MANIPULATING CATTLE AND DEER FORAGING BEHAVIORS FOR THE CONSUMPTION OF LEAFY SPURGE AND CANADA THISTLE

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ABSTRACT

This study tested targeted grazing weeds with cattle and white-tailed deer *(Odocoileus virginianus)*. Using forage manipulation techniques, we attempted to encourage cattle and white-tailed deer to graze weeds. Cattle were encouraged to target graze leafy spurge (*Euphorbia esula L.*). We established that cattle will attempt to consume leafy spurge from feed bunks but not from pasture. Two projects were developed to test targeted grazing of Canada thistle (*Cirsium arvense*) by white-tailed deer. The first project was a behavior study using a rationed pelleted feed with Canada thistle. The second an attractant study involved testing two types of molasses (Molasses and Raffinate) sprayed onto Canada thistle. We found white-tailed deer will consume all diets of pelleted feed and will graze Canada thistle sprayed with either type of molasses. Molasses could be a viable attractant to target graze weeds. More research is needed to determine if these studies are sustainable.

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DEDICATION

This book is being dedicated to my family.

To my parents: Steve and Deb McCann, as well as my brother, Matthew McCann and to my grandparents: Ira and Leona Mills as well as Gerald and Shirley McCann. You have all fueled my curiosity for nature and encouraged me to work as hard as I can to achieve my dreams. Thank you for helping me to find my love of the environment. Your love and support throughout my college career and in life are all I have ever needed. You are my best friends and my support system. I would not be where I am today without all of you.

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Introduction

Manipulation of the foraging behaviors for grazing animals is not a new concept. Throughout history, humans have significantly affected the grazing behaviors of several animal species such as bison (Allred et al. 2011b). Perhaps the most noteworthy interaction has occurred between man and cattle. Cave paintings in France dating back to 15,000 B.C. depict cattle (Friend and Bishop 1978), and it is believed that members of the species were first domesticated in 4,000 B.C. In 3,200 B.C. cattle were used in early agriculture (Carlson 2001). In more recent history (around 1873), cattlemen were responsible for driving cattle herds across the plains from Montana to eastern North Dakota (Fletcher 1960).

Over the years managers have been creating manipulation techniques to assist with convincing cattle to change their foraging behaviors by using fence, water and supplements (Pinchak et al. 1991; Ganskopp and Bohnert 2009). It is important for managers to know how humans can manipulate cattle foraging behaviors, as it could provide the opportunity to change the types of plants they graze, lower the stress levels and increase herd health (Villalba et al. 2010). As mixing forages in the diet can help detect pain and illness, it is important to increase knowledge about the feeding behavior of ruminants to increase the quality of life for the animals (Villalba et al. 2010). In the instance of animal behavior, humans have been altering grazing behaviors for many years. This paper aims to show what some of the manipulated forage behaviors are and how they can be applied to encouraging cattle, and all herbivores, to graze weeds.

Targeted Grazing with Cattle

Land managers need to understand where cattle behaviors originate so they can better understand why they behave the way they do. It is important to know where the cattle learn these behaviors before attempting to change them. There are many different ways cattle learn what to and what not to graze. For example, cattle can learn foraging behaviors from their mother's guidance or simply upon seeing what their peers consume (Provenza 2003; Howery et al. 2010). Mothers influence the behaviors that the young have and their presence can help to increase new knowledge (Sanga et al. 2011). This knowledge gained from their mother will be passed on from generation to generation. Changing cattle behavior might mean changing the behaviors they learned at a young age. Cattle foraging behaviors are influenced both in utero and by life learning experiences (Villalba et al. 2010). Some studies have shown that animal behavior can be impacted by their past experiences (Villalba et al. 2010). Another way that cattle decide what is acceptable to consume is by the feedback they receive after consuming the nutrients in the forage (Provenza et al. 2003).

Post-ingestive feedback often informs an animal if that forage is safe to consume. Animals will sample unknown forages and wait for the post-ingestive feedback to determine if they will continue to graze that forage in the future. However, a study by Launchbaugh et al. (1997) showed livestock often have a fear of trying new forage. One way they recognized how to get over the fear of new forage was to continuously feed cattle novel forage that provides a positive post-ingestive feedback. The continuous positive feedback will encourage cattle to continue trying novel forages.

If managers can manipulate cattle to meet goals such as increasing cattle weight, then it should be possible to manipulate cattle into grazing plant species not normally favored. In the

past, land managers and livestock producers did not consider weeds as a source of forage for cattle grazing (Voth 2011). For example, weeds such as leafy spurge (*Euphorbia esula L.*) have been categorized as causing aversions in cattle (Kronberg et al. 1993). However, with cattle behavior manipulation techniques that have been acquired, cattle grazing weeds is becoming less of a unique idea and more of a possibility.

There are a few manipulation techniques that can be used to change cattle foraging behaviors. For example, fences have been used to limit grazing on large areas (Holechek et al. 2011). Water has also been used as a manipulation tool. Pinchak et al. (1991) used water to dictate where cattle chose to graze. Water can be a factor in a grazer's distribution; humans can manipulate those grazing behavior patterns by placing new water sources in different areas. Changing the location of a water source allows cattle the opportunity to graze a location they otherwise might avoid (Pinchak et al. 1991). For example, in some situations cattle seem to prefer grazing in or near woody vegetation (Allred et al. 2011b). In some circumstances if water is placed in an area with no woody species, cattle might be enticed to graze this new area. Land managers and livestock producers have also used supplements to entice livestock to graze areas that might not have high quality forage (Bailey and Welling 1999). In the past, the most rational thinking by a livestock producer was to try and plan for the "good of the group" when dealing with grazing animals.

Land managers and livestock producers have been dealing with problem weeds throughout recent history. Cattle seem to graze what their comfortable with and what they like. When given the option to graze large areas of land, cattle will avoid many weedy species such as leafy spurge. Cattle can experience negative post-ingestive feedback from plants like leafy spurge (Kronberg et al. 1993) because of the high level of toxins that they contain (Provenza

2003). Land managers and livestock producers are always looking for a tool that is safe, affordable and sustainable to control weeds. I will attempt to compile information that shows manipulation techniques available to land managers and livestock producers, specifically for foraging manipulation that encourage cattle to consume weeds.

Manipulation Techniques

Different types of manipulation techniques can be used to entice cattle to graze forages in specific areas, many of which can be placed into two categories. The first category is techniques that encourage cattle to stay in or out of specific areas. In this article, the category of techniques will be referred to as "Restricting Category" since it restricts cattle movement. The second category uses techniques to entice cattle to graze forages they normally do not graze or to graze in different areas they would otherwise exclude. The second category will be referred to as the "Grazing Consumption Category."

Restricting Category. This category involves the manipulation of cattle movement behaviors. Knowing cattle behaviors allows for the manipulation of what or where cattle forage. In order to improve livestock management and grazing behaviors, fences are often added to either keep cattle in or keep them out of specific areas. Fences are a tool that managers use to protect an area with a threatened biodiversity (Hayward and Kerley 2009). Managers can change the cattle's roaming behavior by limiting the amount of area they roam. With decreased grazing areas of land cattle are less selective when grazing; causing them to graze more uniformly (Holechek et al. 2011).

Grazing Consumption Category. The grazing consumption category involves the manipulation of cattle foraging to impact their grazing consumption choices. This category can be further broken down into three sub-categories: (1) water, (2) supplements, and (3) fire. Water,

supplements, and fire provide three different ways to manipulate the grazing choices. These sub-categories help managers change the animal's natural behaviors and encourage them to graze in new locations. Cattle generally identify a home range and do not often stray too far from it (Rinella et al. 2011). It is important to know the livestock behaviors within a home range. This knowledge of a home range allows a land manager to modify the home range and change their grazing behaviors, forcing them to graze outside their current range. Changing the home range can often be successful using a few different manipulation techniques such as water, supplements, and fire.

Water is an extremely important tool in manipulating cattle to change their home range. Cattle need water to survive and complete their daily functions, including the foraging and digestion process (Pond et al. 2005). Distribution patterns of livestock can be impacted by the distribution of water sources (Holechek et al. 2011). Pinchak et al. (1991) found that depending on the topography 77% of the time cattle choose not to go more than 366 meter away from a water source. While water provides a great tool in manipulating grazing behaviors it is important to understand livestock generally stay close to a water source, heavily grazing the land near these sources.

Adding a water source should achieve the goal of changing the grazing patterns, creating new sources of forage or manipulating the grazing behavior. An example would be drilling a well in an area that does not have water. Adding a water source to a new area can help bring cattle into an area that has higher forage quantity or increase the carrying capacity of a range unit. It helps to evenly distribute the cattle on the land, increasing the home range associated with the original water source. Not only could managers move cattle to improve the forage quantity they can also be moved to areas with higher forage quality. Moving water to new areas is not

only beneficial for the distribution of the livestock on the land but is beneficial for productivity (Holechek et al. 2011).

Supplements are another tool managers can use to help evenly distribute cattle on the land. Salts and supplements are well established tools used in the livestock industry to enhance deficiencies of minerals that may occur on the plants (Vallentine 2001). There are salt and several supplements available to encourage cattle to graze ungrazed or low grazed areas (Vallentine 2001). Supplements can be placed in areas that lack sufficient grazing use or in areas where grazing can impact specific plants. Supplements can also be used in pastures with low-quality forage. Some supplements are very palatable to cattle, thus encouraging them to stay in areas containing these products (Bailey and Welling 1999). Supplements and salt can distribute grazing animals on the land (Holechek et al. 2011). Like water, cattle tend to stay closer to the supplement, causing them to intensely graze around that particular area. Knowing cattle behaviors will allow manipulation of grazing behaviors using supplements to meet the goals of the land manager or livestock producer.

Much like supplements and water there are other tools that managers can use to entice herbivores to change their grazing behaviors. For example, prescribed burning is one tool that has been used for many years. Prescribed fires have been used to help reduce the amount of litter and for the control of undesirable plant species (Holechek et al. 2011). One of the benefits to using prescribed burning is the new growth that follows (Holechek et al. 2011). The new growth is desired by many herbivores such as bison and cattle. Vermeire et al. (2004) states that an important tool for livestock grazing distribution is fire. They found that it did not matter if an area was burned in the spring or in the fall; cattle still grazed the burned areas. Allred et al. (2011a) found similar results in their study that herbivores will choose to graze in areas that have

been burned. These studies demonstrate that fire is one tool that is used to change an herbivores behavior. Herbivores choose to graze in areas that have recently been burned because they receive a positive feedback from those plants. As Allred et al. (2011a) points out burned areas have higher quality forage with lower quantities. Knowing how herbivores react to prescribed burnings allows producers and managers to manipulate the grazing behaviors. Prescribed fires can be used to entice herbivores to graze in areas that might otherwise go unutilized. Prescribed fires are just one example of a tool that producers and managers use to manipulate grazing behaviors.

The main reason for manipulating cattle foraging behaviors is to meet the management objectives. For example, one goal might be to create even distribution of cattle grazing on the land; another goal may include improving livestock weight and performance. There are many reasons why cattle grazing behaviors are manipulated, but in the end it comes down to meeting goals and objectives. What if the goal was to control weeds? It should be possible to take what has been learned over the years and apply that knowledge to create a tool to control the weeds. There are several manipulation strategies to encourage cattle to graze in certain areas and to select specific kinds of plants. Cattle should be encouraged to graze weeds with all of the techniques that have been developed. However, it is important to understand why cattle do not eat specific plants. It is also important to understand the benefits of manipulating cattle to graze weeds.

Target Grazing Leafy Spurge

Weeds come in all shapes, sizes, and colors. They also come with many different types of secondary compounds or metabolites (Gordon and Prins 2008), generally known as defense mechanisms (Jensen et al. 2013). To help better explain this section, leafy spurge has been

selected as an example weed species, because it is difficult to control. Leafy spurge has many morphological and physiological attributes that allow it to take over large areas of land, this weed species like many others, has become a challenge for management.

Leafy spurge is not just a weed it is also listed as a noxious weed in many states, including North Dakota. One definition of a weed is a plant that is growing in an area where it is not wanted, where as a noxious weed is a plant that is not desired because it creates unhealthy predicaments for other species in an area with specific management objectives (Holechek et al. 2011). Leafy spurge is not new to the noxious weeds list, added to North Dakota's list in 1935 (Lym and Travnicek 2012). According to Lym and Travnicek (2012) leafy spurge was the hardest noxious weed species to control, covering as much as 725,000 ha in North Dakota. Perennial weeds such as leafy spurge are hard to control because they have the ability to grow both vegetative and through seed production (Watson 1985; Ball et al. 2000; Lym and Travnicek 2012; Dickinson and Royer 2014).

Leafy spurge has the ability to spread up to one meter away from the parent plants annually (Lym and Travnicek 2012). Since the plants can expand root systems horizontally and vertically, they can distribute rapidly (Watson 1985). It is difficult to eliminate plants that have rhizomatous growth, partially because the roots contain large nutrient reserves (Ball et al. 2000). Plants with vegetative reproduction are often difficult to control because the control method must manage above and below ground material.

Sexual reproduction through seed production is another reason leafy spurge can increase distribution in a short period of time. Leafy spurge has seed pods that are capable of exploding seeds in all directions up to four meters (Ball et al. 2000; Lym and Travnicek 2012; Dickinson and Royer 2014). These seeds can survive in the soil anywhere from five to eight years (Watson

1985; Ball et al. 2000; Lym and Travnicek 2012; Dickinson and Royer 2014). The distance and longevity of the leafy spurge seeds allows this plant to be extremely competitive; causing it to be difficult to control.

It is the combination of vegetative and sexual reproduction that allows for continuous, widespread distribution of weed species such as leafy spurge. It is difficult to find a control method that can impact the spread of both vegetative and sexual reproduction in weed species. Currently, the main control methods for leafy spurge are herbicides, grazing by sheep, biocontrol with insects, timed cultivation, mowing, and burning (Lym and Travnicek 2012). Using a combination of control methods will help to slow the distribution; however, it still may not stop the continuous distribution of leafy spurge and other plants with similar characteristics (Lym and Travnicek 2012).

Defense mechanisms come in several different forms and types. For example, leafy spurge has white "milky" liquid latex that can be found throughout the plant. This latex acts like a toxin, making livestock sick or creating an aversion to the plant (Watson 1985; Ball et al. 2000; Lym and Travnicek 2012; Dickinson and Royer 2014). Other plants may have different chemical toxins or physical characteristics that act like external defense mechanisms. Some of these external mechanisms include thorns or thistles. All of the defense mechanisms protect the plant from being grazed, or in the case of toxins, from being grazed again.

Leafy spurge is a plant species that most cattle avoid. Some authors state that cattle would get sick, or even die, when consuming weeds such as leafy spurge (Ball et al. 2000). Kronberg et al. (1993) reported when cattle graze leafy spurge they have a chance of forming an aversion to the plant. It has been thought that cattle may become extremely sick and lose weight when consuming leafy spurge. However, Voth (2011) reported cattle have consumed leafy

spurge without getting sick. Past educational programs have taught that weeds such as leafy spurge will make cattle sick because of the toxins they contain; however, in actuality most plants found in a plant community contain some amount of toxins (Provenza et al. 2003).

If cattle learn to graze a mixture of plants with the secondary compounds they usually do not get sick, which allows the cattle to graze more (Villalba et al. 2004; Mote et al. 2008). In fact, a mixture of forages or plants can help cattle live a healthier life because it helps create a defense mechanism against diseases (Villalba et al. 2010). Weeds such as leafy spurge have higher forage values than many graminoids species; however, because they are weeds land managers and livestock producers do not consider them forage (Voth 2011). Management could be altered to influence or encourage cattle to graze weeds that contain higher forage values.

So, before we try to change grazing behaviors of livestock it is important to know how grazing behaviors are established. One way cattle learn what to graze is from their dam. They learn to select forage that is palatable and often high in nutritional content, avoiding forages that cause harm (Howery et al. 2010). If land managers and livestock producers learn to change the grazing behaviors that cattle learn from their mother and peers, it might be possible to use those behavioral changes to meet production goals. If cattle grazing behaviors can be changed to consume weeds, then changes can occur to use more plant species diversity and possibly benefit the environment (Mote et al. 2008).

The first step to target graze weeds is training the cows, which in turn influence the grazing behaviors of the offspring (Provenza 2003; Villalba et al. 2004). It is important to train the mother cows to graze weeds because they influence the next generation. The techniques that have been learned can be applied to other areas besides cattle foraging behaviors. An example would be using techniques from the restricting category to change cattle roaming behaviors. It is

also possible to use the grazing consumption category techniques to change grazing behaviors. Supplements and water could be added to areas with higher weed populations. The previously mentioned techniques that are used to change animal behavior for weight gain or better distribution across the land can be used for weed consumption. By changing cattle foraging behaviors to graze weeds the land manager can achieve these management goals.

Targeted Grazing with Wildlife

Farming and ranching, through production agriculture, have been changing the land for centuries, which has changed the grazing behavior and home ranges for most native herbivores (Allred et al. 2011b; Rinella et al. 2011). In more recent years, we have realized it is not only important to manage the land resources for human needs but also for the vast variety of wildlife that require this land (Cooper et al. 2008). For example the white-tailed deer *(Odocoileus virginianus)*, a native herbivore, has been managed for decades for recreational hunting purposes.

Many studies have demonstrated that humans have been manipulating livestock grazing behaviors for improved use of the land resource (Holechek et al. 2011). Voth (2011) demonstrated that behavior manipulation techniques can be used to entice cattle to consume weeds. This section of the literature will present how similar manipulation techniques could be used to entice wildlife, in particular deer, to consume plants in a specific area or on specific plant species. We will examine the current practices, describe a problem weed that could be targeted, specifically Canada thistle *(Cirsium arvense (L.) Scop)*, and discuss the implications of this type of management.

In the environment, every action taken on one species will have a reaction on another species. Sometimes these reactions can be beneficial, but other times they may have a negative

impact. For instance, humans urbanized the world and utilized many of the resources, causing the land to be fragmented, creating a decline in some wildlife habitats. Humans also suppressed fire from the grassland regions, impacting wildlife habitat. Currently, new management practices are starting to address wildlife needs. Cooper et al. (2008) discussed the need to not only manage for livestock but also manage the vast variety of wildlife. They showed white-tailed deer and cattle can graze efficiently together. In fact, they indicated that cattle and deer together can be extremely beneficial to the land because much of their diets do not overlap and they tend to graze on different topography. In general, deer graze farther from water than cattle and deer will not be competing with cattle for foraging resources near water (Cooper et al. 2008).

Target Grazing Canada Thistle

The Great Plains evolved with several different grazing herbivores (Allred et al. 2013). It is important to be open to new management techniques, such as managing deer for weed control. Weeds are a nuisance for land owners and managers. If weeds are not consumed by livestock or wildlife, then they may compete against other forage plants for space. Many weeds, such as Canada thistle are not just common weeds but are listed as noxious weeds. Canada thistle was one of three weeds in North Dakota to be listed in 1885 as a plant that everyone must remove when found (Lym and Travnicek 2012). Canada thistle is the type of weed that can take advantage of disturbed areas. Once it is established, it is difficult to kill.

Canada thistle is a perennial plant that can reproduce both sexually and vegetatively, allowing for it to constantly increase its distribution (Lym and Travnicek 2012). Through sexual reproduction, Canada thistle produces seeds that can be distributed by the wind. However, seed production is not the main mechanism this plant uses to reproduce. The main form of growth is through vegetative reproduction (De Bruijn and Bork 2006). Canada thistle plants have tap roots,

allowing for continuous growth even if the top of the plant is damaged (Lym and Travnicek 2012).

The combination of reproductive systems makes Canada thistle difficult to control. Canada thistle has the ability to take over entire pastures. The continuous expansion of these plants can lead to declining forage for grazing animals. Currently, the predominate methods for controlling Canada thistle are chemical herbicides, cultivating, controlled burns, mowing, or biological control with insects. The best technique often includes a combination of tools to control Canada thistle. However, all of these control methods can be expensive or time consuming and are not guaranteed to work. (Lym and Travnicek 2012)

One possible biological control strategy to control Canada thistle with exciting potential is targeted grazing. White-tailed deer are an option because they do not readily consume this plant. Several studies have shown that herbivores will consume novel forages when they are used to consuming forages that are novel to them (Launchbaugh et al. 1997). Herbivores' forage preferences are known to be determined by a few factors, including post-ingestive feedback, maternal guidance, and peer guidance (Lane et al. 1990; Kronberg et al. 1993; Provenza 2003; Provenza et al. 2003; Villalba et al. 2004; De Bruijn and Bork 2006; Villalba and Provenza 2009; Sanga et al. 2011; Voth 2011). For instance, Provenza (2003) demonstrated that herbivores choose their forage preferences based on post-ingestive feedback. If a deer eats novel forage and becomes nauseous, that deer is not likely to consume that plant again. In addition, by the young watching what their mother and peers graze they will learn what plants to graze or avoid. However, some avoided forages can be consumed and possibly beneficial if the herbivore learns to mix the forages they consume (Villalba et al. 2010; Voth 2011; Jensen et al. 2013). Though Canada thistle is not very palatable, it is very nutritious when immature. With training or

encouragement to mix forages including weeds such as Canada thistle*;* white-tailed deer can overcome this factor of palatability and avoidance.

Future Implication of Targeted Grazing using Cattle and White-tailed Deer

The idea of encouraging cattle and white-tailed deer to consume weeds is a relatively new concept, at least with today's generation of land managers. Voth (2011) has demonstrated the role of encouraging or training cattle to graze Canada thistle. Other studies have shown goats will consume yellow starthistle *(Centaurea solstitialis*; Goehring et al. 2010). Goats were also used to consume leafy spurge in North Dakota (Lym et al. 1997).

One of the greatest concerns about using deer as a biological control for weeds is the possibility of increasing distribution of weed seeds. Urbanek et al. (2012) suggests that white-tailed deer are possibly the reason for decreased biodiversity. In that study, they showed feces may increase seed distribution. Increased seed distribution may mean increased plant distribution. Lefcort and Pettoello (2012) reported that deer do increase distribution of both native and exotic plants. However, they also stated cattle can distribute seeds by feces. If deer could be encouraged to graze weeds like cattle, they would be a great tool to help as a control against weeds. Parks et al. (2008) express the idea that grazing time plays an extremely important part in plant management. They suggested grazing the invasive plant early in the summer before the seed head is produced. Their study also suggested that deer and elk may increase invasive plant distributions if grazing the plants post seed head production. However, more research is needed to see if wildlife such as deer could be a viable biological control tool.

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CHAPTER 2. TARGETED GRAZING LEAFY SPURGE (*EUPHORBIA ESULA*) WITH FREE ROAMING COW-CALF PAIRS

Abstract

Feed costs and control of unwanted plants are two constant expenses for livestock producers. Continual grazing of desirable forages can inadvertently increase invasive plant species. As undesirable plant compositions increase, animals use more energy than normal searching for palatable, nutritional forage. Managers and producers employ targeted grazing to change animal behaviors for the consumption of particular plants, allowing managers and producers to better utilize the land and natural resources. There are several ways that cattle choose what to graze, for example, they may choose what to graze based on post-ingestive feedback and herd/maternal guidance. There are many other factors that can play a role in why cattle choose to graze the forages that they do. For example, gut fill and plant defense mechanisms can play a role in selection choices. This study was designed to manipulate cattle foraging behaviors for targeted grazing of leafy spurge (*Euphorbia esula L.*) at Camp Grafton South near McHenry, North Dakota. In 2013 and 2014, we encouraged cattle to consume leafy spurge by gradually introducing them to a mixture of hay and sweet feed concentrate. The replacement diets were 100%, 50%, and 0% alfalfa hay with 0%, 50%, and 100% freshly cut leafy spurge. Data was collected to determine the total consumption of leafy spurge from the pasture and feed bunks. The study established an increase in the total amount of leafy spurge consumed from the feed bunks. However, no evidence was found to support cattle targeted grazing leafy spurge in the field. More research is needed to discover if targeted grazing leafy spurge with cattle can be done using different targeted grazing techniques.

Introduction

Weeds have been an increasing nuisance to ranchers and land managers for years. According to Holechek et al. (2011) one definition of a weed is a plant growing where it is not wanted. Many weeds such as leafy spurge are classified not only as a weed but as a noxious weed. A noxious species is defined by Holechek et al. (2011) as a plant that is not desired for management objectives because it creates unhealthy predicaments for other species. Leafy spurge has reproductive and physical attributes that enable it to create unhealthy predicaments for other species. Leafy spurge is a plant that thrives in disturbed areas. Currently, it has been found in all but thirteen states of the United States (USDA-NRCS 2015). This plant is continuously increasing its distribution. A few of its attributes allow it to survive and compete against other species. For example, it is a plant that thrives in areas where other plants do not. It has deep roots that allow the plant to outcompete other plants. Leafy spurge also has a defense mechanism against grazers. A big reason why leafy spurge is able to outcompete other species is because it is one of the first plants to emerge in the spring. All of these features allow this plant to compete against other plants. (Ball et al. 2000, Lym and Travnicek 2012, Dickinson and Royer 2014)

Leafy spurge is a perennial plant that in the past was known as one of the hardest noxious weed to deal with (Lym and Travnicek 2012). One reason why leafy spurge is such a nuisance is because it is able to use vegetative and sexual reproduction. Vegetatively leafy spurge is able to increase its distribution from 0.30 to 0.91 meters per year (Lym and Travnicek 2012). Leafy spurge also produces seeds because it has a sexual reproduction mechanism. Each stem on a leafy spurge plant is able to produce an average of 140 seeds which can survive in the soil for up to eight years (Lym and Travnicek 2012). Having two different reproductive mechanisms allows

leafy spurge to continuously increase its distribution. Leafy spurge has many traits both functional and reproductive which gives it the ability to take over entire pastures.

Livestock and humans have been interacting together for centuries (Friend and Bishop 1978). For hundreds of years livestock producers and land managers have been creating production goals and using livestock to meet those goals. Targeted grazing is one tool that has been used to meet goals which involve manipulating livestock forage grazing behaviors. Livestock have been shown to gain their foraging behaviors from peer/maternal guidance and from past experiences (Provenza 2003; Voth 2011). Knowing livestock grazing behaviors allows producers and land managers to use manipulation techniques for targeted grazing. Common manipulation techniques are supplements, fencing, or adding water; all of which encourage livestock to graze in specific areas. Recently there has been the idea of targeted grazing weeds using cattle (Voth 2011). Targeted grazing is a practice that ranchers and land managers have been using for centuries to meet production goals. One manipulation technique that has been used for enhancing foraging diets is mineral feeders (Vallentine 2001).

There is a high demand for inexpensive weed control methods. There is a possibility that cattle can be used as a tool for the control of weeds like leafy spurge. Weeds such as leafy spurge are not normally grazed because of their defense mechanisms along with several other mechanisms. Using cattle as a weed control method would benefit the livestock producers, land managers and the land. Targeted grazing weeds would allow for an increased forage quantity and, in some cases, increased forage quality (Voth 2011). The purpose of this study was to determine if cattle will target graze leafy spurge. Our objective is to expose cattle to leafy spurge in a feed bunk mixed with other feedstuffs which will induce cattle to change their grazing

behavior to target graze leafy spurge in the field. We hypothesized that cattle will consume leafy spurge from the feed bunks and that they will target graze leafy spurge in the field.

Study Area

This study was conducted on Camp Grafton South, part of the Camp Gilbert C. Grafton Army National Guard Training Facility in Eddy County, North Dakota (Figure 2.1). This area is located 28 km north of McHenry, North Dakota and 57 km southeast of Devils Lake, North Dakota (Figure 2.2). Camp Grafton South comprises 3,763 ha (Department of Defense 2010). This study was conducted on pasture 7A, found in the northwest region of the base and located at 47° 43’ 10.44” N, 98° 41’ 43.33” W. This pasture consists of 97 ha and is part of a twice-over rotational grazing system and stocked with 167AUM.

Figure 2.1. Location of Camp Grafton South (black star) located in the eastern central North Dakota in Eddy County. (YellowMaps 2010)

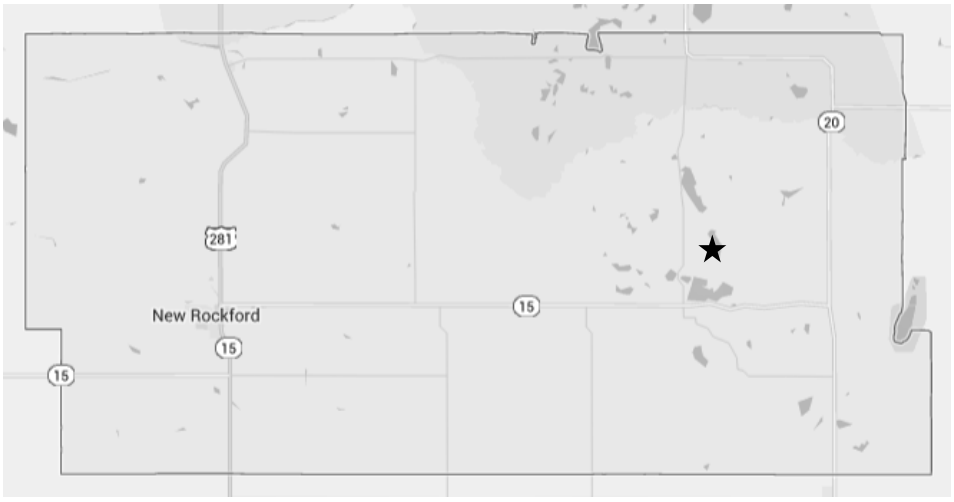

Figure 2.2. Location of study site (black star) in east central Eddy County, North Dakota. (Google Maps 2015)

Climate

The closest weather station is on Camp Grafton South located 13 km north of McHenry, North Dakota (NDAWN 2015). North Dakota is known for its high variability in temperature extremes within days and across seasons. Generally, the summers are characterized as warm and winters cold with a sub-humid continental climate (Barker et al. 2000). Table 2.1 shows the monthly average air temperature for 2013 and 2014 (NOAA 2014; NDAWN 2015). Table 2.2 shows the monthly precipitation amounts for 2013 and 2014 (NOAA 2014; NDAWN 2015). Camp Grafton South is located in MLRA 55B and has an average of 135 frost-free days and 165 freeze-free days (USDA-NRCS 2006). The majority of the precipitation is distributed during the growing season with 405 to 535 mm received as rainfall and 635 to 1,270 mm in the form of snow (USDA-NRCS 2006).

Table 2.1. The average monthly temperature (°C) and departure from 30 year average for Eddy County, North Dakota in 2013 and 2014 (NDAWN 2015; NOAA 2014).

Monthly Average Temperature			
Month	**30 year average**	**2013**	**2014**
January	-13	-13	-15
February	-10	-11	-17
March	-3	-10	-7
April	6	-2	3
May	13	12	12
June	18	18	17
July	21	20	19
August	20	21	20
September	14	17	15
October	6	5	8
November	-3	-4	-7
December	-11	-17	-9

Table 2.2. Total monthly precipitation (mm) and departure from 30 year average for Eddy County, ND in 2013 and 2014 (NDAWN 2015; NOAA 2014).

Total Precipitation			
Month	**30 year average**	**2013**	**2014**
January	15.5	10.9	13.0
February	14.5	11.7	3.1
March	24.9	29.2	4.8
April	30.2	45.0	64.3
May	65.5	99.3	55.6
June	91.9	68.1	125.2
July	86.6	23.1	49.8
August	72.6	25.1	73.4
September	51.8	54.6	30.2
October	42.2	121.4	8.1
November	24.4	24.4	19.6
December	18.8	18.3	2.3
Total	538.9	531.1	449.4

Soil and Topography

The main soil order in MLRA 55B is Mollisols (USDA-NRCS 2006). The study area was comprised of Heimdal-Emrick loams, Esmond-Heimdal loams, Esmond-Heimdal-Darnen loams, Arvilla-Sioux complex, Sioux-Arvilla-Renshaw complex, Embden-Egeland fine sandy loams, and Towner-Heimdal complex (USDA-NRCS 2014). Most of the soils on our study area were classified as loams, fine sandy loams, and loamy fine sands. Camp Grafton South includes several areas of rolling hills and is part of the Central Black Glaciated Plains (USDA-NRCS 2006). This area is comprised of a glacial till plain made up of lacustrine deposits (USDA-NRCS 2006). Camp Grafton South is used for military trainings, but is also used as grazing lands for cattle.

Vegetation

The vegetation in the study consists of several types and species of graminoids, forbs, shrubs, and trees. Graminoid species commonly found in the study area include Kentucky bluegrass *(Poa pratensis* L.*)*, little bluestem *(Schizachyrium scoparium* (Michx.) Nash var. *scoparium)*, slough sedge *(Carex obnupta* L.H. Bailey*)*, and smooth brome *(Bromus inermis* Leyss.*)*. The dominant shrubs found in the study area include western snowberry *(Symphoricarpos occidentalis* Hook.*)*, and leadplant *(Amorpha canescens* Pursh*)*. The study area had varying amounts of leafy spurge *(Euphorbia esula L.)* and other weeds. This is a short list of the plants in the study area as there were many other plant species present. (Prosser et al. 2003, USDA-NRCS 2006, USDA-NRCS 2015).

Material and Methods

This study was conducted with 114 cow/calf pairs and 3-4 bulls (depending on season), during two observational periods (July and August, 2013) and two forage replacement periods (June and August, 2014). Forages and a supplemental sweet feed were distributed in feed bunks strategically placed in a pasture containing leafy spurge. All diets consisted of sweet feed supplement and combinations of alfalfa *(Medicago sativa)* and leafy spurge. The sweet feed supplement was a pelleted mixture of ground corn, wheat middling, soy bean meal, and dried molasses. A minimum of 40 kg of the supplemental ration was placed in the feed bunks twice a day (morning and evening) for six days. There were three replacement rations using leafy spurge and alfalfa with each ration fed for two days (four feedings). The first ration (0%) comprised 54 kg sweet feed supplement and 100% alfalfa. The second ration (50%) consisted of a minimum 40 kg sweet feed supplement, 50% alfalfa and 50% leafy spurge and the third ration (100%) consisted of a minimum 40 kg sweet feed supplement and 100% leafy spurge. Leafy spurge control samples were collected at the same time as the feed bunk leafy spurge to monitor the weight change that occurs due to environmental conditions. This study has a single group, un-replicated design with animals observed to determine number feeding on leafy spurge in the bunk and in the field.

Herding

The cattle generally did not arrive at the feeding location at the scheduled feeding time unless they were herded. On a regular occurrence the cattle needed some encouragement or enticement to move to the feed bunks. Several methods were used to encourage cattle to come to

the feed bunks at the time of feeding. The primary method was the use of a sweet feed supplement as an attractant. Cattle were also rounded up with horses and on foot.

Observational Study

The observational study was conducted during two seasonal periods in 2013 (July and August). The feed replacement study used six feed bunks that were strategically placed in a leafy spurge abundant pasture. Foraging observations were collected during time of feedings and for two hours after feeding while cattle were grazing to determine if cows and calves grazed leafy spurge.

Forage Replacement Study

The forage replacement study was conducted during two time periods in 2014 (June and August). Feed rations were distributed evenly across six feed bunks strategically placed in leafy spurge patches (> 25 live plants per 0.25 m^2) within the pasture. Replacement forage was weighed both pre- and post-feeding. Observations were conducted during time of feeding and for a minimum of thirty minutes after feeding while cattle were grazing.

Leafy spurge was freshly cut with hedge clippers just before the 50% and 100% replacement feedings. Leafy spurge samples used as the control were cut and weighed at the same time as the leafy spurge used in the feeding trial. The control leafy spurge samples were placed outside of the pasture but experienced the same environmental factors as those samples fed to the cattle. The control leafy spurge samples were used to standardize the loss of water weight from the natural air drying conditions. This standardized loss was incorporated into the post feeding trial to better estimate actual consumption of leafy spurge by cattle.

Results

Leafy Spurge Consumption in the Feed Bunk Observational Study

Cattle consumed some of the alfalfa hay in the feed bunks, leaving varying amounts in 2013. Some individual cattle would consume leafy spurge placed in the feed bunks while others avoid it by pushing it around and separating the leafy spurge from the alfalfa. In 2014 the cattle consumed almost all of the alfalfa hay during all feeding periods. Observations were recorded when cattle consumed leafy spurge in the feed bunks (figure 2.3). Calves were observed consuming the leafy spurge from the feed bunks (figure 2.4). In 2013 there was one observation of a calf tasting a leafy spurge plant in the field. By the end of the second study, observers were able to get closer to the cattle. In 2014 there were no affirmative observations of cattle grazing leafy spurge in the field.

Figure 2.3. Cattle consuming leafy spurge from the feed bunks located at Camp Grafton South near McHenry, ND in 2014.

Figure 2.4. Calf consuming leafy spurge from the feed bunks located at Camp Grafton South near McHenry, ND in 2014.

Forage Replacement Period

There was a difference ($P \leq 0.05$) between average pre- and post-feeding weights of all forages placed in the feed bunks in June and August (Figure 2.5 and 2.6). There was no difference ($P \leq 0.05$) between average pre-and post-feeding weights of leafy spurge for both June and August (Figure 2.7 and 2.8). Figure 2.9 and 2.10 demonstrate the average disappearance of the forages from the feed bunks for June and August 2014. All of the P-values were determined using T-tests in excel.

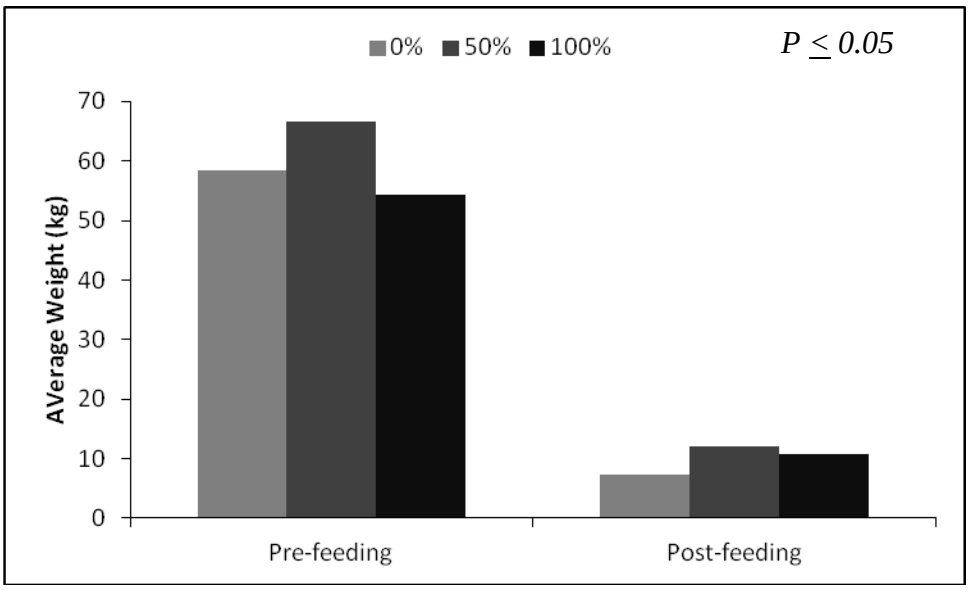

Figure 2.5. Pre- and post-weights of all feed fed to cattle in feed bunks in June at Camp Grafton South near McHenry, ND in 2014.

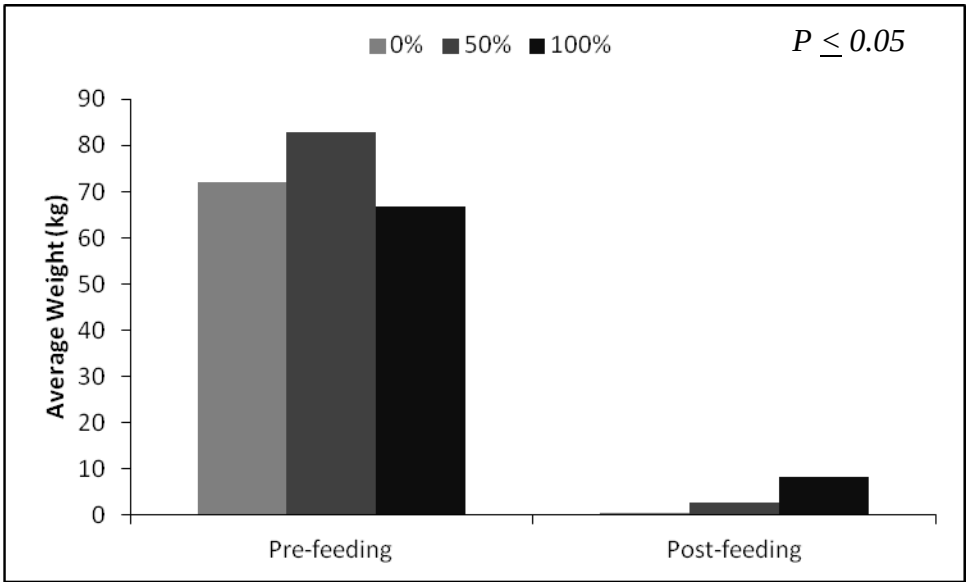

Figure 2.6. Pre- and post-weights of all feed fed to cattle in the feed bunks in August at Camp Grafton South near McHenry, ND in 2014.

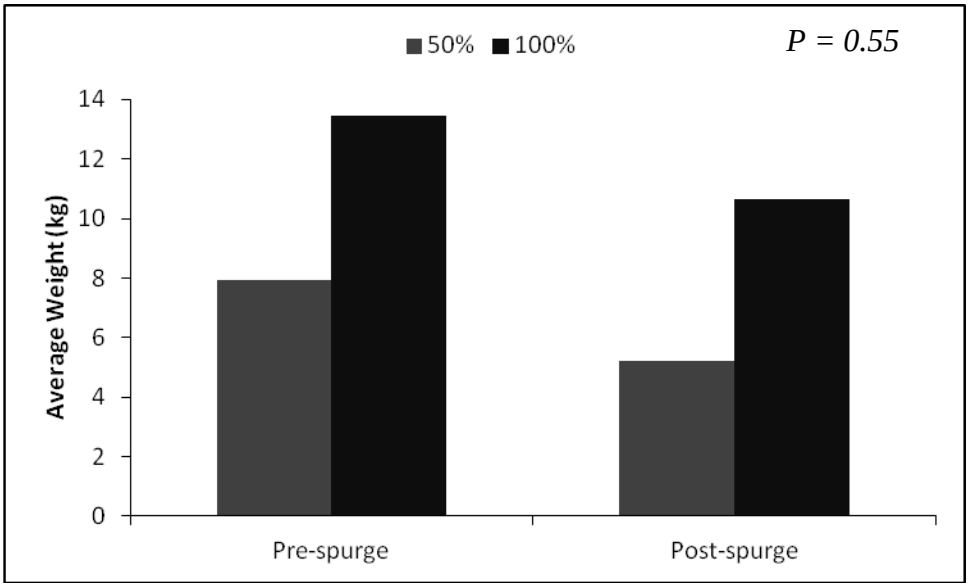

Figure 2.7. Pre- and post-weights of leafy spurge fed to cattle in the feed bunks in June at Camp Grafton South near McHenry, ND in 2014.

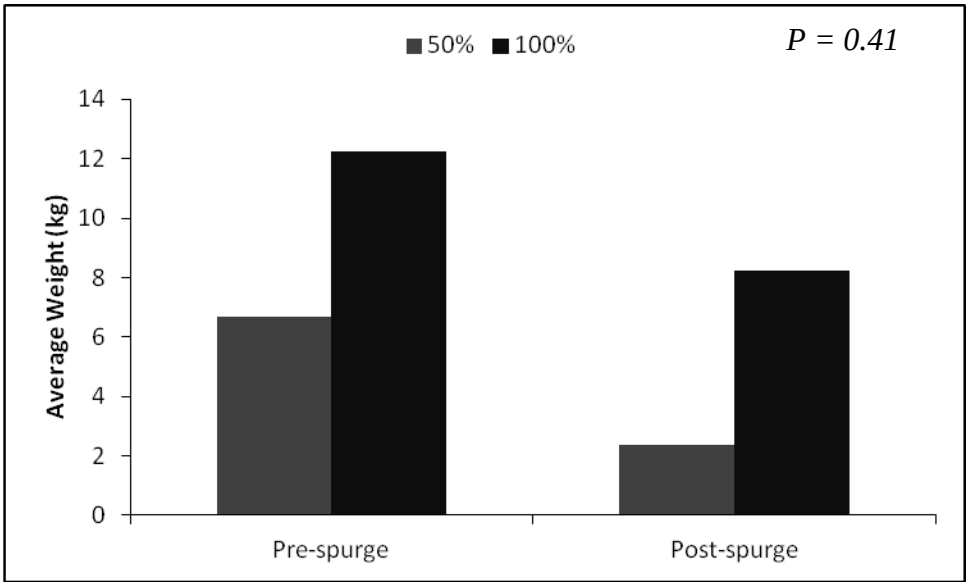

Figure 2.8. Pre- and post-weights of leafy spurge fed to cattle in the feed bunks in August at Camp Grafton South near McHenry, ND in 2014.

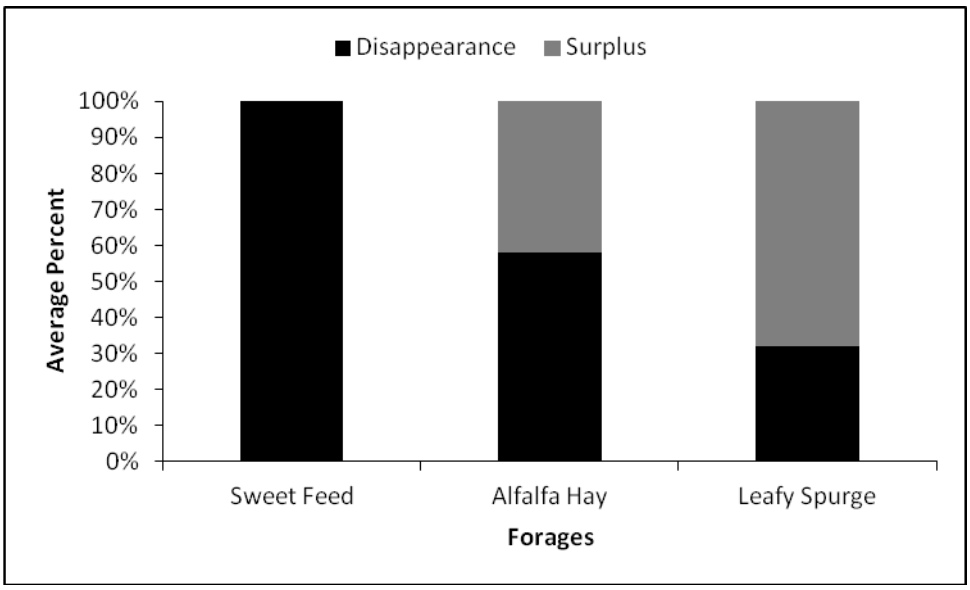

Figure 2.9. The total average percent of disappearance and surplus forage from the feeding bunks in June at Camp Grafton South near McHenry, ND in 2014.

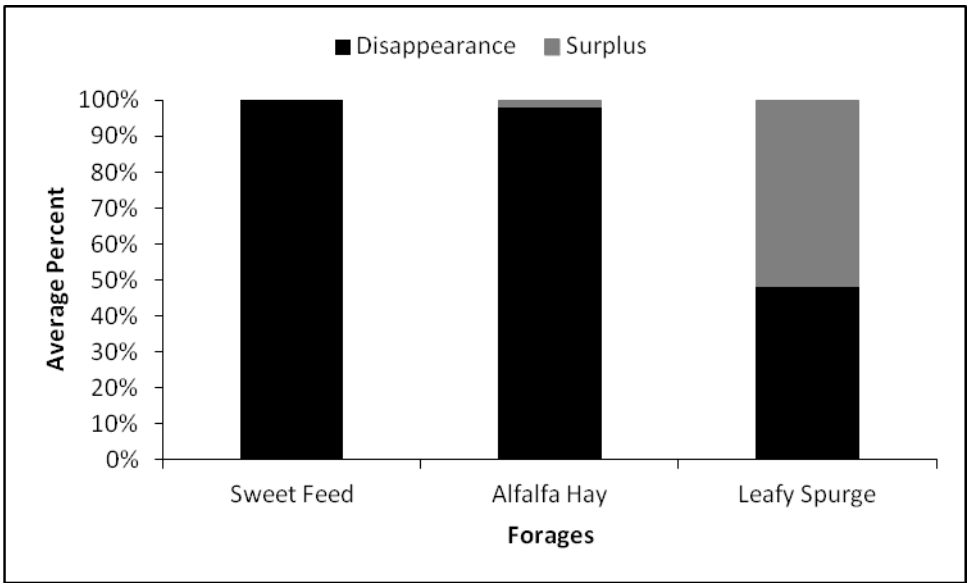

Figure 2.10. The total average percent of disappearance and surplus forage from the feeding bunks in August at Camp Grafton South near McHenry, ND in 2014.

Discussion

Targeted grazing leafy spurge with cattle generally has not been thought of as a feasible management tool. However, in recent years targeted grazing weeds has become more of a

realistic management strategy. This increasing popularity has encouraged more research in the field of targeted grazing nuisance weeds.

Past research has shown that mothers and peers influence their young on what to graze (Provenza 2003; Voth 2011). Allred et al. (2011) has also reported that for years humans have been using grazing behaviors to their advantage. Observations from both 2013 and 2014 have shown it is possible to encourage cattle to consume some level of leafy spurge in a feed bunk. As previously mentioned, several cattle were observed consuming leafy spurge from the feed bunk; some calves were even seen consuming leafy spurge, demonstrating the possibilities for young calves to learn to graze leafy spurge. However, this study only observed a few calves consuming leafy spurge and it only utilized one generation with limited research showing how this would impact the young as they continue to grow. This study did not find evidence of cattle targeted grazing leafy spurge.

There was a difference between pre- and post-forage weights, however, our data showed no significant difference in the pre- and post-leafy spurge weights. Although there was some consumption of leafy spurge from the feed bunks, there were no observations that cattle grazed leafy spurge in the pasture. More research is needed to determine if cattle will graze larger quantities of leafy spurge from the pasture or feeding bunks using different techniques.

Conclusion

In conclusion, there was no significant difference in leafy spurge weights from the control samples and feed bunk samples, and no grazing of leafy spurge in the pasture. Although there was no difference in leafy spurge weight from the feed bunk, there was a disappearance of leafy spurge plants from the feed bunks. This does support the idea that cattle will sample leafy spurge from feed bunks. It also shows that young cattle may be encouraged to consume leafy

spurge from feed bunks and possibly graze leafy spurge from the surrounding area. This will encourage them to try leafy spurge from the feed bunks when no other cattle are present. There is more research that needs to be done to determine if a different study technique would be more encouraging. A generational study should be done to determine if cattle grazing leafy spurge will continue as they mature.

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CHAPTER 3. TARGETED GRAZING CANADA THISTLE (*CIRSIUM ARVENSE*) USING WHITE-TAILED DEER

Abstract

Wildlife may be encouraged to target graze undesirable plants similar to targeted grazing unwanted weeds with cattle. The purpose of our study was to evaluate white-tailed deer consumption of Canada thistle (*Cirsium arvense*) using two separate feeding parameters on Camp Grafton North near Devils Lake, North Dakota. The first study was a behavioral study designed to determine if white-tailed deer will graze Canada thistle in a pelleted form. We ground mature Canada thistle plants with a small Wiley mill and created three pelleted rations with different thistle concentrations (25%, 50%, or 75%) mixture of corn, wheat middling, soybean meal, and dried molasses. Data was collected to observe the total percent of consumed pellets for each concentrate level in 2013 and 2014. White-tailed deer consumed all rations (25%, 50%, and 75%) of the Canada thistle pellets. In 2014, we conducted a second study, an attractant study, measuring the height of Canada thistle plants pre- and post-application of two types of molasses (Molasses and Raffinate) during two different periods (June and August). There was no difference *($P > 0.1$)* between periods or molasses type in grazing height of Canada thistle. However, during the August period there was a difference ($P \leq 0.1$) between the average pre- and post- height by molasses type. Overall, white-tailed deer consumed Canada thistle in a pellet form up to 75% of the ration. White-tailed deer targeted graze Canada thistle when sprayed with Molasses and Raffinate, with Raffinate providing the greater use of the plants compared to Molasses and control. More research is needed to determine if white-tailed deer can be used as a biological control for selected weed species.

Introduction

Weeds are a nuisance that many livestock producers and land managers have to deal with on a daily bases. The current methods that are used for weed control can be expensive and are not guaranteed to work. When weeds grow on pasture lands they can take up available forage for grazing. Weeds such as Canada thistle have been known to cause problems because of their dual reproduction mechanisms. Canada thistle can reproduce both vegetatively and sexually (Lym and Travnicek 2012). Weeds that have both types of reproductive mechanisms are often difficult to control because they are continuously increasing their distribution. There is a need for an inexpensive sustainable control method for weeds. An option to address the continued expansion of Canada thistle (North Dakota Department of Agriculture 2015) in North Dakota might be to use deer as targeted grazers.

Canada thistle was listed by the Dakota Territory in 1885 as a perennial plant that needs to be destroyed on sight (Lym and Travnicek 2012). As previously mentioned Canada thistle has two reproductive (sexual and vegetative) mechanisms that allow for a continuous increase in the plant distribution. The seeds from the sexual reproduction are spread from wind or within the hair and feet of wildlife. The vegetative reproduction is difficult to control because it is below the ground. Each year Canada thistle plant roots can grow 3.7 to 4.6 meters away from the mother plant (Lym and Travnicek 2012). These same roots can allow for new Canada thistle plants to sprout up (Lym and Travnicek 2012). It is very difficult to control this plant because the root system can penetrate to three meters or more (Lym and Travnicek 2012). Of the fifty United States all but eight have Canada thistle (USDA-NRCS 2015) and it is continuing to expand its distribution.

Provenza (2003) demonstrated that herbivores learn grazing behaviors from peer/maternal guidance and from their past experiences. Knowing how behaviors are established allows for them to be manipulated. Targeted grazing is a tool used in livestock production which involves manipulating forage grazing behaviors to meet production goals. Targeted grazing uses the manipulation of forage grazing behaviors to encourage livestock and wildlife to graze in different areas and on different forages. Supplements, fences, and water have all been used to encourage animals to graze in different locations or to graze on different forages. In recent years cattle have been used for grazing weeds (Voth 2011).

Targeted grazing of undesirable plants with cattle has gained popularity. If cattle are successful at targeted grazing weeds there could be a possibility of other herbivores being used for targeted grazing. Traditionally, white-tailed deer have not been used as a tool for weed control. Using white-tailed deer to target graze Canada thistle could increase their forage availability and possibly forage quality. Cooper et al. (2008) found that cattle and deer are complementary grazer because their diets do not overlap for much of the year. If deer learn to graze weeds and cattle do not prefer them; deer would have one more forage source that could benefit the deer/cattle relationship. According to Urbanek et al. (2012) white-tailed deer decrease plant diversity. However, if deer learn to target graze Canada thistle then they could possibly help increase the plant diversity. Encouraging white-tailed deer to target graze Canada thistle could benefit other wildlife species, livestock producers, and land managers.

Target grazing with white-tailed deer would make a bit of a challenge. An incentive would need to be used to encourage the white-tailed deer to graze. Molasses is a great tool to use to encourage herbivores to come to a specific location. Sugar beet molasses (molasses) and concentrated separator by-product (CSB also known as raffinate) are two types of by-products

from sugar beets in the production of sugar. They make the perfect incentive because molasses (Dry matter: CP 8.5%, Sucrose 50.0%, and ash 11.3%) and CSB (Dry matter: CP 19.0%, Sucrose 23.0%, and ash 29.0%) are good supplements for grazing. (Wiedmeier et al. 1992, Shellito et al. 2006)

The purpose of this study was to determine if white-tailed deer would target graze Canada thistle using two different management techniques. We hypothesized that white-tailed deer will consume Canada thistle using different targeted grazing methods (pelleted feed and molasses spray). The study objectives were to determine if Canada thistle pelleted rations and two different types of molasses spray would encourage white-tailed deer to target graze Canada thistle. It is important to find a control for weeds such as Canada thistle which is economically feasible and sustainable.

Study Area

This study was conducted on Camp Gilbert C. Grafton Army National Guard Training Facility in northeastern North Dakota (Figure. 3.1). This area is often referred to as Camp Grafton North; located about 9.5 km southwest of Devils Lake, ND. Camp Grafton North consists of approximately 405 ha of heavily wooded lands intermixed with wetlands and open savannah (Department of Defense 2010). Camp Grafton North is located in the southwestern corner of Ramsey County, ND (Figure 3.2). The study site was a forested community that had been clear-cut and burned in 2006 and 2007 (Hanson 2009). The targeted grazing study area, 48° 03’ 10.80” N 98° 54’33.16” W, consisted of approximately 6.6 ha.

Figure 3.1. Location of Camp Grafton North (black star) located in the eastern central North Dakota in Ramsey County. (YellowMaps 2010)

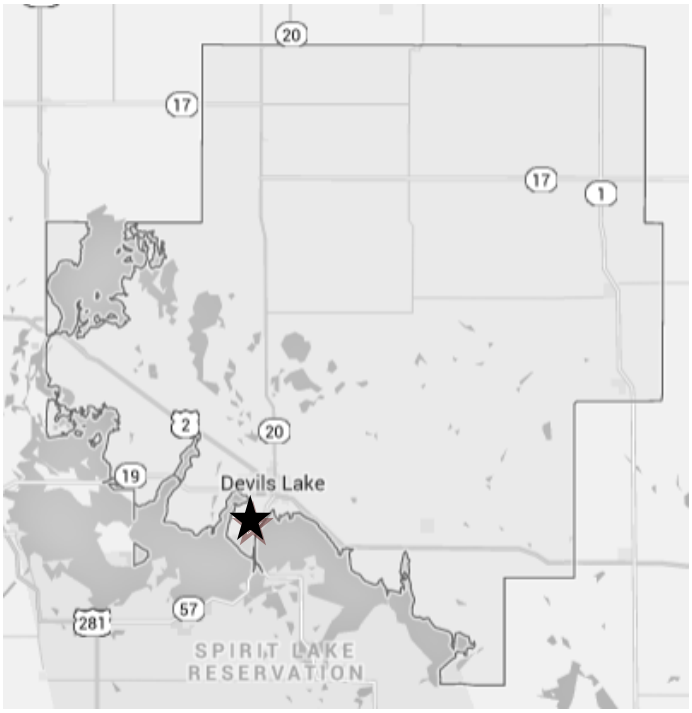

Figure 3.2. Location of study site (black star) on the border of Ramsey County, North Dakota. (Google Maps 2015)

Climate

North Dakota is known for having a wide range of temperatures. The highest daily maximum temperature was recorded in 2013 at 39 °C and the lowest daily minimum temperature was measured in 2004 at -39 °C (NDAWN 2015). Tables 3.1 and 3.2 show the average air temperature and average precipitation by month for 2013, 2014, and the 30 year average (NOAA 2014; NDAWN 2015). The study area was located in MLRA 55A which receives most of its precipitation in the form of rainfall in the summer months and ranges from 355 to 485 mm, with snowfall totals ranging from 635 to 1,270 mm (USDA-NRCS 2006). The area usually receives 125 frost-free days to 155 freeze-free days (USDA-NRCS 2006).

Table 3.1. The average monthly temperature (°C) and departure from 30 year average for Ramsey County, North Dakota in 2013 and 2014 (NDAWN 2015; NOAA 2014).

Monthly Average Temperature			
Month	**30 year average**	**2013**	**2014**
January	-14	-13	-15
February	-11	-11	-17
March	-4	-12	-7
April	6	-3	3
May	13	9	12
June	18	18	18
July	20	20	20
August	20	20	20
September	14	17	15
October	6	6	8
November	-3	-4	-7
December	-12	-17	-9

Table 3.2. Total monthly precipitation (mm) and departure from 30 year average for Ramsey County, ND in 2013 and 2014 (NDAWN 2015; NOAA 2014).

Total Precipitation			
Month	**30 year average**	**2013**	**2014**
January	15.2	0.0	1.3
February	12.2	0.0	0.0
March	21.3	0.0	0.0
April	24.4	18.4	48.8
May	62.5	118.6	66.8
June	100.6	60.7	99.1
July	87.9	42.9	52.3
August	64.5	21.6	46.0
September	47.0	42.7	18.5
October	39.6	81.5	4.8
November	25.4	0.8	0.0
December	17.5	0.0	0.0
Total	518.1	387.2	337.6

Soil and Topography

Mollisols are the dominant soil type for MLRA 55A (USDA-NRCS 2006). According to USDA-NRCS (2014), the study area is comprised of Hamerly-wyard loams and Bottineau loam. The dominant soil is loamy with medium to low surface runoff rates and slow infiltration rates (USDA-NRCS 2014). The study area is described as flat glacial lake plains (USDA-NRCS 2006). At one point a large portion of Camp Grafton North was covered in hardwood forest (Barker et al. 2000). The study sites were located on a disturbed area that was previously clear-cut and burned (Hanson 2009). Camp Grafton North is used for military training, military headquarters and housing.

Vegetation

According to USDA-NRCS (2006), the dominant graminoids found in our study area are western wheatgrass *(Pascopyrum smithii* (Rydb.) Á. Löve*)*, green needlegrass *(Nassella viridula* (Trin.) Barkworth*)*, needle-and-thread *(Hesperostipa comata* (Trin. and Rupr.) Barkworth.*)*, blue grama *(Bouteloua gracilis* (Willd. *ex* Kunth) Lag. *ex* Griffiths*)*, little bluestem *(Schizachyrium scoparium* (Michx.) Nash var. *scoparium)*, prairie cordgrass *(Spartina pectinata ex* Link*)*, northern reedgrass *(Calamagrostis stricta* (Timm) Koeler subsp. Inexpansa (A. Gary) C.W. Greene*)*, big bluestem *(Andropogon gerardii* Vitman*)*, and slough sedge *(Carex obnupta* L.H. Bailey*)* (USDA-NRCS 2006). The dominant shrub species are western snowberry *(Symphoricarpos occidentalis* Hook.*)*, leadplant *(Amorpha canescens* Pursh*)*, and prairie rose *(Rosa arkansana* Porter*)* (USDA-NRCS 2006). Tree species found in the study area included bur oak (*Quercus macrocarpa* Michx.), Green ash (*Fraxinus pennsylvanica* Marshall), American elm (*Ulmus Americana* L.), quaking aspen (*Populus tremuloides* Michx.), balsam popular (*Populus balsamifera* L.), eastern cottonwood (*Populus deltoids* W. Bartram *ex* Marshall), and Boxelder (*Acer negundo* L.) (Barker et al. 2000; USDA-NRCS 2015).

Material and Methods

This project included two studies: a behavior study using pelleted rations to attract deer to consume adjacent plants, and an attraction study using molasses sprayed on targeted plants. The behavior study comprised pelleted feed rations using three levels of Canada thistle over two years (2013, 2014) and consisted of an observational period (July, 2013) and a trial period (July and August, 2014). The attraction study involved two molasses spray treatments conducted at two different periods (July and August, 2014). In both studies, a supplemental sweet feed was

placed on the ground within Canada thistle patches for a minimum of three days before implementing each study as an incentive to attract deer to the area. The supplemental sweet feed was a pelleted mixture of ground corn, wheat middling, soy bean meal, and dried molasses. Liquid molasses and dried beet pulp were also added to the sweet feed to increase the attract-ability of the feed.

Behavior Study - Pelleted Ration

Three pelleted rations were placed within a large Canada thistle patch (approximate radius of 20m) for two days per ration and a total of six days. Each ration consisted of ground corn, wheat middling, soybean meal, dry molasses, and three rations of ground Canada thistle (25%, 50%, and 75%). Each ration was placed on the ground near the center of the Canada thistle patch twice a day (morning and evening) for two days for a total of four feedings per ration.

Observational Period. The observational period for this study was conducted in July, 2013. A total 4.54 kg of each ration was placed out on the study location for each feeding period. Observations of white-tailed deer grazing live Canada thistle plants were recorded before, during, and two hours after each feeding period. Observations were recorded at study site during the before period, and from tree stands 100m from feed location during and after the feeding period.

Trial Period. The trial period was conducted during two periods (July and August, 2014). A minimum 3.63kg of each ration was placed out on the study location for each feeding period. Pelleted feed weights were recorded pre- and post-feeding.

Canada Thistle Collection. Canada thistle plants were collected in the summers of 2012 and 2013 to be dried and prepared for pellets. Collections were performed by using several hedge

clippers to cut fresh Canada thistle plants at the bolt, flower, and seed set growth stage. Once collections were completed the Canada thistle was transported for Fargo, ND, and placed in a 50^{o} Celsius dryer oven for a minimum 72 hours. Dried samples were stored and prepared to be ground until the subsequent study year. Canada thistle plants were ground with a small Wiley mill through a four mm size screen. The ground Canada thistle was transported to the Northern Crops Institute (NCI) where it was mixed into rations and pelleted using a Wenger Tx-52 extruder and dried using a pasta dryer.

Attraction Study - Molasses Spray

The attraction study was developed using a randomized block design (n=2); each block 3x3 m. The study consisted of two replicates and conducted during two periods, July and August in 2014 (Figure 3.3). We studied two different types of molasses (Molasses and Raffinate) from the American Crystal Sugar Company beet plant near Hillsboro, North Dakota. Molasses and Raffinate are both by-products from the production of sugar by sugar beets (Wiedmeier et al. 1992, Shellito et al. 2006). Molasses has a crude protein of 8.5% (DM), sucrose of 50% (DM), and ash of 11.3% (DM). Raffinate also known as concentrated separator by-product (CSB) has a crude protein of 19.0% (DM), sucrose of 23% (DM), and ash of 29.0% (DM, Wiedmeier et al. 1992). Molasses and Raffinate are good incentives for encouraging grazing in new areas or on new forages.

Figure 3.3 shows each replication (2) and the layout of each treatment and control (Raffinate, Molasses, Block Control, and Out Control). The Out Controls were added to test if incidental grazing occurred with each Block Control. The Raffinate and Molasses blocks were sprayed every 1.5 days. Each molasses treatment was treated with a 1,000 ml liquid spray application. The Raffinate treatment was 100% of the products while the Molasses treatment a

mixture of 750ml molasses and 250ml water. Height measurements were collected pre- and post-treatment and measured to the nearest mm.

Statistical Analysis. A T-test ($\alpha = 0.05$) was created with Excel using the Block Control and Out Control testing for incidental grazing. SPSS (IBM-SPSS 2013) was used to analyzing the deer data. A one-way ANOVA test was conducted for post-heights (cm) between treatments for each July and August, 2014. A second one-way ANOVA was created to test the difference in pre- and post-height (cm) across treatments in the August 2014. All of the data was tested at $\alpha = 0.1$ and means separated using a Tukeys test.

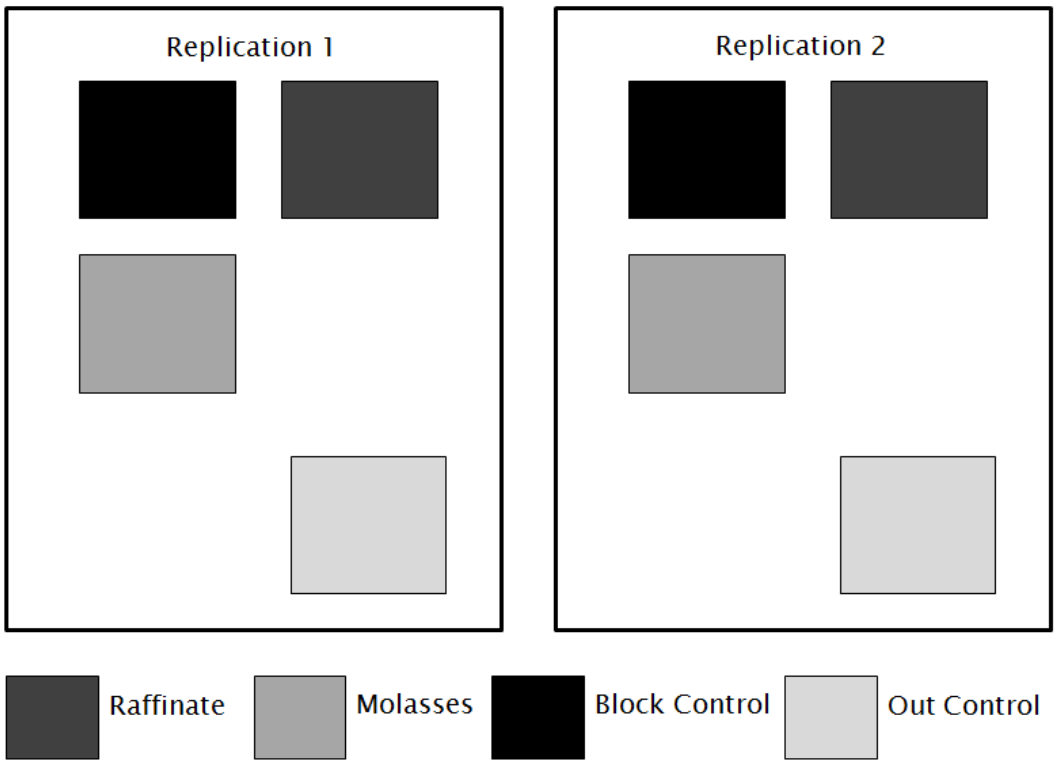

Figure 3.3. Design showing attraction study layout on Camp Grafton North near Devils Lake, ND. Each replication is a 3x3m block containing the Raffinate and Molasses treatments, Block Control, and an Out Control.

Results

Behavior Study - Pelleted Observations in 2013

White-tailed deer consumed a small amount of the 25% Canada thistle pelleted ration when the study began; however, they ate all of the pellets by the end of the feeding period. When the 50% Canada thistle pelleted feed ration was introduced to white-tailed deer they consumed all pellets except those that attained moisture. When the 75% Canada thistle pellets were introduced to white-tailed deer they did not graze much at the start; however consumption increased throughout the feeding period.

Behavior Study - Pelleted Trial in 2014

The 25% and 50% Canada thistle pelleted rations were almost completely consumed during both July and August periods. The 75% Canada thistle pelleted rations was almost completely consumed during the July period; however, consumption ranged from 65% - 100%, depending on feeding during the August period. Overall, white-tailed deer consumed pellets containing all Canada thistle rations (Figure 3.4, 3.5, 3.6 and 3.7).

Figure 3.4. White-tailed deer consuming Canada thistle pellets at Camp Grafton North near Devils Lake, ND in 2014.

Figure 3.5. White-tailed doe with fawns consuming pelleted Canada thistle at Camp Grafton North near Devils Lake, ND in 2014.

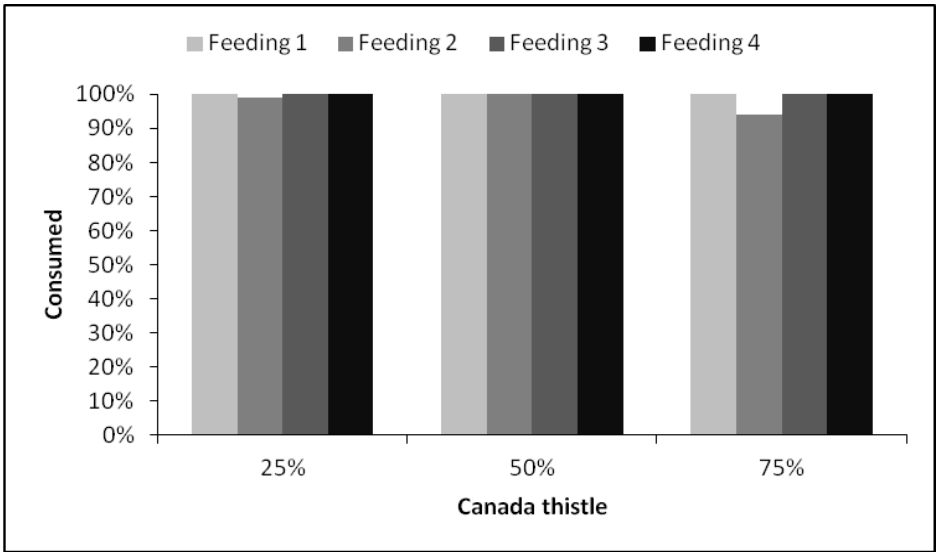

Figure 3.6. Percent pellet consumption by pelleted ration (25%, 50%, and 75%) at Camp Grafton North near Devils Lake, ND in July 2014

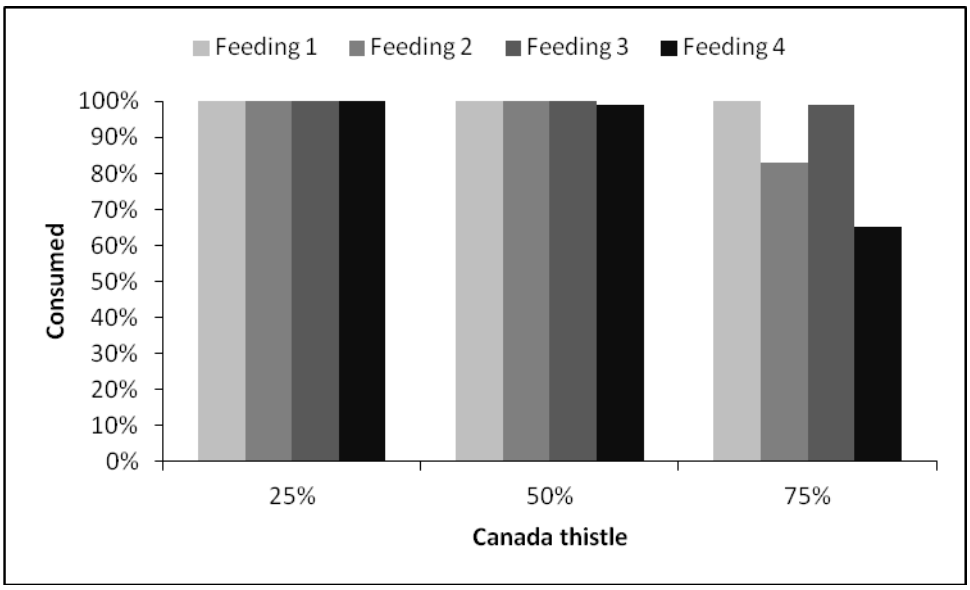

Figure 3.7. Percent pellet consumption by pelleted ration (25%, 50%, and 75%) at Camp Grafton North near Devils Lake, ND in August 2014.

Attraction Study - Molasses Spray

There was no difference *(P = 0.87)* between the Block Control and Out Control (Figure 3.8). Controls from this point on will only be represented by the Control within the blocks. Figure 3.9 demonstrates how leaves and buds were grazed off of the Canada thistle plants. There was no difference *(P = 0.46)* in Canada thistle plant height after treatment for the July and August periods in 2014 (Figure 3.10, Figure 3.11). However, there was a difference ($P \leq 0.1$) between the pre- and post- height by treatment in August 2014 (Figure 3.12). Canada thistle plants sprayed with Raffinate were consumed at a higher level ($P \leq 0.1$) than plants sprayed with Molasses and the Control.

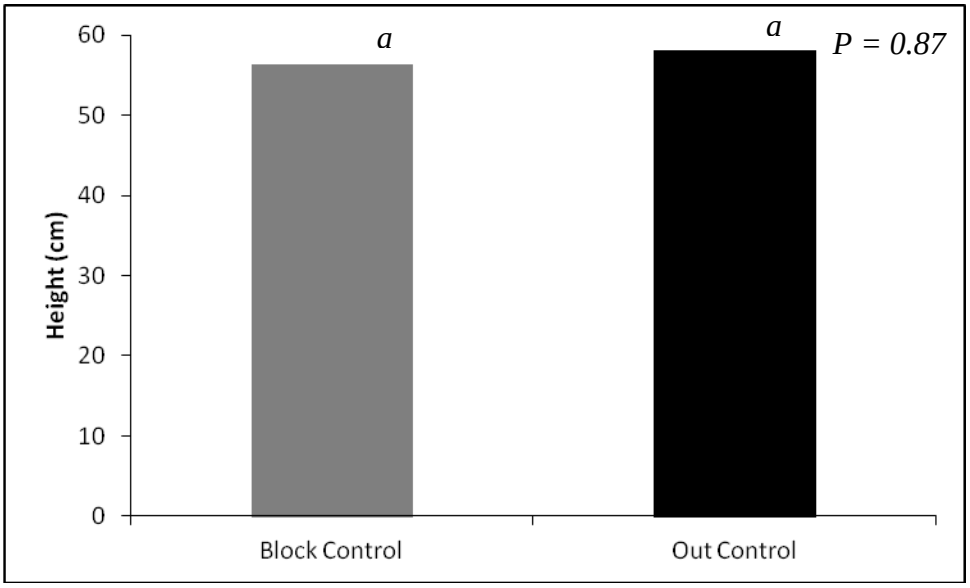

Figure 3.8. Post-treatment Canada thistle plant heights (cm) by Control sites on Camp Grafton North near Devils Lake, ND in July and August, 2014.

Figure 3.9. Post-grazed Canada thistle plant (molasses coated stems) at Camp Grafton North near Devils Lake, ND in 2014.

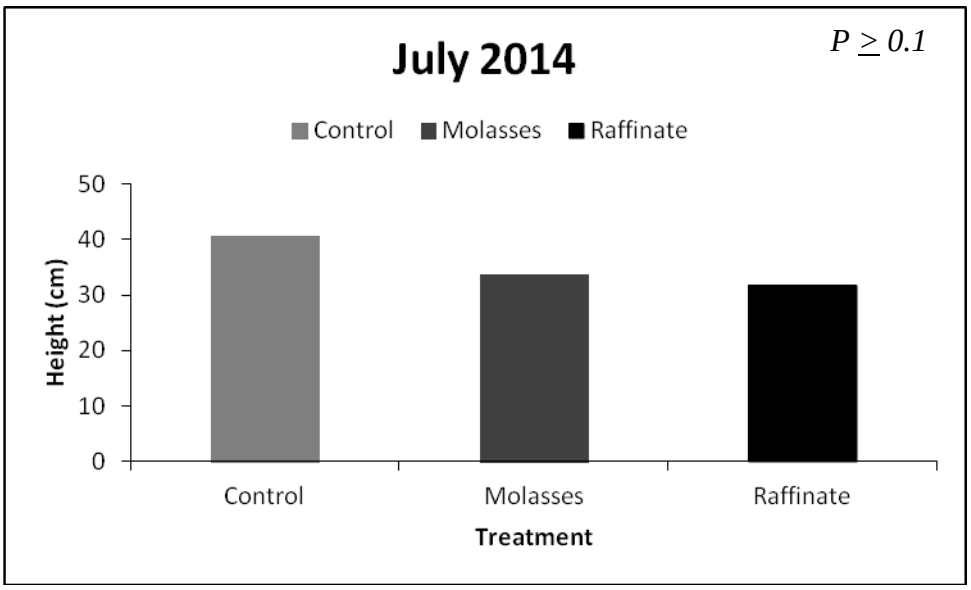

Figure 3.10. Post-height (cm) of Canada thistle plants by application treatment on Camp Grafton North near Devils Lake, ND in July 2014.

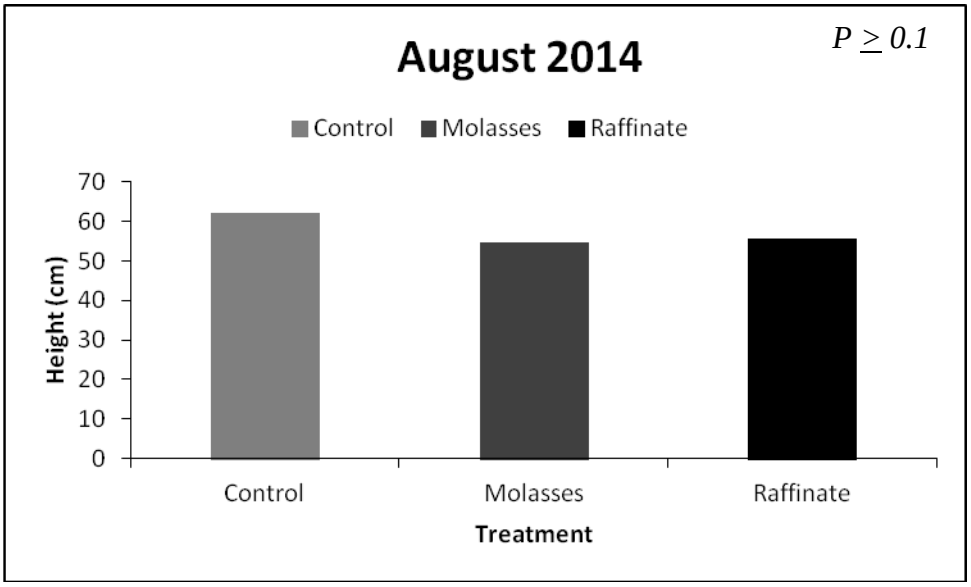

Figure 3.11. Post-height (cm) of Canada thistle plants by application on Camp Grafton North near Devils Lake, ND in August 2014.

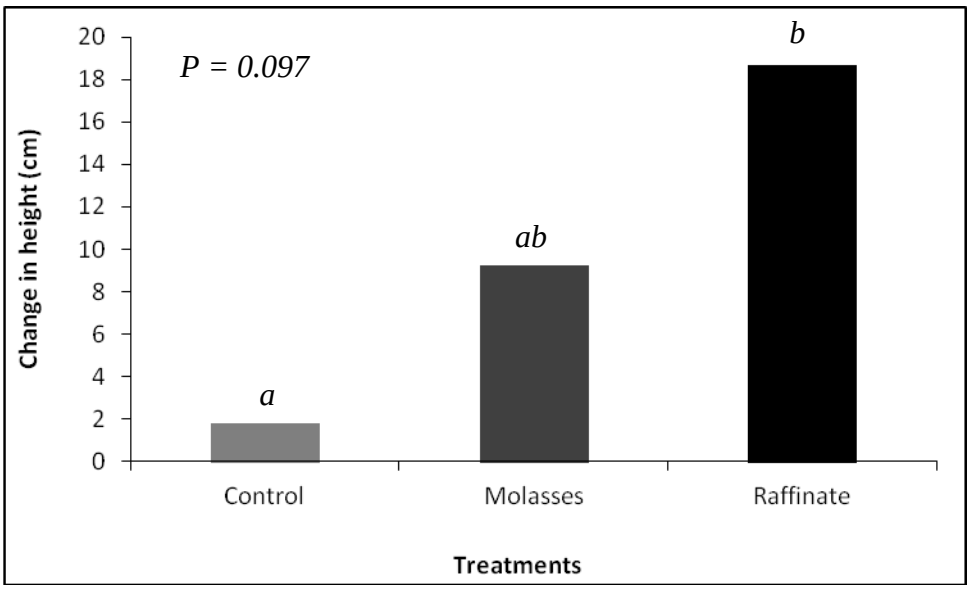

Figure 3.12. Pre- and post-height (cm) difference of Canada thistle plants by application treatment on Camp Grafton North near Devils Lake, ND in August 2014.

Discussion

The concept of encouraging wildlife such as white-tailed deer to graze weeds like Canada thistle is a relatively new concept. If deer could be trained to graze weeds it could benefit the ecological function and productivity of the land and wildlife habitat. Wildlife consuming weeds could benefit livestock producers and land managers by providing another tool to control unwanted plants.

Our findings show white-tailed deer will consume weeds when in a pelleted form. The consumption of Canada thistle pellets by white-tailed deer did not encourage white-tailed deer to target graze live Canada thistle plants in the field; however, it did prove they would consume Canada thistle in a pellet up to 75% of the ration. White-tailed deer consumed pellets from all rations (25%, 50%, and 75%). More research needs to be done to see if it would be possible to use the pelleted rations as a feed source for livestock. It would be important to establish if this could be a sustainable feed source for wildlife or livestock.

The application of molasses as a spray to Canada thistle showed it not only attracts white-tailed deer but also encouraged them to consume live Canada thistle plants. There was no difference between the treatments by season of Canada thistle heights post treatment; however, there was a greater consumption based on plant height removed with the Raffinate treatment compared to Control. This study has established that using Molasses and Raffinate can encourage white-tailed deer to graze Canada thistle in the field. More research needs to be performed to determine what kinds of effects white-tailed deer will have on Canada thistle plants.

Conclusion

White-tailed deer consumed Canada thistle from a pelleted form in rations from 25%, 50%, and 75%. More research needs to be done to establish if Canada thistle pellets could be used in livestock rations. A feedlot study might be the next step for a pelleted ration study.

White-tailed deer will graze Canada thistle in the field when it has been sprayed with Molasses or Raffinate. White-tailed deer appeared to graze more Canada thistle in the August period than June period. This study has shown that it is possible to encourage white-tailed deer to graze Canada thistle through two different methods (pelleted and molasses spray). More research is needed to determine if these studies can be used with other species besides white-tailed deer. It is also important to see how these studies will impact Canada thistle in the field.

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GENERAL CONCLUSION

Targeted grazing of weeds has become more of a reality in recent years. Although there was no difference in pre- and post-forage weight of leafy spurge fed to cattle in a feed bunk, there were observations of cattle consuming leafy spurge within the feed bunk and a calve grazed a leafy spurge plant in the field.

Pelleted weeds such as Canada thistle may be a potential feed source. Our study demonstrated that white-tailed deer will consume Canada thistle pellets at 25%, 50%, and 75% of the diet. Molasses spray may have a future managing weeds and wildlife. There was no difference between height of Canada thistle plants by treatment in July and August; however, there was a difference in the average pre- and post-height of Canada thistle by treatments with Raffinate, providing the greatest consumption of live Canada thistle plants.

These studies demonstrate that it is possible to manipulate foraging behaviors to consume weeds. There was no successful targeted grazing of live plants with cattle (leafy spurge) or the white-tailed deer (Canada thistle) using pelleted studies. The molasses spray study demonstrated it is possible to encourage white-tailed deer to target graze live Canada thistle plants. Overall these studies show that manipulation of grazing behaviors is a tool to use when encouraging cattle and white-tailed deer to consume weeds.