URBAN PRESCRIBED GRAZING AS AN ALTERNATIVE TO CONVENTIONAL LAND MANAGEMENT TECHNIQUES: ENVIRONMENTAL, ECONOMIC, AND SOCIAL IMPLICATIONS

by

ZACHARY ANDREW RICHARDSON

(Under the Direction of Eric MacDonald)

ABSTRACT

This thesis introduces prescribed grazing, or the application of livestock to control unwanted vegetation, as an urban landscape management tool, and justifies its legitimacy in terms of its environmental, economic, and social implications. Research for this thesis was conducted using three methods: a literature review, interviews, and a case study. Data was collected from both peer-reviewed and popular literature in a variety of fields, including environmental psychology, ecological restoration, and husbandry. Interviews with individuals familiar with prescribed grazing were used to gather the most up-to-date information available about logistical details and public perceptions of the practice. The case study provided opportunities to explore specific questions and conduct experiments pertaining to the practice of urban prescribed grazing. Information gathered using these three research methods suggests that prescribed grazing can be an environmentally benign, cost-competitive, and socially engaging vegetation management technique in urban landscapes.

INDEX WORDS: prescribed grazing, goats, sheep, vegetation management, invasive species

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DEDICATION

To my family and friends.

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CHAPTER 1

INTRODUCTION

This thesis introduces prescribed grazing as an urban landscape management tool, and justifies its legitimacy in terms of its environmental, economic, and social implications. Manipulating grazing animals to manage vegetation is an ancient practice. In some parts of the world, sheep and goats have been herded for thousands of years, and their husbandry is entrenched in those communities' cultures. Traditionally, grazing animals are allowed to move through the landscape to feed on vegetation that will support the growth and health of the animals. In this sense, the vegetation is being managed for the benefit of the animals. On the other hand, prescribed grazing is the practice of strategically concentrating grazing animals through different plant communities to achieve vegetation management goals. Using technologies like electric fencing and solar chargers, animals like goats and sheep can be contained within predetermined boundaries. These enclosures are adapted to individual sites, and constructed with the intent of achieving specific vegetation management goals. As a vegetation management technique, prescribed grazing offers unique social, environmental, and economic implications. Whereas most literature published on the subject of prescribed grazing deals with the practice in rural environments, this thesis explores prescribed grazing as a tool for managing landscapes in and around cities.

In urban environments across America, there exists an abundance of overgrown, neglected landscapes. These overlooked spaces appear in the form of road right-of ways,

property margins, "the back 40," abandoned lots, and riparian corridors among others. A result of years of mismanagement—or, more often, a lack of management altogether—these "junkscapes," as author James Howard Kunstler (1993) calls them, are frequently plagued with environmental degradation issues such as non-native, invasive plant invasions and accumulations of trash . Landscape architect and urban ecologist Nina Marie-Lister (2007, 64) further describes junkscapes as "space that is literally being wasted: space within the landscape that is no longer functional, or has never been productively used."

Implied in the term "junkscapes" is the idea that these underutilized landscapes have the potential to be valuable urban greenspaces, and "should be seen as awaiting reactivation" (Lister 2006). The potential benefits of these urban greenspaces are well documented. In his book *Cities and Natural Processes*, Michael Hough describes urban forests as providers of wildlife habitat, recreation areas, air filtering services, and buffers for urban streams and forests (2004). The presence of greenspaces can help mitigate the extreme temperatures associated with the urban built environment (Hough 2004). Moreover, urban greenspaces often serve as an avenue for adjacent residents to reconnect with nature (Ryan and Grese 2005). For landscape architects and urban planners, these pockets of "wilderness" within the matrix of concrete and asphalt offer endless design possibilities to creatively engage urban dwellers, both passively and actively.

Unfortunately, many of these urban landscapes suffer from invasions of aggressive, non-native plant species. If not managed, these invasive plants can have negative environmental impacts, such as outcompeting desirable species for sunlight, space, water, and nutrients (Gordon 1998). When invasive plants are allowed to grow

unchecked, their growth patterns often result in unsightly and unhospitable landscapes. Environmental psychologists note that these environments can evoke feelings of confusion and danger (Kaplan, Kaplan, and Ryan 1998). One can imagine how these perceptions might perpetuate the problem of management inaction and continued growth of undesirable vegetation. In recent decades, researchers such as Richard Louv have explored the troubled relationship between people and place. His concept of "nature deficit disorder" explores the disconnection between individuals and their natural surroundings (2011). Given the increasing number of people who live in American cities, urban junkscapes could play a key role providing the experiences necessary to form healthy people-place bonds.

In the United States, these plant species (not including alien aquatic vegetation) are estimated to cost over 33 billion dollars in terms of losses, damages, and control (Pimentel et al. 2002). Although the preceding figure takes into account agricultural and rural cases, there is evidence that the urban environment may be an especially hospitable sink for invasive plant species (Gulezian and Nyberg 2010). The many fragmented, disturbed, and neglected landscapes within the typical American city are prime areas for invasive plant colonization (Gulezian and Nyberg 2010). In the absence of natural checks and balances, these plants often grow at tremendous rates, making them difficult to manage over extended periods of time (Westbrooks 1998).

Invasive plant infestations are often managed with the use of heavy and hand-held machinery. Depending on the species and the degree to which it is established, these methods can be time consuming, labor intensive, and expensive (Campbell and Taylor 2006, Westbrooks 1998). Unique site limitations are often the cause of landscape

management inaction. Access can be a problem on steep slopes and rough terrain. In some cases, the overgrown vegetation itself can be so dense that it restricts accessibility, visibility, and maneuverability necessary for restoration efforts. Downed trees, bramble snags, and tangled thickets often exacerbate the difficulties associated with mechanical removal of invasive plants. Furthermore, most municipalities mandate that land managers not disturb the soil within a predetermined buffer of urban streams and rivers, making invasive plant removal with heavy machinery logistically very difficult, if not illegal.

Aside from mechanical removal, herbicides such as glyphosate and 2,4-D are famously effective at eradicating unwanted plant species, but often at the cost of unintentionally harming desirable plant species. Additionally, the use of herbicides near waterways, fragile ecosystems, and young children is commonly frowned upon, both in societal and legal sectors. For some land managers, this public perception is enough to discourage the use of herbicides (personal observations).

Prescribed fire is another popular and effective tool for the reclamation of invaded landscapes. Within an urban context, however, these techniques may not be appropriate. As is true with any form of vegetation management, prescribed fire offers a short-term solution, with vegetation returning (often with vigor). Smoke from prescribed burns can dangerously obstruct adjacent traffic, and the inherent proximity of urban greenspaces to other properties makes the use of fire a potential liability. Moreover, the remaining charred stumps and stems may appear unsightly. Although prescribed fire is undoubtedly an effective vegetation management technique and it should most definitely be considered a viable option in appropriate situations, its limitations for use in the city account for its minimal presence in this thesis.

Biocontrol options, such as introduced insects and microbes, can be another effective management tool. However, the concept of releasing non-native organisms into a landscape has its own drawbacks. The process is time-consuming, expensive, and can be difficult to control (Frost and Launchbaugh 2003). Moreover, the introduction of foreign insects into new plant communities can create unforeseen problems, such as feeding on important agricultural crops. For example, in 2009 the bean plataspid, (*Megacopta cribraria*), also known as a "kudzu beetle," was found for the first time in North America in northeastern Georgia (Zhang, Hanula, and Horn 2012). The insect feeds on the aggressive, non-native vine kudzu (*Pueria montana*), prompting researchers to evaluate the effects of bean plataspid herbivory. Now, two years after its discovery in Georgia, the kudzu beetle population is enormous, yet its effectiveness is still under scrutiny. Instead of being welcomed as an effective check on the spread of kudzu, it is often viewed as a pest itself because it consumes soybean and other bean crops, swarms in thick clouds, and leaves a stinging rash when pressed against human flesh.

In some cases, and often most importantly, the expense of recovering overgrown landscapes may not be financially cost-effective for the landowner. In general, it can be assumed that the greater degree to which a landscape is occupied by dense masses of previously unmanaged vegetation, the greater the cost will be to bring the landscape to a maintainable state.

Landscape architects, policy makers, landowners, and land managers will be key players in managing these urban green spaces as communities rediscover their value. There is a need, then, for an environmentally benign, cost-effective, and community-engaging technique for managing these landscapes. Prescribed grazing is becoming an

increasingly popular tool for these urban land management professionals. This thesis explores prescribed grazing as a vegetation management technique for overgrown urban landscapes, and analyzes its environmental, economic, and social implications with respect to conventional alternatives, such as the use of heavy machinery and herbicides.

Methodology

Three different methods were used in researching this thesis: a literature review, case study, and interviews. The literature review yielded information in published literature; the case study provided a tangible example from which observations and experiments could be conducted; and interviews extracted valuable data from individuals familiar with prescribed grazing in urban landscapes. It was necessary to synthesize information from all three research methods in order to derive defensible answers to questions pertaining to urban prescribed grazing because the subject has received little academic attention.

Literature Review

In researching this thesis, a literature review was conducted to search for any existing information relevant to the topic of prescribed grazing, specifically in urban settings. Research was conducted using the University of Georgia (UGA) Library System and several online databases. The bodies of literature examined include published articles, books, and media content. In the early stages of research, it became clear that little written information is available on the subject of urban prescribed grazing. Fortunately, researchers have recently begun studying the effects of prescribed grazing in other settings, namely western United States rangelands. The literature covers a breadth

of topics, such as an overview of prescribed grazing, its basic principles, and vegetation management guidelines, both in general and for specific pest plant species. Additionally, information was gathered from studies dealing with management efforts other than prescribed grazing, such as machinery, herbicides, and prescribed burning.

Because of this void in published literature dealing with urban prescribed grazing, it was necessary to synthesize information from several related fields. Since the scope of this thesis includes the social implications of urban prescribed grazing, books and essays from fields such as ecological restoration, urban ecology, and environmental psychology were also analyzed. These publications did not specifically address urban prescribed grazing, yet they contain information and insights that may be extrapolated to prescribed grazing in urban environments.

In addition to academic literature, a review of relevant information was also conducted in the realm of mass media. Although there is very little published academic research on the subject of urban prescribed grazing, the topic is increasingly common in mass media. News articles, press releases, and online videos were gleaned for relevant information regarding urban prescribed grazing. These sources also proved useful in documenting the increase in the public's awareness of prescribed grazing in urban settings, as well as providing first-hand accounts of its impacts. Although information from mass media is often unverified or anecdotal, it is useful in terms of filling in the voids that exist in academic literature, particularly with respect to social implications. On the other hand, academic literature provides peer-reviewed, legitimate research that can be extrapolated to answer specific questions about prescribed grazing.

Interviews

To augment the information provided by published academic and mass literature, eight semi-structured interviews were conducted with individuals who possessed varying degrees of knowledge and experience related to urban prescribed grazing. The interviewees represent professional urban prescribed grazing service providers, experts of other land management techniques, and urban citizens familiar with the practice of prescribed grazing.

The interview protocol was developed and implemented in accordance with the approach described by Zeisel (2006) and research design, including the interview questions, was approved by the University of Georgia's Institutional Review Board on the 3rd of December, 2012. The questions (Appendix A) were semi-structured and open-ended, allowing the interviewee to identify methods, opinions, lessons learned, and other recollections related to prescribed grazing. The questions are broad in scope, prompting responses about perceptions, costs, feasibility, logistics, and future efforts of prescribed grazing in the urban landscape.

Because the existing body of literature that addresses prescribed grazing in urban places is small, interviews were conducted with six individuals who have established leadership roles in urban prescribed grazing efforts. Brian Cash, for example, is the owner and operator of Ewe-niversally Green, a prescribed grazing service in the metropolitan Atlanta area. Conversations were held with Cash during a three-month internship in the summer of 2013. Cash is well-versed in the logistics of urban prescribed grazing, and his experiences provided current and relevant information. Interviews with Cash and other prescribed grazing contractors were especially useful in determining the

economics and logistics of grazing animals in the city. Jennif Chandler, a prescribed grazing practitioner in and around Athens, Georgia, also shared her valuable knowledge about prescribed grazing in urban areas throughout the research process, beginning in March 2012. Charlene Kirkland, a generous goat farmer outside of Watkinsville, Georgia also proved to be an extremely knowledgeable source of information about the responsibilities associated with caring for livestock. She has graciously shared her knowledge of goat farming since September 2009. Mike Canaday, owner and operator of a large-scale prescribed grazing business in southern California entitled "Living Systems: Innovative Land Management," was also briefly interviewed in January of 2014 to ask specific questions pertaining to prescribed grazing. Conveniently, a recorded interview with Canaday is available on the Internet as a streaming audio file. The interview was recorded and uploaded in 2012 as an episode of Jack Spirko's podcast entitled "The Survival Podcast," and contains numerous interesting anecdotal accounts of prescribed grazing from someone who has tremendous amounts of relevant experience. Another interviewee from the west coast was Craig Madsen, owner and operator of Healing Hooves, a prescribed grazing service provider in Edwall, Washington and surrounding communities. The interview with Madsen, conducted in February 2014, provided insight into the complex issue of protecting animals at night from potential predators, both human and animal. The final interview with someone with direct experience in prescribed grazing, also conducted in February 2014, was with Richard Gibbs, a goat farmer and prescribed grazing service provider in Thorn Hill, Tennessee. His accounts of dealing with city officials, government agencies, and public organizations shed light on the issues

associated with the gradual process of introducing prescribed grazing to a community where it had not occurred in the recent past.

The two remaining interviewees, James Hanula and Gary Crider, were both familiar with prescribed grazing at the time of the interview, but their expertise lies in the management of vegetation with other techniques. Hanula, a research entomologist with the USDA Forest Service, has an impressive knowledge of the control of non-native invasive plants. He has published papers that explore the ecological implications of invasive plants, as well as the papers that discuss the advantages and disadvantages of different management techniques for landscapes overtaken with invasive plants (i.e. herbicides, introduced insects, heavy machinery). Although Hanula's formal research does not yet include prescribed grazing, his knowledge of the economic and environmental implications of using heavy machinery and herbicides was valuable in comparing prescribed grazing with conventional techniques. Gary Crider is a dedicated leader of the volunteer group entitled Memorial Park Weed Warriors, a group of enthusiastic students and local community members committed to removing non-native invasive shrubs from the park. The interview with Crider, conducted in February 2014, produced valuable information on the subject of incorporating volunteers into the management process.

The interviews yielded valuable information from practitioners and individuals with relevant experiences and knowledge pertaining to urban prescribed grazing. The interviews varied in duration; some took place in separate conversations over the course of several months, and others lasted half an hour. The interviews that necessitated phone calls (i.e. Canaday, Gibbs, and Madsen) lasted approximately thirty minutes.

Case Study

In addition to a literature review and interviews, this thesis also draws information from a case study on the University of Georgia campus. As a research method within the field of landscape architecture, Francis (2001) defines a case study as "a well-documented and systematic examination of the process, decision-making and outcomes of a project." Case studies allow for direct observations of specific and relevant issues that are difficult to ascertain from literature reviews or interviews. In researching this thesis, it became clear that a case study would be necessary in order to conduct observations and gather information about urban prescribed grazing. Opportunities for case studies of prescribed grazing projects in urban environments exist in the United States, but few can be found in the eastern United States. Most examples of urban prescribed grazing are on the western coast, especially in southern California. Given the limited time and budget allotted for writing this thesis, geographic location was a limiting factor in selecting a case study.

The project selected for the case study, entitled the Tanyard Creek Chew Crew, is an ongoing, university-initiated, and community-driven project to restore a damaged urban stream and forest in the heart of the University of Georgia campus. The project aims to manage a forgotten and underutilized greenspace in an ecologically sensitive manner, as well as engage the surrounding campus and residential populations in the process.

The Tanyard Creek Chew Crew is an appropriate case study because of its urban context. The 2.7 acre site is surrounded on all sides by the urban fabric: concrete sidewalks, major and secondary roads, a parking deck, administrative and utility

buildings, and residences. Indeed, prescribed grazing efforts at this location are most definitely considered "urban."

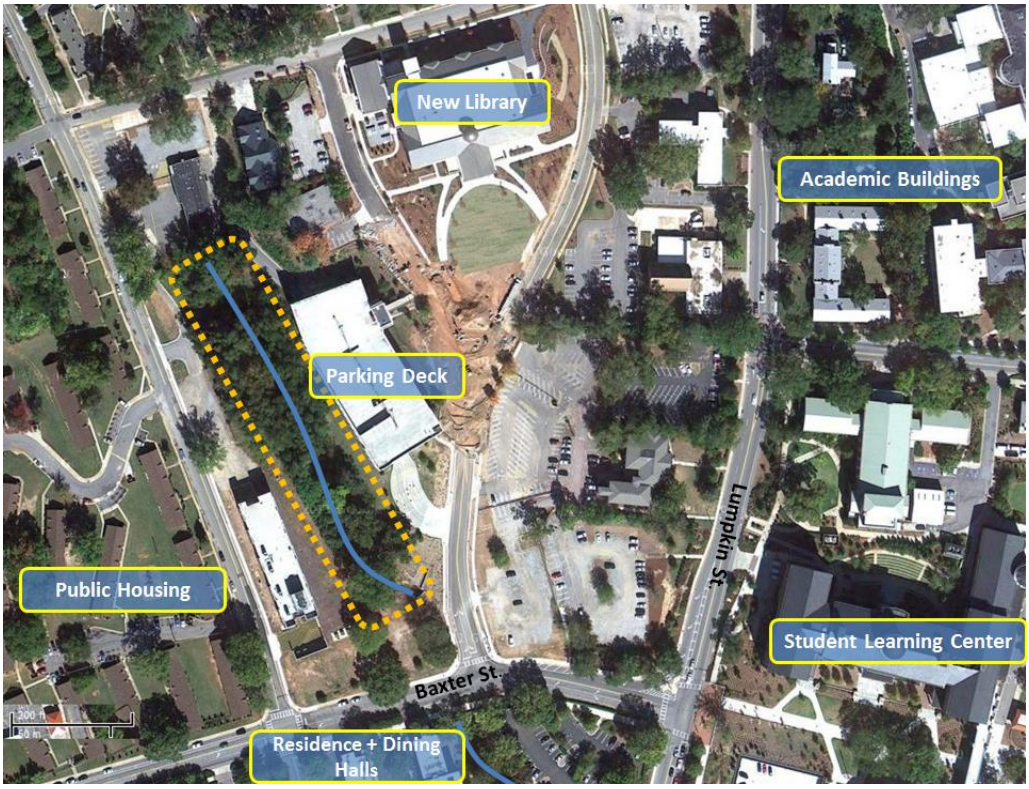


Figure 1. Context map of Tanyard Creek Chew Crew project site. Aerial photo by Google Maps.

Moreover, because of the Tanyard Creek Chew Crew project site's proximity to many urban activities (e.g. driving, walking to and from the university), it holds the unique potential to offer data about the social implications of prescribed grazing on urban dwellers and visitors. This thesis uses data compiled from spring 2012 to spring 2014, during which goats and sheep visited the site six times for varying durations. The data collected includes the number of volunteers involved in restoration activities, images and video capturing interactions between humans and grazing animals, time-lapse photography documenting changes in the project site's vegetation over time, and statistics from experiments conducted on site. These forms of information would be otherwise unattainable from a literature review and case study.

Additionally, the project's origination and continued existence is, in itself, an excellent opportunity to study the implications of a large university adopting prescribed grazing as a component as their larger landscape management plan. The Tanyard Creek Chew Crew project was initiated as a pilot project to study the effectiveness of goats as a tool for vegetation management, as well as how goats might help catalyze interactions between passersby and the project site, thereby providing the potential for deeper, more meaningful relationships between people and place. The project was first funded by a grant from the UGA Office of Sustainability. The College of Environment and Design, Grounds Department, Office of Legal Affairs, and Office of Animal Care and Use were also instrumental bringing the idea to fruition. The project's over-arching mission of researching vegetation management and community engagement allowed for excellent opportunities to record data and observations related to the social and environmental implications of prescribed grazing. Similarly, the publically available financial records associated with the Chew Crew project were helpful in analyzing the cost of the project, and prescribed grazing in general.

Within months of its initiation, the project grew tremendously in unforeseeable ways. Several tangential, interdisciplinary projects have been developed on site to investigate issues related to prescribed grazing in urban areas. These projects brought together students, faculty, and staff from all corners of the campus, with representatives from fields such as landscape architecture, math education, law, English, photography, journalism, ecology, and hydrology. These projects were valuable in exploring issues related to urban prescribed grazing, as well as documenting the progress of the Chew Crew project's underlying effort to manage vegetation.

Several ongoing efforts in relation to the Tanyard Creek Chew Crew project generated data that was particularly useful in researching and writing this thesis. On-site observations, time-lapse photography, and water quality monitoring provided data relating to the environmental implications of prescribed grazing. The analysis of the resources devoted to the Chew Crew project produced information about the economic implications of urban prescribed grazing. Moreover, data regarding the social implications of prescribed grazing was procured through the use of participant observation and content analysis of college-level reflective essays. These research methods are described in more detail below.

Environmental Research Methods

On-site observations of the impacts of prescribed grazing on vegetation and soil were conducted since the beginning of the project in March 2012. These observations are anecdotal, but are useful for capturing information and nuances that could be easily overlooked in a more quantitative strategy. In addition to observations, time-lapse photography was also used to monitor the goats' effectiveness at vegetation removal, as well as the vegetation's response following grazing. During the two years time-lapse photography was used on site, two cameras manufactured by Wingscapes were installed on trees within the project site to monitor vegetation in certain areas (Figure 2). The cameras were programmed to take pictures every three hours between seven o'clock A.M. and 9 o'clock P.M. In March 2014, after the camera had collected sufficient data, the single photographs were combined into a short video using the software Windows Movie Maker. This video was analyzed to research how efficiently goats can accomplish

vegetation management goals. Also useful was the ability to study how the grazed plants grew in the goats' absence over the summer months.

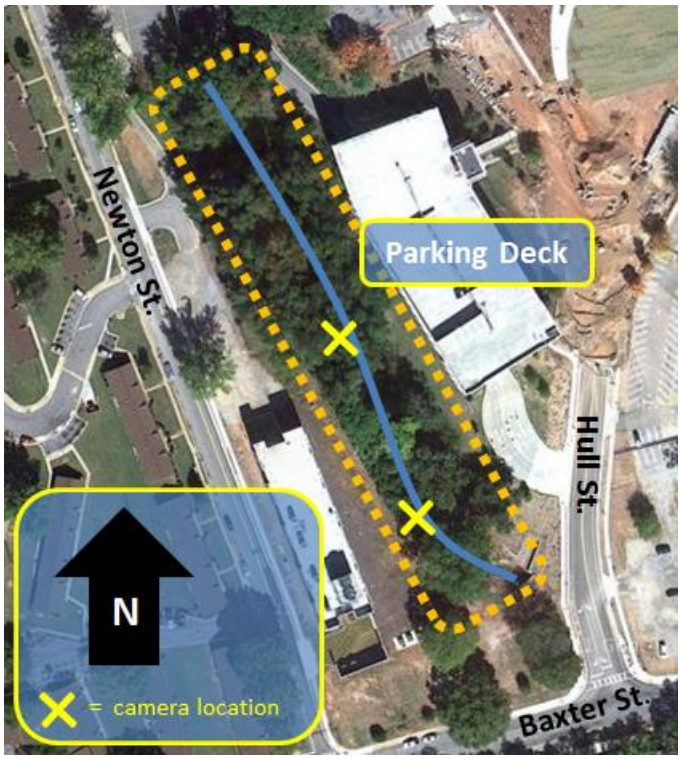


Figure 2. Time-lapse camera locations. Aerial photo by Google Maps.

The third method for analyzing the environmental implications of the Tanyard Creek Chew Crew project was the ongoing monitoring of water quality. After goats had been present on the site during spring 2012, samples of water were first collected on October 23, 2012. The samples were collected from three locations within the project site (Figure 3) and sent to the University of Georgia Feed and Environmental Water Lab. The three sampling locations include the creek's points of entrance into and exit out of the project site, as well as another point at the confluence of an intermittent stream. These locations were strategically selected to be able to determine to what extent fecal matter is present in the stream, and also to be able to determine if the fecal matter that shows up in samples is a byproduct of goats and not an unrelated source, such as a leaking sewage pipe.

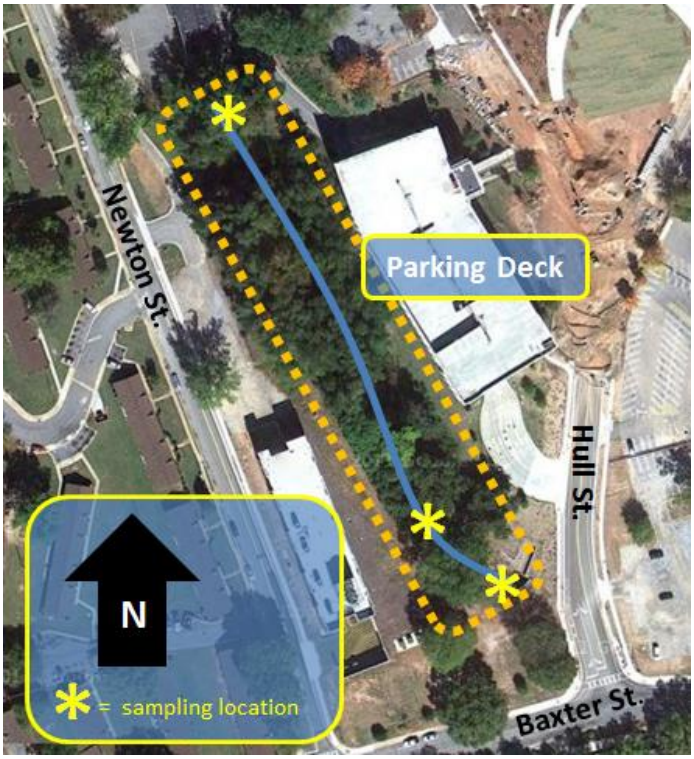


Figure 3. Fall 2012 water quality sampling locations. Aerial photo by Google Maps.

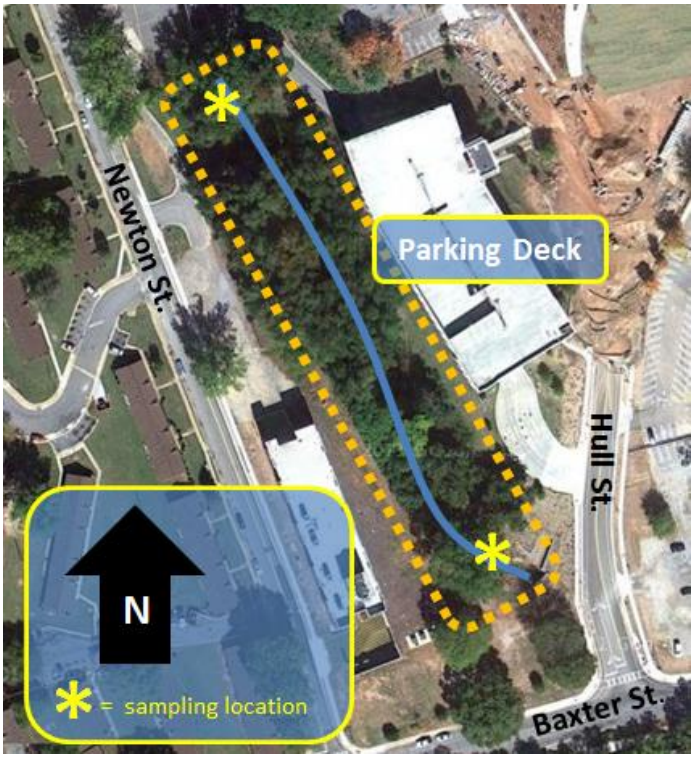


Figure 4. Fall 2013 water quality sampling locations. Aerial photo by Google Maps.

In fall 2013, the water quality sampling and analysis efforts were adopted by the classes of professors Todd Rassmussen and Erin Lipp with additional help from local volunteers. These classes used more sophisticated techniques, employing two Teledeyne ISCO machines at the creek's points of entrance into and exit out of the project site (Figure 4). The ISCO machines collected samples at pre-programmed intervals, and then stored the individual samples in a refrigerated cavity for later analysis. These samples were analyzed for common water quality indicators, but most importantly, they were examined using Rum2Bac analysis, a special process that determines the mammalian species from which the fecal matter was produced. This ability to differentiate goat manure from other sources such as that of humans or dogs was critical in determining if goat fecal matter is indeed problematic in stream systems.

Economic Research Methods

In addition to interviews with practitioners and literature review, an analysis of the financial documents related to the Chew Crew project was used to explore the economic implications of urban prescribed grazing. It is important to note that the project differed from the typical prescribed grazing operation in that the UGA Grounds Department funded the construction of a well-built, semi-permanent fence consisting of traditional woven-wire fencing, gates, two strands of electrical wire, and a solar charger unit. In the case of the Tanyard Creek Chew Crew project, the University anticipated several seasons of prescribed grazing, and opted to build the fence to their own specifications. One can imagine a large institution like the University of Georgia would

want to take every effort to avoid conflicts associated with goats escaping from their enclosure. To address these concerns, administrators elected to hire professional fence builders capable of constructing a long-term enclosure. Normally, prescribed grazing service providers would not rely on fences built by the client, opting instead to erect a temporary fencing system of electric netting.

To accommodate for this difference in fencing options, the cost of constructing the fence enclosing the Tanyard Creek Chew Crew project is not considered to be a part of the costs of the prescribed grazing service. However, the rates for prescribed grazing within the project site were based off of the rates of service providers that include the installation of temporary electric netting. Thus, the costs of the prescribed grazing services financed for the Tanyard Creek Chew Crew project can be analyzed in such a way that allows the project to be comparable to other examples of urban prescribed grazing.

Social Research Methods

Because of its close proximity to heavily travelled vehicular and pedestrian routes along Baxter and Hull streets, the Tanyard Creek Chew Crew project offered unique opportunities to research the social implications of urban prescribed grazing through both structured and unstructured participant observations, as described by Zeisel (2006). The unstructured observations took place between spring 2012 and spring 2014, and provided several accounts of anecdotal evidence that would have been otherwise difficult to obtain through more qualitative sampling strategies.

The structured observations were conducted on two Saturday mornings: September 21, 2013 and November 9, 2013. Both observations sessions lasted sixty minutes, beginning at 10:00 A.M. and ending at 11:00 A.M, and were strategically planned to coincide with the large influx of visitors and attendees of the University of Georgia football games, which are played in a stadium just a short distance away from the project site. Observations were conducted from the fourth story of the parking deck immediately adjacent to the project site (Figure 5). This vantage point permitted an unobstructed view of a popular pedestrian pathway with clear visual and physical access to the project boundaries. The behaviors of men, women, and children passing by the site were observed, and data was collected demonstrating how many passersby showed some form of interaction with the project site. To test the implications of prescribed grazing in this setting, the first observation session (September 21) was conducted without goats present on the project site; the second observation session (November 9) was conducted with goats present on the project site. Comparisons of the two data sets allow for the exploration of the supposition that prescribed grazing in urban landscapes may catalyze more forms of engagement than other vegetation management techniques.

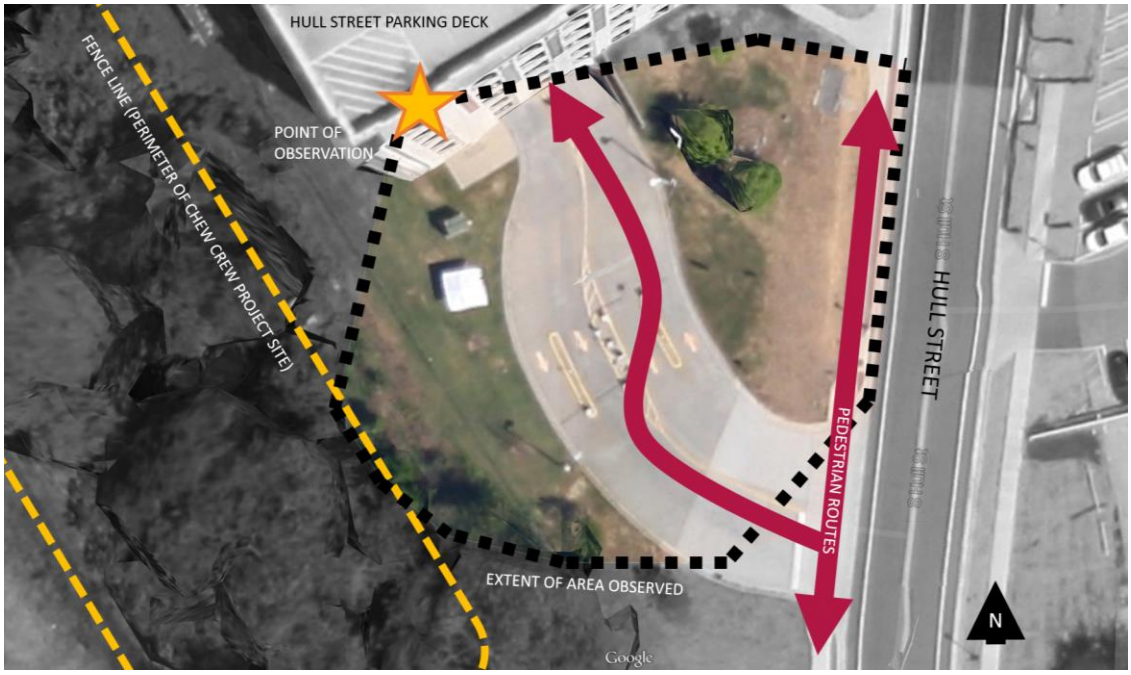


Figure 5. Map of experiment boundaries. Aerial photo by Google Maps.

In addition to direct observations, data was also collected through content analysis of essays written by student volunteers with direct experience with an urban prescribed grazing project. All of the students were enrolled in the course History of the Built Environment (LAND2510) and participated in at least two Chew Crew volunteer events. In their essays, students were asked to reflect upon their volunteer experiences, and to relate their experiences to their studies of the history of the built environment. They were given no further instruction regarding what to write about or how to write it. They were free to write about both positive and negative experiences. The open-ended nature of the assignment was intended to encourage students to write about whatever aspect of the experience was most memorable or significant to them. These reflective essays offered tremendous opportunities for identifying patterns of perceptions, revelations, and behavior described by the students. Their collective thoughts, opinions, and comments

were very useful in studying the effects of prescribed grazing on volunteers, passers-by, local residents, and the general public.

Chapter Summaries

The second chapter of this thesis presents research findings from the literature review. Topics include the history of prescribed grazing, its current status, and relevant information from related fields, such as ecological restoration, animal husbandry, and environmental psychology.

Chapter three explores prescribed grazing specifically in the urban environment by discussing its principles, themes of decision-making, grazing animal qualifications, and detailed examples of present-day urban prescribed grazing operations.

Chapter four analyzes the positive and negative environmental implications of urban prescribed grazing as a vegetation management technique. The environmental implications of two other techniques, heavy machinery and herbicides, are also discussed. Additionally, the option of management inaction is discussed, including the issue of non-native invasive plants and their effects on ecosystems.

Chapter five addresses the economic implications of urban prescribed grazing, heavy machinery, and herbicides as tools for vegetation management in urban areas. Again, the consequences of management inaction are also discussed.

Chapter six explores the social implications of prescribed grazing in and around cities. The social implications of heavy machinery and herbicides, as well as management inaction, are also included in the discussion.

The seventh and final chapter is a presentation of conclusions about the practicality and feasibility of prescribed grazing in urban landscapes.

CHAPTER 2

LITERATURE REVIEW

This literature review surveys existing published works relevant to prescribed grazing in urban settings, general literature related to prescribed grazing in non-urban contexts, and conventional vegetation management techniques. Unfortunately, because the practice of prescribed grazing in urban settings is so new, there is very little peer-reviewed literature on the subject. In fact, in his article "Recent Perspectives in Using Goats for Vegetation Management in the USA," Hart (2001, 172) stated "based on published literature, there is a deficiency of knowledge. This illustrates a big problem with the literature for vegetation management with goats: much of the knowledge is not documented in the literature." Hart ascribed this gap in knowledge to the fact that field tests and experiments dealing with prescribed grazing require longer testing durations -- typically three to five years -- for which funding is difficult to obtain (2001).

The lack of literature focusing on urban prescribed grazing is certainly not because grazing is a new urban landscape management technique in the United States. In fact, a popular 15-acre field in New York City's Central Park is still fondly called the Sheep Meadow, a name inspired by its history of hosting sheep from 1864 until 1934 (Wheeler 2004). Moreover, during his tenure in the White House, President Woodrow Wilson utilized a herd of sheep to maintain the grounds, consciously conserving money during the First World War (Figure 6). However, during the years before the Second World War, grazing animals gradually disappeared from the urban environment.

Figure 6. Sheep grazing on the White House lawn in Washington, D.C. Image by the Library of Congress

In many places, a culture of grazing still exists, especially on rangelands of the western United States. Since the mid-1800s, states like Nevada and Montana have supported sustainable grazing operations (Lane and Douglass 1985). Traditionally, these grazing operations are undertaken on expansive rangeland, with the goal of raising healthy animals over the course of a growing season. In this sense, the vegetation was managed to benefit the animals. This thesis explores the reverse proposition: how animals can be managed to benefit the vegetation. Moreover, traditional grazing operations in the American West take place in rural settings where sheepherders might go weeks before seeing another human, a situation that also is the opposite of the conditions that predominate in the relatively crowded urban landscapes that are the focus of this thesis. Despite these differences, studying the cultures that have evolved around the seasonal and cyclical patterns of grazing animal husbandry in the American West is worthwhile when reconsidering the social implications of reintroducing animals into urban landscapes.

There does exist a growing body of literature about the use of grazing for vegetation management, specifically for non-native, invasive species. The severe ecological and economic threats of invasive plants have fueled keen interest in their

management. Several researchers have tested the efficacy of prescribed grazing on specific plant species (Kleppel and LaBarge 2011, Hart 2000, Frost, Mosley, and Roeder 2013, Lacey, Wallander, and Olson-Rutz 1992, Valderrabano and Torrano 2000). These experiments have explored only a fraction of the total number of invasive plant species, but the findings may be applicable to management scenarios involving similar species.

In response to the increased interest in controlling vegetation with grazing, the American Sheep Industry Association published a comprehensive handbook on the subject entitled *Targeted Grazing: A Natural Approach to Vegetation Management and Landscape Enhancement*. The handbook holds a wealth of valuable information in the form of articles written by researchers and practitioners. The handbook is divided into five sections: Principles and Overview, Meeting Vegetation Management Goals, Guidelines for Specific Plants, Applying Targeted Grazing, and Getting More Information.

In the first chapter, prescribed, or targeted, grazing is defined as "the application of a specific kind of livestock at a determined season, duration, and intensity to accomplish defined vegetation or landscape goals" (Launchbaugh and Walker 2006, 3). The authors list the potential benefits of prescribed grazing, justify its practicality, and submit that it "should be considered as another tool in the kit for constructing desirable ecosystems" (Launchbaugh and Walker 2006, 3). The authors designate patience, commitment, and flexibility as essential management skills when applying prescribed grazing. In addition, a successful grazing prescription requires a working knowledge of the site-specific ecology and animal husbandry (Launchbaugh and Walker 2006). Subsequent chapters address the animal-based considerations surrounding vegetation

management. To be sure, sheep are not goats; and goats are not sheep. The two animals are entirely different, but do share some similarities. Grazing patterns, diet selection, flocking tendencies, as well as health and safety considerations do overlap when managing goats and sheep. This information can be directly translated to urban contexts.

Chapters seven through fifteen of the Targeted Grazing Handbook discuss the use of grazing to meet various vegetation management goals. These goals range from managing herbaceous broadleaf weeds and annual grasses to suppressing weedy brush and trees. Also included are guidelines for accomplishing other land management goals, such as clearing orchards, managing fire risk, improving wildlife habitat, and incorporating grazing into an agricultural system (Wilson and Hardestry 2006, Mosley 2006, Hatfield et al. 2006). Although these chapters focus primarily on management issues prevalent in large, open spaces of the American West, there are many cases in which the knowledge can be applied to different settings elsewhere in the United States. The basic strategies for controlling the different classes of invasive plants would likely be similar, regardless of geographic location. After all, in the eyes of a goat or sheep, a thicket of *Elaeagnus angustifolia* is just as appetizing in an Eastern city as it is on a Western rangeland.

Another excellent resource in researching prescribed grazing in urban settings is the popular book *City goats: The Goat Justice League's Guide to Backyard Goatkeeping*, by Jennie Grant (2012). As the title suggests, the book is directed toward homeowners who are interested in owning one or several dairy goats within the city limits. In this sense, the use of goats to manage overgrown urban vegetation is not a prominent theme of the book. The author does, however, share her expertise concerning the housing and

care of a goat herd in a city, which is directly applicable to urban prescribed grazing. Most relevant to this thesis is Grant's discussion of laws and ordinances that affect the keeping of goats within city limits. Grant uncovers the general history of municipal legislation related to livestock in cities, and shares her own hard-earned experiences in changing the legal framework of Seattle, Washington to allow urban goatkeeping. Moreover, Grant's accounts of her daily encounters with neighbors and passers-by are relevant research material for the section of this thesis that deals with the social application of urban prescribed grazing.

Because urban prescribed grazing requires a thorough understanding of the animals employed in grazing operations, research was conducted on the natural history and management of goats and sheep. In many cases, this research led to books about husbandry, farming, and the biology of goats and sheep. Although the authors of these books probably did not intend to supply information to urban landscape managers, their information is nonetheless useful in the urban context.

In addition to an understanding of the animals, successful urban prescribed grazing treatments also require a working knowledge of the environmental implications associated with grazing in overgrown landscapes. Many ecologists are actively researching the negative effects of non-native, invasive plant species on local ecosystems (Charles and Dukes 2007, Collier, Vankat, and Hughes 2002, Gorchov and Trisel 2003, Gordon 1998, Westbrooks 1998). Additionally, within this body of research are publications focused on the ecological benefits associated with restoring landscapes invaded by non-native plant species (Hanula and Horn 2011a, Hanula and Horn 2011b, Hanula, Horn, and Taylor 2009, Wilcox and Beck 2007, Ward 2002). These publications

did not employ -- nor do they explicitly advocate for -- prescribed grazing as a management method; however, because herbivory accomplishes very similar goals to that of herbicides and machinery, the resulting environmental benefits can be assumed to be very similar as well. Supporting this assumption is a publication reporting the increased species richness following the prescribed grazing of a landscape invaded by multiflora rose (*Rosa multiflora)* (Kleppel et al. 2011).

Detailed discussions of the economic aspects of urban prescribed grazing are absent from existing literature. However, research data about the economic costs and benefits of other vegetation management techniques do exist, particularly with respect to the use of herbicides and heavy machinery. Researchers within the U.S. Department of Agriculture Forest Service at the Southern Research Station produced a detailed publication entitled "Mechanical Removal of Chinese Privet," which presents the costs of a privet removal effort combining herbicides and heavy machinery (Klepac 2007). Also useful in comparing the economics of urban prescribed grazing and other techniques are the federally recommended wage rates offered by the U.S. Department of Labor.

Other than an article published by Richardson and MacDonald (2013), no peer-reviewed literature specifically exploring the social implications of urban prescribed grazing exists. To better understand how prescribed grazing might affect people who live, work, and play near urban landscapes managed by prescribed grazing, research was conducted in areas such as environmental psychology, urban design, and ecological restoration. The book *With People in Mind: Design and Management of Everyday Nature*, by Rachel and Stephen Kaplan, is particularly useful in articulating how humans perceive their natural environment (1998). This information was analyzed to consider

how prescribed grazing might affect humans, in terms of recreation, aesthetics, community engagement, and personal well-being. Additionally, the writings of Richard Louv were helpful in understanding the current disconnect between people and place, and how mental and physical health are directly related to one's relationship with the surrounding natural environment (2011).

The writings of William Jordan were also particularly useful in understanding how restoration efforts are capable of both "repairing damaged ecosystems . . . and forming relationships with them" (2003). Jordan's research pulls from case studies in the upper Midwest, where there exists a thriving culture of community engagement in restoration efforts. His theories are also grounded in biologist E.O. Wilson's concept of "biophilia," or the innate human tendency to affiliate with other life forms.

The Internet was another useful tool in the search for writings on the subject of prescribed grazing in urban landscapes. The websites of prescribed grazing service providers often provided descriptive language, as well as excellent pictures of goats and sheep grazing within city limits. Archived news articles also provided several accounts of prescribed grazing in urban areas across the United States. Similarly, several anecdotal accounts of prescribed grazing in urban areas were discovered in blogs, or regularly updated personal web pages.

CHAPTER 3

PRESCRIBED GRAZING IN THE URBAN ENVIRONMENT

Principles of Prescribed Grazing

Across the United States, land managers are considering prescribed grazing as a management alternative to exclusive reliance on machinery or chemicals for invasive vegetation removal. Also known as "targeted grazing," "intensive grazing," "rotational grazing," or "managed herbivory," prescribed grazing is defined as "the application of a specific kind of livestock at a determined season, duration, and intensity to accomplish defined vegetation or landscape goals" (Launchbaugh and Walker 2006, 3). Not to be confused with other forms of grazing, "prescribed" grazing "refocuses outputs of grazing from production to vegetation and landscape enhancement" (Launchbaugh and Walker 2006, 3). Sheep, goats, and cattle are all worthy of consideration for prescribed grazing applications, but sheep and goats are most commonly used in urban settings because of their more manageable size and behavioral tendencies. In most cases, the animals employed in prescribed grazing applications are contained with some form of electrical or conventional fencing. Often, when left overnight at a prescribed grazing site, the animals are provided shelter and protection, either in the form of a livestock guardian dog or an electrical predator deterrent. Prescribed grazing treatments typically occur over several growing seasons. They can also occur on many different scales, ranging from thousands of animals grazing large pastures to a small herd clearing a quarter of an acre.

Prescribed grazing is, by nature, a form of adaptive management. Landscapes are dynamic systems that respond and adapt to prescribed grazing treatments. Land managers must take this dynamism into account, and be prepared to reflect this flexibility and adaptability in their own management plans (Launchbaugh and Walker 2006). Author and restorationist William Jordan (2003, 13) describes the troubled landscapes of the United States as "works in progress and always will be" . In the realm of prescribed grazing, this idea is implicit in the word "prescribed." Prescribed grazing management plans are alterable in duration, intensity, and season. As such, managers should be prepared to adapt the management plan at any time.

In any case, a successful prescribed grazing treatment should "1) cause significant damage to the target plants; 2) limit damage to the surrounding vegetation; and 3) be integrated with other control methods as part of an overall landscape management strategy" (Launchbaugh and Walker 2006, 4). The first two guidelines are accomplished by close observation and careful manipulation of the season, duration, and intensity of the treatment. The third principle assumes that in any landscape some management goals and objectives may not be achievable by prescribed grazing alone. In these instances, managers should integrate other landscape management techniques where appropriate. For example, in a landscape with overgrown groundcover, shrubs, and trees, prescribed grazing is likely to be effective only on the former two layers of vegetation. To manage the taller trees, one might consider a different technique, such as chemical or mechanical removal, or both.

Season, Duration, and Intensity

Herbivory, or grazing, is a natural process, and plants have co-evolved with herbivores for millions of years. Ideally, a successful prescribed grazing treatment will take place "at the right time to suppress the target plant and leave the desired native plants relatively intact" (Hendrickson and Olson 2006). Therefore, understanding how target plants respond to grazing and planning accordingly are key factors in developing a successful grazing prescription. It should also be noted that targeted plants rarely exist in complete monocultures; usually, plants grow in complex communities. Thus, it is necessary to consider the impact of herbivores on both the targeted plant(s) and the adjacent desirable plants when forming a prescribed grazing management plan (Rinella and Hileman 2009). Describing the growth pattern and response to grazing of plant species is not within the scope of this thesis, but Hendrickson and Olson (2006) note several generalities:

- Grazing plants early in the growing season (i.e. approximately the period of time after plants have fully developed new leaves and eight weeks before the first frost) is typically less damaging to plants.
- Generally, a plant receives the most damage when grazed between the bud stage and full bloom. During this time, grazing animals consume plants' nutritious and highly palatable reproductive organs (i.e. its buds, flowers, fruit, and seeds), effectively weakening the plants by forcing the plants to redistribute stored energy in an attempt to compartmentalize the damage incurred on twigs, bark, and leaves. Moreover, by grazing plants during flowering and seed development, the plants' ability to spread in subsequent growing seasons is decreased.

- Grazing perennial plants during dormancy causes less damage to the plant. During this stage, plants are not actively growing. The growth of plants is triggered by adequate conditions (e.g. sunlight, temperature, water, etc.) at the start of the following growing season. Because the plant does not immediately focus on regrowing, grazing does not force it to use its energy reserves. As such, the plant is not weakened to the extent that it would if grazing were to occur during the growing season.

The timing of a prescribed grazing plan should also take into account the palatability of the target plant. The most successful grazing prescriptions will also consider the palatability of the *non-targeted* plants. For instance, one might target Kentucky bluegrass, an invasive cool-season grass, early in the spring, when it is highly palatable to goats and sheep, and when native grasses are dormant and not as likely to be grazed (Hendrickson and Olson 2006). Moreover, the timing of prescribed grazing treatments can be manipulated to graze target plants before or during seed set, thus decreasing the presence of the target plant within the seed bank (Hendrickson and Olson 2006).

Along with other factors like the time of year and grazing animal stocking density, the length of grazing treatments varies with the vegetation needs of each individual site. Almost always, however, prescribed grazing management plans last several growing seasons, gradually weakening the target plant over time. Because plants grow back in response to grazing, two or more grazing treatments often are necessary in one growing season (Hendrickson and Olson 2006).

Goats v. Sheep

Goats and sheep are the most frequently used animals for prescribed grazing in urban landscapes. Their utilization is justified by a number of factors contributing to their practicality. Their smaller size relative to cows makes goats and sheep a better choice in terms of care and transportability. Both animals are nimble and sure-footed, allowing them to access rough terrain, steep slopes, and hard-to-reach places. Most importantly, goats and sheep are uniquely suited for prescribed grazing because physiological adaptations allow them to consume and digest many of the plants that are of interest to land managers, and still meet their nutritional requirements. Both sheep and goats are ruminants, meaning they have a stomach with four specialized compartments. This adaptation allows the animals to eat large quantities of vegetation, and then completely digest the meal later, a process often called "cudding" or "chewing cud" (Mowlem 1988).

Goats and sheep will consume many of the same plants, although their dietary preferences differ. Categorically speaking, goats are browsers, meaning they consume predominately vegetation in the form of shrubs and woody perennials, and much lower percentages of forbs and grasses. However, these proportions vary with availability (McMahan 1964). Jennie Grant writes, "The Greeks have an expression for this: 'Goats look up and sheep look down.'" (2012, 84). Goats have dexterous tongues and narrow, strong mouths, allowing them to be very selective of which plants and what parts they consume. Goats are also biologically well-suited to consume plants with toxic compounds. Researchers Elizabeth Burritt and Rachel Frost (2006, 12) explain why in the *Targeted Grazing Handbook*: "Relative to body weight, goats also have larger livers than cattle or sheep, so they can more effectively process plants that contain secondary

compounds like terpenes or tannins. . . . Browsers are equipped with salivary glands that produce saliva, which binds tannins. They also possess specialized rumen microbes to break down alkaloids and other toxins in many situations."

In contrast to goats, sheep are considered grazers, possessing mouths that are well-suited to selectively graze close to the ground (Burritt and Frost 2006). This ability translates into sheep preferentially consuming forbs, or herbaceous plants that typically have broad leaves and showy flowers (Burritt and Frost 2006). However, as is the case with goats, sheep vary their diets with respect to the availability of different types of forage vegetation (McMahan 1964). Empirical evidence shows that sheep "will readily consume grass-dominated diets when grasses are succulent or when other forages are unavailable" (Mosley and Roselle 2006). Moreover, their natural flocking tendency facilitates the act of moving sheep from place to place.

Potential Uses

Provided land managers have a working knowledge of both the targeted plants in the landscape and the animals that graze it, goats and sheep can be employed to achieve a number of landscape management goals. When applied correctly, prescribed grazing can be a successful tool in fire fuel-load reduction, wildlife habitat improvement, and unique farming schemes such as orchard management (Wilson and Hardestry 2006, Hatfield et al. 2006, Mosley 2006, Taylor 2006). In addition, sheep and goats are well-suited to help manage unwanted, overgrown vegetation. Often, this vegetation is non-native and invasive, an increasingly critical issue for many land managers' agendas (Westbrooks 1998). As prescribed grazing techniques and technologies continue to be refined, the

application of prescribed grazing with goats and sheep is likely to continue increasing in the near future (Hart 2001).

Urban Prescribed Grazing

Traditional concerns such as safety and confinement of livestock in urban areas have been ameliorated with technological advances like portable electric fencing and solar chargers, making the use of prescribed grazing possible in new, unconventional settings, such as urban and suburban landscapes. In recent years, sheep and goat herders have begun to recognize the potential of prescribed grazing in urban settings to be a viable landscape management service. To capitalize on this opportunity, sheep and goat herders have founded entrepreneurial businesses that specialize in providing prescribed grazing services in and around cities. Ewe-niversally Green, a business that offers prescribed grazing services in and around metropolitan Atlanta is one example of this trend. The company's sheep and goats have helped clear vegetation on a variety urban properties, including schools, residences, greenways, parks, roadsides, and abandoned lots. Similar businesses exist in and around other United States cities, such as San Francisco, California; Seattle, Washington; and Washington, D.C. (Salter, MacDonald, and Richardson 2013).

Figure 7. Prescribed grazing with goats in a dense urban landscape. Photo by Tommi Virtanen.

The concept of "urban prescribed grazing" is very similar to the concept of "prescribed grazing" described earlier in this document, with the major difference being that urban prescribed grazing -- as the word "urban" implies -- focuses grazing efforts for vegetation management in and around cities. The fundamental principles of prescribed grazing still apply, meaning that grazing animals are used to manage vegetation by strategically manipulating the duration, intensity, and timing of grazing prescriptions. However, as one might imagine, grazing sheep and goats in the urban context presents unique challenges. At the same time, the presence of goats and sheep in urban landscapes also affords land managers new and exciting opportunities.

Although cities and suburbs do not possess the contiguous expanses of pasture lands typically associated with rural environments, they do have an abundance of smaller, disconnected patches of vegetation that could provide small ruminants with high-quality forage. These unmanaged and overgrown landscapes occur in the form of highway off-ramps, riparian areas, abandoned lots, steep slopes, floodplains, or margins of properties.

Because these areas are in close proximity to the hustle and bustle of urban life, there is often an increased chance for conflict. Escaped animals are at risk of entering vehicular traffic and potentially causing harm to themselves and humans, or consuming ornamental plants of neighboring landowners. Thus, urban prescribed grazing requires a keen awareness of animal and human safety.

Properly confining goats and sheep to the targeted area is imperative. Escaped sheep and goats are simply not acceptable, and every effort should be taken to prevent escapees. The fence must define the area to be managed, as well as effectively keep animals in, and unwanted visitors out. In cities and suburbs, these undesirable intruders can include coyotes, wild dogs, deer, and mischievous humans. Usually, these potential threats can be abated with the use of electricity, either in the form of single wires or woven netting. The netting option is very popular among urban prescribed grazing service providers. Electric netting, such as the Premier1 product ElectroNet, are available in different heights and lengths, ranging from thirty-five to forty-eight inches tall, and fifty to 164 feet long. The netting is supported by vertical spikes encased in fiberglass, located either 12.5 or 6.8 feet apart, depending on the model (2014). The netting is electrified by connecting it to a solar or battery charger with small clamps. When

installed correctly, this fencing system can produce over eight thousand volts, which is more than enough to contain grazing animals and deter predators.

In situations where appropriate, livestock guardian dogs can also be used to protect goats and sheep from predators or other unwanted intruders (van Bommel and Johnson 2012). These dogs are bred specifically for this purpose, and are extremely effective at deterring unwanted visitors from entering the prescribed grazing site. In short, land managers should be conscious of, but not discouraged by, the logistics of confining and protecting sheep and goats in the urban context.

Once properly confined, sheep and goats offer tremendous opportunities for urban land management. If managed correctly, goats and sheep may provide an environmentally benign alternative to conventional land management techniques like machinery and herbicides. Economically, urban prescribed grazing is a cost effective option for land management, especially on steep slopes or landscapes with limitations on permitted methods of management. Moreover, the prescribed grazing of goats and sheep in urban areas has the potential to engage the surrounding community in the process of restoration, thereby potentially fostering healthy relationships between people and place.

CHAPTER 4

ENVIRONMENTAL IMPLICATIONS

Adaptive and Integrated Land Management

It is important to understand that any type of land management has impacts on plant communities and the sites that contain them. Tires and hooves compress soil (Chancellor 1977, Ssemakula 1983). Stems and leaves are damaged (Klepac 2007, Hendrickson and Olson 2006). Fumes and gasses are emitted. Essentially, a zero-impact land management technique is impossible. In actuality, such a concept is oxymoronic, for land management, even at its most basic level, requires some sort of human-induced disturbance in an attempt to meet specific goals. Impossible, also, is a "silver bullet" vegetation management technique: a one-size-fits-all technique appropriate in any weather, at any time, on any terrain, with any budget, and in any social or political context. Needless to say, such a technique is the Holy Grail for many managers; but, in reality, it is an illusion.

Luckily, many alternatives exist for effective vegetation management. Prescribed fire, herbicides, manual labor, heavy machinery, biological control agents, and prescribed grazing are all options, each with its own environmental impacts. The type and severity of these environmental impacts vary among the techniques. For example, a skid steer is potentially much more destructive to vegetation and soils than a hand trowel. Moreover, not all techniques are appropriate in every scenario. It is recommended, then, that land managers understand the environmental implications of the various management

techniques, and implement an integrated and adaptive strategy with the goal of causing as little harm as possible to the environment.

If an integrated and adaptive landscape management plan requires a working knowledge of various management techniques -- or one's figurative "toolbox," as this body of knowledge is often called -- then, as Launchbaugh and Walker (2006, 3) submit, "targeted grazing should be considered as another tool in the kit for constructing desirable ecosystems." The two authors go even further to say that "it can and *should* be used in combination with other technologies, such as burning, mechanical tree harvesting, hand-grubbing, chaining, applying herbicides, chiseling, and seeding" (emphasis added). For example, a management plan for a landscape invaded by vines such as English ivy (*Hedera helix)* or kudzu (*Pueria montana*) may require three or more techniques. Sheep or goats can be used to defoliate and weaken the plants, increasing maneuverability and visibility in the landscape. However, although all the plants will be stripped of leaves within reach, the underground roots and plant matter elevated in tree canopies will remain untouched. Undoubtedly, one application of grazing alone would not be enough to suppress the target species. To efficiently control all of the targeted plants, it may be necessary to cut vines at the ground level and give sheep and goats access to new growth in subsequent growing seasons. If a quicker result is desired, one might use other techniques in conjunction with prescribed grazing to accomplish vegetation management goals. For example, after sheep and goats defoliate plants within reach, visibility and maneuverability are increased, allowing heavy machinery operators or herbicide applicators to access targeted plants.

Management Inaction and Environmental Consequences

While any management technique has the potential to negatively impact the environment, it is equally important to understand that inaction can have environmental consequences, as well. Indeed, in some cases, active management is not necessary on a regularly scheduled basis. Mature forests, for example, often require minimal input from land managers to function in accordance with management goals, and management plans are formulated accordingly. However, landscapes that have been invaded with non-native, invasive plants are at a higher risk of losing their environmental integrity, experiencing losses in ecosystem structure and function, biodiversity, and unique habitats (Hanula, Horn, and Taylor 2009, Charles and Dukes 2007, Simberloff et al. 2013, Gordon 1998). Unfortunately, landscapes in urban and suburban areas are especially at risk, requiring creative, integrated, and adaptive management techniques (Gulezian and Nyberg 2010). Figure 8, a photograph of the Tanyard Creek Chew Crew site before the arrival of goats, is an example of a previously unmanaged landscape suffering from an invasion of several non-native plant species.

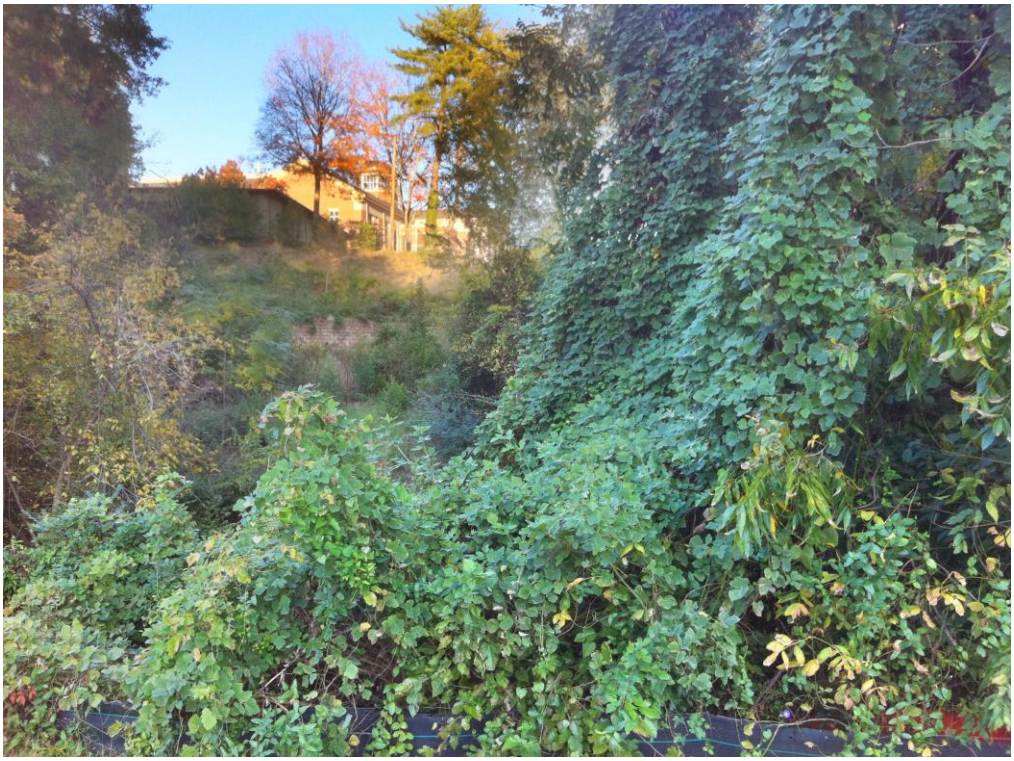


Figure 8. Tanyard Creek Chew Crew project site prior to prescribed grazing treatments. Photo by author.

The environmental impacts of invasive species are not easily quantified, but there do exist general characteristics of invasive species that can be described as environmentally harmful. The impacts of invasive plants can be evaluated at three different scales: ecosystem, community, and population (Gordon 1998). At the ecosystem-level, invasive plants are capable of altering the geomorphology, hydrology, and biochemistry of landscapes (Gordon 1998). Specifically, Gordon lists invasive plants as capable of increasing erosion and sedimentation rates; altering hydrological cycling, water table depth, and surface flow patterns; and affecting soil nutrient availability and water chemistry (1998). Moreover, the presence of invasive plants across a landscape can cause shifts in ecosystem-level disturbance regimes. For example, altered litter accumulation rates in invaded landscapes can affect the frequency and intensity of natural fires (Gordon 1998). At the community- and population-level scales, invasive plants can

alter the structures of plant communities by competing with native species for sunlight, space, water, and nutrients (Gordon 1998). Furthermore, the twining growth patterns of invasive vines such as Japanese honeysuckle (*Lonicera japonica*) and kudzu (*Pueria montana*) can directly damage and kill trees by girdling trunks and branches, thereby restricting the flow of nutrients within the plant's cambium (personal observation). Invasive plants also have the potential to decrease the recruitment of native plant seedlings, and potentially alter the habitat type of invaded landscapes (Gordon 1998, Bruce, Cameron, and Harcombe 1995). Furthermore, many native species of insects and birds do not feed on the leaves or fruit of non-native plants (Westbrooks 1998, Darke and Tallamy 2009). Thus, the gradual domination of plant communities by non-native plants can have profound effects on the entire ecology of a landscape. These potentially environmentally harmful factors led Wilcove et al. (1998) to conclude that invasive species are second only to habitat loss in terms of their potential threat to native, imperiled plants.

Negative Impacts of Conventional Management Techniques

For land managers to best formulate a vegetation management plan with the least possible amount of environmental damage in urban settings, it is important to be familiar with the shortcomings and limitations of all conventional urban land management techniques. This thesis will explore the environmental implications of three vegetation management techniques commonly used in urban landscapes: heavy machinery, herbicides, and biological control agents.

Heavy Machinery

Vegetation management with heavy machinery--also called "roller chopping," "root plowing," "bulldozing," "chaining," or "mowing"--is popular among many land managers because of its perceived ability to work whenever and wherever deemed necessary, and in a timely fashion. In reality, heavy machinery is very limited in its operable hours. First, all heavy machinery used for vegetation management is, or at least should be, used only in daylight hours. Moreover, site conditions like topography and soil moisture must be amenable to heavy machinery, or the equipment will not be able to perform its function. Steep slopes and ditches are physical barriers to large machinery. Given its extreme weight, heavy machinery requires a dry site to maneuver effectively (Chamen et al. 2003). Additionally, overgrown vegetation can engulf and hide debris that accumulates over periods of neglect or management inaction, potentially creating unforeseen and costly conflicts with machinery. For some land managers, this risk of encountering invisible obstructions might be enough to deter management altogether. Moreover, the relatively small and oddly-shaped parcels common in urban areas often make maneuvering heavy equipment impractical. After taking these considerations into account, heavy machinery may only be a logical solution for a limited portion of a management site.

When site conditions permit, heavy machinery can be an effective technique for managing vegetation (Klepac 2007). Landscapes often appear drastically different following a treatment with heavy machinery, which have the power to cut, shred, or rip out vegetation, and leave behind a landscape with relatively open understory and ground layers (Klepac 2007). However, although the post-treatment landscape has a different

appearance, it is important to remember that no single technique is sufficient to adequately manage vegetation. Vegetation typically regrows following treatments with heavy machinery, and sometimes with increased vigor (Hanula and Horn 2011b). The increased availability of sunlight to the ground and shrub layers spurs new growth, and the disturbed soil activates dormant seeds waiting to sprout (Klepac 2007). The subsequent surge of vegetative growth necessitates the combination of a different technique, such as herbicides (Klepac 2007).

Researchers in the forestry and agriculture industries also caution land managers to be aware of heavy machinery's effect on soils (Horn et al. 2007, Chamen et al. 2003). A soil's susceptibility to damage is highly dependent on its individual characteristics. These characteristics include historical land use, existing compaction levels, and moisture content. In any situation, however, heavy machinery has the potential to cause severe stress on soils and the flora and fauna that inhabit it (Horn et al. 2007). Stress on the soil is measured in units of pounds per square inch, or "psi." Values are generated from the ratio of total machine weight to the surface area of the machine in contact with the soil. Thus, the stress that individual machines can potentially inflict on the soil varies with total weight and the amount of surface area supporting this weight. The vulnerability of soils to stress is increased when heavy machinery is employed on "fragile natural forest soils with low bulk densities, low precompression stresses and high air permeability" (Horn et al. 2007). After initial damage by heavy machinery, soils can take up to seventy-five years to recover naturally (Goutal, Boivin, and Ranger 2012). Moreover, as heavy machinery travels over the same soil--either immediately or decades later--stress reaching the subsoil is increased (Chamen et al. 2003).

Because land managers strive to encourage desirable species in the landscape, the effects of heavy machinery on non-target vegetation also should be considered. The compaction of soils has several detrimental effects on surrounding vegetation. In one instance, researchers noted that plant growth was "nearly non-existent" in one area that had been subjected to heavy machinery traffic twenty years prior (Horn et al. 2007). Taylor and Brar (1991, 1) evaluated the effects of compaction on root growth, and found that compaction can "affect rooting through changes in structural arrangement and cracking patterns, soil strength, total porosity, number of large pores, volumetric water content, soil hydraulic conductivity, air filled porosity, and gaseous diffusion rate." Additionally, heavy machinery has the potential to inflict direct physical harm to the roots and above-ground parts of existing desirable plants. In severe cases, damage to above-ground parts of plants can be fatal; however, even minor damage can cause "water, nutrient, and photosynthate transport" within the plant (Costello 2003). Damage to roots can severely affect vascular transport and structural stability, as well as decrease growth rates and cause premature leaf drop (Costello 2003). Furthermore, injury to plants can increase the risk of susceptibility to secondary pests, such as "bark beetles, wood-boring insects, and wood decay or canker fungi" (Costello 2003).

Herbicides

Herbicide applications are widely used for managing vegetation in urban environments. Herbicides are defined as "chemicals that kill plants or inhibit plant growth" (Vencill et al. 2012). More than two hundred active ingredients are registered as herbicides, and these chemicals account for twenty-nine major mechanisms of herbicide

action (Julien and Griffiths 1998). Globally, the most popular herbicide used for vegetation management is the chemical glyphosate (Lanctôt et al. 2013).

Herbicides may be applied in several ways. Soil-applied herbicides are generally defined as chemicals that "affect seed emergence or the growth of weed seedlings and must persist in the soil to be effective" (Vencill et al. 2012). Foliar-applied herbicides are applied to the leaves of targeted weed species. Foliar-applied herbicides can be further described as "*contact* herbicides when only the treated part of the plant is affected," or as "*systemic* or *translocated* when the herbicides enter the plant and moves within it to the site of herbicide action" (Vencill et al. 2012). As with any vegetation management technique, herbicides are most effective when used as a component of an integrated vegetation management plan (Vencill et al. 2012).

When correctly applied, herbicides can have a profound effect on unwanted, overgrown vegetation, especially when used in conjunction with other vegetation management techniques (Vencill et al. 2012, Hanula, Horn, and Taylor 2009). However, as is the case with other management techniques, when applying herbicides to unwanted vegetation, there exists the serious potential to cause damage to desirable species. In some cases, this damage may be fatal to the plant. Unwanted damage to desirable species can be mitigated by taking special efforts to carefully and diligently treat only undesirable species. On the other hand, the risk for unwanted damage increases both with careless application, and as a result of non-selective application methods, like dropping herbicides from helicopters or small planes.

In addition to unwanted damage to vegetation, herbicides, and the surfactants (i.e. the specialized additives that improve the sticking and absorbing properties of liquids) used in combination with them, are under public scrutiny as potentially harmful to microorganisms and fauna both above and within the soil (Banks et al. 2014, Siemering, Hayworth, and Greenfield 2008, Lanctôt et al. 2013). One study suggests that "glyphosate-based herbicides have the potential to alter hormonal pathways during tadpole development" of wood frogs (*Lithobates sylvaticus*) (Lanctôt et al. 2013). Another study suggests the repeated use of herbicides can have long-term effects on soil microbial communities (Banks et al. 2014).

The development of herbicide-resistant weeds is another serious concern to land managers, both in the urban and rural environment. By relying solely on herbicides for vegetation control for extended periods of time, land managers are increasing the chances of cultivating genotypes that are resistant to herbicides (Vencill et al. 2012). This resistance can be developed over time as "a few plants with natural resistance to the herbicide survive an application of the herbicide, and as those plants reproduce and each generation is exposed to the herbicide, the number of resistant plants in the population increases until they dominate the population of susceptible plants" (Vencill et al. 2012).

Biological Controls

The biological control of unwanted vegetation is broadly defined as "the use of a biological agent, a complex of agents, or biological processes to bring about weed suppression" (WSSA 2007). Since the late 1800s, more than 350 biological control agents have been used against more than one hundred target species (Julien and Griffiths

1998). Indeed, prescribed grazing of goats and sheep can be considered a form of biological control. Even generalist fish such as grass carp (*Ctenopharyngodon idella*) are used to "graze" aquatic plant species in managed bodies of water (Vencill et al. 2012). However, most cases of biological control of vegetation utilize insects. Two classic examples are the use of the cactus moth (*Cactoblastis cactorum*) and the Klamath weed beetle (*Chrysolina quadrigemina*) to manage pricklypear cactus (*Opuntia* spp.) and common St. Johnswort (*Hypericum perforatum*), respectively (Appleby 2005).

While some cases of vegetation management with biological control agents are markedly effective, "many other insects have been introduced with varying degrees of success" (Vencill et al. 2012). The emigration of biological control agents from management sites is often difficult, if not impossible, to control once they are released (personal conversation with Hanula). Moreover, some biological control agents have the potential to cause harm to species of interest in addition to the targeted species (Zhang, Hanula, and Horn 2012). For this reason, there exists a rigorous, federally mandated process of quarantining and researching the potential ecological consequences of releasing biological agents (personal conversation with Hanula).

Negative Impacts of Prescribed Grazing

As prescribed grazing becomes more available to landscape architects, planners, city officials, and urban property owners, it will be important to understand the environmental implications of prescribed grazing, especially in relation to other popular land management techniques. "Grazing," Kleppel et al. write, "like other manipulations of landscapes, disturbs the plant community. However, the disturbance caused by grazing

need not disrupt the ecosystem" (Kleppel et al. 2011, 209). As with any management technique, close monitoring and adaptability are paramount to achieving management goals through prescribed grazing with as little damage to the environment as possible.

The most critical factor in prescribed grazing's environmental impact is "(t)he amount of time animals spend on the landscape" (Kleppel et al. 2011, 209). Most, if not all, of prescribed grazing's potential for environmental harm (e.g. overgrazing desirable plants, and increasing rates of erosion of delicate soils) can be minimized, if not prevented, by simply removing animals as soon as vegetation management goals have been met. A well-timed removal of the grazing animals requires close observation of the animals' impact on the site, allowing managers to best decide when the targeted plants have been sufficiently damaged with the least amount of negative effects on desirable plants (Launchbaugh and Walker 2006).

Some critics of prescribed grazing suggest that the manure from goats and sheep produced on site can negatively affect urban streams. However, experiments from the Tanyard Creek Chew Crew project provide evidence that suggest the contrary. After monitoring the water quality from three sampling locations within the paddock, researchers at the Environmental Protection Agency office and the University of Georgia in Athens, Georgia have collected preliminary data suggesting that prescribed grazing had little impact on water quality. It should be noted that this experiment is in its infancy, and there remains much research and testing to confirm that the manure of goats and sheep has little to no negative impact on water quality. However, these findings should not be surprising, given the hydrophobic nature of goats and sheep. Unlike cattle, which will readily wade out and defecate directly into bodies of water, goats and sheep prefer

dry ground. Even to cross streams, goats and sheep will make every effort to not get wet, either by anxiously hopping from bank to bank on rocks or cautiously utilizing downed trees as bridges (personal observations and communication with farmers).

Beneficial Impacts of Urban Prescribed Grazing

As future urban land managers evaluate land management techniques, their considerations should include the potential environmental benefits of prescribed grazing in urban landscapes. First and foremost, goats and sheep are extremely successful in damaging unwanted vegetation by consuming leaves, flowers, seeds, and young twigs. Goats and sheep will also consume the bark of some plant species when availability of other vegetative matter is low. Figure 9 demonstrates this consumption of bark on two common non-native, invasive plant species in the southeastern United States: privet (*Ligustrum sinense*) and silverthorn (*Elaeagnus pungens*). Goats and sheep are able to peel off and consume the periderm, or "bark," of these species relatively easily. If specific vegetation management goals include inflicting severe injury to these two target species, one might consider extending the duration of the grazing prescription beyond defoliation to encourage the animals to consume their bark. At the same time, both the landowner and prescribed grazing service provider should be aware that the extended duration may result in the goats or sheep eating the bark of non-target species, too.

Figure 9. Girdled privet (left) and Russian olive (right). Photo by author.

The animals work around the clock, typically eating from dawn until dusk, but occasionally during the night. The time-lapse images shown in Figures 10 through 13 demonstrate just how effective prescribed grazing with twenty goats can be in reducing biomass in the span of ten days.

Figure 10. Day 1. Photo by time-lapse camera.

Figure 11. Day 2. Photo by time-lapse camera.

Figure 12. Day 5. Photo by time-lapse camera.

Figure 13. Day 10. Photo by time-lapse camera.

The images in Figures 10 through 13 were taken within the Tanyard Creek Chew Crew project site. The photographs depict only a small portion of the 2.7 acre site. During the ten day period when these pictures were taken, the goats had access to significant amounts of vegetation in other parts of the paddock. Thus, these images are not meant to show how quickly urban prescribed grazing can be effective; they are meant to show that prescribed grazing simply *is* effective as a method to control overgrown vegetation. It is important to note, however, that one application of prescribed grazing--although it may appear to be very effective--is usually not sufficient to eliminate target species.

The speed at which prescribed grazing treatments can be achieved (i.e. the duration of individual applications) is for the most part determined both by the size of the targeted area and the number of grazing animals on the site. For instance, if the goats in the time-lapse series above were enclosed within the area pictured, a comparable result would have been achieved in far less time. Similarly, had the goat herd size been double or triple the number actually in the paddock, management goals would have been met much sooner. Mike Canaday, owner and operator of the prescribed grazing service Living

Systems Innovative Land Management in southern California, uses up to five hundred goats per one-acre management site, which he says can be effectively cleared in twenty-four hours (Spirko 2012).

This removal of unwanted vegetation can have direct and indirect positive environmental implications. In especially troubled landscapes (e.g. monotypic stands of overgrown invasive species), the removal of vegetation can boost biodiversity by increasing the availability of sunlight to struggling desirable plants, and encouraging new growth from the seed bank, which may include the seeds of both desirable and undesirable plant species (Kleppel et al. 2011, Hanula, Horn, and Taylor 2009). Furthermore, researchers have found that removing the non-native, invasive plant Chinese privet (*Ligustrum sinense*) can increase not only plant biodiversity, but also the populations and diversity of bees, butterflies, birds, and small mammals (Hanula, Horn, and Taylor 2009, Hanula and Horn 2011a, Hanula and Horn 2011b, Wilcox and Beck 2007). One would expect the removal of other invasive species to provide similar benefits. Because prescribed grazing mimics the management characteristics of the techniques used by these researchers (i.e. significant amounts of vegetation are removed from overgrown sites), it can be hypothesized that similar beneficial impacts may be associated with prescribed grazing (personal communication with Hanula).

In contrast to heavy machinery, prescribed grazing does not require the use of gasoline or diesel. Fuel is most likely necessary when transporting animals, but the natural process of herbivory requires none. Although no studies that compare fuel consumption between heavy machinery and prescribed grazing exist, one would expect gasoline- or diesel-powered heavy machinery to consume more fuel than prescribed

grazing. This expectation will become increasingly important as land managers and owners continue to search for "green" alternatives to conventional landscape management techniques reliant on fossil fuels. Furthermore, instead of emitting gasses as a byproduct of engines, prescribed grazing's emissions consist of goat and sheep manure, which is a nutritional resource to plants. On a similar note, the manure produced by prescribed grazing is beneficial and is often used to improve damaged and compacted soils. Manure helps soils by promoting biotic activity, increasing water holding capacity, incorporating organic matter, and providing essential nutrients to plants (Ace and Haenlein 1983). The relatively low-pressure and unique shape of the hooves of goats and sheep incorporate the manure into the soil as they move across the landscape (personal observation).

Although it has not received formal academic attention, soil compaction by prescribed grazing practices is not likely an issue with sheep and goats due to their relatively light weight and its distribution over the soil. Even the largest goats, like, for example, a healthy, full-grown male Kiko goat, might way around two hundred pounds, with the surface area of one hoof equaling five square inches. The total surface area of that goat's hooves would equal twenty square inches, meaning that goat would be exerting ten pounds of pressure per square inch. Compared to heavy machinery, ten pounds per square inch is tiny.

CHAPTER 5

ECONOMIC IMPLICATIONS

For many urban land managers and owners, the costs associated with removing large masses of overgrown vegetation can prohibit action. It is reasonable to assume that economically-oriented land owners and managers desire to invest only as much money in landscape management as they hope to gain in returns, both tangible (e.g. monetary land value), and intangible value (e.g. aesthetics, recreation, cultural value, ecosystem services). It is also important to remember that no single vegetation management treatment is a cure-all; the reality is that any treatment option (i.e. mechanical, chemical, or biological) will require repeated treatments. For these reasons, there is a pressing need to consider the economic viability of prescribed grazing in order to assess whether the technique is economically competitive with alternative vegetation control methods. In order to make the most economically sound landscape management decisions, land managers need a thorough understanding of the costs associated with the various options for vegetation control, as well as the potential costs of management inaction.

Management Inaction and Economic Consequences

The economic impacts of overgrown, unmanaged landscapes are diverse, but they also are not easily quantified. First and foremost, overgrown and invaded landscapes can directly reduce land value through losses in potential land value (Westbrooks 1998). Overgrown landscapes are generally considered unsightly, thus reducing the property's

"curbside appeal," or publicly visible aesthetic value. These lands also decrease in value because of the costs required to restore mismanaged landscapes to appropriate conditions (Zimdahl 1993). In general, the more overgrown and dysfunctional a landscape is, the more money it will cost to return it to appropriate levels (i.e. a landscape in which one can enter without hesitation, maneuver without obstructions, and view the area with ease). As one can imagine, older, well-established plants are more difficult and expensive to eradicate than younger, newly established plants. If given enough time to store energy for extreme circumstances, well-established plants are very capable of growing back to pre-treatment levels. In some cases, like that of the non-native Chinese privet (*Ligustrum sinensis*) or native sweetgum (*Liquidambar styraciflua*), plants will grow back with vigor, quickly necessitating other treatments (personal communication with Hanula). As a result, an increased intensity and frequency of management actions and time spent performing them are necessary, adding considerably more cost to managing overgrown urban landscapes with recent histories of minimal management.

Moreover, overgrown, unmanaged landscapes can be responsible for future costs associated with repairing or rehabilitating damaged ecosystems. For example, unmanaged riparian landscapes invaded by non-native plants can displace fibrous-rooted native species in favor of new species with taproots, which are less affective at anchoring topsoil, thus increasing erosion and stream channelization (Huenneke 1996). This decreased ability to handle storm events can have profound effects on landscapes downstream, and often has enormous costs associated with mitigation (Westbrooks 1998).

Economic Implications of Conventional Techniques

For urban landscapes, two popular techniques for vegetation management are the use of heavy machinery and herbicides. These two options are popular with land managers not only because of their effectiveness, but also because of their perceived affordability. Understanding the extent of these costs, both in the short and long term, is important for land managers in order to formulate an effective and economically-viable landscape management strategy.

Heavy Machinery

The costs of using heavy machinery can be evaluated in several ways. Some heavy machinery operators charge either by hourly rates or by a predetermined fee per unit of area. Rates per unit of area managed vary with both the service provider, and the status of the landscape to be managed. Hourly rates for heavy machinery operators, as reported by the United States Department of Labor, average almost twenty dollars per hour (2012a). It should be noted, however, that the total hourly rate for the service provider is likely substantially higher, for not only are wages taken into account, but also costs associated with employee and equipment insurance, fuel, maintenance, and repairs.

In a study of the mechanical removal of privet from invaded floodplains (Klepac 2007), monetary costs were analyzed to evaluate the feasibility of vegetation management with a popular model of heavy machinery called a Gyro-Trac(copyright), which is often touted as the most effective piece of heavy machinery when recovering overgrown and invaded landscapes. Unfortunately for land managers, machine prices can cost as much as 300,000 dollars (Klepac 2007). For this reason, GFA Land Clearing, a

landscape management company specializing in the use of Gyro-Trac machinery was contracted to perform the management actions being tested (Klepac 2007). It is reasonable to assume that land owners and managers will not likely be interested in purchasing equipment of that cost, thereby relying on contractors specializing in land management with heavy equipment.

Figure 14. A Gyro-Trac machine at work. Photo by Klepac et al.

The researchers noted that the Gyro-Trac machine's average operating time per acre on two different sites was 5.72 and 6.97 hours. For this study, the total cost per scheduled hour was estimated to be $71.40, which "includes owning, operating, plus labor and benefits, and 20 percent for profit and overhead" (Klepac 2007, 3). Using these numbers, one might expect the cost per acre to range between $408.41 and $497.66. However, the wage rates and diesel prices used in the study are already dated, suggesting

the present day cost will actually be slightly higher. Moreover, the authors note that "it is important to recognize the mechanical treatment of privet, by itself, is not a complete tool. Effective herbicide application is required to control sprouting" (Klepac 2007, 4). The same guideline is applicable for models of heavy machinery other than the Gyro-Trac. With this caveat in mind, land managers should also be aware of the economic implications of herbicide when analyzing the costs of heavy machinery.

Herbicides

A huge industry exists to deal with the research, production, and application of herbicides. In 1995 alone, land managers spent an estimated $5 billion on herbicides (Westbrooks 1998). Although 90% of these herbicide sales were associated with agricultural crops (Gianessi and Sankula 2003), herbicides are also commonly used on private and federally-owned lands, industrial sites, highway rights-of-way, aquatic sites, golf courses, and in forestry lands (Westbrooks 1998). To deal with the physiological variations that exist among plants, both on site and between management sites, land managers can use a wide variety of herbicides, each with its own unique effects.

The prices of these different herbicides vary considerably, with a publication from the University of Florida's extension office showing a range of prices from eleven dollars to six hundred dollars per gallon (2011). The labor costs associated with applying herbicides to landscapes range considerably, too. Application from the ground is labor intensive, especially in very overgrown landscapes. The standard pay rate for "pesticide handlers, sprayers, and applicators", as reported by the United States Department of Labor in 2012, was an average of $15.38 per hour (U.S. Department of Labor 2012b).

In some cases, such as with undesirable vines, trees, and shrubs that are taller than the height of the average human, it is necessary to first wound the plant, and then quickly apply herbicide to the wound, causing the chemicals to move to other parts of the plant through the cambium, effectively killing the entire plant. This method is often colloquially referred to as "cut and paint" or "hack and squirt." When used in conjunction with heavy machinery, herbicides are most effective when applied immediately after the plant has been wounded (Klepac 2007). If applied too late, the efficacy of herbicide applications will be drastically reduced. Because removal of vegetation by heavy machinery can be a relatively quick process, it is recommended that a team of two or three herbicide appliers follow behind to ensure all plants receive a timely application (Klepac 2007).

When managing large tracts, such as agricultural, park or forest lands, some land managers opt to apply herbicide aerially, typically with the use of small airplanes or helicopters. These aerial applications, aside from their potentially negative environmental implications, are often "extremely expensive" (Klepac 2007). Furthermore, aerial application services "can rarely justify treating small tracts (less than 50 acres)." For these reasons, the aerial application of herbicides is not a likely option for urban land managers.

Economic Implications of Urban Prescribed Grazing

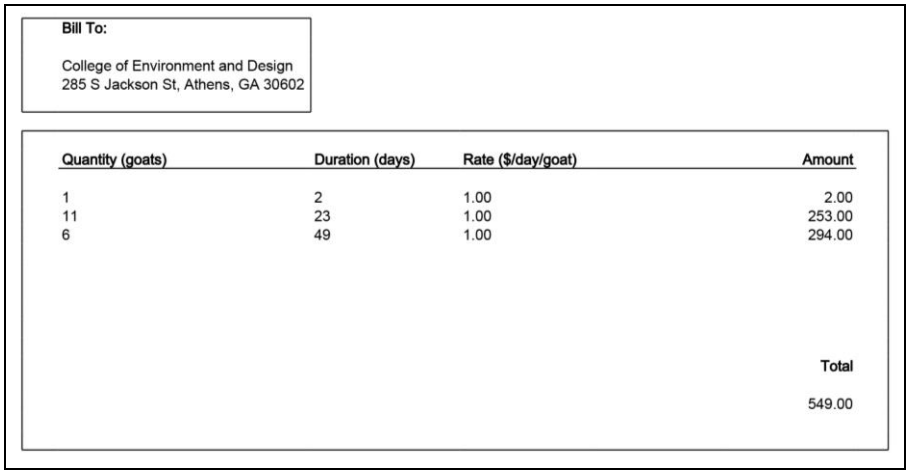
The costs of urban prescribed grazing are analyzed differently than conventional methods. This difference is because the vast majority of physical vegetation management

is done by animals, not humans. Indeed, there are key tasks to be performed by the land manager before, during, and after introducing grazing animals to a site. These key tasks include discussing goals and objectives with the landowner, installing and removing a temporary fence, and transporting animals to and from the site. Another critical task is the daily check-up, when the land manager monitors progress, surveys for complications, and performs any necessary chores (e.g. filling a water trough, removing newly born animals and their mothers, mending fences).

Once sheep or goats arrive on the landscape, human input is minimal until the time comes to remove animals from the site. For this reason, urban prescribed grazing services often have an unconventional method of formulating bills to land owners. Because the vegetation management is being executed by animals, there are no costs associated with hourly wages, unions, insurance, or overtime pay. It goes without saying that sheep and goats are not concerned with raises and vacation time; they only want to eat. Some prescribed grazing service providers offer additional services (i.e. cutting large specimens, applying herbicides, removing debris, sowing seeds of desirable plants, etc.); these additional services are usually billed accordingly (personal communication with Cash).

The number and duration of animals on a site is also used by some service providers to determine payment. For example, the Tanyard Creek Chew Crew urban prescribed grazing project's contract specifies a payment of one to two dollars per animal per day (Figure 15). Similarly, another local prescribed grazing service leases animals for three dollars per animal per day (personal communication with Chandler). In addition to the "per animal per day" payment scheme, some service providers add special fees for

tasks such as fence line clearing or long distance transportation (personal communication with Chandler). This system of add-on charges is especially attractive to land owners with a flexible time frame. If a noticeable result is desired in a short amount of time, more animals can be brought to the site to achieve landscape management goals in relatively short time. On the other hand, this payment scheme allows for the possibility of fewer animals for a longer period of time if the client so desires.



Bill To:

College of Environment and Design
285 S Jackson St, Athens, GA 30602

Quantity (goats)	Duration (days)	Rate ($/day/goat)	Amount
1	2	1.00	2.00
11	23	1.00	253.00
6	49	1.00	294.00

Total

549.00

Figure 15. Example invoice from the Tanyard Creek Chew Crew project.

Other urban prescribed grazing services formulate fees based on acreage being managed. Ewe-niversally Green charges land owners on a sliding scale. For parcels under five acres, the cost is roughly 1500 dollars per acre. For parcels over five acres, the cost is roughly one thousand dollars per acre. This method of pricing is meant to attract land owners with large tracts, allowing urban prescribed grazing services to spend more time on one project site, thus saving time, effort, and costs associated with frequently moving animals between smaller sites (personal conversation with Cash). In using this method for determining payment, prescribed grazing managers are able to put as many animals as necessary on site to achieve vegetation goals in a timely manner.

Prescribed grazing also has the potential to create a saleable byproduct in that goats and sheep can also be marketed for the production of milk, cheese, wool, and meat (Launchbaugh and Walker 2006). This tangential source of revenue is usually not a component of urban prescribed grazing plans, but rather a subsidiary form of income for prescribed grazing service providers. Moreover, when sheep and goats are strategically and sustainably managed, they can be considered a renewable resource. Knowing the gestation period of sheep and goats to be roughly 145 days (Sayer and Cissi 2007), managers in temperate climates can intentionally schedule the weeks of gestation, birth, and young rearing to coincide with lulls in vegetation management jobs, such as during late fall or early spring. Managers typically do not employ female sheep and goats with young offspring, opting instead to use animals without newly born offspring (personal communication with Cash, Chandler, and Kirkland). Using this system of rotation, urban prescribed grazing managers have animals available at all times of year for management purposes, as well as ensure a new crop of "laborers" for the following season.

CHAPTER 6

SOCIAL IMPLICATIONS

Landscape architects, designers, and managers are becoming increasingly aware of the importance of engaging people with the landscapes around them. This connection between people and place has been, and always will be, a consideration in the design of landscapes. This people-place connection is sometimes incorporated into designs through interactive signage, recreation opportunities, and multi-use amenities (e.g. pavilions, gathering spaces, etc.). However, the use of landscape management techniques to catalyze engagement is less common. "Only recently," William Jordan writes, "have landscape managers begun to discover the value of restoration as a strategy for conserving classic landscapes and developing a vital, satisfying relationship with them" (2003). These developed relationships can range from personal shifts in awareness to active participation through volunteerism. Indeed, Rachel and Stephen Kaplan explicitly state as a design guideline that, "permitting local involvement needs to be an ongoing part of management" (Kaplan, Kaplan, and Ryan 1998). As managers of overgrown urban landscapes weigh their vegetation management options, their considerations should include the social implications of the techniques used, both during operation and after completion, as well as the consequences of management inaction.

Management Inaction and Social Consequences

It is likely that most overgrown, neglected urban landscapes achieve far less than their full potential in terms of community engagement. In the context of the contemporary notion of "suburbia," author and activist James Kunstler calls this network of overgrown spaces a "landscape of scary places, the geography of nowhere, that has simply ceased to be a credible human habitat" (Kunstler 1993, 15). His description of these places is perhaps a touch pessimistic or dramatic, but it does enforce the point that these urban spaces are not conducive to human engagement. On a more positive note, in his book *The sunflower forest: Ecological restoration and the new communion with nature,* author and restorationist William Jordan thinks of overgrown and unmanaged urban landscapes as "biological Rip Van Winkles" (2003). Jordan's phrase implicates not only the potential of unmanaged urban landscapes as artifacts of American wilderness, but also the opportunity to form "profound and intimate relationship(s)" with adjacent communities through landscape management processes (2003).

After years of management inaction, urban landscapes and the people around them become increasingly disconnected. Environmental psychologists Rachel and Stephen Kaplan attribute this disconnection to several factors, including safety, confusion, and the absence of "human sign" (1998). The Kaplans suggest urban landscapes with dense, overgrown vegetation can "lead to a concern about becoming lost," as well as anxiety and confusion about what lies beyond the blocked view (1998). The Kaplans explicitly state that "vegetation can be so dense that it is impossible to size up the safety of a place" (Kaplan, Kaplan, and Ryan 1998). Conversely, when vegetation is managed to be near ground level and trees are spaced throughout the landscape, "the

combination leads to a spatial configuration that seems to be highly favored," providing unobstructed views and inviting entry (Kaplan, Kaplan, and Ryan 1998). Moreover, people are highly wary of urban landscapes that lack visual evidence of human use (Kaplan, Kaplan, and Ryan 1998). For many urban dwellers, the Kaplans submit that familiarity with the landscape's appearance is "essential if they are to be actively involved in the natural environment" (Kaplan, Kaplan, and Ryan 1998).

As neglected, undeveloped urban landscapes become more and more overgrown, city dwellers most likely become less and less interested in them. This disinterest, of course, perpetuates the status quo and exacerbates the problem, for the future of these underappreciated urban landscapes depends on their "relationship with the people who inhabit it or share the landscape with it" (Jordan 2003).

Social Implications of Conventional Management Techniques

The management of overgrown landscapes with heavy machinery and herbicides is common in urban settings. Undoubtedly, the effective removal of overgrown vegetation by heavy machinery and herbicides impacts surrounding communities and individuals. For example, the clearing of overgrown floodplains may allow for individuals to passively observe nature, and also create a destination for community birding groups. In such cases, the community's increased engagement with the landscape occurs *after* successful management. It is important, as well, to consider how management techniques can engage communities *during* the process.

Indeed, the participation of local groups and individuals is a crucial component of an increasing number of urban landscapes. Volunteers of restoration efforts are often used in addition to both heavy machinery and herbicides, as well as urban prescribed grazing, as demonstrated by the Tanyard Creek Chew Crew project. In some cases, the levels of participation are impressive and volunteer achievements are staggering. Rachel and Stephen Kaplan report their research on the benefit of such efforts as follows:

> Clearly, the environment benefits from this outpouring of effort. Less tangible are the benefits of to the participants, but the personal gains are many and far-reaching. . . . Research results also point to partcipants' sense of accomplishment, joy in learning new things, pride in contributing to the appearance of their neighborhood, and feeling that the enormity of environmental degradation need not be so hopeless (Kaplan, Kaplan, and Ryan 1998).

When considering community engagement or involvement as an objective of overgrown vegetation management, land managers should be aware of the catalytic potential of different management techniques.

Heavy Machinery

Because heavy machinery used for landscape management usually must be operated by professional or skilled laborers, there is limited opportunity for local individuals to be a part of the application of this technique within the landscape

management process. The lack of opportunity for simultaneous activity between volunteers and heavy machinery is exacerbated by the issue of safety. One can imagine the potential for disastrous conflict. This perception of compromised safety might affect people's willingness to participate in management efforts that involve heavy machinery.

Despite the danger associated with the simultaneous presence of heavy machinery and volunteers, it should be noted that it is indeed feasible for qualified volunteers to be a part of an integrated vegetation management effort. For example, if heavy machinery is used to manage infestations of large shrubs by cutting at ground level, volunteers can be effectively used for follow-up applications of herbicides, as well as hauling away or piling the cut plants.

To community members who are not involved in the management of their local greenspace, the use of heavy machinery may be perceived as obtrusive or heavy-handed. The imposing size and loud noises emitted by such equipment are two factors that might contribute to that perception. Although the level of knowledge between individuals varies, a familiarity with the negative environmental implications of managing landscapes with heavy machinery (i.e., soil compaction, erosion, arbitrary destruction of desirable vegetation or other landscape features, etc.) might also negatively impact its public perception. One commonly seen byproduct of heavy machinery on a landscape is soil displaced by the heavy machinery's tracks, either on site or on visible public surfaces such as roads or paths (e.g. soil fallen from tires).

In some urban landscapes, such as wetlands or riparian buffers, heavy machinery is prohibited as a landscape management option by local codes and ordinances. These

regulations are usually in place to protect these fragile landscapes from compaction and erosion. Athens-Clarke County, Georgia, which contains the project site for the Tanyard Creek Chew Crew, imposes a fifty foot buffer from the centerline of streams where heavy machinery is not permitted (Davoudzadeh and Sullivan 2013). The regulations imposed by a municipality that limit the use of heavy machinery likely affect the perceptions and opinions of those residents. When something is "against the law," even when only in specific situations, it can be perceived as inherently bad. It makes sense that local community members would be less inclined to participate in vegetation management projects alongside practices they consider illegal or bad.

Herbicides

Since the creation of herbicides during the 1940s, the public perception of their use has undergone several shifts (Dwyer 2011). Indeed, present day perceptions of herbicides vary between individuals. However, there are significant paradigm shifts in the perception of herbicides that are worth noting, for many present-day perceptions are still influenced by these historical perceptions. By the 1950s, herbicides were widely used in agricultural practices throughout the United States (Dwyer 2011). The efficacy of the new weed control agents delighted farmers, who, in turn, quickly adopted weed management plans that heavily favored the use of herbicides (Zimdahl 1993). Gradually, however, it has become public knowledge that the overreliance on herbicides instead of traditional farming techniques such as rotating crops and traditional weed control methods was unsustainable (Fryer 1983). By the 1970s, many Americans were familiar

with the widely popular book *Silent Spring*, authored by Rachel Carson, which famously shed light on the harms to the health of humans and the environment caused by the use of pesticides (1964). Further diminishing the public's opinion of pesticides in general was the well-known correlation between the broad use of the chemical DDT (dichlorodiphenyltrichloraethane) and a tragic decrease in population of American bald eagles and other bird species.

Another detriment to the reputation of herbicides arose from the controversial use of aerial herbicide applications by the United States military during the Vietnam War from 1961 to 1971 to defoliate huge swaths of tropical jungle. During that decade, three major herbicides, including the still popular chemical 2,4-D, were used to defoliate over five million acres of South Vietnam, or twelve percent of that nation's total land mass. The herbicides, which were applied on average at rates "13 times that recommended by the U.S. Department of Agriculture for domestic uses such as weed killing," had devastating and long-lasting effects on the local human, animal, and plant communities (Stanford Biology Study Group 1971). It is worth noting that this horrifying example of vegetation management with herbicides is still a significant influence in the perceptions of many Americans today (Dwyer 2011).

By the end of the twentieth century, herbicides again came under public scrutiny, this time due to their associations with genetically modified (GM) herbicide-resistant crops (Madsen and Sandøe 2005). Public disapproval of the manufacturers of genetically modified crops, and the herbicides designed to be compatible with them, has been manifested in numerous demonstrations all over the world. Researchers Madsen and Sandøe (2005) submit that "the public seems to be concerned that risks are not

outweighed by usefulness, that using herbicide resistant crops is the wrong path to sustainable agriculture, that the individual's right to choose GM-free products may be violated, and that these crops are unnatural." Although this aversion to crops that have been genetically engineered to withstand the use of herbicides is a separate issue from the management of overgrown vegetation with herbicides in urban landscapes, the two matters are related. This relation, no matter how distant, is often enough for some individuals to interchange their perception of GM crops with their perception of herbicides in general.

In the essay "A history of weed control in the United States and Canada -- a sequel," Appleby (2005) notes that the weed science discipline has changed significantly in recent decades. He writes, "federal laws affecting pesticides and weeds have been modified, basic studies on weed biology have received more emphasis, and integrated methods of controlling weeds with nonchemical as well as chemical methods have received increasing attention" (2005, 762). Many municipalities have placed legal restrictions on the use of herbicides, prohibiting their use in sensitive areas such as parks, playgrounds, and near bodies of water (Fordyce 2010).

The increased body of knowledge and availability of herbicides has allowed, in some cases, for a broader acceptance among the American public. The introduction of glyphosate in the early 1970s was a key point in this paradigm shift. "Glyphosate," Appleby writes, "is highly efficacious, low in mammalian toxicity, and essentially inactive in soil. . . . It was greeted with enthusiasm and quickly became widely used in many weed situations throughout the world" (2005). Now, herbicides such as glyphosate are readily available to the general public, with products developed specifically for use by

professional land managers, as well as products marketed to homeowners with weekend projects. In the paper "Glyphosate: a once-in-a-century herbicide," Duke and Powels report glyphosate to be "one of the least toxic pesticides to animals. Accordingly, it is used for weed control throughout the world in urban and recreational areas, as well as on industrial and agricultural land" (2008).

As the public's familiarity with herbicides has increased, so too have the opportunities for volunteers to be effective applicators of herbicide treatments in overgrown vegetation management strategies. It is not uncommon in urban landscapes for volunteers to be involved in management efforts through the use of herbicides. This involvement usually takes the form of strategically spraying herbicides onto the wounds of freshly cut undesirable plant species. The Weed Warriors, a group of enthusiastic restorationists volunteering to remove non-native species from a public park in Athens, Georgia, has achieved considerable success by teaching participants to identify the plants on site, and equipping them with pruning saws and spray bottles to eradicate the target species (personal communication with Crider).

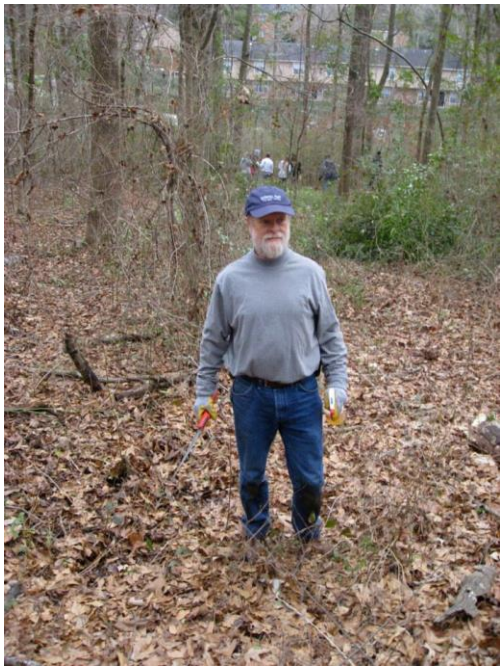


Figure 16. Gary Crider holding a folding pruning saw and bottle of herbicide during a volunteer workday with the Memorial Park Weed Warriors in Athens, GA. Photo by anonymous volunteer.

Social Implications of Urban Prescribed Grazing

The use of prescribed grazing to manage urban landscapes is a socially complex issue. In most urban areas, goats and sheep are rarely, if ever, considered a viable option for landscape management. This lack of consideration may be a result of the general absence of prescribed grazing service providers in most cities. This absence of available service providers, however, is most likely attributed to the illegality, both real and perceived, of using sheep and goats in urban areas. Researchers surveying the legalities of prescribed grazing in nine United States cities found that "few regulations currently are in place to allow and effectively govern prescribed grazing on privately-owned urban lands (Salter, MacDonald, and Richardson 2013). Consequently, many prescribed grazing efforts in these cities may be illegal or only quasi-legal" (Salter, MacDonald, and

Richardson 2013). In many United States cities, the legal framework governing the presence of livestock within the city was developed decades ago, reflecting the prevailing sentiment at the time of livestock and other agriculture-related activities within urban settings as "nuisances" (Salter, MacDonald, and Richardson 2013, Henry 2006). Citizens are often concerned about the odors and noise that can be associated with grazing livestock (Grant 2012). In cities with land use ordinances, livestock are typically relegated to areas zoned for agriculture, subjecting potential prescribed grazing service providers to "adverse legal action by disgruntled neighbors or enforcement by the municipality" (Salter, MacDonald, and Richardson 2013). However, due to the ephemeral nature of prescribed grazing, goats and sheep are rarely present in one place long enough to be deemed a legitimate nuisance in terms of smell or noise (personal communication with Cash, Chandler, Canaday, and Madsen). In fact, avoiding these situations should be a priority of prescribed grazing service providers.

The dated zoning ordinances and codes that inhibit prescribed grazing in urban areas are, however, adaptable when organized efforts are undertaken to change existing laws. Author Jennie Grant chronicles her long and ultimately successful quest to adapt the laws of Seattle, Washington to allow backyard goat keeping in her book, *City goats: The Goat Justice League's Guide to Backyard Goatkeeping* (2012). Similarly in Atlanta, Georgia, prescribed grazing service provider Brian Cash proactively approached the planning departments of communities in and around metro Atlanta with goals of increasing awareness, dispelling myths, demonstrating feasibility, and forging partnerships (personal communication with Cash). In Athens, Georgia, goats and sheep are not allowed within city limits unless the property is zoned for agricultural land uses.

However, at the time of publication of this thesis, the Tanyard Creek Chew Crew project – which is on the University of Georgia campus, immediately adjacent to downtown Athens – has generated interest in prescribed grazing as worthy of consideration for review in future Athens-Clarke County planning commission meetings (personal communication with Athens officials).

As city dwellers and policy makers begin to recognize goats and sheep as efficient tools for urban landscape management, Salter et al. suspect they might also discover that "prescribed grazing may offer another benefit to the human communities that embrace it: the intellectual and emotional delight that can arise from interacting with other species—a phenomenon that biologist Edward O. Wilson described in 1984 as 'biophilia'" (2013). Wilson defines biophilia as "the innate tendency to focus on life and lifelike processes" (1984). Salter et al. go on to suggest that "incorporating animals into the ecological restoration process—not merely as passive beneficiaries of restored wildlife habitats, but as active participants and partners—might enable landscape architects and conservationists to tap into and encourage biophilic tendencies and great joy and fulfillment by users of landscapes" (Richardson and MacDonald 2013).

Evidence from the Tanyard Creek Chew Crew prescribed grazing project and other cases of prescribed grazing in cities support the hypothesis that urban prescribed grazing can facilitate interaction between community members and managed landscapes. In fact, urban prescribed grazing appears to have the potential to be an effective catalyst for reconnecting people with their natural environment. One experiment from the fall of 2013 analyzed the levels of interaction at the interface of the Tanyard Creek Chew Crew project site and a popular pedestrian corridor. Site observations were conducted on two

separate Saturdays, one with goats present on the site and the other without goats present. For this experiment, behavior exhibiting interaction between passersby and the project site was loosely defined as anytime someone changed their original course of action to engage with the project site. The amounts and types of interaction between passersby and the project site varied tremendously depending on the presence of goats.

Prior to the goats' arrival on site, the slopes and floodplain along Tanyard Creek were overgrown with non-native invasive plants such as kudzu (*Pueria montana*), bush honeysuckle (*Lonicera maackii*), Japanese honeysuckle (*Lonicera japonica*), Chinese privet (*Ligustrum sinense*), Japanese knotweed (*Fallopia* japonica), and paper mulberry (*Broussonetia papyrifera*). After a full summer growing season, these non-native plants had formed a thick mass of vegetation over much of the project site (Figure 17). Consequently, views into the project site were significantly blocked. In the entirety of the observation session prior to the initiation of prescribed grazing, only two out of 197, or 1%, of passersby exhibited some sort of interaction with the landscape. The two people, an adult male and a young girl, walked together in the grassy space along the entire fence line, sometimes stopping to peer over and through the fence. Interviews were not possible to obtain, so the motives, perceptions, and opinions of these two individuals will remain unknown.

Figure 17. Vegetation levels before and after prescribed grazing. Photo by time-lapse camera.

On the other hand, observations conducted while twenty goats were present on the project site provided evidence supporting the concept of urban prescribed grazing as a catalyst for interaction. At the time of observation, the goats had been on site for twenty-nine days. During that time, the previously overgrown vegetation had already been significantly reduced, thereby increasing visibility into the project site (Figure 17). During the sixty minutes allotted for observation, thirty-four individuals out of a total of 183, passersby, or 18%, exhibited some degree of interaction with the landscape. The manner in which these individuals interacted with the landscape varied, but some manifestations included taking pictures, watching from the fence line, and reaching into the paddock in hopes of petting a goat (Figure 18). The 17% increase in individuals that interacted with the landscape is a significant statistic, especially for landscape architects and designers that might be interested in creative ways to augment visitors' interactive experience in the landscape. Interestingly, a group of tailgaters decided to set up their headquarters on the modest patch of turf grass immediately adjacent to the project site. When asked how he felt about his site's proximity to the goats, the gentleman in charge of the tailgate answered in the affirmative, proudly proclaiming that he had "the only setup with a petting zoo next door" (personal communication with the author).

Figure 18. Humans and goats interact at the fence line during a tailgate. Photo by author.

Additionally, time-lapse cameras were used on site primarily to monitor vegetation growth patterns, but also in hopes of capturing evidence of community interaction. Figure 18 is one such image depicting how the presence of goats in urban landscapes might lure visitors to the site. Countless other examples of empirical evidence were observed by the author while in and around the project site. On one occasion, the author noticed a vehicle stop abruptly upon exiting the adjacent parking deck. After a moment of silence, a young woman exclaimed from the car, "SHUT UP! Are those goats?" In many cases, newcomers to the site claimed that, prior to the arrival of goats in the landscape, they were not aware of the urban stream that flows through the project site. Furthermore, interviews later revealed that some pedestrians consciously incorporated visits to the project site into their daily commutes (Richardson and MacDonald 2013), suggesting both that urban prescribed grazing can have a lasting impact on individuals in the community, and that these impacts are sometimes significant enough to bring visitors back to the site again and again.

Personal accounts posted on the internet, often in the form of blogs, also attest to the impressions that urban prescribed grazing can have on unfamiliar viewers. One Atlanta resident wrote about her and her young son's serendipitous introduction to a flock of sheep from the prescribed grazing service Ewe-niversally Green (Hunsicker 2013). The post includes a picture of the author's son holding a baby lamb with the following text in the caption below: "My son is holding a baby that was born 6 hours before he held him. We are going to have to move to a farm sometime soon" (Hunsicker 2013). Another Atlanta resident writes about Ewe-niversally Green in the same vein: "The locals are just loving it. It's a big win for the neighborhood. The kids love the novelty and the adults are enjoying the low tech solution that has no impact to the environment" (Viles 2012). Yet another post from Atlanta captures the sentiment of adjacent urban landowners: "Having lived in my neighborhood for the past 11 years, I've never seen this service being done here before and it was very interesting and entertaining to watch. Kudos to my neighbor" (Harger 2011). Elsewhere in the United States, other urban dwellers are actively sharing their positive experiences with prescribed grazing through writing. In an article for the online publication The Grist, one resident of Boulder, Colorado reflects fondly on her experiences with prescribed grazing in her urban back yard:

> Two weeks later, I'm still something of a naturalist celebrity in the neighborhood. Here in my yard, native grass, delicate and shimmering, has begun to peek through the many lumps of residual goat poop. Stripped and browning stalks of formerly proud weeds sway weakly in the still-slightly-barnyard-tinged wind. My vacant lot has become a nascent (if fragrant) Eden. I'm going to bring the goats back in the fall (Rosner 2003).

Collectively, these anecdotes suggest that urban prescribed grazing not only has the potential to provide magical opportunities for rediscovering the natural world, but it can also encourage the exchange of management ideas between landowners and bolster community pride in local landscapes.

Urban prescribed grazing has also proven to be a tremendous catalyst for volunteer participation, as demonstrated by the Tanyard Creek Chew Crew project's weekly volunteer opportunities. After the arrival of goats to the project site in March of 2012, the project enjoyed an unanticipated surge in cross-campus and local involvement. Volunteer opportunities were designed to give students and others a chance to interact with the goats and experience the landscape's transformation (Figure 19). Less than six weeks after its inception, the Tanyard Creek Chew Crew's volunteers included twelve faculty members, sixteen university staff persons, nearly 150 students, and dozens of community members. In total, these volunteers logged 420 hours of service during volunteer workday opportunities offered during the first grazing (Richardson and MacDonald 2013). At the time of this thesis' publication, the Tanyard Creek Chew Crew project will have been actively using prescribed grazing for over two years. In that time, 150 volunteers logged 545 hours of service. Although there is no data with which to compare these volunteer statistics before goats arrived, the data suggests that the presence of goats in the landscape increases volunteer participation.

Figure 19. A volunteer takes a break to scratch the head of a goat. Photo by David Bristow.

To promote Tanyard Creek Chew Crew volunteer workday opportunities to community members, project coordinators created and posted eye-catching posters around the community (Figure 20). These themed posters educated onlookers about upcoming volunteer opportunities, increased awareness of the project, and served as conversation starting points when placed in popular gathering spaces.

Tuesday, October 23
4:00 - 6:00 p

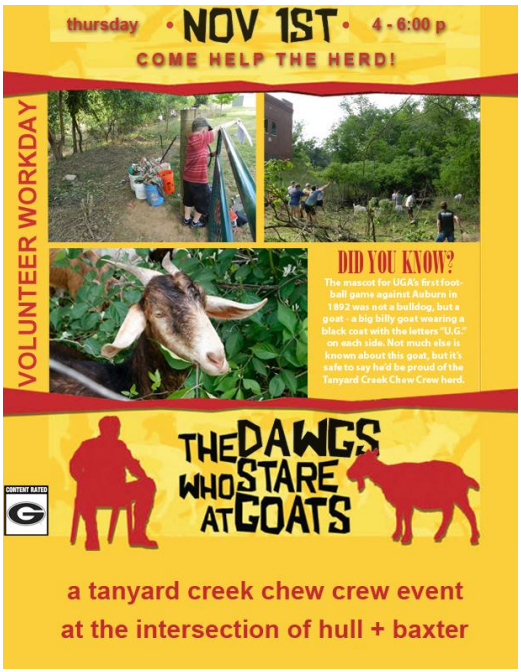


Figure 20. Example posters for Tanyard Creek Chew Crew volunteer workdays. Designs by the author.

Urban prescribed grazing can also engage communities in ways other than volunteerism, as the Tanyard Creek Chew Crew project also demonstrates. By partnering with professors in a variety of disciplines on the University of Georgia campus, students are afforded an opportunity to utilize the project site as an outdoor classroom and learn experientially about interesting issues unique to urban landscapes. For example, students in Dr. Todd Rasmussen's urban hydrology class analyzed the water quality of Tanyard Creek over the course of a semester, ultimately reporting their findings to the university community in a scientific poster. Other professors in the fields of landscape architecture, law, environmental engineering, art education, horticulture, photography, journalism, film making, and English have all formulated creative curricular exercises related to urban prescribed grazing for their students. Often, these students produce impressive work, and thoroughly enjoy the unique experiences acquired during the process (personal communication with students).

Students from Professor Eric MacDonald's History of the Built Environment (LAND2510) course that volunteered with the Chew Crew project were given the opportunity to write a reflective essay about their experiences at the project site. The essays demonstrated a variety of ways in which people can perceive urban prescribed grazing projects. All fourteen students that elected to write an essay directly related their experiences with curricular lessons or concepts. Six students wrote that the Chew Crew project served as a symbol or demonstration of "ethical" stewardship. Six more identified prescribed grazing as "sustainable" or "green." Four students noted that through their experiences with the Chew Crew project, they had gained a new understanding of and appreciation for the benefits and challenges of not just prescribed grazing, but urban

vegetation management in general. One student describes this process in the following passage:

> "Before I volunteered with the Chew Crew, I did not think about issues such as [stewardship] in the regard that I should. I have always been aware that there are negative effects of human landscape development, but I had never taken any time to look into them for real consideration. This provided me with a chance to get up close to one of these situations and to learn about it . . . It has helped me to understand the severity of these problems if they are not dealt with and allowed to continue to exist."

Four students exhibited a fond recollection of discovering Tanyard Creek itself, or some other natural feature in the landscape. Two more students explicitly comment on their feelings of having forged a meaningful relationship with the project site. One student in particular wrote about how he remained engaged with the landscape by incorporating the project site into his daily bike ride. Three of the essays also demonstrated the students' desire to stay involved in the project in the future. One student wrote,

> "Thanks to the Chew Crew, I feel as if I had made an impact on campus, explored possible career options for the future, and made connections with people from different parts of campus. The Chew Crew has been my favorite part of my first semester in college, and I look forward to helping out next semester."

These reflective essays suggest that prescribed grazing in urban settings has the potential to attract individuals to the landscape, enhance perceptions of otherwise neglected spaces, and catalyze a lasting relationship between people and place.

One group of graduate students within the College of Environment and Design created and implemented "KidFest," an event that brought in local children and their parents to interact with goats and the landscape within the Tanyard Creek Chew Crew project site. An ephemeral petting zoo was constructed to encourage children to play with young goats. Students also operated an arts and crafts table, where children were guided in the making of goat-themed headwear. Moreover, local grocers donated milk and cheese from goats to demonstrate how animals used in prescribed grazing can be productive in more ways than just vegetation removal.

Figure 21. A mother and her child enjoy feeding a baby goat during KidFest. Photo by Jordan Tubbs.

Outside of academia, the Tanyard Creek Chew Crew project also garnered community support in the form of a modest grant from the Oconee Rivers Audubon Society, a local organization committed to the preservation and restoration of wildlife habitat through activism and education. Additionally, several other local groups and events throughout Athens have requested "celebrity appearances" by the Chew Crew goats, including the Society for Conservation Biology, the Athens Green Life Expo, and EarthFest.

Events that forge partnerships between community groups, the general public, and grazing animals are unique opportunities to cultivate lasting and meaningful relationships

between people and place. If these events take place on a seasonal or annual basis, they can be considered catalysts themselves for building long-term relationships.

Figure 22. A "celebrity goat field trip" to the Athens Green Life Expo. Photo by Mikey Salter.

CHAPTER 7

CONCLUSIONS

During the last two decades, the number of prescribed grazing operations taking place in and around cities has increased dramatically (Salter, MacDonald, and Richardson 2013). So, too, have the public's awareness and comfort levels with the practice. As more information and examples of prescribed grazing become available to landscape designers, architects, and managers, one would expect urban prescribed grazing to increase throughout the United States. The

As an adaptive management technique, it is important to not consider prescribed grazing--or any other vegetation management technique--to be a "silver bullet" solution to overgrown landscapes. In most cases, an integrated approach is necessary, requiring a combination of different techniques to accomplish management goals. Of course, situations may exist in which prescribed grazing alone can achieve the vegetation management goals; however, the same can be said for heavy machinery and herbicidal techniques. For example, a level, one-acre abandoned lot that has been invaded by kudzu could be effectively managed solely with treatments of either prescribed grazing, heavy machinery, or herbicides. Landscape professionals, then, must make decisions as to which techniques best achieve the environmental, economic, and social goals of the land owner. Although goals and objectives vary widely from project to project, prescribed grazing, as this thesis demonstrates, is certainly worthy of consideration in overgrown urban landscapes.

The prescribed grazing of goats and sheep allows land managers to effectively remove vegetation while being environmentally sensitive. Compared to heavy machinery, goats and sheep are responsible for far less soil compaction and unintentional damage to desirable plants. Instead of consuming fossil fuels and emitting their associated problematic gasses, goats and sheep receive energy from the vegetation they eat, and recycle essential nutrients on-site in the form of manure. Contrary to gasses emitted from machinery, this manure is beneficial, by augmenting biological activity in the soil, improving soil structure, and making nutrients available to plants on site. Moreover, whereas unintended herbicidal damage is sometimes fatal to the plant, one treatment of grazing is usually not enough to entirely kill a plant, allowing land managers to adjust management plans accordingly in future treatments.

Economically, prescribed grazing is similar in cost to both herbicides and heavy machinery. In the cases of steep slopes or fragile wetlands, however, prescribed grazing can be the most inexpensive option for vegetation removal. The special equipment and additional effort required to treat such landscapes with heavy machinery or herbicides increases the cost of vegetation management. As the technology that supports prescribed grazing (i.e. electric fencing and solar chargers) becomes less expensive and more available, the cost of prescribed grazing treatments is likely to decrease, making it even more attractive to landowners. Unique to prescribed grazing and intriguing to land managers, however, is the opportunity to profit from tangential revenue sources associated with prescribed grazing, such as fiber, milk, and meat production. As more communities stress the importance of supporting local markets, prescribed grazing might offer opportunities to both control vegetation and provide saleable products.

The social implications of prescribed grazing in urban landscapes are perhaps the most compelling reasons for land managers to consider goats and sheep as management tools. As demonstrated by the Tanyard Creek Chew Crew project, goats and sheep are very effective in catalyzing interactions between adjacent community members and the landscape. When compared to the catalytic potential of heavy machinery and herbicides, prescribed grazing is the clear leader. The opportunities for engaging the local community around a prescribed grazing site are endless. Indeed, volunteer days and special events are effective ways to reconnect people with place. However, as demonstrated by the Tanyard Creek Chew Crew project, the simple presence of goats in the landscape is enough to attract people and encourage interaction.

These interactions, no matter how seemingly insignificant, are hugely important in cultivating a healthy relationship between people and place. On several occasions at the Tanyard Creek Chew Crew project site, passersby who had stopped along the fence to examine the goats for the first time would declare that they were previously unaware of the project site's natural beauty. "I had no idea there was a creek here," exclaimed one young man. Conversations often evolved into inviting visitors to enter the paddock and "meet the Chew Crew." These impromptu visitors often return to the paddock, sometimes in the form of daily lunch breaks by the site and other times on volunteer workdays. Of course, not everyone that comes in contact with grazing animals will eventually feel compelled to donate time and energy to help restore the prescribed grazing site. However, as the Tanyard Creek Chew Crew project demonstrates, the presence of animals can, in fact, be an excellent starting point for catalyzing community engagement and awareness.

REFERENCES

Stanford Biology Study Group. 1971. "The Destruction of Indochina." Bulletin of the Atomic Scientists **27**(5):36-40.

Premier 1 Supplies. 2014 [cited March 11, 2014. "Fencing - ElectroNet Plus Electric Netting." Available from http://www.premier1supplies.com/fencing.php?mode=detail&fence_id=1.

Ace, Donald L., and George F. W. Haenlein, eds. 1983. "Goat extension handbook / George F.W. Haenlein, Donald L. Ace, editors." In.: Newark, Del. : Cooperative Extension Service, University of Delaware, 1983-.

Appleby, A. P. 2005. "A History of Weed Control in the United States and Canada--A Sequel." *Weed Science* no. 53 (6):762-768.

Banks, M. L., A. C. Kennedy, R. J. Kremer, and F. Eivazi. 2014. "Soil Microbial Community Response to Surfactants and Herbicides in Two Soils." *Applied Soil Ecology* no. 74:12-20.

Bruce, Katherine A., Guy N. Cameron, and Paul A. Harcombe. 1995. "Initiation of a New Woodland Type on the Texas Coastal Prairie by the Chinese Tallow Tree (Sapium sebiferum (L.) Roxb.)." *Bulletin of the Torrey Botanical Club* (3):215. doi: 10.2307/2996086.

Burritt, Elizabeth, and Rachel Frost. 2006. "Animal Behavior Principles and Practices." In *Targeted Grazing: A Natural Approach to Vegetation Management and Landscape Enhancement*, edited by Karen L.; Walker Launchbaugh, John, 10-21. American Sheep Industry Association.

Campbell, Erika, and Jr. Taylor, Charles, A. 2006. "Targeted Grazing to Manage Weedy Brush and Trees." In *Targeted Grazing: A Natural Approach to Vegetation Management and Landscape Enhancement*, edited by Karen L.; Walker Launchbaugh, John, 77-87. American Sheep Industry Association.

Carson, Rachel. 1964. *Silent Spring / by Rachel Carson*: New York : Fawcett Crest, 1964, c1962. 1st Fawcett Crest ed.

Chamen, Tim, Laura Alakukku, Sandra Pires, Claus Sommer, Gordon Spoor, Frans Tijink, and Peter Weisskopf. 2003. "Prevention Strategies for Field Traffic-induced Subsoil Compaction: A Review: Part 2. Equipment and Field Practices." *Soil and Tillage Research* no. 73 (1–2):161-174. doi: http://dx.doi.org/10.1016/S0167-1987(03)00108-9.

Chancellor, W. J. 1977. "Compaction of Soil by Agricultural Equipment / [William J. Chancellor]." In *Bulletin ; no. 1881*. [Berkeley, Calif.] : Division of Agricultural Sciences, University of California, 1977.

Charles, Heather, and Jeffrey S. Dukes. 2007. "Impacts of Invasive Species on Ecosystem Services." In *Biological Invasions*, edited by Wolfgang Nentwig, 217-237. Ecological Studies, no. 193. Berlin and New York: Springer.

Collier, Matthew H., John L. Vankat, and Michael R. Hughes. 2002. "Diminished Plant Richness and Abundance Below Lonicera maackii, an Invasive Shrub." *American Midland Naturalist* no. 147 (1):60.

Costello, Laurence Raleigh. 2003. "Abiotic Disorders of Landscape Plants : A Diagnostic Guide / Laurence R. Costello ... [et al.]." In *Publication / University of California, Agriculture and Natural Resources ; 3420*. Oakland, Calif. : University of California, Agriculture and Natural Resources, c2003.

Darke, Rick, and Douglas W. Tallamy. 2009. *Bringing Nature Home: How You Can Sustain Wildlife with Native Plants*: Timber Press.

Davoudzadeh, Setareh, and Koleen Sullivan. 2013. The Legal Status of Urban Prescribed Grazing in Athens-Clarke County: A Suggested Ordinance. University of Georgia.

Duke, Stephen O., and Stephen B. Powles. 2008. "Glyphosate: A Once-in-a-century Herbicide." *Pest Management Science* no. 64 (4):319-325. doi: 10.1002/ps.1518.

Dwyer, John. 2011. "Weed psychology and the War on Weeds." *Plant Protection Quarterly* no. 26 (3):82-86.

Fordyce, Bruce. 2010. "Pesticides and Public Parks." *Landscape Contractor National* no. 13 (10):34-37.

Francis, Mark. 2001. "A case study method for landscape architecture." *Landscape journal* no. 20 (1):15-29.

Frost, Rachel A., and Karen L. Launchbaugh. 2003. "Prescription Grazing for Rangeland Weed Management: A New Look at an Old Tool." *Rangelands* no. 25 (6):43-47. doi: 10.2307/4001839.

Frost, Rachel A., Jeffrey C. Mosley, and Brent L. Roeder. 2013. "Recovery and Viability of Sulfur Cinquefoil Seeds From the Feces of Sheep and Goats." *Rangeland Ecology & Management* no. 66 (1):51-55. doi: 10.2111/REM-D-11-00218.1.

Fryer, J. D. 1983. "Recent Research on Weed Management--New Light on an Old Practice." In *Recent Advances in Weed Research / edited by W.W. Fletcher*, 181-198. Slough, England: Commonwealth Agricultural Bureaux, 1983.

Gianessi, Leonard P., and Sujatha Sankula. 2003. The Value of Herbicides in U.S. Crop Production. National Center for Food and Agricultural Policy.

Gorchov, David L., and Donald E. Trisel. 2003. "Competitive Effects of the Invasive Shrub, Lonicera maackii (Rupr.) Herder (Caprifoliaceae), on the Growth and Survival of Native Tree Seedlings." *Plant Ecology* no. 166 (1):13-24.

Gordon, D. R. 1998. "Effects of Invasive, Non-indigenous Plant Species on Ecosystem Processes: Lessons from Florida." *Ecological Aapplications* no. 8 (4):975-989.

Goutal, Noémie, Pascal Boivin, and Jacques Ranger. 2012. "Assessment of the Natural Recovery Rate of Soil Specific Volume following Forest Soil Compaction." *Soil Sci. Soc. Am. J.* no. 76 (4):1426-1435. doi: 10.2136/sssaj2011.0402.

Grant, Jennie. 2012. City Goats: The Goat Justice League's Guide to Backyard Goat Keeping. Seattle: Mountaineers Books.

Gulezian, Paul Z., and Dennis W. Nyberg. 2010. "Distribution of Invasive Plants in a Spatially Structured Urban Landscape." *Landscape and Urban Planning* no. 95 (4):161-168. doi: http://dx.doi.org/10.1016/j.landurbplan.2009.12.013.

Hanula, J. L., and S. Horn. 2011a. "Removing an Exotic Shrub from Riparian Forests Increases Butterfly Abundance and Diversity." *Forest Ecology and Management* no. 262 (4):674-680.

Hanula, James L., and Scott Horn. 2011b. "Removing an Invasive Shrub (Chinese Privet) Increases Native Bee Diversity and Abundance in Riparian Forests of the Southeastern United States." *Insect Conservation & Diversity* no. 4 (4):275-283. doi: 10.1111/j.1752-4598.2011.00131.x.

Hanula, James L., Scott Horn, and John W. Taylor. 2009. "Chinese Privet (Ligustrum sinense) Removal and its Effect on Native Plant Communities of Riparian Forests." *Invasive Plant Science and Management* no. 2 (4):292-300. doi: 10.1614/IPSM-09-028.1.

Harger, Emma. 2011. "Wondering Why Those Sheep Are in the Front Yard?" *North Druid Hills - Briarcliff Patch*.

Hart, S. P. 2001. "Recent Perspectives in Using Goats for Vegetation Management in the USA." *Journal of Dairy Science* no. 84:E170-E176.

Hart, SP. 2000. Stocker Goats for Controlling Sericea Lespedeza. Paper read at Sericea Lespedeza and the Future of Invasive Species: A Symposium with a Look to the Future. Kans. State Univ. Agric. Exp. Sta. MF-2453.

Hatfield, Patrick, Hayes Goosey, Andrew Lenssen, and Sue Blodgett. 2006. "Incorporating Targeted Grazing into Farming Systems." In *Targeted Grazing: A Natural Approach to Vegetation Management and Landscape Enhancement*, edited by Karen L.; Walker Launchbaugh, John, 128-140. American Sheep Industry Association.

Hendrickson, John, and Bret Olson. 2006. "Understanding Plant Response to Grazing." In *Targeted Grazing: A Natural Approach to Vegetation Management and Landscape Enhancement*, edited by Karen L.; Walker Launchbaugh, John, 32-39. American Sheep Industry Association.

Henry, D. Dickinson, Jr. 2006. "Contracting for Grazing and Browsing to Achieve Resource Management Objectives: A Primer for Land Managers." In *Targeted Grazing: A Natural Approach to Vegetation Management and Landscape Enhancement*, edited by Karen; Walker Launchbaugh, John. Englewood, CO: American Sheep Industry Association.

Horn, R., J. Vossbrink, S. Peth, and S. Becker. 2007. "Impact of Modern Forest Vehicles on Soil Physical Properties." *Forest Ecology and Management* no. 248 (1/2):56-63.

Hough, Michael. 2004. *Cities and Natural Process: A Basis for Sustainability*. London [u.a.]: Routledge.

Huenneke, L. F. 1996. "Ecological Impacts of Invasive Plants in Natural Resource Areas." *Western Society of Weed Science. Proceedings of the Western Society of Weed Science* no. 49:119-121.

Hunsicker, Tina. 2013. Natural Kudzu Removal in Buckhead and Throughout Atlanta - The Secret Is in the Sheep! In *Real Vininigs | Buckhead*.

Jordan, William R. 2003. *The Sunflower Forest : Ecological Restoration and the New Communion with Nature / William R. Jordan III*: Berkeley : University of California Press, c2003.

Julien, M. H., and M. W. Griffiths. 1998. *Biological Control of Weeds : A World Catalogue of Agents and Their Target Weeds / compiled and edited by M.H. Julien and M.W. Griffiths*: Wallingford, Oxon ; New York : CABI, c1998.
4th ed.

Kaplan, Rachel, Stephen Kaplan, and Robert L. Ryan. 1998. *With People in Mind: Design and Management of Everyday Nature / Rachel Kaplan, Stephen Kaplan, and Robert L. Ryan*: Washington, D.C. : Island Press, c1998.

Klepac, John. 2007. *Mechanical Removal of Chinese Privet [electronic resource] / John Klepac ... [et al.]*, *Research paper SRS: 43*: Asheville, NC : U.S. Dept. of Agriculture, Forest Service, Southern Research Station, [2007].

Kleppel, G. S., Caroline B. Girard, Sophia Caggiano, and Erin LaBarge. 2011. "Invasive Plant Control by Livestock: From Targeted Eradication to Ecosystem Restoration." *Ecological Restoration* (3):209.

Kleppel, G. S., and Erin LaBarge. 2011. "Using Sheep to Control Purple Loosestrife (Lythrum salicaria)." *Invasive Plant Science & Management* no. 4 (1):50-57. doi: 10.1614/IPSM-D-09-00061.1.

Kunstler, James Howard. 1993. *The Geography of Nowhere: The Rise and Decline of America's Man-made Landscape / James Howard Kunstler*: New York : Simon & Schuster, c1993.

Lacey, John R., Rosie Wallander, and Kathrin Olson-Rutz. 1992. "Recovery, Germinability, and Viability of Leafy Spurge (Euphorbia esula) Seeds Ingested by Sheep and Goats." *Weed Technology* no. 6 (3):599-602. doi: 10.2307/3987217.

Lanctôt, C., C. Robertson, L. Navarro-Martín, C. Edge, S. D. Melvin, J. Houlahan, and V. L. Trudeau. 2013. "Effects of the Glyphosate-based Herbicide Roundup WeatherMax® on Metamorphosis of Wood Frogs (Lithobates sylvaticus) in Natural Wetlands." *Aquatic Toxicology (Amsterdam, Netherlands)* no. 140-141:48-57. doi: 10.1016/j.aquatox.2013.05.012.

Lane, Richard H., and William A. Douglass. 1985. *Basque Sheep Herders of the American West: A Photographic Documentary / photographs by Richard H. Lane ; text by William A. Douglass*, *Basque series*: Reno : University of Nevada Press, 1985.

Launchbaugh, Karen, and John Walker. 2006. "Targeted Grazing - A New Paradigm for Livestock Management." In *Targeted grazing: A Natural Approach to Vegetation Management and Landscape Enhancement*, 2-9. American Sheep Industry Association.

Louv, Richard. 2011. *The Nature Principle: Human Restoration and the End of Nature-Deficit Disorder / Richard Louv*: Chapel Hill, N.C. : Algonquin Books of Chapel Hill, 2011.
1st ed.

Madsen, K. H., and P. Sandøe. 2005. "Ethical Reflections on Herbicide-resistant Crops." *Pest Management Science* no. 61 (3):318-325.

Marie-Lister, Nina. 2007. "Trashed Space: Reclaiming Urban Junkscape." In *Trash*, edited by John Knechtel, 64-74. Cambridge, Mass: MIT Press.

McMahan, Craig A. 1964. "Comparative Food Habits of Deer and Three Classes of Livestock." *The Journal of Wildlife Management* no. 28 (4):798-808. doi: 10.2307/3798797.

Mosley, Jeffrey C., and Lovina Roselle. 2006. "Targeted Livestock Grazing to Suppress Invasive Annual Grasses." In *Targeted Grazing: A Natural Approach to Vegetation Management and Landscape Enhancement*, edited by Karen L.; Walker Launchbaugh, John, 67-76. American Sheep Industry Association.

Mosley, Jeffrey C.; Brewer, Tracy K. 2006. "Targeted Livestock Grazing for Wildlife Habitat Improvement." In *Targeted Grazing: A Natural Approach to Vegetation Management and Landscape Enhancement*, edited by Karen L.; Walker Launchbaugh, John, 114-128. American Sheep Industry Association.

Mowlem, Alan. 1988. *Goat Farming*: Farming Press Books, 1988.

Pimentel, D., L. Lach, R. Zuniga, and D. Morrison. 2002. Environmental and Economic Costs Associated with Non-indigenous Species in the United States. In *Biological Invasions: Economic and Environmental Costs of Alien Plant, Animal, and Microbe Species*, edited by D. Pimentel. Boca Raton; USA: CRC Press Inc.

Richardson, Zachary, and Eric MacDonald. 2013. "Four-legged Ecorevelatory Agents of Engagement: Prescribed Grazing As a Tool for Community Building, Ecological Restoration, and Public Interaction."

Rinella, Matthew J., and Benjamin J. Hileman. 2009. "Efficacy of Prescribed Grazing Depends on Timing Intensity and Frequency." *Journal of Applied Ecology* (4):796. doi: 10.2307/27696016.

Rosner, Hillary. 2003. Goats Are the Hip New Thing in Eco-friendly Weed Management. In *Grist*.

Ryan, Robert L., and Robert E. Grese. 2005. "Urban Volunteers and the Environment: Forest and Prairie Restoration." In *Urban Place: Reconnecting with the Natural World.*, edited by Peggy F. Barlett, 173-188. Cambridge, MA US: MIT Press.

Salter, Michael, Eric MacDonald, and Zachary Richardson. 2013. "Prescribed Goat Grazing in Urban Settings: A Pilot Study of the Legal Framework in Nine U.S. Cities."

Sayer, Maggie, and Elaine Cissi. 2007. *Storey's Guide to Raising Meat Goats: Managing · Breeding · Marketing / Maggie Sayer ; [edited by Elaine Cissi]*: North Adams, Mass. : Storey Pub., c2007.

Siemering, G. S., J. D. Hayworth, and B. K. Greenfield. 2008. "Assessment of Potential Aquatic Herbicide Impacts to California Aquatic Ecosystems." *Archives of Environmental Contamination and Toxicology* no. 55 (3):415-431.

Simberloff, D., J. L. Martin, P. Genovesi, V. Maris, D. A. Wardle, J. Aronson, F. Courchamp, B. Galil, E. García-Berthou, M. Pascal, P. Pyšek, R. Sousa, E. Tabacchi, and M. Vila. 2013. "Impacts of Biological Invasions: What's What and the Way Forward." *Trends in Ecology & Evolution* no. 28 (1):58-100.

Spirko, Jack. 2012. The Survival Podcast. In *Mike Canaday on Grazing Goats, Electric Fencing and Working Dogs*, edited by Jack Spirko.

Ssemakula, J. 1983. "A Comparative Study of Hoof Pressures of Wild and Domestic Ungulates." *African Journal of Ecology* no. 21 (4):325-328.

Statistics, US Department of Labor. *Construction Equipment Operators*. United States Department of Labor 2012a [cited March 13, 2014. Available from http://www.bls.gov/ooh/construction-and-extraction/construction-equipment-operators.htm.

Statistics, US Department of Labor. *Pesticide Handlers, Sprayers, and Applicators*. United States Department of Labor 2012b [cited March 13, 2014. Available from http://www.bls.gov/oes/current/oes373012.htm.

Taylor, H. M., and G. S. Brar. 1991. "Effect of Soil Compaction on Root Development." *Soil & Tillage Research* no. 19 (2-3):111-119.

Taylor, Jr., Charles A. 2006. "Targeted Trazing to Manage Fire Risk." In *Targeted Grazing: A Natural Approach to Vegetation Management and Landscape Enhancement*, edited by Karen; Walker Launchbauh, John, 106-114. American Sheep Industry Association.

Valderrabano, J., and L. Torrano. 2000. "The Potential for Using Goats to Control Genista scorpius Shrubs in European Black Pine Stands." *Forest Ecology and Management* no. 126 (3):377-383.

van Bommel, Linda, and Chris N. Johnson. 2012. "Good Dog! Using Livestock Guardian Dogs to Protect Livestock from Predators in Australia's Extensive Grazing Systems." *Wildlife Research* no. 39 (3):220-229. doi: http://dx.doi.org/10.1071/WR11135.

Vencill, W. K., R. L. Nichols, T. M. Webster, J. K. Soteres, C. Mallory-Smith, N. R. Burgos, W. G. Johnson, and M. R. McClelland. 2012. "Herbicide Resistance: Toward an Understanding of Resistance Development and the Impact of Herbicide-resistant Crops." *Weed Science* no. 60 (Sp1):2-30.

Viles, Jacki. 2012. Using Goats to Control Kudzu in Atlanta City Parks. In *DigitalJournal.com*.

Ward, R. W. 2002. "Extent and Dispersal Rates of Chinese Privet (Ligustrum sinense) Invasion on the Upper Oconee River Floodplain, North Georgia." *Southeastern Geographer*. no. 42:29-48.

Westbrooks, Randy G. 1998. *Invasive Plants: Changing the Landscape of America: Fact Book / [author, Randy G. Westbrooks]*: Washington, D.C. : Federal Interagency Committee for the Management of Noxious and Exotic Weeds, 1998.

Wheeler, Jesse M. *Sheep Meadow* 2004 [cited March 11, 2014. Available from http://www.centralpark.com/guide/attractions/sheep-meadow.html.

Wilcove, David S. , David Rothstein, Jason Dubow, Ali Phillips, and Elizabeth Losos. 1998. "Quantifying Threats to Imperiled Species in the United States." *BioScience* no. 48 (8):607-615.

Wilcox, Joshua, and Christopher W. Beck. 2007. "Effects of Ligustrum sinense Lour. (Chinese Privet) on Abundance and Diversity of Songbirds and Native Plants in a Southeastern Nature Preserve." *Southeastern Naturalist* no. 6 (3):535-550.

Wilson, Edward O. 1984. "Biophilia / Edward O. Wilson." In.: Cambridge, Mass. : Harvard University Press, 1984.

Wilson, Linda M., and Linda H. Hardestry. 2006. "Targeted Grazing with Sheep and Goats in Orchard Settings." In *Targeted Grazing: A Natural Approach to Vegetation Management and Landscape Enhancement*, edited by Karen L.; Walker Launchbaugh, John, 99-106. American Sheep Industry Association.

Zeisel, John. 2006. *Inquiry by Design: Environment/behavior/neuroscience in Architecture, Interiors, Landscape, and Planning*. New York, NY US: W W Norton & Co.

Zhang, Y. Z., J. L. Hanula, and S. Horn. 2012. "The Biology and Preliminary Host Range of Megacopta cribraria (Heteroptera: Plataspidae) and its Impact on Kudzu Growth." *Environmental Entomology* no. 41 (1):40-50.

Zimdahl, Robert L. 1993. "Fundamentals of Weed Science / Robert L. Zimdahl." In.: San Diego : Academic Press, c1993.

APPENDICES

APPENDIX A

This list of questions was used as a guideline for interviews with professionals and laypeople possessing valuable experience or knowledge of prescribed grazing.

General Information about the Design and Implementation the Prescribed Grazing Project(s)

1. How does targeted grazing fit into your community's larger, sustainability-related goals, such as environmental stewardship, energy use reduction, innovative land management techniques, or public engagement?
2. Does your community have any unique constraints -- for example, land use regulations, or environmental or climatic conditions -- that made prescribed grazing a difficult or complicated process to implement?
3. Describe, to the best of your ability, the scale and protocol of the prescribed grazing treatment. How long were animals kept on the grazing site(s)? What was the "stocking rate" for the site(s) -- for example, the number of grazing animals per acre or per forage biomass? How was the stocking rate determined? Were animals rotated between several sites, or kept at a central location, like a farm? Were sites subjected to repeated grazings at different times of the year?

4. Describe the system of enclosure: how were animals contained within the designated grazing area(s)? Were the animals provided with shelter, water, and/or supplemental food?
5. Was the herd's safety an issue? If so, what steps were taken to avoid problems with predators or mischievous individuals?
6. Who were the key role players (e.g. local farmers, maintenance crews, volunteers, planners, citizens) in implementing a prescribed grazing project?
7. Who was in charge of transporting the animals and caring for them while they were on the grazing site?
8. Were community residents actively involved in the prescribed grazing project? Please describe the local community's physical interaction with the herd. For example, were residents engaged in volunteer work on the site? Were local residents or community volunteers involved in caring for or otherwise interacting with the animals?
9. How did you fund the project?
10. Did you find the overall costs of the prescribed grazing project to be favorable when compared to conventional vegetation management techniques, such as mechanical removal or herbicide applications?
11. Did the prescribed grazing project experience any significant problems or setbacks along the way? If so, how did these problems impact the public's perception of the project? What was done to rectify the situation?
12. Did the prescribed grazing project result in any positive impacts on the physical condition of the landscape? If so, please describe the positive impacts. Did the project

result in any negative impacts on the physical condition of the landscape? If so, please describe any negative impacts.

Effect of Government Regulations on the Design and Implementation of the Prescribed Grazing Project(s)

13. In envisioning a prescribed grazing project in your community, what legal, regulatory, or "red-tape" obstacles do you foresee arising to affect that project?
14. How is the ownership or temporary leasing of goats/sheep on public and private property regulated in your community?
15. Did local regulations concerning animal welfare, or the keeping of livestock and/or other domestic animals affect the development and implementation of the project? If so, please explain how the project accommodated these regulations.
16. Did local land use and building regulations affect the development and implementation of the project? If so, please explain how the project accommodated these regulations.
17. Did local, state, or federal environmental protection regulations affect the development and implementation of the project? If so, please explain how the project accommodated these regulations.
18. In considering how regulations governing land use, environmental protection, and human and animal welfare affected the prescribed grazing project, can you think of any changes in these regulations (or the way they are administered) that might make a future project easier to design and implement?

19. Did any regulatory rules or processes benefit your project? For example, did the regulatory process make you consider important steps or precautions that you had not already taken into account?

20. Do any of the regulatory rules or processes in place seem counter-productive to you? Are there any regulations in place in your community that, in your opinion, deter prescribed grazing projects with little other benefit?

Public Perceptions of Prescribed Grazing

21. How did the topic of prescribed grazing first arise in your community? What was the community's initial reaction to the topic? Did the public's response to the project change over time? If so, how and why do you think the change occurred?

22. Did administrators and/or the public raise concerns about the cost of the project? If so, how did the project leaders respond to these concerns?

23. Please describe, to the best of your ability, the public's perception of the project site(s) prior to the implementation of the prescribed grazing treatment. Did you notice any shift in residents' perceptions of the site after the prescribed grazing treatment?

24. Has the prescribed grazing project influenced your community's image as a "green" or "sustainability-minded" community?

Concluding Questions

22. What does the future look like for prescribed grazing in your community?

23. Are there any other valuable lessons or observations you would like to share?