ALTRUISM, RISK, ENERGY DEVELOPMENT AND THE HUMAN-ANIMAL RELATIONSHIP

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ABSTRACT

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Research shows that humans form relationships with animals that alter social, psychological and biological processes. However, within environmental decision-making and social psychological research, the importance of human-animal relationships has not been thoroughly explored. This dissertation extends social distance theories to include human-animal relationships and utilizes environmental values, particularly altruism, in a causal chain to assess how individuals perceive the risk high volume horizontal drilling hydraulic fracturing (HVHHF) poses to animals. HVHHF is an ideal lens to investigate this topic because this technology puts animals at substantial risk of harm and creates environments that simultaneously affect humans and animals.

In Chapter 1 I conduct a thorough content analysis of peer-reviewed HVHHF articles to examine how animals and human-animal relationships are represented. The analysis demonstrates that existing research seldom acknowledges animals' inherent value, instead focusing almost exclusively on the use of animals as sentinels for potential human health risks. Furthermore, there are no social science articles assessing the impacts of HVHHF on animals or human-animal relationships. This chapter serves as a call for additional research. I use Chapters 2 and 3 to respond to this call, exploring the social and psychological drivers of perceptions of the risk HVHHF poses to humans and animals.

In Chapter 2 I use an experimental survey design to extend construal level theory of psychological distance (CLT) to interspecies relationships and test whether social distance

between species influences human perceptions of HVHHF risk to animals. Multivariate regression results show that framing HVHHF risk in terms of animals can alter perceptions of HVHHF risk to animals, but that framing risk across different animal groups has varied impacts. This study makes a significant theoretical contribution to the risk literature by demonstrating the importance of including interspecies relationships in CLT. It also has practical implications for organizations interested in gaining public support for policies that address HVHHF harms to animals.

Chapter 3 picks up where Chapter 2 leaves off, continuing to investigate how people perceive the risk HVHHF poses to animals. I draw on the environmental values literature (focusing on altruism) to evaluate the causal link between values and perception of risk to animals. The results from structural equation modeling and logistic regression show that those who adhere to altruistic values (both towards animals and the biosphere) perceive higher risks of hydraulic fracturing to all species. However, decreased social distance between humans and companion animals mediates this relationship, suggesting that decreased social distance in human-animal relationships is an extension of altruism. The findings have important implications for understanding how human-animal relationships influence risk perceptions and for environmental and animal rights movements pursuing policies that promote animal wellbeing. Finally, in the conclusion I connect my findings, address avenues for future research, and discuss policy implications.

This dissertation is dedicated to Mom.
Thank you for always believing in me.

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INTRODUCTION

Throughout the country animals are suffering the consequences of the United States' latest energy boom: high volume horizontal drilling hydraulic fracturing (HVHHF). HVHHF is a well-stimulation process that uses large volumes of pressurized fluid pumped into wells to induce rock fractures as a means to release oil and gas stores. While energy developers use these techniques to extract difficult-to-reach oil and natural gas, the technologies often pollute the natural environment, at times having catastrophic consequences for wildlife, livestock and companion animals. Examining the impacts of HVHHF on animals, Bamberger and Oswald (2012, 2015) document some of these effects.

> In Louisiana, seventeen cows died after an hour's exposure to spilled fracking fluid. (Most likely cause of death: respiratory failure.) In north central Pennsylvania, 140 cattle were exposed to fracking wastewater when an impoundment was breached. Approximately seventy cows died; the remainder produced eleven calves, of which only three survived. In western Pennsylvania, an overflowing waste pit sent fracking chemicals into a pond and a pasture where pregnant cows grazed: half their calves were born dead (Royte 2012:2).

Though alarming in their own right, these effects represent a growing body of work that suggests animals (companion, livestock and wildlife) are likely to experience the greatest negative impacts from HVHHF (Bamberger and Oswald 2012, 2015; Bamberger and Oswald, Robert 2014; Gillen and Kiviat 2012; Kiviat 2013). What we know about these effects, though still extremely limited, comes out of the natural sciences where researchers have monitored animals to understand both the direct impacts of HVHHF on animal health and well-being and the implications of these impacts for human populations.

Importantly, however, there are significant aspects of this energy development story that scholars have not yet explored. Part of almost every account of HVHHF harm to animals is a story about human-animal relationships that may be mentioned, but is left unstudied. These stories vary from farmers fretting about their animals, to individuals connecting animal sickness to their own health. These stories involve policymakers who are regularly deciding whether to regulate HVHHF development or not, whether to force companies to disclose the contents of proprietary HVHHF chemicals, whether to pass legislation that would ultimately protect animals. At the heart of all of these relationships are assessments of the risks that HVHHF poses to both human and animal life. Despite the importance of understanding how people develop these risk perceptions, the social science community has left these questions unexplored.

This dissertation is motivated by the broad desire to understand the human-animal relationship in energy development. In the chapters that follow, I focus on HVHHF because, as a rapidly expanding process, the social and policy implications are both relevant and poorly understood. Although science suggests animals face the greatest harm from the process, in many ways this harm can only influence policies and practice if humans perceive a risk that needs to be addressed. Because both humans and animals are affected, HVHHF provides an ideal case for exploring the ways that humans perceive risk to animals. As a consequence, after more thoroughly examining the scholarship on HVHHF and animals, I focus specifically on what drives individuals' understandings of the risk HVHHF poses to animal populations. In addition to providing insight into HVHHF risk perceptions, these studies also represent the first sociological efforts to understand how individuals think about energy development risks to animals. It does this self-consciously, recognizing that HVHHF is only the latest process in a long history of energy development where virtually every stage in the development process has used and affected animals. Because the current relationship between HVHHF and animals reflects a historical reliance on animals as sentinels, in the remainder of this chapter I explore the history of animals in energy development.

ANIMALS AS ENERGY PRODUCERS-FROM ANTIQUITY TO CONTEMPORARY LIFE

Before the burning of fossil fuels became a popular mechanism to harness energy, people relied on the movement of animal workers to produce energy. Animal-powered engines (see e.g., Major 1978) and animal-powered machines (Major 2008), systems that involved driving animals around a center post, transferred kinetic energy from the animal through a task oriented machine to complete a chore. Historically, horses, donkeys, oxen, and dogs were used; however, depending on accessibility and location other animals were relied upon. Of the few books that thoroughly explore the use of animals as engines, *Animal-Powered Engines* (Major 1978) and *Animal-Powered Machines* (Major 2008) are the most widely noted. Major takes great pride in discussing the mechanics of the operations in detail with no assessment of the animal worker as a living creature. By focusing solely on the mechanics, he paints a picture of the animal as worker or input commodity, but not as an individual. The term "ghost," from the documentary *Ghosts in Our Machine* (Marshall 2013), which explores the often hidden or silenced use and abuse of animals in the modern workforce, applies perfectly when assessing the of history of animals in energy development. Animals as energy producers and sentinels are truly the ghosts in energy development. Their recognition is limited and exploited for human gain. The animal as engine and machine begins in antiquity.

A Brief History of Animal-Powered Engines and Animal-Powered Machines in Antiquity

Human and animal powered gear systems can be traced back to the ancient world. Of all the ancient civilizations that used animals as power sources, the most domestication comes from ancient Egypt, although sources reference the system and not the treatment of animals or how this dynamic altered human-animal relationships. Egyptians used animals for power to build cities and as tools to drive innovation (see e.g., Hlebanja and Hlebanja 2013). Evidence suggests that animals were placed on treadmills to run conveyors; their movement initiated a pulley system, reducing the need for human power and maximizing output. A variety of animals, including sheep, goats, cattle, pigs, camels and dogs were used as producers. It is often assumed that horses were some of the first animals utilized, but the horse did not appear in Egypt until the 13th dynasty (1803 B.C.E. to 1649 B.C.E.) well after animal generated power (see e.g., Hlebanja and Hlebanja 2013). In depictions of Egyptian life, donkeys are most often portrayed as power sources; whereas horses are represented as noble animals for war and transportation at least in the early years after horse arrival. Camels, a symbol of Egyptian life today, were not much used as a power source until after the third millennium (Hlebanja and Hlebanja 2013). Although, much of the understanding about animal powered machines and engines in the ancient world comes from Egypt, there is strong evidence that animals were used to harness power across the ancient world including Europe, Asia and South America (see e.g., Kitchell Jr. 2017).

In fact, the harnessing of animal power drove paper production, especially during the Chinese golden age. It is not known exactly when animal-powered engines were first used in the production of paper, but archeological evidence suggests that animals were used as far back as the Han Dynasty (206 B.C.E. to 220 A.D.) (Lucas 2005). Chinese and Muslim papermakers often preferred animal-power sources to water-power because of geographical restrictions and seasonal changes that could impact water flow needed for production (Lucas 2005). Although much has been written about the use and value of animals in the ancient world, few sources specifically trace use to energy development or assess how the desire of humans to obtain energy impacted animals and human-animal relationships. What we know is that energy production sources and information about the types of animals that performed tasks efficiently traveled around the world. For thousands of years, the economic worth of certain animals would be based on their energy production value, a dynamic that would fundamentally alter human-animal relationships. Although we conceptually understand the engines and machines these animals were used to power, our understanding of the animals as individuals is limited. Indeed our understanding of individual animals, their treatment, and the associated impacts on humans is non-existent well into contemporary life.

A Brief History of Animal-Powered Engines and Animal-Powered Machines in Modern and Contemporary Life

The animal-engine systems pioneered in the ancient world continued for thousands of years into the modern period. In fact, much of the historical research on the use and geographical distribution of animal-powered engines and machines comes out of Europe during the mid-modern period (1750-1914). Specifically, in the 18th and 19th centuries, the most common form of animal engine was the horse-driven mill, widely known and referred to as the gin gang (Major 1978, 1990, 2008). The gin gang was a circular building attached to a smaller barn structure. The circular building held the “driving power” or animal workers, while the smaller barn housed the engine. One or more horses were walked in order to push a cog around a center post or vertical spindle (Major 1978, 1990, 2008). The turning of the spindle powered an engine housed in the attached barn. Gin gangs could be used to power a variety of engines, but were mostly used for grinding grain in horse mills. Little is known about the treatment of horses used in these mills; however, evidence suggests that they were well fed and cared for outside of being used in the mill as they were considered a valuable source of energy (see also e.g., Walton 1974). In Europe, most systems used English ponies; small stocky horses less than 58 inches high. Heavy horses were not bred during the peak of horse-mills, nor would they have been appropriate for the task, as they would easily overpower the engine systems of the 18th and 19th centuries. The construction and maintenance of gin gangs varied across countries. For instance, in some parts of Europe mandates required gin-gang gears to be sheltered (perhaps, to protect grain and other materials being produced), but did not require animal workers to be protected from the elements. This meant that animals could have been forced to walk in open air in challenging weather conditions in order to power machines. Although there are books highlighting the mechanics used to harness energy from animals during the modern age, there is virtually no discussion or recognition of the animal as a sentient commodity in these accounts. Once again, the object of the story is the machine, while the animal is only an energy input.

In the mid-19th century, horse-mills began to be replaced by steam engines in wealthier parts of Europe and the United States (see e.g., Major 1978, 1990, 2008). Foster (2002) notes that work-animal horsepower saw a rapid decline in the U.S. during the postwar period. A similar trend also occurred in Europe. During this time, machines driven by steam or fossil fuels replaced animal-powered engines.

DISEMBODIED ANIMALS FOR ENERGY GENERATION

Beyond the harnessing of kinetic animal energy, before the invention of electricity, in-home energy sources relied on the burning of disembodied animal fats. Historically, animal fats (Waste Animal Fat or WAFs) were used in the production of candles, an essential source of light prior to electricity. WAFs began to be replaced with fossil fuel-driven electricity in the late 19th century.

However, recent innovation has sparked a renewed interest in WAFs extending beyond candle production to the use of animal fats as an oil feedstock in the production of biodiesel. To give some context, roughly one-third of all fats and oils in the U.S. come from animals, animal fats are cost less than vegetable oil because there is minimal demand (Van Gerpen 2014). In fact, much of the domestic animal fat produced in the U.S. is exported (Van Gerpen 2014). The interest in this technology is fueled by the idea that plant-based biodiesels- while renewable- produce higher oxides of nitrogen emissions compared to petro-diesels, but that the use of animal fat in the production of biodiesel may mitigate this increase (Armas et al. 2014; Bousbaa et al. 2013; McCormick et al. 2001). As a result, some scholars argue that use of animal fats may be more environmentally friendly than conventional fossil fuel sources. Kim and colleagues (2013), for example, suggest that WAFs may be particularly important for rural farms operating relatively small agricultural machinery in developing countries. However, this view ignores the sentience of animals and the human-animal relationship, once again focusing only on the animal as commodity input. It is uncertain how the application of WAFs will unfold. Beyond sources of energy in the form of engines, machines and disembodiment, animals also hold a long history as sentinels in production.

THE INTENTIONAL ANIMAL SENTINEL IN ENERGY DEVELOPMENT

Historically, sentinels have been used as intentional environmental monitoring tools signaling potential risks to humans. Birds and small mammals were selected for this task because they responded to environmental stress by showing physical and cognitive symptoms well before humans were impacted. The classic example of a sentinel animal is the canary in the coal mine.

In the late 1890s, John Scott Haldane suggested that canaries and other small animals should be used as risk assessors in mining practices (Acott 1999). He was the first to do so, a recommendation that was backed by his examination of mining disasters and laboratory experimentation with noxious gas animal detectors (Acott 1999). Haldane concluded that exposure to noxious gas was far more lethal than the probability of experiencing an explosion. For this reason, he suggested that a tool was needed to assess the composition of the air and its potential effects on miners. At the time, most lethal gases in coal mines could be detected by observing the flame of a lamp; however, carbon monoxide was visually undetectable. While various chemical tests could signal an unhealthy level of carbon monoxide, such testing equipment could be burdensome to carry and erect inside a mine. Additional concerns stemmed from the need to train individuals to conduct tests, possible operation error, an inability to move equipment quickly should the need arise and a need to monitor continuously.

Because of these difficulties with technology, Haldane suggested that animals could be used in place of technology at lower cost and with greater accuracy. He noted that, "In view of the difficulty of recognizing by ordinary means the presence of poisonous amounts of this gas (carbon monoxide), I propose the plan of making use of a small warm-blooded animal [a mouse or small bird] as an indicator of carbon monoxide" (Acott 1999:161-162) (see also e.g., Duin and Sutcliffe 1992; Goodman 2008). Canaries were specifically chosen because of their rapid breathing rate, small size, high metabolism and the ease at which they could be handled. These unique characteristics also meant that they would show signs of carbon monoxide poisoning sooner than humans when exposed in the same environment. The importance of sentinels to mining operations and the resulting organizational changes are articulated throughout historical documents. For instance, George A. Burrell (1914) wrote in his relatively famous book *The Use of Mice and Birds for Detecting Carbon Monoxide After Mine Fires and Explosions*, "In the author's opinion the use of birds and mice is superior to chemical tests for carbon monoxide in that the test is quickly made, requires no technical experience, and is sufficiently exact" (p.

1251). Again, what is noticeably absent from this book is any analysis of the human-animal relationship, or specifically how miners related to their sentinel companions. At first glance, one might assume that there was limited emotional connection between humans and their sentinel air-monitoring systems. However, Eschner (2016) asserts that canaries "were so ingrained in the culture, miners report whistling to the birds and coaxing them as they worked, treating them as pets" (p. 1). This statement is not surprising considering that coal mining has always been a lonely and dangerous job not just for the worker, but for families as well (Giesen 2014).

It was not until 1986 that the use of canary sentinels were replaced in British mining pits with electronic gas detectors (Goodman 2008). However, the expansion of new energy technologies has given rise to a new type of animal sentinel, one that was not intended, but may provide a wealth of information for human communities. Scholars have been actively monitoring animals living near conventional, unconventional and renewable energy developments, most often to ascertain information about potential human health risks. The next section explores literature assessing the impacts of various energy development types on animals with commentary about what this means for human-animal relationships. Although physical and biological science research about the impacts of various energy development technologies on animals is present but sparse, social science literature on what impacts to animals mean for human-animal relationships is entirely absent.

THE UNINTENTIONAL ANIMAL SENTINEL IN ENERGY DEVELOPMENT

When development occurs, animals may be monitored to assess environmental and health impacts. These are unintentional sentinels because the animal is not deliberately placed in an energy development area, like the canary in the coal mine. Instead, the animal's habitat becomes the place of development, therefore making the animal an unintentional sentinel. Understanding how animals are impacted and what this means for human-animal relationships is particularly important as HVHHF continues to expand. Because humans and animals are so interconnected the impacts on animals likely have physical and psychological spillover effects for humans (see e.g., Bamberger and Oswald 2012, 2015; Bamberger and Oswald, Robert 2014). This section reviews the known impacts of various energy development types on animals and human-animal relationships: non-conventional or alternative (renewable, and biofuels), conventional (nuclear, coal, oil and gas) and unconventional (oil and gas extracted using HVHHF techniques). The goal of this section is to establish what is known about the impacts of various energy technologies on animals and human-animal relationships in order to establish what the research and policy needs are. Although our understanding of the impact of energy development on animals and potential human health implications is expanding, this section will clearly demonstrate that there is no social science research assessing if or how these impacts to animals affect attitudes, public opinion, and social systems.

Non-Conventional Development: Renewables and Alternatives

Non-conventional energy, also known as advanced, energy development has two primary categories: renewable and alternative. Renewable energy comes from natural sources that are harnessed and cannot be depleted which include wind, sunlight, rain, tides/waves and geothermal heat. Alternative energy development uses materials or substances other than fossil fuels, coal and natural gas to produce energy. Biofuels are the most widely known alternative fuel sources.

Renewable energy

Renewable energy is less harmful to the environment compared to other forms of development, but can still impact animal communities. Of all the forms of renewable energy, the impact of harnessing wind energy on animals has received the most attention. In particular, wind farm development can lead to loss of habitat, landscape disturbances, population dispersion, fragmentation, and collision risks (see e.g., Drewitt and Langston 2006; Fox et al. 2006; Hötker, Thomsen, and Köster 2006; Stewart, Pullin, and Coles 2004, 2007; Thomsen et al. 2006).

Among the many researchers working in this area, Jesper Madsen and colleagues have produced a suite of papers documenting wind turbines' impacts (see e.g., Madsen and Boertmann 2008; Masden et al. 2009); of particular importance is their longitudinal study assessing bird responses to wind farm development. Through this research, they document displacement effects, showing that birds distance themselves from turbines even more than a decade after initial development has occurred. This continued distancing, though not as far as the distance birds travel immediately following development, has implications for the functional connectivity of the ecosystem, "defined as the degree to which the landscape facilitates or impedes movement among resource patches" (Madsen and Boertmann 2008:1008) (see also e.g., Baguette and Van Dyck 2007; Taylor et al. 1993). The size and distribution of wind farms may also have negative impacts for migratory birds by limiting direct routes (Masden et al. 2009) and can reduce breeding success (Dahl et al. 2012). In contrast to birds, mammals (particularly elk) have been shown to adapt to turbine placement without exhibiting displacement effects or dietary constraints, meaning that their movement patterns and nutrition are largely unchanged (Walter, Leslie Jr, and Jenks 2006). However, studies on mammals have been limited.

Since much wind development is occurring on and offshore, the impacts to marine ecosystems are also important. Researchers find that noise from turbines may restrict or "mask communication and orientation signals" among fish (Wahlberg and Westerberg 2005:295) and marine animals (e.g., harbor seals, porpoises) may experience similar effects (Carstensen, Henriksen, and Teilmann 2006; Koschinski et al. 2003; Madsen et al. 2006; Thompson et al. 2013). Unique to renewable energy, few of the effects on animals jointly impact humans. However, changes in bird migratory patterns may alter ecosystem dynamics and impact farming systems. In addition, changes in prominence of animals in an area with wind farms, may have psychological ramifications for local residents. There are no studies that assess how people feel about the disruption of bird migratory patterns.

Biofuels as alternative energy sources

Biofuel energy is produced from plants, or waste products from agriculture, commercial, domestic or industrial sources. Over the past few years, demand for biofuels has increased. In highly forested or tropical areas like Southeast Asia, the desire to produce biofuels can lead to deforestation and land fragmentation, which negatively impact biodiversity (Fargione, Plevin, and Hill 2010). In the United States, studies show that changing land to biofuel production, specifically to corn and soybean fields from natural habitat, reduces biodiversity by 60 percent (Fargione et al. 2010). Most studies assert that biofuels reduce dependence on petroleum, create economic opportunities, reduce greenhouse gas emission and other pollutants, increase demand for agriculture, but may also lead to increases in agriculture commodity prices (see e.g., Demirbas 2009; Phalan 2009; Timilsina et al. 2012), which may indirectly impact animals because of land use and commodity demand changes. The substantial loss of biodiversity suggests that in high biofuel production areas people will likely have less interaction or observation of animals. Currently, there are only a few studies that assess the impacts of biofuel production on animal communities and no studies that assess how these impacts affect human-animal relationships. Additional research should be conducted not only to assess how loss of biodiversity impacts localized and regional ecosystems, but if this loss has an impact on humans or human-animal relationships.

Conventional Energy Development

Conventional sources of energy are non-renewable and include: oil, coal, gas and nuclear developments. Although newer technologies like HVHHF are technically conventional developments, they are most often considered unconventional to make a distinction between extraction methods.

Nuclear energy and disasters

Nuclear power has often been promoted as a safe alternative to the burning of fossil fuels; it is not considered a renewable energy source because it requires uranium, a finite resource, which must be mined. Large accidents such as Three Mile Island (1979), Chernobyl (1986), and Fukushima Daiichi 2011) have painted an unwelcoming picture of nuclear energy. Although all energy development forms impact animals, nuclear energy is unique in that its effects on animal life are largely constrained to accidents. When accidents do occur, however, they can be catastrophic for domestic, wildlife and agriculture animals. Although the loss of human life in nuclear accidents is relatively minor in comparison to other energy technologies (coal, petroleum, natural gas etc.) (see e.g., Burgherr and Hirschberg 2008), the economic, community and environmental impacts are staggering (see e.g., Betzer, Doumet, and Rinne 2013; Houts and

Cleary 2010).

Nuclear power plants use uranium fuel to create steam, a process that not only generates energy, but also produces radioactive material. An accident occurs when the heat and pressure from this process is not adequately controlled. The system breaks down and releases steam and radioactive material into the environment. Radioactive contamination can have instantaneous effects (radio toxicity), often reducing the abundance of organisms in an ecosystem. Accumulation effects can change how organisms develop resulting in altered ecosystems (see e.g., Møller et al. 2012). Short-term effects, including species abundance decline, have been documented at Fukushima, while long-term consequences have been recognized at Chernobyl (Møller et al. 2013).

The impact of the Fukushima disaster on animals is unfolding as we speak since a system for evaluating and understanding biological impact at this magnitude was not previously developed (Hiyama et al. 2012). To date, researchers have documented adverse effects, specifically elevated radiation levels, in wildlife (Ishida 2013) including invertebrates (i.e., butterflies, grasshoppers, etc.) (see e.g., Hiyama et al. 2012; Møller et al. 2013); livestock (Fukuda et al. 2013), products produced from animals (i.e., milk) (Manabe et al. 2013), marine life (Fisher et al. 2013) and domestic animals (Mori et al. 2013; Tsubokura et al. 2012). In addition, social scientists have started to explore the shared vulnerability and resilience among companion animals and their owners (Mattes 2017). Broadly, research shows that individuals consider their companion animals during all types of disasters and that people with companion animals are less likely to evacuate if they cannot take their companion animals with them (see e.g., Irvine 2009). Collectively, these studies show that humans and animals both experience radiation exposure, biodiversity decreases, human and animal food and water systems become contaminated and resilience is found between and across species. Although there has been some recognition of the human-animal relationship in nuclear energy development, this recognition comes only from an assessment of nuclear disasters. However, it should be noted that Chenobyl has become an animal refuge, as humans have been restricted from the area for over 30 years (Webster et al. 2016). It is unclear how radiation has impacted the animals in this area. Much of the same trend exists for other energy development types, where recognition of human-animal relationships only happens when disasters occur and, as mentioned above, animals can be used as sentinels.

Coal mining

Since the late 19^{th} century, coal has been widely used to generate electricity, which displaced animal workers. Men tunneled down mines to manually extract coal sending it to the surface in carts and pulleys. Although rapid production dates to the 1800s, extraction of coal deposits dates back to the Roman Empire (Smith 1997). Archeological evidence suggests that indigenous Americans, particularly in the west, mined a variety of things, including coal, but much of this was done as surface mining (Ascarza 2013). As mentioned previously, sentinel animals were used in underground mining operations to monitor toxic gasses. Today, in the United States, underground mining still occurs, but animals are not used as monitoring agents. Instead, miners use sophisticated air quality monitors that may even be referred to as "miner's canaries" (see e.g., Kumar et al. 2013; Pollock 2016). The development of surface mining (strip mining and mountaintop removal) reduced the need to expose individuals to the hazards of underground mining. Although surface mining does not use sentinel animals, it has a greater impact on the environment and can lead to habitat fragmentation and ecosystem distress (Kumar, Chandra, and Usmani 2017).

Not only were animals used as sentinels in mines, they were also used as sentinels in laboratory experiments to assess the risks of mining on human health. For instance, animals were tested on throughout the 20th century to identify more efficient ways of identifying and controlling toxic hazards in mining (see e.g. for review Brown and Donaldson 1989; Castranova et al. 1985; Green et al. 1983; Hodkinson 1959; Szymczykiewicz 1981) In particular, both Hodkinson (1959) and Brown and Donaldson (1989) found that animals exposed to quartz dust and other toxins from coal mines sustained health effects that did not diminish overtime. The testing of coal mining toxins on animals in laboratory environments has largely ended. Today, much of the research on impacts of coal mining on animals comes from monitoring or collecting biological material from animals in their natural environment. For instance, Harrington, Hays, and McBee (2006) found that rats exposed to toxins found in mines sustain DNA damage, as do birds (Bonisoli-Alquati 2014). Not only do these studies provide insight into human health issues, they also suggest that long-term impacts to ecosystems are occurring as DNA structures of animals living near and around mines are being altered, which includes companion animals. Given these results, it is likely that companion animals living near mines also experience DNA damage. There have been no studies that assess health and mortality of companion animals living near mines. In addition, there are no studies that assess what this means for the human-animal relationship. As coal mining has declined in lieu of alternative and unconventional development, increased attention is being paid to the reclamation of abandoned mines.

Scholars have become particularly interested in the rehabilitation and revitalization of abandoned mines to restore ecosystem services (see e.g., Zhang et al. 2017). Operating and abandoned mines create habitat fragmentation, limiting the range and mobility of some species (Kumar et al. 2017), However, Grigg, Shelton, and Mullen (2000) argue that seeding open-cut mines with grasses creates a relatively rapid return of ecosystem services while also limiting erosion and providing surface stability. However, reclaimed systems are quite temperamental because of their unique topography and reduced carrying capacity. While reclaiming mines may reduce land fragmentation, it does not mitigate toxin-exposure problems. For instance, operating and abandoned coal mines can have long-term impacts on the water infrastructure causing problems for humans and animals (see e.g., Choudhury et al. 2017; Howladar, Deb, and Muzemder 2017). In addition, animals living in abandoned mines show signs of toxin exposure and altered DNA sequences (Harrington et al. 2006). Although Harrington and colleagues (2006) specifically look at the impact abandoned mines have on rat physiology, other creatures, such as bats, often reside in caves and are likely to use abandoned mines as habitats. Research shows that bats do frequently use abandoned mines, but the extent of toxin exposure and biological damage is unknown (Whitaker Jr and Stacy 1996). Arsenic and Selenium exposed during mining production may pose a problem to humans and other animals residing near abandoned and operating mines (He, Liang, and Jiang 2002). In addition, coal mines often produce waster that is high in radionuclides. Radioactivity, although not extensively studied, poses an additional concern, depending on geographical region (Singh et al. 2001). Although coal production can pose significant problems for animals, it is unlike other conventional energy development forms in that disasters are often isolated occurrences, but can still have large effects. Although the safety of coal mining has increased over the years, it remains a dangerous job with frequent incidents. In addition coal mining impounds, which store toxic sludge from operations are often poorly constructed and have weak walls. Collapses of impoundments can be catastrophic for workers, the environment and animals (National Research Council 2002).

Oil and gas production, spills and offshore extraction

Conventional oil and gas production has many of the same known impacts on animals as coal mining in terms of land fragmentation and near-source water contamination. However, most of the research assessing the impacts of oil and gas production on animals specifically focuses on spills and contamination because of catastrophic disasters. Oil contamination from a spill may be evident for several years; however, in salt marshes and mangroves, contamination can persist for decades, and arctic coastlines are particularly vulnerable to delayed impacts. For instance, the Exxon Valdez oil spill, which occurred along the Prince William Sound in Alaska on March 24, 1989, is correlated with a reduction in wildlife populations that has had enduring effects (see e.g., Joye and MacDonald 2010; Peterson et al. 2003). Among the animals most impacted by the Exxon Valdez is the sea otter, which has had a stagnant population since the accident (Monson et al. 2000, 2011). The more recent Deepwater Horizon/BP oil spill, which occurred on April 20, 2010, in the Gulf of Mexico, contributed to the contamination of fish and other marine life and has resulted in concerns about impacts to human food systems (Rotkin-Ellman, Wong, and Solomon 2012), though the FDA has assured the public that contamination is inconsequential for human health (Dickey 2012). Although these impacts are specifically associated with disasters from conventional extraction, the risk of oil spills and the problems they create are not likely to go away, and in fact will continue with unconventional extraction since oil is still extracted and then transported through pipelines, on open waters and across political borders.

Unconventional Energy Development

The most prominent form of unconventional development is HVHHF, also known as fracking. HVHHF is a well-stimulation process that uses large volumes of pressurized fluid pumped into wells to induce rock fractures as a means to release previously unattainable oil and gas stores, a process that has spurred an energy boom in the U.S. By increasing the amount of oil being produced, many of the impacts and risks mentioned in the previous section on conventional development are likely to continue (see e.g., Jernelöv 2010). Although many studies have addressed how individuals in extractive communities perceive the costs and benefits of hydraulic fracturing, researchers have largely ignored what this expansion means for animals and human-animal relationships (for exception, see e.g., Bamberger and Oswald 2012, 2014, 2015; Bamberger and Oswald, Robert 2014). In particular, Royte (2012) notes this oversight and suggests that cattle and other farm animals are the new proverbial canaries in the coal mine, unintentional victims of environmental destruction and contamination caused by human hands.

Specific to HVHHF, Bamberger and Oswald (2012) identify the leading source of concern to animals as chemical exposure from contaminated water wells and springs. The animals in this study experienced reproductive, neurological, urological, gastrointestinal, dermatological, upper respiratory, and musculoskeletal impacts, as well as death. Bamberger and Oswald (2012) describe one case in which wastewater leaked into a cattle pasture, causing direct exposure. Within one hour of the leak, 17 cows died. In another case, a leak created a natural experiment whereby 60 cattle had access to a contaminated creek, while a second group of 36 cattle was at pasture and did not have access to the creek. Of the 60 cattle who had access to the contaminated water, 21 died and 16 failed to produce calves the following spring; the 36 who were not exposed showed no symptoms or abnormal health problems. The authors note that because they have restricted movement and continuous exposure, "animals, especially livestock, are sensitive to the contaminants released into the environment by drilling and by its cumulative impacts" (Bamberger and Oswald 2012:72). In addition, the authors show evidence of the potential vulnerability and shared consequences humans and companion animals experience when living near high HVHHF sites. Although this study involved a snowball sample, what they were able to show is that HVHHF affects animals and these impacts have long-term consequences not just for animals, but for humans as well (Bamberger and Oswald 2015).

HVHHF is unique in that most regulation is done at the state or local level rather than at the federal level meaning that impacts are likely to vary across jurisdictions. In fact, hydraulic fracturing is exempt from the Clean Air Act, Clean Water Act, Safe Drinking Water Act (Halliburton Loophole), National Environmental Policy Act, Emergency Planning and Community Right-to-Know Act, Resource Conservation and Recovery Act, Comprehensive Environmental Response, Compensation and Liability Act (Superfund) among others. To date, researchers in the biomedical sciences have identified a number of risks humans and animals face by residing near HVHHF wells. Humans and animals may come into contact with HVHHF toxins when fracking fluids are spilled or illegally dumped into the environment (see e.g., Davis 2012; Davis and Robinson 2012; Entrekin et al. 2011; Gillen and Kiviat 2012; Kiviat 2013; Rozell and Reaven 2012). Not only is accidental exposure a problem, but a number of studies show that livestock will ingest crude oil and other petroleum products when faced with dehydration, have a lack of clean water, are fed contaminated or poor feeds, need to increase their salt intake or because of boredom (Coppock et al. 1995, 1996; Edwards 1989; Edwards, Coppock, and Zinn 1979). Although studies have not been conducted, companion animals and wildlife may drink or bathe in contaminated sources or waste pools for similar reasons. Additional research is needed to assess this possibility. Beyond water contamination, the depletion of water reserves may have long-term consequences for animal populations by reducing wetlands (Kiviat 2013). In addition HVHHF has been shown to alter air quality, contribute to land fragmentation, and produce noise and light pollution.

Research is clear that HVHHF increases air pollution, which poses a concern for human and animal health (see e.g., Colborn et al. 2014; Garti 2012). As with other forms of development, land use changes can create fragmentation leading to species dispersal and biodiversity reduction (Gillen and Kiviat 2012; Kiviat 2013). As Davis and Robinson (2012) note, forest fragmentation can contribute to range restriction and species extinction. The actual well may not be the only problem. For instance, studies show that songbirds and sage grouse avoid newly built development pathways, including roads and pipelines (Bayne and Dale 2011; Doherty et al. 2008). Similarly, deer relocate to areas away from well pads and infrastructure (Sawyer et al. 2006; Sawyer, Kauffman, and Nielson 2009; Sawyer and Nielson 2010). However, not all animals experience the same fate. In studying lizard populations in Texas, Smolensky and Fitzgerald (2011) found that population size was not disrupted by development.

Compared to humans, wildlife are particularly sensitive to noise and light pollution (Kiviat 2013; Gillen and Kiviat 2012). Kivat (2013) suggests that, "continuous loud noise from, for example, transportation networks, motorized recreation, and urban development can interfere with acoustic communication for frogs, birds, and mammals and cause hearing loss, elevated stress hormone levels, and hypertension in various animals" (pg. 5). Habib, Bayne, and Boutin (2007) found that noise pollution from HVHHF drilling in Alberta, Canada, reduced bird-pairing success. However, Francis, Ortega, and Cruz (2009) found that noise effects increased breeding success in birds near wells, likely because of reduced predation. Not only is onshore noise a problem, offshore drilling noises have been found to disrupt underwater animal communication channels (Schlossberg 2016). Although the studies are limited, Kiviat (2013) asserts that light pollution may impact reproduction and foraging.

Unconventional development continues to expand, while our understanding of the impacts to animals and human-animal relationships is limited. Although we have some evidence to suggest that animals are being impacted, it is limited. The regulation of HVHHF at the state and local level is likely to create varied impacts so that information about the effects to animals in one location cannot be easily transferred to another. What is absent from this body of literature is social science research exploring human-animal relationships. Scholars have not yet explored important questions such as how humans think about the risks HVHHF poses to animals, whether closeness to animals influences risk perceptions or how individuals and communities are responding to and managing risks. In fact, public perception of risk is a critical part of mitigating harm, thus, understanding how connections between humans and animals influence opinion becomes particularly important especially when there are shared short and long-term impacts from HVHHF across species.

STRUCTURE OF THE DISSERTATION

The dissertation proceeds as follows. In Chapter 1 I conduct a thorough content analysis of peer-reviewed articles examining high volume horizontal drilling and hydraulic fracturing (HVHHF) to assess how animals and human-animal relationships are discussed. Articles fall into three themes: animal focused articles; animal observant articles and animal sentinel articles. I demonstrate that across all three themes, articles seldom acknowledge the inherent value of animals; instead, they focus almost exclusively on the use of animals as sentinels for potential human health risks. Further, social science articles assessing the impacts of HVHHF on animals and human-animal relationships are non-existent. This chapter serves as a call for additional research. As an environmental sociologists and risk scholar, I use chapters 2 and 3 to explore the social and psychological drivers of HVHHF risk perception across species.

In Chapter 2 I extend construal level theory of social distance to interspecies relationships and test whether social distance influences perception of HVHHF risk across animal groups. To do this I use an experimental survey design premised on the idea that framing can activate individuals' social distance with animal groups. Because individuals are more likely to be altruistic towards groups they perceive to be close to and because past research has differentiated human relationships with companion animals, livestock and wildlife, I hypothesize that framing can activate social distance in ways that influence risk perception. In addition, I test whether animal ownership (a proxy of interspecies social distance) impacts risk perceptions across species. Multivariate regression results show that framing HVHHF risk in terms of animals can alter perceptions of HVHHF risk to animals. Specifically, framing HVHHF risk in terms of companion animals and livestock increases risk perceptions across all animal categories when compared to framing risk in terms of humans. Interestingly this does not hold true for wildlife; framing HVHHF in terms of wildlife only increases perceptions of risk to wildlife themselves and has no impact on perceptions of risk to companion animals or livestock. This finding is particularly interesting because, as CLT suggests, there is a hierarchy of social distance where humans likely experience the least social distance with companion animals (and perhaps livestock) and the greatest social distance with wildlife. As a consequence, presenting HVHHF risks as impacting companion animals and livestock has a spillover effect, allowing individuals to generalize and increase risk perceptions across all animal groups. In addition to the framing effect, companion animal ownership (which decreases social distance) increases risk perceptions. In particular, having a dog increases perceptions of risk across all animal groups. This study has practical implications for organizations interested in gaining public support for policies that address HVHHF harms to animals. Framing of HVHHF risk is often done in terms of impacts to wildlife or the natural environment. Although this might increase perceptions of risk to wildlife, it likely has no impact on how people perceive the impacts of HVHHF on companion animals and livestock. In addition, the findings suggest that wildlife frames may actually decrease individuals' perceptions of HVHHF risk to humans.

Chapter 3 picks up where Chapter 2 leaves off, continuing to investigate what drives how people perceive the risk HVHHF poses to various animal groups. Using survey data, I draw on the environmental values literature to assess the causal link between values and risk perception across species. The results from structural equation modeling and logistic regression, show that altruism (animal and biospheric) is a positive predictor of increased risk perceptions, but that social distance mediates this relationship for risk to companion animals. The findings have important implications for understanding the human-animal relationship and for environmental and animal rights movements pursuing policies that promote animal wellbeing.

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EXPLORING THE PLACE OF ANIMALS AND HUMAN-ANIMAL RELATIONSHIPS IN HYDRAULIC FRACTURING DISCOURSE

ABSTRACT

Throughout human history, energy security has been a prominent concern. Historically, animals were used as energy providers and as companions in mining operations-sentinels. While animals are seldom used for these purposes today in the affluent world, broadly this legacy of use may have far-reaching consequences for how animals are acknowledged in energy development. Given that the US is experiencing an energy boom in the form of high volume horizontal drilling and hydraulic fracturing (HVHHF) and animals are the most at risk, this study uses a thorough content analysis of peer-reviewed articles examining HVHHF to assess how animals and human-animal relationships are discussed. Three dominant themes emerge: animal focused articles, animal observant articles, and animal sentinel articles. Across themes, articles seldom acknowledge the inherent value of animals; instead, the focus is almost exclusively on the use of animals as sentinels for potential human health risks. Further, there are no social science articles that assess the impacts of HVHHF on animals or human-animal relationships. Given that relationships with animals are an integral part of human existence, the impacts of HVHHF on animals likely to go beyond shared health concerns and may alter human-animal relationships.

INTRODUCTION

On a small plot of land in Pennsylvania, Stacey Haney and Beth Voyles raised animals and children. In 2008, they combined their land in order to rent it to a Texas-based oil company that would use high volume horizontal drilling and hydraulic fracturing (HVHHF) to harvest natural gas. Both women thought it was a beneficial plan, providing them with additional income for their respective farms. However, in less than a year after drilling began, Haney's animals, Hunter (dog), Boots (goat), and Boots' offspring had all died. Similarly, Voyles lost her prized dog-Cummins, and at least 15 of Cummins' offspring. Both families also experienced health repercussions (See e.g., Griswold 2011). Their land sits above the Marcellus Shale Deposit, which is an American natural-gas field often used for HVHHF. HVHHF is a type of energy development that involves forcing high volumes of liquid into horizontally drilled wells to stimulate fractures and free up oil and gas stores that can then be recovered.

In 2012, Michelle Bamberger and Robert Oswald, a veterinarian and a pharmacologist, published a paper with the intention of starting a conversation about the impacts of HVHHF on animal populations and the associated connections to human health. Their article relies on 24 reported cases of animal harm. Opening a new avenue for discussion and making clear connections between animal and human well-being, the paper received widespread attention (see e.g., Phillips 2012). Although their paper does not offer generalizable statements about the broad impacts of HVHHF on animals or the associated costs to human health, it does raise numerous questions about the use of animals as sentinels in the expansion of HVHHF. This issue should be part of a larger discussion about the use of animals in energy development, a topic that has implications for both animal and human health, as well as for human-animal relationships.

Whitley (2017) suggests that animals have a long and varied history in energy development that has often been overlooked. From antiquity until recent times animals were used as energy providers. This dynamic only changed with technological innovation at which point animals became intentional sentinels in mining operations and laboratory experiments, being used to assess the risks that mining toxins posed to humans (Whitley 2017). Though using animals as intentional sentinels fell out of favor in the 1960s, HVHHF's rapid expansion has reintroduced their use as harbingers of human risk. Researchers are beginning to monitor (treating them as unintentional sentinels) and once again conduct laboratory experiments on animals (treating them as intentional sentinels) to assess the impacts of HVHHF toxin exposure, often with the objective of learning more about potential risks to human health. Animal research of this kind is clearly important, but there are other avenues for animal-HVHHF research that do not appear to be as well tread.

Understanding the impact HVHHF has on animals and human-animal relationships is important for four key reasons. First, animals are inherently valuable; they contribute to ecosystem success and HVHHF will likely have individual and symbiotic impacts on their wellbeing. Second, although impacts to animals may signal potential risks to humans they are also likely to impact human-animal relationships. For instance, in the example above, Haney and Voyles both experienced psychological trauma over the loss of their animals. Such trauma could be magnified in sensitive populations such as senior pet owners living alone who report greater life satisfaction from having a pet (Himsworth and Rock 2013). In addition, this type of trauma could have implications for animal ownership and rescue in high HVHHF regions. Third, the impact HVHHF has on animals may affect public perceptions of risk, as is the case with natural disasters, where harm to animals influences individuals' risk perceptions and behaviors (Irvine

2009). Finally, HVHHF may impact veterinary services. Bamberger and Oswald (2012) argue that non-disclosure policies make treating animals exposed to HVHHF fluids a challenge. Along these lines, veterinarians in high HVHHF areas are likely coming into contact with greater numbers of exposure cases and this may change how veterinary medicine is practiced.

Despite the importance of these issues, research on HVHHF is highly interdisciplinary and implications for animals are often embedded in ways that make it unclear whether these topics are being investigated. This study seeks to overcome this challenge by conducting a thorough content analysis of all peer-reviewed literature discussing the place of animals in HVHHF to provide a report on the state of the field that 1) determines how animals and human-animal relationships are featured in scientific literature on the impacts of HVHHF, 2) identifies themes among the suite of studies and, 3) assesses what additional research is needed.

BACKGROUND AND THEORY

Environmental Justice and the Place of Animals

Historically, environmental justice (EJ) has addressed the inequitable distribution of environmental services and burdens to vulnerable populations. Sociologists have long drawn on work from deviance studies, political economy and environmental justice to explain toxic exposure, consistently concluding that the poor and people of color have been victims of egregious ecological injustice (see e.g., Mohai and Saha 2006, 2007). This literature is connected to a larger body of work assessing the system of social and political inequalities that are reinforced through access and distribution of the natural environment (see e.g., Bullard, Warren, and Johnson 2005; Pellow 2007). Likewise, much of the literature is focused on the production, manipulation and unlawful disposal of toxic waste (see e.g., Massari and Monzini 2004; Pearce and Tombs 2009; Ruggiero 1996).

Though there has been a concerted effort to apply concepts of environmental justice to human populations, nonhuman animals are nearly absent from this discourse (Kopnina 2014). (Kopnina 2014) argues that scholars are influenced by the "dominant neoliberal ideology of anthropocentrism" (p. 2) (see also e.g., Callicott 1999; Catton and Dunlap 1978; Crist 2012; Kopnina 2012b, 2012a). The traditional tendency of social science to be anthropocentric limits inquiry into animal-environment issues to discussions of implications to humans without regard for the inherent value of animal species (Beirne 2009; Nibert 2002). Kopnina (2014) clarifies this argument, suggesting that the "View of animals as culturally, socially or economically significant objects sees non-humans as facilitators of technological advancements (e.g. medical experiments or genetic manipulations), as an attribute of cultural practice (hunting or whaling) as the objects of economic interest (e.g., animal trade) symbolic ritual (e.g. animal sacrifice), or collateral damage (e.g. road kill or forest clearings)" (p. 4). In energy development, animals have not only been the facilitators of technological advancements, but they have also served as sentinels, living indicators of the risk posed to humans (Whitley 2017). In this way, the use and investigation of animals in energy development is anthropocentric.

An issue becomes an environmental justice concern when, it is socially constructed as a problem (Taylor 2000). White (2013) argues that the nature of mining inherently creates environmental justice concerns because vulnerable populations always suffer. Several researchers have documented the potential risks HVHHF poses to human health through water contamination, fracking fluid spills, air pollution etc. (Korfmacher et al. 2013; Kovats et al. 2014; Wattenberg et al. 2015). In doing so, these researchers have constructed a narrative about

HVHHF as an environmental justice issue with a focus on human health implications. What remains absent from this work, and the larger body of environmental justice literature, is any recognition of animals or human-animal relationships.

Schlosberg (2013) argues that, "one of the remaining border challenges of environmental justice theory is to make important connections with the environment itself…Yes, most of the discussion is about environmental bads and injustices to human beings, but the origins of environmental injustices are as much in the treatment of the non-human realm as in relations among human beings" (p. 43-44). Although all mining practices have environmental impacts, the expansion of development, potential for chemical pollution, and hydrological alteration make HVHHF particularly concerning. Animals are likely to be the first affected in HVHHF development. Direct impacts to animals could have lasting effects on biodiversity and ecological services (Kiviat 2013). In particular, vulnerable animal populations such as those who have restricted ranges, are sensitive to environmental changes, or are endangered may experience amplified effects. The potential risks are so concerning that HVHHF has been identified as a global conservation issue (Lloyd et al. 2005). Importantly, wildlife are not the only victims; the health and wellbeing of livestock and companion animals may also be at risk (see e.g., Bamberger and Oswald 2012, 2015) bringing up questions about the rights of animals to have equitable access to environmental services like clean water and air. The study that follows uses content analysis approach of academic articles to evaluate the extent to which animals are considered in HVHHF discussions. In doing so, it provides tangible evidence in support of Schlosberg's 2013 assertion that we need more discussions of animals as victims in environmental justice narratives.

DATA

This study analyzes all known peer-reviewed articles published between 2012 and 2016 that examine the impacts of HVHHF on animals and/or the implications of these impacts for human-animal relationships. To ensure that the analysis is inclusive, data collection was conducted using three steps. The data gathering process began with Bamberger and Oswald's 2012 paper, described in the introduction, as it is considered the seminal article exploring the potential impacts HVHHF has on animals. First, all citations within the articles citing Bamberger and Oswald (2012) were analyzed. Second, all peer-reviewed articles citing Bamberger and Oswald (2012) were reviewed. Finally, the resulting list was cross-referenced with a search in the Web of Science database looking for peer-reviewed articles featuring hydraulic fracturing (using key terms: hydraulic fracturing, fracking, unconventional energy development, and natural gas development) and animals (using key terms: animals, ecosystems, fisheries, wildlife, livestock, agriculture, invertebrates, biodiversity, fauna, and mammals). A total of 106 articles were identified.

METHOD

This study uses a content analysis approach, a widely used technique to identify and describe patterns in textual data. All text was coded in Nvivo 11.4. Nvivo is a qualitative data analysis software tool that allows for the coding, sorting, querying and sharing of unstructured data. Line data is coded into nodes that are then consolidated into categorical themes. First, all articles were reviewed to give the researcher a feel for the data. Second, abstracts were coded for the presence of animal terms. For instance, if animals were featured in the abstract it was assumed that the animals were a central focus of the article. If animals were not featured in the abstract, it was assumed that they had little importance in the article or were simply a line reference. Additional nodes were identified to code the central themes of each abstract regardless of animal inclusion. Abstracts were chosen as the first level of analysis, because they provide summaries of articles and are likely the first thing people assess before reading an entire article. Third, a line-by-line review of all articles was done to assess when and how animals were discussed. Finally, a second coder was asked to independently code all text. Inconsistencies between the two coders were discussed until consensus was reached. Limited inconsistencies were found, as nodes relied on the presence of specific words related to animals or other subcategories of environmental and social impacts. Three major themes emerged. I discuss these themes and the associated subthemes below.

RESULTS AND DISCUSSION

The analysis aims to clarify the scientific discussion on how HVHHF impacts both animals and human-animal relationships. Of the 106 articles analyzed, only 36 (34%) mention animals in the abstract. Across all articles, three dominant themes emerged. First, 17 (16%) articles directly mention animals or ecosystems in the abstract and focus on the impacts HVHHF has on a specific animal, group, or species. These 17 articles are referred to as “animal-focused” articles. Second, 19 (18%) articles review HVHHF’s impacts and mention animals or ecosystems in the abstract but do not exclusively focus on animals, including non-animal impacts as well. These are referred to as “animal-observant” articles. Finally, the majority of articles (70 articles, 66%) did not mention animals in the abstract but cited the Bamberger and Oswald (2012) article to support a claim about HVHHF impacts to humans. These articles are referred to as “animal-sentinel” articles. Within all groups subthemes emerged.

Animal-Focused Articles

The articles within this group either provide a general overview of the impacts of HVHHF on ecosystems or focus on specific impacts on a species. General overviews of ecosystem impacts consistently conclude that freshwater organisms, species sensitive to land fragmentation, and animals with restricted ranges are the most at risk (Gillen and Kiviat 2012; Kiviat 2013). In these articles, animals are the focal point and the research examines how HVHHF affects them. For instance, research suggests that the redfin darter, a fish who is endangered in some US states, is vulnerable to silt input in streams (Stearman, Adams, and Adams 2015), native brook trout conservation and restoration are at risk (Weltman-Fahs and Taylor 2013), migrating fracturing fluids may cause adverse effects in rainbow trout (He et al. 2016), fish exposed to waters contaminated with fracking fluid show signs of general stress and higher incidences of gill lesions compared to unexposed fish (Papoulias and Velasco 2013), and a positive correlation exists between the presence of HVHHF wells and mercury concentrations in crayfish, and other predatory macro invertebrates and brook trout (Grant et al. 2015). In addition, non-aquatic animals may also be affected by water contamination. For instance, metal accumulation in riparian songbirds is higher in heavy HVHHF areas compared to those residing in areas without HVHHF (Latta et al. 2015).

A handful of articles that focus on specific species demonstrate that land fragmentation contributes to animals avoiding connective roadway, a trend documented in grassland bird species (Thompson et al. 2015), salamanders (Brand, Wiewel, and Grant 2014), mule deer (Lendrum et al. 2012), and river otters (Godwin et al. 2015). Although land fragmentation is not likely to have a big impact on livestock and companion animals, range restrictions might; despite this possibility, studies of HVHHF impacts to livestock and companion animals are scarce. For instance, in the only identified study on livestock, Finkel and colleagues (2013) assess how HVHHF affects cow and milk production over a five-year period, finding that production decreased as HVHHF development increased. Similarly, beyond the original Bamberger and Oswald (2012) article only two studies evaluate the impacts to companion animals. First, (Slizovskiy et al. 2015) use a community health survey with questions about companion and livestock health to assess how the distance to the nearest HVHHF well relates to reported human and animal health. They find that reported health of dogs is significantly lower for people living within 1km of a gas well compared to those living farther away. Second, a follow-up article by Bamberger and Oswald (2015) demonstrated that negative health impacts decreased for families (including animals) moving away from HVHHF areas while health impacts remained the same or increased for those continuing to reside in high volume drilling areas. Finally, two studies assess the impacts of endocrine-disrupting HVHHF chemicals on laboratory mice (Kassotis et al. 2015; Kassotis, Bromfield, et al. 2016).

Assessing the articles in this thematic category can draw three broad conclusions. First, although these articles focus almost exclusively on animals and tend to argue for the inherent value of animals, they largely justify studying impacts to animals by connecting them to human systems. For example, this group of studies generally mentions human health or the preservation of ecosystem services in the conclusion as a justification for focusing exclusively or almost exclusively on animals. Second, there is no social science research in this body of literature. Specifically, there are no assessments of human-animal relationships; there are only assessments of the impacts to animals that may signal potential risks to humans. Finally, and perhaps most surprisingly, the lengthy history of testing mining toxins on animals to assess and mitigate human health risks is alive and well in research. This is interesting because it goes beyond the assumption that animals are simply serving as unintentional sentinels in HVHHF development. Instead, this evidence suggests that animals are also serving as intentional sentinels

Animal-Observant Articles

The articles in this group mention animals in the context of other HVHHF risks and do not focus on a specific animal or species. In most cases, these articles focus on environmental damage or contamination. Terms like "animals" and "ecosystems" are widely used. A total of 19 articles mention animals while giving a general overview of the impacts of HVHHF or focusing on a particular impact category (water, air etc.). Unlike the previous category, the focus of these articles is on broad effects, which happen to include impacts to animals. So, for instance, in thinking about water contamination the author would mention all of the potential impacts, where in the previous category the analysis or discussion would be on the impacts HVHHF has on a particular species or group of animals. Once again, there are no social science articles in this group.

The majority of articles in this thematic category emphasize freshwater ecosystems as their animal focal point. This is not surprising, as these articles cite many of the "Animal-Focused Articles" listed above as supporting evidence. For instance, studies show that chemicals used in hydraulic fracturing pose a risk to ecosystems (Loh and Loh 2016; Vandecasteele et al. 2015; Yao et al. 2015). Specifically, Kassotis and colleagues (2016) find that injection well disposal sites reveal elevated levels of toxins that could disrupt reproduction and development in aquatic animals. Additionally, HVHHF leads to increases in pH in area streams (Lutz and Grant 2016), and water contamination can enter the food chain impacting cattle, poultry, and aquatic life (Kun et al. 2014). Notice that in all of these cases animals are mentioned, but in the context of environmental contamination where the focal point is on environmental contamination, not animals.

Instead of centering on a particular environmental impact, some articles provide general overviews of environmental risks (Brittingham et al. 2014; Burton et al. 2014; Lave and Lutz 2014; Souther et al. 2014). For instance, in an analysis of land use and shale development, (Moran et al. 2015) assert that, "shale gas development will likely have substantial negative impact effects on forested habitats and the organisms that depend upon them" (p. 1276) and (Abrahams, Griffin, and Matthews 2015) note, "well pads, access roads, and gathering lines fragment forestland resulting in irreversible alterations to the forest ecosystem" (p. 153). As can be seen from these statements, animals are considered in broad terms. There is no specific species or group identified.

Finally, a key component of articles within this theme is the effort to position research as important for supporting human systems. For example, multiple scholars argue that failing to understand threats to ecosystems and lacking proper regulatory mechanisms are likely to contribute to ecosystem loss, which has implications for human health (Allred et al. 2015; Bamberger and Oswald 2014; Down, Armes, and Jackson 2013; M. Finkel, Hays, and Law 2013; Jones, Pejchar, and Kiesecker 2015; Kassotis, Iwanowicz, et al. 2016; Robbins 2013; Ticleanu, Nicolescu, and Ion 2014). Three important takeaways emerge from this group. First, articles mention animals as being impacted by HVHHF, but do not focus on a specific group or species. Second, unlike the articles in the animal-focused group, these articles focus on making a connection between animal (and environmental) impacts and human health, paying less attention to the inherent value of nature or animals. Finally, as with the previous group, there are no social science articles.

Animal Sentinel Articles

The majority of animal sentinel articles did not mention animals or ecosystems in the abstract (n=70). Overall, this group used the Bamberger and Oswald (2012) article to support discussions on one of five key HVHHF subthemes: public health concerns (n=24 or 35% of animal sentinel articles), environmental impacts (n=19 or 27% of animal sentinel articles), community impacts and public perceptions (16 or 23% of animal sentinel articles), policy (7 or 10% of animal sentinel articles), and general reviews of broad impacts (4 or 6% of animal sentinel articles).

First, the largest group of articles in this theme emphasizes public health concerns (n=24). These articles discuss the impacts of HVHHF on either broad public health categories (see e.g., Adekola et al. 2016; Boyle et al. 2016; Ferrar et al. 2013; Finkel and Hays 2013; Goldstein and Kriesky 2012; Korfmacher et al. 2013; Mitka 2012; Penning et al. 2014; Perry 2013; Rabinowitz et al. 2015; Rafferty and Limonik 2013; Redmond 2014; Saberi 2013; Saberi et al. 2014; Saunders et al. 2016; Shonkoff, Hays, and Finkel 2014; Steinzor, Subra, and Sumi 2013; Tuller 2015; Werner et al. 2015; Willems et al. 2016) or specifically to infant or reproductive and developmental health (Kassotis et al. 2015; Ma et al. 2016; Payne et al. 2014; Webb et al. 2014). If mentioned, animals are only used to situate the potential and realized impacts to human health or to assert that more research is needed (see Ma et al. 2016). For instance, in a review of HVHHF health impacts, (Shonkoff et al. 2014) cites Bamberger and Oswald (2012) after discussing fracking fluid containment by noting “These containment ponds are often, but not always, lined to protect against leakage; however, case studies have documented reported ruptures to these liners that may have led to water and soil contamination and contributed to fish and livestock deaths (Bamberger and Oswald 2012)” (p. 793). This is the only reference to animals in the article and is simply used to support the thesis that additional epidemiological studies are needed to evaluate risks to human health.

Second, a group of studies within this theme speak to environmental impacts (n=19). Two articles review broad environmental impacts (Arent et al. 2015; Reible et al. 2016), while the remaining 17 focus on air quality or water use and contamination. For instance, HVHHF is known to have broad impacts on air quality (Brown et al. 2014; Colborn et al. 2012; Field, Soltis, and Murphy 2014; Moore et al. 2014), contribute to volatile organic compounds (Bunch et al. 2014), increase toxic vapors (Bai et al. 2016), and pose ambient risks (Brown, Lewis, and Weinberger 2015). Similar to the health impacts subtheme, this group minimally mentions animals in the text or uses (Bamberger and Oswald 2012) as a general nod to potential impacts to human health. For instance, (Bunch et al. 2014) do not mention animals at all, but cite the article to show that few "studies have focused on atmospheric emissions and, in particular, on the potential impacts of such emissions on human health" (p. 833). A second group of environmental impact articles speak to issues of water quality. For instance, these articles discuss the chemical composition of water and wastewater disposal wells near HVHHF sites (Kassotis et al. 2013; Rich and Crosby 2013; Zhai et al. 2016), wastewater spills and water contamination (Koh et al. 2016; Konkel 2016; Penningroth et al. 2013; Sang et al. 2014), and broad debates about water use and contamination (Ernstoff and Ellis 2013). Similar to other articles in this theme, animals are excluded and only mentioned in superficial ways.

Third, there are 16 community impacts and public perceptions articles. This subtheme is the only one to include social science articles. In these articles HVHHF is evaluated in terms of public perceptions (Choma, Hanoch, and Currie 2016; Dokshin 2016; Israel et al. 2015; Morrone, Chadwick, and Kruse 2015; Powers et al. 2015) community disorder and boomtown issues (Jerolmack and Berman 2016; Ruddell and Ortiz 2014), changes in traffic (Graham et al. 2015), economic impacts (Barth 2013; Muresan and Ivan 2015), broad or case-specific social impacts (Garvie, Lowe, and Shaw 2014; Perry 2012), and environmental justice and human rights (see e.g., Clough and Bell 2016; Fry, Briggle, and Kincaid 2015; Johnston, Werder, and Sebastian 2016; Short et al. 2015). Once again, these articles give little attention to the impacts of HVHHF on animals. Specifically, animals and human-animal relationships are not mentioned in survey analyses or in discussions about community impacts broadly. What is most interesting about this collection is that even among the environmental justice focused articles, animals are non-existent. For instance, in discussing the connection between human rights and HVHHF, and Short and colleagues (2015) cite the Bamberger and Oswald (2012) article to suggest that "Land can also be impacted through water, air or soil pollution as we have seen above, along with damage to livestock, vegetation and wildlife" (pg. 15), but give no designated attention to animals in their analysis. Overall, this group mentions animals or ecosystems to support the discussion of potential risks to humans.

Fourth, some articles focus on policy initiatives and debates (n=7). Within this group, articles focus on policies and practices in monitoring and management (Centner and Eberhart 2015; Wylie and Albright 2014), local distance ordinances and management (Centner and Kostandini 2015; Fry 2013), political debates and public policy (Bamberger and Oswald 2013; Beebeejaun 2013), and national acts and orders (Geltman, Gill, and Jovanovic 2016). As with the others, articles in this subtheme either do not specifically mention animals or only mention them to support a claim about human or environmental wellbeing. The single exception to this is Bamberger and Oswald's 2015 follow up article to their original 2012 publication, in which they deliberately discuss the impact of HVHHF on livestock, mentioning that livestock remaining in

HVHHF areas recovered from reproductive distress initially seen on the onset of production, but developed long-term respiratory issues.

Finally, a small group of articles provide general overviews of HVHHF impacts, addressing both environmental and social concerns (n=4) (see e.g, Esterhuyse et al. 2016; Hays et al. 2015; Stephenson 2016; Wang et al. 2014). Once again, this group cites Bamberger and Oswald (2012) without mentioning animals. For instance, Stephenson (2016) notes, “concerns over additives used in hydraulic fracturing fluid mainly center on them reaching the environment from spills at the surface or in transport, from illegal dumping of wastewater, or from damage to the liners of wastewater impoundment dams” (p. 8), which is followed with the Bamberger and Oswald citation. The article does not specifically mention animals. By evaluating articles in the animal sentinel theme, two conclusions emerge. First, a substantial number of articles that theoretically discuss the impacts of HVHHF on animals and human-animal relationships, in actuality only use animals to situate research on the impacts of HVHHF to humans. These articles pay little attention to the direct impacts HVHHF has on animals and human-animal relationships. Second, it is clear that social science, including environmental justice scholars, have paid little attention to the impacts HVHHF has on animals and human-animal relationships.

CONCLUSION

As HVHHF continues to expand, numerous environmental and social impacts are being acknowledged; however, the place of animals in this discourse remains limited, especially among social scientists. Assessing the impacts of HVHHF on animals and human-animal relationships is particularly important because animals have an inherent value, they contribute to ecosystem viability and there will likely be individual and shared impacts between humans and animals.

Studies that mention animals or cite animal related research in the context of HVHHF can be divided into three thematic categories: animal focused, animal observant, and animal sentinel articles. The central goal of animal-focused articles is to assess the risks of HVHHF on animal life, often on a particular species. Animal-observant articles mention impacts of HVHHF to animals, but in the context of other issues or themes. These articles do not focus on animals, but impacts to animals are acknowledged. Finally, the majority of articles cite animal-focused articles to make a claim about the impacts HVHHF has on something or some community other than animals. Social science work is only found in this last category, but nowhere is there a discussion of human-animal relationships in the face of HVHHF or of how HVHHF's impacts to animals influence social and community dynamics. The clear gap in literature mimics the assertions that social science has neglected the natural environment, and in this case animals, as an important topic of analysis for social life.

While some studies acknowledge the inherent value of animals (studies in the animal focused theme), most cite risks to animals as a means of understanding the potential risks to human health. This is perhaps unsurprising, given humans' lengthy history of using animals as intentional and unintentional sentinels in energy development. For instance, scholars have often argued that the tracking and monitoring of sentinel species is an important technique to assess human health risks (McCarthy et al. 1990; Rabinowitz, Scotch, and Conti 2009). A benefit of observing animals in HVHHF areas is that this approach does not isolate and expose animals to toxic chemicals in a laboratory (Rabinowitz, Scotch, and Conti 2010). However, animals are only tracked and monitored when exposure to humans has occurred or is expected to occur. As a consequence, such work may negate the inherent value of animals, since tracking and monitoring is unlikely to occur when there is no concern over human health risks. What is most surprising about the use of animal sentinels in the current energy boom is that past practices of using laboratory animals to test energy development chemicals on has returned. So, not only are animals being used as unintentional sentinels to signal human health risks, animals are also being experimented on in laboratory environments to explore the toxicity of HVHHF fluids. There is growing research that suggests that experimentation on animals is often flawed, misleading, and wasteful (Arluke 2010; Arluke and Michael 2007; Eisenman 2016). Because of this, many scholars and industries have called for alternatives to animal-based experimentation (Khilnani and Khilnani 2016; Kumar et al. 2015). Collectively, these studies suggest that there are serious ethical concerns that need to be considered when using animals for experimentation. In the case of HVHHF, current studies using animals to assess the impacts of HVHHF fluid exposure do not give sufficient thought to external validity or what might be gained or lost from field observation. Although, field observation can make detecting effects difficult which may be a leading reason to do experiments on animals, there are several studies mentioned above that have used field experimentation to document effects. Although there has been some work to assert that animals are sentinels in HVHHF expansion, the use of animals in laboratory experiments to document the potential effects of HVHHF toxins has not been addressed. It is unlikely that many, even within Animal Rights circles, are aware of the laboratory testing conducted on animals to gain insight into the harmful effects of HVHHF chemicals. Such information may be particularly important in aligning animal rights activists and fracktivists movements (a range of people from those who strongly oppose hydraulic fracturing to those who support extensive policy and practice reform before expansion is allowed to continue). Across thematic categories, human health remains a dominant subtheme. Most studies, regardless of their central focus, conclude by discussing the potential or realized risks of HVHHF to human health, but not to human-animal relationships. However, the reality is that HVHHF impacts to animals will likely go beyond shared health concerns.

There are limitations to this study. The focus on peer-reviewed published articles could be considered a limitation. In fact, there are several non-peer-reviewed sources that address the impacts of HVHHF on animals (DeDonder et al. 2015; Hill 2013; National Parks Conservation Association 2013). In addition, there may be additional social and natural science HVHHF articles that discuss animals, but they were not considered as contributing to the dominate discussion because they did not cite the Bamberger and Oswald's (2012) article and could not be found when searching for animal key terms. Finally, because of the historical exclusion of the natural environment and animals from social science literature, there may be social science scholars working in this area that have yet to publish their work. If this is the case, broad searches of all materials including conference papers, dissertations etc. should reveal additional sources that would not have been considered for this particular analysis, but could be evaluated in the future.

Ultimately, this content analysis literature review highlights that numerous gaps in assessing the place of and impact to animals and human-animal relationships. Not only are more geographically- and species-diverse studies needed to assess vulnerability and reliance by social scientists, but social scientists in particular need to assess the effects HVHHF has on human-animal relationships. Scholars need to assess how individual in relationships with animals are responding to HVHHF development. For instance, as discussed above, Finkel and colleagues (2013) find that dairy production has decreased as HVHHF has increased, but why? Are dairy producers encountering more problems with production? Has leasing given them more flexibility and made them les reliant on dairying? How do these producers feel about the changing dynamic? In addition, several reports suggest that people and animals are suffering shared health problems. What does this shared suffering mean for companion animal ownership, loss and veterinary care? What are the social and psychological implications? How have rescue organizations responded to HVHHF, especially in high development areas? Additionally, research suggests that boomtowns may fuel social disorder, which can lead to increases in violence. How do animals fit into this equation? Is there increased animal abuse in these communities? Finally, human relationships with animals may alter how people respond to HVHHF risks. Researchers need to assess if animal ownership or perceived connection to animals alters perceptions. Ultimately, this review suggests that there is much work to be done to centralize animals and human-animal relationships as essential and important factors in assessing the impacts of HVHHF, much of which needs to begin with social scientists.

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IS MY DOG AT RISK? EVALUATING THE INFLUENCE OF INTERSPECIES PSYCHOLOGICAL DISTANCE ON RISK PERCEPTION

ABSTRACT

Interspecies relationships may influence perceptions of risk and resulting behaviors. However, researchers have yet to apply social distance theory across interspecies relationships to explain altruistic responses to animals facing environmental risks. This study bridges these distinct literatures and fills a gap in knowledge by extending construal level theory of psychological distance to include interspecies relationships in evaluating how people perceive environmental risks to animals. Given that high volume horizontal drilling hydraulic fracturing (HVHHF) affects humans and animals collectively, it is an ideal case to assess perception of risk across species. The study uses a framing experiment to activate social distance and animal ownership as a proxy for social distance to evaluate HVHHF risk perceptions across four groups: vulnerable people, companion animals, livestock and wildlife. Findings provide support for the extension of social distance to include interspecies relationships in assessing perceptions of environmental risks that are likely to impact humans and animals.

INTRODUCTION

In particular, understanding environmental risk perception is important for determining how individuals perceive and act in the face of environmental problems, if and when education is needed and how policy should be constructed. Different people assess risk differently, but why this is the case remains a question for debate especially for perceptions of particular environmental issues with substantial uncertainty (see e.g., Fischhoff and Kadvany 2011; Klinke and Renn 2002; Rosa, Renn, and McCright 2014).

In social and cognitive psychology, numerous theoretical frameworks have been proposed to explain risk perception (for review see e.g., Slovic 2016). The most prominent of these are heuristics and biases (see e.g., Tversky and Kahneman 1974), which led to the psychometric model (see e.g., Fischhoff et al. 1978). Researchers have suggested that there are important characteristics outside of these models that influence risk perception, particularly when considering environmental risks. For instance, "knowledge, experience, values, attitudes and emotions influence thinking and judgment about the seriousness and acceptability of risks" (Wachinger et al. 2013). Trust is also an important factor (see e.g. Slovic 2016). Beyond these frameworks and additional variables, interspecies connections may influence perceptions of environmental risks, as many environmental risks include threats to humans, animals and human-animal relationships.

In disaster research, scholars have shown that companion animal ownership is an important factor in determining how individuals react to disaster warnings and whether they choose to evacuate (Trigg et al. 2016b, 2016a). Recognizing this importance, numerous government organizations such that the Federal Emergency Management Agency (FEMA) and the Center for Disease Control (CDC) have created disaster plans and resources that include animal family members (Center for Disease Control 2016; Federal Emergency Management Agency 2015). This recognition is consistent with past research that suggests humans form strong and enduring relationships with companion animals that influence how they process information and behave (see e.g., Blouin 2013; Irvine 2009; Sanders 2003; Triebenbacher 2000; Walsh 2009). Together the animal studies and disaster literatures suggest that interspecies psychological distance- our cognitive perception of how close or distant we are to another creature - is likely to influence risk perceptions.

Construal level theory of psychological distance (CLT) offers one possible explanation of this relationship. CLT posits that psychological distance affects how abstract our conceptions of objects and phenomena are, influencing our perceptions of risk. It is in a sense a theory of altruism, explaining how far our circle of consideration shifts from ourselves to include others, and what perceived aspects of others make them more or less likely to be included in our concerns. CLT has yet to take human-animal relationships into account. Given the previously described relationships between animals, humans and risk perception this is an important omission. The current study takes up this issue, extending CLT by applying it to human-animal relationships in the U.S.

Although this extension could be assessed using many environmental issues, high volume horizontal hydraulic fracturing (HVHHF) has been chosen for three reasons. HVHHF has grown rapidly over the last decade and continues to grow, with over half of current crude oil production and two-thirds of natural gas production coming from hydraulically fractured wells (see e.g., U.S. Energy Information Administration 2016a, 2016b). Despite this growth, concerns and uncertainty over HVHHF's environmental and health impacts remain a central topic of debate and public interest. Because of public concern and uncertainty, and the reality that opposition can change industry direction, researchers have been particularly interested in assessing public perceptions of hydraulic fracturing (see e.g., Choma, Hanoch, and Currie 2016; Reible et al. 2016; Ward, Eykelbosh, and Nicol 2016). Most important for the current theoretical extension, there is mounting evidence that animals, both domestic and wild, have been and will continue to be impacted by hydraulic fracturing (see e.g., Bamberger and Oswald 2012, 2014; Bamberger and Oswald, Robert 2014). Whitley (2017) argues hydraulic fracturing creates a scenario where animals are once again being used as sentinels in energy development. Like the canary in the coalmine, the effects of hydraulic fracturing on animal health and well-being serve as signals of environmental distress and potential harm to humans. This paper extends CLT to interspecies relationships, and uses a novel framing experiment to assess how psychological distance between species influences risk perceptions of hydraulic fracturing.

BACKGROUND AND THEORY

Construal Level Theory and Risk Perceptions

In social psychology, construal level theory (CLT) is a framework explaining how psychological distance influences the way people think about objects and events. CLT has been used to explain how various forms of psychological distance impact social, psychological and behavioral functions (for review see e.g., Liberman, Trope, and Stephan 2007; Trope and Liberman 2003, 2010; Trope, Liberman, and Wakslak 2007). At its root, it suggests that altering the psychological distance between an individual and an object affects a person's perceptions and behaviors (see e.g., Liberman, Sagristano, and Trope 2002; Trope and Liberman 2003). Specifically, CLT asserts that as psychological distance between an individual and an object or event decreases, the object or event is interpreted in more concrete terms, with greater detail.

Conversely, the larger the psychological distance, the more psychologically abstract the object becomes (see e.g., Yaacov 2012). Psychological distance is articulated across four dimensions: temporal, spatial, social and hypotheticality (Fujita et al. 2006; Liberman et al. 2002; Liviatan, Trope, and Liberman 2008; Wakslak et al. 2006). Time and space are fairly straightforward, with events, objects or risks that are further from you in space or time being considered cognitively more distant than those that are closer in space and time. Social distance refers to the perceived similarity individuals feel between themselves and others and events. Hypothetical distance can be understood as the visualization of an event or encounter as likely or unlikely. Though identified separately, these dimensions are interconnected (see e.g. Bar-Anan, Liberman, and Trope 2006). For example, when individuals consider the long-term risks of climate change, it is not just the temporal distance (the consequences of climate change happening in the future), but also their social distance (how likely they think they are to be affected by climate change), and spatial distance (how far away possible climate change impacts are located) that influence their psychological distance.

Psychological distance is particularly important to environmental risk perception because as psychological distance increases, individuals may perceive a risk to be abstract, leading them to discount it (see e.g., Trope and Liberman 2010; Trope et al. 2007; Zwickle and Wilson 2013). This assertion is supported in literature addressing the influence of psychological distance on climate change risk perception (see e.g., Evans, Milfont, and Lawrence 2014; van der Linden 2015; Niles, Lubell, and Haden 2013; Spence, Poortinga, and Pidgeon 2012). However, to date, social distance has been defined as psychological processes that occur among and between humans with no application to other animals. Additionally, the application of CLT to perception to individuals over objects or events (like climate change) and an additional component that likely relates to altruism. So, in applying CLT to perceptions of humans and animals in many ways it can be interpreted as an extension of the altruism literature.

Psychological Distance and Animal Concern

Mounting evidence suggests that interspecies relationships play an essential role in individuals' lives, influence both real and hypothetical behavior, and stimulate risk perception. Scholars have demonstrated that humans develop concrete relationships with animals and often consider companion animals to be family members (Blouin 2013; Sanders 2003; Triebenbacher 2000; Walsh 2009). As a case in point, Trigg and colleagues (2016) suggest that pet owners often identify with their animals psychologically; arguing that the pet becomes part of one's self and an extension of individual identity similar to a sister, friend, or child. Research supporting this claim has shown that having a relationship with a companion animal provides emotional support for abused women (Fitzgerald 2007; Flynn 2000a, 2000b), assists in managing physical and psychological trauma (O'Haire, Guérin, and Kirkham 2015; Packman et al. 2016; Walsh 2009), increases attachment and promotes healthy relationship development in children (Kerns et al. 2016), contributes to the rehabilitation of the incarcerated (see e.g., Furst 2006; Kruger, Trachtenberg, and Serpell 2004; Strimple 2003), supports veterans overcoming trauma (Baker et al. 1998; Foreman and Crosson 2012), supports senior citizens' physical and psychological health (Cusack and Smith 2014; Ebenstein and Wortham 2001), improves the quality of life of hospitalized pediatric cancer patients (Urbanski and Lazenby 2012) and is vital to supporting the health and wellbeing of the homeless (see e.g., Irvine 2013; Kidd and Kidd 1994; Slatter, Lloyd, and King 2012; Taylor, Williams, and Gray 2004). The emotional connection between humans and animals can be so profound that studies of animal loss have demonstrated that people experience losing a domestic animal as similar to losing a human relative or close friend (Gerwolls and Labott 1994).

However, research shows that human concern for animal wellbeing varies with the species considered (Arluke and Sanders 1996; Herzog and Foster 2010). For instance, individuals show greater emotional attachment to domestic animals than to wildlife and livestock (see e.g, Charles 2014; Irvine 2013). Some of this finding is likely due to personal experience, since more people have routine and meaningful interactions with companion animals than with livestock and wildlife. If we think about this finding in terms of psychological distance, we could argue that on average people perceive less social distance with companion animals than with livestock or wild animals.

A series of studies evaluating hypothetical behavior towards animals and humans highlight how past experiences with animals reduces perceived social distance between the self and other animals. For instance, Arluke and Levine (Forthcoming) demonstrate greater public concern for abuse against companion animals than for abuse against humans (Arluke and Levine Forthcoming). They argue that in hearing about animal abuse cases, individuals readily consider their own pets; the abstract nature of the situation becomes personal. Their experiment and conclusions support an assertion that past experiences with animals reduce social distance leading to increased care and concern. Similarly, in a study examining how individuals respond to stories of infant and puppy abuse, Daly, Taylor, and Signal (2014) find that while individuals show greater emotional and behavioral responses towards infants, this effect is meditated by pet ownership. Specifically, pet owners were significantly more bothered by the puppy abuse than those who did not own a pet. Once again, Daly, Taylor and Signal (2014) do not mention social distance, but their experiment demonstrates that past experience with animals (in this case pet ownership) diminishes social distance between humans and animals, leading to increased concern. Likewise, in an experiment framed as an exploration of moral judgments, Topolski and colleagues (Topolski et al. 2013) assessed when and if individuals value animal lives over human lives. In a series of questions, individuals were asked whom they would save in a hypothetical scenario. They find that individuals are willing to save a pet over a human, but that this willingness is greatest when they are close to the pet and not to the human (diminished social distance for animal and increased social distance for human), and decreases as the level of human relationship increases (diminished social distance with the human). For instance individuals are more likely to save their own or a friend's pet when the choice is between the animal and someone they have no personal attachment to, but are more likely to save a person they are close to when the choice is between that person and their pet. These studies suggest that the perceived social distance between animals and humans can influence an individual's thoughts and behaviors, but that there is also a hierarchy in relationships among and across species.

Human-Animal Relationships and Risk

In addition to these studies of hypothetical behavior, the deep emotional connection many humans have with animals has led scholars to ask whether animals influence responses to hazards. This concept has been best developed in the natural disaster and risk management literature. Thompson (2013), for example, explains that, "the willingness of people to risk their own lives during disasters to save those of animals has been well documented" (p. 123). In an early account assessing how horse owners identify their priorities during a disaster, researchers found they rated family safety first, followed closely by the safety of their horses. In addition, 75 percent said the ability to be assured the welfare of their horses would dictate their decision to evacuate (Linnabary et al. 1993). Although research established this relationship in the early 90s, when Hurricane Katrina hit in 2005 there were few disaster preparation and evacuation systems that acknowledged the human-animal bond (see e.g., Hunt, Al-Awadi, and Johnson 2008; Irvine 2009). Because of the lack of understanding and limited policy support to address human-animal relationships, a significant number of people chose not to evacuate (see e.g., Hunt et al. 2008; Irvine 2009). It became clear in the aftermath of Hurricane Katrina that animals needed to be an important part of risk assessment and decision management processes. Since then, there have been a number of systematic changes including the development of organizations to temporarily house animals, and an increased recognition that risk and disaster management plans must honor human and animal relationships (see e.g., Irvine 2009).

Taking these streams of literature together we see there are two important, but as yet unconnected findings: first, humans can have deep emotional bonds with animals which are likely attenuated by psychological distance and second, some humans may incorporate concern for animals into their risk assessments and behaviors. We do not yet understand whether these phenomena are connected such that interspecies social distance influences risk perception. We can evaluate this connection by applying CLT to risk perceptions of hydraulic fracturing, focusing on the ways that human-animal relationships influence perceptions of risk. Given the wealth of information we know about human-animal relationships and the application of CLT, it is assumed that there is a hierarchy of social distance across animal groups, with humans experiencing the least social distance to other humans, followed by companion animals, livestock and wildlife. With this conceptual hierarchy in mind, the extension and application of CLT leads to three hypotheses:

H1: Framing HVHHF risk in terms of companion animals, with whom humans have the least social distance, will encourage individuals to generalize the risk to other animal life resulting in a spillover effect that increases perception of risk across all animal categories.

H2: Framing HVHHF in terms of wildlife, the animal group people have the greatest social distance with, will have no impact on perception of risk to companion animals or livestock.

H3: Individuals who have a companion animal, which reduces social distance, will perceive risks to animals across all categories to be greater than those who do not have a companion animal.

DATA

Experimental survey data was collected in October 2016. The survey was administered online through Qualtrics to a representative[1] sample of 860 individuals living in the United States. The survey included questions on a range of socio-cognitive constructs relating to hydraulic fracturing, risk perceptions, and policy support as well as key personal characteristic questions. Respondents received compensation through Qualtrics for participation and took an average of 13.5 minutes to complete the survey. Based on Qualtrics policies and procedures, compensation is based on the fair market value and is equivalent to minimum wage. Table presents the descriptive statistics of all variables used in the models.

[1] Representation was based on census race categories.

Measurement of Variables

Risk frame (social distance activation)

Each respondent was given one of four hydraulic fracturing risk frames. The frames were identical except for the group that was identified to be at risk from fracking; those listed at risk included people, companion animals, livestock or wildlife. The frames did not mention specific animals (dogs, sheep etc.). The frames appeared as short news stories (approximately 125 words) and identified the information as coming from Washington, D.C. The story did not include a citation or reference to a news source to reduce bias associated with particular news organizations. The frames were not expected to change social distance between groups or alter an individual's relationship with the animal groups discussed, they were simply meant to activate existing social distance. The frames were pretested on undergraduates at a large research university. The social distance activation frame appears in Figure 1 located in the Appendix.

Dependent Variables

Risk perception scales

The dependent variables are perception scales based on one question that assessed perception of harm to a collection of humans and animals living near HVHHF wells. The question is, "How harmful do you think hydraulic fracturing is to each of the following living near the site?" Individuals evaluated the question along a five point Likert scale from "Not at all" to "Extremely." Although principle component analysis revealed that all items from this question could fall on a single factor, suggesting that people view risk to all life similarly, theory and my desire to assess the influence of the frames on activating social distance across animal groups lead me to divide answers to this question into four categories: companion animals, livestock, wildlife and vulnerable humans. The companion animal category includes perception of risk to dogs, cats and horses. The livestock category includes perception of risk to cattle, sheep and pigs. The wildlife category includes perception of risk to deer, coyotes and raccoons. Finally, the vulnerable human category includes perceptions of risk to children, the elderly and pregnant women. I wanted human and animal groups to be as similar as possible; since animals are considered vulnerable populations, I included vulnerable human populations as the comparison group. The included categories- women, children and the elderly- were selected based on confirmatory factor analysis. Table 1 presents the factor loadings and Chronbach's alphas for each scale; the Chronbach's alphas are well above the standard cut point of 0.70 (Nunnally 1978).

Table 1: Factor Loadings and Chronbach's Alphas for Risk Perception Items from Confirmatory Factor Analysis (N=860)

Risk Peception Items	Companion Animals (α=0.978)	Livestock (α=0.982)	Wildlife (α=0.979)	Vulnerable People (α=0.977)
Dogs	1^{+}			
Cats	1.023			
Horses	0.939			
Cattle		1^{+}		
Sheep		0.999		
Pigs		0.987		
Deer			1^{+}	
Coyotes			1.073	
Raccoons			1.039	
Children				1^{+}
Elders				1.008
Pregnant Women				0.976

All estimated factor loadings are significant at $p<0.001$
By constraint^{+}

Independent Variables

Animal ownership (proxy for social distance)

Individuals were asked if they currently have a dog, cat, or horse. Respondents who said yes were coded as 1, while those who did not have any of the listed animals were coded as 0. Although these could be combined into a companion animal ownership variable, there is reason to believe that there may be unique effects across different companion animals on risk perception. Treating horses as companion animals is somewhat complicated. The ASPCA includes the horse as a species suitable to be a companion animal because they are no longer needed for transportation and farm work. Just like dogs or cats, horses do not have secondary uses in U.S. society as food or fiber. However, it should be noted that many government agencies and organizations like the American Veterinary Medical Association, National Animal Identification Act, and the American Horse Council still consider the horse to be livestock. Much of the social resistance to redefining the horse as a companion animal is because horse owners can take advantage of farm tax exemptions. In addition, much of the funding about equine research relies on government funding in research on livestock (see e.g., Blocksdorf 2016). Individuals were also asked if they have or ever had a cow, sheep, or pig. Those who had ever owned a cow, sheep or pig were coded as 1, while those who had never owned livestock were coded as 0. Given the relatively small number of people who have ever owned livestock, a single variable coded as 1 for "has owned livestock" and 0 for "no livestock ownership" was created. Theory behind this variable is that proximity and engagement with animals is likely to decrease social distance, since owning companion animals and livestock relies on a physical relationship, meaning that companion animal and livestock owners likely have regular and routine interaction with their animals. However, it should be noted that most people who have owned livestock have been involved with the use value of livestock in production and/or slaughter, which may contribute to a lack of concern.

Demographic and control variables

Beyond social engagement individuals share with animals, other factors may influence risk perception. Past studies have shown demographic characteristics to have mixed effects on risk perception (see e.g., Siegrist, Gutscher, and Earle 2005; Sjöberg 2000). Age/cohort shows mixed results depending on the risk being evaluated (see e.g., Baird 1986; Freudenburg 1993; Hanoch, Rolison, and Freund 2016; Knoll et al. 2015; Tränkle, Gelau, and Metker 1990). Similarly, income shows mixed results with limited power to explain variance across risk perception models (see e.g., Sjöberg 2000; Wildavsky and Dake 1990). Likewise, the influence of education on risk perception is mixed depending on how education is measured and whether it is years of formal education or a specific type of knowledge about a risk (see e.g., Sjöberg 2000). Within assessments of energy technologies there is limited evidence to suggest that education is a significant predictor of risk perception (see e.g., Yim and Vaganov 2003). Educational attainment is a routine indicator of environmental concern (for review e.g., Gifford and Nilsson 2014). However, for highly politicized issues, education has been shown to have differing impacts for Democrats and Republicans, leading Democrats to show more concern as education increases and Republicans to show less (Dunlap and McCright 2008; McCright et al. 2016; McCright and Dunlap 2011). This trend may be a function of individuals seeking out and obtaining information that reinforces their existing beliefs, which has been documented in climate change opinion formation (see e.g., Wood and Vedlitz 2007).

Of all demographic characteristics, sex is the most consistent indicator in risk perception (see e.g., Siegrist et al. 2005). Women are generally more risk adverse with greater concern over personal and family dangers (Bord and O'Connor 1997; Davidson and Freudenburg 1996; Finucane et al. 2000; Flynn, Slovic, and Mertz 1994; McCright 2010; McCright and Dunlap 2013; Slimak and Dietz 2006; Slovic 1999; Steger and Witt 1989; Whitfield et al. 2009). Race is often included in risk perception analysis because lower-income communities of color have sustained the brunt of hazardous facility siting and exposure to environmental risks. Again, however, there have been mixed results that do not present a consistent pattern (Brulle and Pellow 2006; Crowder and Downey 2010; Cutter 1995; Downey 2005, 2015; Downey and Hawkins 2008). For an extensive review of the personal and social factors that influence environmental concern see e.g., Gifford and Nilsson (2014) and perceptions of energy development(see e.g., Ansolabehere and Konisky (2014). Evidence suggests that there is often an interaction effect between race and gender (see e.g., Kalof et al. 2002; McCright and Xiao 2014). This interaction between race and gender was evaluated and it was not significant, so it is not included in the table.

For this study sex is measured as male or female. Female is the reference category. Age is measured as a continuous variable. Race is measured based on U.S. Census categories. Because of limited respondents in some racial categories the model includes white (non-Hispanic), Latino/a/Chicano/a/Hispanic (non-white), black, and other. The "other" category includes those who identified as Native Hawaiian or Other Pacific Islander, Native American or American Indian or Alaska Native, Asian or Asian American, Indian or Indian American, Arab American or Middle Eastern and Other. These categories were generated by Qualtrics in establishing a U.S. representative sample based on race. Education has ten categories from "12th grade or less" to

"Doctorate degree." Income has five categories from "$0-$24,999" to "$100,000 and up." Ideology is measured on a seven-point Likert scale from "Very liberal" to "Very conservative." Finally, party identification is measured on a seven-point Likert scale from "Very strong Democrat" to "Very strong Republican." For modeling purposes education, income, ideology and party are all treated as continuous variables. Descriptive statistics are presented in Table 2.

Environmental beliefs

In environmental decision-making scholars argue that beliefs dictate how people form opinions and engage in behaviors. Dunlap and colleagues developed a widely used scale known as the New Ecological Paradigm (see e.g., Catton and Dunlap 1978; Catton Jr and Dunlap 1978, 1980; Dunlap 1980; Dunlap and Van Liere 1978). Stern and colleagues (Stern, Dietz, and Guagnano 1995) argue that the measure actually evaluates general beliefs about the vulnerability of the environment to human actions, which are influenced by social structure and values. It has been widely applied as an indicator of environmental concern and has generated consistent results across studies (see e.g., Cordano, Welcomer, and Scherer 2003; Dunlap 2008; Dunlap et al. 2000). The measure is a scale based on seven standard items from the New Ecological Paradigm. Chronbach's alpha for environmental beliefs is 0.779. Descriptive statistics are presented in Table 2.

Table 2: Descriptive Statistics for Chapter 2					
Variables	Obs.	Mean	Std. Dev.	Min	Max
Risk Frame					
Companion	860	0.248	0.432	0	1
Livestock	860	0.249	0.433	0	1
Wildlife	860	0.260	0.439	0	1
People	860	0.243	0.429	0	1
Risk Perceptions					
Companion	860	4.130	0.964	1	5
Livestock	860	4.153	0.956	1	5
Wildlife	860	4.123	0.964	1	5
Vulnerable People	860	4.100	1.011	1	5
Animal Ownership					
Dog	860	0.535	0.499	0	1
Cat	860	0.416	0.493	0	1
Horse	860	0.127	0.333	0	1
Livestock	860	0.158	0.365	0	1
Personal Charac.					
Male	860	0.279	0.449	0	1
Age	860	44.841	15.131	18	86
White	860	0.669	0.471	0	1
Black	860	0.124	0.330	0	1
Latino/Hispanic	860	0.147	0.354	0	1
Other Race	860	0.060	0.238	0	1
Education	860	4.320	2.048	1	9
Income	860	2.647	1.297	1	5
Political Ideology[1]	860	3.881	1.695	1	7
Political Party[2]	860	3.569	1.859	1	7
Environmental Beliefs					
NEP	860	3.526	0.707	1	5

[1]Liberal to conservative
[2]Democrate to Republican

METHODS

I first execute four one-way analysis of variance (ANOVA) models to assess if the mean risk score for each group differs across social distance frames. The results are presented in Table 3. Next, I compare the influence of each social distance frame within each category. The results are provided in Table 4. Finally, I conduct a multivariate regression to evaluate the effects of social distance on perceived hydraulic fracturing risk to various animal groups. Multivariate regression is different from multiple regression in that variables are jointly regressed on the same independent variables with the equations assumed to be related. Although multivariate regression produces the same coefficients and standard errors as multiple regression, multivariate regression calculates the between-equation covariances and allows for testing of coefficients across equations. The Breusch-Pagan test is significant ($p<0.000$), indicating that the residuals of these four risk perception variables are not independent of each other, which supports the use of a multivariate regression model.

RESULTS

Social Distance Frame Activation

The framing experiment allows me to assess whether interspecies social distance can be activated in ways that influence risk perceptions across species. In order to evaluate whether the frames had unique effects on risk perception, I conduct four ANOVAs, one for each category (companion animals, livestock, wildlife and vulnerable people). Results are presented in Table 3. In these models, the dependent variables are respondents' perceptions of the risk facing a given animal group; the ANOVA determines whether there are differences in mean risk perception across the four frames. The results indicate that the frames influenced risk perceptions, showing that within each animal category, at least one of the frames produce a different mean than the other frames. This is significant for all animal groups: companion $p<0.01$, livestock $p<0.01$, wildlife $p<0.05$. Unfortunately, the ANOVA does not tell us which frames produce different mean risk evaluations. Instead, to evaluate differences across frames I conduct a pairwise comparison of means assuming equal variances; the results are presented in Table 4. The results indicate that individuals who received the companion animal frame and those that received the livestock risk frame evaluated risk to all animal categories- companion animals, livestock, and wildlife- as being higher than those who received the human frame. In contrast, individuals who received the wildlife frame only perceive risk to be higher for wildlife, and actually perceive risk to humans to be lower than those who received a human frame. Having determined that the frames significantly altered risk perceptions, I now evaluate the other determinants of interspecies risk perception. To do this, I turn to multivariate regression models, presented in Table 5. The results reinforce the pairwise test. As can be seen from Table 5, the coefficients of the risk frames change slightly with addition of other variables, but their significance does not change.

Table 3: One-Way ANOVA of Risk Perceptions by Risk Frame

Risk Perception Categories	Source	Sum of Squares	*df*	Mean Square	F	Sig
Companion	Between Groups	11.424	3	3.808	4.14	0.0063
	Within Groups	786.657	856	0.919		
	Total	798.081	859	0.929		
Livestock	Between Groups	12.205	3	4.068	4.5	0.0038
	Within Groups	773.081	856	0.903		
	Total	785.286	859	0.914		
Wildlife	Between Groups	7.919	3	2.640	2.86	0.0361
	Within Groups	790.320	856	0.923		
	Total	798.239	859	0.929		
Vulnerable People	Between Groups	4.599	3	1.533	1.5	0.2124
	Within Groups	873.467	856	1.020		
	Total	878.067	859	1.022		

Table 4: Comparisons of Frame Impacts on Perception of Risk to Various Groups				
Frame Comparisons	Companion	Livestock	Wildlife	Vulnerable People
Companion vs People	0.290**	0.229*	0.218*	-0.093
Livestock vs People	0.269**	0.329***	0.232*	-0.045
Wildlife vs People	0.138	0.153	0.220*	-0.195*
Livestock vs Companion	-0.021	0.100	0.013	0.048
Wildlife vs Companion	-0.152	-0.075	0.002	-0.103
Wildlife vs Livestock	-0.131	-0.176	-0.011	-0.151

*** p<0.001, ** p<0.01, * p<0.05

Table 5: Multivariate Regression Results of Social Distance on Perception of Risk Across Categories

Variables	Companion		Livestock		Wildlife		Vulnerable People	
	Coeff	Coeff	Coeff	Coeff	Coeff	Coeff	Coeff	Coeff
Frames								
Companion	0.290**	0.246**	0.229*	0.184*	0.218*	0.171*	-0.093	-0.147
Livestock	0.269**	0.221**	0.329***	0.280***	0.232*	0.177*	-0.045	-0.115
Wildlife	0.138	0.126	0.153	0.145	0.220*	0.207*	-0.195**	-0.224**
Animal Ownership								
Dog		0.154*		0.162**		0.132*		0.119
Cat		0.116		0.103		0.121*		0.065
Horse		-0.263*		-0.292**		-0.272*		-0.190
Livestock		0.180*		0.179*		0.137		0.073
Personal Charac.								
Male		-0.233***		-0.219***		-0.214***		-0.301***
Age		-0.007***		-0.007***		-0.008***		-0.006**
Black[2]		0.233**		0.208*		0.157		0.285**
Latino/Hispanic[2]		0.179*		0.183*		0.118		0.121
Other Race[2]		0.161		0.078		0.093		0.240
Education		-0.006		-0.017		-0.012		-0.019
Income		-0.031		-0.031		-0.030		-0.043
Political Ideology[3]		0.013		0.016		0.013		-0.001
Political Party[4]		-0.052*		-0.063**		-0.068**		-0.054*
Environmental Beliefs								
NEP		0.464***		0.469***		0.475***		0.521***
Constant		2.761***		2.817***		2.887***		2.991
Observations	860		860		860		860	
RMSE	0.959	0.847	0.95	0.835	0.961	0.845	1.01	0.884
R-squared	0.014	0.243	0.016	0.252	0.01	0.248	0.005	0.251

*** p<0.001, ** p<0.01, * p<0.05

[1]Reference category is people

[2]Reference category is white

[3]Liberal to conservative

[4]Democrate to Republican

Animal Ownership

Animal ownership serves as a proxy for perceived social distance. For the purpose of this analysis, three companion animal categories are included: dog, cat and horse. In addition, I include a combined livestock animal ownership category. The multivariate regression results presented in Table 5 indicate that dog owners perceive greater risk to all animal categories while; cat owners only perceive higher risk to wildlife. In contrast, horse owners perceive lower risk across all animal categories. Finally, livestock ownership has a positive, significant influence on perceptions of risk to companion animals and livestock. In all cases I conducted post-estimation tests to evaluate whether owning a given animal actually has distinct effects across the three animal categories, as would be indicated by the differing coefficients. In all cases, even when the coefficients were slightly different across dependent variables (for example when the coefficient for dog ownership was 0.154 for companion animals, 0.162 for livestock, and 0.132 for wildlife), these tests were insignificant, indicating that animal ownership has the same substantive effect on perceived risk across all animal categories.

Controls and Additional Explanatory Factors

In addition to the key findings presented above, Table 5 shows that on average, men perceive risk to be lower than do woman, which is consistent with existing research. Age has a negative effect, where each additional year reduces risk perception by 0.007 to 0.008 ($p<0.001$) points depending on the animal category. This impact is significant, but small. Compared to whites, blacks are more likely to assess higher risks for all categories except wildlife. Compared to non-Hispanic whites, Latinos/Hispanics are more likely to perceive greater risk to companion animals and livestock, but not to wildlife or people. Political party has a negative influence on risk perception across all categories, suggesting that those who identify as Republicans perceive lower HVHHF risk. Political ideology was insignificant. Finally, environmental beliefs are significant positive indicators of perception of risk across all categories suggesting that those who have pro-environmental beliefs also perceive higher risk to animals.

DISCUSSION

This study assesses whether construal level theory of psychological distance can be applied across species in risk evaluation. The question is premised on existing theory and research that suggests people experience varied levels of social distance with different animal groups. In this study, I evaluate what drives individuals' perceptions of the risks high volume horizontal drilling hydraulic fracturing (HVHHF) pose to vulnerable people, companion animals, livestock and wildlife. People likely experience the least social distance with other humans, followed by companion animals, livestock and wildlife. High volume HVHHF provides a useful lens to assess this relationship, as research suggests that HVHHF has and will continue to have impacts on humans and animals both individually and collectively.

The results suggest that the interspecies application of CLT is useful in predicting risk perceptions. First, framing HVHHF risk in terms of a specific animal group increases perceptions of risk to that group. Importantly this may have occurred for one of two reasons: either because people were informed that HVHHF was impacting a particular group and simply reflected what they had been told in their risk assessments, or alternatively, because framing HVHHF risks in terms of an animal group activates an individual's social distance with that group. Hypothesis 1 asserts that framing HVHHF risks in terms of companion animals will not only influence perceptions of risk to companion animals, but will also have a spillover effect. This spillover hypothesis stems from the assumption that because humans have the least social distance with companion animals, encouraging them to think about the risks posed to this group will activate their altruism in a way that translates into greater compassion for all animal life. The results support this hypothesis. Interestingly, this same effect materialized with the livestock frame. The spillover effect for the companion animal and livestock frames suggests that by activating human-animal relationships that have the least social distance, people feel more connected to animal groups in general and respond by perceiving risks to all animal groups to be higher. This dynamic was entirely unexpected for livestock because theory and past research suggests that there is greater social distance between humans and livestock than there is between humans and companion animals. However, this finding may be indicative of the complex relationship humans have with livestock where they may simultaneously be considered companions and food.

What is perhaps most interesting and is another strong indication that interspecies social distance influences risk perception is the fact that the activation of social distance between humans and wildlife performed differently than the activation of social distance between humans and both companion animals and livestock. Specifically, individuals receiving a wildlife frame showed an increased perception of risk to wildlife and a decreased perception of risk to humans. Receiving a wildlife frame had no influence on perception of risk to companion animals or livestock. This finding suggests that, individuals do not conceptualize wildlife in the same way they do companion animals or livestock. It is likely that instead of making a concrete psychological connection to a particular animal or event involving wildlife, individuals simply interpret wildlife as a synonym for the natural environment. This is a key point, as it may support the idea that varied levels of social distance are shared between humans and animal groups, with humans experiencing the greatest social distance with wildlife. Ultimately, this finding supports Hypothesis 2, which asserts that the wildlife frame will have no impact on perception of risk to companion animals or livestock. In addition, the wildlife frame appears to have decreased perceptions of risk to vulnerable humans. This is particularly important information for how risk is communicated. If the goal is to increase perceptions of risk to humans, framing HVHHF in terms of wildlife and the natural environment may be counterproductive.

Beyond the framing results, animal ownership was used as a proxy for social distance with the expectation that experience with animals decreases social distance between the self and animals, increasing concern. Current ownership of a dog, cat or horse, as well as past and current livestock ownership was assessed as predictors of risk perception. Within the companion animal category, having a dog was the only significant predictor to increase perception of risk across all animal categories. This result likely reflects the close bonds humans share with dogs. The scientific reality of this relationship has been documented with mounting evidence showing numerous correlated biological changes in humans and their companion canines (see e.g., Odendaal and Meintjes 2003). MacLean and Hare (2015) document increased circulating oxytocin- often referred to as the love hormone- in *both* humans and companion dogs after they interact. Given the fact that biological changes occur when humans have companion animals, it is likely that psychological change also occurs and that these changes affect attitudes and behaviors. Cat ownership was only significant in increasing wildlife perception. It is unclear what is driving this finding but it may suggest that since cat owners frequently let their animals roam freely, they may be more concerned about their animals coming into contact with contaminated environments or sick wildlife.

Beyond serving as a theoretical extension, the findings have practical implications for understanding perceptions of HVHHF risk and how HVHHF risks should be framed to promote policy support. First, on average individuals perceive the danger of HVHHF to animal populations as being either dangerous or extremely dangerous which suggests this is a topic of public concern. However, little social science attention has been given to the place of animals and human-animal relationships in energy development. (see e.g., Whitley 2017). Second, this experiment suggests that framing HVHHF risks in terms of animals may be useful, but that its utility is dependent on the animal in question. Framing risks in terms of wildlife is unlikely to activate social distance in ways that broadly alter risk perceptions, since this framing only increases perceptions of risk to wildlife and actually decreases perceptions of risk to humans. In contrast, framing HVHHF in terms of the risks to companion animals and livestock is likely to not only increase perceptions of risk to the target groups, but is also likely to have spillover effects on perceptions of risk to other animal groups.

Ultimately, this paper begins the process of expanding risk perception research to include interspecies relationships; however, there are a few limitations. First, the frame activation experiment assumes that responses and the observed spillover effects reflect psychological closeness or social distance with the animal group mentioned. The alternative explanation is that frames simply provide information that individuals reproduce and that spillover effects could simply indicate individuals generalize the provided information across animal groups. This study cannot definitively determine which of these explanations is correct; however, if individuals were simply regurgitating and generalizing, we would expect those receiving the wildlife frame to perceive risk in the same way as those receiving the companion animal and livestock frames. This was not the case, and in fact we see no spillover effect when people are asked to conceptualize risk in terms of animals with which they are the most distant, lending support to the idea that social distance is driving this relationship. Second, animal ownership is used as an approximate measure of social distance. This measure assumes that individuals who own animals feel close and/or consider their animals to be family. Additional measures should be used to assess how similar or connected individuals feel to a variety of animal groups or species. Third, the directionality of the relationship between animal ownership and risk perceptions cannot be conclusively determined. It is possible that the connection between companion animal ownership and risk perceptions reflects a selection bias whereby individuals who care about and are concerned for other species are more likely to own companion animals. Fourth, CLT is only one of the many ways to explain risk perceptions. Additional work should specifically look at the influence of environmental values and beliefs on perception of risk to animals in an integrative model. Fifth, this sample is representative based on U.S. Census racial categories. Descriptive statistics show that the sample is relatively similar to the national population in terms of education, and income, but the sample for this study has a higher proportion of women than the U.S. population. This limitation is challenging to overcome given that the costs of conducting surveys on representative samples across multiple U.S. Census categories is exceedingly high. However, Qualtrics and Mturk sampling have been shown to provide reasonably good data and could be used to help overcome this limitation (see e.g., Berinsky, Huber, and Lenz 2012; Buhrmester, Kwang, and Gosling 2011; Goodman, Cryder, and Cheema 2013; Peer et al. 2012). Finally, this interspecies application of CLT psychological distance focuses on one particular risk and uses only one aspect of CLT, social distance. Additional work should assess how people process risk to animals across multiple issues and should evaluate other aspects of CLT as well (spatial, temporal, hypothetical).

CONCLUSION

This study fills a critical gap in literature by extending construal level theory of psychological distance to explain how human-animal relationships influence risk perception. On the one hand, previous work has used CLT to explain a variety of risk phenomena, but has not assessed the role interspecies relationships play in risk perception. On the other hand, existing work in the interdisciplinary field of animal studies has documented a strong human-animal connection that influences perceptions and behaviors, but these studies often lack a theoretical mechanism to explain their findings. This study has linked these two literatures by extending CLT to include human-animal relationships in the investigation of HVHHF risk perceptions.

The findings suggest that reduced social distance between humans and animals (companion animals and livestock in particular) increases perception of risk from HVHHF to all animals. This is particularly interesting because it offers support for the notion that humans have an underlying relationship with companion animals and livestock. In particular, the activation of social distance between humans and companion animals and humans and livestock has a spillover effect, where individuals are more likely to be concerned about all animals and not just the at-risk group. Among the animal ownership categories, dog owners perceived greater risk to all animal groups, an indication of the strong bonds that humans form with their canine companions.

The human-animal relationship is not shared with wildlife. The wildlife frame had no impact on perception of risk to companion animals or livestock and reduced perception of risk to vulnerable humans. Not only does this finding suggest that people related and internalized the risk to various animal groups differently, it also has practical implications for how risk is communicated. Policy makers, activists and organizations use risk framing as a means to increase public support. If the goal is to increase public support for policies that protect animals from HVHHF, framing risks in terms of wildlife may increase perceptions of risk to wildlife, but will likely have little impact on perceptions to companion animals or livestock. In addition, this study shows wildlife risk framing decreases perceptions of risk to people. Alternatively, given that many people share physical and psychological space with companion animals, framing HVHHF risk in terms of its impacts on dogs or other companion animals may be more effective in gaining support.

APPENDIX

APPENDIX

SOCIAL DISTANCE FRAME

Figure 1: Social Distance Activation Frame.

Fracking Harmful to (People, Farm Animals, Wildlife, Pets)

Monday, September 15, 2016 Posted: 9:06 AM EST

Washington, D.C.—Several recent studies show that (people, farm animals, wildlife, pets) living in close proximity to hydraulic fracturing (or "fracking") sites will experience symptoms of respiratory illness, gastrointestinal disease, and neurological distress.

These recent reports join a growing number of biological studies documenting similar risks from fracking. Concerned by these results, some policy-makers are considering new policies that require companies identify and reduce the risks that their hydraulic fracturing operations pose to (people, farm animals, wildlife, pets).

To gain support for their efforts, these policy-makers are encouraging citizens to participate in community town hall meetings and write their elected representatives to demand action.

A fracked well adjacent to homes. Thirteen new wells are proposed to be drilled here in the next few months.

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ANIMALS AT RISK? ASSESSING THE INFLUENCE OF ALTRUISM AND INTERSPECIES RELATIONSHIPS ON PERCEPTIONS OF HYDRAULIC FRACTURING

ABSTRACT

Much attention has been paid to how people perceive the risks of high volume horizontal drilling and hydraulic fracturing (HVHHF), which is rapidly expanding throughout the U.S. However, limited attention has been paid to evaluating what people think about the dangers HVHHF poses to animals or what drives these perceptions. This omission is important because biological and physical scientists argue that animals face the greatest risks from HVHHF. Through original survey data this study finds that, on average, people believe that HVHHF is extremely dangerous to animal life, but sociologists have yet to assess what drives individuals' perceptions of risk to animals. Using structural equation modeling, this study assesses the causal link between environmental values, as theorized in environmental sociology, and Georg Simmel and Robert Park's conceptions of social distance to identify the social-psychological and personal characteristics driving perceptions of risk to various animal groups. Results show that altruism (towards animal and the biosphere) is a positive predictor of increased risk perceptions, and that social distance mediates this relationship for perception of risk posed to companion animals but not for livestock or wildlife. The findings have important implications for understanding the human-animal relationship and for environmental and animal rights movements pursuing policies that promote animal wellbeing.

INTRODUCTION

The U.S. continues to experience an energy boom spurred by expanded technologies for extracting natural gas and crude oil from shale and so-called "tight formations" (U.S. Energy Information Administration 2017). This form of unconventional production involves the combination of high volume horizontal drilling and hydraulic fracturing (HVHHF). Despite industry growth, the process has received mixed reactions from decision makers and the general public, many of who express concern over the social and environmental impacts. Scholars argue that animals (companion, livestock and wildlife) will experience the greatest impacts from HVHHF and that these repercussions are likely to have spillover effects for humans and human-animal relationships (Bamberger and Oswald 2012, 2014, 2015; Bamberger and Oswald, Robert 2014; Gillen and Kiviat 2012; Kiviat 2013). Given that animals face the most risks from HVHHF development and as a consequence, policies are needed to promote and protect animal welfare, understanding how people evaluate the risks posed to animals from HVHHF is important.

Assessing how people perceive risk is essential to an effective and informed public, which is key to advancing policies that reduce negative social and environmental impacts. Historically, public perceptions have played a vital role in how energy development unfolds. The most striking example is nuclear energy development, where negative public opinion led to policy activism that severely reduced nuclear development (see e.g., Hohenemser, Kasperson, and Kates 1977; Kasperson et al. 1980; Rosa et al. 2010). What is evident from the struggle to harness nuclear energy in the face of public opposition is that public perception matters not simply in managing production, but in determining whether development can happen at all. In terms of HVHHF, public opposition has created intercommunity conflict, prompted social movements, and spurred moratoriums to ban HVHHF (see e.g., Boslett, Guilfoos, and Lang 2016; Dokshin 2016; Vasi and King 2012).

Research shows that individuals hold conflicting views about hydraulic fracturing, expressing both support for the technology and concern over its impacts (see e.g., Christenson, Goldfarb, and Kriner 2017). Theodori (2009) identifies this paradox in his research explaining that, "the general public typically dislikes the potentially problematic social and/or environmental issues perceived to accompany natural gas development. However, on the other hand, local citizens generally appreciate and view favorably the economic and/or service-related benefits that normally accompany such development," (p. 111). In general, studies show that those who are male, older, conservative, and Republican are more likely to support hydraulic fracturing and perceive less overall risk (see e.g., Boudet et al. 2013; Brown et al. 2013; Choma, Hanoch, and Currie 2016; Clarke, Boudet, and Bugden 2013). Those who support HVHHF expansion see the economic value, while those who oppose it see HVHHF as contributing to environmental damage (Brown et al. 2013). For instance, Boudet and colleagues (2016), found that as employment levels in the natural resource and mining section increase in an individual's county so too does support for HVHHF expansion. Although growing attention has been paid to assessing public opinion regarding HVHHF development, research has yet to address what influences opinion on the risks HVHHF poses to animals.

Though it has yet to be studied, there are important reasons to believe that perceptions of risk to animals will be structured in distinct ways. The most important of these is that humans have unique relationships with animals that are likely to make individuals think about the risks animals face as being distinct from general environmental risks. Humans share relationships with animals that alter their psychological, social and physical wellbeing and contribute to attitudinal and behavioral changes. For instance, living with a companion animal increases positive perceptions of animals more generally (see e.g., Daly and Morton 2009; Harold Herzog Jr. and Golden 1988; Kidd and Kidd 1990; Schenk et al. 1994). There are numerous psychological benefits to having relationships with animals, such as being close to a companion animal increases empathetic development (Daly and Morton 2009), supports the physical, emotional and social well-being of older people (McNicholas 2014), and increases reported life satisfaction for those who are divorced and living alone (Himsworth and Rock 2013). Behaviorally, being close to animals alters meat-eating behaviors (Rothgerber and Mican 2014) and influences engagement and support for wildlife conservation and management (Shuttlewood, Greenwell, and Montrose 2016). Specific to environmental risk perception, attachment to animals has been shown to influence risk perceptions by making people more reluctant to evacuate if there is not an inclusive plan for their pets (see e.g., Irvine 2009; Trigg et al. 2016b, 2016a). Given that HVHHF development places animals at the greatest risk and that humans and animals share physical space, understanding how individuals process risks posed to animals is important to fully comprehend the social drivers of HVHHF public opinion.

Building on past research assessing perception of HVHHF risk, I draw on two additional theories, Values Beliefs Norms (VBN) and Social Distance to assess both individual perceptions of the risks HVHHF poses to various animal groups and humans, and whether there is a causal link between values and social distance that helps explain these perceptions.

THEORY

Values and Beliefs

According to Schwartz (1992), values are deeply embedded "desirable, transitional goals, varying in importance, that serve as guiding principles in people's lives" (p. 21). In environmental sociology, values are considered an essential part of environmental decision-making (Dietz 2015; Dietz, Fitzgerald, and Shwom 2005), and risk perception (Slimak and Dietz 2006; Whitfield et al. 2009). In particular, Value-Belief-Norms (VBN) theory has provided a productive model for understanding how individuals make environmental decisions. The theory argues that there is a causal link between values, beliefs, awareness of consequences[2], ascription of responsibility, norms and environmental decision-making. In the case of this study awareness of consequences is considered risk perception. In the VBN model, values are considered more stable than beliefs and consequently are thought to inform beliefs,[3] defined as tenets that people hold to be true. For evaluating risk perception, the values and beliefs components of the model have been shown to be particularly important (Slimak and Dietz 2006). The underlying argument is that when individuals are presented with potential environmental risks, they draw upon their values and general beliefs about the environment to form an evaluation about the severity of the risk.

Among other things, VBN theory has been used to examine support for climate change policies (Dietz, Dan, and Shwom 2007), support for plant-based diets (Whitley, Gunderson, and

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[2] In risk perception literature, Sjöberg (2000) emphasizes "severity of consequences" in evaluating perception of risk. This concept is very similar to the VBN model's "awareness of consequences."

[3] Within environmental sociology, a modified version of the New Ecological Paradigm (NEP) is often used to measure general environmental beliefs (Dunlap et al. 2000; Dunlap and Van Liere 1978).

Charters 2017), support for environmental sustainability programs in universities (Whitley et al. 2016), and support for energy policies (Steg, Dreijerink, and Abrahamse 2005). Repeatedly, this work shows three values to be particularly important in predicting environmental concern: humanistic altruism, biospheric altruism and egoism (self-interest) (see e.g., Dietz 2015; Stern et al. 1999; Stern, Dietz, and Kalof 1993). In this construction humanistic altruism is understood as valuing peace, equality and social justice as guiding principles for one's life. Biospheric altruism is valuing the environment, preserving nature and respecting the earth. Counter to humanistic and biospheric altruism, self-interest or egoistic values center on authority, influence and wealth as guiding principles. Most studies show that altruism (humanistic and/or biospheric) is positively related to pro-environmental decisions and behaviors, while egoism (self-interest) and traditionalism (honoring parents, family security and self-discipline) are negatively related. Although the openness to change value orientation (a varied life, an exciting life and curiosity) shows little influence on general environmental concern or decision-making, scholars suggest it may be important when people consider new technologies (Steg 2016; Steg et al. 2014).

Past studies focus on risks to either humans or to the environment, rather than perception of risks to animals. A recent article by Dietz, Allen, and McCright (2017) suggests that when we are trying to account for human-animal relationships another altruistic value orientation may be needed. Identifying this value as animal altruism, the authors argue that individuals have a distinct value system that drives concern for the animal other. They further suggest that in past research individual concern or connection to animals was likely captured in the biospheric value orientation. Since humans often share close relationships with animals that are distinct from their relationships with other people or their concern for the environment, value-centered concern for animals (animal altruism) is likely different than value-centered concern for the environment (biospheric altruism). This difference is likely to inform how people think about animal related issues and assess risks to animals.

The application of VBN theory leads to several hypotheses about individual perceptions of the risks HVHHF poses to animal life. Since HVHHF is considered an environmental issue, individuals who adhere to biospheric altruism are expected to perceive higher HVHHF risks across all groups. Additionally, those who adhere to animal altruism- indicating caring deeply about non-human animals is a guiding principle of their life- are expected to perceive the greatest risk to animals, though this value is not expected to have an impact on perceptions of risk to humans.

H1: Biospheric altruism will increase HVHHF risk perceptions across human and animal groups.

H2: Animal altruism will increase HVHHF risk perceptions across animal groups.

Although the influence of values on perception of risk to animals is the focus of this paper, past studies suggest that when humans form relationships and communal groups with animals concern and care for animals increases. One way to explain this relationship is by applying social distance theory.

Social Distance

In sociology, social distance represents the distance between different groups in society that cannot be reduced to spatial or biological (genetic) distance (see e.g., Karakayali 2009)[4]. Social distance can be traced to Georg Simmel (1950) and Robert Park (1924) who emphasized normative social distance as the norms that dictate insider and outsider status in a group or community, creating an "us" and "them" mentality. Park (1924) suggested that social distance is the degree of intimacy characterizing social relations while Emory Bogardus (1925) went a step further by operationalizing social distance as a means of mutual sympathy and affinity. As Bogardus (1941) notes, "where there is little sympathetic understanding, social farness exists. Where sympathetic understanding is great, nearness exists" (p. 106).

The assertion that there is a linear relationship between social distance and affinity was formalized by sociologist Gabriel Tarde (1962) and continues to be an underlying assumption of many social distance studies (see e.g., Karakayali 2009). However, recent work argues that the assumption of linearity is conceptually flawed, as individuals often hold identities that override group affinity (Karakayali 2009). Such occurrences may be more likely to happen when group identity is predetermined by society in ways that limit human agency. It is this critique of the linear model that opens space for the inclusion of interspecies groups in conceptions of social distance. When humans acquire companion animals they are essentially forming an interspecies group without shared identity characteristics but resulting from human agency. Despite the lack of shared identity, human-animal relationships often exhibit extreme closeness and affinity, which can alter human perceptions and behavior.

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[4] Social psychologists have drawn on the concept of social distance to form construal level theory (CLT) asserting that objects, events or people who are perceived to be closer are conceptualized in less abstract terms (Trope and Liberman 2010; Trope, Liberman, and Wakslak 2007; Yaacov 2012).

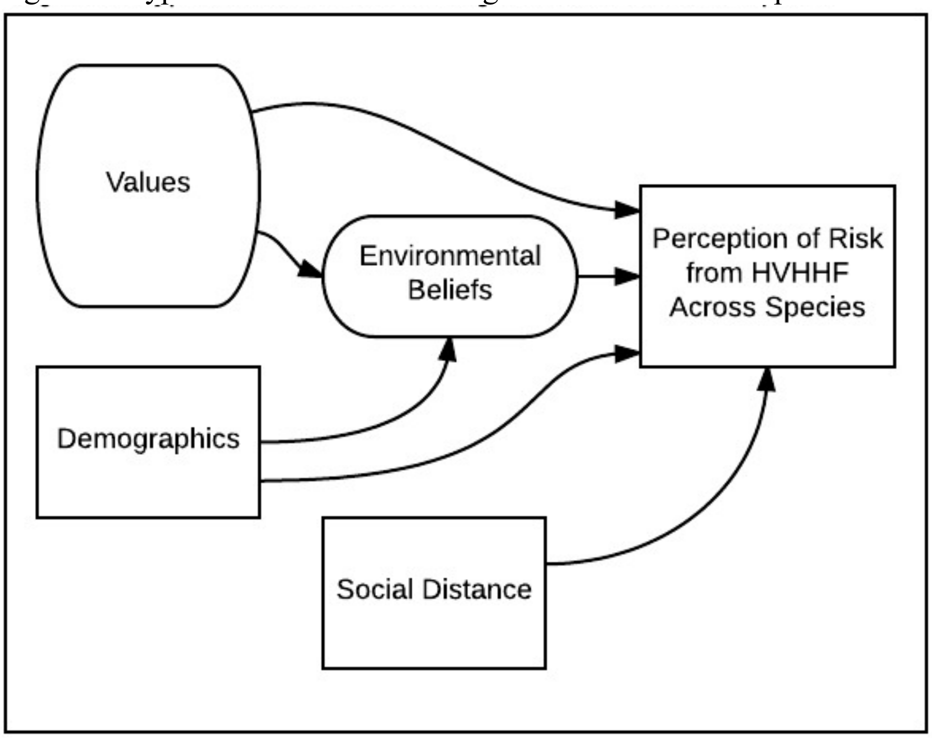
There is a long history of research asserting that humans and animals interact, share space, and develop relationships. For example, according to the American Veterinary Medical Association (2012), over half of companion animal owners (63.2%) described their pets as family members. Another 35.8 percent considered their pets to be companions, not quite like human family members, but definitely not property. Only one percent described their pets as property. This affinity for companion animal family members translates into distinct behaviors. For instance, in a study assessing the functionality of animals as family members, Cohen (2002) found that over 80 percent of her sample would be more willing to give a scarce drug to a family pet in need than to a human stranger. Collectively these studies show that humans often incorporate their pets into their family identities, embracing their companion animals as psychological kin in a way that changes their thoughts and behaviors. This is so pronounced that some scholars argue humans and animals actually form social contracts (Larrère and Larrère 2000; Lund, Anthony, and Röcklinsberg 2004) and that this "human-animal 'eco-contract' acknowledges animals as participants in contractual relations, where they have rights and obligations towards each other" (Armstrong Oma 2010:178). As Knight (2005) asserts, "companion animals…provide[s] the temporal and spatial conditions for human-animal intimacy to emerge" (p. 5) (see also e.g., Donaldson and Kymlicka 2013).

Extending social distance across species acknowledges that the human-animal relationship is symbiotic and prominent in one's social consciousness. Such a distinct relationship influences how individuals evaluate risk to animals. By bringing human-animal relationships into social distance we can begin to hypothesize how things such as animal ownership influence perception of HVHHF risk to animals. Since animal ownership is a voluntary, human-initiated relationship that typically increases human-animal interactions, it is treated as diminishing social distance. Individuals who have diminished interspecies social distance- in other words those who feel closer to animals- are expected to assess HVHHF as posing greater risk to animals than those with less social distance.

H3: By decreasing social distance, animal ownership will increase perceptions of HVHHF risk posed to animals.

The hypothesized model assessing the influence of values and social distance on perceptions of HVHHF risk to animals is presented in Figure 2.

Figure 2: Hypothesized Model Linking Values to Risk Perception



DATA AND METHODS

Data

Data was collected in October 2016. The survey was administered online through Qualtrics to a racially representative[5] sample of 860 individuals living in the United States. Only individuals 18 years or older were allowed to participate. The survey included questions on a range of socio-cognitive constructs relating to hydraulic fracturing, risk perceptions, and policy support as well as key social characteristic questions. Participants received a risk prompt that framed HVHHF risk in terms of humans, companion animals, wildlife or livestock. Though I discuss the results of the framing experiment in Chapter 2, I control for the assigned frame using dummy variables where the human frame is the reference category. Respondents received compensation through Qualtrics for participation and took an average of 13.5 minutes to complete the survey. Based on Qualtrics policies and procedures, compensation is based on the fair market value and is equivalent to minimum wage.

The demographic characteristics of the sample are similar to the U.S. population. The racial breakdown is identical to the U.S. population, as this was the representation parameter. Compared to the U.S. population a larger number of females responded to our survey (72.09%) compared to (50.8%) for the population (U.S. Census Bureau 2017). The break-down of education by degree completed was similar, however a higher proportion of the sample had at least a high school diploma (2.7% compared to 11.6%) (Ryan and Bauman 2016). The average income ranges for the sample were close to the ranges from the U.S. Census Bureau (U.S. Census Bureau 2016). Age ranges were also fairly similar to the U.S. population. Table 6 provides descriptive statistics for all included variables.

[5] Representation was based on Census race categories.

Table 6: Descriptive Statistics for Chapter 3				
Variable	Mean	Std. Dev.	Min	Max
Risk Groups				
Companion	4.038	0.993	1	5
Livestock	4.085	0.978	1	5
Wildlife	4.123	0.939	1	5
People	4.113	0.962	1	5
Values				
Humanistic Altruism	4.479	0.674	1	5
Biospheric Altruism	4.247	0.771	1	5
Animal Altruism	4.367	0.775	1	5
Traditionalism	4.534	0.619	1	5
Egoism	3.481	0.941	1	5
Openness to Change	3.971	0.828	1	5
New Ecological Paradigm				
NEP	3.526	0.706	1	5
Social Distance				
Have Companion Animal	0.727	0.446	0	1
Personal Characteristics				
Male	0.279	0.449	0	1
Age	44.785	15.157	18	86
White	0.669	0.471	0	1
Education	4.314	2.049	1	9
Income	2.644	1.297	1	5
Party (Democrat to Republican)	3.568	1.857	1	7
Ideology (Liberal to Conservative)	3.878	1.694	1	7

Measures

Risk perception

Respondents were asked, "In your view, how DANGEROUS, if at all, is hydraulic fracturing or "fracking" to the following:" companion animals, livestock, wildlife, and people. Responses ranged from "not at all dangerous" (1) to "extremely dangerous" (5).

Value orientations

Environmental value orientations modified by Stern and colleagues (1998) from the Schwartz's (1992) value scale were used with the addition of the recently constructed animal concern altruistic value orientation (Dietz et al. 2017). Respondents were asked to "indicate how important each value is as a guiding principal in your life…" Questions were measured on a 1-5 scale, from "not at all important" (1) to "extremely important" (5). High scores indicate strong adherence to the value item. Eighteen questions were included resulting in six value orientations. The reliability of the scales was assessed using confirmatory factor analysis. The environmental value orientations included in this model are: humanistic altruism, animal altruism, biospheric altruism, egoistic, traditionalism and openness to change.

Beliefs

Environmental beliefs were measured using three items with a 1-5 scale from the New Ecological Paradigm (NEP) (Dunlap et al. 2000; Dunlap and Van Liere 1978). The NEP is designed to measure beliefs about the environment and human relationships with the environment. Responses ranged from "strongly disagree" (1) to "strongly agree" (5).

Social distance

I use current ownership of a companion animal as a proxy for social distance. Though companion animal ownership is not the only way that individuals experience closeness or affinity with animals, it is one of the most common external signs that humans have created a relationship with an animal. As a result, it is a straightforward way to capture human-animal intimacy. Ownership is treated as a sign of reduced social distance and increased affinity with animals as compared to not owning an animal. Companion animal ownership was coded as 1 while not owning a companion animal was coded as 0. Over 72 percent of individuals surveyed have a companion animal this is higher than the averages presented by American Veterinary Association, which estimates that about 56 percent of U.S. households owned a pet in 2011 (American Veterinary Medical Association 2012).

Personal characteristics

Demographic data was collected for respondent's gender, age (in years), race (white and non-white), education, income, party affiliation and political ideology. Education was measured on a 1-9 scale, from "less than high school diploma" (1) to "doctorate degree" (9). Annual income was measured on a 1-5 scale, from "0-24K" (1) to "100K or more" (5). Party affiliation was measured on a 1-7 scale, from "very strong Democrat" (1) to "very strong Republican" (7). Political ideology was measured on a 1-7 scale from "very liberal" (1) to "very conservative" (7).

Data Analysis

For review the hypothesized model is featured in Figure 2 located in Appendix A. Confirmatory factor analysis was used to check the reliability of all included scales. All scales have reliability above the 0.70 cutoff (Nunnally 1978). Factor loadings and Chronbach's alphas are reported in Table 7. The scales are oriented so that the higher the number, the more the individual adheres to the value or belief. Four causal models were estimated using structural equation modeling (SEM) in Stata 14. The endogenous variable of interest is risk perception, which is broken into four categories: companion animals, livestock, wildlife, and people. Theory suggests that personal characteristics and values predict beliefs, measured here as the new ecological paradigm (NEP), the SEM model treats this relationship as causal, where values and personal characteristics predict beliefs, and values, personal characteristics, beliefs and social distance predict risk perception. Although the risk perception scores for humans and each of the animal groups have reasonably high correlations, and may constitute a single measure of "harm to life," theory suggests that social distance between animals and humans works differently across different animal groups; as a result, groups were kept separate. In addition, theory suggests that animal altruism and biospheric altruism likely have unique influences on perception of risk to the animal groups so they were evaluated separately. Both standardized and unstandardized coefficients are reported in Table 8. Diagnostics for linear modeling were assessed, revealing no problems that would jeopardize results. All models achieved a good fit: companion animals (CFI=0.998; RMSEA=0.038, 90% CI=0.000-0.107; TLI=0.931; chi square=2.221), livestock (CFI=0.998; RMSEA=0.038, 90% CI=0.000-0.107; TLI=0.937; chi square=2.221), wildlife (CFI=0.998; RMSEA=0.038, 90% CI=0.000-0.107; TLI=0.935; chi square=2.221), people (CFI=0.998; RMSEA=0.038, 90% CI=0.000-0.107; TLI=0.929; chi square=2.221).

Table 7: Confirmatory Factor Loadings and Reliability Scales		
Factor/Variable	Factor Loading	Alpha
Humanisitic Altruism		**0.844**
Equality, equal opportunity for all	0.796	
Social justice, correcting injustice, care for the weak	0.863	
A world at peace, free of war and conflict	0.748	
Biospheric Values		**0.885**
Respecting the earth, harmony with other species	0.895	
Protecting the environment, preserving nature	0.899	
Unity with nature, fitting into nature	0.768	
Animal Altruism		**0.881**
Treating animals with dignity and respect	0.889	
Preventing cruelty to animals	0.903	
Companionship with animals	0.763	
Traditional Values		**0.784**
Family security, safety, for loved ones	0.727	
Honoring parents and elders, showing respect	0.875	
Self-discipline, self-restraints, resistance to temptation	0.637	
Egositic Values		**0.796**
Influential, having an impact on people and events	0.745	
Authority, the right to lead or command	0.916	
Wealth, material possessions, money	0.616	
Openness to Change Values		**0.867**
An exciting life, stimulating experiences	0.824	
Curious, interested in everything, exploring	0.823	
A varied life, filled with challenges, novelty and change	0.838	
New Ecological Paradigm		**0.779**
If things continue on their present course, we will soon experience a major ecological crisis	0.794	
The balance of nature is very delicate and easily upset	0.765	
The earth is like a spaceship with very limited room and resources	0.704	
Hiumans are severely abusing the environment	0.838	
The balance of nature is strong enough to cope with the impacts of modern industry	0.489	
The so-called ecological crisis facing humankind has been greatly exaggerated	0.638	
Human ingenuity will ensure that we do not make the earth unlivable	0.339	

RESULTS

Direct Effect of Values and Beliefs

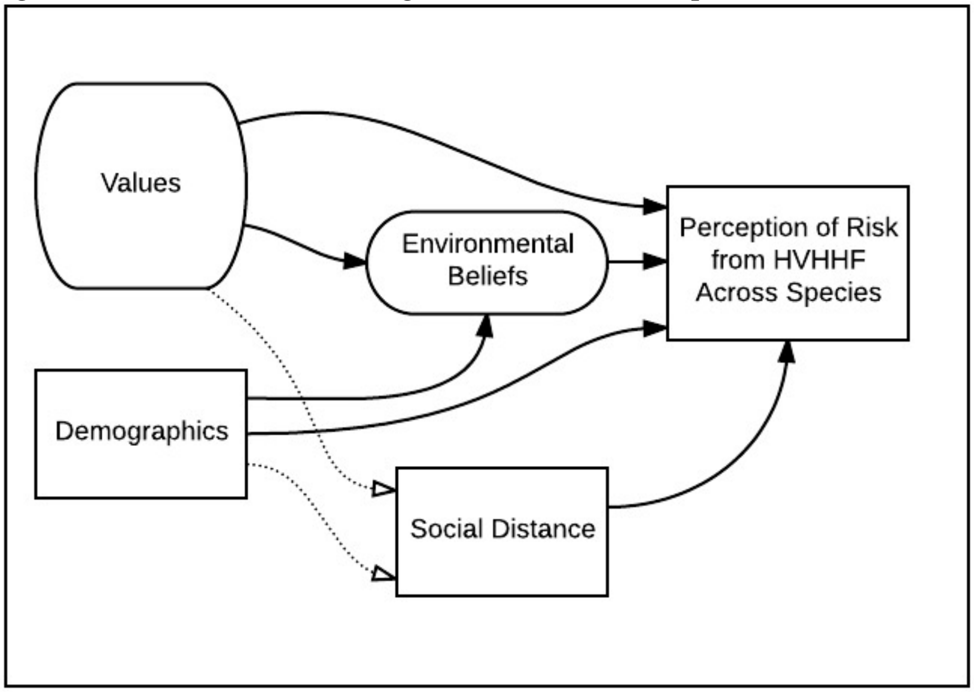
Consistent with previous studies, the structural equation model, presented in Table 8, indicates that values inform environmental beliefs, and that values and beliefs have independent effects on interspecies HVHHF risk perceptions. Interestingly, once values are taken into account, personal characteristics, which were expected to predict beliefs, play a minimal role. Among these variables ideology is the only significant predictor of the NEP; the negative coefficient suggests that more conservative individuals are less likely to have pro-environmental beliefs than less conservative individuals. When values are not accounted for in predicting beliefs, personal characteristics retain importance with those who are male, identify as more conservative, or are Republican are less likely to have pro-environmental beliefs. As indicated by the effects of the NEP variable across animal groups, those with pro-environmental beliefs are more likely to assess HVHHF risk as high to all animal groups and humans. Theory suggests that in addition to acting through beliefs, values also directly inform environmental perceptions. Consistent with Hypothesis 1 and Hypothesis 2, those who adhere to biospheric and/or animal altruism largely assess risk to animals as being greater than those who do not. For example, individuals with the highest score on the animal altruism scale evaluate HVHHF's risk to livestock as being 0.504 (0.126*4) points higher than those with the lowest score on the animal altruism scale. The exception to this is the effect of animal altruism on perceptions of risk to companion animals, which is insignificant. Importantly, and as will be discussed below, this result likely reflects the addition of animal ownership, which is believed to mediate the relationship between animal altruism and risk assessment (see revised model in Figure 2). Interestingly, egoistic values had a similar positive direct effect, increasing perceptions of

HVHHF risks to all animal and human groups. This result is surprising and may indicate an area for future research; the implications of this finding are evaluated in the discussion section.

Table 8: SEM Results Unstandardized (Standardized) Coefficients										
	NEP		Companion		Livestock		Wildlife		People	
Values										
Humanistic Alt.	0.065	(0.062)	0.061	(0.042)	-0.018	(-0.012)	-0.013	(-0.009)	0.076	(0.053)
Biospheric Alt.	0.344	(0.376)***	0.165	(0.128)**	0.135	(0.107)*	0.131	(0.108)*	0.128	(0.103)*
Animal Alt.	0.101	(0.110)**	0.055	(0.043)	0.126	(0.100)*	0.131	(0.108)**	0.021	(0.017)
Traditionalism	-0.109	(-0.095)*	-0.066	(-0.041)	0.042	(0.027)	0.021	(0.014)	0.011	(0.007)
Egoistic	-0.141	(-0.188)*	0.121	(0.115)**	0.121	(0.117)**	0.089	(0.089)*	0.110	(0.108)**
Open to Change	-0.044	(-0.052)	-0.009	(-0.007)	-0.057	(-0.048)	-0.025	(-0.022)	-0.031	(-0.026)
New Eco. Para.										
NEP	--	--	0.480	(0.342)***	0.505	(0.366)***	0.460	(0.347)***	0.462	(0.340)***
Social Distance										
Have Comp. Ani.	--	--	0.235	(0.106)***	0.094	(0.043)	0.115	(0.055)	0.114	(0.053)
Personal Charac.										
Male	-0.086	(-0.055)	-0.136	(-0.062)*	-0.183	(-0.084)**	-0.167	(-0.080)**	-0.240	(-0.112)***
Age	-0.003	(-0.061)	-0.002	(-0.032)	-0.005	(-0.082)**	-0.004	(-0.071)*	-0.001	(-0.021)
White	0.069	(0.046)	-0.115	(-0.055)	-0.109	(-0.052)	-0.044	(-0.022)	-0.003	(-0.001)
Education	0.008	(0.024)	-0.009	(-0.018)	-0.026	(-0.055)	-0.013	(-0.029)	-0.013	(-0.028)
Income	-0.010	(-0.019)	-0.059	(-0.078)*	-0.037	(-0.049)	-0.033	(-0.046)	-0.032	(-0.043)
Party	-0.024	(-0.063)	-0.048	(-0.090)*	-0.052	(-0.099)**	-0.079	(-0.157)***	-0.064	(-0.123)***
Ideology	-0.063	(-0.151)***	0.033	(0.057)	0.008	(0.014)	0.025	(0.046)	0.013	(0.023)
Frame										
Companion	--	--	0.1505	(0.066)	0.1382	(0.061)	0.1742	(0.080)*	-0.0386	(-0.017)
Livestock	--	--	0.1458	(0.064)	0.2508	(0.111)***	0.2551	(0.118)***	0.0097	(0.004)
Wildlife	--	--	-0.0211	(-0.009)	0.1017	(0.046)	0.2448	(0.115)***	-0.0387	(-0.018)
Coeff. of Determination	0.260		0.350		0.363		0.362		0.333	

*p<0.05, **p<0.01, ***p<0.001

Figure 3: Revised Model Linking Values to Risk Perception



Social Distance

Companion animal ownership is used as a proxy for social distance. The results in Table 8 provide support for Hypothesis 3, indicating that those who have companion animals perceive the risk of HVHHF to companion animals to be 0.235 points higher than those without companion animals. Companion animal ownership does not significantly alter risk perceptions for any other group, though it approached significance for perception of risk to people (p=0.09). As mentioned in the previous section, there is reason to believe that in addition to directly affecting risk perceptions, social distance may also mediate the relationship between values and risk perceptions. This possible mediation is suggested most strongly by the finding that animal altruism does not significantly predict perceptions of risk to companion animals when animal ownership is included, but does significantly predict it when animal ownership is excluded (results not shown). This suggests that values influence companion animal ownership and that this human-animal relationship influences how individuals evaluate risk to companion animals. To evaluate this possibility I conduct a logistic regression[6] assessing the influence of values and personal characteristics on animal ownership.

Table 9, presents the logistic regression results. Animal altruism is the only value that significantly predicts animal ownership. The odds ratio suggests that for every one unit increase on the animal altruism scale, an individual is roughly 2.8 times more likely to own a companion animal. In addition, and consistent with past research (see e.g., American Veterinary Medical Association 2012), those who are younger, white, and have a higher income are more likely to have a companion animal. These results provide evidence that companion animal ownership mediates the relationship between values and risk perceptions.

[6] A logistic regression as a compliment to the original SEM model was chosen as SEM models assume linear (continuous) endogenous variables and the inclusion of the social distance variable would violate this assumption. Generalized structural equation modeling (GSEM) is an alternative to a SEM model when responses are binary, ordinal, count, or multinomial. However, in Stata 14.1 there are limited indices to assess model fit and standardized coefficients cannot be calculated, as the model is a combination of linear and non-linear models, making interpretation and presentation challenging for broad audiences. A GSEM model was constructed revealing the same significant variables as the SEM and logic model revealed.

Table 9: Logistic Regression Assessing Influence of Values on Having a Companion Animal (*Social Distance*) (N=860)		
	Odds Ratio	Robust S.E.
Values		
Humanisitic Altruism	0.694	0.163
Biospheric Altruism	1.014	0.171
Animal Altruism	2.829***	0.428
Traditionalism	0.894	0.204
Egoism	0.829	0.100
Openness to Change	0.864	0.121
Personal Characteristics		
Male	1.028	0.193
Age	0.963***	0.006
White	2.002***	0.383
Education	1.000	0.046
Income	1.248**	0.094
Party	1.057	0.059
Ideology	0.959	0.061
Intercept	1.627	0.798
Pseudo R-squared		0.123
Wald Chi-square		93.070
Prob>Chi-square		0.000
Log Pseudolikelihood		-442.275

*p<0.05, **p<0.01, ***p<0.001

Direct Effects of Personal Characteristics

Personal characteristics were used as controls in the models; however, given that we know little about how people perceive risk to animal groups, there are some interesting findings that should be noted. Identifying as Republican decreases perceptions of HVHHF risk to humans and animals. Income is negatively related to perceptions of risk to companion animals, though it is insignificant for other groups. Men assess lower HVHHF risks across human and animal categories. Finally, age had a significant negative effect on perception of risk to livestock and wildlife, but not to companion animals or humans.

Direct, Indirect and Total Effect Compositions

The indirect, direct and total effects from the SEM models are presented in Table 10. This table provides a more nuanced understanding of the relationships between these variables. Because this is a causal model, in some cases direct and indirect effects work against each other and cancel each other out. For example, egoism has a significant, positive, direct effect across all categories; however, its indirect effect is significant and negative, resulting in an insignificant total effect. This insignificant result parallels past research on environmental risk perceptions (see e.g., Slimak and Dietz 2006; Whitfield et al. 2009). In addition, a variable can have a significant indirect effect but a larger, insignificant direct effect that leads to an insignificant total effect. We see this, for example, with traditionalism, where the indirect effect on livestock and wildlife risk is significant, but canceled by the insignificant direct effect.

In contrast to these nuanced effects, biospheric altruism has a significant, positive total effect across all categories. Animal altruism has a significant total effect for wildlife and livestock, but is significant for companion animals only when animal ownership is excluded from the model. Importantly, the SEM model and resulting direct, indirect and total effects do not account for the mediating role animal ownership plays between values and risk perceptions. All of the other values were insignificant for total effects. The total effect of beliefs (NEP) relies only on the direct effect, because the theoretical model does not suggest beliefs have indirect effects. This measure of environmental beliefs had a significant, positive influence across all categories. Similar to the NEP measure, the social distance variable did not have any indirect effects in the SEM model and as a consequence the significant, direct effect found for companion animals remains in the total effects analysis.

The total effect of being male was significant across all models, decreasing perceptions of risk. The total effects of age were only significant for livestock and wildlife, where increases in age decreased perception of risk. The total effect of income revealed that as income increases the perception of risk to companion animals decreases. Finally, the total effect of party strength (more Republican) decreases perceptions of HVHHF risk across all categories.

Table 10: Standardized Direct, Indirect and Total Effects with Significance of Model Variables on Risk Perception Across Species

Variables	Companion			Livestock		
	Direct	Indirect	Total	Direct	Indirect	Total
Values						
Humanistic Alt.	0.061	0.031	0.092	-0.018	0.033	0.015
Biospheric Alt.	0.165**	0.165***	0.330***	0.135*	0.174***	0.309***
Animal Alt.	0.055	0.048**	0.103	0.126*	0.051**	0.177***
Traditionalism	-0.066	-0.052*	-0.118	0.042	-0.055*	-0.013
Egoism	0.121**	-0.068***	0.053	0.121**	-0.071***	0.050
Open. to Chan.	-0.009	-0.021	-0.030	-0.057	-0.022	-0.079
New Eco. Para.						
NEP	0.480***	----	0.480***	0.505***	----	0.505***
Social Distance						
Have Comp. Ani.	0.235***	----	0.235***	0.094	----	0.094
Personal Charc.						
Male	-0.136*	-0.041	-0.178*	-0.183**	-0.044	-0.227**
Age	-0.002	-0.001	-0.003	-0.005*	-0.001	-0.007***
White	-0.115	0.033	-0.082	-0.109	0.035	-0.074
Education	-0.009	0.004	-0.005	-0.026	0.004	-0.022
Income	-0.059*	-0.005	-0.064*	-0.037	-0.005	-0.042
Party	-0.048*	-0.012	-0.060**	-0.052*	-0.012	-0.064**
Ideology	0.033	-0.030***	0.003	0.008	-0.032***	-0.024
Frames						
Companion	0.151	----	0.151	0.138	----	0.138
Livestock	0.146	----	0.146	0.251**	----	0.251**
Wildlife	-0.021	----	-0.021	0.102	----	0.102

*p<0.05, **p<0.01, ***p<0.001

Table 10 (cont'd)						
Variables	Wildlife			People		
	Direct	Indirect	Total	Direct	Indirect	Total
Values						
Humanistic Alt.	-0.013	0.030	0.017	0.076	0.030	0.106
Biospheric Alt.	0.131*	0.158***	0.290***	0.128*	0.159***	0.287***
Animal Alt.	0.131**	0.046**	0.177***	0.021	0.047**	0.068
Traditionalism	0.021	-0.050*	-0.029	0.011	-0.050*	-0.040
Egoism	0.089*	-0.065***	0.024	0.110**	-0.065***	0.045
Open. to Chan.	-0.025	-0.020	-0.046	-0.031	-0.020	-0.051
New Eco. Para.						
NEP	0.460***	----	0.460***	0.462***	----	0.462***
Social Distance						
Have Comp. Ani.	0.115	----	0.115	0.114	----	0.114
Personal Charc.						
Male	-0.167**	-0.040	-0.207**	-0.240**	-0.040	-0.280***
Age	-0.004*	-0.001	-0.006**	-0.001	-0.001	-0.003
White	-0.044	0.032	-0.012	-0.003	0.032	0.029
Education	-0.013	0.004	-0.009	-0.013	0.004	-0.009
Income	-0.033	-0.005	-0.038	-0.032	-0.005	-0.036
Party	-0.079**	-0.011	-0.090**	-0.064**	-0.011	-0.075***
Ideology	0.025	-0.029***	-0.004	0.013	-0.029***	-0.016
Frames						
Companion	0.174*	----	0.174*	-0.039	----	-0.039
Livestock	0.255***	----	0.255***	0.010	----	0.010
Wildlife	0.245***	----	0.245***	-0.039	----	-0.039

*p<0.05, **p<0.01, ***p<0.001

DISCUSSION

Altruism appears to be a leading factor predicting inter-species HVHHF risk perceptions. In some ways, this finding is consistent with past research. Altruism has long been identified as a driving force behind pro-environmental beliefs, attitudes and behaviors; however, these results expand our current understanding of altruism by demonstrating the applicability of Dietz and colleagues' (2017) animal altruism value orientation. The fact that humanistic, biospheric, and animal altruism behave in unique ways emphasizes the idea that altruism is a complex value whose component parts influence distinct environmental concerns and behaviors. Since HVHHF is often considered an environmental issue, biospheric altruism's significant, positive influence on risk perceptions across human and animal groups is largely unsurprising. What is surprising is that animal altruism accounts for variation in risk perceptions above and beyond what is captured by biospheric altruism. Animal altruism's significant, positive effect on perceptions of risk to livestock and wildlife, along with its mediated (by animal ownership) effect on companion animals, suggests that individuals whose concern for animals is a guiding life principle perceive higher risk to animals. While interesting in and of itself, this finding also has practical implications for policy that supports animal welfare in HVHHF areas.

Public support is a key component of successful policy and we have long thought that individuals with strong altruistic values make up an essential base of support for pro-environmental policies. These results suggest, however, that those trying to advance policies to protect animals in HVHHF areas may benefit more from specifically targeting groups and individuals with high levels of animal altruism. Though this may sound obvious, few animal organizations have either spoken-out directly about the impacts of HVHHF or partnered with environmental organizations to protect animals in high HVHHF regions. For example, the American Humane Association, American Society for the Prevention of Cruelty to Animals, (ASPCA), and the American Veterinary Medical Association have been noticeably silent on the issue. Although the Welfare Position Statement from the American Humane Association makes several broad remarks about what is environmentally necessary to raise livestock (such as clean water, air, the ability to move, etc.), it does not specifically identify HVHHF as a concern. (American Humane Association 2012). Further, although there are some exceptions, even those animal organizations that have addressed HVHHF, have not always done so in ways that take a clear policy stance or target those with high levels of animal altruism. For example, the American Veterinary Medical Association (AVMA) has publicly acknowledged the possible need to expand HVHHF development, but also encourages continued research on its impacts on animal health and wellbeing (American Veterinary Medical Association 2016). Similarly, the Nature Conservancy has been involved in compiling sources for best management practices but has not specifically addressed HVHHF's consequences for animals (Bearer et al. 2012). Despite their relative inactivity, these organizations and the individuals who support them may be a key to passing legislation that addresses the HVHHF risks animals face. As a consequence, policy makers may benefit from partnering with the few animal organizations who have made explicit statements about HVHHF- for example the World Wildlife Fund (WWF 2013) has come out against hydraulic fracturing in Europe (Bearer et al. 2012)- and encouraging other animal organizations to get involved. This assertion is further supported by Dietz and colleagues (2017) who show that animal altruism is a predictor of identification with the Animal Rights Movement.

Beyond animal altruism, the analysis produces another interesting result: there is a direct, positive relationship between egoistic values and risk perceptions across groups (though the negative, significant indirect impact ultimately leads to an insignificant total effect). Although environmental values have not been extensively applied to perceptions of energy technology risk, previous studies on the perception of nuclear technology have found no direct relationship between egoistic values and risk perception (see e.g., De Groot, Steg, and Poortinga 2013; Whitfield et al. 2009). That said, a growing body of literature suggests that hedonic values may play a role in environmental decision-making and that the directional influence depends on whether people conceive of the outcomes as self-gratifying. Studies show that hedonic and egoistic values are often correlated, but predict different types of environmental behaviors depending on the self-focus (see e.g., Steg et al. 2014). As with altruism, which has three dimensions in environmental values research, the results by Steg and colleagues (2014) likely indicate that self-interest has at least two dimensions, egoism and hedonism, and that the value that predicts an environmental attitude or behavior will depend on the aspect of self that is perceived to be impacted. Although egoistic values consistently show-up as a negative predictor of environmental concern and behavior, if the environmental impact is perceived as diminishing wealth, authority, self-gratification etc. then egoistic or hedonistic values may show positive correlations.

Although this analysis did not assess the influence of hedonistic values on risk perception, it is possible that the egoistic value measure is accounting for hedonism as well. Thus, the significant positive direct relationship between egoistic values on perception of risk across all life categories may suggest that those who adhere to egoistic values (prioritizing wealth, power and influence) or hedonistic values (enjoying life, gratification for oneself and pleasure) may perceive the expansion of HVHHF as diminishing personal satisfaction or wealth. Individuals' concern about how HVHHF impacts their home values (Muehlenbachs, Spiller, and Timmins 2015) and affects environmental aesthetics may provide evidence to support this claim. Additional studies are needed to assess this idea and to further distinguish the influence and relationship between egoistic and hedonistic self-interest, especially in assessing new energy technologies.

Finally, the social distance findings are interesting. Although the direct, positive relationship between companion animal ownership and companion animal risk perception is perhaps unsurprising- given that pet owners are primed to be more concerned about risks to pets-the fact that pet ownership ends up subsuming the effects of animal altruism is interesting. Studies have not previously investigated how our values influence the steps we take to increase or diminish our social distance with others. These findings, however, suggest that a decision to decrease our social distance with animals (getting a pet) is driven by our existing value structure and specifically by our concern for the animal other. In addition, other aspects of social distance may well be driven by our core values and studies of social distance should incorporate values into the research design. Additionally, future work should investigate whether there is a causal loop such that our values drive our willingness to diminish social distance in the first place, but that diminished social distance in turn influences the strength and prevalence of our values. For example, one can easily imagine how animal altruism could encourage animal ownership that would then reinforce the importance of animal altruism in one's life.

CONCLUSION

There is growing recognition that animals serve a valuable place in human social systems, but there is a paucity of research on their importance in the environmental risk literature generally and studies of public perception more specifically. This study has begun to fill this gap by assessing the social-psychological and personal characteristics that inform perceptions of HVHHF risk to various animal groups. HVHHF risk was chosen as the test application because there are known, shared risks between humans, companion animals, livestock and wildlife, creating the ideal test case to compare perceptions of risk across humans and animal groups. This study is distinct in that it gauges perception of risk not just to humans but to animal groups as well, bridging environmental sociology, animal studies and risk literatures.

The results show that on average people identify HVHHF as being dangerous or extremely dangerous for all animals. Though assessments are similar for the risks posed to humans, what drives perceptions differs across human and animal groups. Those who adhere to biospheric and animal altruism are more likely to perceive the risks of HVHHF to be high for animals, while humanistic altruism has no effect on perceptions of risk for animal groups. Further, those who have diminished social distance with animals, as measured by companion animal ownership, perceive higher risks for companion animals. The results indicate that social distance mediates the relationship between animal altruism and perceptions of risk to companion animals, suggesting that ascribing to animal altruism drives pet ownership and that, by diminishing social distance, pet ownership increases perceived HVHHF risk to companion animals. Together, these findings highlight the importance of considering perceived risks to animals as something distinct from other risk perceptions, suggest that values and social distance structure risk perceptions across species, and reinforce the idea that animal altruism is a distinct and important aspect of individuals' values, shaping perceptions and likely future behavior.

The study has several limitations. First, companion animal ownership is used as a proxy for social distance. Although research suggests that the majority of people consider their companion animals to be family, this does not mean that all people who have companion animals share the same concern or connection with their companion animals or that people who do not have companion animals do not also feel close to animals. Additionally, this study does not evaluate social distance between humans and either livestock or wildlife. Future work should develop and apply animal social distance scales as predictors of animal-oriented attitudes and behaviors. Second, the study does not capture animal-specific beliefs. The NEP is frequently used to assess general beliefs about the environment, but this is not an animal-specific scale. Just as environmental values scholars concluded they needed a variable to account for animal altruism, we also need a variable that accounts for general beliefs about animals. As mentioned above, there are numerous scales that could be modified and applied to meet this goal.

The findings presented above should be considered preliminary, as this is one of the first social science studies to consider human-animal risk assessments in environmental issues. Additional studies are needed to assess whether perception of risk to animals informs policy opinion and support or opposition to HVHHF development. Further, in relation to environmental values work, it is likely that animal altruism is driven by past experiences with animals. This study shows that animal altruism predicts current animal ownership, but animal ownership as a child likely predicts current animal altruism. Future work should examine this relationship. On average, individuals in this study assessed the risk of HVHHF to all life, human and animal alike, as dangerous to extremely dangerous; however, this does not necessarily mean that individuals are concerned by these risks. Additional studies are needed to determine whether perception of risk translates into concern and how this operates across species. Finally, future research should explore how perception of risk informs HVHHF policy support and general support for HVHHF development.

Beyond the practical application this study has for our understanding how people perceive HVHHF risks, this study offers several broad theoretical contributions. First, this study links social distance and environmental values, demonstrating that these bodies of literature are complimentary. Second, this study expands these theoretical frameworks to include recognition of interspecies relationships. These theoretical contributions are likely to assist in better understanding how people perceive and make decisions about an array of objects and events.

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CONCLUSIONS, FUTURE RESEARCH AND POLICY IMPLICATIONS

Historically, animals have been an important part of energy development. Before mechanized operations, animals were used as energy providers. As machine power increased, the focus and use of animals within energy development changed from providers to intentional sentinels. Today, animals are used as a tool for assessing the potential impacts energy development has on human health, wellbeing, and the natural environment, though their present role as sentinels is less intentional than in previous eras. As Royte (2012) notes, cattle and other farm animals are the new proverbial canaries in the coalmine, unintentional victims of environmental destruction and contamination caused by human hands.

Reports of wildlife and companion animals impacted by HVHHF have surfaced. Among other things, wildlife experience habitat fragmentation, water shortages, exposure to water and air contamination, increased collisions with truck traffic, and potential impacts due to noise and light pollution. Although livestock may not experience habitat fragmentation or increased collision risk, their confined quarters make exposure to water and air pollutants a particular problem and raises questions about the impacts on human food systems (Royte 2012). Companion animals experience negative consequences from HVHHF's environmental contaminants, having potentially devastating effects for animal owners and human communities.

Despite these concerns, research on HVHHF's impacts on animals has largely centered on assessing impacts on animals because of their importance to human food systems or because of their implications for human health. In accordance with this philosophy, Christopher Portier, Director of the National Center for Environmental Health at the Centers for Disease Control and Prevention, has called for studies to examine and "include all the ways people can be exposed such as through air, water, soil, plants and animals" (Royte 2012: 6-7). Although this work is important, there is also a desperate need for studies that investigate the effects of HVHHF on human-animal relationships.

The suite of papers presented in Chapters 1-3 begins to fill the gap in social science and HVHHF literatures by first establishing the marginal place of animals in existing research and then exploring how people perceive the risks of HVHHF to animals. What these papers demonstrate is that on average individuals perceive animals to face significant risks from HVHHF. This perception is stronger for individuals who are less psychologically distant from animals and for those who see caring for the environment and animals as guiding principles in their lives (biospheric and animal altruism). The framing experiment further demonstrated that individuals' social distance can be activated in ways that increase their perceptions of risk, suggesting that targeted marketing and education may significantly influence future animal oriented HVHHF policy support. In addition, these studies demonstrate three things that are important for sociological theory more broadly. First, construal level theory can be applied to human-animal relationships, suggesting that individuals experience social distance with non-human groups that influence their perceptions and behaviors. Second, there is additional evidence that animal altruism is important in evaluating how values influence animal-related perceptions. Finally, values and social distance have a complex relationship such that, at least in the present case, values inform social distance, which in turn acts to mediate the relationship between values and perceptions.

FUTURE RESEARCH

There is a shortage of research on the impacts of hydraulic fracturing on animals. In particular, more research is needed to directly assess the impacts of unconventional energy development on specific species. Researchers need to consider how all impacts, including habitat fragmentation, noise, light, and increased truck traffic, can influence animal behaviors. In addition, evolving research needs to assess how development adjacent to national parks impacts ecosystems and tourism. Given that HVHHF may reduce biodiversity, additional studies should be conducted to assess how various species respond to energy development and evaluate whether it makes some species more vulnerable to becoming threatened or endangered. Although we know little about the impacts to wildlife, our understanding of the effects on livestock and associated food systems is even more limited. Comprehensive long-term studies need to assess if and how proximity to unconventional energy development alters livestock production and whether rural water and soil contamination is a concern for human food systems. Finally, there has been virtually no attention paid to the social dimensions of animal harm from unconventional energy development. Scholars should investigate how humans respond to the degradation of animal species and how these responses affect efforts to protect them.

Although studies investigating how humans process HVHHF harm to animals are lacking, broad research shows that watching a companion animal suffer or die can cause extended grief (see e.g., Eckerd, Barnett, and Jett-Dias 2016; Pierce 2013; Testoni et al. 2017) and elicit PTSD symptoms (see e.g., Adrian and Stitt 2017). These symptoms are more likely if the death is traumatic or involves significant suffering. Given reports of animal distress and death from HVHHF, there are likely psychological impacts to humans that are captured in things like newspaper stories but missed in systematic research. In addition to the direct stress of watching an animal suffer, there may be additional harm due to the fact that it can be hard to pinpoint the exact cause of harm. Creating a causal link between HVHHF and animal harm can be especially difficult because the industry relies on non-disclosure policies to protect trademarked chemical secrets, limiting the information that veterinarians can use to save animal lives. This challenge may fundamentally change how veterinary medicine is practiced in high HVHHF areas. To date, there are no studies assessing the psychological implications of having livestock or a companion animal suffer from the effects of HVHHF development. Social science is needed to assess how individuals process the deteriorating health of their animals and what this means for broader animal welfare in communities.

Further, if individuals experience trauma from having an animal harmed through HVHHF, these experiences may influence other human-animal relationships. For example, these individuals may be less likely to pursue additional relationships with animals, they may avoid getting another pet, reducing local adoption rates and increasing local shelter burdens, or they may alter their willingness to get close to animals. Additionally, farmers who witness impacts on livestock may choose to reduce herd size, or be less emotionally engaged with their livestock as a means of self-protection, or give up animal husbandry all together. This last possibility should be investigated regardless of initial harm to animals because leasing land for HVHHF practices may provide farmers with financial security that allows them to leave the agricultural industry. Although they could not identify a cause, Finkel and colleagues (2013) found possible evidence for this in the decline of dairy cattle production in HVHHF areas.

Finally, social scientists should investigate the human-animal relationships associated with HVHHF boomtowns. Rapid expansion of energy development often produces boomtowns. These instantaneous communities lack social cohesion and can breed violence. Several studies have documented increases in crime rates among shale gas boomtowns but these studies do not investigate crime against animals (see e.g., Archbold 2015; James and Smith 2017; Riggs 2013). There is a wealth of literature suggesting that violence against animals is often connected to violence against humans (see e.g., Flynn 2011; McPhedran 2009; Piper 2003). As a result, future studies should explore the relationship between HVHHF boomtowns, crime and animal wellbeing.

POLICY IMPLICATIONS

Stronger regulations are needed to minimize the risks posed to animal life. In theory, federal oversight of HVHHF could occur through a variety of existing acts and regulations such as the National Environmental Protection Act, the Clean Air Act, and the Endangered Species Act, among others. In practice, however, HVHHF has been largely excluded from federal oversight due to the Energy Policy Act of 2005, which was touted as helping address energy shortages and promote energy independence but also exempted unconventional extraction practices from numerous federal regulations. The legislation exempted unconventional development from the erosion control provisions of the Clean Water Act and also from disclosing the contents of fracturing fluids. Even if the Energy Policy Act had not gutted federal regulation, few existing provisions directly apply to animal protection, as most are general environmental or human health protections. Nonetheless, there are possibilities for animal protection in a handful of federal regulations and the remainder of this section discusses the basic principles underlying some of these regulatory acts.

The Safe Drinking Water Act of 1974 (SDWA) (SDWA; 42 U.S.C. § 300F) regulates drinking water quality, which includes ground and surface water sources. Ideally this act limits underground contaminant injection, but it does not apply to fracturing fluids, which are considered well stimulation techniques instead of hazardous waste (EPA 2012). Excluding fracturing fluids from the SDWA was challenged in the late 1990s, which lead to an EPA study that concluded that fracturing fluids posed no substantial risks to drinking water. This study provided justification for the Energy Policy Act of 2005 (42 USC § 13201 et seq.) that specifically exempted HVHHF fluids from SDWA regulation. States and localities may still regulate drinking water sources and place higher regulations and restrictions on unconventional energy development, but there is no federal support within the SDWA for these types of restrictions. Developing legislation to counter the Energy Policy Act and include fracturing fluids in the SDWA would protect not only humans, but domestic animals as well. A further step would be to adjust acceptable contaminant levels to reflect those tolerated by domestic animals, as well as humans.

In addition, the Clean Water Act (CWA) of 1972 (33 U.S.C. §1251 et seq.; formally known as the Federal Water Pollution Control Act) is designed to regulate disposal and discharge of wastewater into surface water. It sets target limits for pollutants, but allows for additional limits to be set by states. Entities desiring to release pollutants must obtain a permit from the appropriate regulatory agency in a given location. Because of the Energy Policy Act, HVHHF sediment in runoff cannot be classified as wastewater discharge and is thus not regulated by the CWA; however, hydraulic fracturing wastewater or flow back *is* included in the regulation and requires a permit for disposal. Developing legislation to regulate sediment would help protect wild and agricultural animals.

The National Environmental Protection Act of 1969 (NEPA; 42 U.S.C. § 4321 et seq.) requires development on federal lands to be evaluated for environmental impacts. This is important for areas like national forests, which require environmental evaluations before development begins. The EPA or an alternative agency like the U.S. Fish and Wildlife Service then reviews evaluations. Although providing some protection, the act does not apply to areas that are adjacent to federal lands, which is problematic since research demonstrates that wildlife on federal lands are impacted by adjacent development (National Parks Conservation Association 2013). Strengthening this act to include setbacks for adjacent land could go a long way in protecting animals within and surrounding National Parks.

One of the only acts that directly protects animals from unconventional energy development is the Endangered Species Act (ESA) (7 U.S.C. § 136, 16 U.S.C. § 1531 et seq.), which is designed to prohibit the death, injury, or even harassment of vulnerable species. Its primary limitation, however, is that it only applies to species are already designated as threatened or endangered. The ESA has been essential in protecting listed species, but recent research suggests that unconventional development may be contributing to biodiversity decline, increasing the number of species added to the list each year in high development areas such as the Marcellus Shale region (Drye 2012). However, tension exists between enforcement agents of the ESA and industry professionals. For instance, in Pennsylvania, energy development companies are required to conduct a habitat review to assess endangered or threatened animal presence in a proposed site (Colaneri 2013). Although beneficial for ecosystem stability, criticisms of the process have given rise to proposed changes that would make it more difficult to put a species on the list. To date, proposed legislation to change classification systems has failed (Colaneri 2013). A further limitation of the ESA is that it only protects wild animals, as there are no federal regulations for livestock or domestic animal exposure.

Although the above discussion focuses on federal actions, much of the regulatory framework is limited to states and localities, where differences among regulatory enforcement in adjacent states can create problems. For example, there is no regional authority that oversees regulation of the Ohio River watershed. Given that Ohio allows the spread of fracturing wastewater on roads as a de-icing agent, this runoff could lead to contamination in West Virginia, which has eliminated the disposal of wastewater on roads. In the Marcellus Shale Region, states differ in their regulatory approaches. Pennsylvania has embraced natural gas development overall, while New York has a statewide moratorium against fracking. Most states have similar regulatory frameworks that govern well spacing from water sources, as well as setback distances from buildings, but enforcement varies across jurisdictions.

ANIMAL ADVOCACY AND ANIMAL RIGHTS

At all levels, animal rights and welfare organizations need to take a greater initiative to protect animals from the negative effects of unconventional energy development. Since animals and national forests do not have legal standing (see e.g., Wells 2007), activists must take up the fight to protect animals from HVHHF. One possible route to do this is Americans Against Fracking (AAF), which is a national coalition dedicated to banning fracking throughout the U.S. Several large national environmental organizations have pledged support for AAF, including Food & Water Watch, Environmental Action, and Greenpeace. Glaringly absent from this list are animal welfare organizations such as the American Humane Association, American Society for the Prevention of Cruelty to Animals, (ASPCA) and the American Veterinary Medical Association. None of these organizations have taken-up HVHHF as a leading concern for animals. In their Welfare Position Statement, for instance, the American Humane Association makes several broad statements about what is environmentally necessary to raise livestock (such as clean water, air, the ability to move, etc.), yet nowhere identifies HVHHF as a concern. (American Humane Association 2012). In contrast, the American Veterinary Medical Association (AVMA) specifically is not against HVHHF, but encourages continued research on its impacts on animal health and wellbeing (American Veterinary Medical Association 2016). Additionally, the World Wildlife Fund (WWF 2013) has also explicitly taken a position in opposition to hydraulic fracturing in Europe and The Nature Conservancy has been involved in compiling sources for best management practices for conservation (Bearer et al. 2012).

The lack of involvement in anti-fracking activism and campaigns among animal welfare and animal rights organizations can be explained by at least three factors. First, HVHHF is a complex and highly politicized issue that many peripheral non-profits may not want to address for fear of losing bipartisan support or funding. To take an anti-fracking stance an organization must be prepared to take on the oil and gas industry, a strategy that could be financially fatal. Second, most animal activist organizations are tasked with addressing multiple immediate issues simultaneously. Issues like animal abuse and cruelty, best practices and animal husbandry and animal fighting are all considered immediate concerns because the impacts are visible and recognizable. In contrast, HVHHF, which is geographically remote, has impacts that are not always visible, and therefore may not be considered of immediate concern. Third, there is a lack of data regarding the impacts of energy development on animals at all levels (domestic, livestock and wild. Nonetheless, animal organizations are likely to be a key component of passing legislation that protects animals. This is particularly true given the findings in Chapter 3 that people with high levels of animal altruism such as the members of these organizations, are more likely to perceive risk to animals and thus, by extension, are likely to be more supportive or protective policies.

CONCLUSION

In summary, this dissertation makes a number of theoretical contributions. First, I highlight the lack of social science research on energy development (particularly HVHHF) that recognizes human-animal relationships. This establishes a gap in the literature. Second, I select to assess how human-animal relationships inform people's perceptions of risk posed to animals by HVHHF. I draw on construal level theory (CLT) of psychological distance to assess this question. Given that CLT has only been applied to humans and objects the application of CLT to include interspecies relationships is novel. Findings confirm that human-animal relationships inform risk perceptions for HVHHF. As a follow-up I assess how values inform this relationship. This particular approach connects the social distance and environmental values literatures from sociology and extends the unified framework by including human-animal relationships. Specifically, this dissertation demonstrates the importance of including human-animal relationships in assessing perception of risk especially when there are shared cross-species impacts. Broadly, this dissertation encourages greater recognition of human-animal relationships not just in environmental decision-making, but in all decision-making processes. For instance, some individuals likely make consumer choices (what car to buy or where to live-apartment or house) based their relationship with a companion animal. Although this dissertation focuses on HVHHF the theoretical contributions have broad implications.

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