not listed as a federally-protected species and are, in fact, classified as vermin in many states (Slobodchikoff et al., 2009). Among the reasons for a historic animosity toward prairie dogs in the Western United States are two dominant misconceptions: first, the belief that prairie dogs transmit the plague to humans, and second, the belief that prairie dogs pose hazards to cattle, which can break their legs in the burrows. The plague is carried by fleas and, once transmitted to prairie dogs, quickly eradicates colonies. While the risk of transmission to humans is extremely low, fear of this disease is entrenched in local residents (DeLaup, Denver's wildlife ecologist, personal communication, Feb. 2010). Cattle may occasionally break their legs in burrows; however, these perceived harms have been greatly exaggerated (Slobodchikoff et al., 2009).

While several previous works have addressed human perceptions toward prairie dogs, they lack a unifying theme. Urban residents have been found to display more positive attitudes toward prairie dogs than rural residents (Reading, Miller, & Kellert, 1999); however, one study that explored attitudes toward prairie dogs in Fort Collins, Colorado, concluded that residential proximity to prairie dog colonies significantly increased both knowledge of the species and an acceptance of controlling their population through poisoning (Zinn & Andelt, 1999). Yet another recent study conducted in the Denver metropolitan area found that public attitudes toward prairie dog management strategies were not affected by a resident's proximity to a colony (Milley, 2008).

A study conducted in Montana found that knowledge was not correlated with values and attitudes toward prairie dogs (Reading et al., 1999). Another attitudinal survey, covering the eleven-state prairie dog range, found that those with direct experience with prairie dogs held more negative views of the species; the authors proposed that wildlife managers should educate the public on the keystone role of the prairie dog (Lamb & Cline, 2003). This may prove quite challenging, as despite year-long educational efforts, secondary school students in northern Colorado still described prairie dogs as nuisances, bad for ranchers, and disease-bearing (Fox-Parrish & Jurin, 2008). These myths and stereotypes about prairie dogs are perpetuated by friends, family, and newspaper articles (Reading et al., 1999).

There are multiple challenges to sustaining prairie dogs over the long term in Denver. Suitable open spaces must be identified and preserved. However, successful restoration and maintenance of prairie dog populations does not depend on ecology alone—how society recognizes and values prairie dogs will play a pivotal role. Since historical stereotypes strongly influence the public sentiment against prairie dogs, social criteria must be evaluated as an additional limitation to prairie dog distribution in an urban landscape. If long-term success with urban prairie dog colonies is possible in the City & County of Denver, the city must cope with anticipated human–wildlife conflicts. In order to successfully implement a planned education campaign, managers need detailed information about trends in residents' attitudes and (mis)perceptions toward urban wildlife, as well as knowledge of *where* these attitudes occur relative to specific colony locations.

Author's personal copy



In this study, our goal is to explore the relationships between demographics, ecological knowledge, educational information, and attitudes—in conjunction with the distribution of open spaces which meet criteria for potential prairie dog habitat—in order to comprehensively examine the prospects for Denver's prairie dogs. This study illustrates how a very simple sampling framework, based on residents' location within a city, provides leverage in interpreting attitudes toward a specific species of urban wildlife. Such results could inform local wildlife protection initiatives, especially those that rely on some form of ecological education.

## Methods

### *Urban remote sensing & GIS methods*

Prairie dogs inhabit short and mixed grass prairie as well as moderately barren land. They clear their burrow mounds of vegetation and clip nearby vegetation. As a result, soil and non-photosynthetic vegetation (NPV) land-cover components are the primary contributors to their habitat's spectral signature (Assal & Lockwood, 2007). Because their habitat is not vertically complex, shade is not expected to be a significant spectral component. The difficulty in classifying prairie dog habitat occurs because colonies can be characterized by a range of compositions, from dominant soil cover to dominant NPV cover. Prairie dogs do not change the vegetation of their colony in a uniform way, so spectral mixing and habitat variability are problems even in rural colony detection (Assal & Lockwood, 2007). We applied remote sensing and GIS analysis to identify potential sites for prairie dog colonies. Our analysis was based on two assumptions: (i) built-up areas, i.e., pixels dominated with impervious surfaces—roads, parking lots, buildings, etc.—are not suitable for habitat, and (ii) the land-cover composition of potential habitat sites will be similar to that of currently existing colonies.

Two August 2002 Landsat Enhanced Thematic Mapper Plus (ETM+) images (P33/R32 and P33/R33) were mosaicked and geo-registered to the NAD 83 UTM Zone 13N projection, and the mosaic was clipped so that the bounding box included the City and County of Denver. Our first goal was to identify pixels that are dominated by natural land-cover components. Spectral mixture analysis (SMA), or spectral unmixing, is a method to effectively deconstruct a pixel into its proportional material components. Each pixel is modeled in terms of the fractional abundance of the "pure" spectra (or endmembers) of materials present (e.g., Adams et al., 1995; Powell, Roberts, Dennison, & Hess, 2007). We applied a spectral mixture model with four endmembers selected from the imagery: NPV, green vegetation, soil, and shade. Because we did not include an endmember to represent urban materials, pixels dominated by impervious surfaces were not modeled and were removed from further consideration as "potential habitat." In addition, the shade component of the SMA model was constrained to 50% because we expected colony habitat to have low shade fractions; this constraint also minimized confusion with dark impervious surfaces, e.g., parking lots and composite shingle roofs, which can often be modeled using a high shade fraction (Powell, 2011). An additional constraint was applied to the model to guarantee a minimum "goodness-of-fit" for each pixel; pixels that failed to meet this constraint were left unmodeled (Powell & Roberts, 2010).

Our second goal was to categorize pixels as potential/existing habitat or non-habitat. Because the primary purpose of this analysis was to build a sampling framework for our attitudinal survey, we chose a binary classification. We applied supervised Mahalanobis distance classification (e.g., Chuvieco & Huete, 2010) to classify successfully modeled pixels into two categories: existing/potential prairie dog habitat and non-habitat. Training areas were obtained from known colony sites (545 pixels extracted from ~45 existing colonies). Digital maps of existing colony boundaries had been generated from ground-based surveys completed by the Denver Parks and Recreation Department (2007). Since prairie dog occupancy is also predicted by slope and patch size of suitable habitat (Proctor, Beltz, & Haskins, 1998), two additional criteria were incorporated. Prairie dogs generally occupy flat sites (Assal & Lockwood, 2007); therefore, areas with slope greater than 10% were excluded from the potential colony category. Areas less than one acre were excluded in order to identify larger patches of open prairie that would be viable for a prairie dog population over a relatively long period of time in a rapidly changing urban setting. Future research could focus on the quality of available habitat in order to facilitate the identification of high-priority habitat patches.

The final SMA fraction images and classified potential habitat map indicated that prairie dog colony habitat was distinguishable from human-built structures, impervious surfaces, irrigated vegetation, and other non-habitat areas. The constrained spectral mixture analysis modeled 48% of the pixels in the study area—those pixels in the scene composed of soil, NPV, green vegetation, and minimal shade. The unmodeled portions of the image (52%) were generally dominated by impervious surfaces and water bodies, and therefore not suitable as habitat. Within known colony boundaries, prairie dog habitat was dominated by NPV and soil, which together generally composed more than 75% of the fractional coverage of those pixels, similar to the findings of Assal and Lockwood (2007). Green vegetation composed a very small proportion of the known prairie dog habitat, with average pixel values around 5%. Supervised classification of SMA fractions assigned 39% of the pixels modeled by SMA to the existing/potential habitat class (Fig. 1). These sites could eventually serve as natural expansion or intentional relocation sites. The non-habitat class (61% of the modeled pixels) primarily contained irrigated urban vegetation, such as golf courses and parks. High-spatial resolution (2.4 m) Quickbird imagery from June/July 2007 was accessed through Google Earth and utilized as reference data to assess accuracy of the potential habitat classification. The overall classification accuracy, based on a comparison of 70 randomly selected points, was approximately 83%. Much of the classification error was due to urban development that had occurred since the date of image acquisition.

### *Attitudinal survey*

This binary habitat/non-habitat classification provided the sampling frame that targeted two populations: residents within 0.5 miles of existing colonies and residents within 0.5 miles of potential colony sites. We distributed 1017 surveys to 11 of these residential areas in August 2009, in and around the City & County of Denver. The surveys were hand-delivered in order to verify the status of the open space as an existing or potential prairie dog colony. There was no incentive for survey completion. Six surveyed areas were within 0.50 miles of existing colony sites, and five were within 0.50 miles of potential colony sites (509 surveys and 508 surveys distributed, respectively). In 2007, approximately 907 acres within the city limits of Denver were occupied by prairie dog colonies, less than one percent of the city's total area. Colony areas varied widely, from ~0.05 acres to ~100 acres; the mean colony area was 12.1 acres and median was 5.8 acres. Although the area occupied by individual colonies fluctuates over time, Denver's colonies are consistently grouped on the less-densely settled urban fringe.

Due to the often-charged nature of prairie dog conservation, we began the survey with a cover letter, followed by demographic information (Morse, 2010). We excluded demographic markers

Author's personal copy



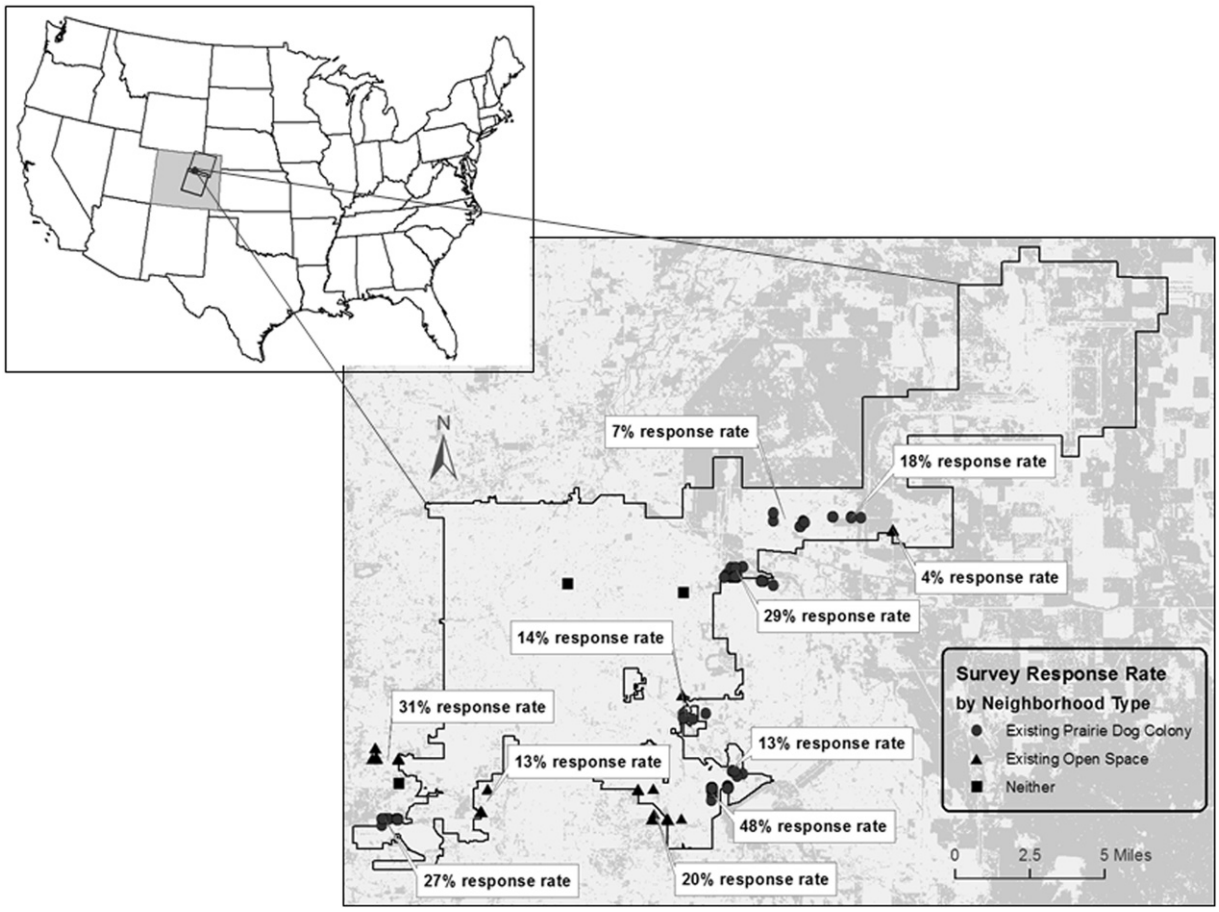



**Fig. 1.** Study area and survey response rates by neighborhood type. Classified image represents potential/existing prairie dog habitat (gray) and non-habitat (white).

such as income and political affiliation which were likely to increase non-response (Dillman, 1978). The next section of the survey included seven multiple choice questions aimed at assessing ecological knowledge to evaluate what impact, if any, ecological knowledge would have on opinions. After the knowledge section, half of the surveys included an educational component—discussing prairie dogs' keystone species role, communication abilities[1] drastic population decline, and the low risk of plague transmission to humans, where the correct answers to the preceding section were provided along with short explanatory paragraphs. This allowed us to assess the impact of written ecological information on attitudes. The survey concluded with an attitudinal section employing a five-point Likert scale (Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree) and a "No Opinion" option. This survey design facilitated comparison with earlier work on attitudes about urban prairie dogs in Fort Collins, Colorado (Zinn & Andelt, 1999), regional work on public knowledge and attitudes about prairie dogs in the Midwest (Lamb & Cline, 2003), and incorporated input regarding local priorities from Denver's wildlife ecologist (DeLaup, personal communication, Feb. 2009). Prior to distribution, the surveys were pre-tested on volunteers consisting of graduate students and university staff in order to ensure clarity.

[1] They also have the most advanced language documented in non-human mammals (Frederiksen & Slobodchikoff, 2007; Slobodchikoff et al., 2009).

*Statistical analysis*

Categorical analysis was used to compare demographic variables to attitudinal responses (JMP 8.0, SAS Institute Inc., 2008). For each attitudinal statement, responses were grouped as "Strongly Agree/Agree" or "Disagree/Strongly Disagree," while "Neutral" and "No Opinion" responses were not included in the analyses. The data were subsequently disaggregated into two subsets: respondents near existing colonies and respondents near potential colony sites. The attitudinal statements were again analyzed in relation to the major variables of interest for each subset: gender, knowledge levels, and inclusion of educational literature. While theoretically it is a possible that non-response bias could significantly influence measures of public opinion, there is increasing evidence that little to no relationship exists between response rates and survey errors (Keeter, Miller, Kohut, Groves, & Presser, 2000; Merkle & Edelman, 2002). This is important because people are increasingly non-responsive to surveys of any nature. Nonetheless, larger sample sizes still contribute to statistical power, and our sample size of $N > 200$ is useful and cost-appropriate in light of the costs of conducting surveys.

## Results

We received 223 surveys for a 22% response rate (Table 1; Fig. 1); 68% ($n = 151$) came from residents living near existing colonies, 31% ($n = 69$) from residents living near potential colonies as determined by remote sensing classification, and 1% ($n = 3$) from other

Author's personal copy



**Table 1**
Summary of returned surveys used in statistical analyses.

| Sub-group | Count ($n$) | Percent (%) |
|---|---|---|
| **Educational component** | **103** | **47** |
| Near existing colony | 69 | 31 |
| Near potential colony site | 34 | 16 |
| **No educational component** | **117** | **53** |
| Near existing colony | 82 | 37 |
| Near potential colony | 35 | 16 |
| **Females** | **126** | **57** |
| Near existing colony | 87 | 40 |
| Near potential colony site | 39 | 17 |
| **Males** | **94** | **43** |
| Near existing colony | 64 | 30 |
| Near potential colony site | 30 | 13 |

addresses (which were discarded). There was a wide range in the attitudinal responses among all respondents. While only 5% of respondents disagreed or strongly disagreed with the statement *I enjoy seeing hawks and eagles in my community,* which was the lowest rate of disagreement on an attitudinal statement between all respondents, about 20% of the respondents agreed or strongly agreed with the statement *Lethal removal of prairie dogs should be the standard management practice on public lands* (Table 2). Thirty-four percent of respondents disagreed or strongly disagreed with the statement *I enjoy or would enjoy having prairie dogs live in my community* (Table 2). The median respondent answered two of seven ecological knowledge questions correctly. This statistic held across gender, residential type, and educational information subsets.

### *Demographic variables and attitudes*

Residence type—whether the survey respondent lived near an existing colony or a potential colony site—exhibited significant differences for two statements (Table 3). Those living near colonies were significantly more likely to agree or strongly agree with the statement *I enjoy or would enjoy having prairie dogs live in my community* ($\chi^2 = 11.4$, $p = 0.02$). Residents living near colonies were much less likely to agree with the statement *Prairie dogs inhabit flat, open space that would be better used for urban development* than residents living near a potential colony site ($\chi^2 = 9.88$, $p = 0.04$). There was only one significant difference in attitudes based upon whether or not a respondent received educational information in their survey packet (Table 3): residents who had received educational information were more likely to disagree or strongly disagree with the statement *Prairie dogs are harmful to ranching* than those who did not receive educational information ($\chi^2 = 10.3$, $p = 0.04$).

Gender was strongly associated with different attitudes (Table 4). On six of ten statements, females living near a colony were significantly more likely to support prairie landscapes and prairie dogs than males. Females living near potential colony sites, were significantly more likely than males to strongly agree, agree, or be neutral with two statements: *Prairie dogs in Denver play an important role in keeping the natural prairie intact* ($\chi^2 = 12.7$, $p = 0.013$) and *I support protecting prairie dogs in Denver* ($\chi^2 = 11.04$, $p = 0.03$). There was no relationship between gender and ecological knowledge.

### *Ecological knowledge and attitudes*

Across all respondents, ecological knowledge levels (i.e., low was 0–1, moderate was 2–4, and high was 5–7 questions answered correctly) were significantly associated with all statements except *Plague outbreaks in prairie dogs are a threat to human health* (Table 3). For most statements, the pattern was consistent: those with low knowledge had the least favorable attitudes, those with moderate knowledge had favorable attitudes, and those with high knowledge had the most favorable attitudes toward prairie landscapes and prairie dogs. Two statements—*Lethal removal of prairie dogs should be the standard management practice on public lands* and *Prairie dogs are harmful to ranching*—deviated from this pattern, as respondents with moderate levels of knowledge showed the most favorable attitudes for these statements.

Individual questions about ecological knowledge were subsequently compared to attitudinal responses. Respondents who correctly answered that *Prairie dog colonies are a very important part of prairie ecosystems* were always more positive toward prairie dogs than those respondents who answered incorrectly ($p < 0.05$ for all ten attitudinal statements). Respondents who correctly answered that *Prairie dogs have extraordinary communication abilities* were more positive toward prairie dogs on eight out of ten attitudinal statements ($p < 0.05$).

## Discussion

In the Colorado Front Range, limited habitat is an obvious constraint for urban prairie dogs. The goal of the remote sensing analysis presented here was to provide a location-specific framework for studying attitudes toward prairie dogs. This analysis determined that there is existing natural space that could be

**Table 2**
Responses to attitudinal statements by count and percentage of total responses.

| Attitudinal statement | Strongly agree or agree | | Neutral or No opinion | | Disagree or strongly disagree | |
|---|---|---|---|---|---|---|
| | Count ($n$) | Percent (%) | Count ($n$) | Percent (%) | Count ($n$) | Percent (%) |
| I enjoy or would enjoy having prairie dogs live in my community. | 89 | 40 | 58 | 26 | 75 | 34 |
| I enjoy seeing hawks and eagles in my community. | 171 | 77 | 40 | 18 | 12 | 5 |
| Prairie dogs in Denver play an important role in keeping the natural prairie intact. | 127 | 53 | 69 | 29 | 43 | 18 |
| Lethal removal of prairie dogs should be standard management practice on public lands. | 45 | 20 | 48 | 22 | 130 | 58 |
| Prairie dogs are harmful to ranching. | 67 | 29 | 93 | 41 | 69 | 30 |
| I support protecting prairie dogs in Denver. | 99 | 44 | 69 | 31 | 55 | 25 |
| Restoring native prairie habitat in Denver is important to me. | 105 | 47 | 71 | 32 | 46 | 27 |
| Plague outbreaks in prairie dogs are a threat to human health. | 78 | 32 | 71 | 30 | 91 | 38 |
| I would consider a nearby prairie dog colony to be a positive amenity in a Denver neighborhood. | 87 | 39 | 52 | 23 | 84 | 38 |
| Prairie dogs inhabit flat, open space that would be better used for urban development. | 30 | 13 | 62 | 28 | 131 | 59 |

Author's personal copy



**Table 3**
Categorical comparisons across all residents.

| Attitudinal statement[a] | Residence type[b] | | Education info[c] | | Knowledge[d] | |
|---|---|---|---|---|---|---|
| | $\chi^2$ | $p$ | $\chi^2$ | $p$ | $\chi^2$ | $p$ |
| I enjoy or would enjoy having prairie dogs in my community | 11.4 | 0.02* | 1.7 | 0.80 | 23.1 | 0.003* |
| I enjoy seeing hawks and eagles in my community | 6.3 | 0.18 | 9.0 | 0.06 | 23.0 | 0.003* |
| Prairie dogs in Denver play an important role in keeping the natural prairie intact | 0.7 | 0.95 | 4.2 | 0.38 | 26.4 | 0.0009* |
| Lethal removal of prairie dogs should be the standard management practice on public lands | 7.2 | 0.12 | 4.2 | 0.38 | 34.6 | <0.0001* |
| Prairie dogs are harmful to ranching | 3.2 | 0.53 | 10.4 | 0.04* | 15.9 | 0.0044* |
| I support protecting prairie dogs in Denver | 6.1 | 0.19 | 2.2 | 0.69 | 25.7 | 0.0012* |
| Restoring native prairie habitat in Denver is important to me | 2.6 | 0.63 | 1.3 | 0.86 | 33.7 | <0.0001* |
| Plague outbreaks in prairie dogs are a threat to human health | 1.5 | 0.83 | 4.3 | 0.37 | 12.0 | 0.15 |
| I would consider a prairie dog colony to be a positive amenity in a Denver neighborhood | 8.8 | 0.07 | 7.3 | 0.12 | 27.0 | 0.0007* |
| Prairie dogs inhabit flat, open space that would be better used for urban development | 9.9 | 0.04* | 8.0 | 0.09 | 27.2 | 0.0007* |

Significant results ($p < 0.05$) denoted with *.
[a] Attitudinal responses grouped as Agree/Strongly Agree and Disagree/Strongly Disagree.
[b] Residence Type compares respondents living near existing colonies and near potential colony sites.
[c] Educational Info compares respondents based on whether survey included educational information.
[d] Knowledge compares respondents with low, moderate, high knowledge levels.

dedicated to prairie dogs colonies within the Denver city limits. Given both ecological and social constraints, the long-term outlook for Denver's prairie dogs is precarious. However, this research demonstrates that there is urban habitat for prairie dogs in Denver and that urban neighborhoods can be accepting of these animals.

The results of our attitudinal survey indicated that females were consistently more favorable toward prairie dogs and prairie landscapes than males. Ecological knowledge also appears to have a significant and positive effect on attitudes toward this species. As this survey was fairly simple and there was no follow-up with respondents, future studies should consider ways to add qualitative depth in an effort to better understand why these groups had more positive attitudes.

To promote acceptance of prairie dog colonies, our findings suggest that managers should educate residents about the minimal risks of plague, the important keystone role of prairie dogs, and their advanced communication abilities. In this study, the plague was more of an explicit concern to urban residents than prairie dogs' impacts on ranching. More than a third of residents responded neutrally about the impact of prairie dogs on ranching; yet, only about one-fifth were neutral about the impact of prairie dogs on human health. Residents with high levels of knowledge felt more strongly that the plague was a human health threat than residents with moderate knowledge, and high-knowledge residents were also more likely to support lethal management techniques. One possible explanation for this contradiction is that residents with higher knowledge are informed to the extent that they understand the association with prairie dogs and the plague, although they do not believe that the risk to humans is low. Since increased perception of risk appears to negatively impact attitudes toward prairie dogs, a lowered perception of risk achieved through education could lead to more positive attitudes (Lybecker, Lamb, & Ponds, 2002).

**Table 4**
Categorical comparisons for residents based on gender and residential location.

| Attitudinal statement[a] | Existing[b] | | Potential[c] | |
|---|---|---|---|---|
| | $\chi^2$ | $p$ | $\chi^2$ | $p$ |
| I enjoy or would enjoy having prairie dogs in my community | 7.9 | 0.10 | 9.2 | 0.06 |
| I enjoy seeing hawks and eagles in my community | 0.72 | 0.95 | 2.0 | 0.75 |
| Prairie dogs in Denver play an important role in keeping the natural prairie intact | 11.2 | 0.03* | 12.7 | 0.013* |
| Lethal removal of prairie dogs should be the standard management practice on public lands | 10.2 | 0.04* | 8.7 | 0.07 |
| Prairie dogs are harmful to ranching | 17.2 | 0.002* | 3.7 | 0.45 |
| I support protecting prairie dogs in Denver | 14.6 | 0.006* | 11.0 | 0.026* |
| Restoring native prairie habitat in Denver is important to me | 15.2 | 0.004* | 0.5 | 0.97 |
| Plague outbreaks in prairie dogs are a threat to human health | 6.6 | 0.16 | 4.1 | 0.39 |
| I would consider a prairie dog colony to be a positive amenity in a Denver neighborhood | 8.2 | 0.08 | 6.6 | 0.16 |
| Prairie dogs inhabit flat, open space that would be better used for urban development | 15.8 | 0.003* | 3.2 | 0.52 |

Significant results ($p < 0.05$) denoted with *. All significant differences indicate more positive support for prairie dogs by females.
[a] Attitudinal responses grouped as *Agree/Strongly Agree* and *Disagree/Strongly Disagree*.
[b] *Existing* compares attitudes of respondents based who live near existing colonies.
[c] *Potential* compares respondents who live near potential colony sites.

There were two knowledge questions for which a correct response had a positive impact on attitudes: prairie dogs' keystone species role and their communication abilities. The keystone species angle is one of the strongest arguments—from an ecological standpoint—in favor of conserving and restoring prairie dog populations; as an added benefit for wildlife managers, it appears to correspond with positive attitudes toward Denver's urban prairie dogs. Residents who responded correctly to this question may be aware of the association between the presence of prairie dogs and the presence of charismatic raptors. Regardless of other views on prairie landscapes and prairie dogs, respondents overwhelmingly viewed hawks and eagles favorably. The predator–prey link may be an effective argument, in terms of changing residents' attitudes, for building public support for urban prairie dog colonies. Second, the advanced communication abilities of prairie dogs seem to imbue them with a charismatic intelligence; our results indicate that people who know that prairie dogs have a language were more likely to support their presence in Denver.

The relatively brief educational information included in the survey was not effective in changing overall attitudes. Because we could not follow up with respondents, we have no way of knowing whether residents even read the material, much less if they found it convincing. Furthermore, those with pre-existing unfavorable attitudes toward prairie dogs may have perceived explanations of their ecological importance as biased. However, educational information was associated with higher rates of disagreement for the statement *Prairie dogs are harmful to ranching*, suggesting that even minimal educational information may begin to change attitudes.

Residents living near colonies were more likely to agree or strongly agree with the statement *I enjoy or would enjoy having prairie dogs live in my community*. In addition, they were much more

Author's personal copy



likely to disagree or strongly disagree with the statement *Prairie dogs inhabit flat, open space that would be better used for urban development* than residents near potential colony sites. These results suggest that development of prairie for human use, at the detriment of prairie dogs, is less acceptable to residents who live near an urban colony.

There are several possible underlying causes for this trend. The most optimistic is that regardless of previous viewpoints, residents in close proximity begin to accept their prairie dog neighbors and minimized perceived and actual costs to landscaping and human health. Because the residences classified as near a colony encompassed a 0.01 mile–0.50 mile range, many respondents did not find prairie dogs literally in their backyard, and there may have been enough distance to minimize conflict. Another potential confounding factor is that residents who do not like prairie dogs may choose not to live near colonies. Yet another possible factor may be the result of non-response bias, as residents living near colonies were more likely to respond than residents living near potential colonies. Those with frequent interactions with prairie dogs—whether positive or negative—appear more interested in the survey than the population at large, as represented by those living near areas classified as potential colony sites. Another potential non-response bias could be the higher proportion of women who responded to the survey; however, a previous study in the Denver metropolitan area that explored perceptions of prairie dogs and open space fragments found only negligible differences between respondents' and non-respondents' demographics and attitudes (Milley, 2008).

Our study found that females were more overall positive toward prairie dogs and prairie landscapes; previous studies have found that women tend to hold more pro-environment attitudes (Reading, Stern, & McCain, 2006). However, women who live near potential colony sites exhibited less favorable attitudes toward prairie dogs than women near existing colonies. This provides tentative support for the postulation that women who live near colonies are influenced by exposure to prairie dogs and develop more favorable attitudes toward the species. However, this study did not assess the underlying reasons behind the attitudes. Future studies could address this need through a combination of surveys and follow-up interviews.

This study uncovered patterns that directly contrast with attitudinal patterns found over a decade ago in Fort Collins, Colorado (Zinn & Andelt, 1999). In that case study, respondents living near colonies were more likely to express unfavorable attitudes toward prairie dogs. The authors even noted that "…long-term proximity to prairie dogs may make negative aspects of the animals' presence more salient" (Zinn & Andelt, 1999, p. 1104). The authors of that study claimed that, at that time, Fort Collins's longer-term residents, who inhabited the urban-rural fringe where prairie dogs were found, were potentially still connected to the area's recent agricultural past, while newer, suburban residents had not embraced the view that prairie dogs were a nuisance and a threat to human livelihoods. Knowledge was not strongly associated with attitudes among the surveyed population in Fort Collins; however, the current study found the opposite relationship in Denver. The temporal difference between studies could be one explanation, as urban growth tends to pull in many new residents with non-utilitarian wildlife belief systems (Manfredo et al., 2003). This may provide further support to the postulation that prejudice can play a significant role in attitudes toward prairie dogs; if those who grew up steeped in the vision of prairie dogs as vermin may maintain that bias. This is a supposition worth further exploration.

This survey was not able to measure all variables that might contribute to residents' attitudes toward Denver's prairie dogs. Nonetheless, the results strongly suggest that even moderate knowledge about prairie landscapes and prairie dogs improves attitudes. Educational efforts should emphasize prairie dogs' role as a keystone species, especially with regard to birds of prey, and on their advanced communication abilities. Consistent and persistent education may progressively debunk fears of the plague among urban residents. Furthermore, the gender gap in attitudes indicates that outreach efforts by wildlife managers should focus on men.

## Conclusion

The existing construct of nature in the United States bestows the privileged status of wilderness and wildlife upon pristine environments and charismatic animals, while local ecosystems are often under-appreciated (Cronon, 1995). One consequence of this division is that our cities have far too little space for urban wildlife, and these creatures are rarely accepted as part of the urban landscape. Urban wildlife, and especially the conflict that often emerges around its presence, therefore cannot be separated into ecological and social components when considering the long-term outlook for a species.

This urban wildlife case study shows that prairie dogs—which are a critical component of the native prairie ecosystem—have the potential to be sustained in the City and County of Denver. Information on public attitudes toward prairie dogs and potential habitat sites is critical for successfully managing this species in urban and suburban settings. Our results suggest that preservation of natural prairie lands and protection of prairie dogs is broadly supported by Denver residents, especially among women and residents with moderate ecological knowledge. Proximity of residents to existing colonies was also an important factor in this case study; in contrast with previous work (Zinn & Andelt, 1999), existing residents located near prairie dog colonies viewed them more favorably than urban residents living near potential colony sites.

The spatial aspect of attitudes toward wildlife merits further attention, particularly in the urban fringe. In order to conserve open space and native species, wildlife managers must have relevant and detailed information about the ecological and social landscapes. Attitudes may vary significantly based upon residents' gender, knowledge, and location within the city, as in this case study, or attitudes may vary due to other demographic factors. Exploring these relationships can provide wildlife managers and other stakeholders with insight that may ultimately improve the outlook for urban species or even an urban ecosystem.

This study, while preliminary, provides a template for determining if and where there is local support for wildlife initiatives. Wildlife managers can use this spatial information to effectively allocate limited educational resources to neighborhoods where prairie dog colonies can be viably sustained. Future research should include an in-depth, qualitative component which would explore some of the suppositions made about the relationships between gender, knowledge, and attitudes toward prairie dogs. Wildlife managers would also benefit from a longitudinal study on residential attitudes, with a close examination of the educational outreach, both before and after urban prairie dog reintroduction.

## Acknowledgments

The authors gratefully acknowledge Ashley DeLaup, wildlife ecologist for the City and County of Denver, for her time and input, and for providing access to Denver Parks and Recreation spatial data on prairie dog colonies. Field work was financially supported by the Department of Geography at the University of Denver. We thank the editor and two anonymous reviewers for constructive comments on an earlier version of the manuscript.

Author's personal copy



## References


Adams, J. B., Sabol, D. E., Kapos, V., Almeida Filho, R., Roberts, D. A., Smith, M. O., et al. (1995). Classification of multispectral images based on fractions of end-members: application to land-cover change in the Brazilian Amazon. *Remote Sensing of Environment, 52*, 137–154.

Assal, T. J., & Lockwood, J. A. (2007). Utilizing remote sensing and GIS to detect prairie dog colonies. *Rangeland Ecology & Management, 60*, 45–53.

Chuvieco, E., & Huete, A. (2010). *Fundamentals of satellite remote sensing*. Boca Raton: CRC Press.

Cronon, W. (1995). The trouble with wilderness or, getting back to the wrong nature. In W. Cronon (Ed.), *Uncommon ground: Toward reinventing nature* (pp. 7–25). New York: W.W. Norton & Company.

Dillman, D. A. (1978). *Mail and telephone surveys: The total design method*. New York: Wiley-Interscience.

Forrest, S. (2005). Getting the story right: a response to Vermeire and colleagues. *BioScience, 55*, 526–530.

Fox-Parrish, L., & Jurin, R. R. (2008). Students' perceptions of a highly controversial yet keystone species, the black-tailed prairie dog: a case study. *The Journal of Environmental Education, 39*, 3–15.

Frederiksen, J. K., & Slobodchikoff, C. N. (2007). Referential specificity in the alarm calls of the black-tailed prairie dog. *Ethology, Ecology & Evolution, 19*, 87–99.

Garden, J., McAlpine, C., Peterson, A., Jones, D., & Possingham, H. (2006). Review of the ecology of Australian urban fauna: a focus on spatially explicit processes. *Austral Ecology, 31*, 126–148.

Garreau, J. (1992). *Edge city: Life on the new frontier*. New York: Anchor Books.

Hoogland, J. L. (1995). *The black-tailed prairie dog: Social life of a burrowing mammal*. Chicago: University of Chicago Press.

Hoogland, J. L. (2006). *Conservation of the black-tailed prairie dog: Saving North America's western grasslands*. Washington, D.C: Island Press.

James, P., Tzoulas, K., Adams, M. D., Barber, A., Box, J., Breuste, J., et al. (2009). Towards an integrated understanding of green space in the European built environment. *Urban Forest & Urban Greening, 8*, 65–75.

Keeter, S., Miller, C., Kohut, A., Groves, R. M., & Presser, S. (2000). Consequences of reducing nonresponse in a large national telephone survey. *Public Opinion Quarterly, 64*, 125–128.

Kotliar, N. B., Miller, B. J., Reading, R. P., & Clark, T. W. (2006). The prairie dog as keystone species. In J. L. Hoogland (Ed.), *Conservation of the black-tailed prairie dog: Saving North America's western grasslands* (pp. 53–64). Washington, D.C: Island Press.

Lamb, B. L., & Cline, K. (2003). Public knowledge and perceptions of black-tailed prairie dogs. *Human Dimensions of Wildlife, 8*(2), 127–143.

Lomolino, M. V., & Smith, G. A. (2004). Terrestrial vertebrate communities at black-tailed prairie dog (*Cynomys ludovicianus*) towns. *Biological Conservation, 115*, 89–100.

Lybecker, D., Lamb, B. L., & Ponds, P. D. (2002). Public attitudes and knowledge of the black-tailed prairie dog: a common and controversial species. *BioScience, 52*, 607–612.

Magle, S. B., & Crooks, K. R. (2007). Interactions between black-tailed prairie dogs (*Cynomys ludovicianus*) and vegetation in habitat fragmented by urbanization. *Journal of Arid Environments, 72*, 238–246.

Magle, S. B., & Crooks, K. R. (2009). Investigating the distribution of prairie dogs in an urban landscape. *Animal Conservation, 12*, 192–203.

Manfredo, M. J., Teel, T., & Bright, A. D. (2003). Why are public values towards wildlife changing? *Human Dimensions of Wildlife, 8*, 287–306.

Merkle, D., & Edelman, M. (2002). Nonresponse in exit polls: a comprehensive analysis. In R. M. Groves, D. A. Dilman, J. L. Eltinge, & R. J. A. Little (Eds.) (pp. 243–258). New York: Wiley.

Messmer, T. A. (2000). The emergence of human-wildlife conflict management: turning challenges into opportunities. *International Biodeterioration & Biodegradation, 45*, 97–102.

Milley, B. (2008). *Understanding the value of habitat fragments as conservation units: Connecting biological and human dimensions information*. M.S. Thesis. Colorado State University, Fort Collins, Colorado, USA.

Morse, L. K. (2010). *Scampering in the city: Examining the ecological and social viability of black-tailed prairie dogs (Cynomys ludovicianus) in Denver, Colorado*. M.S. Thesis. University of Denver, Denver, Colorado, USA.

Potere, D., Schneider, A., Angel, S., & Civco, D. L. (2009). Mapping urban areas on a global scale: which of the eight maps available now is more accurate? *International Journal of Remote Sensing, 30*, 6531–6558.

Powell, R. L. (2011). Characterizing urban subpixel composition using spectral mixture analysis. In X. Yang (Ed.), *Urban remote sensing: Monitoring, synthesis and modeling in the urban environment* (pp. 111–128). United Kingdom: John Wiley & Sons.

Powell, R. L., & Roberts, D. A. (2010). Characterizing urban land-cover change in Rondônia, Brazil: 1985–2000. *Journal of Latin American Geography, 9*, 183–211.

Powell, R. L., Roberts, D. A., Dennison, P. E., & Hess, L. L. (2007). Sub-pixel mapping of urban land cover using multiple endmember spectral mixture analysis: Manaus, Brazil. *Remote Sensing of Environment, 106*, 253–267.

Proctor, J., Beltz, M., & Haskins, W. (1998). *A GIS model for identifying potential black-tailed prairie dog habitat in the Northern Great Plains shortgrass prairie*. M.S. Thesis. University of Montana, Missoula, Montana, USA.

Reading, R. P., Miller, B. J., & Kellert, S. R. (1999). Values and attitudes toward prairie dogs. *Anthrozoos, 12*, 43–52.

Reading, R. P., Stern, D., & McCain, L. (2006). Attitudes and knowledge of natural resource agency personnel towards black-tailed prairie dogs *(Cynomys ludovicianus). Conservation and Society, 4*(4), 592–618.

Ricketts, T., & Imhoff, M. (2003). Biodiversity, urban areas, and agriculture: locating priority ecoregions for conservation. *Ecology and Society, 8*(2). http://www.consecol.org/vol8/iss2/art1.

Savard, J.-P. L., Clergeau, P., & Mennechez, G. (2000). Biodiversity concepts and urban ecosystems. *Landscape and Urban Planning, 48*, 131–142.

Slobodchikoff, C. N., Perla, B. S., & Verdolin, J. L. (2009). *Prairie dogs: Communication and community in an animal society*. Cambridge: Harvard University Press.

Stark, M. (12 July 2009). *When it comes to controlling wily coyotes without deadly force, simple answers remain elusive*. The Canadian Press.

U.S. Census Bureau. (2009). *Table 10—Cumulative estimates of the components of population change for metropolitan and micropolitan statistical areas: April 1, 2000 to July 1, 2008*. Retrieved April 2010, from. http://www.census.gov/population/www/estimates/CBSA-est2008-comp-chg.html.

Wolch, J. (2002). Anima urbis. *Progress in Human Geography, 26*(6), 721–742.

Wolch, J. (2006). Harmony: America's latest conservation community. In R. L. Kemp (Ed.), *Cities and nature: A handbook for renewal* (pp. 110–115). United States: McFarland and Company Inc.

Wolch, J. (2007). Green urban worlds. *Annals of the Association of American Geographers, 97*, 373–384.

Wolch, J., West, K., & Gaines, T. E. (1995). Transspecies urban theory. *Environment & Planning D: Society & Space, 13*, 735–760.

Zinn, H. C., & Andelt, W. F. (1999). Attitudes of Fort Collins, Colorado, residents toward prairie dogs. *Wildlife Society Bulletin, 27*, 1098–1106.