THE EFFECT OF URBAN TREE CANOPY COVER AND VEGETATION LEVELS ON INCIDENCE OF STRESS-RELATED ILLNESSES IN HUMANS IN METROPOLITAN STATISTICAL AREAS OF TEXAS

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ABSTRACT

THE EFFECT OF URBAN TREE CANOPY COVER AND VEGETATION LEVELS ON INCIDENCE OF STRESS-RELATED ILLNESSES IN HUMANS IN METROPOLITAN STATISTICAL AREAS OF TEXAS

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Urban living is often characterized by a hectic pace which can result in a great deal of stress. One-third of Americans are reportedly living with extreme stress, with 75-90 percent of visits to primary care physicians being for stress-related problems. It is known that green areas have positive physiological impacts on human health. Past research found that visiting green areas lowers blood pressure, reduces headache and fatigue, improves mood and hastens recovery from stress. The main objective for this study was to determine if stress-related illness rates in regions of Texas were related to vegetation rates and tree canopy cover. Past research found that high blood pressure and heart attack are two major stress-related illnesses, so in this study, only these two stress-

related illnesses were considered. Data on stress-related illnesses was collected from the Center for Health Statistics and the Texas Department of State Health Services for all 25 Metropolitan Statistical Areas (Metropolitan Statistical Areas or MSAs are counties or group of counties with a central city or urbanized area of at least 50,000 people) of Texas. Percent canopy cover was calculated for each MSA using the Multi-Resolution Land Characteristics (MRLC) National Land Cover Data canopy cover dataset. Vegetation rates for all the MSAs were examined for each MSA of Texas and were mapped for illustration using ArcView© 9.1 GIS (Redlands, CA) software. Visual relationships among the data were observed. Quantitative data was also analyzed using PASW® (SPSS statistical analysis software). When mapping stress-related illness rate into MSA regions of Texas, no clear trend was observed with vegetation rates or percent tree canopy cover when compared with stress-related illness rates. Semi-partial correlations were calculated to analyze the relationship between tree canopy cover and vegetation rate and stress-related illness rate variables after controlling the effect of external variables like income levels, age, population and ethnicity. There was no significant relationship found between stress-related illness data when compared to percent canopy and vegetation index for any the 25 MSAs of Texas.

CHAPTER I
INTRODUCTION

Stress is a psychological state that develops when an individual is confronted with situations that exhaust or exceed their internal and external resources. It is the body's way of rising to a challenge and preparing to meet a tough situation with focus, strength, stamina, and heightened alertness (Mirela, 2009). The term "stress" was originally defined as "the non-specific response of the body to any demand for change" (Seyle, 1936, p. 103). Other research defined stress as a process in which environmental demands strain an organism's adaptive capacity, resulting in both psychological as well as biological changes that could place a person at risk for illness (Cohen et al., 1995).

The situations and pressures that cause stress are known as stressors (Richard et al., 1984). Any change, positive or negative, can have a stressful impact on the human mind or body. Therefore, anything that puts high demands on a person or forces a person to adjust can be stressful (Holmes and Masuda, 1974). Stress can be generated by external stressors such as relationship difficulties, major life changes, work, financial problems, children and family, illness, or by internal stressors such as the inability to accept uncertainty, pessimism, unrealistic expectations, perfectionism or negative self-talk (Seyle, 1983).

Stressors can cause different types of stresses; acute stress, episodic acute stress, and chronic stress, each with its own characteristics, symptoms, duration, and treatment approaches. Many major illnesses may be due to or exacerbated by stress. These can include cardio-vascular diseases, high blood pressure, negative effects on the immune system, digestive problems, angina or coronary heart diseases, depression, high blood cholesterol, insomnia, and hyperthyroidism (NICHD, 2004). Stress is recognized as a factor in headaches; people with either tension or vascular headaches named stress as one of the leading precipitating factors (Spierings et al., 2000; Deniz et al., 2004).

Research has indicated that the higher the person's stress level, the more likely a person is to become ill (Cohen et al., 1991; 1993, 1998; Cohen and Pressman, 2005). A study by Rosengren et al. (2004) identified a set of psychological stressors including workplace and home stress, financial problems, major life events in the past years, depression and external locus of control (a theory in personality psychology in which individuals believe that their decisions and life are controlled by environmental factors which they cannot influence) that were significantly related to the risk of heart attack. Furthermore, the action of stress hormones affects the development of diseased arteries which leads to high blood pressure (Fauvel et al., 2001).

Physical symptoms of stress include fatigue, headache, muscle tension, upset stomach, change in appetite, change in sex drive, and feeling dizzy. Psychological symptoms of stress include experiencing irritability or anger, feeling nervous, lacking energy, and feeling as though one could cry. In addition, almost half of Americans reported lying awake at night due to stress. While Americans are dealing with high levels of stress on a daily basis, the health consequences are most serious when that stress is managed poorly. Stress is taking a toll on people and contributing to health problems, poor relationships and lost productivity at work (APA, 2004). A survey by the American

Psychology Association reported that 43 percent of Americans say they overeat or eat unhealthy foods to manage stress, while 36 percent skipped a meal because of stress.

According to the American Psychological Association [APA] (2007), healthy behaviors used to manage stress include listening to music, reading, walking in green areas, spending time with family and friends, and praying. This research also found that most of the people in America lack the motivation to make lifestyle and behavior changes after a diagnosis of stress and only 35 percent reported that they would modify their behavior following the diagnosis of a chronic condition.

Plants have a positive relationship with humans, community and human culture. To be around plants can be beneficial to human beings (Relf, 1992). Visiting green areas in cities can counteract stress, renew vital energy, and speed healing processes (McPherson, 2000). People who live in a greener environment showed more signs of healthy living (De Vries et al., 2003). Furthermore, a study documented that if college students under stress from an exam viewed plants, their positive feelings increased, while fear and anger decreased (Ulrich, 1979). Even brief visual contact with plants, such as urban tree plantings or office parks, might be valuable in restoration from mild daily stress. Views of nature had positive, physiological impacts on individuals whether or not they were consciously aware of them (Ulrich and Simon, 1986).

Horticulture has a long history as a treatment for individuals with a variety of diagnoses (Watson and Burlingame, 1960). Owen (1994) documented that visiting a botanical garden lowered blood pressure and reduced the heart rate of visitors. A similar study showed that the presence of vegetation sped up recovery from stress (Kaplan, 1993; Ulrich et al., 1991). Views of nature or visual encounters with vegetation appeared to be greatest for the mental health of individuals experiencing stress or anxiety (Ulrich, 1985). Leisure in green environments provided feelings of relaxation, autonomy and made people open for reflection (Gezondheidsraad, 2004).

In a study in New York, researchers found that community gardening had a positive effect on enhancing physical activeness and also on reducing levels of stress and mental fatigue (Armstrong, 2000). People with access to nearby natural settings or parks were found to be healthier overall when compared to other individuals, and long term, indirect impacts of "nearby nature" included increased levels of satisfaction with one's home, job, and life in general (Kaplan and Kaplan, 1989).

Problem Statement

The intent of this study was to assess the relationship between urban tree canopy cover and vegetation levels in Metropolitan Statistical Areas (MSAs) of Texas and the reported rates of stress-related illnesses.

Purpose and Objectives

The main objective of this research study was to determine if rates of stress-related illnesses in people living in Metropolitan Statistical Areas (MSAs) of Texas were related to the levels of tree canopy cover or amount of vegetation. Specific objectives of this study included:

1. Collecting published data on stress-related illnesses in humans living in MSAs of Texas.
2. Mapping rates of numbers of patients suffering from stress-related illnesses in different MSAs in Texas.
3. Mapping the tree canopy cover for different MSAs of Texas.

4. Mapping vegetation levels for different MSAs of trees.
5. Comparing the stress-related illnesses rates in different MSAs of Texas with the mapped tree canopy cover and vegetation levels to determine if stress-related illnesses rates were related to tree canopy cover/vegetation coverage.

Definition of Terms

Stress-related illnesses - illnesses which are presumed to be related to stress such as cardiovascular diseases, high blood pressure levels, heart attack, high cholesterol levels, musculoskeletal disorders and psychological disorders, asthma, and weak immune system (NICHD, 2004).

MSAs - Metropolitan Statistical Areas; MSAs are counties or group of counties with a central city or urbanized area of at least 50,000 people (United States Census Bureau, 2012).

Urban Vegetation levels/ Tree canopy - “A term applied to certain urban areas, including parks, preserves and public or private lands. In general, these places are over an acre large, are well separated from manmade developments and contain forests, gardens, grass or foliage”. (Oregon Public Broadcasting, 2006, p. 102).

Hypothesis

As tree canopy cover or vegetation levels increases in and around metropolitan statistical areas (MSAs), the rate of occurrence of stress-related illnesses among humans living in these areas will decrease.

Limitations

The limitations of this study included the following:

1. Some stress-related illnesses are caused by genetic health problems so it was not possible to differentiate the number of patients who had normal life stress illnesses from patients having genetic stress illnesses.
2. Stress-related illness data included statistics related to patients suffering from traumatic after-stress, which were not among the above mentioned stress-related illnesses because of its very weak correlation with urban vegetation levels or tree canopy.
3. This study focused only on MSAs of Texas within the 2006 year and the available data for the year.

CHAPTER II
LITERATURE REVIEW

This chapter includes an overview of stress-related illnesses with special attention paid to the following topics:

Description and definitions of:

a. Stress-related illness

b. Cost of stress-related illness to society

c. Cost of stress-related illness to individuals

d. Stress-related illness and demographics

In addition, this chapter discusses the benefits of plants to people specifically focused on the following relationships:

a. Importance of urban vegetation levels and/or tree canopy cover

b. Connection between urban vegetation levels and people

c. Passive interaction with plants

d. Active interaction with plants

Stress / Stress-related illness

Stress is a part of everyone's life. A certain amount of stress is to be expected in daily life, but too much stress may be harmful (Cristin and Eugene, 1997). The term “stress” has several different meanings; hence, whenever it is used, it is important to distinguish between the stress as a cause (the condition or adverse circumstance that threatens an individual’s psychological and physiological integrity), and stress as an effect (the resulting state of disturbance or distress). Stress can be defined as a process in which environmental demands strain an organism's capacity to adapt accordingly to the demands, resulting in both psychological as well as biological changes that could place a person at risk for illness (Cohen et al., 1995). Things that cause stress are called "stressors" (Rubin et al., 1993). Many events such as a disaster, life crisis, life changes, and daily hassles can be grouped as "stressors" (Rubin et al., 1993). Examples of stressors include: natural disasters such as hurricanes or earthquakes; major life changes such as illness, divorce, unemployment or marriage; and or daily problems such as traffic jams (Rubin et al., 1993).

Hans Seyle, a pioneer in stress research, first described the psychological syndrome of stress in 1936. He defined stress as "the non-specific response of the body to any demand made upon it" (Seyle, 1974, p. 102). The body's reaction to a stressor became known as the "general adaptation syndrome" (GAS) or the "biological stress syndrome." Dr. Seyle described the syndrome as progressing through the three stages: 1. the alarm reaction (the first reaction to the new situation, the stressor), 2. the stage of resistance (the continued exposure to the stressor and learning to cope), and 3. the stage of exhaustion (the depletion of energy reserves which leads to fatigue and eventually death).

Stress affects everyone, young and old, rich and poor (Despues, 1999). Stress is not necessarily a bad thing (Despues, 1999). Thomas Holmes asserted that any and all change is stressful because it forces individuals to adapt to new, unfamiliar circumstances (Brehm and Kassin, 1993). Holmes believed that the change resulting from both positive (eg: marriage, promotion, graduation) and negative (eg: divorce, unemployment) life events are stressful and may possibly do harm to an individual's health (Brehm and

Kassin, 1993). Even though stressors may vary, they all elicit the same biological stress response. It does not matter whether the situation is pleasant or unpleasant. The body must adapt to change in order to maintain its homeostasis. Pleasurable events may be thought of as “stress” while unpleasurable events may be thought of as “distress” (Seyle, 1974).

When an individual faces significant stress, his/her body might mobilize for action in what is called a fight or flight reaction (Rubin et al., 1993). During the fight or flight reaction, heart rate increases, breathing is accelerated, and the muscles tense up as if in preparation to throw something like a rock (fight) or to run away (flight) (Rubin et al., 1993). When a threat is identified, activity in the sympathetic nervous system rises and the adrenal glands release the hormone epinephrine (or adrenaline) and norepinephrine into blood stream and at the same time corticosteroid hormones which release fatty acids for energy, are released by the adrenal glands (Rubin et al., 1993). This nervous and hormonal activity causes digestion to stop, causes an increase in blood sugar levels, and triggers the heart to pump more blood to the muscles (Rubin et al., 1993). If stress persists after the initial fight or flight stage reaction, the body’s reaction enters a second stage in which the activity of the sympathetic nervous system declines and epinephrine secretion is lessened, but corticosteroid secretion continues at above normal levels. Finally, if the body is unable to cope, then there is likely to be breakdown of bodily resources. It is in this stage that there may be a reduction of the levels of epinephrine and norepinephrine in the brain, a state related to depression (Rubin et al., 1993).

The body produces these stress hormones to help a person react to a situation with more speed and strength. Stress hormones increase blood pressure, heart rate, and blood sugar levels. Small amounts of stress are believed to be beneficial, but chronic (persisting or progressing over a long period of time) high levels of stress are thought to be harmful (Segerstrom et al., 2004). Stress that is chronic can increase the risk of obesity, heart disease, depression, and various other illnesses. Stress also can lead to unhealthy behaviors, such as overeating, smoking, or abusing drugs or alcohol which may, in turn, increase cancer risk (NCH, 2008). Stressful life events are related to the risk of exposed individuals developing an illness (Cohen et al., 1998).

A research study conducted by University of Maryland Medical Center (UMMC, 2011) indicated that psychological stress is also a possible contributor to acute coronary syndrome (ACS), a collection of symptoms that signify heart attack or approaching heart attack. In one study, men who suffered ACS at work or up to 2 hours after work were found to have anger and negative emotions. A review of studies on blood qualities found that high levels of psychological stress are associated with harmful changes to the blood (Segerstrom and Miller, 2004). The research suggested that stress has the potential to trigger ACS, particularly in patients with heart disease. The studies also suggested that the risk is greatest immediately after the stressful incident, rather than during it (UMMC, 2011).

Stress induces changes in blood pressure and left ventricular function in mild hypertension (Lindvall et al., 1991). Mental stress induces a rapid increase in heart rate as well as in systolic arterial pressure (Forsman and Lindblad, 1983). Stress elicits hypothalamic-pituitary-adrenal axis activation, which may contribute to subsequent blood pressure elevation (Davis et al., 2002). It is well established that a sudden emotional activation can lead to an acute rise in arterial blood pressure (Forsman and Lindblad, 1983).

Cost of stress-related illness to society

Heart attack and high blood pressure are the two major stress-related illnesses (NCHS, 2008). Nearly 79 million American adults have been diagnosed with high blood pressure (AHA, 2011). High blood pressure was a primary cause of death for 326,000 Americans in 2006 (Lloyd et al., 2009). About one out of three U.S. adults has high blood pressure (NCHS, 2008). In 2008, over 616,000 people died of heart diseases in United States, almost every one out of four deaths (CDC, 2012). In 2010, coronary heart disease alone was projected to cost the United States $108.9 billion (Heidenreich et al., 2011).

Health care consumed 17 percent of the U.S. gross domestic product (GDP) in 2009, up from 13.4 percent in 1991 (U.S. Department of Commerce, 2009). Gibson (1993) documented that 90 percent of medical patients have stress-related symptoms or disorders. He also suggested that health care utilization resulting from stress cost U.S. industries $68 billion annually and reduced their profits by 10 percent. The Occupational Safety and Health Administration (OSHA) has estimated that stress costs the American work force over $300 billion annually in reduced productivity, workers' compensation benefits, and absenteeism (Rosch, 2001).

Cost of stress-related illness to individuals

Numerous studies looked at the effect of stress on the individual (Murphy and Cooper, 2000; Quick et al., 1992). Major costs included mental illness, coronary heart disease, certain types of cancer, a series of minor health complaints of a physical or psychological nature such as psychosomatic (disorders, thought to be caused or aggravated by psychological factors such as stress) symptoms, migraines, stomach ulcers (Cooper, 1996). It had been estimated that 75 to 90 percent of all doctors' visits are due to the effects of stress (APA, 2011).

Stress-related illnesses and demographics

Forty-three percent of all adults experience adverse health effects due to stress (APA, 2009). Studies have shown that ethnicity, gender and socioeconomic status are inversely related to mortality caused by an increase in cardiovascular reactivity due to stress (Davis et al., 2002). Heart disease is the leading cause of death for people of most ethnicities in United States, including African Americans, Hispanics and Whites. African Americans suffer the most deaths at about 24.4 percent (Minino, 2008). Work stress has been associated with increased risk of cardiovascular diseases (Vrijkotte et al., 2000).

Stress is also taking toll on children. Almost a third of children reported that in the last month they had experienced a physical health symptom often associated with stress, such as headaches, stomach aches or trouble falling asleep (APA, 2011).

Additionally, while men reported an increase in activity level in response to the stress, women reported symptoms of depression and anxiety and were more apt to express their feelings. In a survey done by National Heart Lung and Blood Institute it is found that males older than 45 years and females older than 55 years are more prone to high blood pressure and heart attack. In another survey done in 2012 by Center for Disease Control and Prevention (CDC), it was reported that the number of heart attack cases in the White population was greater than any other ethnicity. Similar research studies have shown that African American and Whites suffer more from high blood pressure issues when compared to than any other ethnicities, (African American = 34 percent and Whites = 26 percent). In 1994, a telephone survey done by Commonwealth Fund Minority Health Survey (CMHS) reported that African Americans have the higher overall stress levels of all to Americans.

Stress is also related to unemployment; research has shown that unemployed workers are twice as likely as their employed counterparts to experience psychological problems such as depression, anxiety, low subjective well-being and poor self-esteem (Paul and Moser, 2009). Stress from unemployment does not affect all the groups equally; rates of stress from unemployment are higher among Latinos (13.1 percent) and African Americans (15.7 percent) when compared to European Americans (9.5 percent). A study reported that unemployed women suffer from poorer mental health and lower life satisfaction when compared to unemployed men (McKee-Ryan et al., 2005). Unemployed women are more likely to report physical symptoms of stress, including irritability, anger, fatigue and lack of motivation (APA, 2009). In a survey (APA, 2007), it was shown that people within the income level of $15,000 to $24, 999 had increases in stress-related disease such as high blood pressure and heart attack.

The importance of urban vegetation levels and/or tree canopy

Urban vegetation or green space is “a term applied to certain urban areas, including parks, preserves and public or private lands. In general, urban vegetation or green spaces are over an acre large, that are well-separated from manmade developments and areas of forests, gardens, grass or other foliage” (Oregon Public Broadcasting, 2006, p. 102). Recent surveys in American cities had listed the importance of urban vegetation level as a priority among urban residents (The Trust for Public Land, 1999). In a 1995

Regional Plan Association poll, two key factors were safe streets and access to green and open spaces for an acceptable quality of life (The Trust for Public Land, 1999).

Vegetation level or green space can contribute to an increase in property values for adjacent properties, influence the behavior of shoppers in a retail business district, contribute to human health and physical well-being, improve air quality and reduce storm water runoff (Crompton, 2001; Wolf, 2003; Sherer, 2004; Wolf, 2005). Several studies have shown that homes adjacent to naturalistic parks and open spaces typically have an 8 percent to 20 percent higher appraised property value than similar properties elsewhere (Crompton, 2001). According to studies conducted at the University of Washington, people claim to be willing to pay 10 percent more for products in a shopping area with trees (Wolf, 2003).

Urban vegetation levels or tree canopy covers add value to local communities because it is integral to land use planning, mitigating water and energy shortages, improving air control, protecting global climate, enhancing public health programs and increasing land value and local tax bases (McPherson, 2006). North America’s (Canada, Mexico, and United States) urban population is 348 million or 80 percent of the total population. The number of people residing in urban areas of North America is expected to increase to 439 million or 85 percent by 2025 (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2006).

Collectively urban tree canopy in the contiguous U.S. accounts for nearly one-quarter of the nation’s total tree canopy cover- some 74.4 billion trees (Dwyer et al, 2000). Because of the proximity of urban tree canopy to people, urban tree canopy can provide substantial environmental, social, economic and recreational benefits to urban dwellers (McPherson, 2006). Trees influence thermal comfort, energy use and air quality by providing shade, transpiring moisture, and reducing wind speeds. The establishment of 100 million mature trees around residences in the United States is said to save about $2 billion annually in reduced energy costs (Akabari et al., 1988, 1992; Donovan and Butry, 2009).

Trees improve air quality by lowering air temperatures, altering emissions from building energy use and other sources and removing air pollutants through their leaves. Urban trees in the conterminous United States remove some 784,000 tons of air pollution annually, at a value of $3.8 billion (Nowak et al., 2006). Urban trees affect climate by storing carbon emissions; research has found that urban trees in United States store 770 million tons of carbon (Nowak and Crane, 2002). A study in Dayton, OH showed that during an intense storm the tree canopy was estimated to reduce potential runoff by 7 percent (Sanders, 1986). Properly designed trees and shrubs can reduce noise pollution (Anderson et al., 1984). Urban forests can also create and enhance animal and plant habitat and can also act as a “reservoir” for endangered species (Howenstine, 1993).

Landscaping with trees in yards, parks and greenways increases the value of the area. A study has found that on average, prices for goods purchased in Seattle were 11 percent higher in landscaped areas than in the areas with no trees (Wolf, 1998). Urban trees provide several health benefits; for example tree shade reduces ultraviolet radiation and its associated health issues (Hiesler et al., 1995).

Kaplan (1992) defined nature to include “one plant or many plants, and also the place created by them. It includes a street tree as well as trees in an atrium. Research suggested that active interaction with nature, such as directly growing plants, was related to improved psychological and physiological health in children and adults (Kaplan, 1973; Lewis, 1978; Cammack et al., 2002; Waliczek et al., 2005). These benefits included increased self-esteem and reduced stress levels. Several field studies on the impact of landscape enhancements have demonstrated a variety of positive impacts on communities and traffic safety (Mok et al., 2003). Topp (1990) has indicated that appropriate tree planting and landscaping has a psychological effect of reducing driving speed.

Community gardening can be defined as a group of individuals within a local setting who work together, either in individual plots or in one collective garden toward the common goal of cultivating a piece of land for the purpose of creating beauty, producing food and building social cohesion (American Community Gardening Association, 2004). According to the American Community Gardening Association (ACGA), successful, thriving community gardens have been found in most major cities around the United States (ACGA, 2004). In 2004, ACGA estimated that around 150,000 community gardens were in existence (ACGA, 2004). Thus, the popularity of community gardens shows a desire for urban green spaces in cities.

In general it is seen that urbanized lifestyle has led to people spending 80 percent or more of their time in indoor settings (Fjeld et al., 1998) and research has suggested that interior plants may offer some psychological and restorative values such as reduced tension (Ulrich et al., 1991), better coping mechanisms (Lohr and Pearson-Mims, 2000), and increased ability for concentration and attention (Taylor et al., 2001). A recent study found that employees in offices with plants rated their job satisfaction more positively when compared to employees in offices with no plants present (Dravigne et al., 2008). In another study, plants and daylight lamps in an office environment were found to reduce health problems like fatigue, headaches and reports of dry and sore throat and dry hands (Fjeld et al., 1998). The popularity of plants in interior settings shows a need amongst office workers to have greenery close by.

Connection between urban vegetation levels and people

E. O. Wilson, a prominent American naturalist, once said that people's attraction to plants is involuntary because of evolution (Kellert and Wilson, 1993). He believed that humans evolved as beings profoundly entangled with the workings of nature, and that this kinship with nature was deeply fixed in our genotype (Kellert and Wilson, 1993). Horticulture, as a human activity, may be one way people address their need to have contact with or take part in the natural world. Horticulture, present in our routine environment, can be a way for people to passively or actively interact with the natural world. Relf (1992) redefined the term horticulture to include the benefits of horticulture for "human life quality." Previously, horticulture was defined as, "the science and art of growing fruits, vegetables, flowers and ornamental plants" (Relf, 1992, p. 103). Relf claimed that this definition only included one side of the field of horticulture: the science. The art of horticulture, or the part horticulture plays in human well-being, was ignored (Relf, 1992). Relf's definition read as follows: "Horticulture- the art and science of growing flowers, fruits, vegetables, trees and shrubs, resulting in the development of the minds and emotions of individuals, the enrichment and health of communities, and the integration of the garden in the breadth of modern civilization" (Relf, 1992, p. 103). The field of horticulture has increased its scope to include the interactions, both passive and active, between plants and people.

Passive Interaction with Plants

Researchers from various disciplines attempted to evaluate the relationship between nature, green spaces and vegetation and the feelings of well-being and positive emotional states among humans. Most only considered the benefits of plants if people were actively involved in having hands-on experiences with plants rather than considering the passive benefits plants have on daily life. Passive experiences can include the value of a shade tree, the colorful flower bed in front of an office building or even a potted plant outside the office or a classroom to people participating in an environment.

International studies have documented positive health effects of green areas on human health (Kaplan and Kaplan, 1989; Marcus and Barnes, 1999; Ulrich, 1984). Cardiovascular and mental illnesses as well as physical symptoms such as low back and neck pain are positively affected (De Vries, 2004; Dilani, 2001). It has also been documented that green areas and daylight are beneficial for children, adults and elderly people (Herzog et al., 1997; Kielhofner, 1997; Kuller and Wetterberg, 1996; Relf, 1992). In a Swedish study (Grahn and Stigsdotter, 2003), 953 selected individuals from nine cities were frequent users of green areas. They answered a questionnaire about their use of urban green space, their health and the level of stress experienced. The results suggested that the more often a person visited green spaces, the less stressed he or she was regardless of the individual's age, sex and socio-economic status. Another study reported that a worker who has a view of green space could experience improved work performance (Kaplan, 1993). Research also reported the possibility that people responded favorably to vegetation in urban environments as opposed to places that were urban and plant-less (Ulrich, 1984). Ulrich (1984) reported that alpha waves (the brain waves associated with wakeful relaxation) were higher among individuals who were shown color slides of areas with vegetation when compared to those who were shown urban, plant-less settings (Ulrich, 1984).

Recent studies have indicated that contact with nature, even if only visual, is beneficial for mood, aided in recovery from mental fatigue and improved behavior and health (Hartig et al., 1991; Kaplan, 1995; Taylor et al., 2001; Wells, 2000). The state of reduced mental fatigue and recovery of attention is referred to as a “restorative experience” (Kaplan et al., 1998). Another study confirmed that hospital patients having views of nature outside their windows recuperated more quickly and required a smaller quantity of painkilling medications when compared to those without a view of nature (Ulrich, 1992). Further, another researcher argued that the lack of contact with nature might contribute to certain mental and social problems among city dwellers (Stainbrook, 1973). Researchers also indicated that nature fascination at a cognitive level was a strong reason for gardening even when the gardener is not actively involved in the garden (Kaplan and Kaplan, 1989).

In a similar study, Kuo and Sullivan (2001) found the possibility that the contact with nature by inner city residents helped quell mental fatigue and reduced aggression and violence and could also indicated that greater levels of vegetation levels or green space can lead to reduced crime activity.

Researchers noticed that more and more studies were finding that views of nature scenes dominated by vegetation had positive effects on health (Ulrich et al., 1991; Ulrich and Parsons, 1992). The researchers also reported that, “views of vegetation foster restoration from stress apparently because of a combination of beneficial effects. They produce increases in positive feelings; reduce negatively toned or stress-related feelings such as fear, anger or sadness; hold interest/attention effectively and hence may block or reduce stressful thoughts" (Ulrich and Parsons, 1992, p. 105).

A Swedish study revealed that garden access and views of the garden in the workplace positively influenced stress and trivsel, a Swedish term meaning comfort, pleasure and well-being (Stigsdotter, 2004). Another study found that workers with a window view were more productive and possessed greater satisfaction with their jobs and physical working conditions (eg: visual appearance, lightening, temperature, comfort, etc.) (Brill, 1984; Cuttle, 1983; Farrenkopf and Roth, 1980). Research also found that in daylit classrooms there was an increased level of scholastic achievement, better sociability, higher concentration levels, and lower sick leave rates as compared to the students with a windowless classroom (Heschong et. al., 2002; Kuller and Lindsten, 1992; Nicklas and Bailey, 1997).

Active interaction with plants

In people/plant relationships the role played by humans is more active. Active involvement in gardening can help people develop new skills such as improved communication (Relf, 1981). Researchers have found that gardening fosters emotional growth and gives people a positive self-image, a feeling of responsibility and increases feelings of self-worth (Relf, 1981). Research has indicated that gardening satisfaction was strong in the categories of "nature fascination" and "peacefulness and quiet" (Kaplan and Kaplan, 1989, p. 100). Researchers have indicated that active participation in horticulture can satisfy both sides of human creativity: "fostering life" as well as "acquiring objects" (Matsuo, 1996).

In one study, community gardeners were surveyed on quality of life issues related to Maslow's hierarchy of needs. Results showed that gardening helped meet quality of life needs on the higher levels of esteem and self-actualization as well as those needs toward the bottom of the pyramid related to food and safety. Also, social benefits were found to be important to African American and Hispanic respondents (Waliczek et al., 1996).

Many successful horticulture or gardening programs exist for seniors, developmentally challenged adults, adolescents and children. Gardens have also been planted by soldiers as recently as the war in Iraq (Levine, 2006). A United States soldier reportedly planted a garden in Tikrit, Iraq as a way of coping with his homesickness (Levine, 2006).

In recent years, entire gardening curriculums like the Junior Master Gardener® (JMG) Program designed by Texas A&M University have become a part of education in many American schools (Texas Cooperative Extension, the Texas A&M University System, 2002). Recent research has shown that over 85 percent of respondents to national surveys stated that JMG® has increased youth interest in science, and over 83 percent of respondents said youth were more enthusiastic about learning (Cummings and Boleman, 2002). Researchers claimed that using gardening and hands-on classroom activities as part of the science curriculum for as little as once weekly can help improve science achievement test scores (Klemmer, et al., 2005; Smith et al., 2005). In addition to improved academic success, youth gardening research also showed that gardening projects increased self-esteem, helped students develop a sense of ownership and responsibility and increased parental involvement in school (Alexander and Hendren, 1998).

Value of urban vegetation in cites

Metropolitan areas are urban heat islands, significantly warmer than the surrounding rural areas, up to 9 degrees warmer during the day and as much as 22 degrees F at night (Oke, 1987; 1997; Streutker, 2002). Increasing urban vegetation in United States metropolitan areas that typically are pronounced heat islands, such as Houston, TX, could lower temperatures in the city and also reduce air pollution associated with health problems (Akbari, 2002).

Green belts are linear strips of land that provide a continuous amount of tree cover (Petit et al., 1998). Research has found that green belts around factories and other industrial locations reduce air pollution by serving as a sink for pollutants (Rao et al., 2004). Rao et al. (2004) found that a green belt planting around an industrial area reduced air pollutant emissions by as much as 63 percent, including sulfur dioxide by 39 percent, nitrogen oxides by 40 percent, 37 percent of particulate matter and a 93 percent reduction in carbon monoxide levels (Rao et al., 2004). In 1984, it was estimated in Los Angeles that one million new trees would remove 200 tons of particulate pollution each day when the trees reached 10 years old (Petit et al., 1998). In some areas, tree shelterbelts are used to block winds that carry dust and particulate matter (Akbari, 2002).

Leaves of trees can take up pollutants such as ozone, nitrogen dioxide, ammonia, sulfur dioxide and particles, which can cause serious health problems (Tyrvainen et al., 2005). Trees act as natural filters and remove polluting gases by absorption through their leaves and other parts (Trowbridge and Bassuk, 2004). Trees remove airborne dust and chemical matter, or particulate matter from the air, where it is stored on leaves, twigs and trunks until it is washed to the ground by rain (Beckett et al., 1998; Petit et al., 1998; Trowbridge and Bassuk, 2004). Both trees and herbaceous vegetation can directly absorb gaseous pollutants through stomata openings in their leaves (Akbari, 2002; Sieghardt et al., 2005).

Vegetation of Texas

Texas has a wide variety of climate and geography conditions across the state, which leads to a very wide variety in native vegetation across its natural regions (Diamond et al., 1987). Classifications of different vegetations that occur across the state include: forests, woodlands, shrublands, grasslands, swamps and marshes (Diamond et al., 1987).

East Texas, also known as the Piney Woods region of Texas, main vegetative composition of this region consists of pine-hardwood forests, farmlands and pasture (Preserving Texas' Natural Heritage, 1978; Diamond et al., 1987). The major vegetative type in this area is pine (*Pinus spp.)* (Preserving Texas' Natural Heritage, 1978; Diamond et al., 1987). To the west of the Piney Woods region border, the Oak Woods and Prairies natural region begins (Preserving Texas' Natural Heritage, 1978). Ranches, with oak-hickory forests and tall grass prairies being the dominant vegetation types, are very common in this region (Preserving Texas' Natural Heritage, 1978). The Blackland Prairie region, is a major grassland area of Texas which borders the Oak Wood and Prairie regions (Preserving Texas' Natural Heritage, 1978; Diamond et al., 1987).

The Texas coast lies in the Gulf Prairies and Marshes region, a mosaic of oak woodlands, marshes and grasslands that have been heavily invaded by mesquite, oaks, prickly pear and acacias (Preserving Texas' Natural Heritage, 1978). The Coastal Sand Plains is a very small natural region lying on the Texas Coast, and mainly consists of salt marshes and grasslands that have been taken over by oak scrub vegetation (*Quercus spp*.) (Preserving Texas' Natural Heritage, 1978).

The South Texas Brush Country natural region is dominated by thorny brush vegetation, and further south, a tropical climate prevails, which makes it a prime location for tropical vegetation (Preserving Texas' Natural Heritage, 1978). Over the years, this tropical vegetation has been largely replaced by agricultural crop land. The Edwards Plateau region, also known as the "hill country," is dominated by scrub forests of elm (*Ulmus spp*.), cedar (*Juniperus ashei*), live oak (*Quercus spp.*) and mesquite (*Prosopis glandulosa*) (Preserving Texas' Natural Heritage, 1978).

In the Rolling Plains region of Texas, mesquite (*Prosopis glandulosa*), oak (*Quercus spp*.), juniper (*Juniperus spp*.), acacia (*Acacia spp.*) and mimosa (*Mimosa borealis*) are found mixed with grassland vegetation (Preserving Texas' Natural Heritage, 1978). Most of the Texas panhandle, the High Plains region is characterized by short and tall grass prairie (Preserving Texas' Natural Heritage, 1978). Junipers (*Juniperus spp*.) are now common to both the Rolling Plains and High Plains regions of Texas (Diamond et al., 1987).

The furthest western region of Texas is known as the Trans Pecos. This area is dominated by desert shrublands, desert grasslands, yucca (*Yucca spp.)* and juniper (*Juniperus spp*.) savannas and forests of pine (*Pinus spp*.) and oak (*Quercus spp*.) and other large varieties of vegetative communities (Preserving Texas' Natural Heritage, 1978; Diamond et al., 1987)

CHAPTER III
METHODOLOGY

The intent of this study was to determine if rates of stress-related illnesses in people living in Metropolitan Statistical Areas (MSAs) of Texas were related to the levels of tree canopy cover or amount of vegetation in MSAs of Texas. Specific objectives for this study included:

1. Collection of published data on stress-related illnesses in humans living in MSAs of Texas.
2. Mapping rates of numbers of patients suffering from stress-related illnesses in different MSAs of Texas.
3. Mapping the tree canopy cover for different MSAs of Texas.
4. Mapping vegetation levels for different MSAs of Texas.
5. Comparing the stress-related illness rates in different MSAs of Texas with the mapped tree and vegetation levels to determine if stress-related illness rates were related to tree/vegetation coverage.

Metropolitan statistical areas of Texas

The state of Texas has been divided into 25 different MSAs for the purposes of demographic and statistical analyses by various departments and organizations in Texas (Labor Market and Career Information Department of the Texas Workforce Commission, Real Estate Center at Texas A&M University, 2006). Each MSA was comprised of a county or group of counties with a population of at least 75,000 and contained a central city or urbanized area of at least 50,000 (Labor Market and Career Information Department, 2006). Metropolitan Statistical Areas, or MSAs, included the following regions: Abilene, Amarillo, Austin-Round Rock, Beaumont-Port Arthur, Brownsville-Harlingen, Bryan-College Station, Corpus Christi, Dallas-Fort Worth-Arlington, El Paso, Houston-Baytown-Sugarland, Killeen-Temple-Fort Hood, Laredo, Longview, Lubbock, McAllen-Edinburg-Mission, Midland, Odessa, San Angelo, San Antonio, Sherman-Denison, Texarkana, Tyler, Victoria, Waco, and Wichita Falls.

Stress-related illness data collection

Stress-related illness data was collected from the Center for Health Statistics, Texas Department of State Health Services for the year 2006 (Vincent, 2012). Stress-related data was taken from the year 2006 in order to be consistent with the available data of urban tree canopy cover and vegetation levels. Major stress-related illnesses included in this study were high blood pressure and heart attack (NICHD, 2004). Research studies have found that these were the illnesses which had stress as one of the major causes (NICHD, 2004).

For this study, stress-related illness data was collected from all MSAs of Texas from the Behavior Risk Factor Surveillance System (BRFSS) which is a sub-agency under the Texas Department of State Health Services. BRFSS is a state based system of health surveys that generates information about health risk behaviors, clinical preventive practices, and health care access and use primarily related to chronic diseases and injury. Stress-related illness data was collected by Texas Department of State Health Services (BRFSS) through a cross-sectional telephone survey conducted by state health departments with technical and methodological assistance provided by Center for Disease

Control and Prevention (CDC). Every year, states conducted monthly telephone surveillance using a standardized questionnaire to determine the distribution of risk behaviors and health practices among non-institutionalized adults.

Two questions considered for this study were: “Have you ever been diagnosed with high blood pressure?” and “Have you ever been diagnosed with heart attack?” (Vincent, 2012). Respondents who answered ‘yes’ to the above questions were considered for the stress-related illness sample.

Mapping of tree coverage/vegetation rates

Mapping of urban tree canopy cover and vegetation levels of MSAs of Texas was performed in collaboration with Texas A&M University using ArcView® 10 designed by Environmental Systems Research Institute (ESRI, Redlands, CA, 2010).

To determine the percent urban canopy or vegetation levels for the MSAs in this study, a normalized difference vegetation index (NDVI) was calculated from satellite imagery (Landsat) for each MSA. Landsat Satellite Imagery was performed with sensors which measured the amount of reflected energy for each 30m X 30m area for each of the seven segments of the electromagnetic spectrum. There are total of seven bands of data for Landsat, each of which provides a record of the amount of energy reflected in a specific portion of electromagnetic spectrum.

For this study, out of seven bands, only two bands (near infrared and red) were used. These two bands were required to calculate NDVI. This index was used as a simple numerical indicator to analyze remote sensing measurement to determine the amount of green vegetation in the observed target area. The resulting index range for this calculation was between -1 to 1 (barren/non-vegetation to dense green vegetation, respectively).

The calculation was as follows (NIR = near infrared): NDVI = (NIR – Red) / (NIR + Red).

Landsat 5™ imagery was obtained from United States Geological Survey (U.S.G.S.) Glovis site (U.S. Department of the Interior, 2010). Image "tiles" were downloaded to cover the extent of all MSAs included in the study. Each "tile" covered an area of 185 km (115 mi) wide. In order to obtain an accurate NDVI for each MSA, the imagery must be high quality and as cloud free as possible. The images selected and used in the study were designated by U.S.G.S. as having a cloud cover of 0% and an image quality of 9 out of 10 (Note that 0% cloud cover may still include isolated clouds). The downloaded image tiles were for the maximum foliage months of April to September 2006 when possible.

The tiles were then "mosaiced" or pieced together to create one seamless image for each MSA. "Mosaicing" merged adjacent tiles into one image file removing overlapping values between tiles. The NDVI was calculated for each image using ENVI™ (Redlands, CA) image- processing software. This process resulted in a grid with values ranging from -1 to 1.

The NDVI grid was transferred to the GIS software, where statistics were calculated for each MSA. Statistics generated included the minimum NDVI value, the maximum NDVI value, and mean NDVI value.

External Variables

Data were collected on several external variables which were known to precipitate symptoms of stress-related illness in order to control the impact in this study. Age, income levels, population and ethnicity data for each MSA were obtained from the

United States Census Bureau (U.S. Census Bureau, 2012). Age over 45 years and income level of $15,000 to $24,000 has been reported to increase the chance of high blood pressure and heart attack (CDC, 2012). African Americans suffer more from high blood pressure problems whereas Caucasians suffer more from heart attacks (CDC, 2012).

Data Analysis

Stress-related illness data, NDVI and canopy cover data were analyzed using PASW® Statistics 18 (Chicago, IL). Descriptive statistics analyzed the vegetation cover levels for each MSA. A linear regression analysis was used to calculate the extent to which age, income levels and ethnicity covaried with stress-related illnesses. Semi-partial correlations were calculated to analyze the relationship between tree canopy cover/vegetation rate and stress-related illness rate variables while controlling for the effects of age, income levels and ethnicity on stress-related illnesses.

CHAPTER IV
RESULTS

The main objective for this study was to determine if rates of stress-related illness in Metropolitan Statistical Areas of Texas were related to tree canopy cover and vegetation levels in Metropolitan Statistical Areas of Texas. Specific steps for this study included:

1. Collecting published data on stress-related illnesses in humans living in MSAs of Texas.
2. Mapping rates of numbers of patients suffering from stress-related illnesses in different MSAs in Texas.
3. Mapping the tree canopy cover for different MSAs of Texas.
4. Mapping vegetation levels for different MSAs of trees.
5. Comparing the stress-related illnesses rates in different MSAs of Texas with the mapped tree and vegetation levels to determine if stress-related illness rates are related to tree/vegetation coverage.

Findings Related to Objective One

The first objective included collecting published data on stress-related illnesses in humans living in MSAs of Texas. Stress-related illness data were collected from the Center for Health Statistics, Texas Department State Health Services for the years 2005-2006 (Vincent, 2012). Two major stress-related illnesses considered in this study were high blood pressure and heart attack. In order to determine if people had stress-related illnesses (high blood pressure and heart attack), people were asked these questions on a survey administered by Texas Department of State Health Services, “Have you ever been diagnosed with high blood pressure?” and “Have you ever been diagnosed with heart attack?”. Those whom responded “yes” were included as the sample in the study.

A total of 19,793 adult respondents were interviewed by the Texas Department of State Health Services within the MSAs of interest, out of which 6,495 adults were asked if they had high blood pressure and 13,298 adults were asked if they ever had a heart attack. In total, 1,494 adults provided a valid response of “yes” for the question concerning high blood pressure and 532 adults provided a valid response of “yes” for the question concerning heart attack (Vincent, 2012).

The state of Texas has been divided into 25 different Metropolitan Statistical Areas (MSAs) for the purposes of demographic and statistical analyses by various departments and organizations in Texas (Labor Market and Career Information Department of the Texas Workforce Commission, Real Estate Center at Texas A&M University, 2006). Each MSA is comprised of a county or group of counties with a population of at least 75,000 and contains a central city or urbanized area of at least 50,000 (Labor Market and Career Information Department, 2006). Metropolitan Statistical Areas, or MSAs, include the following regions: Abilene, Amarillo, Austin-Round Rock, Beaumont-Port Arthur, Brownsville-Harlingen, Bryan-College Station, Corpus Christi, Dallas-Fort Worth-Arlington, El Paso, Houston-Sugarland-Baytown, Killeen-Temple-Fort Hood, Laredo, Longview, Lubbock, McAllen-Edinburg-Mission, Midland, Odessa, San Angelo, San Antonio, Sherman-Denison, Texarkana, Tyler, Victoria, Waco and Wichita Falls.

The stress-related illness data were compiled and compared within the 25 Metropolitan Statistical Areas of Texas (Vincent, 2012). Each MSA was analyzed and ranked in order from highest to lowest percentage of high blood pressure (Table 1) and heart attack (Table 2). Respondents within MSAs were asked the questions: "Have you ever been diagnosed with high blood pressure?" and "Have you ever been diagnosed with a heart attack?" If they responded "yes" to the questions, they were included in the sample for their corresponding MSA. Some MSAs did not have a total of at least 50 respondents answering the high blood pressure diagnosis questions positively. Therefore, for some MSAs, data was missing for high blood pressure (Table 1).

The Texas Department of State Health Services communicated the total sample size for each stress-related illness including high blood pressure and heart attack for every MSA (Table 1 and 2). The number of patients suffering from each specific type of stress-related illness was recorded in the form of a percentage, in order to normalize the sample data to general population, for data analysis (Vincent, 2012).

The Beaumont-Port Arthur MSA had the highest high blood pressure rate at 38.4 percent (Table 1). There was a 4.9 percent difference in high blood pressure rates between Beaumont-Port Arthur MSA and the second highest level of incidence of high blood pressure, which was 33.5 percent for the Lubbock MSA. After that, the drop in high blood pressure rates across the different MSAs becomes comparatively smaller, ranging from 0.1 to 3.5 percentage points. The Austin-Round Rock MSA had the lowest high blood pressure rate at 15.7 percent (Table 1).

Table 1: Compilation of results for high blood pressure rates, ranked in order from highest to lowest, in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

Ranking	MSA	Population sample (no.)	High BP[z] sample (no.)	High BP[z] patients (%)
Highest 1	Beaumont-Port Arthur	97	37	38.4
2	Lubbock	67	22	33.5
3	Abilene	64	21	33.2
4	Waco	51	17	32.7
5	Longview	52	16	30.4
6	Brownsville-Harlingen	66	18	28.1
7	Bryan-College Station	56	16	28.0
8	Corpus Christi	71	18	25.9
9	Amarillo	71	17	24.1
10	Houston-Baytown-Sugarland	947	222	23.4
11	San Antonio	521	121	23.3
11	Dallas-Ft. Worth-Arlington	1176	274	23.3
12	McAllen-Edinburg-Mission	115	22	19.5

Table 1 - continued

Ranking	MSA	Population sample (no.)	High BP[z] sample (no.)	High BP[z] patients (%)
13	El Paso	650	124	19.0
14	Killeen-Temple-Ft. Hood	76	14	18.8
Lowest-15	Austin-Round Rock	526	82	15.7
	Laredo	<50[y]		
	Midland	<50[y]		
	Odessa	<50[y]		
	San Angelo	<50[y]		
	Sherman-Denison	<50[y]		
	Texarkana	<50[y]		
	Tyler	<50[y]		
	Victoria	<50[y]		
	Wichita Falls	<50[y]		

[z]Data on percentage of high blood pressure were obtained from the Center for Health Statistics, Texas Department State Health Services for the years 2005-2006. The data were rounded to the next highest or lowest raw number based on the normalized percentage of patients reported to have high blood pressure in the overall population.
[y]MSAs which had less 50 respondents who answered positively for high blood pressure diagnosis.

The Texarkana MSA had the highest heart attack rate at 11.5 percent (Table 2). There was a 3.3 percent difference in heart attack rates between Texarkana MSA at 11.5 percent and the second highest rate of heart attacks, which was 8.2 percent for Sherman-Denison MSA. After that, the drop in heart attack rates across the different MSAs became much smaller, ranging from 0.1 to 0.7 percentage points. The Laredo MSA had the lowest heart attack rate at 0.0 percent (i e. it had no heart attack patients in year 2006).

Table 2: Compilation of results for heart attack rates, ranked in order from highest to lowest, in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

Ranking	MSA	Population sample (no.)	Heart attack[z] (no.)	Heart attack[z] patients (%)
1-Highest	Texarkana	58	7	11.5
2	Sherman-Denison	62	5	8.2
3	San Angelo	63	5	7.5
4	Tyler	278	19	6.9
5	Abilene	129	9	6.8
6	Longview	195	12	6.1
7	Beaumont-Port Arthur	207	12	5.7
8	Amarillo	160	9	5.6
9	Bryan-College Station	111	5	4.9
10	Wichita Falls	107	5	4.8
11	Lubbock	630	28	4.5
12	Houston-Baytown-Sugarland	1,480	62	4.2
13	Austin-Round Rock	1,042	40	3.9
14	Dallas-Ft. Worth-Arlington	2173	83	3.8
15	Brownsville-Harlingen	147	5	3.4
16	Corpus Christi	174	6	3.3
17	McAllen-Edinburg-Mission	265	8	3.0

Table 2 - continued

Ranking	MSA	Population sample (no.)	Heart attack[z] (no.)	Heart attack[z] patients (%)
18-tie	San Antonio	1,035	30	2.9
18-tie	Odessa	56	2	2.9
19	El Paso	1,146	32	2.8
20	Midland	58	1	2.4
21	Waco	102	2	2.0
22	Victoria	69	1	1.9
23	Killeen-Temple-Ft. Hood	177	3	1.6
24-Lowest	Laredo	62	0	0.0

[z] Data on percentage of heart attacks were obtained from the Center for Health Statistics, Texas Department State Health Services for the years 2005-2006. The data were rounded to the next highest or lowest raw number based on the normalized percentage of patients reported to have heart attacks in the overall population.

Findings Related to Objective Two

The second objective of the study included mapping rates of stress-related illnesses (i.e. high blood pressure and heart attack) and vegetative composition for each Metropolitan Statistical Area (MSA) of Texas. An overview map of Texas was used to map rates of high blood pressure and heart attacks to provide illustration of regions and illness (Figures 1 – 23). An overall map of stress-related illnesses as it related to specific MSA and location in Texas did not appear to reflect any clear pattern of stress-related illness rates in different vegetative regions of the state (Figure 1).

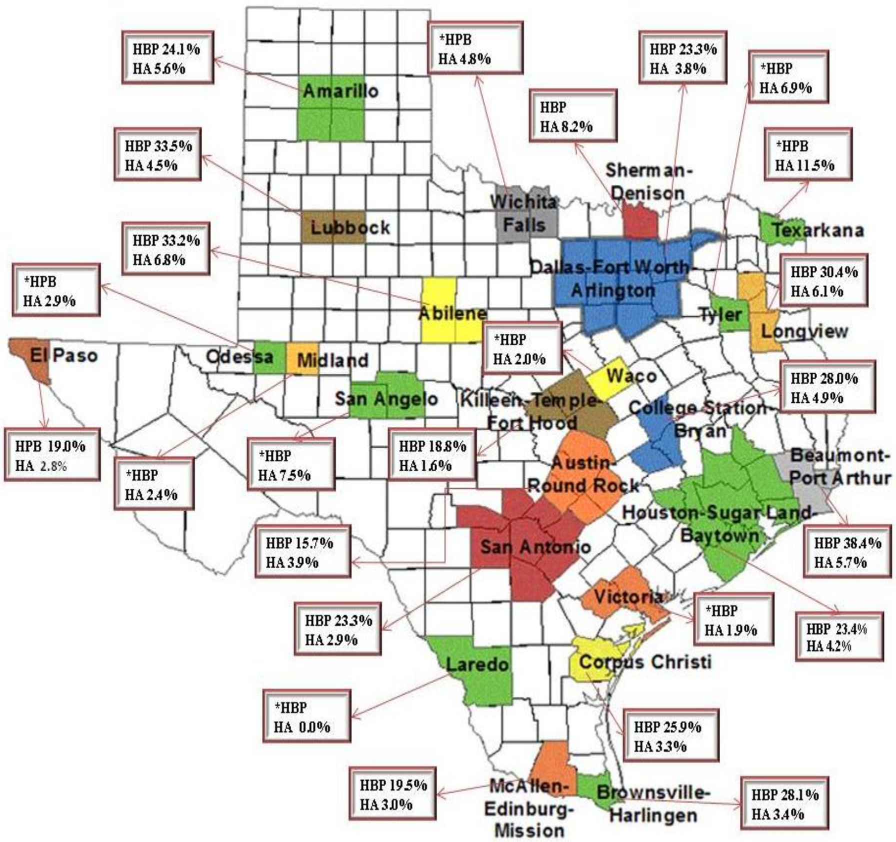

Figure 1: High blood pressure (HBP) and heart attack (HA) data inserted into a general Texas state map and including corresponding Metropolitan Statistical Areas (MSA) of Texas.

***MSAs which had less than 50 respondents who answered positively for high blood pressure diagnosis.**

Texas has a wide variety of climate and geography conditions across the state, which leads to differences in native and endemic vegetation across its natural regions (Diamond et al., 1987). This variety in climate and geography also leads to a diversity of agricultural and horticultural crops grown in each natural region of the state (Texas CropMAP, 2003)

<u>Abilene stress-related illness rates and vegetative cover</u>

Abilene (Figure 2) had the 3rd highest percentage of incidence of high blood pressure at 33.2 percent and 5th highest percentage of heart attack rate at 6.8 percent. The vegetation for the region includes the Havard Shin Oak (*Quercus havardii*), Pecan (*Carya illinoinensis*), Red Oak (*Quercus buckleyi*), Cottonwood (*Populus deltoides*) and Elm trees (*Ulmus spp*.). Major crops grown in this MSA include wheat, forages, sorghum, cotton (Texas CropMAP, 2003).

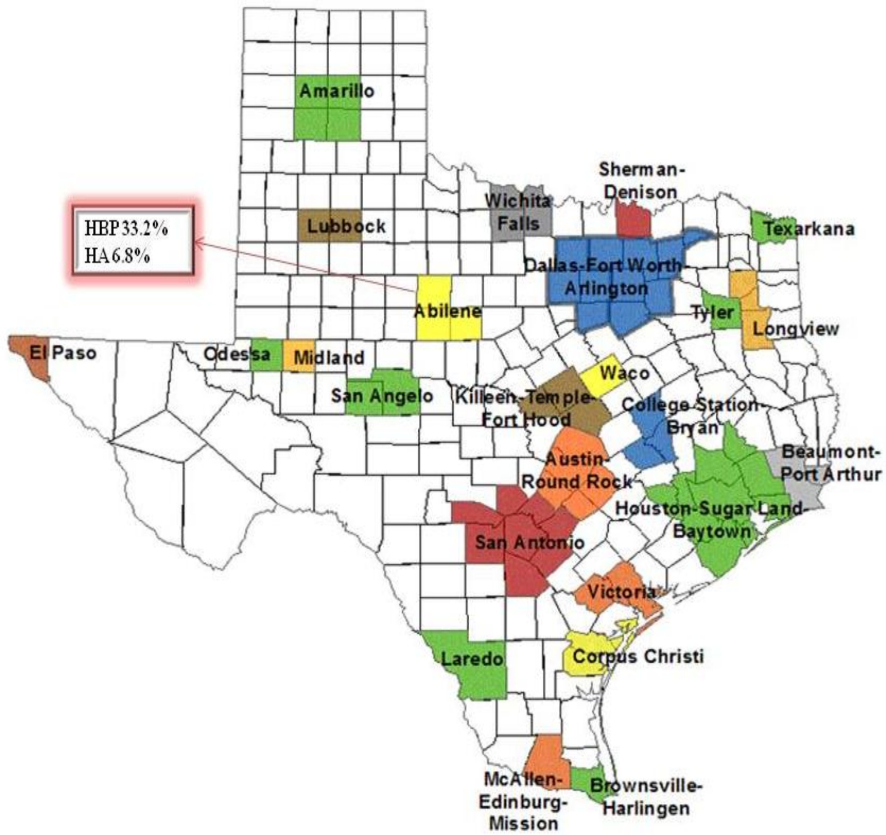

Figure 2: High blood pressure (HBP) and heart attack (HA) rate for the Abilene MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

<u>Amarillo stress-related illness rates and vegetative cover</u>

Amarillo (Figure 3) had 9th highest percentage of incidence high blood pressure at 24.1 percent and 8th highest percentage of heart attacks at 5.6 percent. The vegetation for the region is a mix of cropland and mesquite (*Prosopis glandulosa*) brush/shrubland. This area of Texas has a lot of flat grasslands and farmlands with very few trees. Major crops grown in the Amarillo MSA include cereals such as corn, wheat and sorghum, soybeans, and hay, with smaller acreage in pecans (*Carya illinoinensis*) and cotton (Texas CropMAP, 2003).

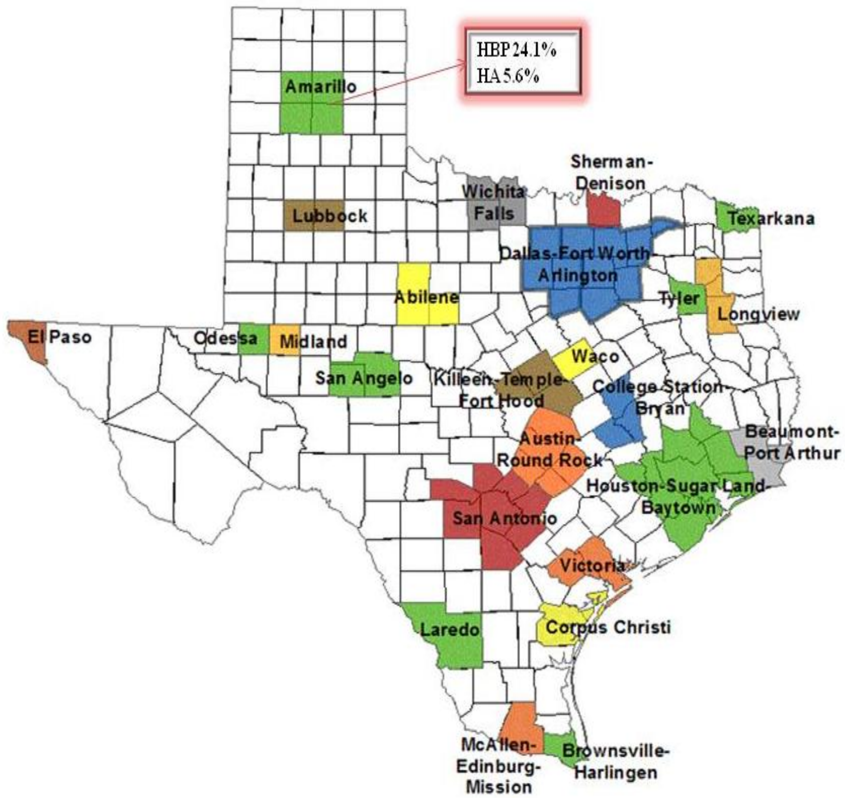

Figure 3: High blood pressure (HBP) and heart attack (HA) rate for the Amarillo MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

<u>Austin-Round Rock stress-related illness rates and vegetative cover</u>

Austin-Round Rock is ranked number four of the largest four major metropolitan/urban areas of Texas (U.S. Census Bureau, 2008), but its high blood pressure rate is 15.7 percent and heart attack rate is only 3.9 percent (Table 1; Figure 4), ranking lowest for high blood pressure and 13th for heart attack rate of the MSAs used in this study. Austin has been named one of America's top 10 greenest cities (Svoboda, 2008). The city of Austin devotes 15 percent of its land to parks and other open spaces and boasts 32 miles of bike trails (Grist, 2007). Vegetation in the Austin-Round Rock MSA consists of a mix of Live Oak (*Quercus virginiana*)-Ashe Juniper (*Juniperus ashei*) woodlands, Live Oak (*Quercus virginiana)*-Mesquite (*Prosopis glandulosa*)-Ashe Juniper (*Juniperus ashei*) Parks, Post Oak (*Quercus stellata*) Wood and Forest-grassland mosaic, Silver Bluestem (*Bothriochloa saccharoides*)-Texas Wintergrass (*Nassella leucotricha*) grasslands, along with areas of cropland throughout (Figure 4). Major crops grown in the Austin-Round Rock MSA include cereal crops such as corn, sorghum, wheat and oats, hay, with smaller acreages in a variety of vegetable, fruit and nuts crops, cotton and nursery/floriculture crops (Texas CropMAP, 2003).

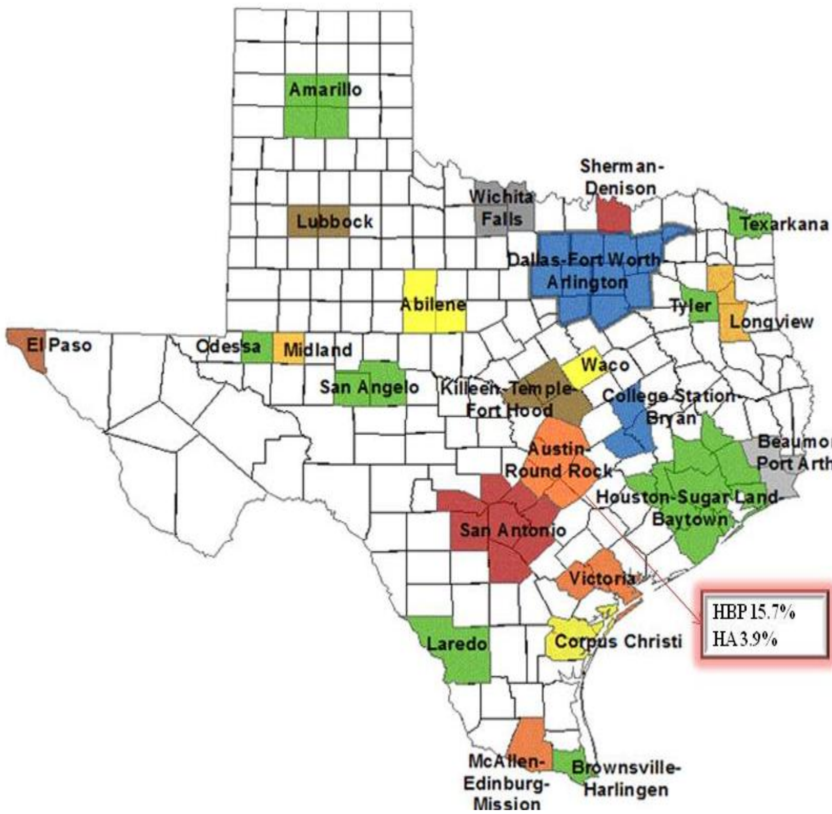

Figure 4: High blood pressure (HBP) and heart attack (HA) rate for the Austin Round-Rock MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

<u>Beaumont-Port Arthur stress-related illness rates and vegetative cover</u>

Beaumont-Port Arthur MSA ranks highest in high blood pressure rates of all the MSAs, with a 38.4 percent high blood pressure rate, and ranks 7th highest of all the MSAs at a 5.7 percent for heart attack rate. Vegetative composition of the Beaumont-Port Arthur MSA consists of Pine (*Pinus spp*.)-Hardwood forests, cropland, and Willow Oak (*Quercus phellos*)-Water Oak (*Quercus nigra*)-Blackgum (*Nyssa sylvatica*) forests (Figure 5). Crops of the Beaumont-Port Arthur MSA include cereal crops of rice, grain legumes and soybeans, hay and forage crops, fruit and nut crops, cotton and nursery/floriculture crops (Texas CropMAP, 2003).

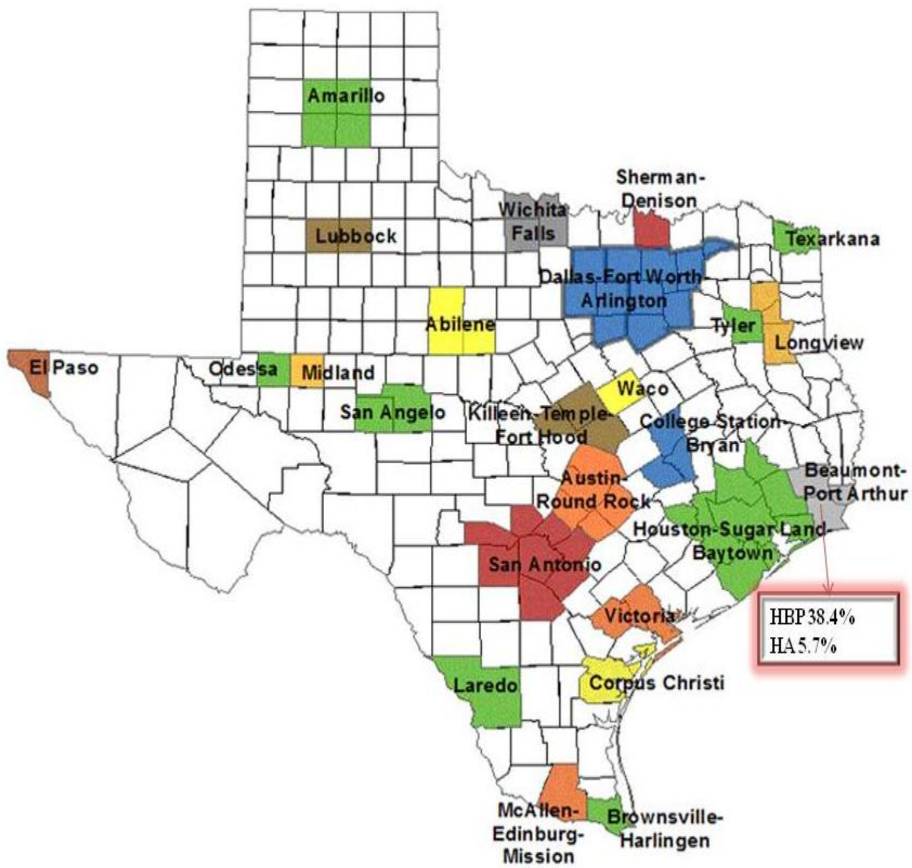

Figure 5: High blood pressure (HBP) and heart attack (HA) rate for the Beaumont-Port-Arthur MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

HBP stands for high blood pressure and HA stands for heart attack.

<u>Bryan-College Station stress-related illness rates and vegetative cover</u>

At 28.0 percent for high blood pressure rates and 4.9 percent for heart attack rates, College Station-Bryan ranks 7th highest and 9th highest, respectively, of all the MSAs of

Texas (Figure 6). Vegetation for College Station-Bryan mainly consists of Post Oak Woods (*Quercus stellata*), Blackland Prairies and other native introduced grasses. Crops commonly grown in this MSA are maize, sorghum, soybean and forage crops (Texas CropMAP, 2003).

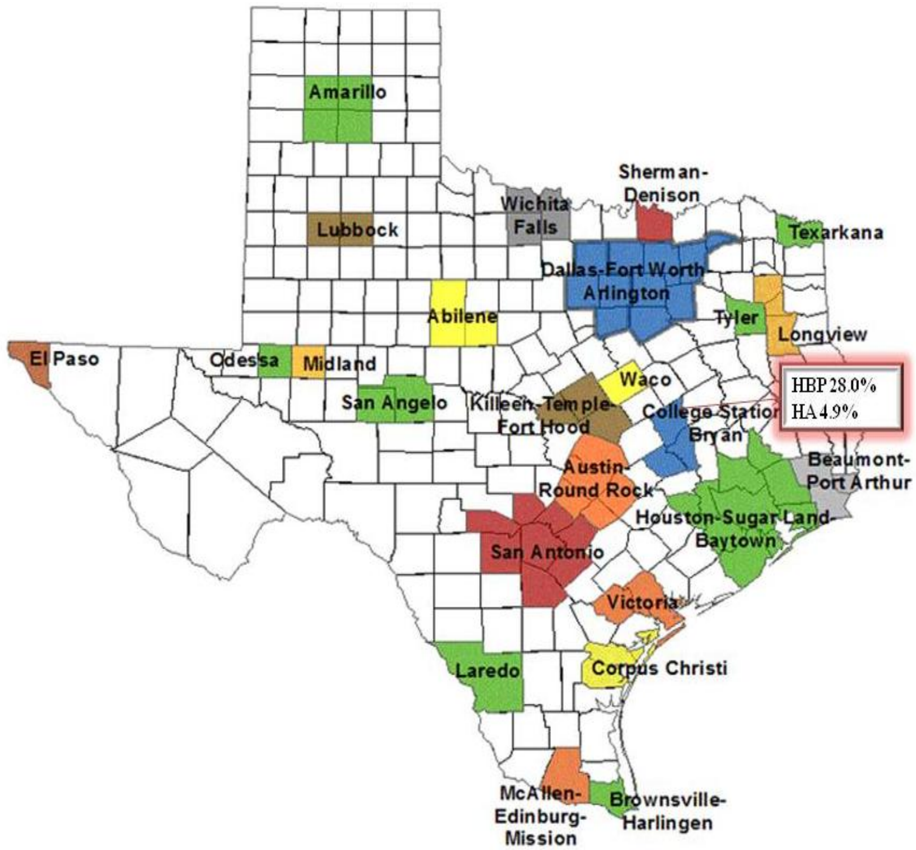

Figure 6: High blood pressure (HBP) and heart attack (HA) rate for the Bryan-College Station MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

<u>Corpus Christi stress-related illness rates and vegetative cover</u>

The high blood pressure rate for this area stands at 25.9 percent, and heart attack rate for this area is 3.3 percent. It is ranked the 8th highest for high blood pressure rates and 16th highest of heart attack rates of all the MSAs (Figure 7). The Corpus Christi MSA has a large amount of agronomic cropland, with Mesquite (*Prosopis glandulosa*)-Blackbrush (*Acacia rigidula*) brushlands and Live Oak (*Quercus spp.*). Crops that are commonly grown in the Corpus Christi MSA include cereal crops such as corn, sorghum, wheat, hay, vegetable crops of sweet corn and watermelon, cotton, fruit and nut crops of peaches and pecans (*Carya illinoinensis*) and nursery/floriculture crops (Texas CropMAP, 2003)

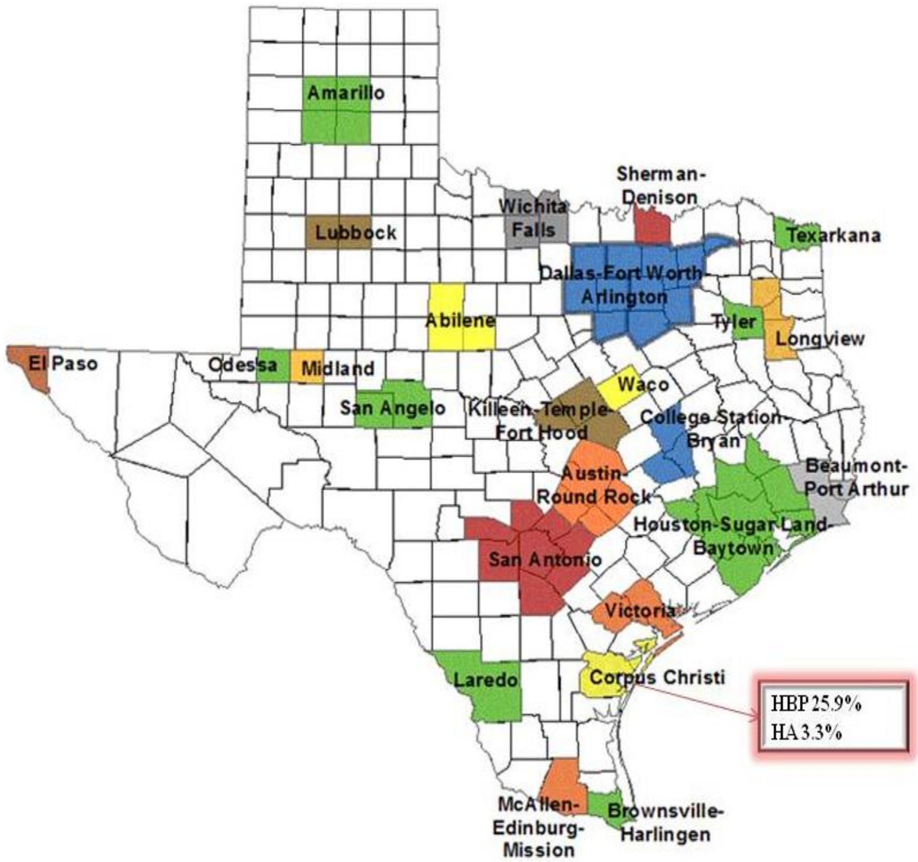

Figure 7: High blood pressure (HBP) and heart attack (HA) rate for the Corpus Christi MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

<u>Dallas-Fort Worth-Arlington stress-related illness rates and vegetative cover</u>

At 23.3 percent for high blood pressure and 3.8 percent for heart attack, the Dallas-Fort Worth-Arlington MSA (Figure 8) ranks 11th highest for high blood pressure rates and 14th highest for heart attack rates of the Texas MSAs. Dallas-Fort Worth-Arlington is the largest of Texas top four major metropolitan areas (U.S. Census Bureau, 2008). Vegetation for the Dallas-Fort Worth-Arlington MSA consists of Post Oak

(*Quercus stellata*) Woods/Forests and grassland mosaic, Bluestem (*Schizachyrium scoparium*) Grasslands, Elm (*Ulmus spp.),* Hackberry (*Celtis spp*.) Parks/woods, Silver Bluestem (*Bothriochloa saccharoides),* Texas Wintergrass (*Nassella leucotricha*) grasslands. Major crops grown in counties that occur in the Dallas-Fort Worth-Arlington MSA include cereal crops such as corn, sorghum, wheat and oats, hay, varieties of vegetable, fruit and nut crops, cotton and nursery/floriculture crops (Texas CropMAP, 2003).

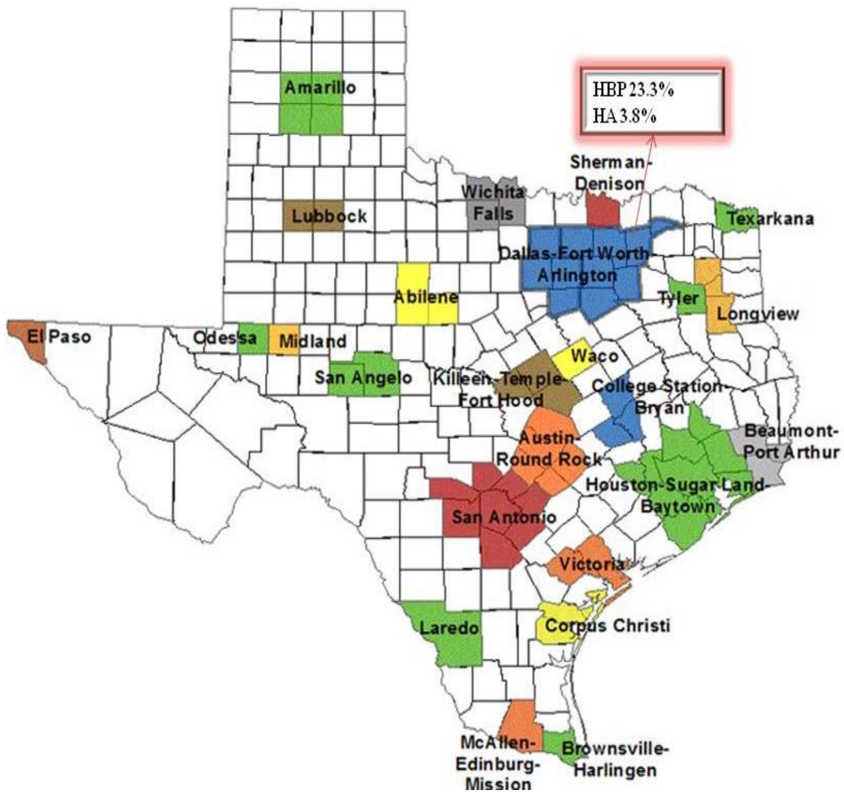

Figure 8: High blood pressure (HBP) and heart attack (HA) rate for the Dallas Fort Worth-Arlington MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

<u>El Paso stress-related illness rates and vegetative cover</u>

The high blood pressure rate for El Paso MSA was 19.0 percent, which ranked 15th highest of the all MSAs used in this study, whereas heart attack rate for El Paso was

9.8 percent, which ranked 19th of all the MSAs used for this study. El Paso (Figure 9) is comprised of arid lands, desert grasslands, called Tobosa. El Paso mainly comprise Black Grama (*Bouteloua eriopoda*) and Tobosa (*Hilaria mutica*) and vegetation is also comprised of thick, heavy brush/shrublands called the Mesquite (*Prosopis glandulosa*)-sandsage (*Artemesia filifolia*) shrublands (Diamond et al., 1987; Preserving Texas' Natural Heritage, 1978). Crops grown in El Paso include sorghum, wheat and oats, hay and forage crops, a wide variety of vegetable and fruit and nut crops, cotton and nursery/floriculture crops (Texas CropMAP, 2003).

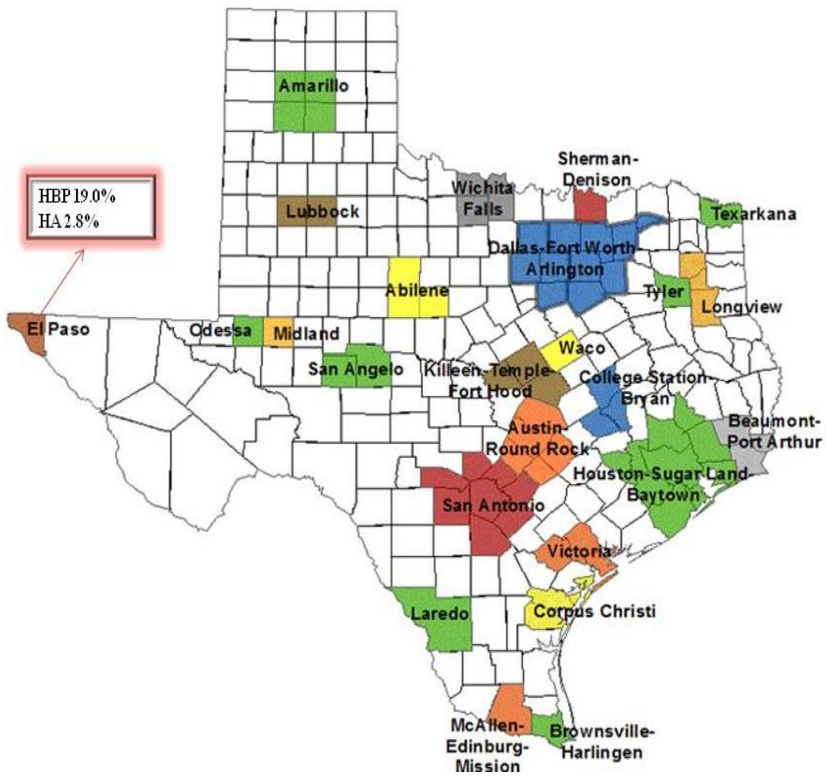

Figure 9: High blood pressure (HBP) and heart attack (HA) rate for the El Paso MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

Houston-Sugarland-Baytown stress-related illness rates and vegetative cover

The Houston-Sugarland-Baytown MSA (Figure 10), with 23.4 percent high blood pressure rate and 4.3 percent heart attack rate, ranked 11th highest and 12th highest, respectively, of all the MSAs used in the study.

Houston-Sugarland-Baytown MSA is 2nd largest MSA of Texas (U. S. Census Bureau, 2008). Vegetative composition of the Houston-Sugarland-Baytown MSA consists of Pine (*Pinus spp*.)-Hardwood forests, cropland, Willow Oak (*Quercus phellos*)-Water Oak (*Quercus nigra*)-Blackgum (*Nyssa sylvatica*) forests, and Bluestem (*Schizachyrium scoparium*) grasslands. Major crops grown in the counties of the Houston-Sugarland-Baytown MSA include cereal crops such as corn, sorghum, wheat and rice, soybeans, hay and forage crops, a wide variety of vegetable, fruit and nut crops, cotton and nursery/floriculture crops (Texas CropMAP, 2003)

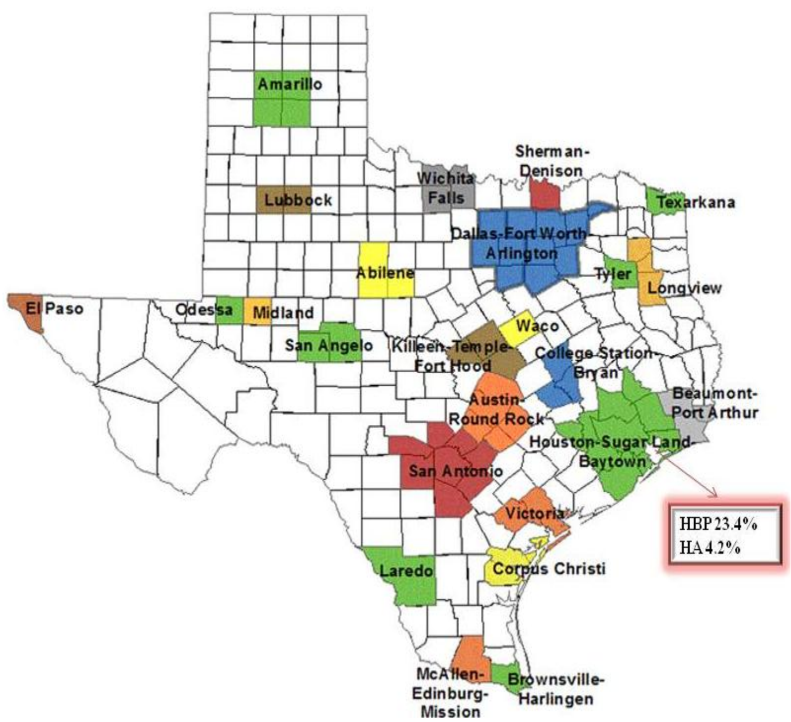

Figure 10: High blood pressure (HBP) and heart attack (HA) rate for the Houston-Sugarland-Baytown MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

Killeen-Temple-Fort Hood stress-related illness rates and vegetative cover

At 18.8 percent, Killeen-Temple-Fort Hood MSA (Figure 11) has the 16th highest high blood pressure rate of MSAs and at 1.6 percent, Killen-Temple-Fort Hood has the second lowest heart attack rate of the MSAs used in the study. Vegetative communities of this MSA include a mix of Live Oak *(Quercus spp.*), Cedar *(Juniperus ashei*) woodlands, Live Oak (*Quercus spp.*)-Mesquite (*Prosopis glandulosa*)-Ashe Juniper (*Juniperus ashei*) Parks/woodlands, Post Oak (*Quercus stellata*) Woods/Forests and grassland mosaic, Silver Bluestem (*Bothriochloa saccharoides*)-Texas Wintergrass (*Nassella leucotricha*) grasslands, along with areas of cropland. Crops grown within the counties of this MSA include cereal crops of sorghum, wheat and oats, hay and forage crops, a variety of vegetable, fruit and nut crops, cotton and nursery/floriculture crops (Texas CropMAP, 2003).

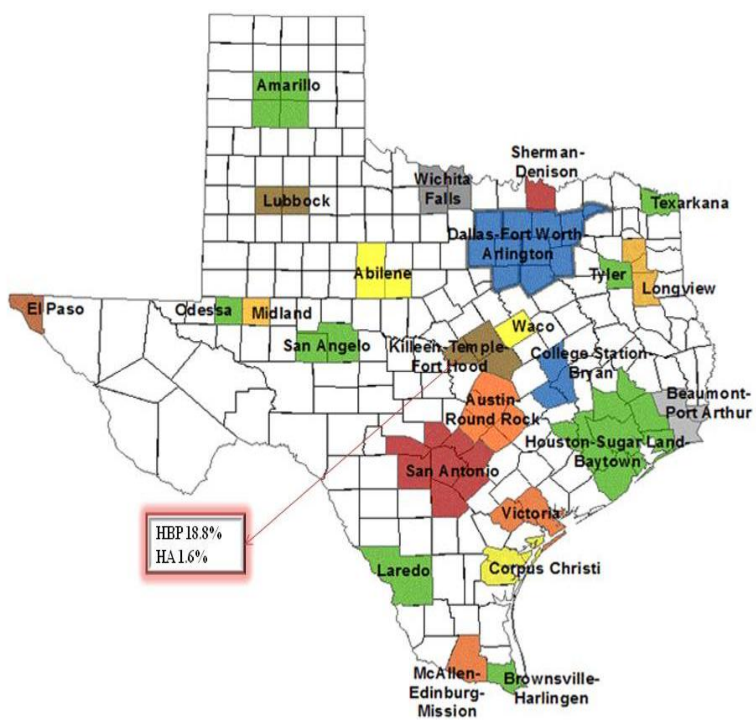

Figure 11: High blood pressure (HBP) and heart attack (HA) rate for the Killeen-Temple-Fort Hood MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

Lubbock stress-related illness rates and vegetative cover

Lubbock MSA ranks 2nd highest for high blood pressure rates, at 33.5 percent, and ranks 11th highest for heart attack rates at 4.5 percent of all 25 MSAs used in this study (Figure 12). A major portion of the Lubbock MSA consists of cropland, with Mesquite (*Prosopis glandulosa*)-Lotebush (*Zizyphus obtusifolia*) brushland and areas of juniper (*Juniperus spp*.) woods occurring in the more Southeastern corner. Major crops grown in counties of the Lubbock MSA include cereal crops of corn, sorghum, wheat, oats and sunflower seed, grain legumes such as soybeans, cowpeas and southern peas, hay and forage crops, a variety of vegetable, fruit and nut crops, cotton and nursery/floriculture crops (Texas CropMAP, 2003).

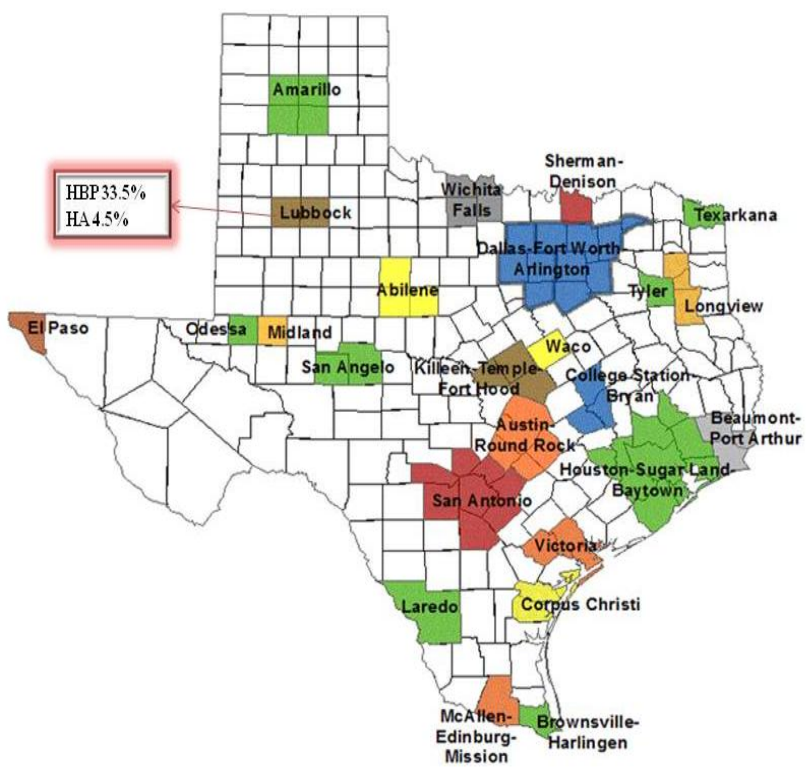

Figure 12: High blood pressure (HBP) and heart attack (HA) rate for the Lubbock MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

McAllen-Edinburg-Mission and Brownsville-Harlingen stress-related illness rates and vegetative cover

The McAllen-Edinburg-Mission and Brownsville-Harlingen MSAs are located in the Lower Rio Grande Valley region of Texas. Despite of having similar vegetation, the MSAs have different rates of high blood pressure and heart attacks. Brownsville-Harlingen ranks 6th highest at 28.1 percent for high blood pressure and ranks 15th at 3.4 percent for heart attacks (Figure 13). McAllen-Edinburg-Mission ranks 12th at 19.5 percent for high blood pressure and ranks 17th at 3.0 percent for heart attacks out of all other MSAs (Figure 13). Both of these areas consist primarily of cropland, but McAllen-Edinburg-Mission does have Mesquite (*Prosopis glandulosa*)-Granjeno *(Celtis pallida*) shrublands. The Lower Rio Grande Valley is also located in a subtropical environment, and has much milder winters compared to other areas of Texas (Beckett et al., 1998; Bolund and Hunhammar, 1999). For this reason, both of these MSAs have larger acreages of varieties of vegetable, fruit and nut crops, cotton, sugarcane and nursery/floriculture crops when compared to other MSA regions (Texas CropMAP, 2003).

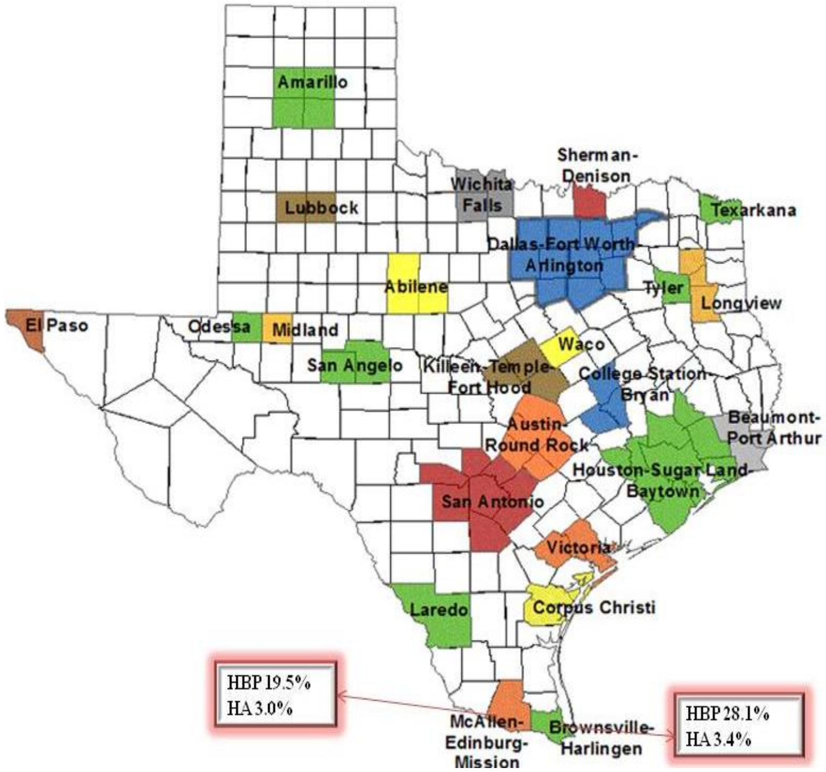

Figure 13: High blood pressure (HBP) and heart attack (HA) rate for the McAllen-Edinburg-Mission and Brownsville-Harlingen MSAs in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

San Antonio stress-related illness rates and vegetative cover

San Antonio MSA is ranked 3rd largest of the 4 major metropolitan/urban areas of Texas (U.S. Census Bureau, 2008). At 23.3 percent the city's high blood pressure rate is ranked 11th out of the 25 MSAs, and at 2.9 percent, San Antonio ties with Odessa ranked 18th in heart attack rates of all other Texas MSAs (Figure 14). At one time, it was reported that San Antonio, TX had lost 22 percent, or 45,000 acres, of heavy tree canopy due to urbanization (Kollin, 2003). San Antonio urban communities are continuing to develop and more trees are lost daily. Crops grown in counties located within the San Antonio MSA include cereal crops such as corn, sorghum, wheat and oats, hay, soybeans, a variety of vegetable, fruit and nut crops, cotton and nursery/floriculture crops (Texas CropMAP, 2003).

Vegetation in the San Antonio consists of a mix of Live Oak (*Quercus spp.*)-Ashe Juniper (*Juniperus ashei*) woodlands and parks, Live Oak (*Quercus spp.*)-Mesquite (*Prosopis glandulosa*)-Ashe Juniper (*Juniperus ashei*) Parks, Mesquite (*Prosopis glandulosa*)-Live Oak (*Quercus spp.*)-Bluewood (*Condalia hookeri*) Parks, Post Oak (*Quercus stellata*) woods, forests and grassland mosaic, Blackbrush (*Acacia rigidula*) and brushlands.

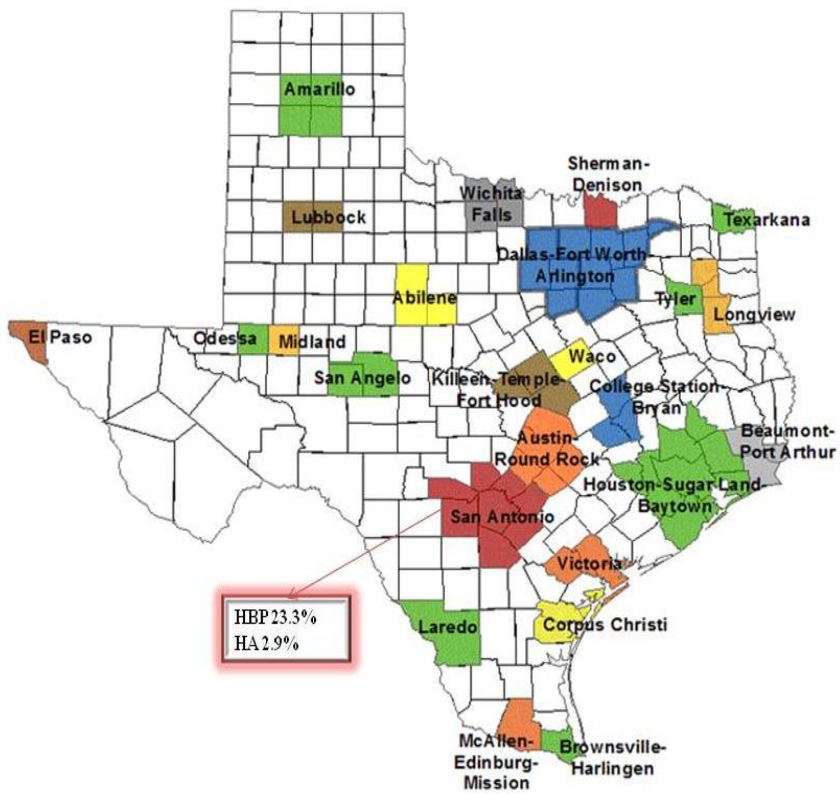

Figure 14: High blood pressure (HBP) and heart attack (HA) rate for the San Antonio MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

<u>Tyler and Longview stress-related illness rates and vegetative cover</u>

Despite similarities in geographic make-up, these MSAs have different high blood pressure and heart attack rates. Longview ranks 5th highest for high blood pressure rate at 30.4 percent, and 6th highest for heart attack rates at 6.1 percent, whereas Tyler ranks 4th highest for heart attack rates at 6.9 percent. However, high blood pressure rates for Tyler have not been recorded because respondents who answered positively for high blood pressure diagnosis were less than 50 (Figure 15). Tyler and Longview MSAs have the same geographic make-up, which include smaller tracts of cropland dispersed among Pine (*Pinus spp*.)-Hardwood forests and Post Oak (*Quercus stellata*) woods. Acres of crops found in these MSAs include hay and forage crops, a variety of vegetable, fruit and nut crops, nursery/floriculture crops, and only a small acreage devoted to the cereal crop of corn (Texas CropMAP, 2003).

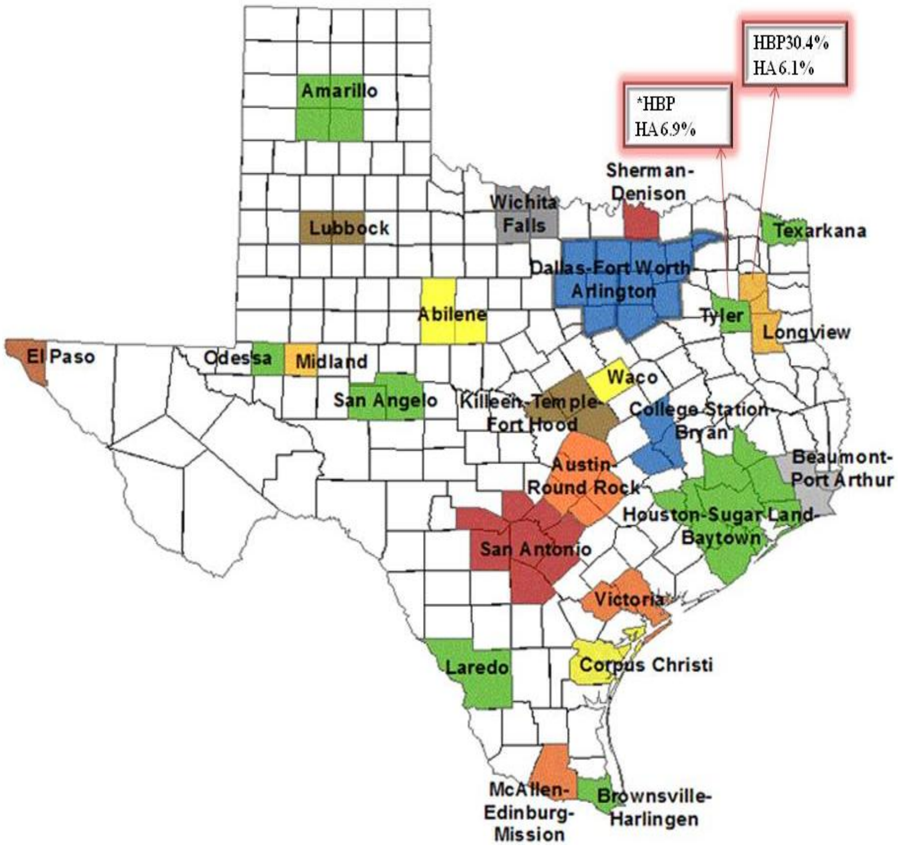

Figure 15: High blood pressure (HBP) and heart attack (HA) rate for the Tyler and Longview MSAs in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

***MSAs which had less 50 respondents who answered positively for high blood pressure diagnosis.**

Laredo stress-related illness rates and vegetative cover

Respondents who answered positively for high blood pressure diagnosis were less than 50 in number, so high blood pressure data were missing for this MSA. However, Laredo was ranked at lowest for rates of heart attacks at 0.0 percent (Figure 16). Laredo MSA has few hills and flat land covered with grassland, Oak (*Quercus spp*.), and Mesquite-Blackbrush (*Prosopis glandulosa*). Crops mainly grown in this MSA are forages and sorghum (Texas CropMAP, 2003).

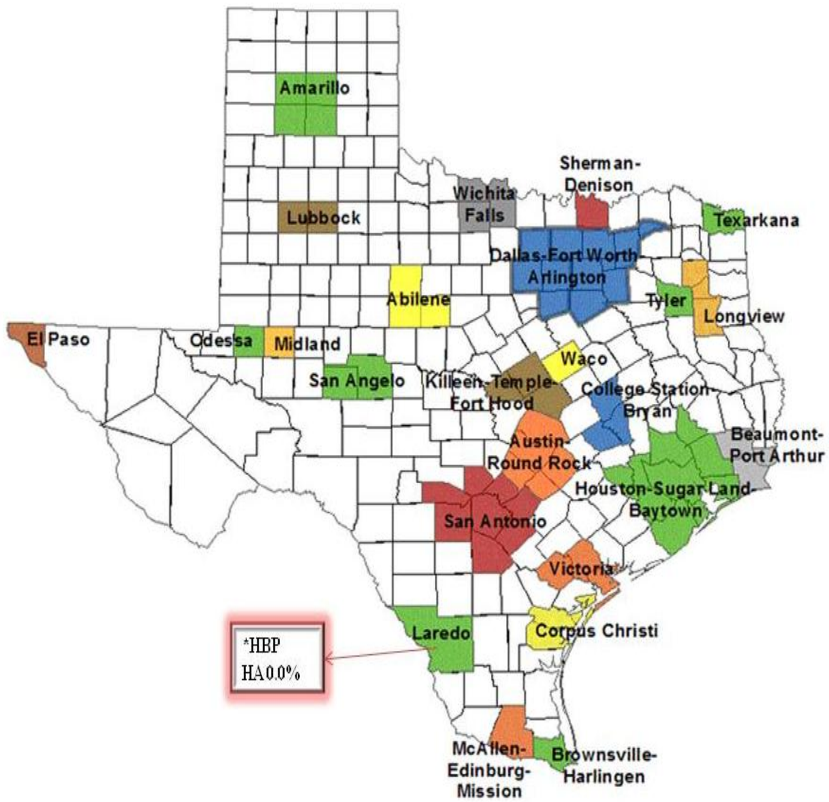

Figure 16: High blood pressure (HBP) and heart attack (HA) rate for the Laredo MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

***MSAs which had less 50 respondents who answered positively for high blood pressure diagnosis.**

<u>Wichita Falls stress-related illness and vegetation cover</u>

Wichita Falls MSA ranks 10th highest at 4.8 percent for heart attack rates, but because of less than 50 positively diagnosed respondents, data for high blood pressure were missing for this MSA (Figure 17). Vegetation of this MSA mainly includes Mesquite *(Prosopis glandulosa*)- Lotebrush (*Zizyphus obtusifolia)* Shrubs. Main crops are wheat, forages, cotton, sorghum, pecans (*Carya illinoinensis*), oats and nursery crops (Texas CropMAP, 2003).

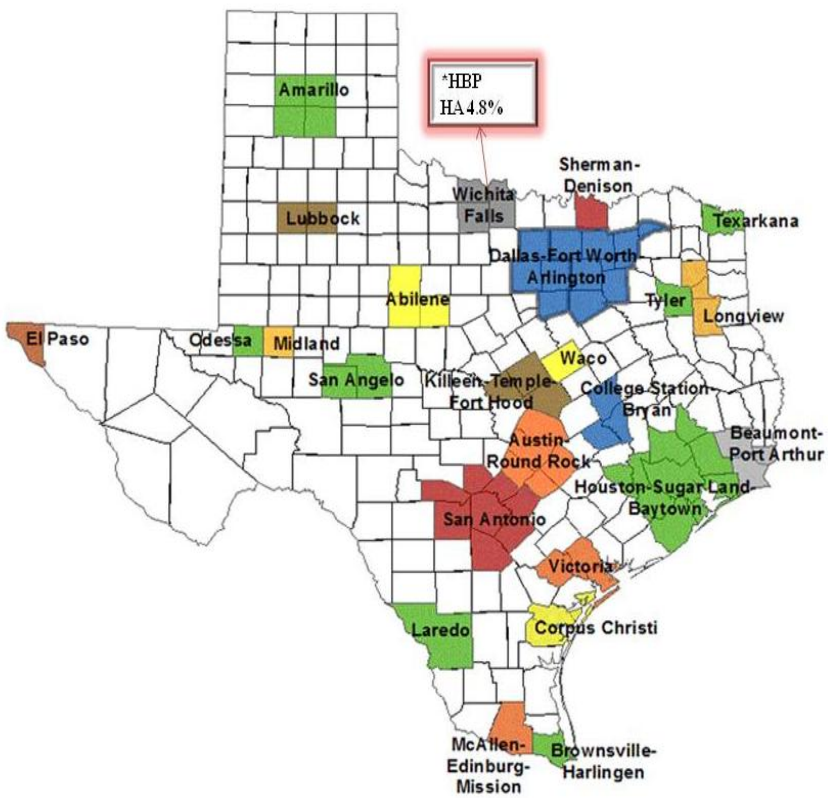

Figure 17: High blood pressure (HBP) and heart attack (HA) rate for the Wichita Falls MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

***HBP is for MSAs which had less 50 respondents who answered positively for high blood pressure diagnosis.**

Waco stress-related illness and vegetation cover

Waco ranks 4th highest for high blood pressure rates at 32.7 percent and ranks 4th lowest for heart attack rates at 2.0 percent (Figure 18). Vegetation types in Waco are mainly Mesquite (*Prosopis glandulosa*) Brush and Blackland prairies. Crops grown in this area are maize, sorghum, wheat, oats, soybean, forages, pecan (*Carya illinoinensis*), cotton, nursery and greenhouse crops (Texas CropMAP, 2003).

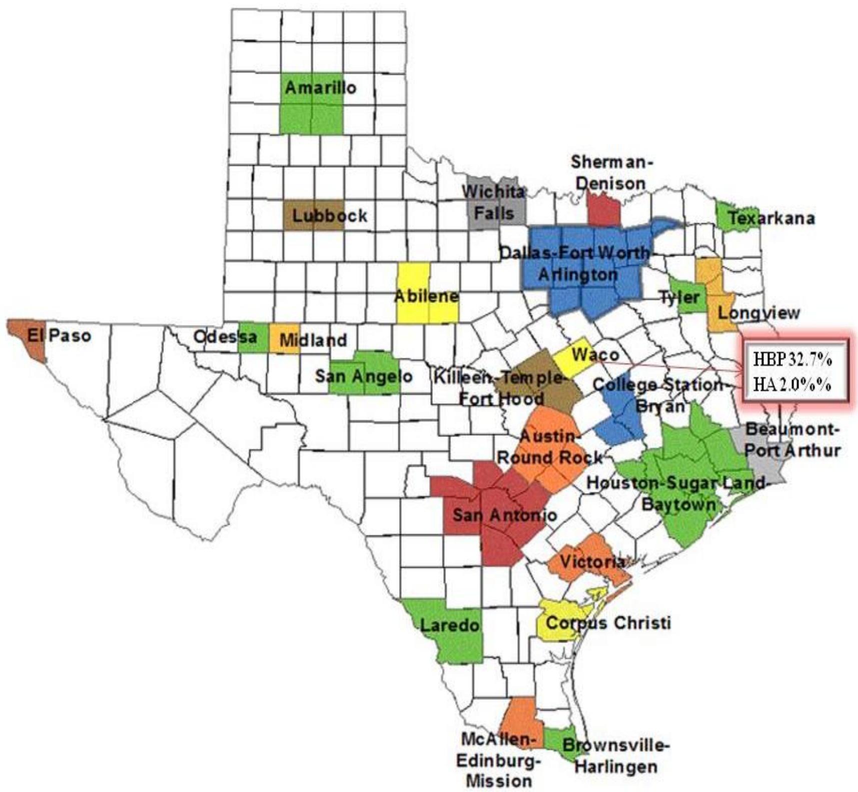

Figure 18: High blood pressure (HBP) and heart attack (HA) rate for the Waco MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

San Angelo stress-related illness and vegetative cover

San Angelo MSA ranks 3rd highest for heart attack rates at 7.5 percent. Because of less than 50 respondents who answered positively for diagnosis of high blood pressure in this MSA, data for high blood pressure were missing (Figure 19). San Angelo lies in

Edward Plateau Region and vegetation of this MSA is Hardwood Forest. Crops grown include wheat, hay, pecans (*Carya illinoinensis*), sorghum, cotton, hay, maize and oats (Texas CropMSA, 2003).

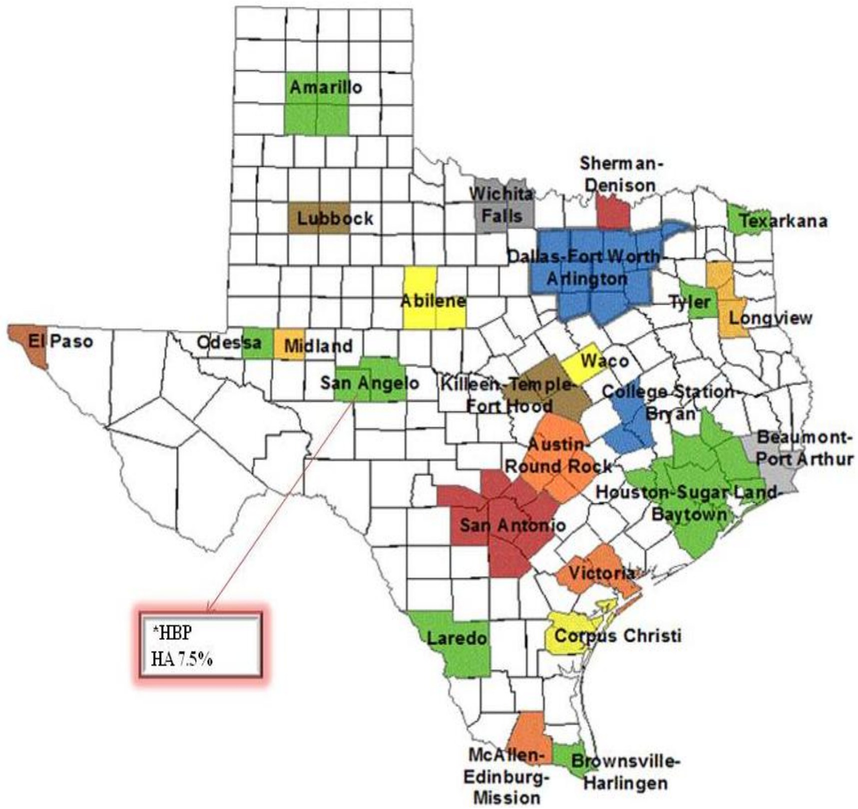

Figure 19: High blood pressure (HBP) and heart attack (HA) rate for the San Angelo MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

*** HBP stands for MSAs which had less 50 respondents who answered positively for high blood pressure diagnosis.**

<u>Victoria stress-related illness and vegetative cover</u>

Victoria MSA ranks 3rd lowest at 1.9 percent for heart attack. Data for high blood pressure for this MSA was missing because of less than 50 respondents who answered positively to the high blood pressure diagnosis question (Figure 20). Vegetation of this MSA is Post Oak (*Quercus stellata*) Forest and Grassland Mosaic, Willow Oak (*Quercus* *phellos*), Water Oak (*Quercus nigra*). Crops grown in this region are maize, rice, sorghum, soybean, forages, sunflower and nursery crops (Texas CropMAP, 2003).

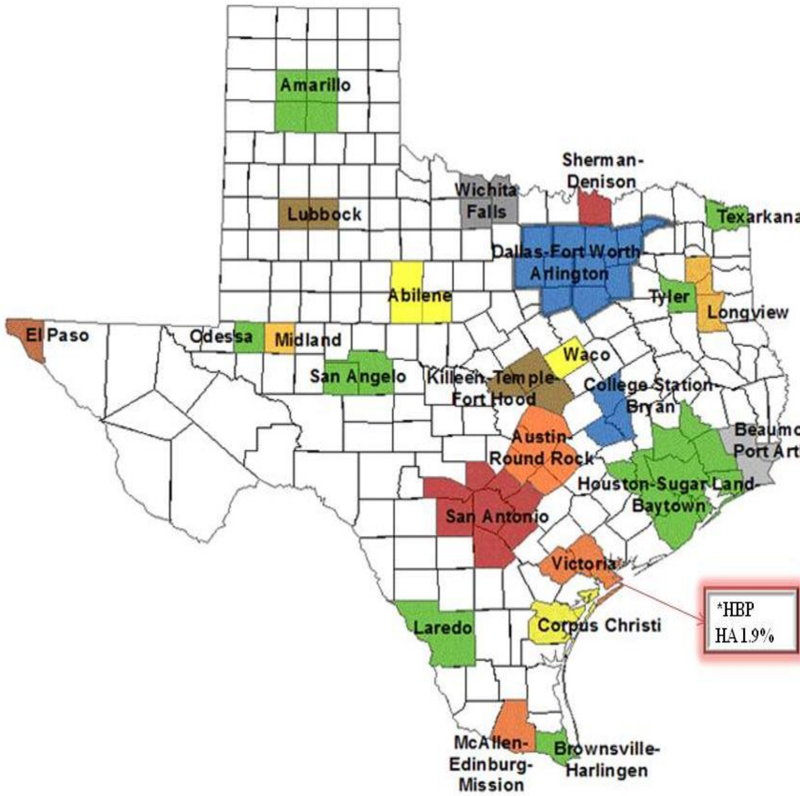

Figure 20: High blood pressure (HBP) and heart attack (HA) rate for the Victoria MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

***HBP stands for MSAs which had less 50 respondents who answered positively for high blood pressure diagnosis.**

<u>Texarkana stress-related illness and vegetative cover</u>

Texarkana has the highest rate of heart attack at 11.5 percent of all the MSAs. The number of respondents who answered positively to the questions related to high blood pressure diagnosis was less than 50, so data were missing for high blood pressure diagnosis for this MSA (Figure 21). Vegetation of this MSA is Pine (*Pinus spp.*) Hardwood forest and introduced grassland, along with crops such as maize, wheat, soybean, pecans (*Carya illinoinensis)*, forages, sorghum, nursery and greenhouse crops (Texas CropMAP, 2003).

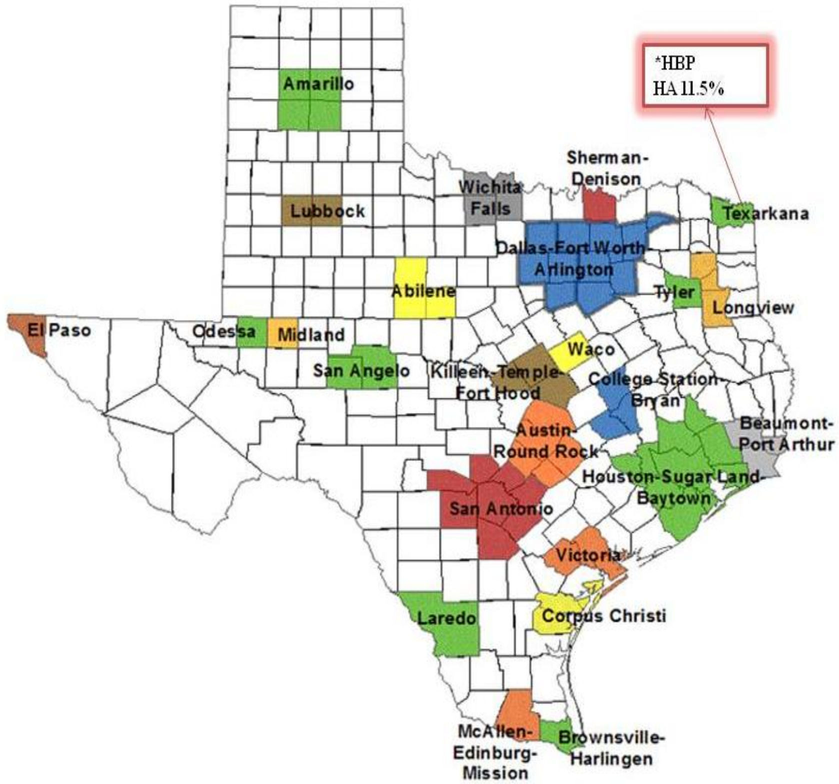

Figure 21: High blood pressure (HBP) and heart attack (HA) rate for the Texarkana MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

***HBP stands for MSAs which had less 50 respondents who answered positively for high blood pressure diagnosis.**

<u>Odessa and Midland stress-related illness and vegetative cover</u>

Midland ranks 20th and Odessa ranks 18th for heart attack rates at 2.4 percent and at 2.9, respectively. High blood pressure data for both the MSAs were missing due to less than 50 respondents who answered positively to high blood pressure diagnosis questions (Figure 22). Both Odessa and Midland MSAs lie in the High Plains. Vegetation type includes desert grassland, Live Oak (*Quercus spp.*), Pinyon Pine (*Pinus edulis*), and Mesquite (*Prosopis glandulosa*)-Lotebrush (*Zizyphus obtusifolia*). Crops grown in this area include cotton, forages, nursery and greenhouse crops, pecan (*Carya illinoinensis*), sorghum and wheat (Texas CropMAP, 2003).

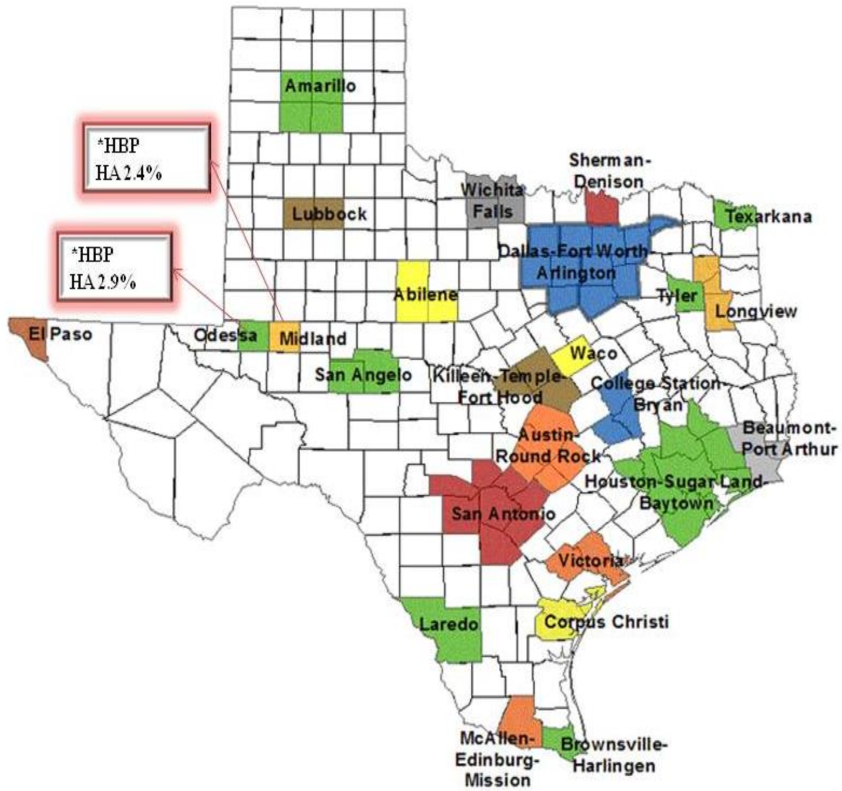

Figure 22: High blood pressure (HBP) and heart attack (HA) rate for the Odessa and Midland MSAs in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

***HBP stands for MSAs which had less 50 respondents who answered positively for high blood pressure diagnosis.**

<u>Sherman-Denison stress-related illness and vegetative cover</u>

At 8.2 percent Sherman-Denison ranks 2nd highest for heart attack rates. Because of small sample sizes of less than 50 who answered positively to high blood pressure diagnosis questions, data were missing for this MSA (Figure 23). Vegetation of this MSA is young forest, grassland, Post Oak (*Quercus stellata*) Forest, Grassland Mosaic and Mesquite (*Prosopis glandulosa*) Shrubs. Crops grown in this MSA include forages,

maize, wheat, sorghum, oats, soybean, pecans (*Carya illinoinensis*), peanuts, nursery and floriculture crops (Texas CropMAP, 2003).

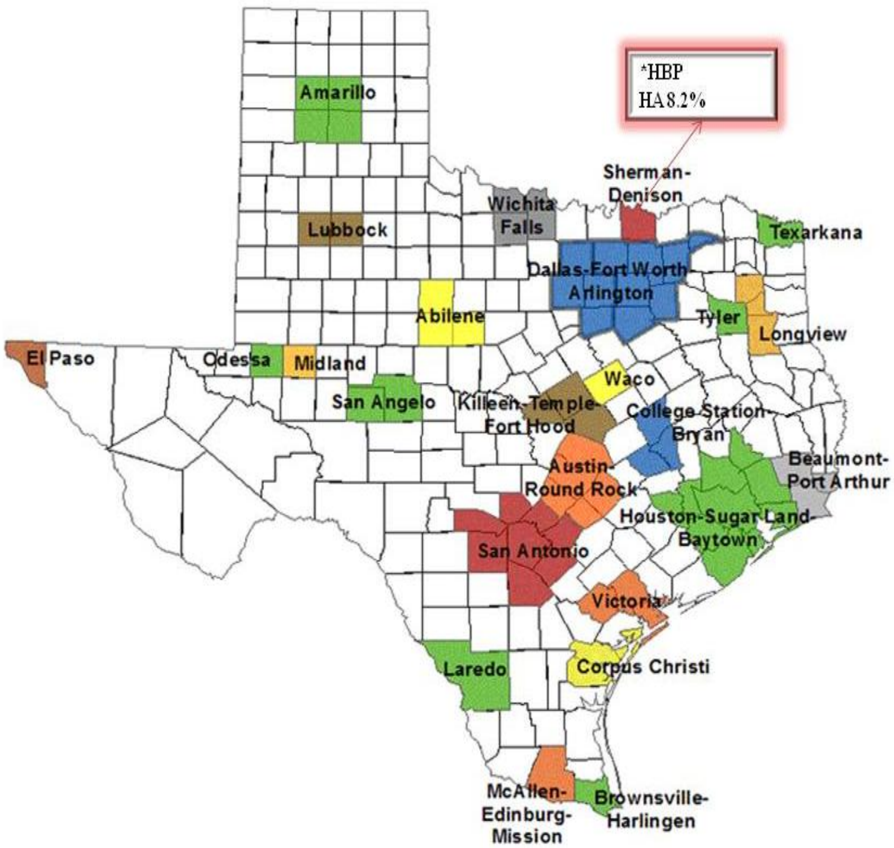

Figure 23: High blood pressure (HBP) and heart attack (HA) rate for the Sherman-Denison MSA in the study of the effect of tree cover and vegetation on incidence of stress-related illness in Metropolitan Statistical Areas of Texas.

***HBP stands for MSAs which had less 50 respondents who answered positively for high blood pressure diagnosis.**

<u>Findings Related to Objective Three</u>

The third objective of the study was to measure canopy cover in the Metropolitan Statistical Areas (MSAs) of Texas.

<u>Calculating canopy cover</u>

Percent canopy of woody vegetation was calculated for each MSA to determine what proportion of each MSA was herbaceous low groundcover and small shrubby-vegetation versus that of woody plant materials such as trees and taller shrubs. Statistics were calculated for each MSA using the Multi-Resolution Land Characteristics (MRLC) National Land Cover Data canopy cover dataset (Table 3).

Table 3: Ranking of Metropolitan Statistical Areas in order of highest to lowest percent canopy cover and total MSA acreage in the study of the effect of tree cover and vegetation on incidence of stress-related illnesses in Metropolitan Statistical Areas of Texas.

Ranking	MSA	Acres	Percent canopy[z]
1–highest	Longview	1,159,916.6	45.31
2	Texarkana	592,751.23	39.63
3	Tyler	609,491.7	39.28
4	Beaumont-Port Arthur	1,457,562.6	34.83
5	Houston-Sugarland-Baytown	5,895,401.9	28.52
6	Bryan-College Station	1,366,481.36	24.39
7	Austin-Round Rock	2,739,283.9	23.51
8	San Antonio	4,722,912.8	20.43
9	Victoria	1,460,081.31	20.10
10	Killeen-Temple-Ft. Hood	1,828,212.9	17.47
11	Sherman-Denison	626,906.63	14.10
12	Waco	678,502.60	9.98

Table 3 - continued

Ranking	**MSA**	**Acres**	**Percent canopy**^{z}
13	Dallas-Ft. Worth-Arlington	5,943,136.1	9.71
14	Abilene	1,763,723.93	9.03
15	Corpus Christi	1,142,613.3	6.67
16	San Angelo	1,658,729.26	3.83
17	Brownsville-Harlingen	602,397.6	3.66
18	Wichita Falls	1,710,745.89	2.69
19	McAllen-Edinburg-Mission	1,013,246.9	2.44
20	Amarillo	2,358,170.7	2.32
21	Laredo	2,158,763.50	1.31
22	El Paso	656,445.2	0.38
23	Lubbock	1,154,110.7	0.27
24	Midland	577,978.35	0.24
25-lowest	Odessa	578,230.95	0.14

^{z} **Percent canopy was calculated using a normalized difference vegetation index calculated from satellite imagery (Landsat) to determine what proportion of each MSA was groundcover versus woody vegetation such as trees and shrubs**.

The MSAs located in and around the Piney Woods natural region of East Texas had the highest rates of percent canopy cover. Longview had the highest total percent canopy cover with 45.31 percent; Texarkana MSA had 39.63 percent canopy cover and Tyler had 39.28 percent canopy cover (Table 3). The Piney Woods region of Texas vegetative composition is composed of pine-hardwood forests (*Pinus spp*.), with tracts of farmlands and pasture throughout (Diamond et al., 1987; Preserving Texas' Natural Heritage, 1978). The major dominating vegetative type in this area is evergreen pine (*Pinus spp*.) (Diamond et al., 1987; Preserving Texas' Natural Heritage, 1978).

The lowest percent canopy cover occurred in MSAs located in the furthest northwest region of Texas (Odessa and Midland) and the Texas Panhandle area (Lubbock) (Preserving Texas' Natural Heritage, 1978). Junipers (*Juniperus* s*pp*.) are common to both the Rolling Plains and High plains natural regions of Texas (Diamond et al., 1987). Odessa had the lowest percent canopy cover at 0.14 percent; Midland had just 0.24 percent and Lubbock, the third lowest, had 0.27 percent canopy cover (Table 3). Odessa MSA in west Texas is comprised of semi-arid mesquite-mixed grasslands, subtropical steppe (a vast semiarid grass-covered plain) (Preserving Texas' Natural Heritage, 1978).

Findings Related to Objective Four

The fourth objective of the study was to map the vegetation cover for different Metropolitan Statistical Areas (MSAs) of Texas. Vegetation rates were examined for each MSA of Texas and were mapped for illustration using ArcView© 9.1 GIS (Redlands, CA) software.

To determine the information regarding percent vegetation/greenness for the Metropolitan Statistical Areas (MSAs) in this study, a normalized difference vegetation index (NDVI) was calculated from satellite imagery (Landsat) for each MSA. Landsat imagery contains the two bands (near infrared and red) required to calculate NDVI. This index is a simple numerical indicator used to analyze remote sensing measurements to determine the amount of green vegetation in the observed target. The resulting index range for this calculation is -1 to 1 (barren/non-vegetation to dense green vegetation, respectively).

The calculation is as follows (NIR = near infrared): NDVI = (NIR - Red) / (NIR + Red).

Landsat 5^{TM} imagery was obtained from the United States Geological Survey (USGS) Glovis site (U.S. Department of the Interior, 2010). Image "tiles" were downloaded to cover the extent of all MSAs included in the study. Each "tile" covered an area of 185 km (115 mi) wide. In order to obtain an accurate NDVI for each MSA, the imagery must be high quality and as cloud free as possible. The images selected and used in the study were designated by USGS as having a cloud cover of 0 percent and an image quality of 9 out of 10 (Note that 0 percent cloud cover may still include isolated clouds.). The downloaded image tiles were for the maximum foliage months of April to October 2006 when possible. The year 2006 was chosen in order to coincide with the dates of the collected stress-related illness data. If data with the above criteria were not available, the next closest date to that (skipping dormant months) was acquired. Out of the all MSAs used in this study, the following three had image tiles that were pulled from either September or October of 2006: Dallas-Fort Worth-Arlington, Lubbock and Killeen-Temple-Fort Hood.

The tiles were then "mosaiced" or pieced together to create one seamless image for each MSA. Examples of "mosaiced" tiles for some of the MSAs are in Figures 24 to 31. "Mosaicing" merges adjacent tiles into one image file removing overlapping values between tiles. High NDVI values are represented by brighter pixels, whereas low NDVI values are represented by darker pixels. Brighter (white) pixels indicate vegetation and different shades of gray represent bare ground to vegetation, depending on the brightness of the pixel. The lighter grays are most likely vegetation whereas the darker grays will be bare ground. Black pixels represent water or cloud coverage.

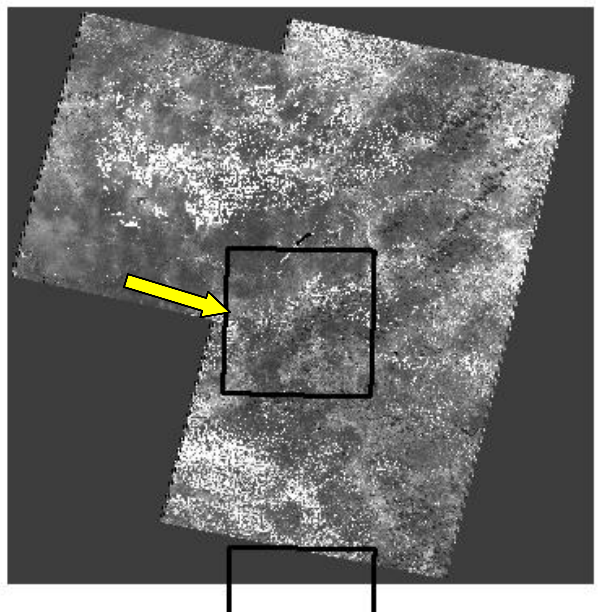

Figure 24: Satellite imagery of vegetative greenness for the Amarillo MSA (MSA outlined in black and indicated with arrow) in the study on the effect of tree cover and vegetation on incidence of stress-related illnesses in Metropolitan Statistical Areas of Texas.

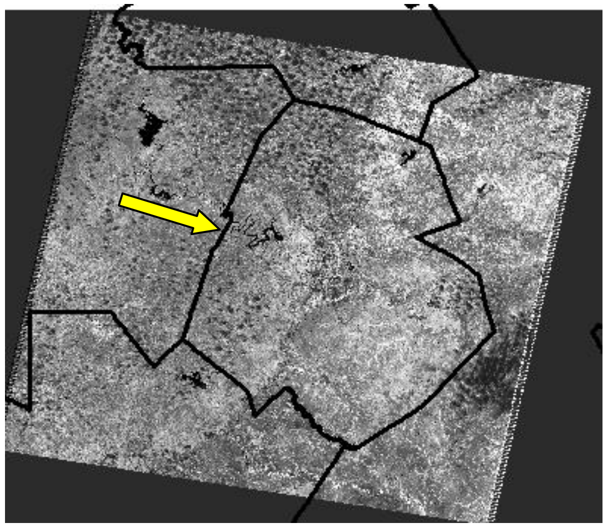

Figure 25: Satellite imagery of vegetative greenness for the Austin-Round Rock MSA (MSA outlined in black and indicated with arrow) in the study on the effect of tree cover and vegetation on incidence of stress-related illnesses in Metropolitan Statistical Areas of Texas.

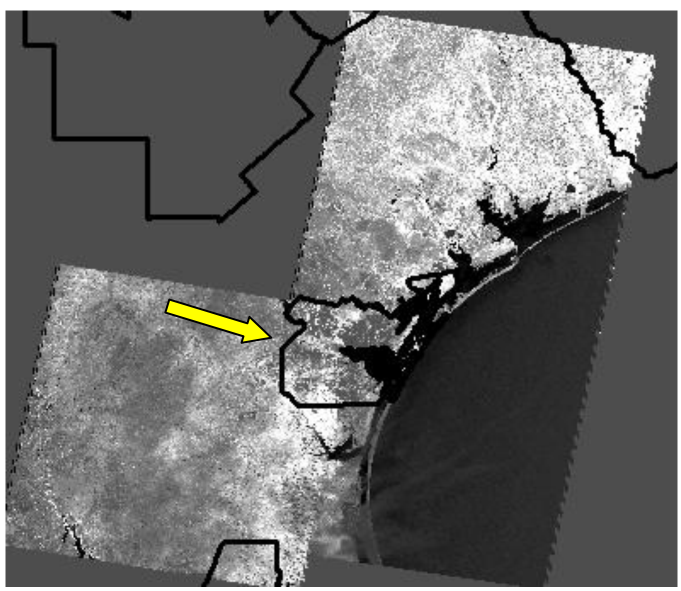

Figure 26: Satellite imagery of vegetative greenness for the Corpus Christi MSA (MSA outlined in black and indicated with arrow) in the study on the effect of tree cover and vegetation on incidence of stress-related illnesses in Metropolitan Statistical Areas of Texas.

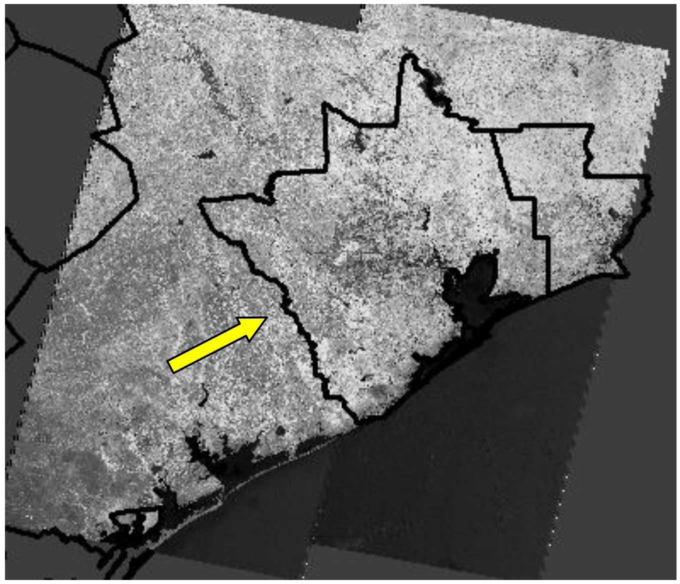

Figure 27: Satellite imagery of vegetative greenness for the Houston-Sugarland-Baytown MSA (MSA outlined in black and indicated with arrow) in the study on the effect of tree cover and vegetation on incidence of stress-related illnesses in Metropolitan Statistical Areas of Texas.

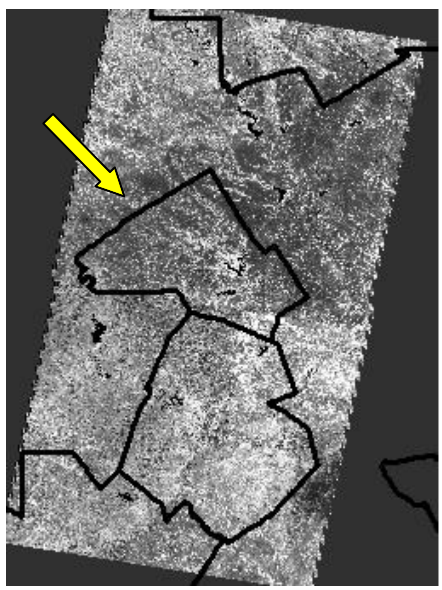

Figure 28: Satellite imagery of vegetative greenness for the Killeen-Temple-Ft. Hood MSA (MSA outlined in black and indicated with arrow) in the study on the effect of tree cover and vegetation on incidence of stress-related illnesses in Metropolitan Statistical Areas of Texas.

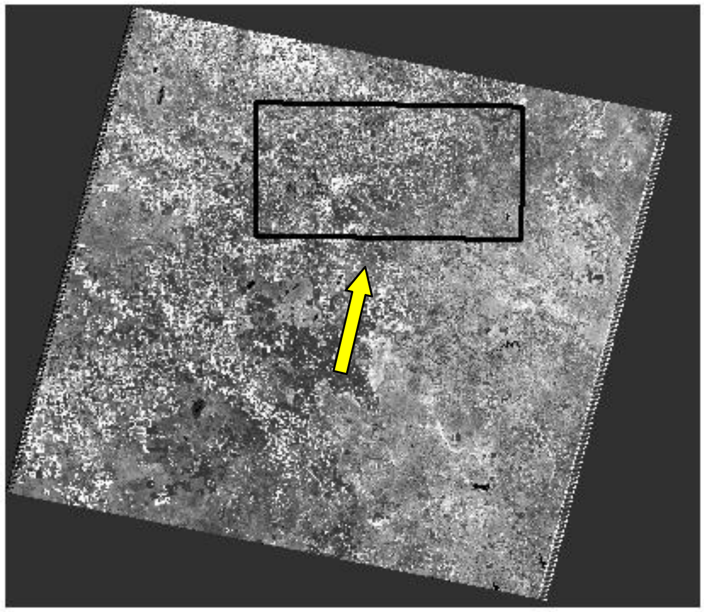

Figure 29: Satellite imagery of vegetative greenness for the Lubbock MSA (MSA outlined in black and indicated with arrow) in the study on the effect of tree cover and vegetation on incidence of stress-related illnesses in Metropolitan Statistical Areas of Texas.

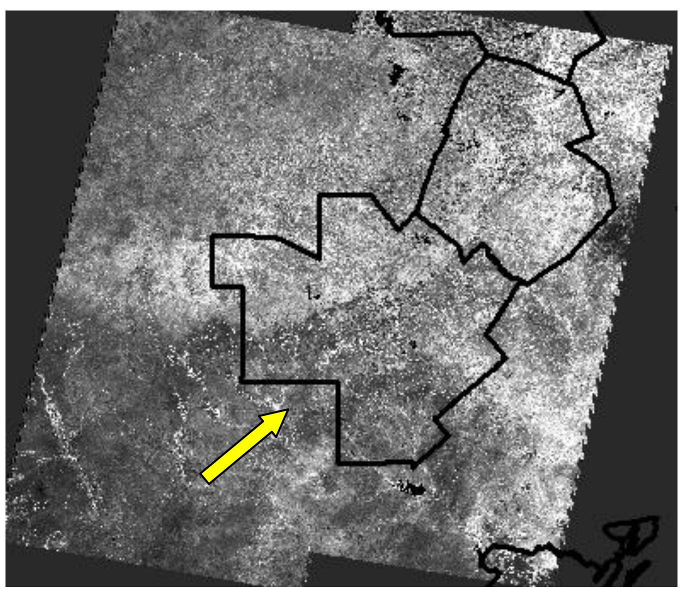

Figure 30: Satellite imagery of vegetative greenness for the San Antonio MSA (MSA outlined in black and indicated with arrow) in the study on the effect of tree cover and vegetation on incidence of stress-related illnesses in Metropolitan Statistical Areas of Texas.

Calculating vegetative cover

As stated in the methodology, the NDVI grid was transferred to ENVI^{TM} (Redlands, CA) image processing software, where statistics were calculated for each MSA. Descriptive statistics determined included minimum NDVI value, maximum NDVI value, and the average NDVI value for each MSA within the study (Table 4). The MSAs were listed in order from highest to lowest average NDVI value.

Table 4: Minimum, maximum and average normalized difference vegetation index (NDVI) for Metropolitan Statistical Areas (MSA), ranked in order highest to lowest average NDVI, in the study of the effect of tree cover and vegetation on incidence of stress-related illnesses in Metropolitan Statistical Areas of Texas.

Ranking	MSA	MinNDVI[z]	MaxNDVI[z]	AvgNDVI[z]
1–highest	Longview	-0.49	0.78	0.53
2	Tyler	-0.49	0.79	0.51
3	Bryan-College Station	-0.49	0.88	0.48
4	Texarkana	-0.60	0.79	0.46
5	Beaumont-Port Arthur	-0.65	0.95	0.45
6	Houston-Sugarland-Baytown	-0.66	0.82	0.44
7	Victoria	-0.51	0.79	0.34
8	Austin-Round Rock	-0.54	0.72	0.30
9	Sherman-Denison	-0.66	0.77	0.29
10	Dallas-Ft. Worth-Arlington	-0.99	0.82	0.26
11	Lubbock	-0.54	0.79	0.25

Table 4 - continued

Ranking	MSA	MinNDVI[z]	MaxNDVI[z]	AvgNDVI[z]
12	San Antonio	-0.98	0.78	0.24
13-tie	Abilene	-1.00	0.88	0.23
13-tie	Wichita falls	-1.00	0.71	0.23
14	McAllen-Edinburg-Mission	-0.98	0.77	0.21
15	Killeen-Temple-Ft. Hood	-0.66	0.74	0.19
16	Corpus Christi	-0.72	0.75	0.19
17	Brownsville-Harlingen	-0.49	0.73	0.16
18	Waco	-0.60	0.71	0.14
19	San Angelo	-0.61	0.76	0.12
20-tie	Amarillo	-0.53	0.79	0.11
20-tie	Laredo	-1.00	0.70	0.11
21	Odessa	-0.33	0.71	0.08
22	Midland	-0.39	0.74	0.07
23-lowest	El Paso	-0.56	0.76	0.02

[z]Normalized difference vegetation index, or NDVI, was calculated from satellite imagery (Landsat) for each MSA. Landsat imagery contains the two bands (near infrared and red) required to calculate NDVI. This index is a simple numerical indicator used to analyze remote sensing measurements to determine the amount of green vegetation in the observed target. The resulting index range for this calculation is -1 to 1 (barren/non-vegetation to dense green vegetation, respectively).

When comparing MSAs based on average NDVI, the top three locations for percent canopy were also the same top three for average NDVI. Longview MSA averaged 0.53 NDVI, while Tyler had a 0.51 average NDVI and the College Station-

Bryan average NDVI value was 0.48 (Table 4). However, when looking at the MSAs with the lowest three average NDVI scores, there was some variation when compared to the percent canopy cover order. El Paso averaged the lowest rate of vegetation at 0.02, while Midland stood 2nd lowest at 0.07. Previously, Odessa was the lowest with respect to percent canopy, while Midland was 2nd lowest. Odessa had the third lowest average NDVI score, at 0.08 (Table 4).

Findings Related to Objective Five

The fifth objective of the study was to compare the stress-related illnesses rates in different areas of Texas with the mapped tree and vegetation cover areas to determine if stress-related illnesses rates were related to tree/vegetation coverage.

The calculated tree cover canopy data values for each MSA were compared to their corresponding percentage of stress-related illnesses (i.e. high blood pressure and heart attack) from objective one. Upon first review, no clear corresponding orders were seen in rankings between the high blood pressure and heart attack percentages and the corresponding percent canopy covers for each MSA (Table 5).

Table 5: Comparison of ranking of Metropolitan Statistical Areas (MSAs) for highest to lowest stress-related illness, high blood pressure rate and lowest to highest percent canopy in the study on the effects of tree cover and vegetation on high blood pressure rates in regions of Texas.

High blood pressure ranking[z]	MSA	Percent canopy ranking[y]	MSA
1 – highest	Beaumont-Port Arthur	1 – lowest	Odessa
2	Lubbock	2	Midland
3	Abilene	3	Lubbock

Table 5 - continued

High blood pressure ranking[z]	MSA	Percent canopy ranking[y]	MSA
4	Waco	4	El Paso
5	Longview	5	Laredo
5	Brownsville-Harlingen	6	Amarillo
6	College Station–Bryan	7	McAllen-Edinburg-Mission
7	Corpus Christi	8	Wichita Falls
8	Amarillo	9	Brownsville-Harlingen
9	Houston-Baytown-Sugarland	10	San Angelo
10	San Antonio	11	Corpus Christi
11	Dallas-Ft. Worth-Arlington	12	Abilene
12	McAllen-Edinburg-Mission	13	Dallas-Ft. Worth-Arlington
13	El Paso	14	Waco
14	Killeen-Temple-Ft. Hood	15	Sherman Denison
15	Austin-Round Rock	16	Killeen-Temple-Ft. Hood
16	Laredo	17	Victoria

Table 5 - continued

High blood pressure ranking[z]	**MSA**	**Percent canopy ranking**[y]	**MSA**
17-Lowest	Midland	18	San Antonio
	Odessa[x]	19	Austin-Round Rock
	El Paso[x]	20	Bryan-College Station
	San Angelo[x]	21	Houston-Sugarland-Baytown
	Sherman-Denison[x]	22	Beaumont-Port-Arthur
	Texarkana[x]	23	Tyler
	Tyler[x]	24	Texarkana
	Victoria[x]	25-highest	Longview

[z]Data on percentage of high blood pressure were obtained from the Center for Health Statistics, Texas Department State Health Services for the years 2005-2006. The data were rounded to the next highest or lowest raw number based on the normalized percentage of patients reported to have high blood pressure in the overall population.
[y]Percent canopy was calculated using a normalized difference vegetation index calculated from satellite imagery (Landsat) to determine what proportion of each MSA was groundcover versus woody vegetation such as trees and shrubs.
[x]MSAs which had less 50 respondents who answered positively for high blood pressure diagnosis.

It was noticed that Lubbock had the second highest high blood pressure rate and second lowest canopy cover ranking. This was similar to Abilene and Waco. However, Beaumont-Port Arthur had a high canopy cover and also a large percentage of high blood pressure sufferers (Table 5).

Table 6: Comparison of ranking of Metropolitan Statistical Areas (MSAs) for highest to lowest stress-related illness, heart attack rate and lowest to highest percent canopy in the study on the effects of tree cover and vegetation on heart attack rates in regions of Texas.

Heart attack[z] ranking	MSA	Percent canopy ranking[y]	MSA
1 – highest	Longview	1-lowest	Odessa
2	Texarkana	2	Midland
3	Tyler	3	Lubbock
4	Beaumont-Port Arthur	4	El Paso
5	Houston-Sugarland-Baytown	5	Laredo
6	Bryan-College Station	6	Amarillo
7	Austin-Round Rock	7	McAllen-Edinburg-Mission
8	San Antonio	8	Wichita Falls
9	Victoria	9	Brownsville-Harlingen
10	Killeen-Temple-Ft. Hood	10	San Angelo
11	Sherman-Denison	11	Corpus Christi
12	Waco	12	Abilene
13	Dallas-Ft. Worth-Arlington	13	Dallas-Ft. Worth-Arlington
14	Abilene	14	Waco
15	Corpus Christi	15	Sherman-Denison
16	San Angelo	16	Killeen-Temple-Ft. Hood

Table 6 - continued

Heart attack[z] ranking	MSA	Percent canopy ranking[y]	MSA
17	Brownsville-Harlingen	17	Victoria
18	Wichita Falls	18-tie	San Antonio
19	McAllen-Edinburg-Mission	18-tie	Austin-Round Rock
20	Amarillo	19	Bryan-College Station
21	Laredo	20	Houston-Baytown-Sugarland
22	El Paso	21	Beaumont-Port-Arthur
23	Lubbock	22	Tyler
24	Midland	23	Texarkana
25-Lowest	Odessa	24-higest	Longview

[z]Data on percentage of heart attack were obtained from the Center for Health Statistics, Texas Department State Health Services for the years 2005-2006. The data were rounded to the next highest or lowest raw number based on the normalized percentage of patients reported to have high blood pressure in the overall population.
[y]Percent canopy was calculated using a normalized difference vegetation index calculated from satellite imagery (Landsat) to determine what proportion of each MSA was groundcover versus woody vegetation such as trees and shrubs.

No clear trend was seen when high blood pressure rates (percentages), heart attack rates (percentages) and Average NDVI ranking from highest to lowest were compared (Table 6 and 7).

Table 7: Average NDVI values ranked in highest to lowest corresponding to high blood pressure and heart attack values MSAs of Texas in the study of the effect of urban tree canopy cover and vegetation levels on the incidence of stress-related illnesses in Metropolitan Statistical Areas of Texas.

MSA	High blood pressure[z] (%)	Heart attack[z] (%)	Avg. NDVI ranking
Longview	30.4	6.1	1–highest
Tyler	<50[y]	6.9	2
Bryan-College Station	28.0	4.9	3
Beaumont-Port Arthur	38.4	5.7	4
Texarkana	<50[y]	11.5	5
Houston-Baytown-Sugarland	23.4	4.2	7
Austin-Round Rock	15.7	3.9	8
Sherman-Denison	<50[y]	8.2	9
Dallas-Ft. Worth-Arlington	23.3	3.8	10
Lubbock	33.5	4.5	11
San Antonio	23.3	2.9	12
Abilene	33.2	6.8	13-tie
Wichita Falls	<50[y]	4.8	13-tie
McAllen-Edinburg-Mission	19.5	3.0	14
Killeen-Temple-Ft. Hood	18.8	1.6	15
Corpus Christi	25.9	3.3	16
Brownsville-Harlingen	28.1	3.4	17
Waco	32.7	2.0	18

Table 7 - continued

MSA	High blood pressure[z] (%)	Heart attack[z] (%)	Avg. NDVI ranking
San Angelo	<50[y]	7.5	19
Amarillo	24.1	5.6	20-tie
Laredo	<50	0.0	20-tie
Odessa	<50	2.9	21
Midland	<50[y]	2.4	22
El Paso	19.0	2.8	23-lowest

[z]Data on percentage of high blood pressure were obtained from the Center for Health Statistics, Texas Department State Health Services for the year 2005-2006. The data were rounded to the next highest or lowest raw number based on the normalized percentage of patients reported to have high blood pressure and heart attack in the overall population.
[y]MSAs which had less than50 respondents who answered positively for high blood pressure diagnosis.

Demographic considerations and stress-related illness rates

Because population demographics, age, income levels and ethnicity are known to influence stress-related illness rates (CDC, 2012) and in order to control for these influences, the overall population for each MSA, along with the corresponding breakdown demographic information including ethnic background percentages, age percentages, and income levels from $15,000 to $24,000 percentage were collected from U. S. Census Bureau (U. S. Census Bureau, 2012).

The population of each MSA, the percent distribution within ethnicities, and percent high blood pressure and heart attack rate were organized (Table 8).

Table 8: Demographic breakdown, including overall population and percent distribution within ethnicity, and high blood pressure and heart attack rate for each Metropolitan Statistical Area (MSA) included in the study of the effect of urban tree canopy cover and vegetation levels on the incidence of stress-related illnesses in Metropolitan Statistical Areas of Texas.

MSA	Popn. (no.)	Cauc (%)	Afr-Am (%)	Asian (%)	Hisp (%)	Others	High blood pressure (%)	Heart attack (%)
Abilene	158,548	74.18	6.82	1.43	6.93	10.64	33.20	6.80
Amarillo	240,981	67.64	5.63	1.99	22.65	2.09	24.10	5.60
Austin-Round Rock	1,506,425	57.01	7.39	4.3	29.35	1.95	15.70	3.90
Beaumont-Port Arthur	378,793	62.00	24.42	2.16	9.86	1.56	38.40	5.70
Brownsville-Harlingen	387,717	12.58	0.10	0.78	86.07	0.47	28.10	3.40
Bryan-College Station	196,734	61.07	13.16	3.79	20.25	1.73	28.00	4.90
Corpus Christi	414,379	38.50	3.23	1.27	55.27	1.73	25.90	3.30
Dallas-Ft. Worth-Arlington	6,006,094	53.10	13.92	4.67	26.48	1.83	23.29	3.81
El Paso	734,669	14.10	2.44	0.98	81.40	1.08	19.00	2.80
Houston-Baytown-Sugarland	5,542,048	43.22	16.80	5.56	32.91	1.51	23.40	4.20

Table 8 - continued

MSA	Popn. (no.)	Cauc (%)	Afr-Am (%)	Asian (%)	Hisp (%)	Others	High blood pressure (%)	Heart attack (%)
Killeen-Temple-Ft. Hood	355,958	57.72	19.19	2.41	17.24	3.44	18.80	1.60
Laredo	231,470	78.78	0.17	0.50	[y]	[y]	[z]	0.00
Longview	207,652	69.17	17.97	0.59	10.75	1.52	30.40	6.10
Lubbock	260,548	59.70	7.12	1.47	30.32	1.39	33.50	4.50
McAllen-Edinburg-Mission	700,634	8.81	0.39	0.75	89.45	0.06	19.50	3.00
Midland	124,380	56.43	6.60	1.11	34.86	1.00	[z]	2.40
Odessa	127,462	45.44	4.41	0.34	49.48	0.33	[z]	2.90
San Angelo	105,325	60.01	4.26	0.29	33.56	1.88	[z]	7.50
San Antonio	1,948,437	38.25	5.91	1.75	52.67	1.42	23.30	2.90
Sherman-Denison	118,478	81.20	5.73	0.84	9.25	2.98	[z]	8.20
Texarkana	134,510	68.30	24.19	0.50	4.28	2.73	[z]	11.50
Tyler	194,635	64.85	17.88	0.89	14.77	1.61	0.00	6.90
Victoria	112,461	48.28	4.19	1.27	43.95	2.31	[z]	1.90
Waco	226,189	61.54	14.50	1.64	20.97	1.35	32.70	2.00
Wichita Falls	146,497	74.29	8.69	1.82	12.72	3.00	[z]	4.80

[z] Data were missing because these MSAs had less 50 respondents who answered positively for high blood pressure diagnosis.
[y]Data were missing because United States Census indicates that data for this geographic area cannot be displayed because the number of sample cases is too small.

Controlling for external variables

A linear regression analysis was used to calculate the extent to which age, income levels, population and ethnicity covaried with heart attack and blood pressure (Table 9 and 10). An unstandardized residual of stress-related illness variables was calculated which indicated the stress-related illness rates for each MSA controlling the extent to which age, income levels, population and ethnicity covaried with heart attack and high blood pressure in this study. This calculated value is used later in the study to independently assess the relationship of each stress-related illness with the variables of interest (NDVI and percent canopy cover) while controlling for the external variables identified. No variables were found to be statistically significant related to high blood pressure (Table 9). However, age over 45 years was statistically significant related to heart attack rates (*P*=0.03) (Table 10).

Table 9: Linear regression analysis calculating the extent to which population, ethnicity, income levels and age covaried with high blood pressure rates in the study of the effect of urban tree canopy cover and vegetation levels on the incidence of stress-related illnesses in Metropolitan Statistical Areas of Texas.

Model	**Unstandardized coefficients**		**Standardized coefficients**		
	B	**SE**	***ß***	**t**	***P***
Constant	4.917	22.230		0.221	0.828
Age group over 45 years[z]	0.432	0.680	0.201	0.635	0.536
Income group $15,000 to $24,999[z]	0.424	1.205	0.108	0.352	0.731
African American[z]	-0.037	0.347	-0.035	-0.105	0.981

[z]These variables were selected to control for on the basis of a literature review indicated the impact of each of these on high blood pressure.

Table 10: Linear regression analysis to calculate the extent to which population, ethnicity, income levels and age covaried with heart attack rates in the study of the effect of urban tree canopy cover and vegetation levels on the incidence of stress-related illnesses in Metropolitan Statistical Areas of Texas.

Model	**Unstandardized coefficients**		**Standardized coefficients**		
	B	**SE**	***ß***	**t**	***P***
Constant	-3.269	5.079		-0.644	0.527
Age group over 45 years[z]	0.350	0.105	0.616	3.330	0.003*
Income group $15,000 to $24,999[z]	0.018	0.200	0.071	0.090	0.929
Caucasian[z]	-0.058	0.068	-0.171	-0.856	0.401

[z]These variables were selected to control for on the basis of a literature review indicated the impact of each of these on heart attack rates.
***Statistically significant at the 0.05 level**.

Percent canopy cover and stress-related illness

A Pearson's product-moment correlation between the percent canopy cover and the residual stress-related illness variables was calculated. This resulted in a semi-partial correlation investigating the relationship between percent canopy cover and each stress-related illness controlling for the effect of external variables including population on each stress-related illness. No statistically significant relationships were found (Table 11). This suggested that there was no relationship between percent canopy cover and the prevalence of stress-related illness in humans when controlling for the external demographic variables previously identified in the study.

Table 11: Semi-partial correlations between percent canopy cover and residual heart attack and blood pressure independent of the effects of population in the study of the effect of urban tree canopy cover and vegetation levels on the incidence of stress-related illnesses in Metropolitan Statistical Areas of Texas.

Control variables			Heart attack residual[z]	Blood pressure residual[z]
Population	Percent canopy cover[y]	Correlation	0.039	-0.205
		P	0.885	0.447
		N	15	15

[z]Calculated by linear regression analysis which indicated the heart attack and high blood pressure rates for each Metropolitan Statistical Area controlling for the extent to which population, age, income level and ethnicity covaried with heart attack and high blood pressure in this study.
[y]Calculated using a normalized difference vegetation index calculated from satellite imagery (Landsat) to determine what proportion of each MSA was groundcover versus woody vegetation such as trees and shrubs.

NDVI and Stress-related illness

A Pearson's product-moment correlation between the minimum, maximum and average NDVI and the residual stress-related illness variables was calculated. This resulted in a semi-partial correlation investigating the relationship between minimum, maximum and average NDVI and each stress-related illness controlling for the effects of external variables including population on the stress-related illnesses. No statistically significant relationship was found. This finding indicated that, in this study, there was no relationship between overall levels of vegetation calculated by the NDVI and stress-related illness in humans independent of the external demographic variables identified previously.

Table 12: Semi-partial correlation between minimum, maximum and average normalized difference vegetation index and heart attack and high blood pressure independent of the effects of ethnicity, age, income levels and population in the study of effect of urban tree canopy cover and vegetation levels on the incidence of stress-related illnesses in Metropolitan Statistical Areas of Texas.

Control variable			**Min NDVI[z]**	**Max NDVI[z]**	**Avg. NDVI[z]**
Population	Heart attack residual[y]	correlation	0.200	0.336	0.328
		P	0.458	0.203	0.215
		N	15	15	15
	High blood pressure residual[y]	correlation	-0.133	0.379	-0.085
		P	0.624	0.148	0.754
		N	15	15	15

[z]Calculated from satellite imagery for each MSA. This index is a simple numerical indicator used to analyze remote sensing measurements to determine the amount of green vegetation in the observed target. The resulting index range for this calculation is -1 to 1 (barren/non-vegetation to dense green vegetation, respectively).
[y]Data on percentage of high blood pressure were obtained from the Center for Health Statistics, Texas Department State Health Services for the year 2005-2006. The data were rounded to the next highest or lowest raw number based on the normalized percentage of patients reported to have high blood pressure and heart attack in the overall population.

CHAPTER V
SUMMARY, CONCLUSIONS, RECOMMENDATIONS

Purpose of the Study

The intent of this study was to determine if rates of stress-related illnesses in people living in Metropolitan Statistical Areas (MSAs) of Texas were related to the levels of tree canopy cover or amount of vegetation in MSAs of Texas. Specific objectives for this study included:

1. Collection of published data on stress-related illnesses in humans living in MSAs of Texas.
2. Mapping rates of numbers of patients suffering from stress-related illnesses in different MSAs of Texas.
3. Mapping the tree canopy cover for different MSAs of Texas.
4. Mapping vegetation levels for different MSAs of Texas.
5. Comparing the stress-related illness rates in different MSAs of Texas with the mapped tree canopy cover and vegetation levels to determine if stress-related illness rates are related to tree canopy cover/vegetation coverage.

Summary of the Review of Literature

The term "stress" has several different meanings; hence whenever it is used, it is important to distinguish between the stress as a cause (the condition or adverse circumstance that threatens an individual's psychological and physiological integrity), and stress as an effect (the resulting state of disturbance or distress). Stress can be defined as a process in which environmental demands strain an organism's capacity to adapt accordingly to the demands, resulting in both psychological as well as biological changes that could place a person at risk for illness (Cohen et al., 1995). Things that cause stress are called stressors (Rubin et al., 1993). Many events such as a disaster, life crisis, life changes, and daily hassles can be grouped as stressors (Rubin et al., 1993). Examples of stressors include: natural disasters such as hurricanes and/or earthquakes; major life changes such as disease, divorce, unemployment, marriage, and or daily problems such as traffic jams (Rubin et al., 1993). Stress affects everyone, young and old, rich and poor (Despues, 1999). Stress is not necessarily a bad thing (Despues, 1999).

Stress induces changes in blood pressure and left ventricular function in mild hypertension (Lindvall et al., 1991). Mental stress induces a rapid increase in heart rate as well as in systolic arterial pressure (Forsman and Lindblad, 1983). Stress elicits hypothalamic-pituitary-adrenal axis activation (i.e. increased glucocorticoid secretion), which may contribute to subsequent blood pressure elevation (Davis et al., 2002). It is well established that a sudden emotional activation can lead to an acute rise in arterial blood pressure (Forsman and Lindblad, 1983).

Nearly 76 million American adults have been diagnosed with high blood pressure (AHA, 2011). High blood pressure was a primary cause of death for 326,000 Americans in 2006 (Lloyd et al., 2009). About one out of three U.S. adults has high blood pressure (NCHS, 2008). Heart attack and high blood pressure are the two major stress-related illnesses (NICH, 2004). A survey by CDC reports that over 616,000 people died of heart diseases in the United States in 2008 and almost every one out of four deaths is due to heart attack (CDC, 2012). In 2010, coronary heart disease alone was projected to cost the United States $108.9 billion (Heidenreich et al., 2011).

Forty-three percent of all adults experience adverse health effects due to stress (APA, 2002). Heart disease is the leading cause of death for people of most ethnicities in United States, including African Americans, Hispanics and Whites. African Americans suffer the most deaths at about 24.4 percent (Minino, 2011).

In general, it is seen that urbanized lifestyle has led to people spending 80 percent or more of their time in indoor settings (Fjeld et al., 1998) and research has suggested that interior plants may offer some psychological and restorative values such as reduced tension (Ulrich et al., 1991), better coping mechanisms (Lohr and Pearson-Mims, 2000), and increased ability for concentration and attention (Taylor et al., 2001). A recent study found that employees in offices with plants rated their job satisfaction more positively when compared to employees in offices with no plants present (Dravigne et al., 2008). In another study, plants and daylight lamps in an office environment were found to reduce health problems like fatigue, headaches and reports of dry and sore throat and dry hands (Fjeld et al., 1998). The popularity of plants in interior settings shows a need amongst office workers for having greenery close by.

International studies have documented positive health effects of green areas on human health (Kaplan and Kaplan, 1989; Marcus and Barnes, 1999; Ulrich, 1984). Recent studies have indicated that contact with nature, even if only visual, is beneficial for mood, aided in recovery from mental fatigue and improved behavior and health (Hartig et al., 1991; Kaplan, 1995; Taylor et al., 2001; Wells, 2000). The state of reduced mental fatigue and recovery of attention is referred to as a “restorative experience”

(Kaplan et al., 1998). The researchers also reported that, "views of vegetation foster restoration from stress apparently because of a combination of beneficial effects. They produce increases in positive feelings; reduce negatively toned or stress-related feelings such as fear, anger or sadness; hold interest/attention effectively and hence may block or reduce stressful thoughts" (Ulrich and Parsons, 1992, p. 105). Another researcher argued that the lack of contact with nature might contribute to certain mental and social problems among city dwellers (Stainbrook, 1973).

Urban vegetation levels or tree canopy adds value to local communities because it is integral to land use planning, mitigating water and energy shortages, improving air control, protecting global climate, enhancing public health programs and increasing land value and local tax bases (McPherson, 2006). Because of the proximity of urban tree canopy to people, urban tree canopy can provide substantial environmental, social, economic and recreational benefits to urban dwellers (McPherson, 2006). Trees influence thermal comfort, energy use and air quality by providing shade, transpiring moisture, and reducing wind speeds. Trees improve air quality by lowering air temperatures, altering emissions from building energy use and other sources and removing air pollutants through their leaves. Urban trees in the conterminous United States remove some 784,000 tons of air pollution annually, at a value of $3.8 billion (Nowak et al., 2006). Trees act as natural filters and remove polluting gases by absorption through their leaves and other parts (Trowbridge and Bassuk, 2004). Both trees and herbaceous vegetation can directly absorb gaseous pollutants through stomata openings in their leaves (Akbari, 2002; Sieghardt et al., 2005).

Texas has a wide variety of climate and geography conditions across the state, which leads to a wide variety in native vegetation across its natural regions (Diamond et al., 1987). Classifications of different vegetations that occur across the state include forests, woodlands, shrublands, grasslands, swamps and marshes (Diamond et al., 1987).

Methodology

Metropolitan statistical areas of Texas

The state of Texas has been divided into 25 different Metropolitan Statistical Areas (MSAs) for the purposes of demographic and statistical analyses by various departments and organizations in Texas (Labor Market and Career Information Department of the Texas Workforce Commission, Real Estate Center at Texas A&M University, 2006). Each MSA is comprised of a county or group of counties with a population of at least 75,000 inhabitants and contains a central city or urbanized area of at least 50,000 people (Labor Market and Career Information Department, 2006). Metropolitan Statistical Areas, or MSAs, included the following regions: Abilene, Amarillo, Austin-Round Rock, Beaumont-Port Arthur, Brownsville-Harlingen, Bryan-College Station, Corpus Christi, Dallas-Fort Worth-Arlington, El Paso, Houston-Sugarland-Baytown, Killeen-Temple-Fort Hood, Laredo, Longview, Lubbock, McAllen-Edinburg-Mission, Midland, Odessa, San Angelo, San Antonio, Sherman-Denison, Texarkana, Tyler, Victoria, Waco and Wichita Falls.

Stress-related illness data collection

The stress-related illness data were compiled and compared within the 25 Metropolitan Statistical Areas of Texas (Vincent, 2012). Each MSA was analyzed and ranked in order from highest to lowest percentage of high blood pressure (Table 1) and heart attack (Table 2). Respondents within MSAs were asked the questions: "Have you ever been diagnosed with high blood pressure?" and "Have you ever been diagnosed with a heart attack?" If they responded "yes" to the questions, they were included in the sample for their corresponding MSA. Some MSAs did not have a total of at least 50 respondents answering the high blood pressure diagnosis questions positively. Therefore, for some MSAs, data was missing for high blood pressure (Table 1).

The Texas Department of State Health Services communicated the total sample size for each stress-related illness including high blood pressure and heart attack for every MSA (Table 1 and 2). The number of patients suffering from each specific type of stress-related illness was recorded in the form of a percentage, in order to normalize the sample data to general population, for data analysis (Vincent, 2012). Stress-related illness data was collected from the Center for Health Statistics, Texas Department of State Health Services for the year 2006 (Vincent, 2012).

Mapping of stress-related illness data with corresponding vegetative cover

Mapping of urban tree canopy and vegetation levels of MSAs of Texas was performed in collaboration with Texas A&M University using ArcView® 10 designed by Environmental Systems Research Institute (ESRI, Redlands, CA 2010).

To determine the percent urban canopy or vegetation levels for the MSAs in this study, a normalized difference vegetation index (NDVI) was calculated from satellite imagery (Landsat) for each MSA. Landsat Satellite Imagery, was performed with the sensors which measure the amount of reflected energy for each 30m X 30m area for each of the seven segments of the electromagnetic spectrum. There are total of seven bands of the data for Landsat. Each band of data provides a record of the amount of energy reflected in a specific portion of electromagnetic spectrum.

For this study, out of seven bands, only two bands (near infrared and red) were used. These two bands were required to calculate NDVI. This index was used as a simple numerical indicator to analyze remote sensing measurement to determine the amount of green vegetation in the observed target area. The resulting index range for this calculation was between -1 to 1 (barren/non-vegetation to dense green vegetation, respectively).

The calculation was as follows (NIR = near infrared): NDVI = (NIR - Red) / (NIR + Red).

Landsat 5™ imagery was obtained from United States Geological Survey (U.S.G.S.) Glovis site (U.S. Department of the Interior, 2010). Image “tiles” were downloaded to cover the extent of all MSAs included in the study. Each “tile” covered an area of 185 km (115 mi) wide. In order to obtain an accurate NDVI for each MSA, the imagery must be high quality and as cloud free as possible. The images selected and used in the study were designated by U.S.G.S. as having a cloud cover of 0% and an image quality of 9 out of 10 (Note that 0 percent cloud cover may still include isolated clouds). The downloaded image tiles were for the maximum foliage months of April to September 2006 when possible.

The tiles were then “mosaiced” or pieced together to create one seamless image for each MSA. “Mosaicing” merges adjacent tiles into one image file removing overlapping values between tiles. The NDVI was calculated for each image using ENVI™ (Redlands, CA) image- processing software. This process resulted in a grid with values ranging from -1 to 1.

The NDVI grid was transferred to the GIS software, where statistics were calculated for each MSA using the Multi-Resolution Land Characteristics (MRLC)

National Land Cover Data canopy cover dataset. Statistics generated included the minimum NDVI value, the maximum NDVI value, and mean NDVI value.

External Variables

Data were collected on several external variables which were known to precipitate symptoms of stress-related illness in order to control the impact of those variables in this study (CDC, 2012). Age, income level, population and ethnicity data for each MSA were obtained from the United States Census Bureau (2012). Age over 45 years and income level of $15,000 to $24,000 has been reported to increase the chance of high blood pressure and heart attack (CDC, 2012). African Americans suffer more from high blood pressure problems whereas Caucasians suffer more from heart attacks (CDC, 2012).

Data Analysis

Stress-related illness data, NDVI and canopy cover data were analyzed using PASW® Statistics 18 (Chicago, IL). Descriptive statistics analyzed the vegetation cover levels for each MSA. A linear regression analysis was used to calculate the extent to which age, income levels and ethnicity covaried with stress-related illnesses. Semi-partial correlations were calculated to analyze the relationship between tree canopy cover/vegetation rate and stress-related illness rate variables while controlling for the effects of age, income levels, population and ethnicity on stress-related illnesses.

Results and Discussion

Summary of findings related to Objective One

Objective one was to collect published data on stress-related illnesses in humans living in MSAs of Texas. The stress-related illness data was gathered from the Center for Health Statistics, Texas Department of State Health Services for the year 2006 (Vincent, 2012). Beaumont-Port Arthur MSA had the highest high blood pressure rate at 38.4

percent. The Austin-Round Rock MSA had the lowest high blood pressure rate at 15.7 percent.

The Texarkana MSA had the highest heart attack rate at 11.5 percent. The Laredo MSA had the lowest heart attack rate at 0.0 percent (i e. there were no heart attack patients in year 2006).

Summary of findings related to Objective Two

Objective two was to map rates of numbers of patients suffering from stress-related illness in different MSAs of Texas. An overall map of stress-related illnesses as it related to specific MSAs within Texas did not appear to reflect any clear pattern of stress-related illness rates in different vegetative regions of the state.

Summary of findings related to Objective Three

Objective three was to map the tree canopy cover for the different MSAs of Texas. The MSAs located in and around the Piney Woods natural region of East Texas had the highest rates of percent canopy cover. The lowest percent canopy cover occurred in MSAs located in the furthest northwest region of Texas (Odessa and Midland) and the Texas Panhandle area (Lubbock) (Preserving Texas' Natural Heritage, 1978).

Summary of findings related to Objective Four

Objective four was to map vegetation levels for different MSAs of Texas. The MSAs were listed in order from highest to lowest average NDVI value. Longview MSA averaged 0.53 NDVI, while Tyler had a 0.51 average NDVI and the College Station-Bryan average NDVI value was 0.48. El Paso averaged the lowest rate of vegetation at 0.02, while Midland stood 2nd lowest at 0.07. Odessa had the third lowest average NDVI score, at 0.08.

Summary of findings related to Objective Five

Objective five was to compare the stress-related illness rates in different MSAs of Texas with the mapped tree and vegetation levels to determine if stress-related illness rates were related to tree canopy cover/vegetation coverage. Calculated canopy cover data values for each MSA were compared to their corresponding percentage of stress-related illnesses (i.e. high blood pressure and heart attack) from objective one. No clear corresponding orders were seen in rankings between the high blood pressure and heart attack percentages and the corresponding percent canopy covers for each MSA.

No clear trend was seen when high blood pressure rates (percentages), heart attack rates (percentages) ranking lowest to highest and MSAs with average NDVI ranking from highest to lowest were compared.

A Pearson's product-moment correlation was calculated between the percent canopy cover and the residual stress-related illness variables while controlling for the effect of external variables on each stress-related illness. No statistically significant relationships were found. This suggested that there was no relationship between percent canopy cover and the prevalence of stress-related illness in humans when controlling for the external demographic variables previously identified in the study.

A Pearson's product-moment correlation was calculated between the average NDVI and the residual stress-related illness variable while controlling for the effects of external variables on the stress-related illnesses. No statistically significant relationship was found. This finding indicated that, in this study, there was no relationship between overall vegetation calculated by the NDVI and stress-related illness independent of the external demographic variables identified previously.

Statement of Conclusions

It is concluded from this research that tree canopy cover/vegetation levels have no relationship with stress-related illness rates. Statistical analyses of collected data also did not reveal any relationships between the variables. However, results of this study also did not suggest that stress-related illness rates were aggravated by the presence of increased tree canopy cover/vegetation levels.

These results were surprising given that past research suggested that visiting green areas in cities can counteract stress, renew vital energy, and speed healing processes (McPherson, 2000). People who live in a greener environment showed more signs of healthy living (De Vries et al., 2003). Furthermore, a study documented that if college students under stress from an exam viewed plants, their positive feelings increased, while fear and anger decreased (Ulrich, 1979). Even brief visual contact with plants, such as urban tree plantings or office parks, might be valuable in restoration from mild daily stress. Views of nature had positive, physiological impacts on individuals whether or not they were consciously aware of them (Ulrich and Simon, 1986).

Two major stress-related illnesses which were selected for this study were high blood pressure and heart attack. While several external variables were considered and controlled for, this indicated that these stress-related illnesses are related to various variables which were not able to be considered or controlled for statistically. For example, Rosengren et al. (2004) identified a set of psychological stressors including workplace and home stress, financial problems, major life events in the past years, depression and external locus of control that were significantly related to the risk of heart attack. Many events such as a disaster, life crisis, life changes, and daily hassles can be grouped as “stressors” (Rubin et al., 1993). Also, in this study, detailed information of respondents on their location or area where they reside (urban or rural) was not provided by the agency.

Therefore, as data used in this study was very limited in terms of number of respondents, location or area of residence of respondent as well as data limitations on potential influential external variables (employment status, physical health, family conditions, genetics, etc.) which could have impacted stress-related illness rates.

Recommendations for Further Research

1. It is recommended that when conducting future research that more detailed stress-related illness data sources be used since data for this study was somewhat limited from the source agency.
2. It is recommended that future research focus on detailed information of residence of the respondents to know if respondents are from rural or urban areas of a MSA, since in this study this detailed information of respondents was not provided by the agency. Past research has found that people living in urban areas suffer more from stress-related illnesses than their rural counterparts.
3. It is recommended that future research focus on comparing the relationship of stress-related illness and tree canopy cover/vegetative cover between geographical/vegetative regions of the entire United States in order to look at more extensive data with regards to sample sizes and vegetative data.

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