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Urban Growth in Central Texas: Soils and Single-Family Home Development

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Urban Growth in Central Texas: Soils and Single-Family Home Development

by

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Abstract

Urban Growth in Central Texas: Soils and Single-Family Home Development

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This study investigates the potential impacts on soils from development practices associated with new single-family residential home construction in the extra territorial jurisdiction (ETJ) of Pflugerville, Texas. My research question is: Are regulations that directly focus on soil conservation advisable within Pflugerville's ETJ, and what areas of development ought to be primarily targeted by these regulations in order to better ensure the long-term stability of soil health and the minimization of soil loss? The rationale for this question is based on the city's projected future population growth, the projected future demand for single-family residences, as well as the development and management practices typically associated with new single-family residential development in the ETJ of Pflugerville. I hypothesize that due to Pflugerville's proximity to Austin and Round Rock, in addition to the relative abundance of available land to the east of the city of Pflugerville, that it is likely to continue experiencing sustained population and residential development growth, particularly in the form of new single-family residences in the ETJ. A population projection was conducted up to the year 2030, which in conjunction with average persons-per-household and single-family home permitting data, estimates potential consumer demand for single-family residences. The imperative to prevent soil loss is conceptually linked to ecosystem service benefits resulting from healthy and intact soils, such as improved water quality and the regulation of peak flow rates during storm events. Single-family residential development is evaluated in terms of conventional on-the-ground construction practices gathered from interviews with developers of single-family homes in the Pflugerville ETJ, as well as planning and regulatory specialists. These analyses are intended to inform regulatory and decision making processes regarding the importance and potential integration of soil preservation and conservation at the individual construction site level.

Table of Contents

Chapter 1: Research Question and Topic Background

In recent decades a profound and unprecedented shift has been taking place across the globe. In developed and developing nations alike, people are migrating to urban and urbanizing areas at a rate never before experienced. Nearly half of all people in developed countries and close to 75% of the developing world currently live in cities (United Nations, 2002; Bierwagen, 2005). Researchers contend that if these trends continue, by the year 2050 more than 50% of the entire world's population will reside in urban areas (Newman and Jennings, 2008). This trend of urban expansion, often in the form of poorly planned residential and commercial sprawl, has widespread implications for soils and the ecosystem services which they support. Ecosystem services refer to "the benefits of nature to households, communities, and economies" that are derived without direct economic cost by the recipient (Boyd & Banzhaf, 2007). A few brief examples of ecosystem service benefits resulting from healthy and intact soils include water quality preservation, regulation of storm water runoff, reduced soil loss due to the effects of erosion, decomposition of organic matter, detoxification of organic pollutants, nutrient cycling, and the production of food and fiber for human use (Stokstad, 2005). These numerous benefits provide a broad justification for protecting soils from long-term damage at the construction site level through more effective development regulation.

My study focuses on the growing Central Texas city of Pflugerville. The criteria used in selecting Pflugerville as the focal city of this research project is based upon a combination of several key attributes. First, the city's population has grown considerably over the past decade (in terms of total population) and continues to grow, which indicates a strong likelihood that the area (in terms of new single-family residential housing units) will expand beyond its current city limits and move increasingly into the unregulated extraterritorial jurisdiction (ETJ). The broad imperative to preserve long-term soil stability aimed specifically at certain residential construction practices (addressed in terms of soil loss from erosion) make up the primary analytical criteria applied to Pflugerville. I hypothesize that future single-family residential development will be located disproportionally in Pflugerville compared to the immediate surrounding region (in terms of the overall rate of new development), and specifically to sites in the city's current ETJ, due to its proximity to two large nearby urban centers of employment; Round Rock to the northwest and Austin to the southwest.

My hypothesis was constructed based on the observation that there is a large amount of developable land to the east of downtown Pflugerville, which differentiates it from similar cities near both Austin and Round Rock. Cedar Park is a good example of a city situated in a similar context to that of Pflugerville. However, the land lying to the south and to the west of Cedar Park is much less developable than areas to the east of Pflugerville. This is due to development restrictions imposed by Travis County to protect the Edwards Aquifer recharge zone, in addition to the highly desirable and therefore often prohibitive cost of land around Lake Travis and to the west of Austin, not to mention the added construction costs of developing in rocky terrain. Land to the east of Pflugerville on the other hand, butts up against fewer development restrictions and still is in close proximity to both Austin and Pflugerville. Additionally, due to the predominance of "single-family, detached houses that are more affordable than other communities in the region," the city of Pflugerville is likely to experience a disproportionately heavy push for prolific, low-density development (City of Pflugerville 2030 Comprehensive Plan). Although the comprehensive plan for the city specifically states that it seeks to curtail this type of low-density residential development in the future, it has yet to be seen if the existing regulations based on the 2030 plan will be successful in suppressing such development. My hypothesis speaks to the research question proposed by this study: How will the likely future demand and development of new single-family residences in Pflugerville's ETJ potentially contribute to soil loss and erosion? The imperative to preserve soils is an extension of the movement to conserve the many indispensible ecosystem processes and services provisioned by healthy functioning soils, such the natural decontamination of groundwater.

Land use changes are bound to impact and alter local soil conditions and processes in both intended and unintended ways. Some ecological impacts caused by the alteration of soils include changes to local hydrology, water quality, vegetation abundance, biodiversity, and microclimate management (Alberti, 1999; Conway, 2009). These changes are most typically associated with negative outcomes over both short and long-term time scales, which result from certain prolific development practices like clear-cutting and soil compaction. Understanding this connection is the first step in tailoring development practices and development regulations to more fully account for their ecological impacts.

Preserving undisturbed soils is integral to maintaining the necessary processes they carry out. Soil processes can be thought of as the chemical and material inputs, outputs, and transformations occurring within soils themselves or which are dependent on soils to properly function (Palm et al., 2007). The term soil health is used here to describe the ability or capacity of soils to function as a living system, within ecosystem and geographic boundaries, and to support plant and animal productivity and health, as well as to maintain or enhance water quality (Doran and Zeiss, 2000). The impacts of new development, especially prolific new development such as in the case of single-family residential construction, often have negative impacts on soils and soil ecological processes due in large part to tacit practices that disregard the ecological ramifications of particular development practices occurring onsite. The fact that a lack of effective development regulation often exists in the ETJ's of many urban areas, like Pflugerville's ETJ for instance, exacerbates the scope and gravity of the issue. It is for these reasons that the research carried out here is focused on informing and influencing development regulators, as well as city planners and policy makers who have the collective potential to cultivate a regulatory environment better suited to minimizing the negative impacts from development related to onsite soils and thereby maximizing the ecological integrity and overall quality of life for the area.

A schematic representation of my research design is presented in Figure 1.

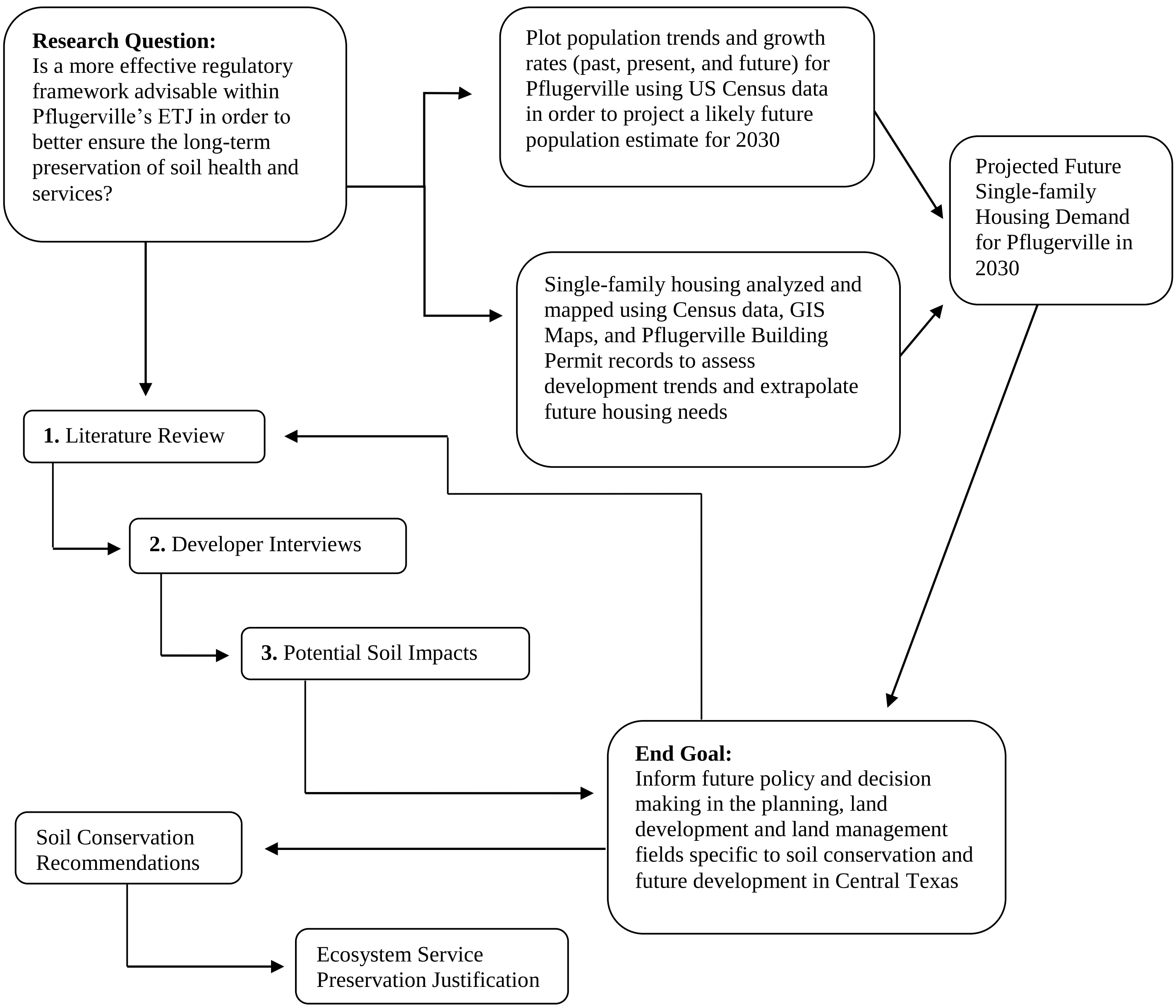


Figure 1: Future Scenario Planning

Before discussing where Pflugerville is likely headed, in terms of future population and new development, it will be helpful to investigate its past. The following is a brief history of the settlement and development of Pflugerville, Texas.

Pflugerville, Texas

The city of Pflugerville was founded in 1860 by Mr. William Bohls. The city began its life as a small farming and ranching town tucked into the Texas black-land prairie on a site approximately 15 miles northeast of Austin (http://www.cityofpflugerville.com; Handbook of Texas Online). The city was named after German immigrant Henry Pfluger who originally owned a ranch homestead near what later would become the present day city of Pflugerville (http://www.cityofpflugerville.com/index.aspx?nid=18).

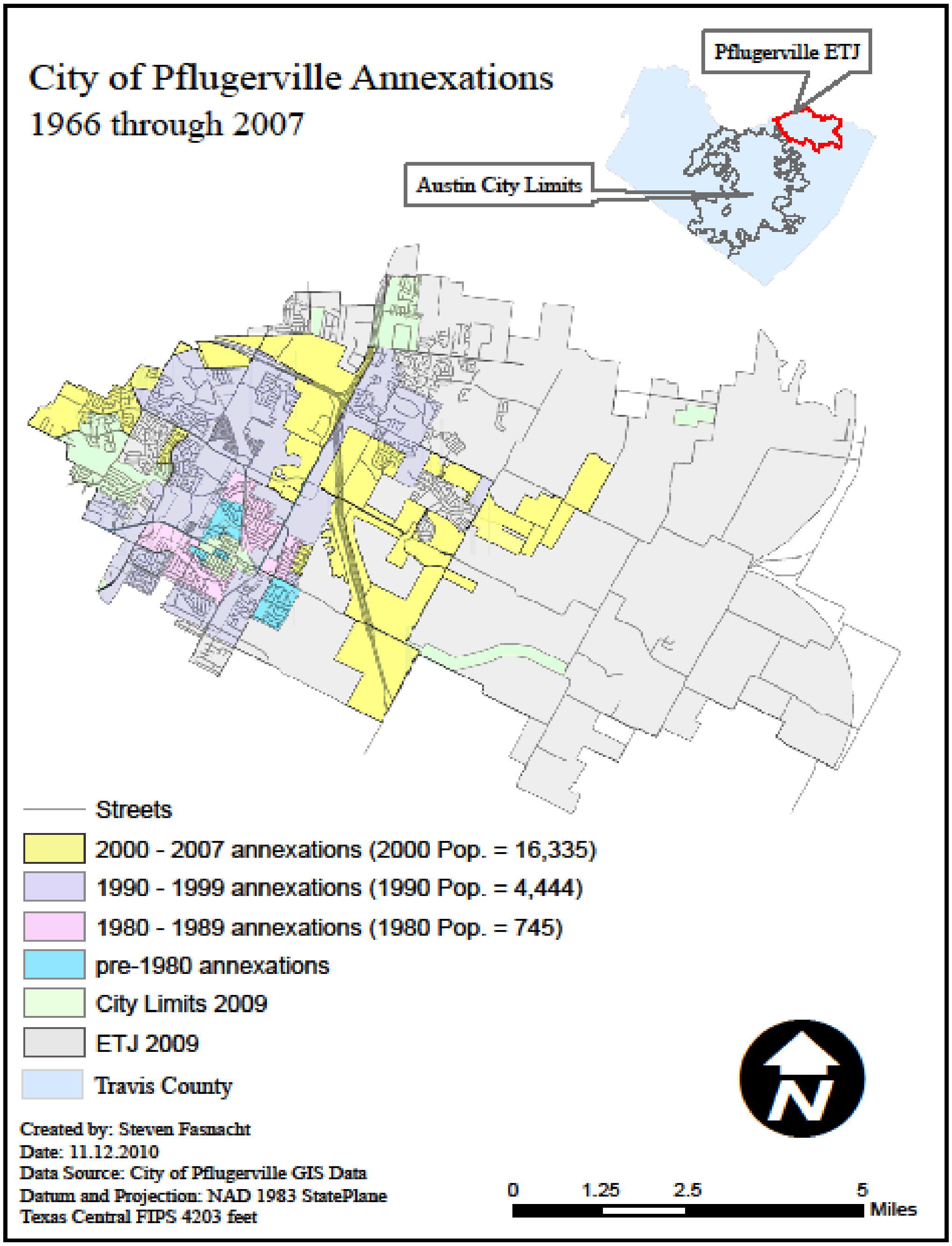
Pflugerville's population growth was rather torpid until the turn of the 20th century with the arrival of the Missouri-Kansas-Texas railroad line in 1904 (http://www.cityofpflugerville.com). With the greatly increased ability to transport goods to a greater number of markets, business in Pflugerville boomed. As the city made the most of these new opportunities, the population grew to accommodate the needs of the new businesses and to take advantage of the regions newfound prosperity. Pflugerville did quite well for itself, in terms of population growth and overall development, until the great depression and on through World War II when many residents packed their bags and headed to larger, more prosperous cities.

The city of Pflugerville has been growing in population since the time it was first incorporated as a municipal entity in the year 1965 (http://www.cityofpflugerville.com). More specifically, during the eight years between 1980 and 1988 the city of Pflugerville's rate of new development surpassed all other communities in the state (http://www.cityofpflugerville.com). The city's growth was so great that its boundaries began to blur with those of northeast Austin (City of Austin History Center). This expansion of Pflugerville can be attributed in large part to the economic boom that occurred in Austin during the same time period, which was driven by increasing outside investment interests in Austin, primarily in the form of land speculation and development (Orum, 1987).

New development in Pflugerville slowed considerably in the late 1980's due to the economic recession experienced throughout the state of Texas (Handbook of Texas Online). However, the general trend of increasing population growth and new development was not halted in Pflugerville. As the city's population continues to expand geographically and necessitate increasing amounts of new development, specifically housing, concerns over the ecological ramifications still greater future urban expansion may bring to the municipal region are beginning to be raised.

The city of Pflugerville has been working to protect and maintain many of its important environmental amenities and sensitive ecological areas from development pressures, such as Gilleland and Wilbarger Creeks and their corresponding riparian corridors which support local wildlife (City of Pflugerville 2030 Comprehensive Plan). In general, the city has been adopting development regulations that cater to some specific goals by which to guide and govern future growth. First, Pflugerville is a city invested in increasing its current level of urban density though greater infill development (City of Pflugerville 2030 Comprehensive Plan). Infill development is defined as "the planned conversion of empty lots, underused or rundown buildings, and other available space in densely built-up urban and suburban areas for use as sites for commercial buildings and housing, frequently as an alternative to overdevelopment of rural areas" (Dictionary.com; accessed 2010). A second major tenant of the 2030 Comprehensive Plan flows directly out of this first imperative.

The vast majority of available and developable land in Pflugerville resides to the east of the city's downtown. "Most of the area is currently undeveloped but faces immense pressures" from development interests (City of Pflugerville 2030 Comprehensive Plan). The city wants to avoid an unplanned, free-for-all mindset driving new development to the east. Rather the city seeks to focus on new development projects that cluster into specific centers or hubs allowing for connectivity and integration with the existing urban core while avoiding new development in the city's currently unincorporated areas (City of Pflugerville 2030 Comprehensive Plan). Those areas in the ETJ which have not yet been annexed by the city of Pflugerville are considered to be unincorporated lands. (See Map 1 depicting land annexation trends in the city of Pflugerville.) The goal behind limiting development in the unincorporated areas reflects an effort to conserve open space land for development necessities likely to arise in the future, as well as current and future agricultural usages (City of Pflugerville 2030 Comprehensive Plan).



Map 1: Pflugerville Land Annexation History

Now that the city's background and future trajectory have been discussed, an investigation of literature pertaining to this research studies hypothesis will now be conducted.

Chapter 2: Literature Review

The following sections address related bodies of literature that contribute to and inform this research project. The argument that undisturbed or less severely disturbed soils are important to preserve in the face of escalating urban and sub-urban development due to the integral role they play in the provisioning and preservation of ecosystem service benefits and overall ecosystem functionality is investigated from several angles in this chapter. What follows is a brief road-map of sorts outlining the structure of this literature review.

This chapter is comprised of five different sections focusing on unique bodies of research related to and dealing with soils and development. First, literature on *Ecosystem Services* and *Ecological Economics* will be investigated as a means to initially frame and validate foundational aspects of this research inquiry. Understanding how soils directly contribute to a high quality of life through the services they provide, and potential ways to account for and measure these services are explored. The framing of the argument that undisturbed or less severely disturbed soils are important to preserve due to their integral role in the provisioning of so many ecosystem service benefits will be done in the *Ecosystem Services* literature review section. This section will focus primarily on identifying specific ecosystem service benefits associated with undisturbed/healthy soils as well as defining some terms used in the field. *Ecological Economics* is briefly investigated as a way to evaluate ecosystem service benefits in terms of the monetary costs their absence would engender, although the research conducted herein does not directly address or extend the scope of ecological economics. The literature review moves on to address *Soil Ecology* from this point.

The second section, entitled *Soil Ecology*, looks at the ways in which soils form, the characteristics and ecological processes indicative of healthy soils, and how healthy soils allow for the proper functioning and provisioning of a broad array of vital ecosystem services. Human impacts on soils and soil formation processes, in terms of development activities, are investigated as are the many connections between land use change and changes in soil health. Specific impacts to undisturbed soils via construction practices associated with prolific low-density development patterns, such as single-family detached housing units, will be investigated by this section as well.

The next two sections focus on general practices by which development activities may more conscientiously address on-site soil impacts resulting from construction activity, as well as potential avenues that may actually contribute to and promote soil conservation while still allowing for needed new developments. These topics and ideas are covered in the *Conservation Development* and *Low Impact Development* literature review sections.

Conservation Development is dedicated to forging mutually beneficial relationships between human development and natural resource/environmental conservation. Simply put, conservation development adheres to the precept that open spaces should be preserved as near to intact as possible for the benefit of the ecosystems as a whole, as well as for the enjoyment and use of future generations. This section describes the objectives and benefits of controlled/managed urban and sub-urban growth. Conservation development relies on predevelopment site planning in order to not only preserve an ample amount of existing open space but to take maximum advantage of existing green infrastructure, such as natural topography or healthy riparian zones. This approach not only retains a higher degree of the lands preexisting character than with traditional development, but it increasingly reduces the burden placed on future urban infrastructure. Although the general framework and guiding principles between conservation development and low impact development are nearly identical, their approaches differ. Where conservation development leaves off, in terms of making specific recommendations as to development practices, low impact development picks up.

Low Impact Development encourages many of the same objectives for new development activities that Conservation Development promotes. Low Impact Development however makes specific recommendations as to construction practices and land management techniques in order to reduce infrastructural burdens incurred by new development, most typically in terms of storm-water management. This subject will be covered in greater detail in the *Low Impact Development* literature review section.

Ecosystem Services

To better understand the concept of ecosystem services, it is useful to break down the term and define its constituent parts. An 'ecosystem' can be defined as "a set of interacting species and their local, non-biological environment functioning together to sustain life" (Moll and Petit, 1994; Bolund and Hunhammar, 1999). A 'service' is defined by Merriam Webster Dictionary as "useful labor that does not produce a tangible commodity" (Merriam Webster online Dictionary, accessed 2010). This use of the term 'service' can also be expanded to include the many tangible goods provided by ecosystem functioning and processes. A 'good' is defined as "something that has economic utility or satisfies an economic want" (Merriam Webster online Dictionary, accessed 2010). Certainly potable groundwater can be considered a directly consumable good whereas the many processes and services involved in the existence, availability and provisioning of clean groundwater are not monetized because of their "external" nature to the marketing and management of urban amenities. The term ecosystem service benefits encapsulate the definitions of an ecosystem, a service, and an economic good into one unified concept.

Ecosystem services are defined as the conglomeration of "benefits humans derive, directly or indirectly, from ecosystem functions" (Costanza et al., 1997; Bolund and Hunhammar, 1999). Another similar, though more systems oriented view is posed by Gretchen Daily, which states that "ecosystem services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (Daily, 1996; pg. 3). Additionally, ecosystem services are "socially important consequences of ecosystem processes" (Wall et al., 2004; pg. 9). Each of these definitions make explicit that the very notion of ecosystem services focuses on and necessitates an anthropocentric desire to improve and sustain the quality and longevity of human life across this planet.

The Millennium Ecosystem Assessment (2003) outlines several different categories of ecosystem service benefits in terms of the unique goods and services they provide. These include provisioning services, regulating services, and supporting services. Provisioning services can be thought of as the "products obtained from ecosystems, such as food, fiber, fuel, fresh water, biochemicals, genetic resources, and ornamental resources" that are used by humans, often for direct consumption in one form or another (MEA, 2003; pg. 57 – 59). Regulating services can be defined as "the benefits obtained from the regulation of ecosystem processes, including air quality maintenance, climate regulation, erosion control, water purification and waste treatment, pollination, and storm protection" (MEA, 2003; pg. 57 – 59). Similarly, supporting services represent the basic functions occurring within ecosystems at a variety of scales that "are necessary for the production of all other ecosystem services" (MEA, 2003; pg. 57- 59). Some examples of supporting services include the many processes facilitating soil formation, plant pollination, nutrient cycling, and biological/genetic diversity (Newman & Jennings, 2008). Each category of goods and services begins with essential ecosystem functions and processes operating healthfully and in tandem to sustain life.

Ecosystem processes can be thought of as the "inputs or losses of materials and energy to and from the ecosystem and the transfers of these substances among components of the system" (Wall et al., 2004; pg. 9). These interactions between biological and non-biological elements within ecosystems allows for a huge amount of variation in ecosystem functionality, which in turn provides humans with the great array of ecosystem service benefits we commonly experience and depend on. Ecosystem function is defined by De Groot et al. (2002) as “a translation of ecological complexity (structures and processes) into a more limited number of functions, where the functions, in turn, provide the goods and services that are valued by humans” (De Groot et al., 2002; pg. 394). Interestingly, ecosystem service benefits derived from healthy soils fit into all three of these categories.

A few examples of ecosystem services resulting from healthy and intact soils include the bioremediation of wastes and pollutants, provisioning of potable water, the mitigation of floods and droughts, erosion control, control of pests and pathogens, the production of food, fiber and fuel, as well as nutrient cycling (Wall et al., 2004). The presence of abundant vegetation, necessitating healthy soils, also helps to regulate the local microclimate. Take for instance the planting of street-trees as a tactic to mitigate the impact of urban heat island effects in many large cities. This is not the only difference in ecosystem service benefits of urban areas compared to non-urban or rural areas.

Those living in urban areas are much more aware of human imposed boundaries than those individuals living in a more rural setting, generally speaking. For example, in more urban settings one is met with different adjudications of land boundaries; from land within the city limits, land in the ETJ, and all the different geographic nuances which typically dominate inner-urban areas. However, “it is possible to define the city as one single ecosystem or to see the city as composed of several individual ecosystems” (Bolund and Hunhammar, 1999; pg. 294). Bolund and Hunhammar describe seven different facets of urban ecological systems that, although managed and manipulated, still function according to biophysical processes. The seven urban ecosystems described by the authors are street trees, lawns/parks, urban forest, cultivated land, wetlands, lakes/sea, and streams (Bolund and Hunhammar, 1999). Obviously many non-urban areas are home to the same sort of processes, which begs the question, how do ecosystem services change as a result of changing land uses over time?

My research attempts to bring the two elements of urbanization of non-urban land, and ecosystem service benefits conceptually closer together. While no long-term monitoring is conducted by my research, and the ecosystem services provided by undisturbed soils is neither directly measured nor monitored, my study does focus on each of the two aforementioned elements, the urbanizing of non-urban land and ecosystem service benefits, to offer future recommendations to those governing decisions dealing with how and where land-use changes occur. This latter facet speaks to the means by which better planning and regulating decisions can be made regarding impacts to undisturbed soils resulting from changing land use patterns. This area of ecosystem service literature is also generally lacking. Integrating the concepts, ideas, and values inherent in the definition(s) of ecosystem services into land use planning and developmental regulation decision making is an area that should and likely will be expanded by future research projects. Such concerns and objectives guide the research conducted here, as the final products are intended to contribute to the body of literature surrounding land use planning and regulation in terms of the numerous benefits derived from healthy, undisturbed soils.

Ecological Economics

Ecological economics, both as a concept and a practice reiterates the distinctly human perspective inherent throughout the discourse on ecosystem services and their ability to be monetarily quantified. Before beginning a discussion on the principal foundations and concepts associated with ecological economics, some key terms must first be defined. The word ecological refers to a branch of natural science "concerned with the interrelationships of organisms and their environments" (Merriam Webster online Dictionary, accessed 2010). Economics can be described as "a social science concerned chiefly with description and analysis of the production, distribution, and consumption of goods and services" (Merriam Webster online Dictionary, accessed 2010). Taken together, ecological economics can be thought of as a "transdisciplinary field of study that addresses the relationships between ecosystems and economic systems" in hopes that the undervaluing and discounting of ecosystem benefits may be mitigated through internalizing the existing neo-classical economic system that currently externalizes them (Costanza, 1991).

There are certainly many different forms economic systems can and do take, however for the purposes of this research the typical market driven or neo-classical economic model is used to juxtapose the model posed by ecological economics. The primary difference between the two models has to do with how each view the limits of economic growth. For instance, in a typical neo-classical economic system there are no limits to GDP growth as it is something which exists outside the confines of the natural world (Rees, 2003). This model is typically concerned with emphasizing efficiency to achieve the highest short-term return on initial investment, assumes that economic substitutions are always viable, and functions within a monetary framework (Rees, 2003). Conversely, ecological economics sees human economic systems as fundamentally rooted in the context of the natural world and subject to all the rules by which it functions. Typically this stance differs from the neo-classical view in that it proposes a closed economic system that draws sustenance from a finite natural world, favors long-term assessments and goals, and expands the monetary framework to include social capital (Rees, 2003).

The importance of value driven judgments cannot be over stated in the pursuit to understand the concept and practice of ecological economics. Something, be it a good or a service, must be valued in order for it to be preserved into the future. Herein lies the primary difficulty with the practice of ecological economics; it is hard to put disparate and diffuse ecosystem service benefits, wrought with so many "free-rider" and "double-counting" problems, in neat and familiar economic terms (De Groot et al., 2002). The term ‘double-counting’ refers to the fact that ecological functions and processes often overlap, for example gas-regulation can be valued individually or as part of the larger climatic framework, making some services more difficult to pin down in terms of economic valuation and categorization (De Groot et al., 2002). The term ‘free-rider’ refers to a situation in which one group pays for something, in this case the protection or provisioning of certain ecological services, but a dynamic prevails where other groups which have not contributed are able to take part in the use and enjoyment of these same services for free. What’s more, the very idea of valuation is a social construct existing for a certain number of people at a certain time, totally subject to and even driven by changing attitudes and preferences (Mendelsohn & Olmstead, 2009). This temporal nature of economic valuation and decision making often manifests itself into different concepts of valuation, which reflect differing priorities.

De Groot et al. (2002) explore three concepts of ecosystem valuation; ecological value, socio-cultural value, and economic value. Ecological value is “determined both by the integrity of the regulation and habitat functions of the ecosystem and by the ecosystem parameters such as complexity, diversity, and rarity” (De Groot et al., 2002; pg. 403). These conditions refer to the overall health and continuity present within an individual ecosystem, that is the level to which the specific ecosystem in question functions compared to other similar ecosystems and how it operates in conjunction with the many varied and unique ecological conditions which define its context.

Socio-cultural valuation deals with the ways in which social norms inform and influence value judgments which can vary widely across cultures. However, this difference may actually serve to unify cultures and society’s in that each has a common stake in preserving the benefits collected from the natural world. “Natural systems are thus a crucial source of non-material well-being” and function as the very foundation on which societies are based (De Groot et al., 2002; pg. 403).

Economic valuation tends to be the most widely applied form of value driven accounting. It encompasses four basic components: (1) direct market valuation, (2) indirect market valuation, (3) contingent valuation, and (4) group valuation (De Groot et al., 2002). Direct market valuation refers to the products or 'goods' generated by ecosystem functions which have monetary trade potential (De Groot et al., 2002). Similarly, indirect market valuation focuses on those products of ecosystem function that are less discrete and consequently more difficult to quantify, namely the 'services' rather than 'goods' generated from ecosystem function (De Groot et al., 2002). Contingent valuation deals with consumer preferences and consumer willingness to pay based on hypothetical scenarios involving different potential consumer choices (De Groot et al., 2002). Group valuation is an outgrowth of social and political theory stating that decisions made regarding the management and alteration of natural systems ought to be rooted in open public debate (De Groot et al., 2002).

For the most part, all of the authors referenced here are in mutual agreement in regard to the burgeoning necessity of re-evaluating how our economic systems view and value ecosystem service benefits. These authors agree that the practice of ecological economics reflects a helpful, albeit imperfect, economic accounting system allowing for previously externalized environmental factors in order to achieve more transparent and precise accounting. However, some contend that there is much lost in translation from trees to dollars and that ecosystems and ecosystem services as a whole will always be greater than the sum of their constituent parts. Relying too much on abstract economic principles can be a slippery-slope rewarding 'less-bad' behavior, especially in light of the many failures of neoclassical economic theory in terms of producing negative environmental impacts, although it is clear that small steps can produce great achievements if dedication to a higher set of goals is incorporated early on.

My research does not contribute directly to the field of ecological economics. No economic accounting is carried out within these pages, however this research builds from the same driving premise that guides and initially created the field of ecological economics. Namely that the benefits derived from healthy ecosystems are often degraded by development activities and that these natural and intrinsically valuable goods ought to be preserved and used most carefully so as to not erode our foundation of natural capital. In making the case for greater soil conservation through policy implementation in light of the increasing residential development of Pflugerville, my research stands on similar grounds to ecological economics but they do not speak directly to one another.

Soil Ecology

Soils and the services derived from healthy, well-functioning soils play an integral role in this research project. They form the ecological foundation by which this study gauges the potential environmental impacts of future residential development in the Pflugerville ETJ. Soils are assessed within my study in terms of their functional qualities and common ways in which development activities influence soil functionality by impacting and altering soil conditions. Healthy soils form the foundation necessary for a plethora of diverse organisms to thrive on a global scale. A better understanding of how humanities contemporary technological and mechanical advancements, in terms of urban development and landscape change, fit into the balancing act sustained by vast interconnected natural systems necessitates a better understanding of the systems themselves.

Merriam Webster Dictionary defines ‘soil’ as “the upper layer of Earth that may be dug or plowed and in which plants grow” (Merriam-Webster.com, accessed 2011). Another definition characterizes soils as natural (not human made) materials which have formed over a long period of time through the varied interactions between climate, parent materials, and living organisms (Dudal et al., 2002). Soils across the globe come in many different forms and as such comprise a great many functional qualities. However, there is one thing all soils have in common with each other; they take a very long time to form.

Soils are formed through a combination of geologic, biologic, and climatic factors interacting over geologic time periods. The primary factors contributing to soil formation are pre-existing parent material (rock and mineral composition), climate, hydrologic activity, topography, the influence of living organisms (both autotrophs and heterotrophs), and the duration of these combined interactions (Whalen & Sampedro, 2010). Indeed more extreme examples come to mind that quickly influence soil formation and soil characteristics, such as volcanic activity and earthquakes. However, these events are generally isolated and geographically distinct, though not unimportant. They contribute greatly to the vast array of soil types found all across the world, which allow for the plethora of diverse organisms found on Earth to exist.

Soils are considered living organisms by soil and ecosystem scientists and certainly by scholars in the ecosystem services benefits literature. For example, the concept of soil health reflects the position held among soil and ecosystem scientists that soils are made up of biotic and abiotic components, and are considered to be biologically active and living. Soils are comprised of living organisms as well as nonliving material, the combined synergies and interactions between which allow for and facilitate the numerous ecological services we come to associate with healthy soils.

Maintaining the naturally occurring biotic and abiotic relationships present within soils is fundamental to promoting healthy soil functioning in the present as well as into the future. Soil health is defined as "the capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain plant and animal productivity (food production), maintain or enhance water and air quality, and promote plant and animal health" (Doran and Zeiss, 2000). The terms soil health and soil quality can be confusing as they often mean very similar things. The quality of soil is directly related to a soils ability to function within the boundaries of its given ecosystem, whether disturbed or undisturbed, the ability to sustain plant and animal communities through the provisioning of goods like food and building materials, enhance or at least maintain water and air quality, as well as to support human health and habitation (Doran and Zeiss, 2000; Heneghan et al., 2008). The soil forming process of mineralization in particular and soil structure in general inform the fertility or quality of the forming soil to a great extent.

"Mineralogy determines inherent soil fertility through the type of weatherable minerals present in the sand and silt fractions of the soil and the number of ion exchange sites on the clay minerals" present in the preexisting parent material (Palm et al., 2007; pg. 101). Primary production potential based on soil fertility, although important, is far from the only service healthy high quality soils provide.

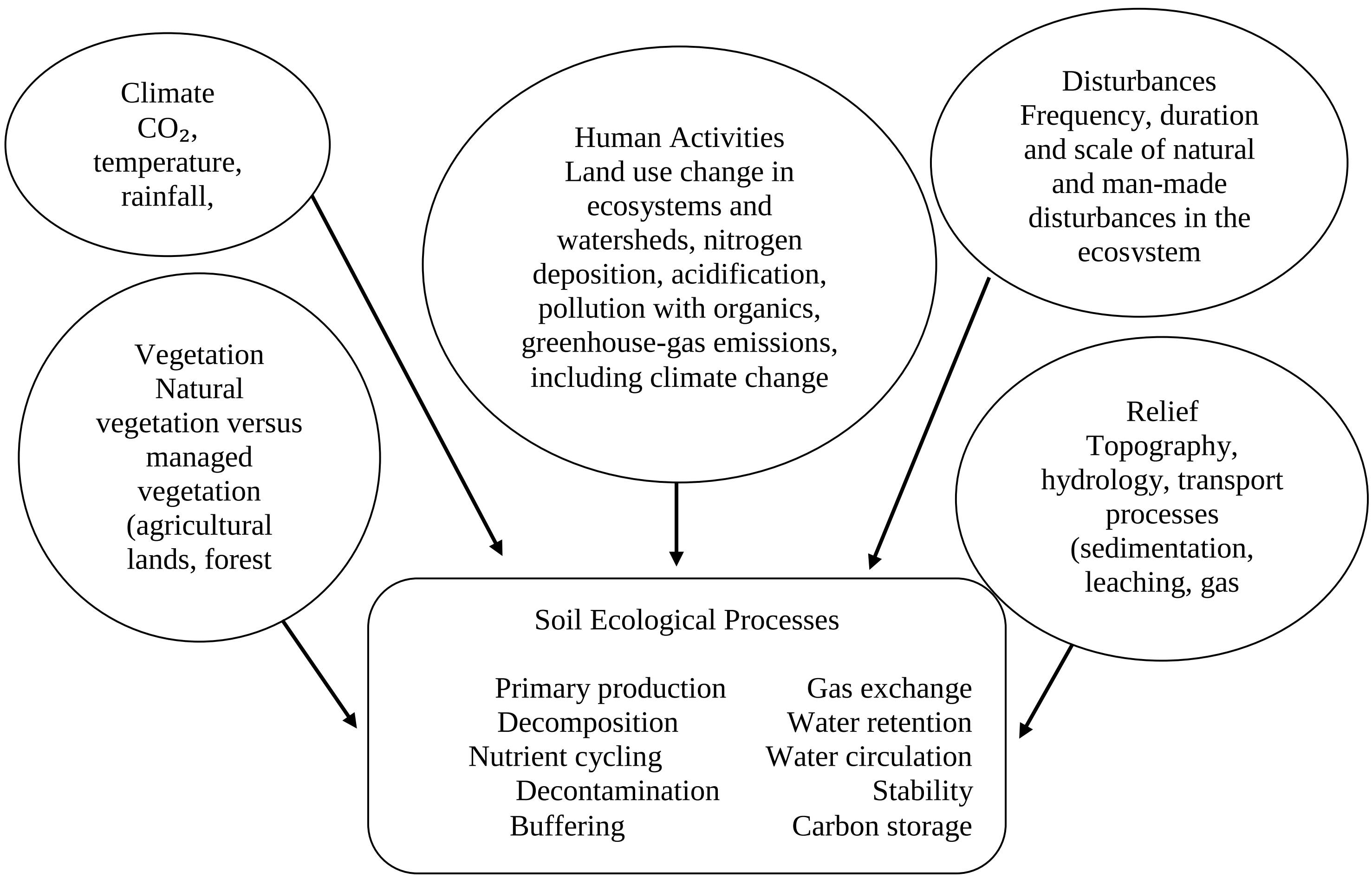


Figure 2: Controlling Factors (Whalen and Sampedro, 2010; pg. 26 Fig. 1.17)

Soil processes can be thought of as the numerous inputs, losses, transfers and transformations of both material and energy occurring within or which are dependent upon the soil itself (Palm et al., 2007). Soil ecological processes consist of primary production (plant life), decomposition of biomass, carbon sequestration, nutrient cycling, chemical buffering, decontamination, gas exchange, water retention and circulation, and physical stability (Whalen and Sampedro, 2010). Of course each one of these services is brought about and maintained by a combination of factors operating within a relative equilibrium. Whalen and Sampedro refer to these as 'controlling factors.' The above diagram (Figure 2) is pictured in their book, "Soil Ecology and Management," articulating the various controlling factors responsible for influencing and regulating the services provided by healthy soils.

As landscape changes occur through human activities, alterations to the character and function of impacted soils also typically ensue. In general, the most common impacts on soils from human development activities cause changes in a soil's texture. Soil texture determines a soil's bulk density, porosity, and pore size-distribution (Palm et al., 2007). "These combined properties affect the movement of water in the soil, chemical and biological transformations, and the exchange of gases with the atmosphere" (Palm et al., 2007; pg. 101). The ways in which these soil textural changes are specifically brought about differs from project to project. However, there are two general categories of construction practices that the vast majority of these soil influencing factors fall into. These are soil compaction and soil loss due to erosion.

The importance of addressing on-the-ground practices responsible for causing soil disturbances and leading to soil degradation at the site level needs to be emphasized. New development activities typically impact on site soils in two primary ways: through vegetation removal and soil compaction via heavy vehicle traffic. Vegetation removal refers to the extensive removal of living plant matter, large and small, from an undeveloped construction site. The developmental context employed here assumes no predevelopment planning to limit and/or guide decisions regarding the amount of vegetation necessitating removal. This type of prolific vegetation removal creates many problems for on-site soils as well as for the surrounding ecosystem as it effectively begins the cascading condition of soil degradation. “Once the vegetation is removed, erosion is extensive,” potentially impacting both steep as well as less steep slopes dramatically (Palm et al., 2007; pg. 111). If soils, particularly the uppermost layer which constitutes the majority of a soil’s organic matter and nutrient content, are eroded they will be unable to engage in the numerous ecological processes, such as the bioremediation of toxins and water holding capacity, so integral to an ecosystems survival.

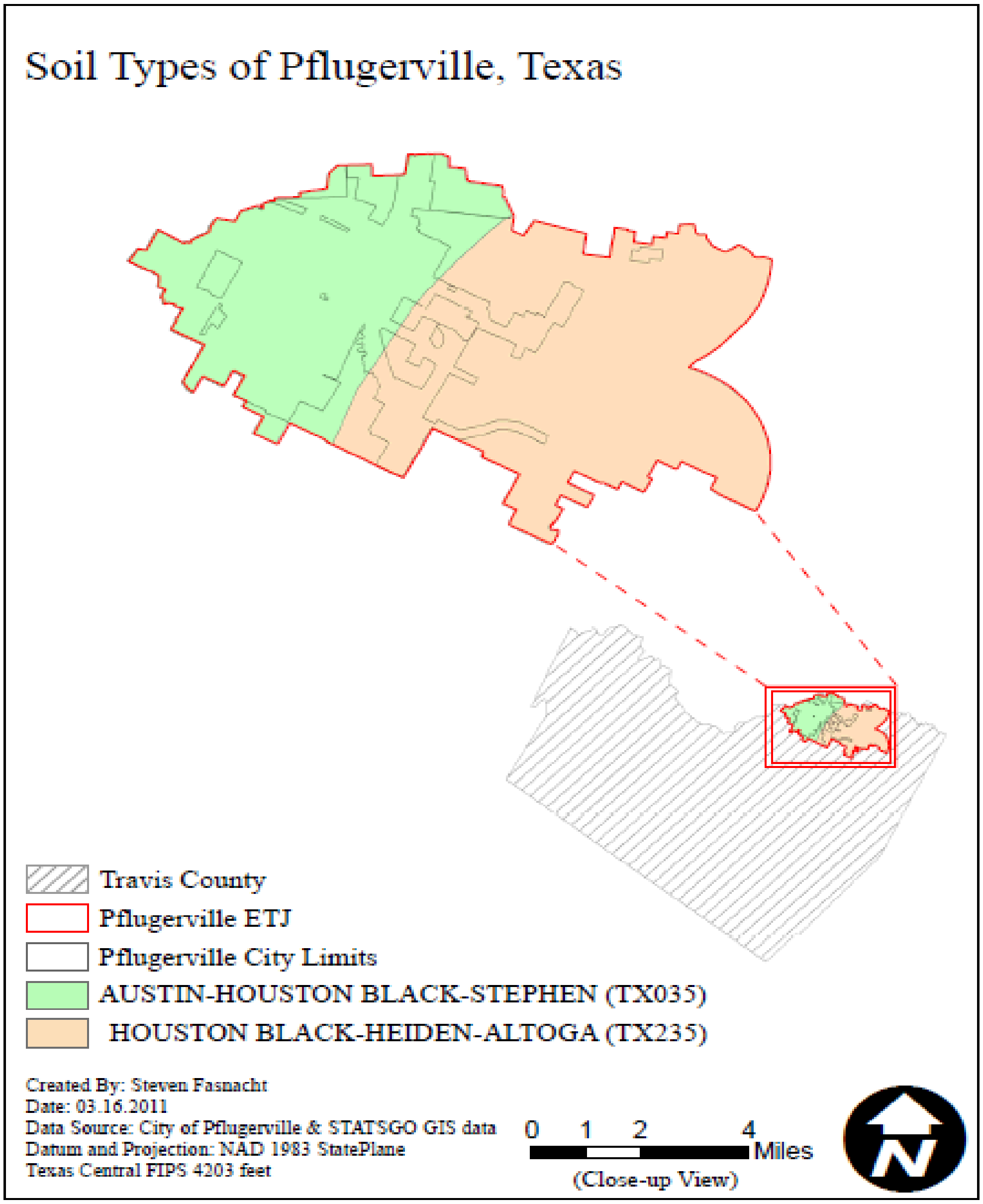
A soil’s uppermost layer, the topsoil, “is of prime importance for soil management, soil fertility and crop production” and is therefore the focal point of most soil conservation initiatives (Dudal et al., 2002; pg. 93-4). Soil organic matter affects a soil’s ability to retain and release nutrients, store and release water, engage in the exchange of gases with the surrounding atmosphere, detoxify harmful materials, and suppress plant-pathogenic microbes (Doran and Zeiss, 2000; Palm et al., 2007). Other common ways in which soils can be negatively impacted by new development activities are not as easily recognized.

Soil compaction represents a physical degradation of soil, which occurs by “the structural breakdown of the soil through aggregate disruption, surface sealing, and compaction” (Palm et al., 2007; pg. 119). Soil degradation itself “can be defined as the adverse changes in soil properties and processes leading to a reduction in ecosystem services” normally provided by healthy, well-functioning soils (Palm et al., 2007; pg. 119). Soil compaction occurs most often and in its more extreme form after preexisting vegetation has been removed from a new development site and heavy construction vehicles/equipment arrive onsite. In terms of impacts on soil ecological processes, compaction reduces a soils ability to retain water while simultaneously causing an increase in the overall amount and rate of surface water runoff further exacerbating soil loss through erosion (Palm et al., 2007). These impacts have a trickledown effect impacting many ecological processes and services as well as other ecosystems themselves. For example, excessive nutrient and sediment deposition in aquatic ecosystems can cause nutrient imbalances resulting in low dissolved oxygen levels leading to the die-off of many higher forms of aquatic life. Of all the ways new development activities can negatively impact soils, compaction or surface sealing is by far the most prolific and arguably the most devastating to the existing soil's functionality, biotic stability, and overall resilience.

Ecological resilience refers to the speed or pace at which an ecological system, a soil ecosystem for instance, may return to its state prior to experiencing a disturbance or perturbation (Suding et al., 2004). Of course the gravity and duration of negative impacts rendered onto soils through development activities greatly depends on the specific development project's construction and site management practices, the soil type(s) present onsite, as well as climatic variations occurring during the site preparation and construction processes. Soils being characterized as 'loamy' or intermediate textured soils are the most susceptible to the effects of compaction (Palm et al., 2007). Loam is defined as "a soil consisting of a friable mixture of varying proportions of clay, silt, and sand" (Merriam Webster Dictionary; accessed 2011). The reason that loamy soils are the most susceptible to the negative repercussions of compaction can be found in the overall abundance and size of clay particles found in the soil. Loam soils typically have low levels of clay resulting in an increased likelihood of aggregate destabilization when compacted, while simultaneously having sufficient amounts of particulate clay matter necessary to obstruct soil pore-space causing surface sealing, which results in decreased water retention and increased levels of storm water runoff (Palm et al., 2007).

The geographic area occupied by Pflugerville is bisected by two soil type combinations. The western portion of Pflugerville, as defined by the city's ETJ, is made up of Austin – Houston Black – Stephen soil series (STATSGO; CAPCOG). The eastern section of Pflugerville is home to a Houston Black – Heiden – Altoga soil series amalgamation (STATSGO; CAPCOG). Map 1.2 illustrates the geographic distribution of these soil series across Pflugerville's ETJ. The soil distribution as depicted below by Map 1.2 is in actuality not a true straight line but rather a mixture of the two soil types where the separation is shown to occur.

The Natural Resources Conservation Service (NRCS) branch of the US Department of Agriculture defines the 'Austin' soil series as a well-drained, moderately permeable silty-clay soil mixture, experiencing medium to rapid levels of runoff (NRCS; Austin). The 'Houston Black' soil series is characterized by deep, weakly consolidated clay soils (deeper than the Austin series), having very slow levels of water permeability when moist and very high levels when dry and cracking (NRCS; Houston Black). Houston Black is valued for its ability to cultivate a variety of important crops for the region; specifically sorghum, cotton and corn (NRCS; Houston Black). The 'Stephen' soil series is characterized as being shallow, well-draining and primarily located on upland areas (NRCS; Stephen). The eastern portion of Pflugerville is somewhat similar in soil series composition to the west, although they do differ in some important ways.



Map 2: Pflugerville Soils

Looking to the east one again finds a large prevalence of the Houston Black soil series; more so than in the ETJ's western areas. The next most common soil series in this eastern area is the 'Heiden' series. This soil series is can be found in level or upland areas and are characterized as being well-drained and having low levels of runoff (NRCS;

Heiden). This soil is described as being often utilized for grass/hay cultivation and pasture land, although some areas can support cotton and sorghum cultivation, which makes sense as it was formerly considered part of the Houston Black series (NRCS; Heiden). Lastly, we encounter the 'Altoga' series in eastern Pflugerville. Like the Houston Black, the Altoga series is characterized by deep, well-draining soils typically found on moderate to strongly sloping uplands and are primarily utilized as pasture land (NRCS; Altoga). It being the case that the eastern regions Pflugerville's ETJ are less populated and developed than those areas to the west, it follows that those eastern soils should be the primary focus of soil conservation efforts in Pflugerville.

The way in which soils aggregate requires a great amount of time and is difficult, if not impossible, to truly replicate through restorative interventions. Most deep soil profiles present in terrestrial ecosystems take thousands of years to form, if not longer (Whalen and Sampedro, 2010). This being said, vegetation has a relatively higher level of ecological resilience when compared to soils themselves, although the overall ecological resilience of vegetation greatly predicates its type. More ecologically valuable vegetation, a stand of old growth trees for instance, have a much lower level of ecological resilience than say a stand of bamboo due to the long duration which they require to reach their maximum potential, ecologically speaking. Once a soil has been compacted, its internal regulating processes may be permanently altered, depending on the soil's initial composition and the extent of compaction. All the authors cited herein agree that soil compaction, and conditions which exacerbate soil compaction such as extensive vegetation removal and heavy vehicle traffic, ultimately result in negative changes for the surrounding ecosystem and should be managed to the greatest extent possible.

On the whole, the authors contributing to this literature review section are in agreement with one another on the crucial role soils play in the everyday functioning of a plethora of vital living systems, as well as the burgeoning need for greater soil conservation efforts globally. Rather than encountering specific and fundamental disagreements between the authors, a difference of perspective in regards to certain facets of soil research was more often found. The numerous authors contributing to this chapter can be grouped into camps concerned with differing facets or perspectives on soil research such as the ecological ramifications of continued urban expansion, soil ecology and biological functioning, soil conservation, ecological processes and ecosystem services provided by healthy soils, as well as soil hydrology. Each addresses a unique piece of the pie so-to-speak, exhibiting the fact that there exist many corners of specialized knowledge and study in regard to soils and the enormous ecological and biological systems they support. As our world continues to grow and change so too does our collective knowledge and understanding of the relationships and feedbacks existing between soil ecological systems/processes and our own built environment. This being the case, it is no surprise that gaps still exist in places where the research literature has not yet fully caught up to shifting practices and contemporary concerns.

Diana Wall refers to aspects of soil science research where she feels the field would do well to expand its current depth of inquiry. Guiding and contributing to her assessment are the Scientific Committee on Problems in the Environment (SCOPE) and a committee on Soil and Sediment Biodiversity and Ecosystem Functioning (SSBEF) who jointly convened in 1995 to produce scientific recommendations to policy makers regarding best management practices and conservation tools to assist in soil preservation (Wall, 2004). During the course of their research, the teams synthesized what they believed to be the major gaps existing within the present body of knowledge and research surrounding soils. The committees saw the need for a greater amount of study addressing three overarching areas of soil and ecosystem research. The three areas of research sited as being in greatest need of expansion are soil and sediment biodiversity and ecosystem functioning *within* domains or habitats, soil and sediment biodiversity and ecosystem functioning *across* domains or habitats, and addressing the threats to soil and sediment biodiversity and ecosystem functionality specifically resulting from anthropocentric activities (Wall, 2004; pg. 6-8). The latter of the three research recommendations carried the highest degree of urgency due to the fact that specific data regarding soil and ecosystem vulnerability to human activities, e.g. development. Ways in which "this vulnerability might be ameliorated by management options was considered an urgent priority for further research and synthesis" (Wall, 2004; pg. 8).

The strongest common theme resonating throughout each authors work relates the importance of soils to ecosystem health and functionality, and the mounting threats to soils from contemporary human activities. The research conducted by my project directly speaks to Wall's concern over addressing vulnerabilities to soils as a result of human development. Policy recommendations and general founding principles of soil conservation are investigated in this research in an effort to provide decision makers responsible for land development and management with the justification for protecting and preserving soils on new residential development sites. The prevalence of residential development, particularly in a rapidly growing and mostly unregulated area, makes this research agenda very significant in terms of potentially aiding or hindering the soil conservation movement. There exists a clear consensus, amongst the authors cited herein, which stresses that human development and environmental conservation must join together on mutually vested grounds in order to shape a better and brighter future.

Conservation Development

Conservation Development is an approach to residential subdivision design and construction which seeks to minimize the adverse environmental impacts that can be caused by conventional development activities. It takes more of a spatial approach to environmentally mindful development rather than a purely technical approach. The movement supports the notion that, wherever possible and to the greatest extent possible, it is best to preserve ecologically functional open space and utilize existing natural features to offset the need to build additional supportive infrastructure for new development projects. Randall Arendt, a land-use planner and conservation development pioneer, defined a 'conservation subdivision' in the early 1990's as a new residential development in which “half or more of the buildable land area is designated as undivided, permanent open space” (Tiffany et al., 2005; pg. 14). Similarly, the Lady Bird Johnson Wildflower Center defines conservation development as development which seeks to significantly reduce its own ecological footprint and which promotes contiguous open spaces amongst clustered residential housing units in an effort to enhance the sustainability of a development project (Tiffany et al., 2005; pg. 27). Preserving open space is a product of the desire to secure environmental amenities for those living in the subdivision, maintain predevelopment levels of ecological functioning in the area, and maintain wildlife corridors. Conservation development encourages planners and developers to ask two fundamental questions before going into any new development project; how can development be undertaken and realized in the most environmentally sensitive way possible, and in what ways can decision makers such as planners use development as a tool to actively promote and propagate environmental conservation (Tiffany et al., 2005)?

The Lady Bird Johnson Wildflower Center has taken a pioneering role in the field of conservation development to create the Sustainable Sites Initiative. The Sustainable Sites Initiative (SSI) is a comprehensive document offering helpful guidelines and recommendations to developers and land managers concerned with preserving local ecologies and designing communities for sustainability. Similar to the Leadership in Energy and Environmental Design (LEED), the SSI operates on a point system in which points are awarded based on the fulfillment of certain requirements involving specific conservation objectives. To help individuals and firms meet these objectives, the SSI stresses an integrated management and design approach to development, incorporating the knowledge base of a multitude of fields interested in preserving the character, ecology, and continuity of the land undergoing development. The document covers facets of predevelopment site design such as water, vegetation, building materials, and soils.

Generally speaking, the “undervaluation of soils is one of the most significant failings of the conventional development approach” (LBJ Wildflower Center, 2009; pg. 14). To address this prolific problem, the SSI stresses the importance of developing and implementing a soil management plan for all new development projects. A soil management plan is a comprehensive and integrated document focused on the preconstruction phase of development and consists of several general guidelines and recommendations specific to soil conservation. For example, some fundamental elements of a soil management plan would include limiting soil disturbance in all its controllable forms, aiding in the post-construction restoration of land negatively impacted land, and define specific protected boundaries for onsite soils and vegetation preservation (LBJ Wildflower Center, 2009).

The figure below (Figure 3) is derived from the LBJ Wildflower Center’s 2009 document, “The Case for Sustainable Landscapes,” and depicts the cascading ecological effects unmitigated soil disturbance and conversely, soil conservation typically have for a new development site.

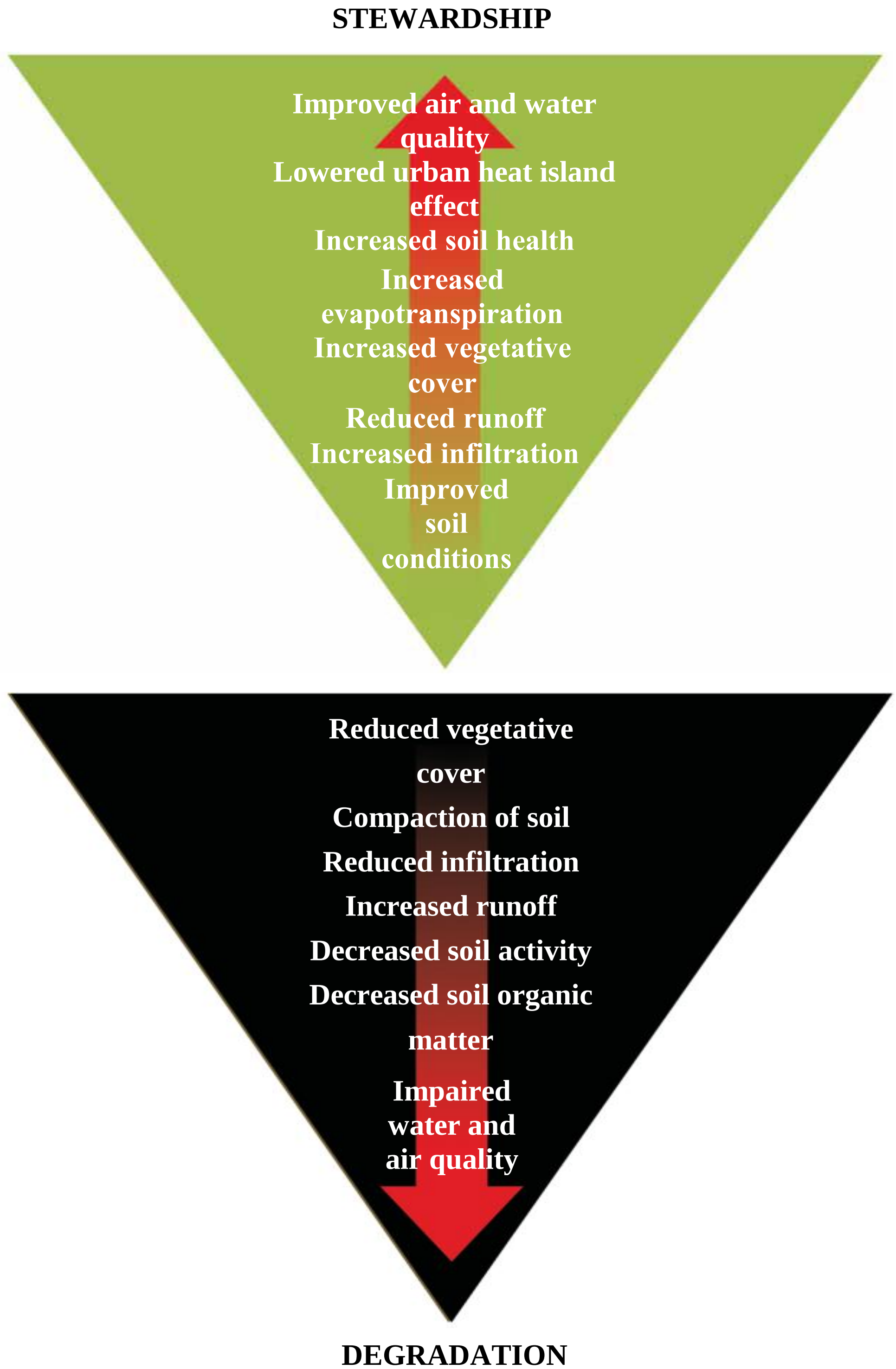


Figure 3: Soil Degradation vs. Stewardship (LBJ Wildflower Center, 2009 fig. 2-5; pg. 20)

Developments designed for conservation typically evolve out of a four phase process including a community assessment, conservation planning, conservation zoning, and finally the actual designing of the subdivision itself (Arendt, 1999; Tiffany et al., 2005). Development and market trends must first be assessed to better understand the needs of the community itself through a community assessment. Next, a thorough ecological survey of the land slated for development is needed in order to identify and preserve appropriate lands as permanent interconnected open space. In order to actually preserve these lands as permanent interconnected open space, the municipality in which the project site(s) reside must adopt conservation zoning encouraging developers to set aside at least 50% of a proposed subdivisions land as open space. After these steps have been effectively implemented a conservation development project can begin designing the final plans for the community including sidewalk/trail amenities, street locations, individual housing unit sites, and delineating the final location of lot lines within the subdivision.

Prolific new development, specifically single-family residential housing, can have a profound impact on an area's ecosystem as the practices of one project tend to be amplified due to the large number of units and sites undergoing construction utilizing similar methods. It is estimated by The American Farmland Trust that every minute, two acres of mostly prime farmland is lost to development (Pieranunzi et al., 2006). The increasing rate of land area and soil type loss to urban development expansion represents a major contemporary driver of global change, affecting and altering biodiversity of soils as well as the provisioning of ecosystem services worldwide (Amundson et al., 2003; Wall, 2004). The challenge is that both development and conservation are sorely needed. A common ground or balance between human development and environmental preservation is sought by pioneering movements such as conservation development and initiatives such as the SSI. These alternative approaches to conventional development represent a potential way forward to deal with many of the environmental problems we are currently facing, mitigate looming future obstacles, and provide much needed residential development and amenity for a growing population. However, some very real barriers are often confronted when attempting to create a conservation subdivision development.

Upwards of 80% of a subdivision's development costs are fixed and/or are dependent on the development's density (Tiffany et al., 2005). These costs include that of the land itself that is to undergo development, construction of necessary roads and community amenities, as well as the utilities and supportive infrastructure needed. Under the guidelines of conservation development a good deal of the subdivision's land must be preserved as open space, resulting in decreased lot sizes and increased housing unit density (in terms of proximity to one another) within the development, as well as an increase in the overall number of units themselves (Tiffany et al., 2005). This can affect a developments appeal to potential residents as there is sizable demand for more traditional single-family housing developments located in subdivisions nearby but not within a city, whose residents can enjoy relatively larger lot sizes and home square footage at a relatively lower price than can be found within the city.

A large percentage of the market may not accept the new form of subdivision, developers are very wary about undertaking an unproven form of subdivision design and construction. However, home buyers are often willing to spend a little more for homes located near open green space while the developer is simultaneously able to save a bit on infrastructure costs by utilizing naturally occurring amenities (Pieranunzi et al., 2006). Additionally, local governments can be wary of permitting residential development over other forms of taxable development as it often costs more for local governments than it generates in tax revenue. In Hays County, Texas for instance, residential development cost the county $1.26 for every $1 of tax revenue collected (Pieranunzi et al., 2006). A conservation development would be less costly to serve for a county than a conventional development seeing as the conservation development would rely less heavily on local infrastructure, consist of more densely clustered housing units, and require fewer roads to be built and maintained within the development (Pieranunzi et al., 2006). Even though sizable economic obstacles can arise when attempting to construct a subdivision based on conservation development principles, financial incentives and opportunities can still be found for developers interested in incorporating conservation into their residential development projects.

Aside from economic and market driven constraints, many regions face hurdles in the form of preexisting political and economic relationships/alliances that govern land use controls and regulation. For instance, the dynamics of municipal and county power relationships combined with a lack of an industry accepted definition of what exactly conservation development consists of have held back the progress of the conservation development campaign in many states. Texas is an example of a state struggling with these very same issues (Tiffany et al., 2005; pg. 22).

Texas land development activities are regulated at three distinct levels consisting of state, county, and municipal jurisdictions (Tiffany et al., 2005). The fact that undeveloped, usually unincorporated lands have arguably the most to gain (or retain) from conservation development presents a legal issue for potential projects as these sites are governed/regulated by counties, rather than municipalities, who derive their authority primarily from specific statutes found in the state constitution (Tiffany et al., 2005). The primary difference between municipal and county land use controls in Texas revolves around the issue of flexibility.

Comparatively, municipalities (cities/ETJ) have much more flexibility than counties do in terms of tailoring development projects to a specific vision for the area/region due to the fact that municipalities have final zoning authority within the boundaries of their jurisdictions. This zoning authority grants municipalities the ability to regulate land use in terms of the location and use of buildings, overall population density, groundwater usage, lot size, along with many other facets of land use (Tiffany et al., 2005). Counties on the other hand, only derive powers explicitly conveyed to them by the state constitution or state law (Tiffany et al., 2005). In general, the implementation of some of these statues and the peripheral areas surrounding the statutes can be weak and unclear, resulting in a much less regulated environment for developers as the county lacks the regulatory teeth necessary to enforce certain standards of development; limitations on impervious cover for example (Tiffany et al., 2005). In other words, developers may, but are not actually required to design and build residential developments in ways that promote environmental conservation and landscape preservation.

In 2001 Senate Bill 873 (SB 873) was enacted in the state of Texas and granted 30 counties in the state of Texas, Travis County included, municipality-like powers regarding land use regulation (Tiffany et al., 2005). This expansion of power allows counties to enforce regulation of new subdivisions in terms of right-of-ways, minimum lot frontages, setbacks, and other regulations pertaining to responsible development, although simultaneously maintaining restrictions on counties from explicitly regulating land use (aka zoning), building height, and density (Tiffany et al., 2005). The only real authority counties have in terms of outright land use regulation is the ability to bar development of lands deemed unsuitable for construction, for instance due to their location within a major floodplain (Tiffany et al., 2005). Though some may argue this bill is far from ideal, it still represents a step in the right direction in terms of minimizing the barriers to conservation development in Texas.

Although many aspects of conservation development as an idea or framework for new development projects are quite laudable, critics argue that in practice the movement often amounts to nothing more than a ‘green-washed’ form of sprawl. These critics argue that conservation development does nothing to promote actual mixed-use development, access to alternative modes of transportation, or provide affordable housing options for the community (Tiffany et al., 2005). As was previously stated, homes located in conservation subdivisions can often times be more expensive than their conventional equivalents due to their proximity to open green space, in addition to their trendy appeal. Randall Arendt himself, a pioneer of conservation development, suggests building more golf course elements into conservation developments, where the practice of "substituting community greens for putting greens, and greenways for fairways" would be common practice (Tiffany et al., 2005; pg. 14). To many this would seem to be the antithesis of conserving an area's natural character and function, not to mention promoting an aire of classist exclusivity. However this is certainly not always the case, just as it is not always the case that conventional developments are viscously conceived things bent on world destruction.

The fact that conservation development is a relatively new discipline, time is the primary limiting factor informing the apparent gaps in the field's literature. In the case of the present research, the primary contribution to the field is the scenario model of growth and development projected for Pflugerville up to the year 2030. This scenario model seeks to make the case for ecologically and environmentally responsible development as a way forward to a more secure and fruitful future. In a state home to many regions currently experiencing and predicted to continue experiencing rapid population growth, "conservation development represents a promising tool to accommodate population growth in unincorporated areas of Texas while protecting the environment" (Tiffany et al., 2005).

Low-Impact Development

Low-impact development (LID) is a planning and design tool, conceptually similar to conservation development, which stresses the importance of preserving and actively utilizing onsite natural features in the most advantageous way possible. Pioneering efforts in what is now called 'low-impact development' began in Maryland during the early 1990's (EPA, 2000). Low-impact development is defined by the National Association of Home Builders (NAHB) as "an approach to land development that uses various land planning and design practices and technologies to simultaneously conserve and protect natural resource systems and reduce infrastructure costs" (NAHB Research Center, 2003; pg. 1). Speaking specifically to concerns over dealing with water onsite, the EPA defines LID as "a site design strategy with a goal of maintaining or replacing the predevelopment hydrologic regime through the use of design techniques to create a functionally equivalent hydrologic landscape" (EPA, 2000; pg. 1). The definition offered by NAHB is reflective of the LID movement as a whole in that it speaks to the pervasive goal of conserving scarce resources, whether they are determined to be environmental, economic, or both. The latter focus taken by the EPA on maintaining the hydrodynamics of a site is reverberated throughout the movement in actual practice as the most commonly addressed aspect of site design and planning by LID deals with managing stormwater runoff.

The principal focus LID directs toward managing onsite stormwater reflects the need to both minimize overland pollution flows as well as maximize the ecological functionality of a site. Overland pollution refers to the pollutants that are often picked up during rain events and transported by flowing water over land until they enter a body of water and deposit their accumulated cargo of pollutants including motor oil and animal waste. Although reducing waterborne pollutants by curtailing runoff is only one aspect of the rationale behind minimizing runoff through design decisions that decrease the overall amount of impervious cover on a site. "LID approaches and practices are designed to reduce runoff by means of infiltration, evapotranspiration, and reuse of rainwater" (LBJ Wildflower Center, 2009). Reducing the amount of runoff water leaving a site has a positive impact on the areas water table, the physical stability of a site in that erosion will be reduced, and an areas overall water quality (NAHB Research Center, 2003). The practices and techniques utilized by LID to address water management onsite are tailored to best suit each individual project as no two are exactly alike, though they all seeks to reduce the amount of impervious cover on a new development site (NAHB Research Center, 2003).

Not all sites are suitable to low-impact development techniques. Some factors that influence the overall suitability of a site to LID are the soil conditions (soil permeability) found on site, the depth of the area's water table, and the slope of the land (EPA, 2000). All these factors determine the extent to which a reduction in impervious cover is likely to benefit the site, both ecologically and economically. Impervious cover refers to any building material, traditional concrete and roofing materials for instance, that are designed to quickly shed water and move it off a site. The goal of using pervious construction materials to the greatest extent possible is to slow the rate of runoff, thereby mitigating many negative ecological impacts of fast-moving runoff, as well as allowing the natural water tables to be recharged through the percolation of water into the ground. This can be accomplished in a variety of ways using several different design and construction techniques including water penetrable paving materials (aka pervious paving), bioswales, raingardens, and creating development restricted buffer zones around riparian areas (EPA, 2000; LBJ Wildflower Center, 2009).

Pervious paving materials are one way to limit the amount of impervious cover on a site while simultaneously maintaining the intended functionality and stability of onsite amenities, such as parking lots and sidewalks. Although these materials do require greater maintenance than their traditional counterparts, annual high-powered vacuuming for instance, they provide a great deal of additional benefits for the site such as reducing or eliminating water ponding and facilitating groundwater recharge (EPA, 2000). Constructing bioretention areas, such as swales and raingardens, is also a key feature of LID designed to ameliorate many of the negative impacts associated with impervious surface runoff.

Bioswales and raingardens, which are basically non-channeling or stationary bioswales, are another approach to managing onsite stormwater and reducing runoff. Bioswales and the like, also known as bioretention cells, are primarily composed of six key elements allowing them to channel, slow, filter, and absorb stormwater runoff from a development site. To begin, a bioswale must be graded so that it is lower than the surrounding site as to attract and direct runoff water. They are typically bordered by strips of grass which function as a buffer to the bioswale should the amount of stormwater runoff exceed the capacity of the swale (EPA, 2000).   The foundation or bed of a bioswale is comprised of fine particulate aggregate, usually sand, which improves drainage and aeration of the above planting medium, as well as improving the swales filtration and pollutant removal capacity (EPA, 2000). Next, a layer of planting soil and a layer of organic matter (mulch) are added. These layers not only provide a nutrient rich environment necessary to sustain vegetation and absorb heavy metals suspended in runoff water, they also provide refuge to many microorganisms that are known to help break-down and decompose petroleum-based pollutants; one of the most common sources of overland pollution (EPA, 2000). Lastly, vegetation is selected based on a variety of criteria, including site climate, elevation and bioremediation needs, and planted in the bioswale where they help filter and detoxify runoff water, hold the soil aggregates in place within the swale, and slow the flow rate of runoff water as it moves through the swale (EPA, 2000). Reducing the flow-rate of runoff water is immensely important seeing as a major cause of erosion, soil loss, and overland pollution is stormwater runoff leaving a site at a high velocity. The utilization of vegetated surfaces to slow, direct and filter stormwater runoff are not only relegated to the ground level of a site, as is exhibited by the use of green roofs in low-impact developments.

Green roofs, also known as vegetated rooftops, have been shown to be very effective in reducing the overall volume of stormwater runoff leaving a site (EPA, 2000). This type of roof amendment is especially effective in urban areas that have as high occurrence of combined sewer overflow when the infrastructures capacity to deal with stormwater is exceeded (EPA, 2000). A green roof's effectiveness in these areas is due in part to the large amount of fixed impervious ground cover in these types of areas, and a predominance of the more easily retrofitted rooftops. Of course, the specific climate and precipitation of an area preclude a green roof's potential design and success. Green roofs can differ in terms of their aesthetic appeal and overall use, some being more encouraging of human traffic and use than others, although they all are composed very similar parts. In general, the more elaborate and interactive roofscapes are known as 'intensive' green roofs and those not intended for aesthetic appeal or human traffic are called 'extensive' green roofs' (Bass, 1999).

In their simpler form, a green roof consists of a waterproof covering to prevent the roof itself from water damage, a root impenetrable barrier to prevent damage to the waterproof covering and the roof itself, next a growing medium usually composed primarily of a lightweight water absorbent inorganic material along with sufficient organic matter to provide the necessary nutrients, and last the vegetation is planted (Roofscapes, Inc., accessed 2011). Green roof vegetation varies widely, though is typically selected for its drought tolerance and overall fortitude. Although green roofs require minimal supplemental irrigation once the vegetation becomes established, they do require and initial period of irrigation in order to reach functional maturity. In more arid regions, such as Central Texas, additional irrigation is often needed to mitigate the impacts of long period without precipitation. Additionally, some green roofs are designed with additional layers, such as insulation and more elaborate drainage/water storage features in order to better suit a project's needs.

The primary limitation or constraint on green roof retrofits, besides the cost, is the roof's weight load capacity. If a roof is overloaded, especially an older retrofitted roof, damage to the integrity of the structure can be caused and even the collapse of the roof entirely. Even though green roofs use lightweight growing mediums and protective materials, they do impose considerable weight on a structure when fully saturated with water. This can be a factor when considering retrofitting older structures with green roofs as older roofing weight loads are not generally intended to support the additional weight of a green roof. Green roofs can also be used in conjunction with rain catchment systems, such as rain barrels, which can help conserve onsite water resources if they are utilized for irrigation of onsite landscaping helping to further reduce the operating costs of the development.

There exist many strategies in LID that address onsite stormwater management to the benefit of both economic and environmental health of a site. For instance, conserving water resources, especially in more arid regions, directly benefits the local infrastructure as well as reduces its operating costs. Additionally, "LID techniques prevent or reduce the impact of development on groundwater, lakes, rivers, streams, and coastal waters" (LBJ Wildflower Center, 2009; pg. 22). The benefits of LID are not solely environmental. In general, LID practices have been found to save development projects on average between 15 and 80 percent of total capital costs (LBJ Wildflower Center, 2009; pg. 22). Figure 4 depicts the benefits typically derived from implementing LID techniques on a new development site specific to certain stakeholder groups including developers, home owners, municipalities, and the environment.

Even though numerous benefits can be derived from the implementation of LID techniques, there simultaneously exists several challenges to undertaking development, especially new development, using the techniques and methods prescribed by LID. Many of these challenges deal with public perception of LID methods and goals, as well as preexisting building codes and zoning ordinances, such as prescribed street-widths and other obligatory practices that can make reducing the total amount of impervious cover onsite difficult (EPA, 2000). "Two of the most frequent challenges facing developers who contemplate the use of LID center around restrictive local ordinances and local officials' and citizens' opposition to the approach" (NAHB Research Center, 2003; pg. 15). However, integrated stakeholder and community involvement in a new low-impact development project as well as integrated planning in general all improve a projects chance for success. The developer can also take the route of obtaining waivers or variances from the municipality in order to overcome some of the burdensome regulatory obstacles commonly facing LID, although these waivers and variances can be time consuming and costly to obtain (NAHB Research Center, 2003).

Developers
• Reduces land clearing and grading costs • Reduces infrastructure costs (streets, curbs, gutters, sidewalk) • Reduces storm water management costs • Increases lot yields and reduces impact fees • Increases lot and community marketability
Municipalities
• Protects regional flora and fauna • Balances growth needs with environmental protection • Reduces municipal infrastructure and utility maintenance costs (streets, curbs, gutters, sidewalks, storm sewers) • Fosters public/private partnerships
Home Buyer
• Protects site and regional water quality by reducing sediment, nutrient, and toxic loads to water bodies • Preserves and protects amenities that can translate into more salable homes and communities • Provides shading for homes and properly orients homes to help decrease monthly utility bills
Environment
• Preserves integrity of ecological and biological systems • Protects site and regional water quality by reducing sediment, nutrient, and toxic loads to water bodies • Reduces impacts to local terrestrial and aquatic plants and animals • Preserves trees and natural vegetation

Figure 4: LID Stakeholder Benefits (NAHB Research Center, 2003; pg. 14)

In terms of LID literature, the gaps encountered therein are primarily related to the burgeoning nature of the field. Even though LID has been in existence conceptually since the early 1990’s, it has yet to make an impact that is reflected in common planning practice and regulatory policy formation on a national scale. However, there certainly are early adopters of more progressive building codes and development regulations. Austin is an example of a city that has been incorporating elements of environmental conservation into its development policy and decision making process for many years. It represents a unique example of regional development policy, especially relative to the Central Texas region.

In the 1970's and 1980's there arose two seemingly opposed positions on the direction Austin's growth and development ought to take (Orum, 1987). Fueled largely by outside land development interests, Austin was experiencing monumental growth both in terms of population and development. For instance, the amount of Austin land being sold in the early 1980's quadrupled by 1984 (Orum, 1987; pg. 308). Austin was beginning to grow like never before and this expansion of its economic and population base worried some and exited others. Some Austinites, such as many in the business community at the time, feared that increased development regulation would result in a lack of jobs and inevitably stunt the city's future economic growth potential. Other residents feared for the long-term survival of many ecological features they came to associate with Austin at risk, such as Barton Springs Pool. Generally speaking, these points of view can be boiled down to those of a more business-friendly/capitalist attitude and those of a more eco-friendly/community oriented mindset, both of which have been quite polarizing stances both in times past and present (Orum, 1987).

In 1972, the director of city planning for Austin decided to do something to address concerns over the negative impact unmanaged growth can have on a city by helping to spearhead the Austin Tomorrow Program (Orum, 1987). This program sought to bring Austinites together as a democratic body in hopes of citizens articulating and ultimately "constructing their own plans of the future of Austin" (Orum, 1987; pg. 293). The products of this visioning program were intended to be incorporated into the city's new master plan. They primarily include the following tenants (Orum, 1987; pg. 294):

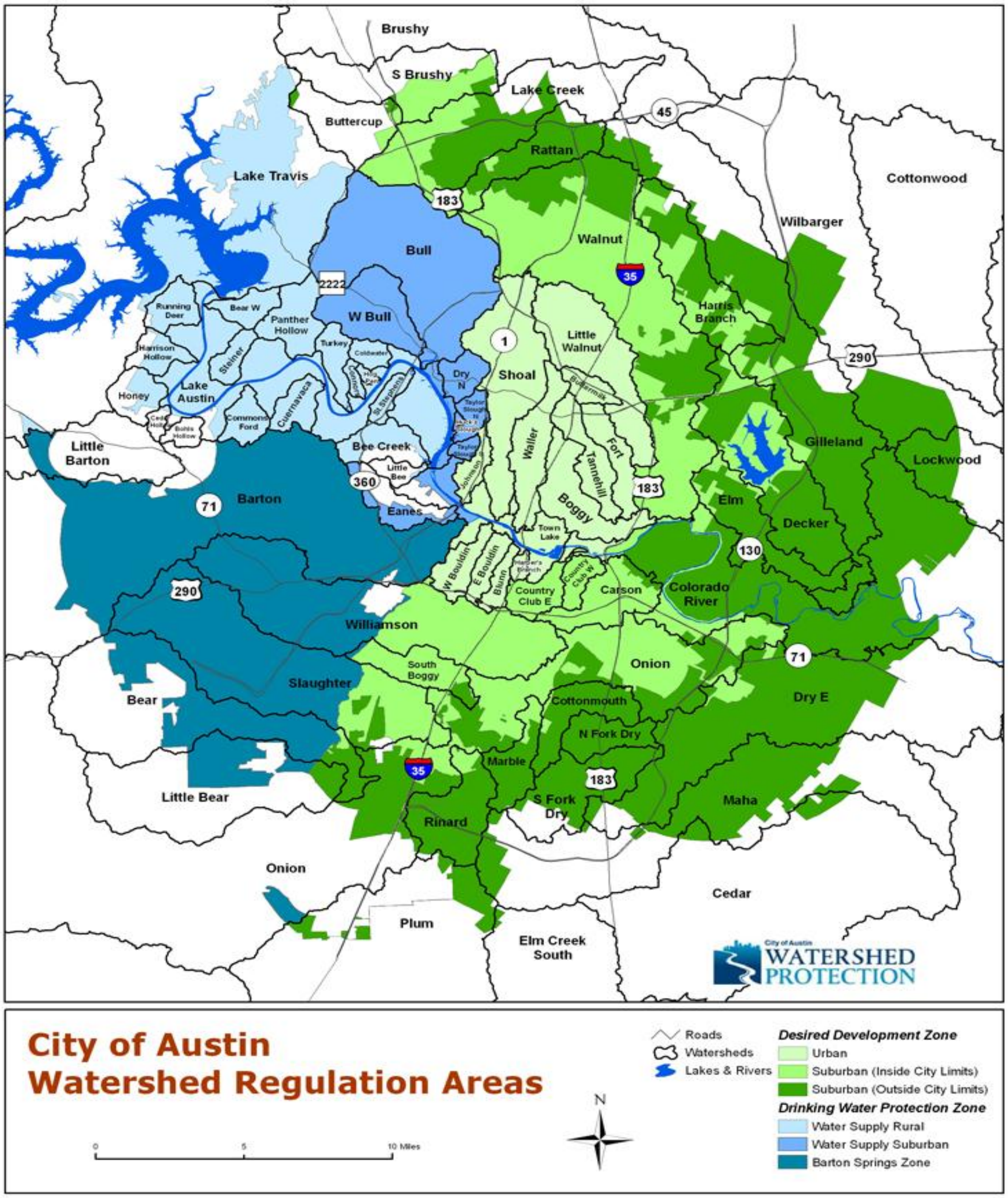
- Addressing the negative consequences of uncontrolled and unmanaged growth, both within the city itself and outside the city limits (in the ETJ), represents the number one concern for the participants of the Austin Tomorrow Program.
- Growth should be planned for and directed, through effective land use controls implemented by the city government, and avoid locating in specific high-risk areas such as floodplains.
- The character of Austin, both in terms of its environmental amenities and historic/cultural attributes, ought to be preserved for the long-term enjoyment of the Austin public.
- All new residential developments should be required to set aside park lands/public open space at each development site.

Many in the Austin community, particularly those in positions of power which required compromise, did not see these two issues as such polarizing stances; rather they saw the potential for mutual respect and cooperation to achieve a combined set of these goals. Many on the Austin city council during the 1970's held differing views of which direction Austin ought to focus on for its future: environmental conservation or economic growth? Although for the most part all parties on either side of the issue conceded that neither plan of action was realistic "if there were limits placed on the city's expansion" in the strictest of senses, which is to say no growth (Orum, 1987; pg. 296). However, growth "at any cost" was also widely considered to be a non-starter (Orum, 1987; pg. 299).

The city of Austin has adopted a Smart Growth Plan, which seeks to limit and/or restrict development in certain areas primarily to protect watershed health and preserve water quality for the region. This plan seeks to direct new urban development away from areas deemed to be highly ecologically sensitive, such as the Edwards Aquifer from which Austin derives a large amount of its water, and towards the eastern black-land prairie regions where the watersheds are considered to be more resilient to disturbance.

Map 3 created by the City of Austin's watershed protection department illustrates where future development is desired and where it is restricted.

Growth in-and-of itself is neither inherently good nor bad, rather it is simply necessary. The necessity of growth precludes our very existence as human beings as it does the world around us from which we gather our sustenance. The question of whether growth is good or not is not an accurate assessment of the situation; a clearer and more effective inquiry would ask what kind/form of growth Austin, or any place for that matter, as a community desires. Working to better align the shared goals of conservation and development is a near future imperative if the negative impacts of sustained urban growth are to be avoided.



Map 3: Watershed Protection Zones (http://www.ci.austin.tx.us/watershed/ordinances.htm)

Looking at the above map one can see that future urban and suburban development is primarily targeted toward the eastern portions of Austin. The primary objective for directing future growth in such a way is to protect the largest groundwater recharge zone in the area, the Edwards Aquifer, which lies to the southwest of the city. Although the areas to the east of Austin are considered generally less environmentally sensitive to the immediate disturbances of development activities than those areas to the west, the eastern regions of Austin still ought to be treaded upon as lightly as possible by new construction in order to preserve ecosystem health and services into the future. Because of the development restrictions present in western Austin, this study will focus more heavily on the areas that may be overlooked by many conservation efforts; namely greenfield sites located in the eastern regions of Austin's ETJ.

In time and as more LID projects prove themselves to the development and planning communities, there is likely to be greater and greater acceptance and application of LID techniques and practices. Advocacy of design and planning strategies, such as low-impact development, are an important component of bringing about this goal.

It is the role of this research to provide an advocacy platform for LID to developers and policy makers, among other related development strategies and fields, in the context of population and new development growth in Pflugerville, Texas. The contribution this research makes to the field of conservation and low-impact design, planning, and development are reflected in the policy recommendations drawn from the literature, interviews, and demographic projections. The fact that each project is different and each region unique argues for local implementation of LID techniques and practices to give stakeholders and decision makers a clearer view and better understanding of benefits specific to these types of development strategies.

Summary

This literature review consisting of sections concerning ecosystem services, ecological economics, soil ecology, conservation development, and low-impact development form the academic foundation for this research. Without this review many of the underlying assumptions and past works pertaining to the subject of development and conservation could not have been fully represented or explored to give the necessary context to the research conducted within project. Each was selected to contribute its own unique perspective on the issue of environmental conservation and human development, specifically single-family residential development.

The ecosystem services section illustrates the myriad of ways in which life, human and otherwise, is sustained on this planet by a complex array of interconnected and interacting ecological processes. Ecological economics gives the reader a more familiar frame of reference by which to understand the implications of ecosystem services by using a monetary approach to qualifying and quantifying ecosystem processes and services. Knowledge of soil ecology and the ways it relates to soil health are integral to understanding the potential impacts on soil health and function due to certain development activities. The conservation development and low-impact development sections serve to illustrate two examples of strategies attempting to unite the goals of both conservation and development, albeit in slightly different ways and with slightly different focuses. The cumulative knowledge acts as a crash-course in the material useful in understanding the context and situation that is being addressed in this research.

Chapter 3: Research Design

Understanding the philosophical foundations and assumptions of a research project, also known as research methodology, can be helpful in informing the reader of why certain methods of data acquisition and analysis were used by the researcher. What follows is a brief assessment of these foundational assumptions and observations regarding the physical world around us, as well as a more detailed look at the specific means by which data has been gathered and analyzed for this study.

Methodology

Cultivating a better understanding of where I as the researcher stand in terms of my assumptions regarding the nature of reality and knowledge is helpful when attempting to make the modes of inquiry surrounding this body of work more accessible and clearer to future readers. There exist many different views and ideas pertaining to the nature of reality and the pursuit of knowledge based upon the experience of that reality. My study relies on a generally post-positivist paradigm of research inquiry. In addition, the research method known as "triangulation" is employed by this study as well.

Post-positivism can be framed as a belief or view of reality that exists external to oneself and "that can only be known within some level of 'probability'" (Groat and Wang, 2002 pg. 32). To put it another way, this paradigm of inquiry states that some type of apprehensible reality exists, although the exact or true nature of this realty can never be fully known to the observer who is forever locked inside his/her individual bubble of unique perspective. However, productive attempts can be made to shift and/or expand our perspectives through language and other methods of data communication which move us closer to grasping a more complete understanding of the reality pertaining to the subject of investigation. Reality exists, although we may never fully know or comprehend just what that reality is in its true or purely objective form, we can still make small discoveries based on limited truths from which meaningful action can grow. Such thinking has brought me to the assumption that there are "multiple, apprehendable, and sometimes conflicting realities that are the products of human intellects" and are all subject to change over time (Guba and Lincoln, 1994 pg. 111). It is this limited, working definition and assumption of reality and the pursuit of knowledge which form the core drivers of my research paradigm.

To complement the post-positivist framework of this research, the data acquisition and analysis method of triangulation is utilized to interpret three different types of data. Triangulation can be described as "the use of a variety of data sources in a study" (Janesick, 1994; pg. 214). The goal of utilizing a variety of data sources or types of data, even if the same area of research is investigated by the various data sources, is to glean a variety of perspectives on the issue of inquiry in order to round-out ones perspective. The sources or forms of data analyzed in my research include peer-reviewed articles, books, census demographic and housing data, population extrapolation formulas, interview data, and geospatial information. Pulling from several different types of data can help each individual piece of information to strengthen others by building and validating this research through a variety of data perspectives. The specific methods applied to data analysis are explained in the *Methods* section below.

Methods

My research is primarily concerned with informing policy making in regard to preserving undeveloped soils in Pflugerville's ETJ. To address this, three main types of data interpretation are utilized: GIS, Population Projection, and Interviews. Specific soil impacts from new construction activities are primarily targeted for analysis, such as prolific soil compaction on and around construction sites. In order to gauge the approximate number of new single-family dwelling units the population of Pflugerville is likely to necessitate by the year 2030, its future population was projected by applying a constant rate of growth to past population counts taken by the US Census Bureau. The constant rate of growth used to project Pflugerville's future population was the average annual rate of population growth experienced by the city from the years 2000 through 2009. Single family housing demand was then projected up to the year 2030 based on the average number of persons-per-household recorded by the US Census Bureau for the year 2000 (which was roughly 3 persons per household), the number of occupied housing units for the same year (5,146) and the previously mentioned future population projection up to 2030.

The decision to run a population projection to calculate Pflugerville's future total population was chosen over other forms of population extrapolation, population forecasting for example, due to the availability of a constant increment of annual growth. Richard Klosterman defines a population projection as a calculation "of future conditions that would exist as a result of adopting a set of underlying assumptions" (Klosterman, 1990; pg. 4). In other words, projections constitute an if-then relationship with the data being used; in this case if the average annual growth rates hold true up to the year 2030 then the likely total future population of the city is projected to be X. It is conceded by this research that the reliability of applying a population projection to calculate relatively long-term changes to a city's overall population can be precarious. However, exact figures are not really needed by this research as its larger goal is to assess overall, generalized population growth trends to inform scenario modeling of potential future development.

Prior to calculating a growth rate, the percentage of total annual population increase must first be found for the city. The percent increase of population growth from year-to-year was calculated by first subtracting the most recent population (2009) by a base population (2000) in order to find the amount of population increase. Next, this amount of increase was divided by the base population. This results in a decimal figure, which when multiplied by 100 gives a whole number representing the percentage of population increase occurring between two dates.

The following formula was used to conduct simple population extrapolation using total population figures (Klosterman, 1990; pg. 13):

$$r = [(Yt + 1) - Yt]/Yt$$

Within this formula, *r* stands for the constant rate of growth and *Yt* stands for the total population at a given time. "Growth rate" is defined as the change in the dependent variable, *Y* or population for a certain time period, divided by a starting point or base population (Klosterman, 1990). In order to calculate the average annual growth rate of Pflugerville from 2000 through 2009 using total populations, and thereby being able to predict approximate total future populations (assuming the average annual growth rate used continues to hold true into the future), the following formula was used:

$$(Y_{2009} / Y_{2000}) \wedge (1/9) - 1$$

The most recent population available from the US Census Bureau (2009) was divided by the base population (2000) and raised to the power of 1/9 (the number of year's difference between 2009 and 2000) and subtracted by 1.

Population growth trends and demographic data specific to Travis County have been assessed for this research. Geospatial data sources are used to construct a hypothetical future scenario of expanding urban development in Pflugerville. In terms of the GIS components of my research, maps were generated showing the soil types existing in Pflugerville's ETJ, annexation trends over time, and single-family housing development trends over time in the ETJ. The necessary data were gathered from municipal, state, and federal sources.

As the city's population continues to grow, concerns over site impacts from new residential development becomes increasingly pressing. Chapter 4 in this study addresses the potential for future population growth in Pflugerville up to the year 2030, in addition to projecting future single-family housing demands based on US Census figures of average persons per household recorded during the year 2000. The year 2030 was chosen to calculate the future population projection of Pflugerville because it offers a glimpse of what the next twenty years may bring to the cities in terms of population, as well as aiding in calculating the projected housing needs of the future populations. 2030 is a year far enough into the future that running projections for overall population and housing needs can meaningfully direct current action to curb the negative ecological impacts of urban and suburban development, while it is not too distant a date as to invalidate the working hypothesis that the average annual growth rate between 2000 to 2009 will hold true into the future.

To more rigorously ground this research in contemporary practice and experience, four interviews were conducted with individuals involved in the development of single-family homes. Subcontracting organizations who conduct environmental assessments and analyses on behalf of the home developer were interviewed as were the planning department of Pflugerville and the building regulation compliance office of Pflugerville. The rationale behind interviewing individuals from these fields was to gain a clearer perspective of what actually occurs on the ground at a new single-family home development site and how the city of Pflugerville sees the city's future development unfolding. Understanding how soils are regarded by the developer and the ways in which they are impacted by commonly employed techniques represents an important part of making recommendations for future policy intended to aid in the long-term conservation of soils and their ecological benefits.

All four interviews were conducted in very much the same way. Each interview had an average duration of around 45 minutes. The interviewer and interviewee(s) were both seated at a table and the interviewee(s) were asked several, commonly 10, predetermined questions. Where appropriate and advantageous, additional questions were asked in order to better expand upon and investigate previously unforeseen facets of inquiry.

In many ways these organizations or fields serve as a kind of litmus test for developmental/environmental regulation. Where these two regulatory impetuses converge, the developers, consultants and subcontractors must interpret these regulations and implement them in their day-to-day practices. This puts them in a unique situation to expound upon what works, what doesn't and why they find this to be the case. Based on their experience with effective and ineffective regulations, the data gathered from these interviews serves to inform the research in unique and important ways. It puts a human perspective on the challenges and opportunities of implementing a soil conservation plan through developmental regulation. Ultimately human interactions are what need to undergo a change if counterproductive tacit practices are to be addressed and what better way to assess the nature of these interactions and relationships than to conduct personal interviews with the parties themselves.

Chapter 4: Growing Central Texas Cities

Addressing the externalities increased urbanization is likely to engender is a goal for many in the conservation and planning communities. To begin assessing the possible ecological impacts future urban expansion is likely to have, one must first gauge the potential amount and rate of future residential development. To accomplish this task, I have chosen to utilize population extrapolation techniques to generate future population projections for Austin and Pflugerville up to the year 2030. The following is an explanation and characterization of past and future population trends in Travis County and Pflugerville, Texas.

Travis County

Contrary to the worldwide trend of increased urban migration, some cities in the United States have been losing residents as a result of the recent economic recession. However, amid the struggle and uncertainty facing many states, Texas has shown itself generally to be a comfortable outlier to many of the nation's recession woes. A branch of the Brookings Institute found that 6 of the 21 cities that have fared best through this recession are located in Texas (relocation.com, 2010). The robust and growing economies of many Texas cities have been attracting a large influx of new residents to the state in recent years. Central Texas, specifically Travis County, is by no means an exception to this Texas-centric migration trend. Travis County has experienced a steady increase in its overall population since the year 2000. The county grew from 812,280 residents in 2000 to an estimated 1,026,158 in 2009 (US Census Bureau).

Pflugerville

The city of Pflugerville has experienced a huge amount of population growth since 1990, more than tripling its population by the year 2000. Between 2000 and 2009 this city on the northeastern fringe of Austin is estimated to have increased its population by 161%; more than doubling the population held in 2000. Figure 1.4 shows past population trends in Pflugerville through the year 2009. If growth trends similar to those experienced between 2000 and 2009 continue, Pflugerville would be expected to support a population of over 400,000 residents by the year 2030. Figure 1.5 illustrates what future population growth in the city of Pflugerville may look like if the city maintains a constant growth rate of 11.3% per year, which was derived from the population growth that took place between the years 2000 through 2009.

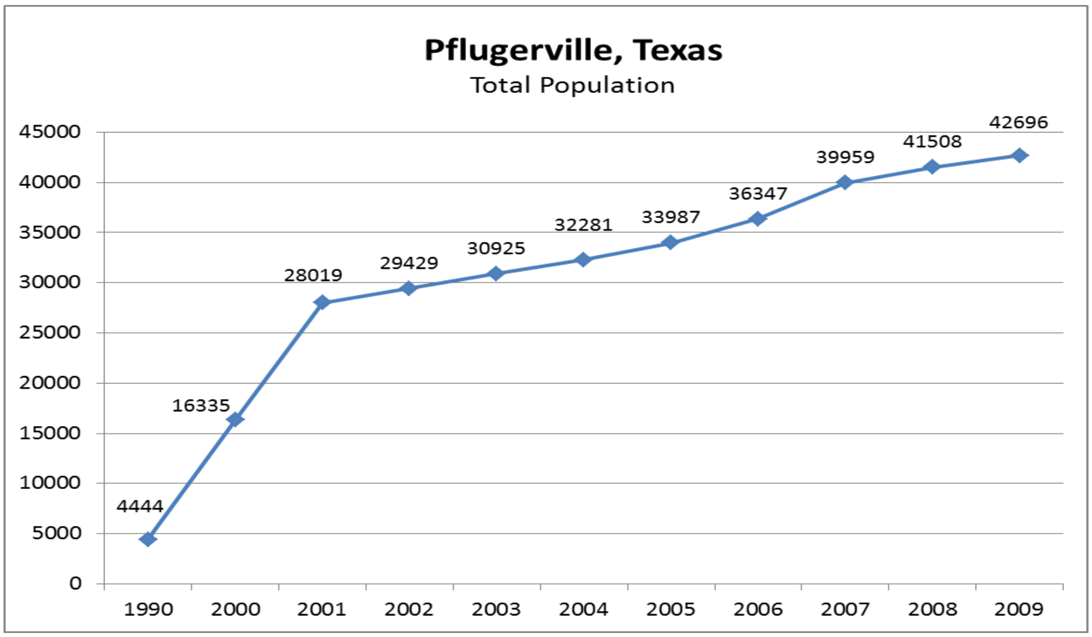


Figure 5: Past Pflugerville Populations (US Census Bureau)

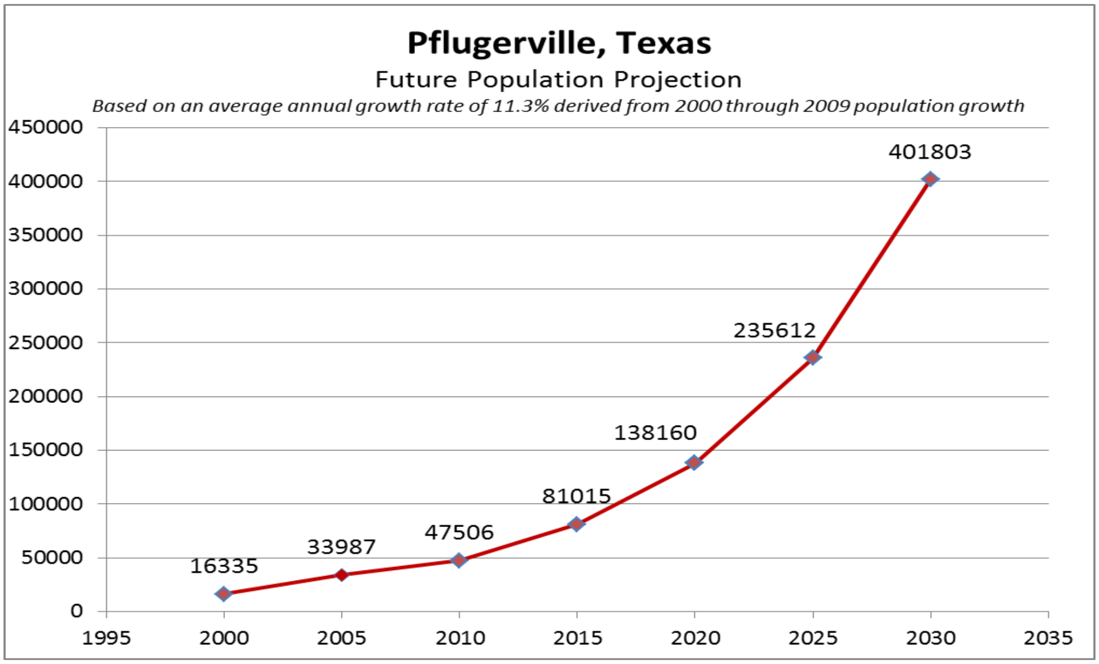


Figure 6: Projected Future Pflugerville Populations (US Census Bureau)

Pflugerville Single-Family Housing Demand

The city of Pflugerville is projected to experience quite a sizable housing boom itself by the year 2030. In the year 2000 the US Census Bureau accounted for a total of 5,146 occupied housing units in the city of Pflugerville, Texas. Within those 5,146 housing units, there was found to be on average about 3 persons per household at the time (US Census Bureau). Working from the assumption that this number of people per household will persist into the future, and that the previously calculated average annual growth rate which occurred between the years 2000 and 2009 will hold constant (an 11% population increase annually), the city of Pflugerville is likely to experience a huge increase in housing demand over the next twenty years. Figure 1.7 shows the number of housing units needed in Pflugerville up to 2030.

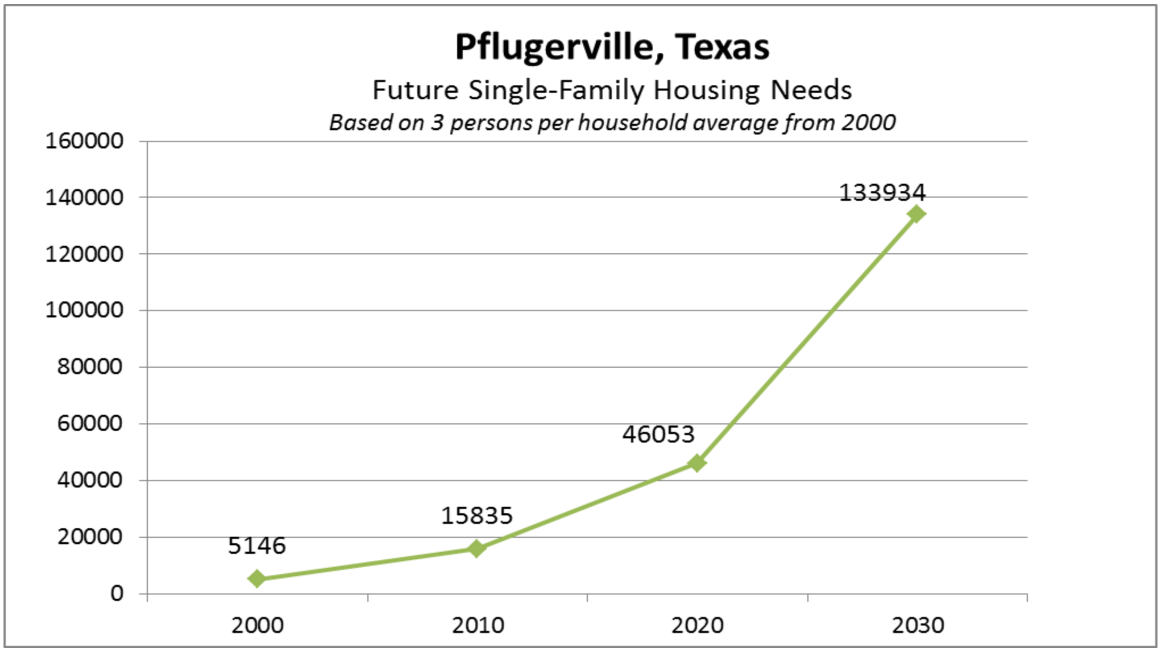


Figure 7: Projected Future Single-Family Housing Needs (US Census Bureau)

In summary, Pflugerville is poised to undergo considerable sustained urban and suburban growth in terms of total population and single-family housing developments. While it is true that not all these newly arriving urbanites will demand a single-family residence, many are certain to do so. Given the information conveyed in this and previous chapters, plans pertaining to the conservation and preservation of the valuable soils represent should not be easily overturned to suit the temporary desires of profit seeking firms.

Chapter 5: Interviews

Four interviews were conducted for this research in an effort to more fully inform the various perspectives and fields reflected and discussed within this study. All of the interviews were done in-person and had a common duration of about one hour. In the interest of maintaining confidentiality, the specific names of individuals and the specific organizations they represent will remain absent, with the exception of offices affiliated with the municipality of Pflugerville.

The individuals interviewed that are employed by the city of Pflugerville worked for the planning and building compliance departments. A major developer and builder of single-family homes in the ETJ of Pflugerville was interviewed as was an independent environmental/geotechnical engineering firm subcontracted by a different large home developer to conduct preconstruction site assessments. All questions revolved around new single-family home development in Pflugerville's ETJ, impacts on soils from new development activities, and the direction the ETJ is headed in terms of future development.

Geotechnical Engineer

The first interviewee was the environmental/geotechnical engineering consultancy firm and was conducted on the twelfth of April, 2011. The services this consultancy firm provides to a large single-family home developer, which for the sake of confidentiality will go unnamed, consist of predevelopment site assessments regarding the soil and hydrologic conditions of a site. The consultancy firm usually takes borings at various intervals on a site to determine soil type, soil plasticity, and soil depth. Soil plasticity is a term which essential means soil movement; the greater the plasticity of a soil the greater the potential for the soil to move over time (Interview Data, 4-12-2011).This agency is most concerned with assessing the potential amount of soil moment on a site. This soil condition is greatly determined by the amount of clay in a soil. For instance, Pflugerville has two main soil types; Austin Chalk to the west and Tailor Clay to the east (Interview Data, 4-12-2011). These soil types refer more to overall plasticity but are consistent with the Houston Black and Austin-Houston mix as discussed in chapter 2. In terms of development concerns, the Austin Chalk is the most stable and therefore least precarious to develop as it consists primarily of limestone and a thin layer of clay (Interview Data, 4-12-2011). The Tailor Clay is composed, not surprisingly by an increased amount and depth of clay. The greater the clay contents of a soil, the greater the likelihood that it will experience shrink-swell conditions. Shrink-swell refers to soil movement caused by fluctuations in groundwater (Interview Data, 4-12-2011). As a soil is increasingly hydrated, it will swell and likewise when it is parched, the soil will shrink. This can cause major problems for a structures foundation, not to mention making the construction of the structure itself extremely precarious.

To combat these detrimental conditions often encountered in the ETJ of Pflugerville, several steps can be taken by the developer and home builder should they see fit. The builder may see fit to call for the use of a suspended ground floor and/or have the housing support beams set deeper (Interview Data, 4-12-2011). The precarious clay can be removed and replaced with a fill material with less plasticity, although this can quickly become expensive and time consuming (Interview Data, 4-12-2011). Another method used to temporarily ameliorate the effects of shrink-swell soils is known as moisture conditioning. Moisture conditioning involves pumping or injecting water into a prepped new development site so that the soil is fully swelled (Interview Data, 4-12-2011). The rationale behind this technique is to prevent shrink-swell fluctuations during the construction process to help insure a better end product. This being said, it should be pointed out that home foundations are built according to standards that prevent them from failing, which is not problem free (Interview Data, 4-12-2011). This means that even though site conditions may clearly point to many future problems for the structure if costly precautions are not taken in the construction process, the structure is most often built without these extra precautions being taken. However, this is more of a reflection of home developer's risk-adverse nature combined with generally uninformed consumer preferences.

These preferences, as gleaned from this interview, come down to an economic bottom line. Not to say that price is insignificant, far from it, although it was the consensus of the respondent that people by and large would want to put more money in upgrades they could directly see and use, like granite countertops or a backyard pool, rather than a more stable and durable foundation (Interview Data, 4-12-2011).

In general, the main regulatory concerns sited in this interview in regard to soils were the use of silt fencing to prevent soil loss on a new development site. However, this concern is mostly targeted at preventing hazardous road conditions as construction vehicles leaving the site can deposit dirt and mud on a roads surface, and to prevent drainage systems from becoming clogged with dirt (Interview Data, 4-12-2011). Laying a construction entrance, which is basically a course rocky driveway, is another way to keep soil off roadways and on the site itself as it is intended to remove the majority of soil debris on the tires of vehicles leaving a new development site (Interview Data, 4-12-2011). Development of floodplains and around creeks/streams is discouraged and these areas are usually left as parkland (Interview Data, 4-12-2011). Construction methods were not shown to be fundamentally different in the ETJ as compared with development occurring inside the city limits of Pflugerville, but rather reflect the soil conditions present on the individual site itself regardless of where it is located. The use of silt fencing at strategic points around a new development site, determined by a consulting firm and a city building inspection official, is mandatory for all development projects. It was the feeling of the respondent that the monitoring and enforcement of the silt fence erosion control mandate could be much better (Interview Data, 4-12-2011).

This respondent's frame of interpretation was consistent with their advisory role on behalf of outside parties. The geotechnical consulting firm employee interviewed saw the firm's job ending with what is asked of them by their client. As they have no power to influence practices beyond their specialized knowledge base, their frame is one of temporary technical advisors to a home builder, home developer, or whomever the client entity may be.

Single-Family Home Developer

The second interview was conducted with a large developer and builder of single-family homes in the Pflugerville ETJ on morning of the fifteenth of April, 2011. The developer/builder typically purchases finished lots that have already been prepped for construction. In terms of the site prep process, a meeting is usually held with the site prep contractor, city officials, and a site designer (Interview Data, 4-15-2011 A). Most onsite vegetation is removed prior to construction on a new development site, scrub brush and grass is always removed, although larger mature trees are assessed in terms of species and the amenity they add to a site (Interview Data, 4-15-2011 A). However, this is only done in areas that require a tree survey to be conducted, which the Pflugerville ETJ does not (Interview Data, 4-15-2011 A). Even though much of the existing vegetation is removed, I was assured by the developer that many new trees are planed after construction is finished. According to this developer site prep usually takes anywhere from 5 to 7 months to complete and an additional 3 to 4 for the home construction itself (Interview Data, 4-15-2011 A).

The biggest day-to-day challenges this developer cited primarily had to do with encountering unforeseen drainage issues with the new development site and troubles with city inspectors, who ultimately have final say on the legality of a new development project (Interview Data, 4-15-2011 A). Encountering unforeseen drainage issues with a new development site may argue for a broader and more in depth understanding of the soil and hydrologic conditions both of the site itself and of the surrounding area. In terms of encountering precarious soil conditions, several steps can and are taken by this developer including the surface application of lime to soils with a high concentration of clay, and using ‘Geogrids’ (plastic webbing) placed on the exposed soil of a new development site to better hold it in place in the absence of vegetation (Interview Data, 4-15-2011 A). The developer stated that incorporating a broader view of the specific sites context within a larger area would be advantageous to preventing future drainage issues and foundation problems associated with them (Interview Data, 4-15-2011 A).

Preventing unnecessary soil compaction is not something that is addressed or seemingly considered by the developer. Certain aspects of a new construction project require soil to be intentionally compacted to facilitate a stable foundation. In terms of alternative development approaches and/or techniques, like LID or conservation development, their applicability is very site specific and their application is almost entirely driven by consumer willingness to internalize the often higher costs of these residential developments (Interview Data, 4-15-2011 A). As most consumers are not aware of all the complexities reflected in the design and construction of homes and are generally very averse to price increases, there does not seem to be a large demand for alternatives to conventional single-family residential developments (Interview Data, 4-15-2011 A). This development firm did admit they had noticed a preference for single-family homes in the ETJ of Pflugerville relative to new single-family homes in the city limits, although this trend was only consistent with first time home buyers (Interview Testimony, 4-15-2011 A).

This respondent’s frame of interpretation again revolved around a clearly delineated job description, which basically consists of the fact that the firm is in the business of building single-family residential homes in an effort to make profit. They are not interested in adding more regulatory hurdles, as they see them, to their already difficult job. All decisions seem to revolve around this economic bottom line and as such a minimal amount of outside assistance and collaboration is sought. The reasoning for this is that these types of activities tend to be expensive and time consuming for an industry most interested in turning liabilities; houses need to be sold, into economic profit by providing what the market demands.

City of Pflugerville Building Inspections Official

A building inspection official for the city of Pflugerville was interviewed on the fifteenth of April, 2011 in the afternoon. Soil conservation is not really something that the city is concerned with, apart from keeping soil onsite, off roadways and out of the municipality's drainage infrastructure. Silt fencing was again said to be the only required form of erosion control on a new development site, and that even this was not always enforced and/or monitored properly (Interview Data, 4-15-2011 B). According to this individual, new development sites are usually cleared of all vegetation before any utilities are installed or streets are built (Interview Data, 4-15-2011 B).

In terms of new development within the city limits compared to the ETJ of Pflugerville, the city official stated that the ETJ was growing a bit faster than the city limits in terms of new single-family residential home construction (Interview Data, 4-15-2011 B). According to the city official, the ETJ is widely expected to be "nothing but rooftops" in the next 20 years (Interview Data, 4-15-2011 B). The city official did not see any real likelihood of alternative forms of residential development infiltrating the more traditional methods of home and subdivision construction, especially in the ETJ where more first time home buyers are gravitating (Interview Data, 4-15-2011 B). Again, this was related to dominant trends within the conventional building culture. It was the feeling of this respondent that the likely domination of low-density single-family home construction in the ETJ would actually provide more ecological benefits compared to higher density development in that a greater overall amount of ecological functionality would be preserved (Interview Data, 4-15-2011 B). This was interesting in that it would seem an abundance of low-density development would create a greater amount of impervious cover than would a higher-density development.

This respondent's frame of interpretation seemed to reflect a general ambivalence to the potential negative ecological impacts of conventional low-density residential development. I gathered that she felt prolific low-density development in the ETJ of Pflugerville was both inevitable and beneficial to the city. The standard operating procedure currently taken by the city in regard to new development activities seemed to this respondent to be totally sufficient both now and into the foreseeable future.

City of Pflugerville Planners

Two officials with the city of Pflugerville's planning department were interviewed together on the eighteenth of April, 2011. In general, both planners stated that they anticipated the majority of the new ETJ development to be clustered around specific hubs as designated by major roads and municipal infrastructure (Interview Data, 4-18-2011). There was a strong consensus that the city wants to minimize the extent to which it extends its infrastructural responsibilities into the ETJ. This was sighted as primarily a financial issue as extending infrastructure, water and drainage for instance, was highly time consuming and expensive for the city.

In terms of the likelihood alternative forms of single-family residential development might be increasingly employed, especially in the ETJ, the planners were quite skeptical. From their experience, they saw home developers as having very entrenched preconceived notions about site design and a general unwillingness to compromise unless forced to via obligatory regulations (Interview Data, 4-18-2011). Within the city limits however, a general lack of available space and an increased willingness to accept higher-density development reflects itself in the push for more infill development (Interview Data, 4-18-2011).

The only areas directly protected from development in the ETJ are floodplains as designated by FEMA (Interview Data, 4-18-2011). There are no existing regulations applicable to the ETJ that make explicit reference to soils besides the mandatory use of silt fencing around new development projects, however this is more a product of a desire to protect existing drainage and road infrastructure rather preserve existing onsite soils (Interview Testimony, 4-18-2011). From the planner's perspective, home developers themselves had a strong preference to develop in the ETJ due to the greater availability of developable land, the overall cheaper cost of land, and the less stringent regulatory requirements (Interview Testimony, 4-18-2011). The planners also stated that due to the municipalities reluctance to extend current infrastructure, many developers have gone about setting up MUD's (municipal utility districts) outside the city limits, which besides representing a large debt burden the city does not want to take on, these MUD's also do not contribute to the city's tax base (Interview Testimony, 4-18-2011).

Looking to the future, the planners showed some interest in the possibility of extending some municipal powers into the ETJ; or rather as they put it, granting the county some municipal regulatory powers (Interview Testimony, 4-18-2011). A factor partially informing this perspective is the experience that developers only respond to mandatory regulation, and even then the attitude is generally begrudging (Interview Testimony, 4-18-2011). This being their experience with developers, there is seen to be few other leverage points aside from greater regulation and enforcement of current regulations.

Summary

In general, home developers and the city officials are each entrenched in their own camps and generally unwilling to compromise unless it directly affords them some sort of benefit, such as a higher quality final product being produced at a lower cost for the city, which it seldom seems to. No one I interviewed saw alternative residential development strategies such as LID or conservation development as feasible or likely on a larger scale. This is partially due to developer's unwillingness to risk implementing construction practices that are unproven and potentially financially costly, in addition to their perception that consumers are unwilling to accept higher home prices for features they cannot clearly or directly see or use. Independent development projects in which the developer works directly with the home buyer seem to be the only real exception to this trend, as the situation typically seems to be one in which the home buyer is generally more informed as to the possible alternative development strategies and their consequences as well as the fact that they tend to be more willing/able to spend more money on the project. This implies that a change in consumer preferences is the only real way to achieve the goals of more environmentally sensitive home construction and design.

In each case, there was a general sense of self enforced isolation between potential collaborators. The interviewees either had a ‘don’t tell me how to do my job’ attitude or were ambivalent about the activities beyond their individual firm’s responsibilities and duties to a project. However, this seems to be the prevailing trend within the context of the environment these firms and departments operate in. Developers are primarily concerned about their financial bottom line and the level of risk they are taking on, as is the city, as is the private contractor. All groups of people I interviewed are fundamentally concerned with their own economic viability, whether it is related to large scale development projects or the city’s tax base or their companies’ reputation with potential clients. Traditional practices are entrenched as are long standing animosity between the municipality and the developers. These tacit practices, consumer preferences and divisions of labor are the primary hurdles to overcome if alternative residential development strategies are to be given a better chance at proving themselves in relation to more traditional development techniques.

Chapter 6: Results, Recommendations and Future Research

According to single-family residential housing unit permitting data provided by Pflugerville's permitting specialist, the city has been experiencing a relative decline in the number of permits being issued for homes in the city limits and a relative increase in the number of permits issued for homes in the ETJ since 2009. Figure 8 depicts trends in single-family home permits issued by the city of Pflugerville for the years 2003 through 2010. The data cited herein was obtained through the permiting specialist for the city of Pflugerville. The years 2006 through 2008 reflect a drastic decrease of housing permits in both the city limits and the ETJ. During this time the housing market was in a poor shape nationally, reflected in the low numbers of permits being issued. As time has passed, both the city limits and the ETJ have been rebounding. In general, a larger amount of new development appears to be gravitating to the ETJ over the city limits, which was supported by building permit data and interview data.

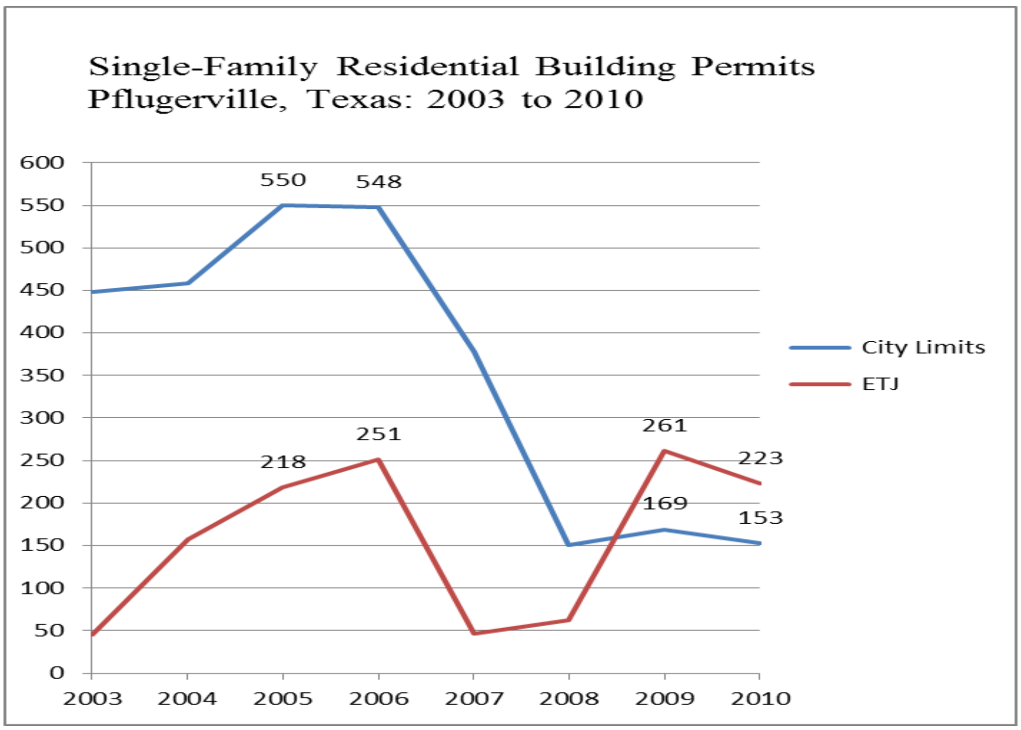


Figure 8: Single-Family Residential Development Trends (City of Pflugerville Building Permit Data)

If expectations are correct, the ETJ is poised to undergo a tremendous amount of residential housing growth in the coming years. It seems the most direct way to leveage alternatives to prolific low-density development is to shift consumer preferences. This is without a doubt easier said than done. In the end, consumers should have a wide variety of choices regarding housing type. Although it seems clear that a drastic change in day-to-day business toward greater enviornmental mindfulness is not on the horizon.

Because the primary way soils are addressed on a new single-family home development site is with the application of silt fencing, an improvement in the monitoring and enforcement of this existing regualtory requirement is warented. Establishing buffer zones where the existing vegetation is left untouched on the new development site, especially in strategic locations to replace or suppliment the use of silt fencing could result in environmental benefits as well as financial savings. If vegetation buffers were used in concert with silt fencing, the likelyhood of success and wider implementation would be increased. Although this would require a higher level of cooperation than many of the players in this scenario are used to or even desire.

Being that consumer preferences, to a large extent, have created the environemnt of low-density single-family residential development currently experinced in many urban and suburban areas across the county, there may be a strong potential for consumers to shift and help demand new, more environmentally friendly development trends. This however remains to be seen. As is the case with most change, it will certainly be a long and gradual process characterized by many small gains and losses. If consumer preferences change, the market will react to accommodate these new tastes. Hopefully this will end up working to our collective advantage as more people become aware of the impacts of their choices.

In the short-term, the most practical recommendation I can make is that the current methods of monitoring and enforcing silt fencing erosion controlls on new development sites could be substantially improved. In light of the large amount of residential growth Pflugerville's ETJ is projected to experience, this small step would benefit a very large area. In terms of farther reaching and more profound changes, the only way these changes will come about is if consumer preferences shift to demand more environmentally friendly forms of single-family residential development.

The perspective of potential first-time home buyers would be helpful to integrate into future dialogue and study regarding the feasibility of alternative forms of residential home design and construction. This investigation would primarily target consumer preferences and decision-making reasoning. Further research investigating the evolution of changes in consumer housing preferences is warrented. Research of this kind may help uncover trends in how consumer preferences shift and change over time, as well as potentially identifying catalysts to initiate this activity. In the end, taking this route may be more effective in addressing the complicated issue of balancing consumer housing needs, consumer housing preferences, a risk-adverse supply chain, and regulatory mandates to achieve a more environmentally responsible consumer culture.

Appendix: Maps and Figures

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