

Urban business attitudes regarding rodents,  
rodent control methods, and impact on wildlife

By

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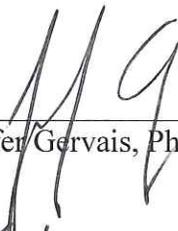
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**Introduction:**

Birds of prey and carnivorous mammals are known to feed on small birds, rodents and other small mammals. Humans perceive many of the prey animals of these predators, as well as the predators themselves, as “pests”, and seek to control them. Control methods for these unwanted pests, particularly rodents, have the potential to impact non-target species as well, such as San Joaquin kit fox (*Vulpes macrotis mutica*), bobcat (*Felis rufus*), mountain lion (*Puma concolor*), and coyote (*Canis latrans*).

Rodenticides are products used to specifically control rodents. Rodenticides include, but are not limited to: live traps, glue boards, snap traps and chemicals such as anticoagulants. Rodenticides have been used as a means to control both predators and the smaller animals that serve as their food source (Alterio 1996). In this study, we have particular interest in those rodenticides classified as anticoagulants. Anticoagulants prevent blood clotting by disrupting the vitamin K cycle (Brakes and Smith 2005). Without the ability to form blood clots, animals bleed uncontrollably, and eventually die from internal hemorrhaging.

Anticoagulants are generally grouped into two categories, first and second generation. Erickson and Urban (2004) compared first and second generation anticoagulants. First generation anticoagulants are metabolized and/or excreted quickly, are less acutely toxic and usually must be ingested over several days to reach a high enough concentration in the body to be lethal for most individuals. Second generation anticoagulants are more acutely toxic and retained much longer in body tissues, thus requiring smaller doses to be lethal (Erickson and Urban 2004).

Non-target animals may come into contact with rodenticides in three different ways: eating the rodenticides directly, eating animals that have not metabolized the rodenticides and may have undigested anticoagulants in their stomach or cheek pouches, or eating animals that have metabolized the rodenticides. Predators who consume such animals are therefore poisoned themselves.

Direct poisoning is not the only way animals die from anticoagulant exposure. Many studies (McDonald and Harris 2000; Eason et al. 2002; Riley et al. 2007) have shown that predators, after consuming poisoned prey, can be killed or incapacitated by secondary poisoning. Murphy et al. (1998) found rodents that have been poisoned by anticoagulants leave their dens to die, which exposes their carcasses as targets for scavenging. Anticoagulant exposure can also lead incapacitation which exposes affected animals to other dangers such as predation by other animals (Hunt et al. 1992; Knopper et al. 2007). For example, Schitoskey (1975) stated that San Joaquin kit foxes (an endangered species) are known to eat freshly killed carcasses and could possibly bring these carcasses back to their dens to feed their young. Non-target foragers may be directly poisoned as well. In a longitudinal study over 15 years, with two three-year sampling periods, anticoagulants were found in 20% of tawny owl samples (Walker et al. 2008).

Rodenticides are used and impact wildlife across a variety of land uses. Non-target wildlife were found dead and disabled one day after anticoagulant was used on a nearby cornfield (Augspurger et al. 1996). Farmers in Northern Ireland used anticoagulants every year, even when rodent populations were not considered to be a problem (Tosh et al. 2011). Eason and Olgivie (2009) suggest that the rodenticide

brodifacoum may be used in aerial application to protect native flora and fauna and relieve pressure from exotic species damage on islands off the shore of New Zealand. Duckett (1984) states rodenticides are used in oil palm forests to control rodent populations. Gamekeepers in England use rodenticides to control for grey squirrels (*Sciurus carolinensis*) (McDonald and Harris 2000). Hunters illegally controlling for fox (*Cannis vulpes*) in Greece caused the death of *A. monachus*, a rare bird species (Antoniou et al. 1996). Animals recovered by the California Fish and Game Service near a stream in Northern California had Diphacinone present in their tissues (Littrell 1988).

Human efforts at rodent control and related rodenticide use in urban areas may also have negative impacts on wildlife (Riley et al., 2007). Human urbanization alters natural habitats by fragmenting and sometimes eliminates habitats, forcing the local wildlife to adapt. For example, Riley et al. (2003) stated that little is known about how bobcats and coyotes respond to pressures from urbanization, but rodenticides are known to affect these species based on necropsy analysis. Testing bird carcasses received from all over the State of New York found a larger portion of the birds carcasses within an urban area tested positive for anticoagulants when compared with less urbanized areas (Stone et al. 2003). In such situations, human landscaping efforts may create “easy” food sources for wildlife (e.g., fruit trees and gardens). These food sources may lead to rodents and other pest species invading the landscaping, causing humans to use methods of control, including chemicals that can have non-target effects on wildlife. However, humans who use rodent control products are often not aware how this activity in an urbanized landscape may have secondary non-target effects (Morzillo and Mertig, 2011a).

In an effort to mitigate rodenticide impacts to humans and the environment, in May 2008, the United States Environmental Protection Agency (US EPA) published new federal guidelines for 10 rodenticides. These guidelines include limitations in amount (i.e. elimination of “consumer” size containers), application (e.g. bait stations required for outdoor above-ground placement), merchant (e.g. agriculture supply stores) and people who use them (professional applicators) in order to minimize potential for exposure to these products by children and wildlife (US EPA, 2008).

To better understand linkages between rodenticides and wildlife in urban areas, Morzillo and Mertig (2011a, b) evaluated how anticoagulants may be getting into the environment from residential sources (residential use), whether people are aware of the potential impact to wildlife, and whether knowledge of possible non-target impacts on wildlife might change how people use anticoagulants. Morzillo and Mertig (2011a,b) found that even though households had very limited previous knowledge the respondents indicated a potential to change their rodenticide use practices. However, urban areas are also comprised of land uses other than residences such as, parks and schools. What remains unknown, and is addressed here, is how anticoagulant use practices by businesses may contribute to these non-target impacts.

To further add to our knowledge of how human anticoagulant use practices are contributing anticoagulant rodenticides into the environment, I evaluated pesticide use practices by businesses, with a specific focus on rodent control. To do this I had six objectives:

- 1) Determine what species rodenticides are being targeted. Morzillo and Schwartz (2011) found rats and mice to be the most common pests targeted for by households. I hypothesized that rats and mice would be the most common species targeted.
- 2) Evaluate what initiates the use of rodenticides. Results from Morzillo and Mertig (2011a) suggested that observation of pests and property damage are the most common reasons for pesticide use. I hypothesized that seeing pests, or signs of them such as droppings, would be the most common reason that business owners start using rodenticides. Property damage and preventative maintenance are other possible reasons for use.
- 3) Understand attitudes toward rodents. Morzillo and Mertig (2011a) found that attitudes toward rodents were highly negative among households. I hypothesized that business respondents will have negative attitudes toward rodents.
- 4) Determine attitudes toward non-target impact of rodenticides. Morzillo and Mertig (2011a) found 40-45% of respondents were “somewhat concerned”, whereas fewer respondents were “very concerned” about how chemical rodenticides may be affecting wildlife in the local area. I hypothesized business respondents would be concerned about non-target impacts to wildlife.
- 5) Evaluate knowledge about non-target impacts. Morzillo and Mertig (2011b) found that very few respondents, less than 10%, had prior knowledge of local non-target effects. I hypothesized that business respondents would have minimal prior knowledge about possible wildlife impacts.
- 6) Determine whether knowledge of rodenticides’ impact on wildlife would change use of rodenticides. Morzillo and Mertig (2011b) found more than half of respondents

were “very likely” to change type of rodenticides used upon learning of possible affects of non-target wildlife. I hypothesized that a willingness to change rodenticides use would vary among businesses, and by business type.

## **Material and Methods**

### **Study Areas**

To evaluate my research objectives, I used existing data collected in 2007 from two locations in California, USA. These locations were chosen because local biologists have observed possible lethal effects of anticoagulants on non-target wildlife. southwest areas of Bakersfield were the first location. This area is comprised of mixed residential, residential services (e.g., shopping plazas), industrial zones, golf courses, a small university campus, and the channelized Kern River. An urban population of the San Joaquin kit fox inhabits the Bakersfield area (Bjurlin and Cypher 2005). This federally endangered species has likely suffered mortality as a result of rodenticide exposure (McMillin et al. 2008).

The second study area consisted of portions of southeastern Ventura and western Los Angeles Counties in proximity to the Santa Monica Mountains National Recreation Area (denoted by the National Park Service as SAMO). This second (SAMO) area had generally less dense urban development than Bakersfield, mostly composed of mixed (ranging from low to high density) residential, residential services, one golf course, and some industrial areas interspersed among natural areas. Three important non-target species that inhabit SAMO are the bobcat, coyote, and mountain lion. A majority of bobcats and mountain lions tested had anticoagulants in their system. Toxin load in both

species was directly related to habitat use, such that a direct relationship existed between toxin load and proportion of habitat used that consisted of developed land use (Riley et al. 2003, 2007). Animals that take advantage of more developed landscapes have shown to have higher toxin loads (Riley et al. 2003, 2007).

## **Survey**

Local wildlife ecologists provided data regarding animal movement across the study areas. Those data were used to determine sampling areas of this study. The study population for this study was determined using street addresses. Street addresses were used because they have spatial context and relative permanency, whereas telephone numbers may change with household occupants and can be difficult to acquire (e.g. unlisted and mobile numbers).

For my research objectives, the units of observation were businesses and home owners associations (HOAs). Therefore, my sampling frame was the list of all business addresses and HOAs within the boundaries determined by wildlife movement data. HOA data were provided by the National Park Service. Business address information was purchased from Marketing Systems Group (Fort Washington, PA), which compiles datasets from United States Postal Service (USPS) delivery sequence files. PO boxes, seasonal home, and mail-drop addresses were excluded, particularly because spatial information is inconsistent when using these types of addresses. The Office of Management and Budget (OMB Control #2080-0077), Office of Human Research Ethics at the University of North Carolina-Chapel Hill (OHRE; IRB #07-0775) and Office of Research Integrity at Oregon State University (IRB #4442) granted permission for use of human subjects.

For the initial data collection, a modified version of the Tailored Design Method was used in an effort to increase the response rate (Dillman 2000). In September 2007, a pre-notice and questionnaire were mailed to businesses in Bakersfield ( $n = 500$ ) and SAMO ( $n = 500$ ), followed by a thank you/reminder postcard, and a second questionnaire to those who did not respond to the first survey mailing. Similar methods were used for HOAs ( $n = 213$ ). HOAs surveyed were from the SAMO area, only. A non-response follow-up survey containing nine key questions from the original survey was sent to all subjects who did not return a questionnaire (Bakersfield  $n = 381$ , SAMO  $n = 382$ , and HOAs  $n = 177$ ), in order to determine if substantial differences existed between respondents and non-respondents.

## **Data**

In the original data collection, in order to identify who controlled for rodents and other animals (*Use*), respondents were asked, “Have you or anyone else tried to control rodents or other animals on your property within approximately the past five years?” (Table 1). Respondents were given three possible answers: yes, no or unsure. Respondents who responded ‘yes’ were then asked specific details regarding control, control methods, product use and product application.

To evaluate what animal(s) were being targeted (*Species*), respondents were asked to identify species by checking all that applied from the following list: (a) mice, (b) rats, (c) squirrels, (d) gophers, (e) wood rats and (f) rabbits (Table 1). Space was provided for respondents to indicate other species they might be targeting that were not included in that list.

To evaluate the reason for control (*Reason*), respondents were asked what initiated their use of rodenticides (Table 1). Respondents were asked to check all that applied: (a) indoor observation of pests, (b) outdoor observation of pests, (c) property damage on own property, (d) property damage on neighbor's property, (e) damage to own landscaping, (f) damage to neighbor's landscaping, (g) preventive use (have not seen animals) (h) part of routine treatment by hired company. Space also was provided for respondents to indicate whether other reasons may have caused them to start using rodenticides.

To determine if knowledge about rodenticide impacts on wildlife would change use of rodenticides, respondents were asked to evaluate four statements regarding potential changes in rodenticide use behavior as: very likely, somewhat likely, unsure, somewhat unlikely or very unlikely. Statements were: (a) Continue to use the same rodenticide(s) on my property (*ContinueUse*), (b) Change the type of rodenticide(s) that I use (*ChangeTypeUse*), (c) Reduce my use of chemical rodenticides (*ReduceUse*) and (d) Stop using rodenticides all together (*StopUse*; Table 1). Responses were measured on a five-point scale (5 = very likely, 1 = very unlikely); larger numbers indicated the respondent's increased potential of engaging in the action implied by the variable name (e.g. stop use completely).

In the original survey space was provided for businesses to fill in their business type. For my analysis, I coded businesses by type using U.S. Census Bureau criteria (USDC 2011). I used 13 different categories for coding business types: Accommodation and Food Services; Arts, Entertainment, and Recreation, Construction; Educational Services; Finance and Insurance; Health Care and Social Assistance; Professional,

Scientific, and Technical Services; Public Administration; Real Estate and Rental and Leasing; Retail Trade; Transportation and Warehousing; Wholesale Trade; and Other.

Regardless of whether the respondents indicated that they were actively using rodenticides or not, all participants were asked a series of questions regarding attitudes toward rodents and concern for non-target effects on wildlife in their area (*AttRodents*; Table 1). On the survey, responses to each statement were coded using five-point Likert scales indicating level of agreement (5 = strongly agree, 4 = agree, 3 = unsure, 2 = disagree, 1 = strongly disagree). Statements were: (a) I don't like rodents, (b) I am afraid of rodents, (c) I don't want rodents in my place of business, (d) I don't want rodents on my property and (e) I am concerned about the spread of disease on my property.

For *AttRodents*, I used exploratory factor analysis (Morzillo and Mertig, 2011a and b) to reduce the number of statements by including only those items that factored together in construction of scale scores. Principal component analysis (PCA) with varimax rotation was used for data reduction. I measured internal reliability of the combination of selected statements identified by PCA using Cronbach's alpha ( $\alpha$ ; Cortina 1993). Four of the five previously named items (a, c, d and e) were used to construct a scale score for *AttRodents* ( $n=1,906$ ;  $\alpha=0.78$ ).

All respondents were also asked two questions to evaluate concern about non-target impact of rodenticides (*Concern*; Table 1). Responses to those questions were measured on a three-point scale: 3 = very concerned, 2 = somewhat concerned, 1 = not concerned. Statements were: (a) Chemical rodenticides may be affecting wildlife in your area, and (b) Chemical rodenticides may be affecting endangered or threatened wildlife in your area. The two responses were summed to obtain a scale score.

All respondents were asked to evaluate awareness about non-target impacts (*Aware*). Respondents were asked if they were aware that wildlife in their area had shown evidence of exposure to chemicals found in common rodenticides prior to receiving the survey. Respondents were asked to reply with a yes or no answer. They were also provided with space to list where they received previous information.

### **Statistical Analysis**

I used IBM SPSS Statistics 19 (SPSS, Inc.) for all statistical analysis. Pearson's correlation ( $r$ ) and p-values ( $p$ ) were used to determine correlations between variables.

## **Results**

The overall response rate for the businesses survey was: Bakersfield = 21.7% ( $n = 106$ ); SAMO = 23.48% ( $n = 115$ ); HOA = 17% ( $n = 36$ ). According to responses on the returned non-response surveys ( $n = 89$ , 11.4%), the most common reasons cited for refusal to fill out the original survey included, 1) I never received the survey (46.1%), and 2) I am not responsible for rodent control on my property (30.3%). HOA respondent ( $n = 23$ ; 13%) comments included, 1) I never received the survey (39.1%), and 2) I do not have time to answer surveys (39.1%).

Of the businesses who replied, those that had been controlling for rodents were: Bakersfield = 27 (25.7%); SAMO = 30 (26.1%) and HOA = 26 (72.2%). The two largest overall categories of business types that responded were 1) Technical Services and Retail Trade (Bakersfield 26.7%, SAMO 25.2%; Table 2) and 2) Professional, Scientific and Technical Services (Bakersfield 19.0%, SAMO 24.3%; Table 2). Of the overall business

types who responded to the survey, 1) Finance and Insurance and 2) Transportation and Warehousing had not been controlling for rodents in the past 5 years (Table 3).

Among species targeted (*Species*), mice and rats ranked highest for both locations. Bakersfield (25.9%) respondents also were controlling for squirrels, as were SAMO (10.0%) respondents (Table 4). The greatest percentage of HOAs were controlling for gophers (Table 4), which also were targeted by both Bakersfield (22.2%) and SAMO (16.7%) respondents. For all three sites the most common reason for beginning the use of rodenticides (*Reason*) was the indoor observation of pests (Bakersfield = 15.2%, SAMO= 15.7%, HOAs = 30.6%; Table 5). The second leading cause was property damage on own property for Bakersfield (8.6%, Table 5) and outdoor observation of pests for SAMO (13.0%, Table 5) and HOAs (55.6%, Table 5).

More than ten percent of respondents at each site agreed that they would continue their current rodenticide use (*ContinueUse*; Table 6a). Of the respondents from Bakersfield, the Transportation and Warehousing and Wholesale Trade suggested the least potential to continue their current use of same rodenticides given effects to wildlife (Fig. 1). Businesses that responded from SAMO were least likely to continue use; given effects to wildlife were 1) Accommodation and Food Services and 2) Whole Sale Trade (Fig. 2).

Less than half of respondents from both sites suggested that they would change the type of rodenticide they were currently using (*ChangeTypeUse*; Table 6b). However, more than 29% of respondents at each site replied that changing the type of rodenticide that they used did not apply to them (Table 6b). Of the businesses in Bakersfield, 1) Educational Services and 2) Transportation and Warehousing indicated the potential to

change the type of rodenticides being used given knowledge of harm to local wildlife (Fig. 3). SAMO businesses that indicated the potential to change the type of rodenticides being used given knowledge of harm to local wildlife included 1) Public Administration and 2) Transportation and Warehousing (Fig. 4).

Less than thirty-five percents of respondents suggested potential to reduce their chemical use (*ReduceUse*; Table 6c). Of the responding businesses in Bakersfield, the Real Estate and Rental and Leasing and Transportation and Warehousing indicated the potential to reduce the use of rodenticides given knowledge of harm to local wildlife (Fig. 5). SAMO businesses that indicated the potential to reduce the use of rodenticides given knowledge of harm to local wildlife were Public Administration, Real Estate and Rental and Leasing and Transportation and Warehousing (Fig. 6).

Respondents indicated the potential to stop their current use of rodenticides all together by greater than ten percent (*StopUse*; Table 6d). Of the responding businesses in Bakersfield 1) Construction, Transportation and Warehousing and 2) Wholesale Trade indicated the potential to stop the use of rodenticides completely given knowledge of harm to local wildlife (Fig. 7). SAMO businesses that indicated the potential to stop the use of rodenticides completely given knowledge of harm to local wildlife were 1) Rental and Leasing and 2) Transportation and Warehousing (Fig. 8).

A negative attitude towards rodents (*AttRodents*) was found at each site; the range of possible scores was 5-20. Bakersfield average score was 17.78 (SD±2.48), and SAMO average score was 17.57 (SD±3.04). Overall businesses average score was 17.67 (SD±2.78). The average score for HOAs was 17 (SD±2.35).

Prior to receiving the survey, some businesses were aware of the possible side effects of rodenticides to non target wildlife (3.0% of Bakersfield and 5.2% of SAMO). However, a greater percentage of HOAs than businesses were aware of possible side effects (22.2%). By comparing the species of animals that was being controlled to *ContinueUse*, *ChangeTypeUse*, *ReduceUse* and *StopUse* I found in Bakersfield that respondents who were controlling for squirrels indicated an unlikelihood to continue their current use of rodenticides ( $r = -.602$ ,  $p = .004$ ). SAMO showed no significant results when comparing awareness to those four variables. HOA data showed that as mice were less controlled for, respondents were more likely to stop using rodenticides all together ( $r = -.604$ ,  $p = .001$ ). The same was found for control of gophers ( $r = -.554$ ,  $p = .003$ ).

By comparing previous knowledge of impacts of rodenticides to local wildlife (*Knowledge*) with average attitudes toward rodents score (*AttRodents*), I found that respondents who had prior knowledge of impacts of rodenticides had a higher average *AttRodents* score (i.e. more negative). In Bakersfield respondents who had prior knowledge had an average *AttRodents* score of 19.33 (SD±1.35); the average score of those who did not have prior knowledge was 17.71 (SD±2.50). In SAMO respondents who had prior knowledge had an average *AttRodents* score of 19.33 (SD±1.35); the average score of those who did not have prior knowledge was 16.83(SD±3.49). HOA respondents who had prior knowledge had an average *AttRodents* score of 19.33 (SD±1.35); the average score of those who did not have prior knowledge was 17.71 (SD±2.50).

Overall *Concern* scores for all three sites were generally high; possible scale score range was 2-6. Bakersfield average score was 3.86 (SD±1.42). The SAMO average score

was 4.37 (SD±1.37). The overall businesses average score was 4.08 (SD±1.47). The HOAs average score was 4.34 (SD±1.47). This indicated a concern for effects of rodenticides on wildlife.

By comparing *Concern* score and *ContinueUse*, *ChangeTypeUse*, *ReduceUse* and *StopUse*, I found that in Bakersfield an increased concern score indicated a greater potential to reduce use of chemical rodenticides ( $r = .419, p = .006$ ) and a greater potential to stop chemical use ( $r = .337, p = .006$ ). In SAMO, an increased *Concern* score was correlated to less potential to continue use of rodenticides ( $r = -.338, p < .001$ ), greater potential to change type of rodenticides ( $r = .226, p = .045$ ), greater potential to reduce use of chemical rodenticides ( $r = .490, p < .001$ ), and greater potential to stop use of rodenticides all together ( $r = .295, p = .008$ ). HOAs showed no significant relationship between concern and control variables.

## Discussion

Urban areas provide important contexts for studying interactions between ecological and social systems and the resulting dynamics (Grimm et al. 2008; Liu et al. 2007). Here I sought to understand how businesses in an urban environment contribute to such interactions. Limited data exist concerning how human rodenticide use practices affect non-target wildlife (Riley et al. 2007 and 2003). Some studies have attempted to understand how household use may be contributing to such side effects (Morzillo and Mertig 2011 a, b; Morzillo and Schwartz 2011). Other studies have looked at agricultural practices (Harrison, Porter and Forbes 1988; Tosh et al. 2011). To my knowledge, this is the first attempt to directly link mechanisms of rodent control activity and human

awareness about how actions may affect the local ecosystem (i.e., non-target rodenticide effects on local wildlife) from a business perspective.

San Julian (1987) stated that while humans are trying to be friendlier toward wildlife and the damage possibly caused by wildlife. However, human tolerance for wildlife presence is based upon the species of wildlife, such that humans are less tolerant of wildlife damage caused by what they consider pests (San Julian 1987). In my analysis, many different reasons were cited for initiating the use of rodenticides. Respondents in Bakersfield mostly cited indoor observation of pests, while SAMO and HOAs were approximately evenly split between indoor observation of pests, outdoor observation of pests, and damage on own property. Household data for the same site(s) (Morzillo and Mertig 2011a) found, among reasons listed, that the indoor and outdoor observation of pests were the leading reason respondents initiated the use of rodenticides. The two locations were compositionally different (inner-city urban setting of Bakersfield versus the relatively larger residential lot sizes and prevalence of lower density development of SAMO), which partially may explain the preponderance of reports of pest damage to landscaping for SAMO.

Within a broader social context, my results support trends in the household data presented by Morzillo and Mertig (2001 a, b) and Morzillo and Schwartz (2011), yet allow us to expand our knowledge within a new context related to rodent control practices of businesses. Pest control was ubiquitous across respondents from both locations, and a wide range of selected control products and practices was reported. Attitudes toward rodents were near the high (i.e., negative) end of the scale of my scale score range. In general, mammals are typically favored for conservation (Czech et al.

1998). Rats, which were among the most commonly controlled-for species (Morzillo and Schwartz 2011), have ranked beside cockroaches, mosquitoes, and wasps among Americans' least favorite species (Kellert and Berry 1980). Batt (2009) suggested that perhaps the negative perception of rats by humans is a fear-related response because of an association of rats with disease. The direct relationship between attitudes toward rodents and likeliness to target rodents may support this psychological linkage, as a majority of statements that factored together in construction of the *AttRodents* variable were related concerns about welfare as a result of rodent presence. Of note is that respondents who indicated prior knowledge of rodenticide had higher *AttRodents* score (more negative) than those who did not. However, this could be an artifact of the sites studies here and small sample size of those with prior knowledge does not allow us to generalize results to the local area or make strong conclusions about this relationship. Morzillo and Mertig (2001a, b) found households overall had negative attitudes towards rodents. Diaz (2006) stated that mite prevention and control practices include rodent control. Homeowners may be protecting pets or children who live in the household from the perceived risks that come with rodents. Increased exposure to rodents leads to a greater chance of being infected by disease(s) they may be carrying (Demers et al. 1985).

Overall, businesses indicated potential to change their rodenticide use, given knowledge that rodenticides had been affecting wildlife in the area. They also indicated strong disagreement and not applicable responses to change type of rodenticide being used. This may be an artifact of how the statement was written. The statement did not clarify whether chemical or physical rodenticides were used. According to Boland et al. (2010) how a question is written can have an affect on how it is answered. I believe that

physical rodenticide users may be those who indicated the continued use and not applicable responses to potential to continue their current use practices. Also of note is that this question (*ContinueUse*) was asked of all respondents including those who indicated they had not used rodenticides in the last five years.

Learning and knowledge influence how humans make decisions (Fazey et al. 2006). Concern (*Concern*) for wildlife was high in the study areas. Respondents from SAMO and HOAs scored higher on the concern scale. My data suggested that a higher concern score for wildlife in the area of Bakersfield, the more likely respondents were to reduce or stop their use of rodenticides. SAMO data showed that the more concerned respondents were for wildlife in the area, the more unlikely they were to continue use, and the more likely they were to change type use, reduce use and stop use of their current rodent control products. This suggests that the more concerned people are about wildlife in their area the more likely they are to change their current rodenticide use practices to reduce their impact(s) on wildlife. This would be consistent household respondents, who were also concerned about wildlife in the area (Morzillo and Mertig 2011a).

When comparing household analysis (Morzillo and Mertig 2011b) to my analysis, businesses were almost half as likely to be previously aware of rodenticide impact to non-target wildlife (*Aware*). I believe that this discrepancy in awareness of non-target effects may be because efforts of Park Services to inform people living in the area of non-target effects are focused on residents of the area, not on business owners and others working in the area.

Overall, the results support my hypotheses. However, objective 6 was that willingness to change rodenticides use would vary among businesses, and by business

type. Since the sample size of businesses in each category was small (i.e. as low as one) these data can not be generalized to a larger population. It is possible that if business owners were more aware of how their rodenticide use(s) could possibly be effecting wildlife in their area they would be willing to change those practices. Holding rodenticide awareness seminars in or near downtown and industrial areas, or running an awareness series in the local newspaper could help to increase such awareness. Future research ideas include comparing variables between male and female respondents, as well as those responsible for rodent control among different age groups (i.e. 20-29 year olds, 30-39 year olds, 40-50 year olds and 51 and above).

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Table 1. Survey questions used to construct variables.

Survey Question	Variable
Have you or anyone else tried to control rodents or other animals on your property (during the past 5 years)?	<i>Use</i>
Which of the following types of animals have you or someone else been trying to control in your property?	<i>Species</i>
What caused you (or someone else) to begin controlling these animals on your property?	<i>Reason</i>
For each statement [about rodents] <sup>a</sup> , please indicate whether you strongly agree, agree, are unsure, disagree, or strongly disagree?	<i>AttRodents</i>
How concerned would you say you are about...: Chemical rodenticides may be affecting wildlife in your area? Chemical rodenticides may be affecting endangered or threatened wildlife in your area?	<i>Concern</i>
In your area, wildlife have been shown evidence of possible exposure to chemicals found in common rodenticides. Were you aware of this before receiving this survey?	<i>Awareness</i>
If chemical rodenticides were affecting wildlife in your area how likely would you be to change or reduce your current use?	<i>Continue Use</i> <i>Change Type Use</i> <i>Reduce Use</i> <i>Stop Use</i>

Table 2. The percentage of businesses per category and by site that responded to survey.

Business Type	Bakersfield (%) <i>n</i> =100	SAMO (%) <i>n</i> =107
Accommodation and Food Services	8.6	7.0
Arts, Entertainment, and Recreation	1.0	7.0
Construction	7.6	3.5
Educational Services	1.0	2.6
Finance and Insurance	8.6	6.1
Health Care and Social Assistance	6.7	7.8
Professional, Scientific, and Technical Services	19.0	24.3
Public Administration	1.9	0.9
Real Estate and Rental and Leasing	1.0	1.7
Retail Trade	26.7	25.2
Transportation and Warehousing	1.9	0.9
Wholesale Trade	1.9	1.7
Other <sup>a</sup>	9.5	4.3

<sup>a</sup> Other was comprised of businesses that did not fit into the categories listed in Department of Commerce categories (*n*= 5). Also included with others is: Administrative and Support and Waste Management and Remediation Services (*n*=2); Manufacturing (*n*=2); Mining, Quarrying, and Oil and Gas Extraction (*n*=2); Miscellaneous Retail (*n*=1); Transportation, Communications, Electric, Gas, And Sanitary Services (*n*=1) and “other” respondents that did not fit the guidelines from: <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2007>

Table 3. Businesses using rodenticides to control pests.

Business Type	Bakersfield <i>n</i> =27 controlling/total <sup>a</sup>	SAMO <i>n</i> =30 controlling/total <sup>a</sup>
Accommodation and Food Services	4/9	1/8
Arts, Entertainment, and Recreation	1/1	4/8
Construction	1/8	1/4
Educational Services	1/1	1/3
Finance and Insurance	0/9	0/7
Health Care and Social Assistance	3/7	2/9
Professional, Scientific, and Technical Services	2/20	7/28
Public Administration	2/2	0/1
Real Estate and Rental and Leasing	0/1	1/2
Retail Trade	9/28	9/29
Transportation and Warehousing	0/2	0/1
Wholesale Trade	1/2	1/2
Other <sup>b</sup>	3/10	3/5

<sup>a</sup> Proportion of number of businesses controlling by category, of those that responded from that category.

<sup>b</sup> Other was compiled of businesses that did not fit into the categories listed at Dept of Commerce categories (*n*= 5). Also included with others is: Administrative and Support and Waste Management and Remediation Services (*n*=2); Manufacturing (*n*=2); Mining, Quarrying, and Oil and Gas Extraction (*n*=2); Miscellaneous Retail (*n*=1); Transportation, Communications, Electric, Gas, And Sanitary Services (*n*=1) and “other” respondents that did not fit the guidelines from

Table 4. Species targeted, by site.

Species	Bakersfield % n = 27	SAMO % n = 30	Home Owners Associations <sup>a</sup> % n = 26
Mice	66.7	66.7	57.7
Rats	44.4	66.7	84.6
Squirrel	25.9	10.0	11.5
Gophers	22.2	16.7	57.7
Wood Rat	0	0	0
Rabbits	0	10	11.5
Other	14.8	6.7	15.4

<sup>a</sup> HOA were only evaluated in SAMO area.

<sup>b</sup> Respondents were asked to “check all that apply” when responding to this question. As a result, values of each category may total more than 100%.

Table 5. Reason use of rodenticides was initiated on property.

Reason	Bakersfield % <i>n</i> = 100	SAMO % <i>n</i> = 107	Home Owners Associations <sup>a</sup> % <i>n</i> = 36
Indoor observation of pests	15.2	15.7	30.6
Outdoor observation of pests	6.7	13.0	55.6
Property damage on own property	8.6	10.4	33.3
Property damage on neighbor's property	1.0	0	5.6
Damage to own landscaping	7.6	5.2	33.3
Damage to neighbor's landscaping	0	0.9	13.9
Preventive use (have not seen animals)	1.9	0.9	0
Part of routine treatment by hired company	5.7	7.8	19.4
Other	1.9	0.9	0

<sup>a</sup> HOA were only evaluated in SAMO area.

<sup>b</sup> Respondents were asked to “check all that apply” when responding to this question. As a result, values of each category may total more than 100%.

Table 6a. Potential of respondents to continue to use the same rodenticides  
(*ContinueUse*) given knowledge of harm to local wildlife.

Statement	Very Likely (%)	Somewhat Likely (%)	Unsure (%)	Somewhat Unlikely (%)	Very Unlikely (%)	Not Applicable (%)
Bakersfield (n=27)	22.2	29.6	18.5	14.8	11.1	3.7
SAMO (n= 30)	13.3	46.7	10.0	16.7	3.3	6.7
HOAs <sup>a</sup> (n=26)	11.5	53.8	15.4	11.5	3.8	3.8

<sup>a</sup> HOA were only evaluated in SAMO area.

Table 6b. Potential to change the type (*ChangeTypeUse*) of rodenticides currently used.

Statement	Very Likely (%)	Somewhat Likely (%)	Unsure (%)	Somewhat Unlikely (%)	Very Unlikely (%)	Not Applicable (%)
Bakersfield (n=27)	25.9	3.7	3.7	7.4	29.6	29.6
SAMO (n= 30)	13.3	6.7	3.3	13.3	20.0	43.3
HOAs <sup>a</sup> (n=26)	19.2	0	0	7.7	30.8	42.3

<sup>a</sup> HOA were only evaluated in SAMO area.

Table 6c. Potential to reduce the use (*ReduceUse*) of chemical rodenticides used given knowledge of harm to local wildlife.

Statement	Very Likely (%)	Somewhat Likely (%)	Unsure (%)	Somewhat Unlikely (%)	Very Unlikely (%)	Not Applicable (%)
Bakersfield (n=27)	33.3	3.7	3.7	7.4	29.6	22.2
SAMO (n= 30)	13.3	3.3	3.3	33.3	16.7	30.0
HOAs <sup>a</sup> (n=26)	19.2	7.7	11.5	3.8	38.5	19.2

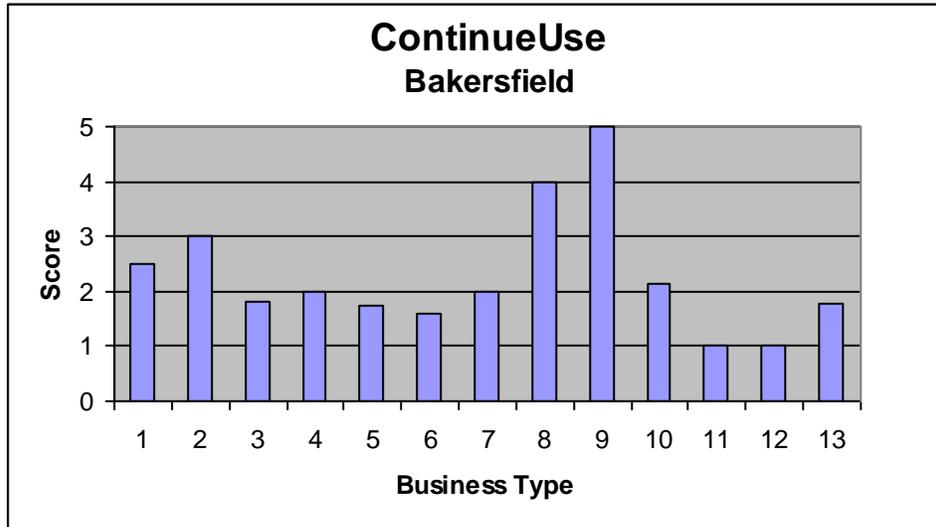
<sup>a</sup> HOA were only evaluated in SAMO area.

Table 6d. Potential to stop use (*StopUse*) of rodenticides altogether given knowledge of harm to local wildlife.

Statement	Very Likely (%)	Somewhat Likely (%)	Unsure (%)	Somewhat Unlikely (%)	Very Unlikely (%)	Not Applicable (%)
Bakersfield (n=27)	25.9	29.6	11.1	11.1	7.4	14.8
SAMO (n= 30)	13.3	10.0	13.3	26.7	10.0	23.3
HOAs <sup>a</sup> (n=26)	11.5	38.5	15.4	11.5	11.5	11.5

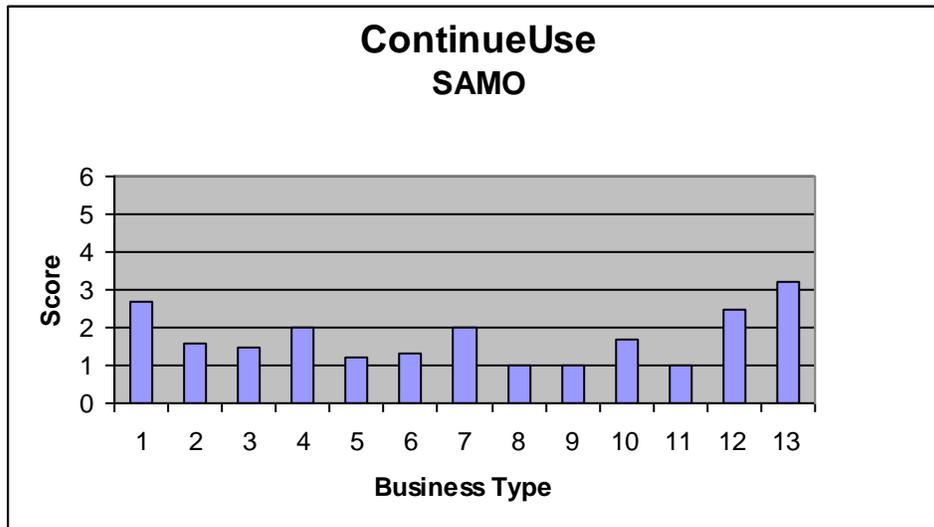
<sup>a</sup> HOA were only evaluated in SAMO area.

Fig. 1. Average scores for *ContinueUse* based on business type<sup>a</sup> in Bakersfield.



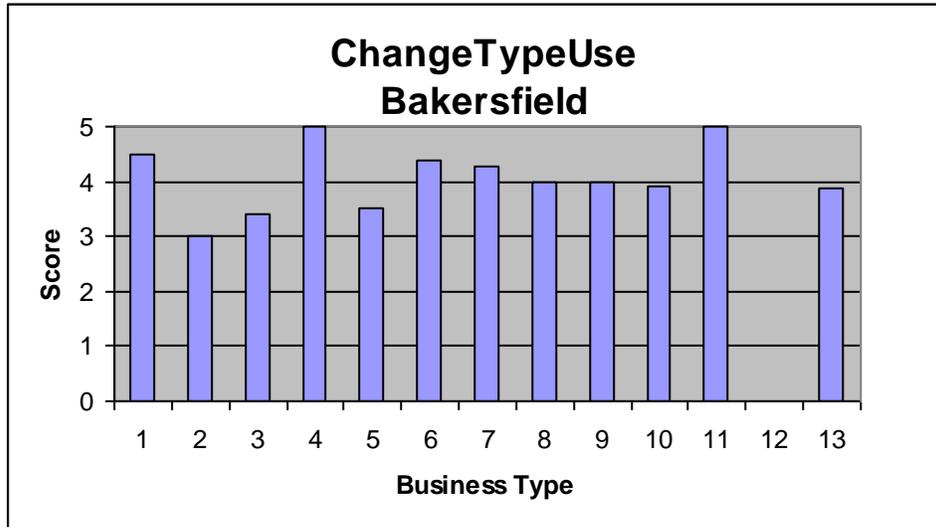
<sup>a</sup>1. Accommodation and Food Services 2. Arts, Entertainment, and Recreation  
3. Construction 4. Educational Services 5. Finance and Insurance 6. Health Care and  
Social Assistance 7. Professional, Scientific, and Technical Services 8. Public  
Administration 9. Real Estate and Rental and Leasing 10. Retail Trade 11. Transportation  
and Warehousing 12. Wholesale Trade 13. Other.

Fig. 2. Average scores for *ContinueUse* based on business type<sup>a</sup> in SAMO.



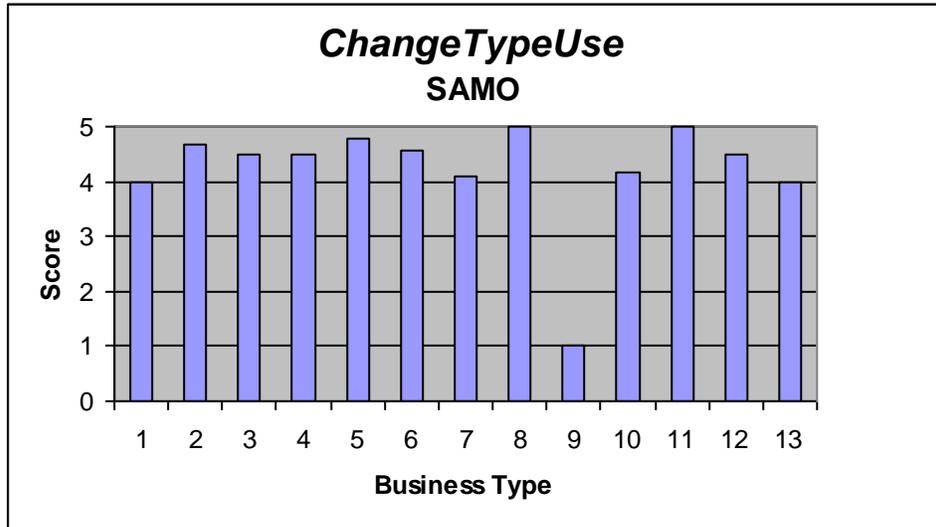
<sup>a</sup>1. Accommodation and Food Services 2. Arts, Entertainment, and Recreation  
3. Construction 4. Educational Services 5. Finance and Insurance 6. Health Care and  
Social Assistance 7. Professional, Scientific, and Technical Services 8. Public  
Administration 9. Real Estate and Rental and Leasing 10. Retail Trade 11. Transportation  
and Warehousing 12. Wholesale Trade 13. Other.

Fig. 3. Average scores for *ChangeTypeUse* based on business type<sup>a</sup> in Bakersfield.



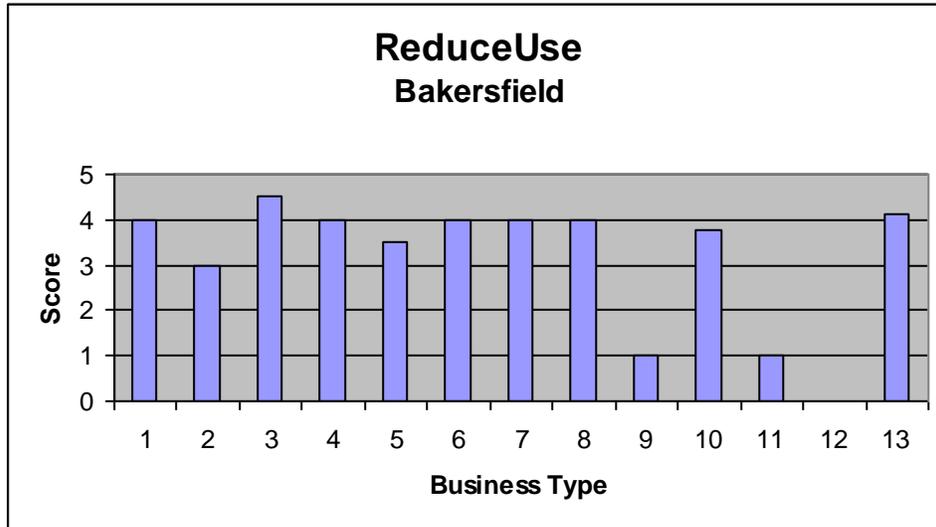
<sup>a</sup>1. Accommodation and Food Services 2. Arts, Entertainment, and Recreation  
3. Construction 4. Educational Services 5. Finance and Insurance 6. Health Care and  
Social Assistance 7. Professional, Scientific, and Technical Services 8. Public  
Administration 9. Real Estate and Rental and Leasing 10. Retail Trade 11. Transportation  
and Warehousing 12. Wholesale Trade 13. Other.

Fig. 4. Average scores for *ChangeTypeUse* based on business type<sup>a</sup> in SAMO.



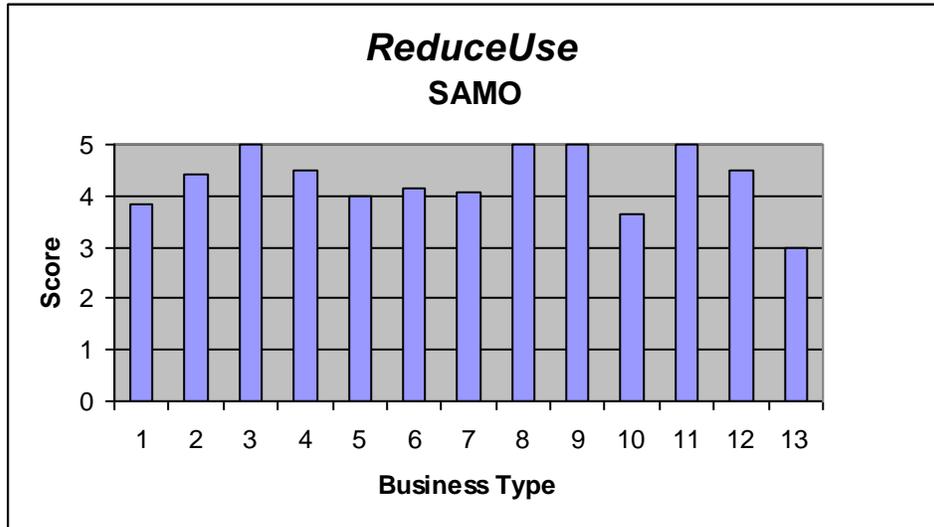
<sup>a</sup>1. Accommodation and Food Services 2. Arts, Entertainment, and Recreation  
3. Construction 4. Educational Services 5. Finance and Insurance 6. Health Care and  
Social Assistance 7. Professional, Scientific, and Technical Services 8. Public  
Administration 9. Real Estate and Rental and Leasing 10. Retail Trade 11. Transportation  
and Warehousing 12. Wholesale Trade 13. Other.

Fig. 5. Average scores for *ReduceUse* based on business type<sup>a</sup> in Bakersfield.



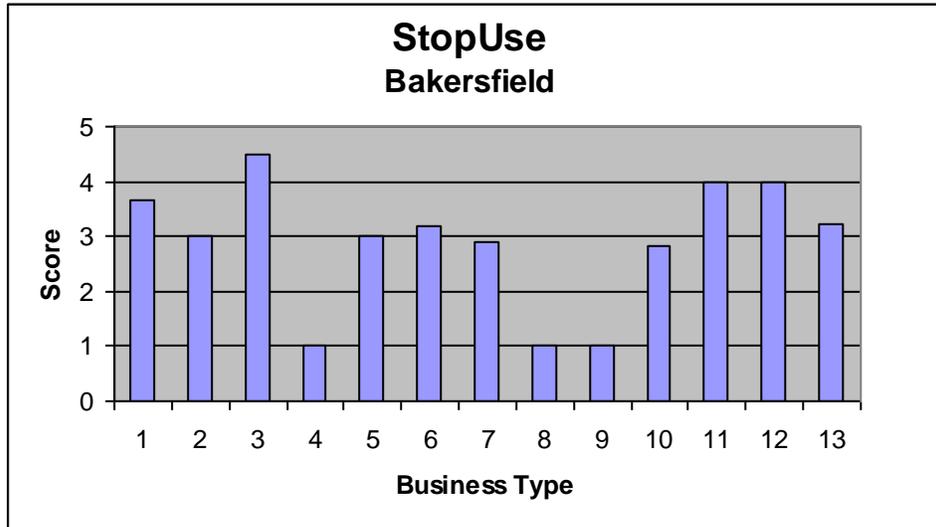
<sup>a</sup>1. Accommodation and Food Services 2. Arts, Entertainment, and Recreation  
3. Construction 4. Educational Services 5. Finance and Insurance 6. Health Care and  
Social Assistance 7. Professional, Scientific, and Technical Services 8. Public  
Administration 9. Real Estate and Rental and Leasing 10. Retail Trade 11. Transportation  
and Warehousing 12. Wholesale Trade 13. Other.

Fig. 6. Average scores for *ReduceUse* based on business type<sup>a</sup> in SAMO.



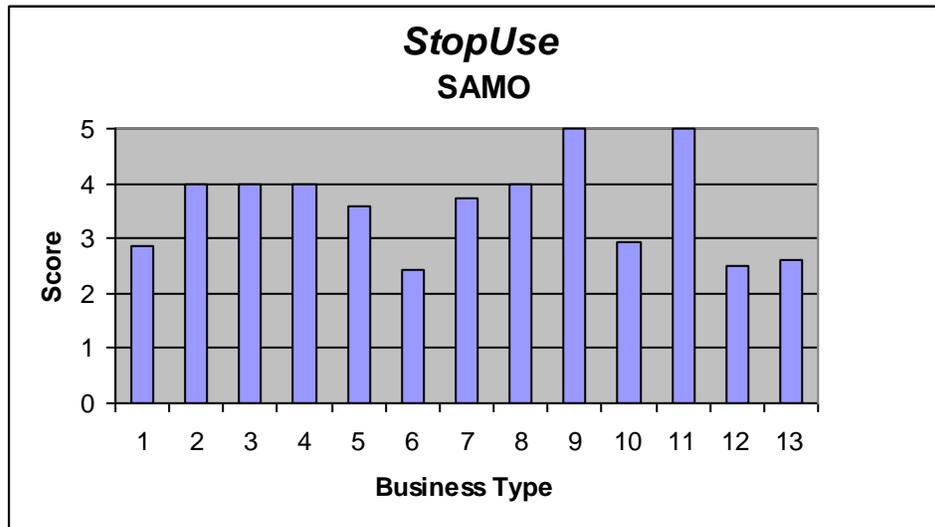
<sup>a</sup>1. Accommodation and Food Services 2. Arts, Entertainment, and Recreation  
3. Construction 4. Educational Services 5. Finance and Insurance 6. Health Care and  
Social Assistance 7. Professional, Scientific, and Technical Services 8. Public  
Administration 9. Real Estate and Rental and Leasing 10. Retail Trade 11. Transportation  
and Warehousing 12. Wholesale Trade 13. Other.

Fig. 7. Average scores for *StopUse* based on business type<sup>a</sup> in Bakersfield.



<sup>a</sup>1. Accommodation and Food Services 2. Arts, Entertainment, and Recreation  
3. Construction 4. Educational Services 5. Finance and Insurance 6. Health Care and  
Social Assistance 7. Professional, Scientific, and Technical Services 8. Public  
Administration 9. Real Estate and Rental and Leasing 10. Retail Trade 11. Transportation  
and Warehousing 12. Wholesale Trade 13. Other.

Fig. 8. Average scores for *StopUse* based on business type<sup>a</sup> in SAMO.



<sup>a</sup>1. Accommodation and Food Services 2. Arts, Entertainment, and Recreation  
3. Construction 4. Educational Services 5. Finance and Insurance 6. Health Care and  
Social Assistance 7. Professional, Scientific, and Technical Services 8. Public  
Administration 9. Real Estate and Rental and Leasing 10. Retail Trade 11. Transportation  
and Warehousing 12. Wholesale Trade 13. Other.