EVALUATION OF WILDLIFE FOOD PLOT SEED MIXES FOR KANSAS

by

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Abstract

Three wildlife seed mixes were tested, Perfect Plot (BioLogic), Rack Force (Evolved Harvest), and Bird and Buck Whitetail and Gamebird mix (Star Seed). Two methods of research were conducted, (1) a food plot monitoring field study, and (2) a seed germination laboratory test. Food plots were planted in northwest (Jennings) and northeast (Manhattan) Kansas. Single season occupancy models from Program MARK were used to determine plot usage and preference of the seed mixes. Feeding patterns were analyzed from two locations targeting white-tailed deer (*Odocoileus virginianus*). Camera trap data were also analyzed for raccoon (*Procyon lotor*), wild turkey (*Melagris gallopavo*), and coyote (*Canis latrans*). During the summer 2014, the Bird and Buck mix retained the greatest amount of desirable vegetation, compared to the Rack Force and Perfect Plot mixes, which exhibited intermediate and relatively poor stand condition, respectively. White-tailed deer were documented at 100% occupancy using all (i.e., 100%) plots of all three mixes in Manhattan and Jennings, Kansas. In Manhattan, a significant increase in feeding events was observed for the months of July (45% of days) and August (50% of days) compared to the month of June (34% of days; $p < 0.02$). In contrast, deer feeding events in Jennings declined from 67% and 55% of days in June and July, respectively, to only 18% of days in August ($p < 0.001$). After initially having establishment issues among all three mixes, a laboratory study was initiated comparing the germination rates of each seed mix. Ten 1-gram random samples of each seed mix were tested in complete darkness at a constant 25-30^{o} C for 25 days. When comparing daily germination rates of the seeds in the mixes, peak germination for all mixes ($p < 0.0001$) occurred on days 5-10 and 12-14. A single expected germination rate of similar plant types (i.e. alfalfa, clover, chicory, grasses) was computed from the seed tag, and then compared to the observed proportion of total seeds sampled that germinated. Bird and Buck recorded the highest germination, 79%, only 0.5% less than the expected overall germination. Perfect Plot and Rack Force recorded germination rates of 49% and 52%, which respectively, were 7% and 11% less than was expected.

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Finally, to my family and friends, Thank-you for always being there for me, lending a listening ear, and providing words of encouragement in times of need. I am truly grateful for always having your support in all of my endeavors.

Dedication

"We abuse land because we see it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect."

—Aldo Leopold

I would like to dedicate this thesis to all outdoor enthusiasts who have a true appreciation of the living world around us. Always remember, it's not about the destination but the journey of how we get there that makes living an outdoor lifestyle so exciting. I would like to especially dedicate this to my parents, who from the time I could walk have included me in outdoor recreation activities which have made me passionate about spending time in the great outdoors. They have taught me what it means to respect the land and to have a true appreciation of the fish, wildlife, and resources that build the community of God's creation to which we belong.

With that in mind, I challenge all people to take a youngster on an outdoor adventure, away from screens and technology, so they too can form lasting memories and develop a respect for the plants, animals, and landscapes that exist today.

Chapter 1 - Introduction

Wildlife management has been around for centuries, and it is known all living things need food, water, cover, and space to sustain a healthy population. Aldo Leopold, a pioneer in conservation, stated five basic tools required for wildlife management; fire, ax, plow, gun, and cow (Leopold 1933). Today, basic habitat management techniques are often overlooked, and the average individual now views food plots as an essential part of white-tailed deer (*Odocoileus virginianus*) management. In correlation with this trend, many outdoor enterprises within the hunting industry have started formulating and selling wildlife food plot seed mixes. Companies test and evaluate their products. However, independent studies on the comparative performance and actual wildlife benefits of these seed mixes are limited.

Food plots in Kansas have been widely used by private landowners and deer managers to attract white-tailed deer to their properties. To date, little research has been conducted on seed mixes planted across the central Great Plains regarding the performance of commercialized mixes in this area, or the utilization rates and benefit these mixes provide for wildlife. The goal of this thesis research was to approach these issues and assess the establishment, wildlife use, and germination of three commercial (compositionally similar) white-tailed deer seed mixes.

Thesis Outline

This thesis is organized into four chapters. Chapter 2 is a review of the literature regarding supplemental feeding of deer in Kansas; deer needs (diet, nutrition, disease risk), and climate change. Chapters 3 and 4 present the findings from our field study and laboratory research. Chapter 3 is presented in publication format as submitted to the Journal of Wildlife Management. This chapter, the field study, analyzes a new approach using camera trap data to monitor food plot plantings. It should be known, at the initiation of our project, we had plots planted in three locations across northern Kansas. From east to west the locations were Manhattan, Osborne, and Jennings. During our study, Osborne did not receive timely rainfall and both plantings resulted in failed crops. Thus, no useable data from Osborne was available or included in this thesis. However, in Chapter 3, the results from Jennings and Manhattan were discussed. Chapter 4 is presented in publication format as submitted to Transactions of the Kansas Academy of Science. This chapter, the laboratory study, reviews the results of our seed mix germination study.

Research Objectives

Specific objectives for each portion of the research (field and laboratory studies) can be found in the introductions of each chapter. However, the five overall objectives for this research were:

1) Identify and select three seed mixes from popular wildlife companies that were advertised as drought tolerant and could be planted in semi-arid portions of central Great Plains.
2) Plant and test three mixes from different companies (containing similar plant types) across a natural precipitation gradient.
3) Observe any visual differences indicating drought stress/tolerance among the mixes.
4) Compare utilization rates of food plot mixes, by native ungulates (white-tailed deer)
5) Make recommendations for consumers about planting commercialized food plot seed mixes in Kansas

Chapter 2 - Review of the Literature

White-tailed deer (*Odocoileus virginianus*) are one of the most actively pursued game species in North America. Although once extirpated from the state, Kansas is now known as a premier state for producing quality whitetails (KDWPT Tracks 2000). Today, Kansas is 97% privately owned (USDA VPA-HIP 2011), and Aldo Leopold (1934) once said *"Conservation will ultimately boil down to rewarding the private landowner who conserves the public interest."* State programs such as the Walk In Hunting Access (WIHA), Wildlife Habitat Incentive Program (WHIP), Conservation Reserve Program (CRP), and legislation like the farm bill are key players in private lands access and management (Knoche and Lupi 2012). Incentive programs like these have led to widespread conservation efforts which positively influence White-tailed deer and other wildlife species across the United States (Cote et al. 2004, Smit et al. 2007). With increasing deer populations, hunting has become a huge revenue booster in many states and is a critical tool in managing populations (Brown et al. 2000). The economic value placed on white-tailed deer is at an all-time high and deer populations are now accessible to the general public in areas they once ceased to exist (Conover et al. 1997, Smith et al. 2010).

Across the United States, food plot plantings and deer hunting has become a billion dollar industry (Conover et al. 1997). Brown and Cooper (2006) report that less than 7% of hunters nationwide hunt trophy white-tailed deer, however, most of the economic impacts from deer-related activities are from hunters. In Kansas, an estimated 401 million dollars were spent on hunting expenditures while another 208 million was spent on non-consumptive wildlife uses. During the 2012, 2013 deer hunting season 123,195 people hunted deer and a reported 94,070 deer were harvested (KDWPT Annual Report).

Meeting rising demands from consumers, advertisers have quickly taken advantage of marketing deer management via food plot plantings (Kroll 1991, Koerth and Kroll 1998, Brown and Cooper 2006, Moorman et al. 2006), and in 2011, hunters spent ~$700 on food plot plantings across the United States (USFWS 2011). Many seed companies have formulated a “magic” combination of legume seed blends that are heavily advertised throughout the outdoor industry. The demand to plant supplemental forages for supporting wildlife populations is constantly rising, but is also a controversial topic (Cooper 1995, Russell et al 2001, Brown and Cooper 2006, Smith et al. 2010). One misconception among consumers, largely due to advertisements, is that one mix will solve all deer nutrition and forage needs for an entire year. Koerth and Kroll (1999) claim “there are no magic bullets, and there are no magic beans, there are, however, management strategies that if implemented properly can significantly improve your deer herd.” Although little is known about over the counter seed mixes that are often used for food plots, numerous other deer nutrition, selectivity, and food plot use studies have been conducted (Chapmen et al. 2008, Heiman and Fulbright 1997, Johnson et al. 1987, Kroll 1991, Ozoga and Verme 1982).

Sometimes expensive to establish (Johnson et al. 1987, Kroll 1991, McBryde 1995), many people plant food plots to affect deer movement in hopes of attracting them to a location for harvest (Smit et al. 2007, Brown and Cooper 2006). This type of plot is often called a harvest plot and is the most common type planted in Kansas. The other plot type is referred to as a supplemental food plot that is planted to produce quality forage during the summer or winter stress periods (Ozoga and Verme 1982, Kroll 1991). In Kansas private landowners and deer managers often use supplemental feedings to attract white-tailed deer to their property for complementing their hunting desires or to produce income for their outfitting businesses.

To meet all seasonal nutrient requirements of white-tailed deer, a variety of plants (forbs, grasses, shrubs, and browse) are needed throughout the year (Everitt and Gonzales 1981). Plant selection of deer diets vary by season (Hill 1942, Vangilder 1982), and deer select plants based on digestible energy and protein content (Berteaux 1998, Dostaler 2011). Strickland et al. (2005) state deer in the south require lower amounts of digestible energy than do the deer in northern latitudes, and Beier (1987) found that females consistently select a higher quality diet than males.

There are two significant environmental stress periods for white-tailed deer (hot, dry summers and long cold winters) which also vary with latitude (Strickland et al. 2005). During extreme weather events within those periods, survival can often be dependent on nutrient availability whereas supplemental feeding can be beneficial to wild deer populations (Ozoga and Verme 1982). The main dietary constituents for deer are energy content, protein, phosphorus, and calcium (Kroll 1991). In the wild one or more of the nutrients may be lacking at different times of the year, however, white-tailed deer are a very adapted species and have found ways to survive under a multitude of conditions including nutrient stress (Brown and Cooper 2006). The life stage of the deer often influences the amount of nutrients needed for growth, maintenance, and fueling life processes (Wallmo et al. 1976). Protein is commonly thought as the most limiting factor of native forages and has been studied in detail. In general, a minimum requirement of 7-8% protein is needed for body maintenance (Berteaux et al. 1998, Wallmo et al. 1976). To ensure maximum performance, a reported 16% protein is required for all deer, including; growing fawns, lactating does, and to achieve maximum antler growth for bucks (Kroll 1991, Verme and Ullrey 1972). Other major nutrients like calcium and phosphorus have been studied, however, consistent results are lacking. In general, when considering calcium and phosphorus, intake and availability of those nutrients also vary by season (Everitt and Gonzalez 1981, Brown and Cooper 2006).

A determining factor of deer disturbance via grazing is often driven by seasonal fluctuations in plant type, growth (i.e. plant life stage), and nutrient availability. It is known that in semi-arid environments deer affect the vegetative characteristics in their home range (Crider et al. 2015), and can even alter plant population composition and vigor (Russel et al. 2001). In Kansas, a leading agricultural producing state (KDA 2013), all cultivated crops can be considered accidental food plots and are a form of supplemental food for wildlife (Knoche and Lupi 2007). Consequently, overgrazing by localized deer populations can cause significant damage to crops (Conover 1997, Mortimer 2004, Knoche and Lupi 2007) and native prairies (Anderson et al. 2001). Damage to the landscape by deer in some cases is often an indicator of deer overabundance. Overabundance is a common problem in many parts of the United States and leads to species vulnerability, and negative deer/human interactions (Cote 2004).

The resulting negative deer-human interaction involving the general public is through deer/vehicle collision. It is estimated there are over 1.5 million vehicle accidents involve deer each year, which equates to a billion dollars in damages (Conover 1997). Disease spread is also an area of concern for humans. Lyme disease is the most common vector-borne illness found in the United States, and white-tailed deer play a role in distributing and maintaining tick populations (Githeko et al. 2000, Cambell and VerCauteren 2011). The Lyme disease pathogen and tick abundance is often determined by the population size of their vectors (deer). Kilpatrick et al. (2014) reported there was an increase in human contraction of Lyme disease in areas where deer populations were inflated. They also found that by decreasing deer populations tick infestation was reduced (Kilpatrick et al. 2014).

Disease spread within deer populations puts the white-tailed species at risk of large die-offs, especially in overpopulated areas (Cote et al. 2004). Chronic wasting disease (CWD), epizootic hemorrhagic disease (EHD), and the bluetongue virus are diseases known to cause widespread mortality in white-tailed deer (Cambell and VerCauteren 2011). There have been reported cases of all of these diseases in Kansas.

The first case of CWD in the state was a captive elk in 2001, since then; 74 infected white-tailed deer, and one mule deer (2011) have been reported. CWD is a transmissible spongiform encephalopathy that grows prions in infected animals affecting their neurological systems through neurodegeneration (Cambell and VerCauteren 2011). CWD is not known to affect humans. However, it is considered fatal to deer (Williams and Miller 2001). The known distribution of CWD is limited and poses a significant threat to deer herds across the United States as it is transmitted in one of two ways, (1) directly through deer-deer contact, or (2) indirectly through contact with environments (soil, grasses etc.) that have been contaminated by the excretions of infected individuals (Williams and Miller 2002, Cambell and VerCauteren 2011).

In Kansas, the most recent outbreak of EHD was in 2012, and an estimated 1,274 deer died having various impacts on localized populations, as the outbreak was described as patchy (KDWPT). EHD and bluetongue are closely related. EHD typically has seasonal outbreaks (late summer into fall) which correspond with the life cycle of the biting midges that serve as the vectors to transfer the disease between the white-tailed deer (Fischer et al. 1985). The outbreaks typically decline going into winter as the midges cannot survive in colder temperatures. Recently, climate change and rising temperatures have allowed vectors eggs, larva, and vertebrates to survive throughout the winter, consequently, increased chances of vector-borne and infectious disease epidemics are likely (Shope 1991, Githeko et al. 2000, Feria-Arroyo et al. 2014).

Increasing temperatures across North America have also caused drought conditions devastating large proportions of the U. S., with the Great Plains among the most impacted regions (Lal et al. 2012). These fluctuations in temperature and moisture have spiked the spread of disease (Githeko et al 2000), reduced the amount of native forage growth in many regions (Lashley and Harper 2012), and increased the difficulty of establishing crops and supplemental feeding plots (Hehman and Fulbright 1997, Bonner and Fulbright 1999). Extreme weather events (i.e. heavy precipitation with extended hot or cold dry periods between) are the expected climate trends in the foreseeable future (Githeko et al. 2000, Lal et al. 2012). Coupled with a growing human population, climate change poses a serious threat to wildlife species both directly and indirectly through effects on food quality, forage availability, and habitat fragmentation or destruction (Travis 2003, Delgado et al. 2011, Lashley and Harper 2012). There is now a greater recognition of the importance of fundamental principles of conservation agriculture (Lal et al. 2012). A holistic approach to climate change mitigation and adaptation includes carbon sequestration, reducing greenhouse gas emissions, improving water quality, and regulating water use (Delgado et al. 2011).

Around the world, the increasing risk of climate change has impacted agroecosystems, and wildlife populations alike. Intensive management of deer and other wildlife has become more critical to the long-term sustainability of these species (Jorge et al. 2012). Hunting in some areas is a major threat to wildlife in the form of exploitation (Bulte and Horan 2002); however, for white-tailed deer, hunting has been and will continue to be the primary mechanism of controlling populations in both rural and urban areas across the United States (Brown et al.

2000). Supplemental feeding via wildlife food plot plantings is very beneficial for managing the species and can also serve as; (1) a source to aid in the mitigation of climate change, (2) help reduce impacts of wildlife on agriculture production and (3) provide hunting opportunities and alternative sources of income to landowners and wildlife managers. Further research is needed to identify different types of food plot seed mixtures that (scientifically tested) are proven to grow in a certain geographic region and when properly planted will still have sustainable production in the presence of climate change.

Chapter 3 - Using Occupancy Models to Determine Wildlife Food Plot Preference in Kansas

Abstract

We incorporated the use of single season occupancy models from Program MARK to determine usage and preference of three commercial wildlife seed mixes: Rack Force (Evolved Harvest), Perfect Plot (BioLogic), and Bird and Buck (Star Seed) — by white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), wild turkey (*Melagris gallopavo*), and coyotes (*Canis latrans*). The mixes were tested in two locations of northwest and northeast Kansas referred to as Jennings and Manhattan, respectively. During the summer of 2014, the Bird and Buck mix retained the greatest amount of desirable vegetation, compared to the Rack Force and Perfect Plot mixes, which exhibited intermediate and relatively poor stand condition, respectively. White-tailed deer, our target species, were documented at 100% occupancy (i.e. using all plots) on all three mixes in a Manhattan and Jennings. In Manhattan, a significant increase in the number of feeding events was observed for the months of July (45% of days) and August (50% of days) compared to the month of June (34% of days; $p < 0.02$). In contrast, the number of deer feeding events in Jennings declined from 67% and 55% of days in June and July, respectively, to only 18% of days in August ($p < 0.001$). Of the other species, turkey showed higher occupancy on the Bird and Buck mix in both Manhattan and Jennings, while coyotes had lower occupancy on the Perfect Plot mix in Manhattan and Jennings. We did not find any seed mix specific trends in raccoon occupancy, however, a large geographic effect was observed and detections were primarily limited to Manhattan.

Introduction

White-tailed deer (*Odocoileus virginianus*) populations in Kansas have made a comeback since the early 1900's, primarily through extensive management (KDWP 2000).With a now viable population the economic value for deer in Kansas and across the United States has also increased (Conover 1997). Establishment and maintenance of seasonal food plots have become popular forms of habitat enhancement by land managers (Kroll 1991). In semi-arid habitats such as those found in Texas, low rainfall is a limiting factor to deer nutrition and food plot success (Kroll 1991, Bonner and Fulbright 1999). As annual precipitation in Kansas continues to decline it is probable that Kansas would experience similar issues.

Although numerous food plot studies have been conducted throughout the United States, few published reports are available for the central Great Plains. Thus, we conducted a study to evaluate the wildlife seed mixes that provide suitable feeding patterns during the summer stress period across Kansas. Through the use of remotely triggered cameras we used occupancy modeling to analyze feeding patterns and determine plot use and/or seed mix preferences for game species found in Kansas. Our target species was white-tailed deer (*Odocoileus virginianus*), and other species analyzed were raccoon (*Procyon lotor*), wild turkey (*Melagris gallopavo*), and coyotes (*Canis latrans*).

Infrared triggered cameras have been used since the 1950's (Cutler and Swann 1999). Camera technology and data collection techniques have improved tremendously since and many studies have been conducted on white-tailed deer populations (Jacobson et al. 1997, Koerth and Kroll 2000, McCoy et al. 2011). Camera trap analysis techniques have also been reviewed and critiqued (Swann et al. 2004, Foster and Harmsen 2012), or compared to other forms of data collection such as road counts (Roberts et al. 2006), aerial surveys (Koerth et al. 1997), or telemetry data analysis (Duquette et al. 2014). Our study uses demographic data differently by developing encounter histories of feeding events, not just species presence. Most evaluations of food plot value are determined by forage production and overall quality of the biomass produced by each plot mix (Higginbotham and Kroll 1991). Taking a different approach, we analyzed feeding patterns by our targeted species using occupancy models in Program MARK. The objectives of our study are to: (1) Compare advertised drought tolerant seed mixes for wildlife food plots in Central Great Plains. (2) Use occupancy modeling to compare white-tailed deer use of food plot mixes. (3) Determine if white-tailed deer preferred one mix over the others.

Study Area

The Kansas landscape is comprised of three different grasslands largely driven by a declining gradient of precipitation from east-to-west. Eastern Kansas is dominated by the mesic tallgrass prairie, while western Kansas is dominated by the xeric short-grass prairie. The region between these two grasslands ecosystems is dominated by the mixed grass prairie. Our study locations were chosen to exploit the natural rain gradient extremes for the state and we hypothesized seed mix production would decrease in the more arid regions of Kansas. The northeastern tallgrass prairie region was represented by the forestry research area of Tuttle Creek State Park near Manhattan, Kansas. The representative western short grass prairie site was on private land <15 kilometers south of Jennings, Kansas.

Weather data were obtained from existing weather stations. At Jennings, the weather station was located in Dresden, Kansas approximately 10 kilometers northwest of the planted plot location. In Manhattan, a weather station was located one mile northwest of the Tuttle Creek site. Both weather stations used a NWS COOP 8” manual gauge; data were retrieved from the National Climatic Data Center (NCDC).

The average annual precipitation (30-year normals) for the study sites as reported by NCDC were 522 mm in Dresden, and 852 mm in Manhattan. During those 30 years, the average monthly summer rainfall amounts during June, July and August in Dresden were, respectively, 76 mm, 93 mm, and 68 mm, and in Manhattan were 133 mm, 106 mm , and 102 mm, respectively. Recorded precipitation amounts for June, July, and August 2014 (the study period) were 137 mm, 45 mm, and 109 mm, respectively, for Dresden, and 221 mm, 28 mm, and 92 mm, respectively, for Manhattan. During our sampling period, Manhattan received more precipitation than Dresden (341 mm vs. 291 mm) and overall, both locations fell short of the 30-year normal averages.

Methods and Materials

Project Design

The plots at both sites were located in wooded river bottoms. A 6 x 3 completely randomized block design was used. At each location there were six food plot block replications, each food plot block contained three quarter-acre plots (~1,000 m^2), with 1-m buffers between plots, and a 3-m buffer between replications (Fig. 3.1). Prior to planting, soil samples were taken from each block to determine pH, phosphorous, nitrogen and potassium. Analyses were completed by the Kansas State University Soils Lab. A seed bed at each site was prepared through discing and plots were plated according to recommended seed rates from each tested mix. Two weeks after the plots were planted an exclosure (1-m^2) was placed in the center of each plot to provide a visual indicator of growth minus the influence of white-tailed deer. Exclosures were constructed of one 4.9 m x 1.27 m cattle panel. The two ends of the panel were fastened and the panel was then bent to form a circle. To keep small mammals out, 0.6-m tall chicken wire was zip-tied to the bottom of the exclosure. Two 2-m t-posts were driven into the ground at the middle of each plot and fastened to the cattle panel holding it stable. Each plot was monitored with two cameras (Bushnell Trophy Cam HD, 119537C), one attached to each side of the exclosure (Fig. 3.1). Photos from both of the cameras were pooled when developing the encounter histories for analysis for individual plots.

Seed Mixes

Three wildlife seed mixes were tested. Two mixes came from popular wildlife seed companies who sell their seed online and at retailer outlets across the United States: Perfect Plot from BioLogic (West Point, Mississippi) and Rack Force from Evolved Harvest (Baton Rouge, Louisiana). The third mix called Bird and Buck White-tail and Gamebird mix came from Star Seed (Osborne, Kansas). For this paper, each mix will be called by its labeled package name: Perfect Plot, Rack Force, and Bird and Buck. All three mixes contained different varieties and percentages of alfalfa, clover and chicory (Table 3.1). The Bird and Buck mix also had native grasses included. Each mix was planted according to the recommended seeding rates on the bag.

We used a John Deer Frontier CS1360 conservation seed drill (152 cm planting width) to plant the seed mixes. Food plots were planted on 12-15 June 2013, but warm season annual weeds outcompeted the seed mix growth. Horseweed (*Conyza canadensis*) and foxtail (*Alopercurus sp.*) were major weed species at both locations. Other common weeds in Jennings included redroot pigweed (*Amaranthus retroflexus*) and puncture vine (*Tribulus terrestris*), whereas those at Manhattan were shepherd’s purse (*Capsella bursa-pastoris*), hemp (*Cannabis sativa*), giant ragweed *(Ambrosia trifida)* and velvetleaf (*Abutilon therophrasti*). Due to poor plot establishment, plots were mowed with a rotary cutter and a 0.5-m mowing height was set to cut the weeds above the established seed mix plants. Two weeks before replanting, Glyphosate was applied kill any remaining weeds and seed mixes were replanted on 23-27 August 2013. After this second planting, cool season weeds including cheat grass (*Bromus tectorum*) and henbit (*Lamium amplexicaule*) were identified but were not an issue for mix establishment.

Trail Cameras

Bushnell Trophy Cam HC trail cameras (119537C, Bushnell, Overland Park KS) were used to monitor the plots. These were 8 megapixel resolution cameras with video capabilities and an adjustable Passive Infrared (PIR) sensor with a white flash for night viewing. Each camera was equipped with a 32GB SD card and Energizer Advanced lithium batteries were used to power each unit. The cameras were placed 1.1-m above the ground, as recommended by Bushnell, to be the optimum height for capturing photos of deer. Other studies used camera traps over bait piles and had 1-5 minute intervals between pictures (Jacobson et al. 1997, McCoy et al. 2011). Because we monitored food plots, cameras were set to take a picture every 30 seconds after the initial trigger.

Encounter Histories

More than 15,000 pictures were analyzed from each location, revealing a variety of game species using the food plots. Camera trap data were obtained from all plots during June, July, and August in 2014. The capture histories had a total of 90 sampling periods one for each day, and three 30-day detection/non-detection encounter histories were created (one for each month). By having a 30 second interval between pictures, we felt confident in our ability to determine whether the photographed deer was actively feeding on the plot or simply passing through. White-tailed deer encounter histories were coded as feeding events; 1 = detected; caught in act of feeding with head down, or with vegetation in mouth, 0 = not detected; not present, or not caught feeding with head down, and . = not sampled due to camera failure. All other species encounter histories and were coded 1= detected; present on plot, 2 = not detected; not present on plot, and . = not sampled due to camera failure.

Preliminary analyses on all species were completed using Program MARK, single season occupancy models with three attribute groups (one group for each seed mix). The probability of detection (*p*) models had four effects (1) a group effect of seed mix (g), (2) time-dependence only (t), (3) an interaction between the two (g*t), and (4) a constant model that pooled across groups (.). Occupancy (ψ) models had two effects; (1) a group effect of seed mix (g), and (2) a constant model (.) that pooled across groups.

A total of 8 models were included in our candidate set of models. AIC_c-based model selection was used to determine which model(s) had the best fit to the encounter history data. Parameter estimates from the top ranked model gave two estimates: 1) Occupancy (ψ) - the proportion of plots occupied by a species and 2) Encounter rates (*p*) - the probability that a species is detected on a plot. The detection/non-detection encounter histories for white-tailed deer were further analyzed and compared to the model estimations using a mixed-model approach in SAS Proc Glimmix, with blocks treated as random effects and the data distribution specified as binomial. Program MARK occupancy estimations were used to report notable trends for coyotes, turkey, and raccoon.

Results

Seed Mix Establishment

Spring green-up started in mid-March at Manhattan and early-April in Jennings. Manhattan displayed more rapid growth and rapeseed, clover, and alfalfa were observed growing by the first week of April 2014. In Jennings growth was delayed and the same amount of forage growth was not seen until the second week of May 2014, and more weedy species were visible on the plots.

The Bird and Buck mix had rapeseed and crimson clover establish early in the growing season, at peak growth, all clover species and alfalfa could be identified. The Rack Force and Perfect Plot mixes produced inconsistent stand establishment with considerable weed growth in some replications, more so at the western site than in Manhattan. Rack Force established a strong stand of alfalfa, with some yellow and white clover intermixed, while Perfect Plot produced alfalfa with white clover that grew sparsely throughout. When available moisture was sufficient, all mixes produced better established stands of forage.

By the end of August, noticeable differences in the quality and quantity of vegetation were evident between the Manhattan and Jennings locations (Fig. 3.2). Manhattan food plots remained productive throughout the summer (Fig. 3.2a), but productivity in plots at Jennings declined precipitously in August, and little planted vegetation remained while there was a concomitant increase in weedy cover (Fig. 3.2b). Discernable differences in the quality of the different seed mixes occurred by late June at the Jennings site (Fig. 3.3), the Bird and Buck mix retained the greatest amount of planted vegetation (Fig. 3.3a) compared to the Rack Force and Perfect Plot mixes, which exhibited intermediate (Fig. 3.3b) and relatively poor (Fig 3.3c) stand condition, respectively. No difference in vegetation quality was observed among seed mixes at the Manhattan location.

Image Analysis

Daily wildlife species encounters (percent of total) over 90 days were 83% white-tailed deer, 5% coyotes, 5% turkey, and 7% raccoon. Program MARK and SAS Proc Glimmix produced similar estimates of occupancy rates and feeding probabilities, confirming occupancy models can be a useful tool in determining wildlife preference and feeding trends. For the white-tailed deer data, two models had a parsimonious fit, Delta-$AIC_c < 2$ (Table 3.2). Estimates were used from the occupancy model [p(g*t), ψ(g)]. The model shows the encounter rates (p) have an interaction between seed mix (g) and time (t), while occupancy (ψ) has a seed mix effect (g).

White-tailed deer at both locations generally exhibited 100% occupancy rates on all three seed mixes. Detection of feeding events (p) varied across months at both locations (Tables 3.3, 3.4), but the pattern of use between locations was inconsistent (Fig. 3.4). In Manhattan, the SAS results showed, feeding events were significantly higher ($p < 0.02$) in July (45% of days) and August (50% of days) compared to the month of June (34% of days). In contrast, deer feeding events in Jennings declined from 67% and 55% of days in June and July, respectively, to only 18% of days in August ($p < 0.001$; Fig. 3.4).

At the more mesic Manhattan location, a seed mix effect was not evident for deer feeding events (p = 0.6289), and feeding events averaged 40% to 45% of days for all mixes (Table 3.3; Fig. 3.4). At the xeric Jennings site, however, there was moderate evidence that use by deer varied among seed mixes (p =0.062; Table 3.4). In this case, Bird and Buck mix maintained the highest number of observed feeding events (Fig. 3.2). Feeding events averaged 56% of days for the Bird and Buck mix vs. 37% of days for the Rack Force mix ($p = 0.097$). No useable camera data were recorded for the BioLogic mix during the month of August, but use for June and July averaged 52% of days vs. 70% of days for the Star Seed mix ($p = 0.044$).

In Manhattan and Jennings the model that best fit the data for coyote, turkey and raccoon was [p(g*t), ψ(g)]. Coyotes, wild turkey, and raccoons all had low probabilities of detection, averaging less than 0.10 at both locations. The low probability of detection precluded analysis of patterns with SAS, but notable occupancy trends from Program MARK are reported here.

Coyotes recorded occupancy rates of 100% on the Bird and Buck and Rack Force mixes at both locations, while lower occupancy rates occurred for the Perfect Plot mix. This was particularly true for the Jennings site, where only 69% occupancy was observed. Wild turkey displayed the highest occupancy rates on the Bird and Buck mix at both locations. At Manhattan occupancy was 83% on the Bird and Buck mix, while the Perfect Plot and Rack Force mixes had 68% occupancy. At Jennings, occupancy for turkeys was 98% on the Bird and Buck mix, 93% on the Rack Force mix, and 87% on the Perfect Plot mix (Fig 3.5). Detections of raccoons were primarily limited to the Manhattan location, where the occupancy rates were greatest for the Perfect Plot and Bird and Buck mixes (67%), but much lower on the Rack Force mix (33%).

Discussion

Limitations of previous camera trap studies included bias and other issues when determining abundance estimations and population characteristics (McCoy et al. 2011, Swann et al. 2004, Rowcliffe et al. 2008). Foster and Harmsen (2012) critically reviewed 47 published camera trap studies, to examine the use-misuse of camera trap data. The biases that they found were due to low heterogeneity in capture, lack of individual identification, low sample size, camera location/spacing, and the size of the sample area (Foster and Harmsen 2012). Many camera trap studies with deer as the target species occur over bait stations which resulted in one or more of the reported biases creating inflated or inaccurate estimates of many deer characteristics (Koerth and Kroll 2000, McCoy et al. 2011). Our analysis did not require individual recognition or estimated abundance. We sampled a small sample area (~2.5ha per location) but by using occupancy models we were able to determine if there was a seed mix preference among species. We cannot assume perfect detection but the 15 × 60 m plots, and 30-second intervals between photographs enabled us to record deer on all margins of the plot. Overall, with this monitoring design, we feel we have found a novel use of occupancy models and they can be used to determine food plot preference of a target species.

White-Tailed Deer

We knew there were well established white-tailed deer populations in Manhattan and Jennings and we were not surprised white tailed deer recorded 100% occupancy on each seed mix during June, July, and August. The high occupancy rates indicate the food plots provided enough forage to be utilized by the deer throughout June, July and August. We hypothesized that reduced rainfall and drought stress in western Kansas would result in lower food plot productivity. Visual cues were used to support this hypothesis and trail camera pictures from each site were compared. Manhattan photographs revealed lush green vegetation and the absence of dry brown vegetation through August. In contrast, photographs of plots in Jennings demonstrated some green vegetation in early August, but by the end of the month vegetation was mainly dried up clover, alfalfa, and weed species. The precipitation gradient among our study sites likely caused the vegetative differences which indicate a drought effect on the mixes.

This hypothesis is also supported by the differential grazing trends observed across locations from our occupancy model estimates. In Manhattan, abundant forage from the mixes was available for the deer to feed upon throughout the sampling period. Thus, all three mixes show an increase of feeding events as the summer progressed. In contrast, at Jennings, we saw a decrease in feeding events among all three mixes during the sampling period. Drought conditions in Jennings likely reduced seed mix production during the latter portions of summer. Consequently, during July and August the deer spent less time feeding on the plots and were forced to search for other sources of food. These results are consistent with those reported by

Feather and Fulbright (1995) in southern Texas when they observed that warm season forages did not persist through August.

In general, when the mixes were established and productive we found the deer used all mixes. However, the best established plots recorded the highest feeding activity throughout the summer. For example, in Jennings (where a mix effect was observed), we observed an increase in the number of feeding events for the Bird and Buck seed mix which retained the greatest amount of desired vegetation during the summer months.

Other Species

Turkey

Similar trends among seed mixes were observed for turkey occupancy rates. This game species had a higher occupancy on the Bird and Buck mix in both locations, suggesting this mix was preferred over the Perfect Plot and Rack Force mixes. The composition of the Bird and Buck mix includes a variety of native grasses, which provide a food source different from the other mixes, and may be a better fit for this bird species.

Coyote

Coyotes trended towards lower occupancy at both locations on the Perfect Plot mix. This trend suggests that prey animals that the coyotes actively pursue are using the plots differently. Pursuit of the prey, therefore, may have caused them to be observed more often on the Bird and Buck and Rack Force mixes. For example, we recovered multiple pictures with rabbits in a coyote’s mouth. Live rabbits were not detectable due to the vegetation height, but we conclude that rabbits may have been using the Buck and Rack Force plots more than those planted with the Perfect Plot mix.

Raccoon

Analysis of raccoon occupancy rates did not reveal any seed mix specific trends; however, a large geographic effect was observed. On all plots there were only 12 detections over the 90-day sampling period in Jennings vs. 145 detections in Manhattan. It is likely that raccoons were not using a specific resource from our food plots but mostly using the plots for pursuit of prey or movement as a travel corridor.

All of the other species claims will require further investigation, and a different plot monitoring technique will be needed to confirm their validity. Considering the white-tailed deer analysis, we hope to run similar analysis on new datasets in the future to determine if we can find similar trends, or if seasonal trend can be observed across the geographic differences from east to western Kansas. The design of this project and the resulting camera data library facilitate the diverse use of occupancy models. To achieve the objectives of our study, we chose to code the encounter histories for our target species (white-tailed deer) as feeding events. Moving forward with this technique, we hope to incorporate individual covariates such as geographic coordinates, daily precipitation, temperatures, and distance to significant resources such as roads, cover, or water. We also further plan to utilize the multi-state models Program MARK offers to look at buck-doe-fawn ratios and or day/night feeding activity. By examining these various aspects and developing new encounter histories we feel confident that occupancy models from Program MARK will enhance our ability to determine not only preference but also come to robust conclusions about wildlife behavior on food plots.

This paper makes conclusions about drought effects on and use of food plot mixes in the absence of forage sample data. Although forage samples were not collected the camera traps enabled us to compare pictures from each location over time, and we are confident in making these conclusions because of the observed correspondence between visual assessment of plot quality and statistical comparisons of feeding behavior. Further investigation is needed, but based on this initial analysis, we are optimistic about using occupancy models as tools to gain insight on determining food plot success from the wildlife's point of view.

Management Implications

Weeds in both locations competed for water during both plantings, and grew taller at some point in the summer than established seed mix plant species, thus effectively also outcompeting planted species for light. Once the weeds began creating a canopy over the mix, mowing the plots was the best management tool. The goal of mowing was to expose the established mix under the weeds without causing considerable disturbance of the established seed mix plants. This technique worked very well and the established plants were able to persist and grow later into the summer without weed competition. When planting food plots in the central Great Plains we recommend (1) Talking to local NRCS or Extension offices before planting to determine what plants are best suited for your area; (2) Having a weed management plan ready to implement; and (3) Purchasing the seed from a nearby seed dealer and not from retailers. We found the seed mix to be the most cost effective as well as the most efficient mix in the field.

Acknowledgements

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Service offices, and the landowners. A special thanks to B. K. Sandercock for the guidance in using Program MARK, from the data entry to analysis. Most of all we extend a huge thanks to all the Landowners for providing access to their land, time, lending us their equipment and sharing their expertise for this project.

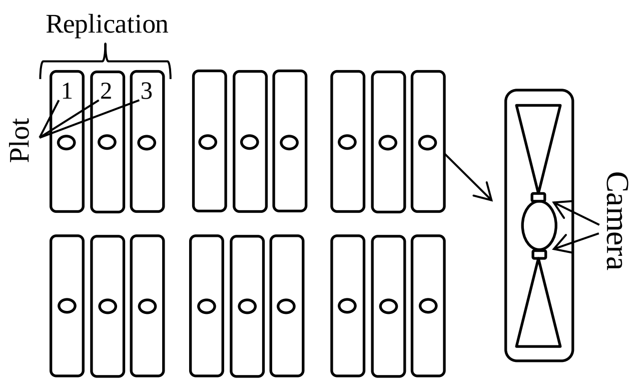

Figure 3.1: Illustration of the randomized complete block design used at each location. Each seed mix was planted in six replicated 15 × 60 m plots. A ~1m^2 circle exclosure was placed at the center of each plot. Two trail cameras were used to monitor each plot and were attached to opposite sides of the exclosure.

Figure 3.2 Vegetation differences in at the end of the summer, 27August, 2014. Manhattan (A) had very lush green vegetation at the end of the summer, which persisted through fall and into winter. Jennings (B) showed signs of drought, with very little green vegetation from the mixes remaining. Plots consisted mainly of dried up brown vegetation and weeds.

Figure 3.3: Representative examples of the amount of growth from each seed mix in Jennings Kansas at the end of June 2014. (A) Star Seed plots exhibited the most growth of the three seed mixes. Alfalfa, along with multiple varieties of clover, can be seen flowering throughout the plot. (B) Evolved Harvest plots displayed acceptable growth, with a few more weeds (marestail) present. Alfalfa and yellow/white clover can be seen flowing throughout the plot. (C) BioLogic plots displayed the least amount of growth. Weeds predominate and, although some alfalfa is flowering throughout the plot, very few clovers can be seen.

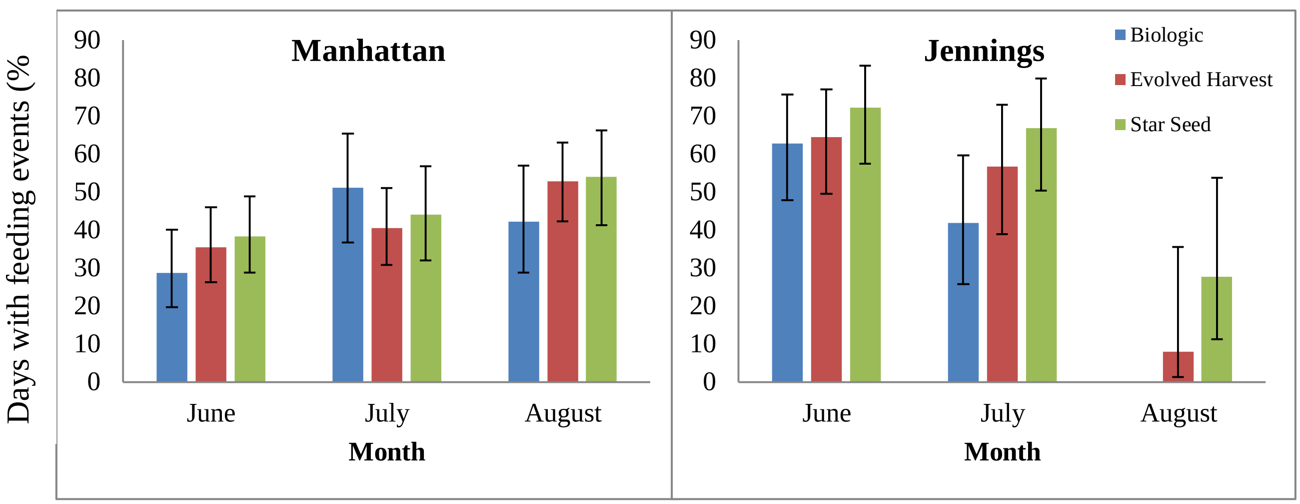

Figure 3.4: Probability of June through August feeding events by white-tailed deer for three seed mixes at Manhattan and Jennings, Kansas. Bars represent confidence intervals.

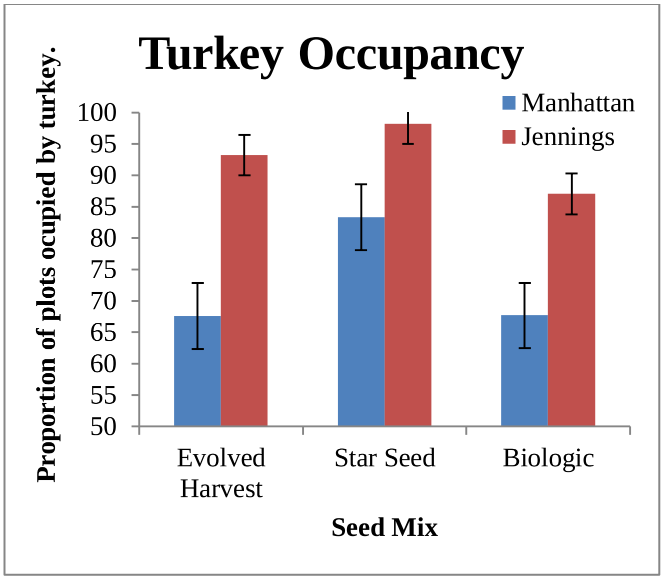

Figure 3.5: Summer (June through August) occupancy rates (± standard error) of wild turkey for three seed mixes at Manhattan and Jennings, Kansas. Turkey recorded the highest occupancy rates on the Star Seed mix at both locations during the 90 day monitoring period.

BioLogic: Perfect Plot	
Seed Type	**% Composition**
Clover: Ivory White, Border Balansa, Balady Berseem, Temuka White, Waimak White, Cardinal Red	46.40%
Rapeseed (Bio Magic and Mairaki)	9.93%
WF 100 Chicory	5.03%
Windham Winter Pea	4.06%
Baralfa 53HR Alfalfa	4.01
Inert matter	29.49%
Other crop seed/Weed seed	0.18%
Evolved Harvest: Rack Force	
Seed Type	**% Composition**
Baralfa 53HR Alfalfa	26.02%
Clover (Kotare White, Medium Red, Madrid Yellow)	24.88%
Forage Feast Chicory	4.85%
Inert Matter	0.60%
Other crop seed/Weed seed	0.05%
Coating Material Inoculant	43%
Star Seed: Whitetail and Gamebird Mix	
Seed Type	**% Composition**
Clover- (Alsike, Arroleaf, Berseem, Crimson, Ladino Red)	51%
Alfalfa	15%
Rapeseed	15%
Grasses (Partridge Pea, Switchgrass, Annual Ryegrass, Timothy, Kentucky Bluegrass)	13%
Inert matter	1.10%
Other Crop Seed/ Weed Seed	0.4%

Table 3.1 A list of the seed mix plant variety and percent seed that make up each of the three selected seed mixes.

Model	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par	Deviance
[p(g*t) Psi(.)]	523.4944	0	0.52719	1	91	503.2614
[p(g*t) Psi(g)]	523.7121	0.2177	0.47281	0.8969	93	503.2614
[p(t) Psi(.)]	553.7636	30.2692	0	0	31	568.9746
[p(t) Psi(g)]	559.2279	35.7335	0	0	33	568.9746
[p(.) Psi(.)]	693.6133	170.1189	0	0	2	624.3099
[p(g) Psi(.)]	695.7206	172.2262	0	0	4	620.1404
[p(.) Psi(g)]	699.8902	176.3958	0	0	4	624.3099
[p(g) Psi(g)]	704.2801	180.7857	0	0	6	620.1404

Table 3.2: Candidate set of occupancy models from Program MARK for the white-tailed deer encounter histories. Seed mixes were the groups (g), and AIC_c model selection was used. Models with Delta AICc < 2 were considered to have a parsimonious fit to the data, and estimates were taken from [p(g*t) Psi(g)].

Fixed Effect	DF	F Value	Pr > F
Mix	2, 29	0.47	0.6289
Month	2, 29	6.74	0.0040
Mix × Month	4, 29	1.11	0.3723

Random Effect	Estimate	Standard Error
Block	0.0250	0.0379
Block × Mix	0.0847	0.3455
Residual	1.6247	0.4807

Table 3.3: Generalized linear mixed model analysis of deer feeding events at Manhattan, KS during summer 2014.

Fixed Effect	DF	F Value	Pr > F
Mix	2, 22	3.16	0.0621
Month	2, 22	12.12	0.0003
Mix × Month	4, 22	0.77	0.5233

Random Effect	Estimate	Standard Error
Block	0.0217	0.1038
Block × Mix	0.6292	1.0054
Residual	2.8422	1.0753

Table 3.4: Generalized linear mixed model analysis of deer feeding events at Jennings, KS during summer 2014.

Chapter 4 - Wildlife Food Plot Seed Mix Germination

Abstract

Germination of forage legumes are affected by a number of different environmental factors which impacts the establishment of food plots for wildlife. Pertinent to this issue, we tested the germination rate of three popular wildlife seed mix blends; Perfect Plot (BioLogic), Rack Force (Evolved Harvest), and Bird and Buck, Whitetail and Gamebird mix (Star Seed). Ten 1-gram random samples of each mix were tested in complete darkness for 25 days at 25^{o} C. Germinated seeds were identified by species, removed from the petri-dishes, and counted individually every 24 hours. Similar plant types (alfalfa, clover, chicory, grasses) from the seed tags were combined, and a single expected germination rate per seed type was computed. This single expected germination rate was then compared to the observed proportions of total seeds sampled that germinated. Seeds of the Bird and Buck mix had the highest germination, 79%, only 0.6% lower than the expected overall germination. Perfect Plot and Rack Force seeds exhibited germination rates of 49% and 52%, which respectively, were 8% and 11% lower than what was expected. For the Bird and Buck mix, grass seeds had 7% more germination than expected. While, rape seeds showed 6% less germination than was expected ($p < 0.0001$). Clover and rape seeds in the Perfect Plot mix had, respectively, 18% and 9% lower germination than expected ($p < 0.0001$). For the Rack Force mix, respectively, clover and alfalfa seeds showed 16% and 17% lower germination than expected ($p <0.0001$).

Keywords: alfalfa, clover, chicory, food plot, germination, Kansas, legumes, *Odocoileus virginianus*, white-tailed deer, wildlife, seed mix

Introduction

White-tailed deer (*Odocoileus virginianus*) management involves two primary strategies. (1) Extensive management, in which populations are managed within the limitations of the habitat; and (2) Intensive management, in which both the population and the habitat are manipulated to increase wildlife productivity (Koerth and Kroll 1998). In most cases, the goal of intensive management is to increase the quality of the deer herd through enhancing the habitat quality. Land managers do this by managing plant quantity and quality to meet nutrient and forage intake requirements of localized deer populations (Wallmo et al. 1977). Supplemental feeding via food plots has become a wildly popular way of meeting these needs. To meet these needs, many commercial seed mixes typically include a combination of legumes. The logic behind such mixes is that the presense of a variety of species will increase the probability of plot success (Koerth and Kroll 1998) and also meet the seasonal palatability, nutritional, and forage yield requirements of deer with one planting (Chapman et al. 2009).

Forage legumes are planted across the United States and are known for their association with soil bacteria that convert atmospheric nitrogen to usable forms, while still being able to produce high quality forage (Evers 1980, Brar et al. 1991, Carlsson and Huss-Danell 2003). Further, forage legumes provide high quality food for ruminant animals (Broderick 1995). Thus, legume plantings are used to enhance livestock production (Brar et al. 1991), improve wildlife management (Chapman et al. 2009), and for erosion control, which subsequentally have a positive effect on wildife (Evers 2011). Although widely used, successful establishment of forage legumes is often a problem (Butler et al. 2014). One way to combat issues in establishment of food plots is through seed inoculation. Seed inoculation is commonly used as a form of insurance against failed establishment of legume crops (Deaker 2004). Rhizobium is a soil bacterium that fixes nitrogen and rhizobia strains are applied to seed during inoculation. The rhizobia forms a symbiotic relationship with the roots of legumes which encourage nodulation, aid in legume establishment, and help the plants fix nitrogen after emergence (Evers 2011). Temperature affects the rate of germination and percent germination of most seeds (Roberts 1987, Watt and Bloomberg 2012). Numerous studies have reported temperature ranges that demonstrate high levels of germation for each variety (Young et al. 1970, Townsend and McGinnies 1972, Evers 1980, Roberts 1987, Brar et al. 1991, Butler et al. 2014). By using inoculation and planting during proper conditions, healthy legume stands can be established in food plots during late fall and early spring that produce high quality forage for wildlife (Young, et al. 1970, Chapman et al. 2009).

With the widespread popularity for planting wildlife food plots, seed companies have promoted their company seed mixes through advertising on television, in magazines, and through sponsorships (Kroll 1991, Moorman, et al. 2006). When reviewing the literature on advertised "scientifically tested" seed mixes from seed companies, no published research results are available. Interestingly, companies were not willing to donate seed for this project but claimed all research testing of their mixes was conducted independently. Our original research was directed at the use of three types of food plots, which were established by using three different advertised seed mixes. Because we had difficulty establishing food plots from these three mixes across northern Kansas we hypothesized that germination may have played a role in establishment. From this, we designed a germination test focused on three primary objectives; 1) to compare germination for several seed types in each of the seed mixes, 2) analyze temproal patterns of germination for these same seeds and mixes, 3) provide recommendations based on observed and expected patterns of germination. Expected germination was based on the information proviced on the seed tags of these mixes.

Methods and Materials

Project Design

Seven days prior to the beginning of the experiment a Fisher Isotemp Incubator (Series 200, Model 230G) was calibrated to sustain a steady temperature of 25^{o} C. Thirty 1-gram samples of seed were used, and ten petri dish (100mm x 15mm FisherBrand) replications for each seed mix were labeled. Perfect Plot (BioLogic) petri-dishes were labeled B-(1-10), Rack Force (Evolved Harvest) dishes were labeled E-(1-10), and Bird and Buck (Star Seed) dishes were labeled S-(1-10). A 90mm Whatman ashless circle filter paper was placed on the bottom of each labeled petri dish. Once all the petri-dishes were labeled they were set aside until the temperature of the oven held a constant temperature (25^{o} C) for three consecutive days, and then the seeds were weighed. A five-gram measuring spoon, which ensured all various seed sizes could be equally represented, was used to take each random sample. The scooped sample was slowly poured into a tared weigh boat on a scale (Mettler AE200). Once a reading of 1.000 gram was observed, the door of the scale was shut, and a final measurement was recorded for each plate. Each weighed sample was then placed on the filter paper of the samples corresponding petri-dish. This weighing process was repeated until ten replications for each seed mix had a recorded weight. After all samples were weighed, distilled water in a 500 ml wash bottle was used to apply 1-ml of water to the filter paper in each dish. All 30 replications were placed in the incubator and were tested in continuous darkness. For the duration of the test, 1-ml of water was applied every 36 hours to keep the filter paper moist. The germinated seeds from each plate were removed, counted individually, and recorded by species. Seed Germination was defined as radicle emergence and counts occurred once every 24 hours for 25 days.

Seed Mixes and Inoculant Types

The three selected seed mixes for this study all consisted of alfalfa, clover, and chicory varieties. The full name of the first mix is Bird and Buck White-tail and Gamebird mix. This paper will refer to this mix as Bird and Buck, it was packaged by Star Seed (Osborne, Kansas; Table 4.3). The Perfect Plot mix was from BioLogic (West Point, Mississippi; Table 4.1), and Rack Force mix was from Evolved Harvest (Baton Rouge, Louisiana; Table 4.2).

Different inoculants and processes to inoculate were used for each mix. The Bird and Buck mix applied a PRE-VAIL legume inoculant, which contains rhizobium and micronutrients for nitrogen fixation. PRE-VAIL is designed to improve early seedling vigor through increased root development and excellent nodulation. The Perfect Plot mix used Nitro-Coat Advantage and had multi-strain rhizobia for alfalfas and clovers applied to each seed variety to reach maximum nodulation, stand establishment and yield potential. The Rack Force mix was inoculated with Barenbrug Yellow Jacket enhanced seed coating. Yellow Jacket uses Zeba's water absorption technology (600x its weight in water) and is designed to help the seed utilize available moisture as needed for germination and establishment.

Statistical Analysis

Due to the nature of the seed coating/ inoculant on the Perfect Plot and Rack Force mixes, ungerminated seed could not be identified by species. However, if a seed germinated, the seed coating was knocked off and the seedling was identified by plant type (i.e. alfalfa, clover, chicory, grass). All analyses of germination rates were conducted using SAS Proc Mixed (SAS

Institute Inc., Cary, NC). In the first analysis, the number of total seed per 1-gram sample and percent germination of the total sample were compared among mixes. Seed mix was treated as a fixed effect, with no random effects specified for this analysis (i.e. the residual error was the only random effect). The second analysis compared daily percent germination of each plant type represented in each mix. A total daily percent germination of each seed type per sample was recorded, and the cumulative total germination for each plant type within mix was analyzed. Day was analyzed as a repeated measure within each plate and plant type. The final analysis compared observed germination rates to expected germination rates across plant types. For example, the reported composition of all varieties of clover included in the mix were multiplied by their expected germination rates (based on seed tags) and added together to obtain the expected final composition of clover following germination. The difference between the observed and expected proportion (relative to the total number of seed per sample) for each plant type at the end of the experiment was compared for each mix separately, with plate treated as a random effect. Significance for all tests was accepted at $p \leq 0.05$.

Results

The average number of seeds per one gram sample was significantly different for each mix ($p < 0.0001$; Fig.4.1a). Perfect Plot had the highest number of seeds per gram (582), followed by Bird and Buck (450), and then Rack Force (377). The Bird and Buck recorded the highest germination per sample at 79%, which was 30% and 28% higher germination than the Perfect Plot and Rack Force mixes, respectively ($p < 0.001$). There was no evidence of a difference between the Perfect Plot and Rack Force mixes ($p = 0.3861$; Fig. 4.1b).

When analyzing Bird and Buck's the daily percent germination, significant germination occurred on days 5-10 ($p < 0.0001$) and also days 12-14 ($p \leq 0.0106$). Mix specific plant types had statistically significant germination on various days throughout the study. Clover seeds in Bird and Buck showed evidence of germination on days 5-10 ($p < 0.0001$) and days 12-14 ($p \leq 0.0010$). Alfalfa and grass seed germinated on days 6-10 ($p \leq 0.0215$), rape seeds germinated on day 6 and 7 ($p < 0.0001$), and millet germinated on day 6 ($p = 0.0116$). The Bird and Buck mix had a total germination of 79%, and when analyzing the cumulative total germination for each plant type, we observed 40% of the germinated seeds were of the clover variety. Alfalfa and grass seeds, respectively, accounted for14% and 18% of the germination while the remaining 8% of germinated seeds were 6% rape and 2% millet (Fig. 4.2a)

Comparing Perfect Plot's daily percent germination, significant germination occurred on days 5-8 ($p < 0.0001$), day 10 ($p < 0.0001$), and days 12-14 ($p \leq 0.0005$). Clover seeds in the Perfect Plot mix had significant germination, on days 5-14 ($p \leq 0.0199$), rape seeds germinated on days 5 and 6 ($p \leq 0.0002$), and chicory seeds recorded higher germination on day 6 ($p < 0.0001$). Alfalfa seeds in the Perfect Plot had low germination and no day(s) recorded significant germination. We observed a total of 49% germination in the Perfect Plot mix, and when analyzing the cumulative total germination for each plant type within the mix we found the majority of the germinated seeds, 39%, were of the clover variety. Alfalfa, rapeseed, and chicory seeds accounted for the remaining 10% of germinated seeds recording, respectively, 2%, 3%, and 4% germination (Fig. 4.2b).

Considering the daily percent germination for the Rack Force mix, we found significant germination to occur on days 6-10 ($p \leq 0.0360$), and days 12-14 ($p < 0.0001$). Clover seeds germinated on days 6-10 ($p \leq 0.0207$), and 12-14 ($p < 0.0001$), while alfalfa and chicory seeds germinated on days 6-8 ($p < 0.0001$). The Rack Force seeds had a total germination of 52%, and when analyzing the cumulative germination, alfalfa and clover seeds accounted for an equal 22%

each, and chicory seeds accounted for the remaining 8% of the germination in the Rack Force mix (Fig. 4.2c).

A separate analysis was carried out for each mix to compare the observed germination rates (across plant types) vs. the germination rates expected from the seed tags. For the Bird and Buck mix, grass and alfalfa seeds had proportions of germinated seeds above what was expected while rapeseed, millet, and clover seeds had proportions of germinated seeds below what was expected (Fig. 4.3a.). Rapeseed and grass were statistically different and 6% less rape seeds germinated than expected ($p < 0.0001$). In contrast, 7% more grass seeds germinated than expected ($p < 0.0001$). The Perfect Plot mix had proportions of germinated seeds lower than expected for all four plant types (Fig. 4.3b). Clover and rape seeds had, respectably, an 18% and 9% lower composition than expected following germination ($p < 0.0001$). The proportion of chicory and alfalfa seeds that germinated were only 2% and 3% less than was expected, respectively ($p \leq 0.293$). In the Rack Force mix, chicory seeds germinated at the expected rate. However, respectively, 16% and 17% less clover and alfalfa seeds germinated than was expected ($p < 0.001$; Fig. 4.3c).

After pooling the proportion of seeds that germinated (different from anticipated) for all seed types included in each mix, the Bird and Buck seed performed at the expected rate and was only -0.6% different than the overall germination on the seed tag. However, respectively, the Perfect Plot and Rack Force mixes exhibited -8% and -11% less germination than was expected according to their seed tags.

Discussion

Evers (1980) concludes a first step in successful legume establishment is through good seed germination. It is known that temperature affects cool season legume germination (Watt and

Bloomberg 2012). The optimum temperature for cool season legume germination varies among species. The temperature range reported by Evers (1980) and Butler et al. (2014) was 15-25^{o} C, while Brar (1991) reported 10-25^{o} C, however, all three authors determined that in general 20^{o} C inhibits maximum germination for most species. In hopes to match climate conditions of northern Kansas at the time of planting, we used 25^{o} C for our test.

Young et al. (1970) reports there are two major times maximum legume germination occurs. The first occurs in fall when temperatures begin to cool and fall rains allow moisture requirements to be met. The second time occurs in the spring when moisture conditions are ideal, but temperatures are typically low, especially at night, and show lower germination rates than fall plantings (Young 1970). During our field study, it took two plantings to get a successful establishment. The first planting occurred in late spring and as Brar (1970) reported, high temperatures and weed infestations reduced our stand establishment. We found fall planting to be the most advantageous for all the mixes, consistent with Young et al. (1970) and Butler (2014). Evers (1980) reported crimson clover was the fastest to germinate, and other studies (Brar et al. 1991, Butler et al. 2014) found crimson clover, red clover, and alfalfa were best adapted to germinate in all temperature ranges. In contrast, arrow leaf and other varieties (not included in our tested seed mixes) were slower to germinate and had poor germination at higher temperatures (Evers 1980, Brar et al. 1991, Butler et al. 2014). The seed mix coatings didn't allow us to identify ungerminated seeds for the Perfect Plot and Rack Force mixes, so our germination test cannot confirm species-specific findings. Notably, however, we did notice crimson clover to be the first clover species to grow in our field plots. Also consistent with previous findings we observed alfalfa and white clovers grew longer into the summer than other species (Evers 2011). In our germination study, the Bird and Buck and especially in the Perfect

Plot mix, we observed two noticeable spikes in clover germination on different days. Consistent with the claims discussed, the different spikes in germination that we observed were likely caused by having multiple varieties of clover seed in the mixes. For example, the species that produced early peaks in germination were likely crimson clover or a clover species with similar germination characteristics to crimson clover. The second spike was then caused by slower germinating species.

When working with such a diverse seed size in these mixes, we knew it might be difficult to represent equally all seed types for the mix. When considering germination over time (running total), and comparing results to the percent composition of each mix we claim our random samples were in fact representative of each product. For example, the Bird and Buck and Perfect Plot mixes were ~50% clover, and we observed the majority of the seeds that germinated within our Bird and Buck, and Perfect Plot samples were clover seeds. As for the Rack Force mix, it contained an equal representation of alfalfa and clover (~25% each), and we observed equal germination from the alfalfa and clover seeds in our samples.

When considering overall seed mix germination, Bird and Buck, showed significantly higher germination than the other two mixes, and also, represented the germination rates that were expected according to the seed tag. Perfect Plot and Rack Force reported overall seed mix germination lower than what was expected. These results correlate with the establishment we saw on the plots during our field study and we conclude, like Evers (1980), seed germination can affect successful legume establishment.

Evers (2011) states, the process of how inoculants are applied to the seed, and then how pre-inoculated seed is stored until planting can often have an effect on germination. This may be one explanation for the lower germination rates in the Perfect Plot and Rack Force mixes. All three mixes were inoculated; however, the Bird and Buck mix didn't have any visible seed coating surrounding individual seeds. The Perfect Plot mix had a hard bluish/gray seed coating, and Rack Force had a thick yellow seed coat. A factor affecting the germination of the Perfect Plot and Rack Force mixes may have been the time seeds were spent being shipped to retailers for sale, and also the conditions at which the seeds were stored in the stores before purchase. One or a combination of both factors may have led to reduced germination, thus, should be taken into consideration when purchasing seed for food plot plantings.

Recommendations

We recommend extensive research be conducted prior to choosing and purchasing wildlife food plot seed. Take soil samples of potential plot sites to determine what seed varieties will perform best for those areas. Choose a planting date that fits the climate where the plots will be planted, and be sure to match the temperature and moisture requirements for the seed types being planted. Also, read the seed tags of prior to purchasing a mix. We did not find any surprising components in the Bird and Buck mix, however, when reviewing the Perfect Plot seed tag we found 29.5% of the mix is inert matter. Similarly, for the Rack Force mix, 43% of what is included in the mix composition is seed coating material/inoculant. When comparing prices of the mixes we tested, Bird and Buck was half the cost. A one-acre bag of the Bird and Buck mix cost $33. For the Perfect Plot or Rack Force mixes, depending where the seed is purchased, it will cost $60-70 for a one-acre bag. All things considered, we recommend purchasing seed from a nearby seed dealer, and not from a retailer.

Acknowledgements

This project was funded by the Wildlife Outdoor Enterprise Management program through the Kansas State University Horticulture Department. The authors would like to thank Dr. Walter Fink for the use of his lab and equipment to initiate the germination test, and also, Dr. Kevin Donnelly and Bryson Haverkamp for assisting with seed identification. Most of all we extend a huge thanks to everyone not mentioned who donated time and expertise in making this project a success.

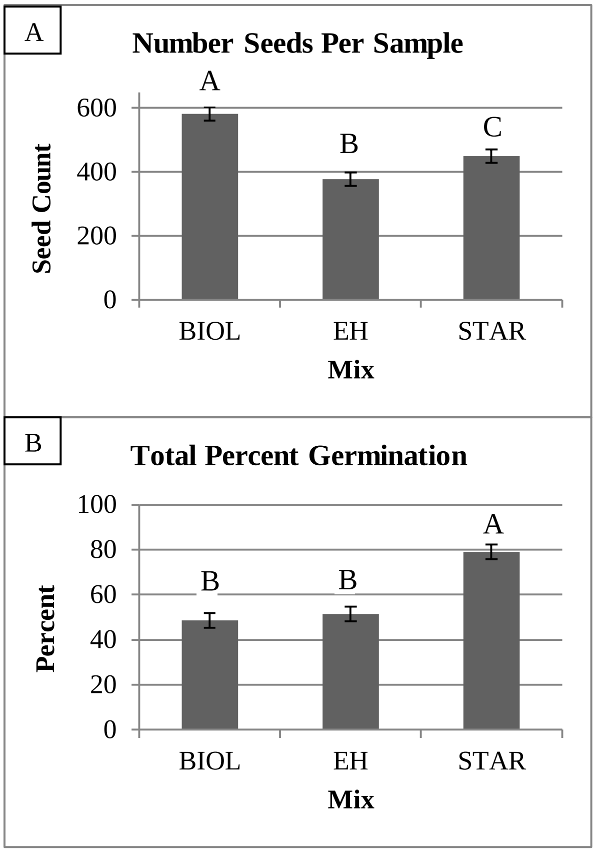

Figure 4.1: Seed mix germination test results comparing three seed mixes; Perfect Plot (BIOL), Rack Force (EH), and Bird and Buck (STAR). The mixes tested ten 1-g replications in completed darkness at 25 C for 25 days.
A. Average total number of seed per 1-g sample for each mix, ± standard error (20.9321). Perfect Plot (BIOL, 582 seeds), Rack Force (EH, 377 seeds), and Bird and Buck (STAR, 450 seeds).
B. Total observed percent germination of each seed mix ± standard error (3.3294). Perfect Plot (BIOL, 49%), Rack Force (EH, 52%), and Bird and Buck (STAR, 79%).

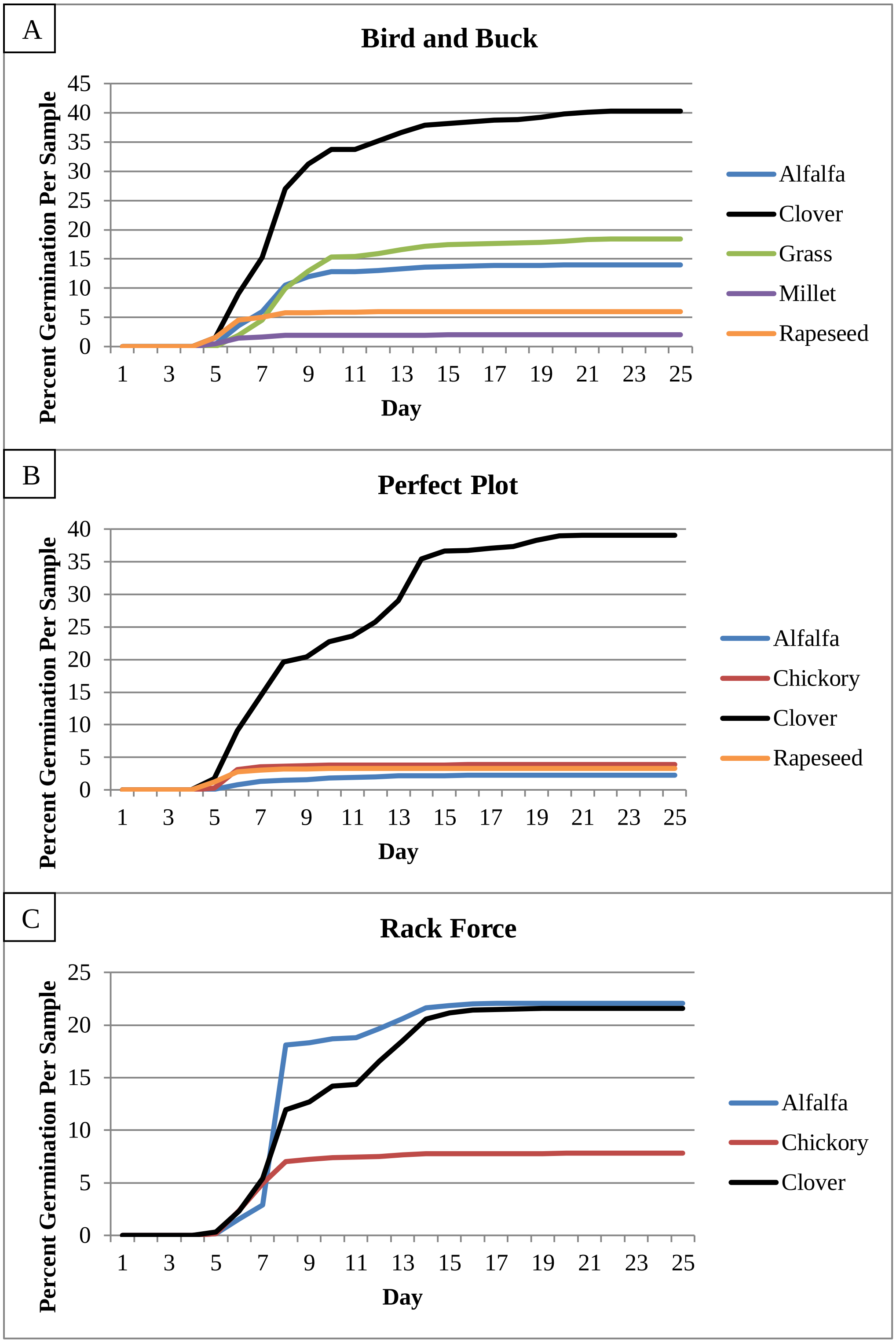

Figure 4.2: Cumulative daily percent germination (25-days) for all plant types included in each mix.
A. Star Seed, Bird and buck mix (0-45%)
B. BioLogic, Perfect Plot mix (0-40%).
C. Evolved Harvest, Rack Force mix (0-25%).

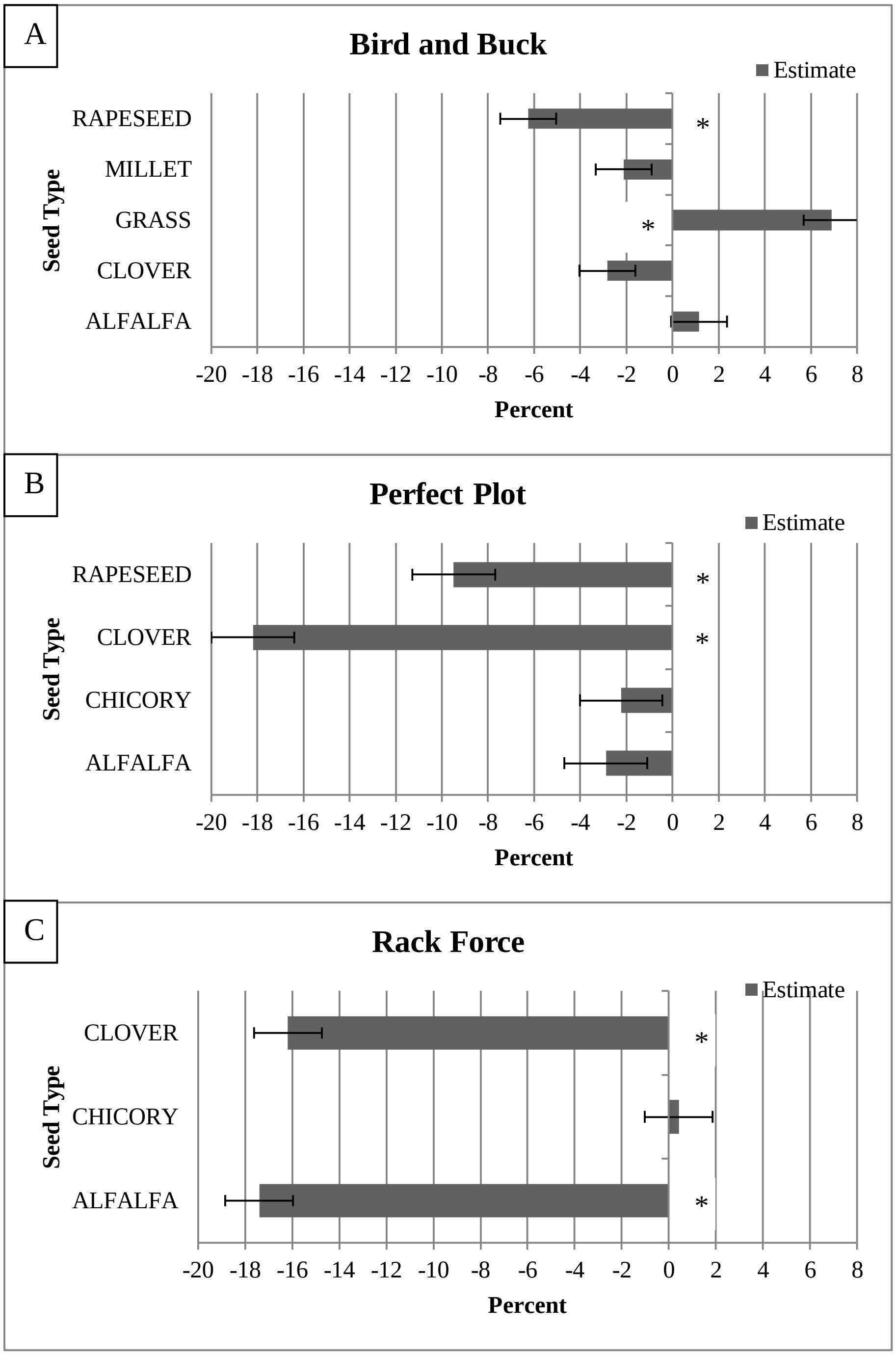

Figure 4.3: The percent (-20% to 9%) different from expected proportion of total seeds tested that germinated per plant type in each seed mix.
A. Bird and Buck, Star Seed mix ± standard error (1.2117).
B. Perfect Plot, BioLogic mix ± standard error (1.7884).
C. Rack Force, Evolved Harvest mix ± standard error (1.4434).

Star Seed- Bird & Buck Whitetail & Gamebird Mix: Lot #NC225		
Seed Type	**Pure Seed**	**Germination**
Alfalfa	15%	80%
Rapeseed	15%	80%
Proso Millet	5%	80%
Clover	51%	80%
Grasses	13%	80%
Inert Matter	1.10%	
Other Crop Seed	0.30%	
Weed Seed	0.10%	
Dormant Seed= 5%		
Origin: USA & Canada		

Table 4.1: Star Seed, White tail and Gamebird seed mix composition and germination rates of the plant types included in the mix. Clover and Grasses did not list specific species percentage, just the species included in the mix. Clover species were; Alsike, Arrowleaf, Berseem, Crimson, Ladino Red. Grass species included were; Switchgrass, Annual Ryegrass, Timothy, Kentucky Bluegrass.

BioLogic- Perfect Plot: Lot #L73-12-M1330					
Seed Type	**Pure Seed**	**Germination %**	**Hard Seed**	**Total Germ**	**Origin**
Ivory II White Clover	11.77%	82	3%	85%	Oregon
Border Balansa Clover	11.33%	85	0%	85%	Australia
Balady Berseem Clover	9.85%	85	0%	85%	Egypt
Temuka White Clover	6.55%	69	3%	72%	New Zealand
WF 100 Chicory	5.03 %	80	0%	80%	Oregon
BioMagic Rape	4.97 %	85	0%	85%	New Zealand
Mairaki Rape	4.96%	85	0%	85%	New Zealand
Windham Winter Pea	4.06%	85	0%	85%	Washington
Wiamak White Clover	4.71%	80	5%	85%	New Zealand
Baralfa 53HR Alfalfa	4.01%	85	0%	85%	Washington
Cardinal Red Clover	2.19%	85	0%	85%	Oregon
Other Crop Seed	0.09%				
Inert Matter	29.49%				
Weed Seed	0.09%				

Table 4.2: BioLogic, Perfect Plot seed mix composition, expected germination rates, and origins of the seeds included in the mix.

Evolved Harvest- Rack Force: Lot #60746				
Seed Type	**Pure Seed**	**Germination**	**Hard Seed**	**Origin**
Baralfa 53HR Alflafa	26.02%	85%		Washington
Kotare White Clover	12.47%	85%	1%	New Zealand
Medium Red Clover	7.46%	85%	4%	Oregon
Madrid Yellow Clover	4.95%	85%	5%	Oregon
Forage Feast Chicory	4.85%	85%		Oregon
Other Crop Seed	0.04%			
Inert Matter	0.60%			
Weed Seed	0.01%			
Coating Material Inoculant	43.00%			

Table 4.3: Evolved Harvest, Rack Force seed mix composition and expected germination rates, and origin of each species in the mix.

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Appendix A - Chapter 3 Appendix

Weather Data

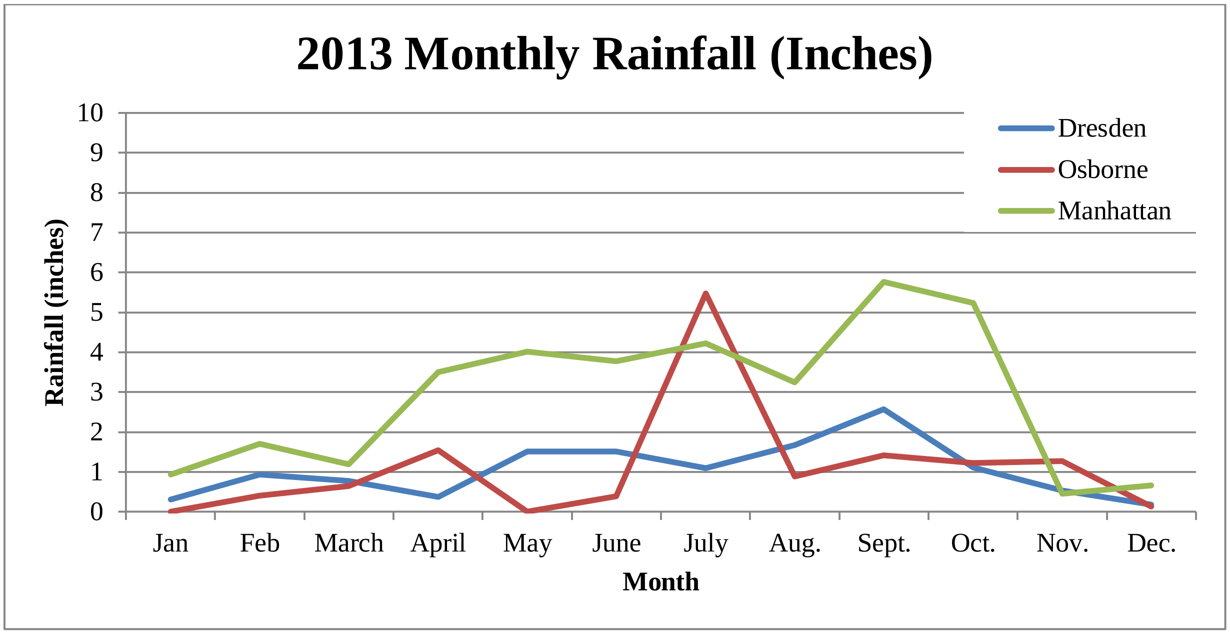

Figure A.1: Actual monthly rainfall (2013) in Dresden, Osborne, and Manhattan, Kansas.

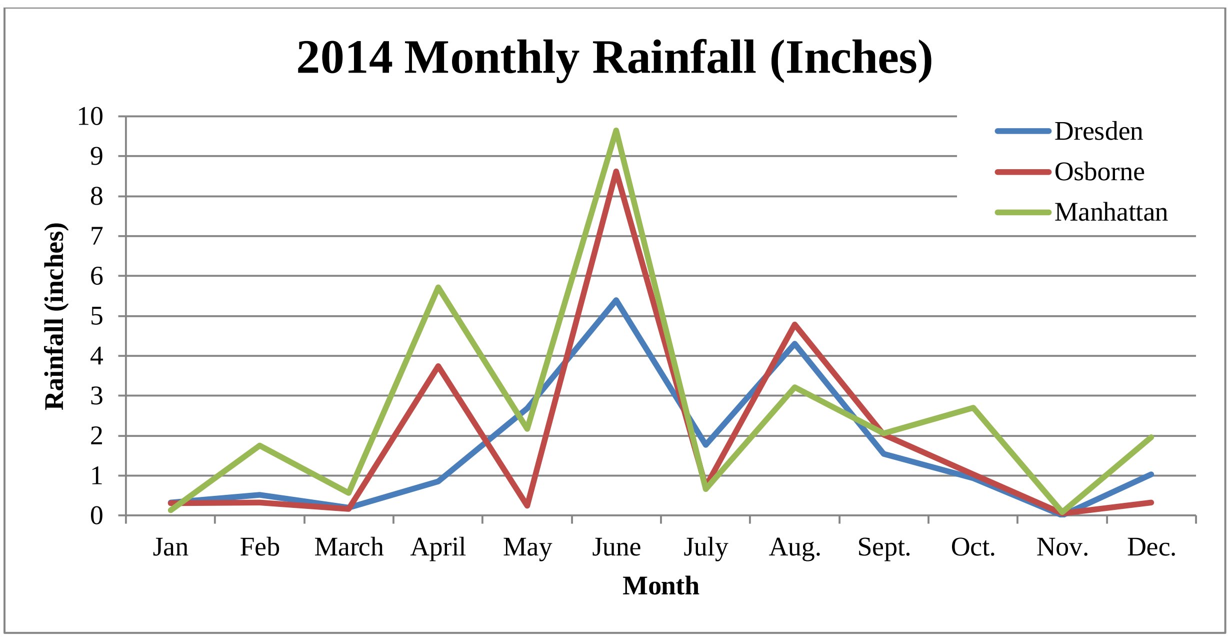

Figure A.2: Actual monthly rainfall (2014) at Dresden, Osborne, and Manhattan, Kansas.

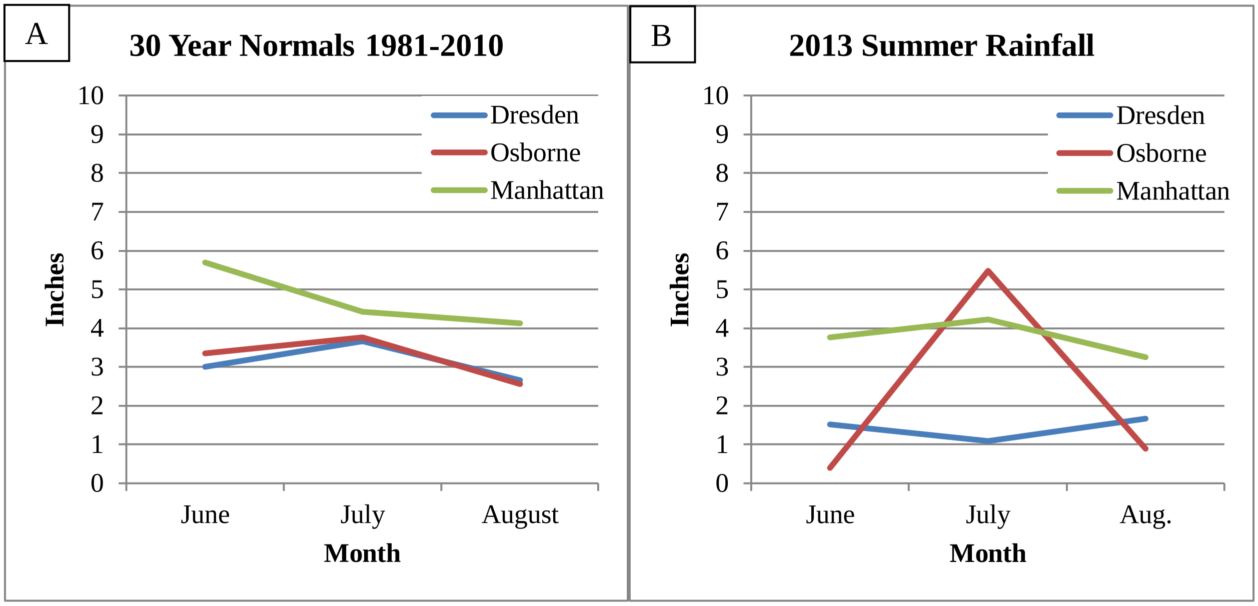

Figure A.3: A. Average historical summer rainfall (30 year normals) in Dresden, Osborne, and Manhattan, Kansas (inches). B. Actual summer rainfall during 2013 summer (inches).

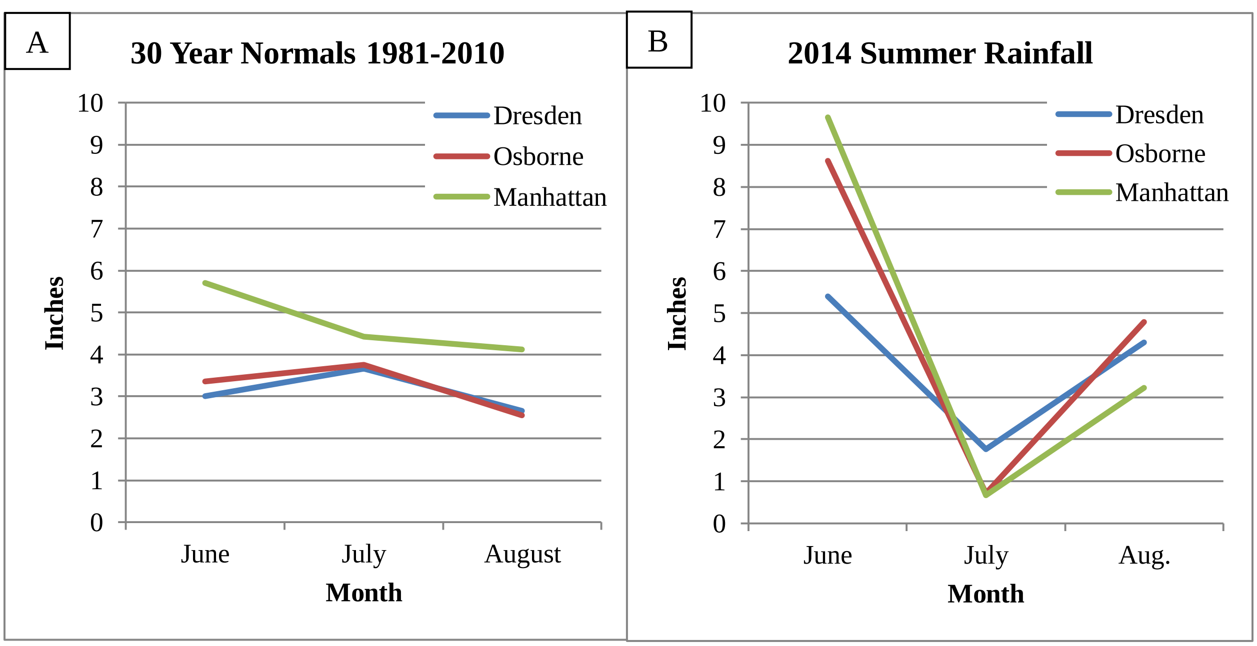

Figure A.4: A. Average summer rainfall (30 year normals) in Dresden, Osborne, and Manhattan, Kansas (inches). B. Actual summer rainfall during 2014 summer (inches).

Average Monthly 30 year Normals (1981-2010)[ACIS]

	Dresden	Osborne	Manhattan
Jan	0.47	0.54	0.63
Feb	0.57	0.59	1.08
Mar	1.4	1.87	2.49
Apr	2.02	2.52	3.17
May	3.44	3.75	5.09
Jun	3.01	3.35	5.7
Jul	3.66	3.76	4.42
Aug	2.66	2.55	4.12
Sep	1.57	3.73	3.43
Oct	1.51	1.92	2.69
Nov	0.87	1.12	1.73
Dec	0.66	0.71	1.07
Annual:	21.84	26.41	35.62

Table A.1: Average annual rainfall (30 year normals) at Dresden, Osborn, and Manhattan, Kansas (inches).

Actual Monthly Rainfall During Study Period

	Dresden		Osborne		Manhattan	
	2013	**2014**	**2013**	**2014**	**2013**	**2014**
Jan	0.31	0.32	0	0.31	0.94	0.13
Feb	0.93	0.52	0.40	0.33	1.71	1.76
March	0.78	0.2	0.65	0.17	1.19	0.57
April	0.37	0.85	1.55	3.75	3.5	5.71
May	1.51	2.69	0.00	0.24	4.02	2.17
June	1.51	5.4	0.39	8.62	3.77	9.65
July	1.09	1.77	5.48	0.72	4.22	0.67
Aug.	1.67	4.31	0.89	4.79	3.25	3.22
Sept.	2.57	1.54	1.41	2.02	5.76	2.06
Oct.	1.11	0.93	1.22	1.04	5.24	2.7
Nov.	0.53	T	1.27	0.06	0.46	0.09
Dec.	0.18	1.03	0.13	0.33	0.67	1.96
Annual:	12.56	19.56	13.39	22.38	34.73	30.69

Table A.2: Actual recorded monthly rainfall during 2013 and 2014, in Dresden, Osborne, and Manhattan, Kansas (inches)

Average Summer Rainfall, 30 Year Normals (ACIS) During Study Period

	Dresden	Osborne	Manhattan
June	3.01	3.35	5.7
July	3.66	3.76	4.42
August	2.66	2.55	4.12
Total:	9.33	9.66	14.24

Table A.3: Summer (June, July, August) average annual rainfall (30 year normals) in Dresden, Osborn, and Manhattan, Kansas (inches).

Actual Summer Rainfall (June, July, August)

	Dresden		Osborne		Manhattan	
	2013	**2014**	**2013**	**2014**	**2013**	**2014**
June	1.51	5.4	0.39	8.62	3.77	9.65
July	1.09	1.77	5.48	0.72	4.22	0.67
Aug.	1.67	4.31	0.89	4.79	3.25	3.22
Total:	4.27	11.48	6.76	14.13	11.24	13.54

Table A.4: Actual recorded rainfall amounts (inches) during the 2013 and 2014 summers in Dresden, Osborne, and Manhattan, Kansas.

Program MARK Files

Manhattan; white tailed deer encounter history

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/* Manhattan Deer encounters in June- groups are Evolved, Star, BioLogic */
000010010010110010001000010001 1 0 0;
101000110000011000100000000000 1 0 0;
110100110001000011010010010000 1 0 0;
011100011010010111100000000100 1 0 0;
011000100001010001000101000100 1 0 0;
010100011110111110010110110000 1 0 0;
000110010010111111100001111111 0 1 0;
101010010101110100110010000000 0 1 0;
001010010011010110000000000100 0 1 0;
001000100010011011110000000010 0 1 0;
110000010000010010000000000010 0 1 0;
011000010101110111110000100001 0 1 0;
001010010000110010100000001000 0 0 1;
000100101110010001010000000100 0 0 1;
001000000001110111100000000100 0 0 1;
011100011010.................. 0 0 1;
000000001110001101110001000000 0 0 1;
010100100000010110000001100000 0 0 1;
```

Table A.5: June white-tailed deer (30 day) encounter history for Manhattan location.

```
/* Manhattan Deer encounters in July- groups are Evolved, Star, BioLogic */
001111111000111010011001111111 1 0 0;
100111010101000001000111101000 1 0 0;
001011101000000000001100011001 1 0 0;
001010100110000110100001010011 1 0 0;
010001100101100001000000010001 1 0 0;
000000010000000101010101100101 1 0 0;
111010011110011000000101100101 0 1 0;
001101111101011111111100101000 0 1 0;
.............................. 0 1 0;
001000101101100100100001110110 0 1 0;
000000010100000000010000101010 0 1 0;
000100001..................... 0 1 0;
011111011110011100011101110101 0 0 1;
100001111101111100010000101000 0 0 1;
.............................. 0 0 1;
.00000111000000000000001110010 0 0 1;
000010111101000000101001010011 0 0 1;
.............................. 0 0 1;
```

Table A.6: July white-tailed deer (30 day) encounter history for Manhattan location.

```
/* Manhattan Deer encounters in August- groups are Evolved, Star, BioLogic */
001111111111011111011010000001 1 0 0;
101100110000000001001010101001001 1 0 0;
011110010001000110011001101011 1 0 0;
010101101011000010011010111101 1 0 0;
010101111111001110111101100101 1 0 0;
011111111000001100000000011101 1 0 0;
001111100111110001011111000001 0 1 0;
110100101100010110100111000110 0 1 0;
.............................. 0 1 0;
010111110001001101111111101111 0 1 0;
001000111100010000111000111000 0 1 0;
.....1010000110010010100001111. 0 1 0;
001111100111000001011001000001 0 0 1;
100110100000000001100001000101 0 0 1;
.............................. 0 0 1;
00011111101110001000001010 0... 0 0 1;
111111011101111000101001000000 0 0 1;
.............................. 0 0 1;
```

Table A.7: August white-tailed deer (30 day) encounter history for Manhattan location.

Jennings; white tailed deer encounter history

```
/* June 30 day Jennings deer feeding encounters groups are Evolved, Star, BioLogic */
010100100010001011000101001100 1 0 0;
001101111111011110111011011111 1 0 0;
011111111111111111111111111001 1 0 0;
000111111101111010110111111111 1 0 0;
010111010001010110110111111010 1 0 0;
111000000000101010010101110110 1 1 0 0;
000110111011101111101111011111 0 1 0;
010101111111011110110111111111 0 1 0;
101111011110101100001101110111 0 1 0;
111111111101110001110111011110 0 1 0;
010111011100001100111000111011 0 1 0;
111111110101111100010111111111 0 1 0;
000001101111111101011101011111 0 0 1;
001110110001011111101111001111 0 0 1;
001111111111011101101001011111 0 0 1;
010111011101110010100100011011 0 0 1;
011111101110001101110100001111 0 0 1;
010101010001011111001011000101 0 0 1;
```

Table A.8: June white-tailed deer (30 day) encounter history for Jennings location.

```
/* 30 day Jennings deer feeding encounters groups are Evolved, Star, BioLogic */
010.............01000000000000 1 0 0;
101110000101011111100010010110 1 0 0;
111111111011011001010010100010 1 0 0;
110111111111111111111110101010 1 0 0;
01111110011100000............. 1 0 0;
110000000100010001111100010011 1 0 0;
110........................... 0 1 0;
100101000101000001110010011010 0 1 0;
110100111010010001110111001010 0 1 0;
111111111011101001111101111000 0 1 0;
011111011001111111111111111010 0 1 0;
110111211011111111111101100111 0 1 0;
110000000000000000000000000000 0 0 1;
111.............00000000100100 0 0 1;
111111111011101011010100000100 0 0 1;
011101111000110010110101110010 0 0 1;
1011111111011000010111001 0..... 0 0 1;
100110110010000000111100001110 0 0 1;
```
Table A.9: July white-tailed deer (30 day) encounter history for Jennings location.

```
/* August 30 day Jennings deer feeding encounters groups are Evolved, Star, BioLogic */
000000000000000000000000000000 1 0 0;
000000000000100000000000101100 1 0 0;
0............................. 1 0 0;
00000001000000................ 1 0 0;
.............................. 1 0 0;
100000........................ 1 0 0;
.............................. 0 1 0;
001000000000100010000001010101 1 0 1 0;
001000000000000001............... 0 1 0;
0110.......................... 0 1 0;
01000001...................... 0 1 0;
110100000000000110001010010100 0 1 0;
0010.......................... 0 0 1;
.............................. 0 0 1;
0100000....................... 0 0 1;
0000000....................... 0 0 1;
.............................. 0 0 1;
1010.......................... 0 0 1;
```
Table A.10: August white-tailed deer (30 day) encounter history for Jennings location.

Model Estimates

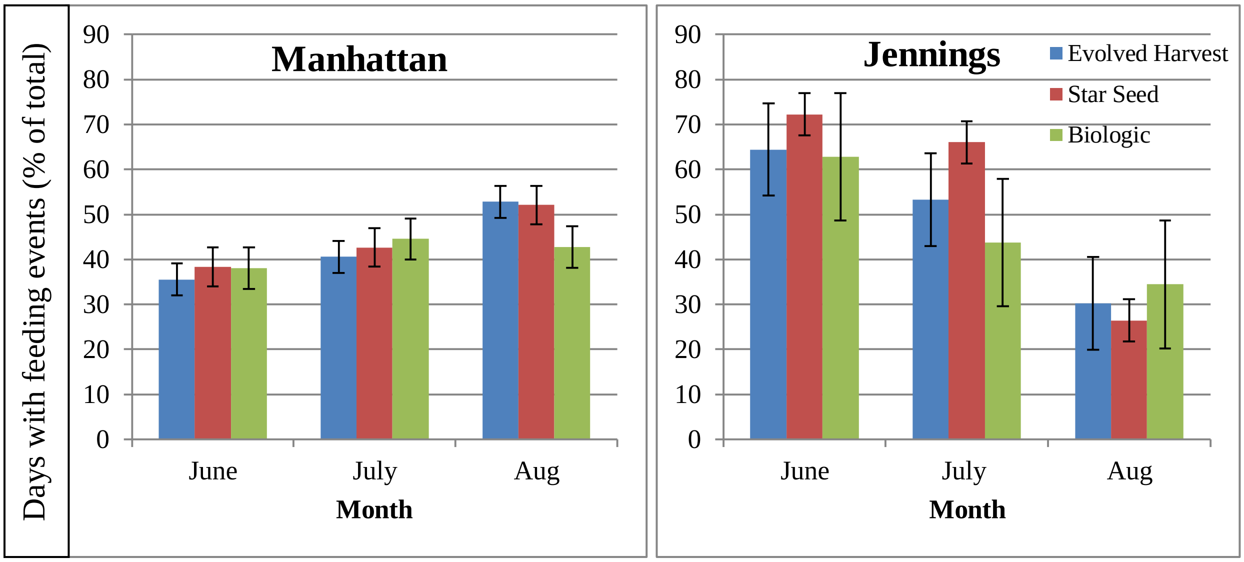

Figure A.5: Estimates from the preliminary white-tailed deer analysis in Program MARK. Probability of June through August feeding events by white-tailed deer for three seed mixes at Manhattan and Jennings, Kansas (± standard error).

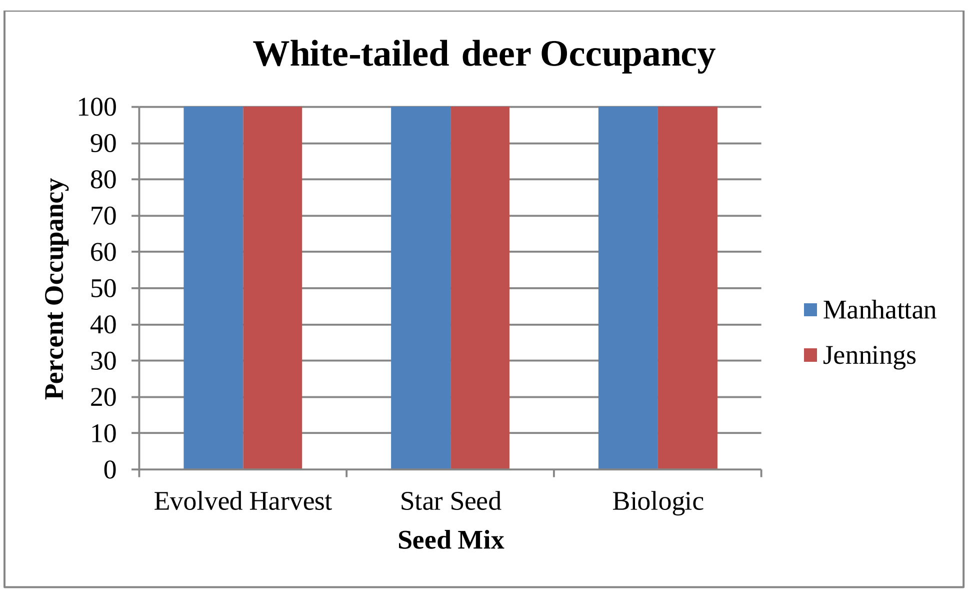

Figure A.6: White tailed deer percent occupancy of each seed mix during the summer of 2014. Deer recorded 100% occupancy for all three seed mixes in both locations during the 90 day sampling period.

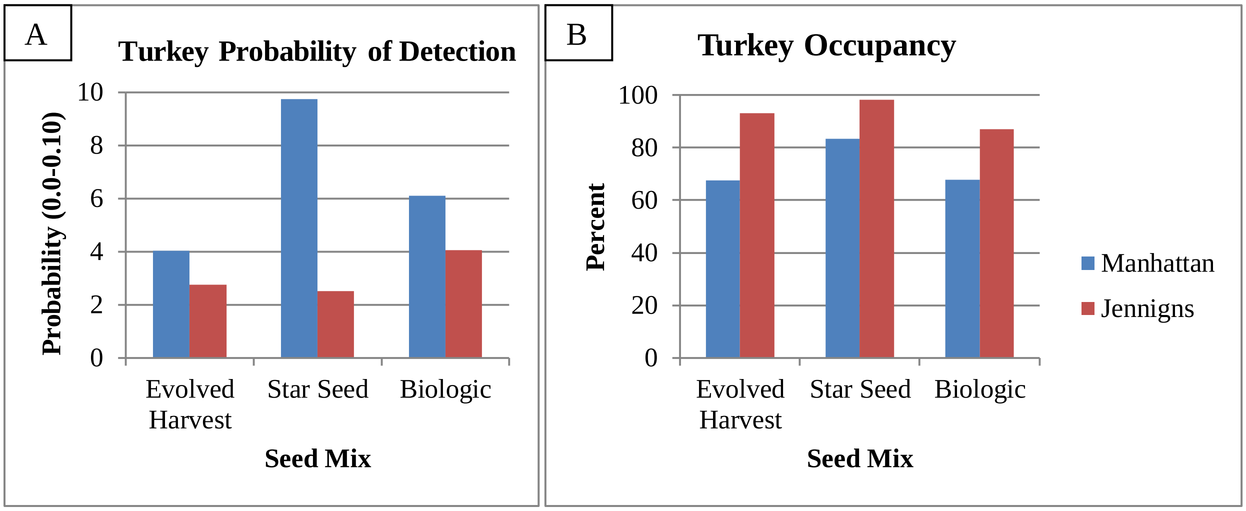

Figure A.7: Parameter estimates from the 90 day turkey encounter histories.
A. The probability turkeys were detected on each seed mix in Manhattan and Jennings, Kansas.
B. Turkey percent occupancy for each seed mix in Manhattan and Jennings, Kansas. Bird and Buck recorded highest occupancy in both locations.

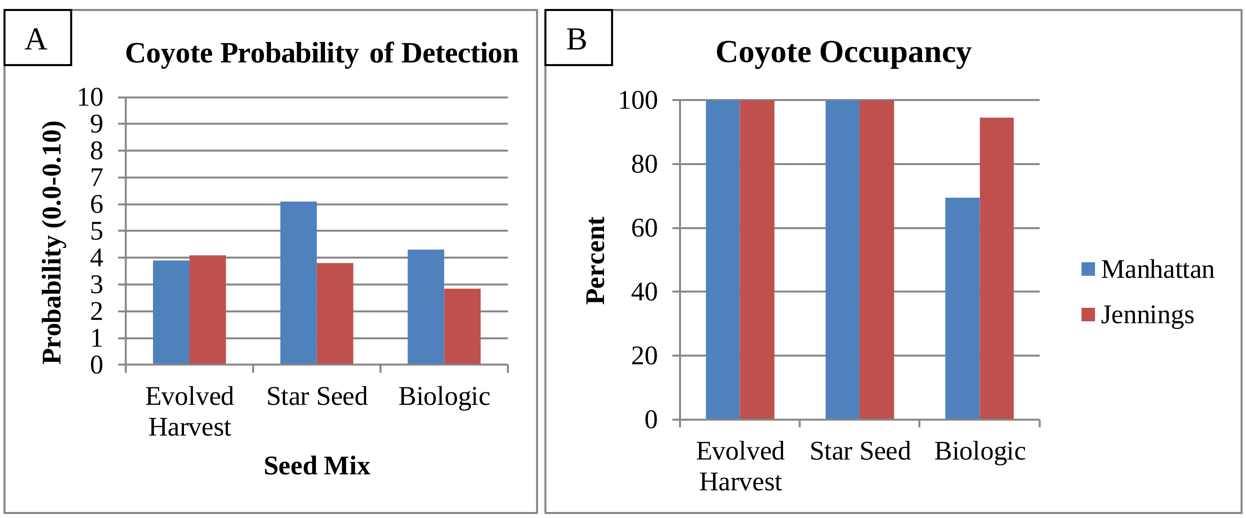

Figure A.8: Parameter estimates from the 90 day coyote encounter histories.
A. The probability coyotes were detected on each seed mix in Manhattan and Jennings, Kansas.
B. Coyote percent occupancy for each seed mix in Manhattan and Jennings, Kansas. BioLogic recorded reduced (<100%) occupancy on the BioLogic mix in both locations.

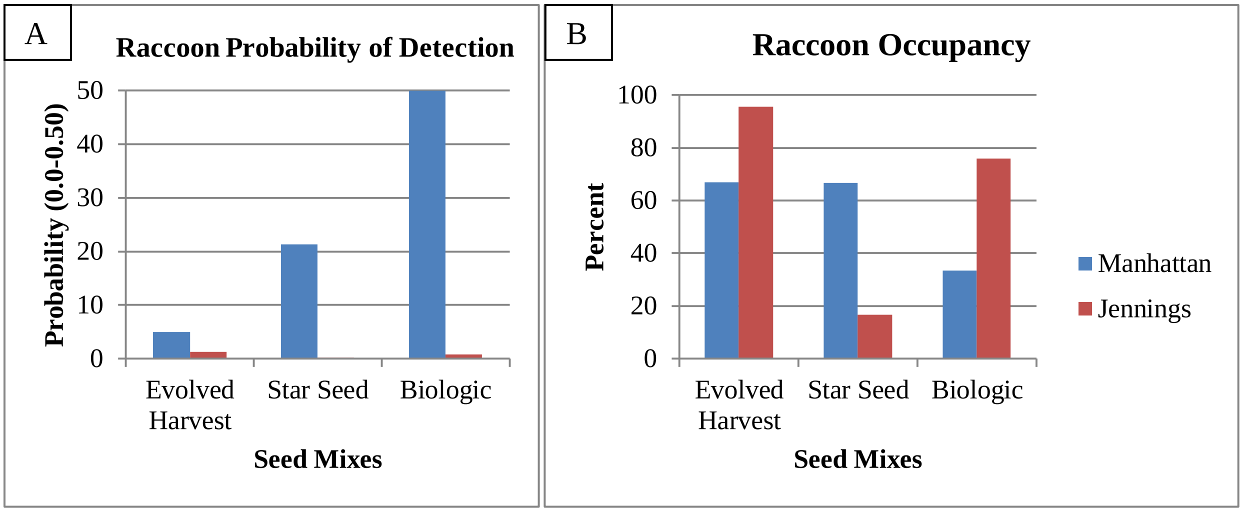

Figure A.9: Model estimates from the 90 day raccoon encounter histories.
A. The probability raccoons were detected on each seed mix in Manhattan and Jennings, Kansas. Raccoon were widely encountered on the Manhattan food plots, however, only a few encounters were recorded in Jennings.
B. Raccoon percent occupancy of each seed mix in Manhattan and Jennings, Kansas. With such few encounters Jennings occupancy estimations are very inflated, and not very precise (confidence intervals range from ~0-1). A different plot management and sampling technique is needed to increase the precision of this estimate.

Appendix B - Chapter 4 Appendix

Seed Germination Data

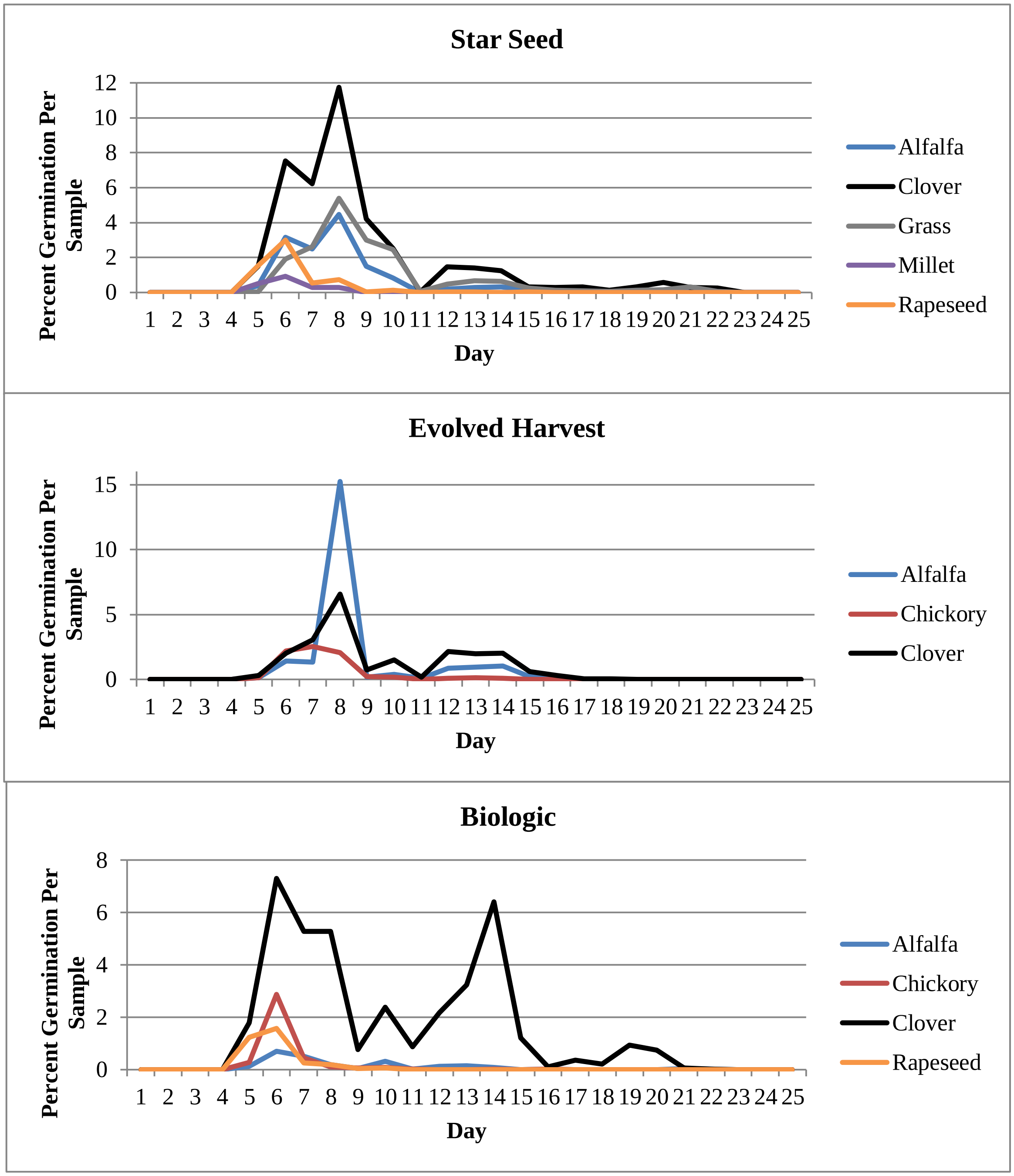

Figure B.1: Daily percent of total seed sampled that germinated, separated by plant type.

(S-1)	Day	Alfalfa	Rapeseed	Proso Millet	Clover	Alsike	Arrowleaf	Switchgrass	Annual Ryegrass	Timothy	Kentucky Bluegrass	Unknown
	1	0	0	0	0	0	0	0	0	0	0	
	2	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	0	0	0	0	0	
	4	0	0	0	0	0	0	0	0	0	0	
	5	4	3	0	0	0	0	0	0	0	0	
	6	5	24	2	18	0	0	1	7	1	0	
	7	10	5	4	3	0	0	1	8	0	0	
	8	2	3	1	27	13	6	1	0	0	0	
	9	14	0	0	14	2	11	5	9	6	0	
	10	13	1	0	19	10	17	3	8	11	0	
	11	0	0	0	0	0	0	0	0	0	1	
	12	1	0	0	0	0	7	1	0	4	1	
	13	2	0	0	1	0	10	0	1	0	0	
	14	3	0	0	0	7	0	0	0	2	0	
	15	0	0	0	1	0	0	0	0	0	0	
	16	0	0	0	0	0	1	0	0	2	1	
	17	1	0	0	1	0	0	0	0	0	0	
	18	0	0	0	0	0	0	0	0	0	0	
	19	0	0	0	0	1	0	0	0	0	0	
	20	0	0	0	0	0	0	0	1	3	0	
	21	0	0	0	0	0	0	0	0	2	0	
	22	0	0	0	0	0	0	0	0	0	0	
	23	0	0	0	0	0	0	0	0	0	0	
	24	0	0	0	0	0	0	0	0	0	0	
	25	0	0	0	0	0	0	0	0	0	0	
Germinated		55	36	7	84	33	52	12	34	31	3	0
Not-germinated		2	0	0	22	0	17	6	2	6	10	12

Total: Germinated 347

Not-germinated 77

Total Seed in Sample 424

Table B.1: Star Seed, White-tail and Gamebird seed mix germination data (Plate S-1).

(S-2) Day	Alfalfa	Rapeseed	Proso Millet	Clover	Alsike	Arrowleaf	Switchgrass	Annual Ryegrass	Timothy	Kentucky Bluegrass	
1	0	0	0	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	0	
5	0	1	0	0	0	0	0	0	0	0	
6	5	9	5	14	0	0	0	4	1	0	
7	4	4	0	11	5	0	1	1	3	0	
8	36	6	4	54	39	27	1	6	3	0	
9	4	1	0	5	6	9	1	0	3	0	
10	2	0	0	2	0	5	0	2	11	2	
11	0	0	0	0	0	0	0	1	0	0	
12	0	0	0	0	0	5	0	0	0	1	
13	0	0	0	0	1	8	0	0	0	0	
14	0	0	0	5	2	4	0	0	2	2	
15	4	1	1	0	0	0	0	0	0	0	
16	3	0	0	0	0	2	0	0	1	0	
17	0	0	0	1	0	1	0	1	1	0	
18	0	0	0	0	0	0	0	0	1	0	
19	0	0	0	0	0	1	0	0	0	0	
20	0	0	0	3	0	0	0	0	2	0	
21	0	0	0	1	0	0	0	0	0	2	
22	0	0	0	4	0	0	0	0	0	0	
23	0	0	0	0	0	0	0	0	0	0	
24	0	0	0	0	0	0	0	0	0	0	
25	0	0	0	0	0	0	0	0	0	0	Unknown
Germinated	58	22	10	100	53	62	3	15	28	7	0
Not-germinated	3	0	0	14	6	32	5	2	5	20	23

Total: Germinated 381

Not-germinated 87

Total Seed in Sample 468

Table B.2: Star Seed, White-tail and Gamebird seed mix germination data (Plate S-2).

(S-3) Day	Alfalfa	Rapeseed	Proso Millet	Clover	Alsike	Arrowleaf	Switchgrass	Annual Ryegrass	Timothy	Kentucky Bluegrass	
1	0	0	0	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	0	
5	0	7	2	1	0	0	0	1	0	0	
6	36	14	0	28	0	0	3	15	5	0	
7	0	0	1	5	2	0	0	4	0	0	
8	35	0	1	24	24	22	2	12	17	0	
9	11	0	0	0	2	5	0	1	23	2	
10	3	0	0	2	0	1	0	4	2	2	
11	0	0	0	0	0	0	0	0	0	0	
12	0	0	0	0	0	7	0	1	0	2	
13	3	0	0	0	0	10	1	0	0	4	
14	4	0	0	0	0	7	0	0	7	2	
15	0	0	0	2	0	1	0	0	1	0	
16	0	0	0	0	0	0	0	0	1	0	
17	0	0	0	1	0	0	0	0	0	0	
18	0	0	0	0	0	0	0	0	0	0	
19	0	0	0	1	1	0	0	0	1	0	
20	0	0	0	4	0	2	0	0	0	0	
21	0	0	0	1	0	0	0	0	0	2	
22	0	0	0	3	0	0	0	0	0	1	
23	0	0	0	0	0	0	0	0	0	0	
24	0	0	0	0	0	0	0	0	0	0	
25	0	0	0	0	0	0	0	0	0	0	Unknown
Germinated	92	21	4	72	29	55	6	38	57	15	0
Not-germinated	0	0	0	19	0	31	0	3	9	8	12

Total: Germinated 389

Not-germinated 82

Total Seed in Sample 471

Table B.3: Star Seed, White-tail and Gamebird seed mix germination data (Plate S-3).

(S-4)	Day	Alfalfa	Rapeseed	Proso Millet	Clover	Alsike	Arrowleaf	Switchgrass	Annual Ryegrass	Timothy	Kentucky Bluegrass	
	1	0	0	0	0	0	0	0	0	0	0	
	2	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	0	0	0	0	0	
	4	0	0	0	0	0	0	0	0	0	0	
	5	1	0	1	2	0	0	0	0	0	0	
	6	27	10	3	29	0	0	1	4	2	0	
	7	40	0	0	28	24	16	11	0	0	0	
	8	0	1	1	0	0	0	0	9	3	1	
	9	8	0	0	5	11	17	0	5	8	0	
	10	7	0	0	5	7	10	2		5	0	
	11	0	0	0	0	0	0	0	0	0	0	
	12	7	0	0	8	1	17	0	0	2	2	
	13	3	0	0	5	3	13	0	1	5	0	
	14	6	0	0	5	1	6	1	1	2	0	
	15	1	0	0	1	1	0	0	0	1	0	
	16	0	0	0	0	0	0	0	0	0	0	
	17	0	0	0	0	0	0	0	0	1	0	
	18	0	0	0	0	0	0	0	0	0	1	
	19	0	0	0	0	0	1	0	0	0	0	
	20	0	0	0	0	0	0	0	0	0	1	
	21	1	0	0	0	0	0	0	0	2	1	
	22	0	0	0	0	0	0	0	0	1	0	
	23	0	0	0	0	0	0	0	0	0	0	
	24	0	0	0	0	0	0	0	0	0	0	
	25	0	0	0	0	0	0	0	0	0	0	Unknown
Germinated		101	11	5	88	48	80	15	20	32	6	0
Not-germinated		5	0	0	11	1	11	3	5	7	17	39

Total:	Germinated	406	
	Not-germinated	99	Total Seed in Sample 505

Table B.4: Star Seed, White-tail and Gamebird seed mix germination data (Plate S-4).

(S-5)	Day	Alfalfa	Rapeseed	Proso Millet	Clover	Alsike	Arrowleaf	Switchgrass	Annual Ryegrass	Timothy	Kentucky Bluegrass	
	1	0	0	0	0	0	0	0	0	0	0	
	2	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	0	0	0	0	0	
	4	0	0	0	0	0	0	0	0	0	0	
	5	0	5	0	4	0	0	0	0	0	0	
	6	8	8	7	22	0	0	0	8	0	0	
	7	1	3	3	0	2	0	0	6	0	0	
	8	36	4	4	0	30	19	8	6	7	1	
	9	11	0	0	8	16	4	3	3	11	0	
	10	5	0	0	3	0	4	1	3	7	2	
	11	0	0	0	0	0	0	0	0	0	0	
	12	0	0	0	2	3	11	0	0	3	3	
	13	4	0	0	0	2	8	0	0	1	2	
	14	2	0	0	6	3	0	0	0	5	0	
	15	0	0	0	0	0	0	0	0	0	0	
	16	0	0	0	1	0	2	0	0	0	0	
	17	0	0	0	1	1	0	0	0	0	0	
	18	0	0	0	0	0	0	0	0	0	0	
	19	0	0	0	0	0	0	0	0	0	0	
	20	0	0	0	0	0	0	0	0	0	0	
	21	0	0	0	0	0	0	0	0	0	0	
	22	0	0	0	0	0	0	0	0	0	0	
	23	0	0	0	0	0	0	0	0	0	0	
	24	0	0	0	0	0	0	0	0	0	0	
	25	0	0	0	0	0	0	0	0	0	0	Unknown
Germinated		67	20	14	47	57	48	12	26	34	8	0
Not-germinated		0	0	0	79	0	18	5	0	6	26	4

Total:	Germinated	333	
	Not-germinated	138	Total Seed in Sample 471

Table B.5: Star Seed, White-tail and Gamebird seed mix germination data (Plate S-5).

(S-6) Day	Alfalfa	Rapeseed	Proso Millet	Clover	Alsike	Arrowleaf	Switchgrass	Annual Ryegrass	Timothy	Kentucky Bluegrass	Unknown
1	0	0	0	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	0	
5	9	19	3	9	0	0	0	0	0	0	
6	0	25	4	29	25	0	1	0	0	0	
7	0	0	0	28	16	0	4	9	1	0	
8	32	1	1	39	21	26	2	15	28	0	
9	2	0	0	2	11	4	2	0	6	0	
10	0	0	0	0	1	0	0	1	4	6	
11	0	0	0	1	0	0	0	0	0	0	
12	1	0	0	0	0	0	0	1	0	0	
13	0	0	0	0	0	0	0	0	0	0	
14	0	0	0	0	0	2	0	0	0	0	
15	0	0	0	0	0	0	0	0	0	0	
16	0	0	0	0	2	1	0	0	0	1	
17	0	0	0	1	0	3	0	0	1	1	
18	0	0	0	3	0	0	0	0	0	0	
19	0	0	0	2	0	0	0	0	0	0	
20	0	0	0	1	0	0	0	0	0	0	
21	0	0	0	0	0	0	0	0	4	0	
22	0	0	0	2	0	0	0	0	0	0	
23	0	0	0	0	0	0	0	0	0	0	
24	0	0	0	0	0	0	0	0	0	0	
25	0	0	0	0	0	0	0	0	0	0	
Germinated	44	45	8	117	76	36	9	26	44	8	0
Not-germinated	3	0	0	20	4	12	6	2	3	22	40

Total: Germinated 413

Not-germinated 112

Total Seed in Sample 525

Table B.6: Star Seed, White-tail and Gamebird seed mix germination data (Plate S-6).

(S-7)	Day	Alfalfa	Rapeseed	Proso Millet	Clover	Alsike	Arrowleaf	Switchgrass	Annual Ryegrass	Timothy	Kentucky Bluegrass	
	1	0	0	0	0	0	0	0	0	0	0	
	2	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	0	0	0	0	0	
	4	0	0	0	0	0	0	0	0	0	0	
	5	0	13	6	0	0	0	0	0	0	0	
	6	11	11	7	25	33	0	0	0	0	0	
	7	6	1	2	38	14	0	4	5	1	0	
	8	11	4	0	17	10	14	1	7	34	11	
	9	0	0	0	2	1	0	1	0	1	4	
	10	1	2	0	3	2	4	1	1	2	0	
	11	0	0	0	0	0	0	0	0	0	0	
	12	0	0	0	1	1	1	0	0	0	0	
	13	0	0	0	0	0	2	0	0	0	0	
	14	0	0	0	0	1	4	0	0	0	1	
	15	0	0	0	0	0	0	0	0	0	4	
	16	0	0	0	0	1	2	0	0	0	0	
	17	0	0	0	1	0	2	0	0	0	0	
	18	0	0	0	0	0	0	0	0	0	0	
	19	0	0	0	0	0	3	0	0	1	0	
	20	0	0	0	0	0	0	0	0	0	0	
	21	0	0	0	0	0	4	0	0	2	0	
	22	0	0	0	0	0	2	0	0	1	0	
	23	0	0	0	0	0	0	0	0	0	0	
	24	0	0	0	0	0	0	0	0	0	0	
	25	0	0	0	0	0	0	0	0	0	0	Unknown
Germinated		29	31	15	87	63	38	7	13	42	20	0
Not-germinated		5	0	0	7	0	21	0	4	6	13	4

Total: Germinated 345

Not-germinated 60

Total Seed in Sample 405

Table B.7: Star Seed, White-tail and Gamebird seed mix germination data (Plate S-7).

(S-8)	Day	Alfalfa	Rapeseed	Proso Millet	Clover	Alsike	Arrowleaf	Switchgrass	Annual Ryegrass	Timothy	Kentucky Bluegrass	
	1	0	0	0	0	0	0	0	0	0	0	
	2	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	0	0	0	0	0	
	4	0	0	0	0	0	0	0	0	0	0	
	5	0	19	7	17	0	0	0	0	0	0	
	6	17	7	2	43	0	0	3	12	0	0	
	7	24	1	0	12	13		7	9	3	1	
	8	23	1	0	17	6	6	0	2	13	4	
	9	2	1	0	8	4	7	0	0	12	0	
	10	2	2	0	3	1	1	0	1	0	0	
	11	0	0	0	0	0	0	0	0	0	0	
	12	0	1	0	0	0	0	0	0	0	0	
	13	0	0	0	0	0	0	0	0	0	0	
	14	0	0	0	0	0	0	0	0	0	0	
	15	0	0	0	1	0	3	0	0	1	1	
	16	0	0	0	0	0	0	0	0	0	0	
	17	0	0	0	0	0	1	0	0	0	0	
	18	0	0	0	0	0	0	0	0	0	0	
	19	0	0	0	0	0	0	0	0	3	0	
	20	0	0	0	0	0	2	0	0	0	0	
	21	0	0	0	0	0	3	0	0	0	0	
	22	0	0	0	0	0	0	0	0	0	0	
	23	0	0	0	0	0	0	0	0	0	0	
	24	0	0	0	0	0	0	0	0	0	0	
	25	0	0	0	0	0	0	0	0	0	0	Unknown
Germinated		68	32	9	101	24	23	10	24	32	6	0
Not-germinated		3	0	0	10	0	32	3	3	9	16	0

Total: Germinated 329

Not-germinated 76

Total Seed in Sample 405

Table B.8: Star Seed, White-tail and Gamebird seed mix germination data (Plate S-8).

(S-9)	Day	Alfalfa	Rapeseed	Proso Millet	Clover	Alsike	Arrowleaf	Switchgrass	Annual Ryegrass	Timothy	Kentucky Bluegrass	Unknown
	1	0	0	0	0	0	0	0	0	0	0	
	2	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	0	0	0	0	0	
	4	0	0	0	0	0	0	0	0	0	0	
	5	0	1	1	3	0	0	0	0	0	0	
	6	19	22	8	32	0	0	1	8	0	0	
	7	10	9	2	18	6	0	4	10	2	1	
	8	21	9	0	9	7	14	2	3	12	1	
	9	2	0	0	13	0	8	1	0	9	2	
	10	2	0	0	2	0	0	0	2	3	0	
	11	0	0	0	0	0	0	0	0	0	0	
	12	0	0	0	0	1	2	0	0	0	0	
	13	0	1	0	0	0	0	0	1	0	0	
	14	0	0	0	0	0	5	0	2	0	0	
	15	0	0	0	0	0	3	0	0	1	0	
	16	0	0	0	0	0	0	0	0	0	0	
	17	1	0	0	0	0	0	0	0	0	0	
	18	0	0	0	0	0	2	0	0	0	0	
	19	2	0	0	0	1	1	0	0	0	0	
	20	0	0	0	0	0	5	0	0	0	0	
	21	0	0	0	0	0	3	0	0	0	0	
	22	0	0	0	0	0	0	0	0	0	0	
	23	0	0	0	0	0	0	0	0	0	0	
	24	0	0	0	0	0	0	0	0	0	0	
	25	0	0	0	0	0	0	0	0	0	0	
Germinated		57	42	11	77	15	43	8	26	27	4	0
Not-germinated		4	0	0	20	0	29	3	2	0	13	14

Total: Germinated 310

Not-germinated 85

Total Seed in Sample 395

Table B.9: Star Seed, White-tail and Gamebird seed mix germination data (Plate S-9).

(S-10)	Day	Alfalfa	Rapeseed	Proso Millet	Clover	Alsike	Arrowleaf	Switchgrass	Annual Ryegrass	Timothy	Kentucky Bluegrass	Unknown
	1	0	0	0	0	0	0	0	0	0	0	
	2	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	0	0	0	0	0	
	4	0	0	0	0	0	0	0	0	0	0	
	5	4	0	1	29	0	0	0	0	0	0	
	6	12	4	2	36	0	0	2	5	0	0	
	7	16	0	0	27	5	0	5	9	3	0	
	8	12	0	0	18	12	13	1	0	14	3	
	9	11	0	0	5	8	3	2	2	3	0	
	10	2	0	0	5	4	1	2	5	6	2	
	11	0	0	0	0	0	0	0	0	0	0	
	12	0	0	0	0	0	2	0	0	1	0	
	13	1	0	0	0	1	2	0	0	0	0	
	14	1	0	0	0	0	1	0	0	1	0	
	15	2	0	0	0	0	1	0	0	1	0	
	16	0	0	0	0	0	1	0	0	0	0	
	17	2	0	0	0	0	0	0	0	0	0	
	18	0	0	0	0	0	0	0	1	0	0	
	19	0	0	0	1	0	1	0	0	0	0	
	20	1	0	0	2	1	5	0	0	0	0	
	21	0	0	0	0	0	0	0	0	0	0	
	22	0	0	0	0	0	0	0	0	0	0	
	23	0	0	0	0	0	0	0	0	0	0	
	24	0	0	0	0	0	0	0	0	0	0	
	25	0	0	0	0	0	0	0	0	0	0	
Germinated		64	4	3	123	31	30	12	22	29	5	0
Not-germinated		0	0	0	28	0	25	0	0	5	14	31

Total: Germinated 323

Not-germinated 103

Total Seed in Sample 426

Table B.10: Star Seed, White-tail and Gamebird seed mix germination data (Plate S-10).

(EH-1) Day	Alfalfa	Clover	Chicory	
1	0	0	0	
2	0	0	0	
3	0	0	0	
4	0	0	0	
5	0	0	0	
6	1	4	3	
7	0	0	2	
8	32	8	14	
9	0	3	0	
10	2	18	1	
11	1	1	0	
12	8	20	0	
13	13	15	2	
14	9	15	1	
15	3	6	0	
16	1	1	0	
17	0	0	0	
18	0	0	0	
19	0	0	0	
20	0	0	0	
21	0	0	0	
22	0	0	0	
23	0	0	0	
24	0	0	0	
25	0	0	0	Total
Germinated	70	91	23	184
Not-germinated	31	121	0	152
			Total Seeds in Sample	336

Table B.11: Evolved Harvest, Rack Force seed mix germination data (Plate E-1).

(E-2) Day	Alfalfa	Clover	Chicory	
1	0	0	0	
2	0	0	0	
3	0	0	0	
4	0	0	0	
5	0	0	0	
6	2	3	3	
7	0	3	8	
8	21	23	13	
9	0	0	1	
10	1	10	1	
11	0	0	0	
12	3	3	1	
13	1	3	0	
14	9	12	0	
15	4	4	0	
16	2	1	0	
17	0	1	0	
18	1	0	0	
19	0	0	0	
20	0	0	0	
21	0	0	0	
22	0	0	0	
23	0	0	0	
24	0	0	0	
25	0	0	0	Total
Germinated	44	63	27	134
Not-germinated	33	177	1	211
			Total Seeds in Sample	345

Table B.12: Evolved Harvest, Rack Force seed mix germination data (Plate E-2).

(E-3)	Day	Alfalfa	Clover	Chicory	
	1	0	0	0	
	2	0	0	0	
	3	0	0	0	
	4	0	0	0	
	5	0	1	0	
	6	0	2	0	
	7	5	8	15	
	8	72	18	9	
	9	1	1	0	
	10	4	6	3	
	11	0	0	0	
	12	3	10	1	
	13	1	12	0	
	14	4	23	0	
	15	1	3	0	
	16	3	5	0	
	17	1	0	0	
	18	0	0	0	
	19	0	0	1	
	20	0	0	1	
	21	0	0	0	
	22	0	0	0	
	23	0	0	0	
	24	0	0	0	
	25	0	0	0	Total
Germinated		95	89	30	214
Not-germinated		26	135	2	163
				Total Seeds in Sample	377

Table B.13: Evolved Harvest, Rack Force seed mix germination data (Plate E-3).

(E-4)	Day	Alfalfa	Clover	Chicory	
	1	0	0	0	
	2	0	0	0	
	3	0	0	0	
	4	0	0	0	
	5	1	1	1	
	6	4	9	19	
	7	5	10	13	
	8	71	20	8	
	9	1	6	2	
	10	1	8	0	
	11	0	0	0	
	12	2	0	0	
	13	1	2	0	
	14	1	4	0	
	15	0	4	0	
	16	0	2	0	
	17	0	0	0	
	18	0	0	0	
	19	0	0	0	
	20	0	0	0	
	21	0	0	0	
	22	0	0	0	
	23	0	0	0	
	24	0	0	0	
	25	0	0	0	Total
Germinated		87	66	43	196
Not-germinated		24	110	2	136
				Total Seeds in Sample	332

Table B.14: Evolved Harvest, Rack Force seed mix germination data (Plate E-4).

(E-5) Day	Alfalfa	Clover	Chicory	
1	0	0	0	
2	0	0	0	
3	0	0	0	
4	0	0	0	
5	0	1	0	
6	6	12	10	
7	2	11	5	
8	59	28	8	
9	1	1	0	
10	0	2	0	
11	0	0	0	
12	0	8	0	
13	3	4	1	
14	1	2	0	
15	0	1	0	
16	0	0	0	
17	0	0	0	
18	0	1	0	
19	0	0	0	
20	0	0	0	
21	0	0	0	
22	0	0	0	
23	0	0	0	
24	0	0	0	
25	0	0	0	Total
Germinated	72	71	24	167
Not-germinated	31	188	3	222
			Total Seeds in Sample	389

Table B.15: Evolved Harvest, Rack Force seed mix germination data (Plate E-5).

(E-6) Day	Alfalfa	Clover	Chicory	
1	0	0	0	
2	0	0	0	
3	0	0	0	
4	0	0	0	
5	0	1	0	
6	12	7	7	
7	10	20	9	
8	77	26	3	
9	1	6	2	
10	1	1	0	
11	1	2	1	
12	0	8	0	
13	4	3	1	
14	1	2	0	
15	0	1	0	
16	0	0	0	
17	0	0	0	
18	0	1	0	
19	0	0	0	
20	0	0	0	
21	0	0	0	
22	0	0	0	
23	0	0	0	
24	0	0	0	
25	0	0	0	Total
Germinated	107	78	23	208
Not-germinated	21	162	4	187
			Total Seeds in Sample	395

Table B.16: Evolved Harvest, Rack Force seed mix germination data (Plate E-6).

(E-7)	Day	Alfalfa	Clover	Chicory	
	1	0	0	0	
	2	0	0	0	
	3	0	0	0	
	4	0	0	0	
	5	0	1	0	
	6	7	5	9	
	7	3	16	13	
	8	61	22	9	
	9	2	0	0	
	10	1	1	0	
	11	0	2	0	
	12	4	1	0	
	13	2	3	0	
	14	3	1	0	
	15	0	0	0	
	16	0	0	0	
	17	0	0	0	
	18	0	0	0	
	19	0	0	0	
	20	0	0	0	
	21	0	0	0	
	22	0	0	0	
	23	0	0	0	
	24	0	0	0	
	25	0	0	0	Total
Germinated		83	52	31	166
Not-germinated		28	200	3	231
				Total Seeds in Sample	397

Table B.17: Evolved Harvest, Rack Force seed mix germination data (Plate E-7).

(E-8)	Day	Alfalfa	Clover	Chicory	
	1	0	0	0	
	2	0	0	0	
	3	0	0	0	
	4	0	0	0	
	5	4	7	4	
	6	14	15	11	
	7	17	28	8	
	8	31	21	3	
	9	0	3	1	
	10	0	2	0	
	11	1	1	0	
	12	4	17	0	
	13	2	14	1	
	14	5	5	0	
	15	0	0	0	
	16	0	0	0	
	17	0	0	0	
	18	0	0	0	
	19	0	0	0	
	20	0	0	0	
	21	0	0	0	
	22	0	0	0	
	23	0	0	0	
	24	0	0	0	
	25	0	0	0	Total
Germinated		78	113	28	219
Not-germinated		12	154	1	167
				Total Seeds in Sample	386

Table B.18: Evolved Harvest, Rack Force seed mix germination data (Plate E-8).

(E-9) Day	Alfalfa	Clover	Chicory	
1	0	0	0	
2	0	0	0	
3	0	0	0	
4	0	0	0	
5	0	0	0	
6	9	18	19	
7	1	9	4	
8	79	72	2	
9	0	4	0	
10	2	2	1	
11	1	1	0	
12	2	11	0	
13	2	10	0	
14	1	5	3	
15	0	1	0	
16	0	2	0	
17	0	0	0	
18	0	0	0	
19	0	1	0	
20	0	0	0	
21	0	0	0	
22	0	0	0	
23	0	0	0	
24	0	0	0	
25	0	0	0	Total
Germinated	97	136	29	262
Not-germinated	8	154	2	164
			Total Seeds in Sample	426

Table B.19: Evolved Harvest, Rack Force seed mix germination data (Plate E-9).

(E-10) Day	Alfalfa	Clover	Chicory	
1	0	0	0	
2	0	0	0	
3	0	0	0	
4	0	0	0	
5	0	0	0	
6	1	2	3	
7	8	13	19	
8	76	16	7	
9	1	4	3	
10	2	3	0	
11	0	0	0	
12	6	3	1	
13	6	9	0	
14	3	5	0	
15	0	1	0	
16	0	0	0	
17	0	1	0	
18	0	0	0	
19	0	0	0	
20	0	0	0	
21	0	0	0	
22	0	0	0	
23	0	0	0	
24	0	0	0	
25	0	0	0	Total
Germinated	103	57	33	193
Not-germinated	28	165	3	196
			Total Seeds in Sample	389

Table B.20: Evolved Harvest, Rack Force seed mix germination data (Plate E-10).

(B-1) Day	Clover	Chicory	Rapeseed	Alfalfa	Unknown	Total
1	0	0	0	0		
2	0	0	0	0		
3	0	0	0	0		
4	0	0	0	0		
5	16	5	12	2		
6	41	9	9	0		
7	5	1	1	1		
8	21	0	1	0		
9	1	0	0	1		
10	18	0	0	8		
11	8	0	0	0		
12	19	0	0	1		
13	40	0	0	0		
14	39	0	0	1		
15	3	0	0	0		
16	2	0	0	0		
17	1	0	0	0		
18	2	0	0	0		
19	7	0	0	0		
20	6	0	0	0		
21	0	0	0	2		
22	0	0	0	0		
23	0	0	0	0		
24	0	0	0	0		
25	0	0	0	0		
Germinated	229	15	23	16	0	283
Not-germinated	-	4	-	-	379	383
					Total Seeds in Sample	666

Table B.21: BioLogic, Perfect Plot seed mix germination data (Plate B-1).

(B-2)	Day	Clover	Chicory	Rapeseed	Alfalfa		
	1	0	0	0	0		
	2	0	0	0	0		
	3	0	0	0	0		
	4	0	0	0	0		
	5	12	5	5	2		
	6	41	18	14	11		
	7	10	1	3	1		
	8	6	0	0	1		
	9	3	1	1	0		
	10	5	0	1	2		
	11	3	0	0	0		
	12	7	0	0	2		
	13	9	0	0	1		
	14	35	1	0	1		
	15	12	0	0	0		
	16	1	0	0	1		
	17	0	0	0	0		
	18	1	0	0	0		
	19	4	0	0	0		
	20	6	0	0	0		
	21	1	0	0	0		
	22	0	0	0	0		
	23	0	0	0	0		
	24	0	0	0	0		
	25	0	0	0	0	Unknown	Total
Germinated		156	26	24	22	0	228
Not-germinated		-	2	-	-	391	393
						Total Seeds in Sample	621

Table B.22: BioLogic, Perfect Plot seed mix germination data (Plate B-2).

(B-3)	Day	Clover	Chicory	Rapeseed	Alfalfa		
	1	0	0	0	0		
	2	0	0	0	0		
	3	0	0	0	0		
	4	0	0		0		
	5	12	1	13	0		
	6	28	15	7	8		
	7	32	5	1	3		
	8	6	1	0	0		
	9	2	0	0	0		
	10	12	0	0	2		
	11	1	0	0	0		
	12	7	0	0	3		
	13	13	0	0	2		
	14	34	0	0	1		
	15	4	0	0	0		
	16	0	0	0	0		
	17	0	0	0	0		
	18	0	0	0	0		
	19	4	0	0	0		
	20	6	0	0	0		
	21	0	0	0	0		
	22	0	0	0	0		
	23	0	0	0	0		
	24	0	0	0	0		
	25	0	0	0	0	Unknown	Total
Germinated		161	22	21	19	0	223
Not-germinated		-	9	1	-	295	305
						Total Seeds in Sample	528

Table B.23: BioLogic, Perfect Plot seed mix germination data (Plate B-3).

(B-4)	Day	Clover	Chicory	Rapeseed	Alfalfa		
	1	0	0	0	0		
	2	0	0	0	0		
	3	0	0	0	0		
	4	0	0	0	0		
	5	8	0	8	0		
	6	46	26	16	5		
	7	9	5	0	2		
	8	6	0	0	1		
	9	0	0	0	0		
	10	4	0	0	0		
	11	3	1	0	0		
	12	12	0	0	0		
	13	19	0	0	0		
	14	24	0	0	0		
	15	15	0	0	0		
	16	0	0	0	0		
	17	0	0	0	0		
	18	1	0	0	0		
	19	3	0	0	0		
	20	3	0	0	0		
	21	0	0	0	0		
	22	0	0	0	1		
	23	0	0	0	0		
	24	0	0	0	0		
	25	0	0	0	0	Unknown	Total
Germinated		153	32	24	9	0	218
Not-germinated		-	2	-	-	324	326
						Total Seeds in Sample	544

Table B.24: BioLogic, Perfect Plot seed mix germination data (Plate B-4).

(B-5) Day	Clover	Chicory	Rapeseed	Alfalfa	Unknown	Total
1	0	0	0	0		
2	0	0	0	0		
3	0	0	0	0		
4	0	0				
5	7	1	7	0		
6	40	13	9	0		
7	54	1	1	6		
8	35	1	3	0		
9	5	0	0	0		
10	2	0	2	1		
11	2	0	0	0		
12	8	0	0	0		
13	6	0	0	0		
14	26	0	0	0		
15	14	0	0	0		
16	0	1	0	0		
17	0	0	0	0		
18	3	0	0	0		
19	0	0	0	0		
20	1	0	0	0		
21	0	0	0	0		
22	0	0	0	0		
23	0	0	0	0		
24	0	0	0	0		
25	0	0	0	0		
Germinated	203	17	22	7	0	249
Not-germinated	-	3	-	-	241	244
					Total Seeds in Sample	493

Table B.25: BioLogic, Perfect Plot seed mix germination data (Plate B-5).

(B-6)	Day	Clover	Chicory	Rapeseed	Alfalfa		
	1	0	0	0	0		
	2	0	0	0	0		
	3	0	0	0	0		
	4	0	0	0	0		
	5	17	1	6	2		
	6	20	10	5	4		
	7	77	1	0	6		
	8	7	0	0	0		
	9	2	0	0	0		
	10	21	0	0	2		
	11	9	0	0	1		
	12	27	0	0	0		
	13	36	0	0	0		
	14	163	0	0	0		
	15	6	0	0	0		
	16	1	0	0	0		
	17	0	0	0	0		
	18	2	0	0	0		
	19	13	0	0	0		
	20	14	0	0	0		
	21	1	0	0	0		
	22	0	0	0	0		
	23	0	0	0	0		
	24	0	0	0	0		
	25	0	0	0	0	Unknown	Total
Germinated		416	12	11	15	0	454
Not-germinated		-	-	-	-	212	212
						Total Seeds in Sample	666

Table B.26: BioLogic, Perfect Plot seed mix germination data (Plate B-6).

(B-7)	Day	Clover	Chicory	Rapeseed	Alfalfa		
	1	0	0	0	0		
	2	0	0	0	0		
	3	0	0	0	0		
	4	0	0	0	0		
	5	0	0	0	0		
	6	34	14	12	1		
	7	29	4	3	3		
	8	71	2	2	6		
	9	5	0	0	0		
	10	31	3	0	0		
	11	14	0	0	0		
	12	21	0	0	0		
	13	14	0	0	3		
	14	27	0	0	0		
	15	4	0	0	0		
	16	0	0	0	0		
	17	21	0	0	0		
	18	0	0	0	0		
	19	17	0	0	0		
	20	6	0	0	0		
	21	0	0	0	0		
	22	0	0	0	0		
	23	0	0	0	0		
	24	0	0	0	0		
	25	0	0	0	0	Unknown	Total
Germinated		294	23	17	13	0	347
Not-germinated		-	3	-	-	270	273
						Total Seeds in Sample	620

Table B.27: BioLogic, Perfect Plot seed mix germination data (Plate B-7).

(B-8) Day	Clover	Chicory	Rapeseed	Alfalfa	Unknown	Total
1	0	0	0	0		
2	0	0	0	0		
3	0	0	0	0		
4	0	0	0	0		
5	19	2	8	0		
6	63	12	8	5		
7	31	1	2	3		
8	46	1	0	3		
9	2	0	0	0		
10	6	0	0	0		
11	0	0	0	0		
12	1	0	0	1		
13	8	0	0	2		
14	21	0	0	1		
15	3	0	0	0		
16	0	0	0	0		
17	0	0	0	0		
18	1	0	0	0		
19	4	0	0	0		
20	3	0	0	0		
21	2	0	0	0		
22	0	0	0	0		
23	0	0	0	0		
24	0	0	0	0		
25	0	0	0	0		
Germinated	210	16	18	15	0	259
Not-germinated	-	-	-	-	303	303
					Total Seeds in Sample	562

Table B.28: BioLogic, Perfect Plot seed mix germination data (Plate B-8).

(B-9) Day	Clover	Chicory	Rapeseed	Alfalfa	Unknown	Total
1	0	0	0	0		
2	0	0	0	0		
3	0	0	0	0		
4	0	0	0	0		
5	8	1	7	0		
6	55	29	0	6		
7	14	4	2	1		
8	14	0	1	0		
9	14	1	1	1		
10	32	0	0	3		
11	8	0	0	0		
12	14	0	0	0		
13	22	0	0	0		
14	5	0	0	0		
15	0	0	0	0		
16	0	0	0	0		
17	0	0	0	0		
18	2	0	0	0		
19	4	0	0	0		
20	0	0	0	0		
21	0	0	0	0		
22	0	0	0	0		
23	0	0	0	0		
24	0	0	0	0		
25	0	0	0	0		
Germinated	192	35	11	11	0	249
Not-germinated	-	7	-	-	270	277
					Total Seeds in Sample	526

Table B.29: BioLogic, Perfect Plot seed mix germination data (Plate B-9).

(B-10)	Day	Clover	Chicory	Rapeseed	Alfalfa	Unknown	Total
	1	0	0	0	0		
	2	0	0	0	0		
	3	0	0	0	0		
	4	0	0	0	0		
	5	5	0	4	2		
	6	49	16	11	0		
	7	44	2	1	3		
	8	94	1	3	0		
	9	9	1	0	0		
	10	9	2	0	1		
	11	4	0	0	0		
	12	13	0	0	0		
	13	26	0	0	0		
	14	18	0	0	0		
	15	8	0	0	0		
	16	2	0	0	0		
	17	0	0	0	0		
	18	0	0	0	0		
	19	1	0	0	0		
	20	0	0	0	0		
	21	0	0	0	0		
	22	1	0	0	0		
	23	0	0	0	0		
	24	0	0	0	0		
	25	0	0	0	0		
Germinated		283	22	19	6	0	330
Not-germinated		-	-	-	-	262	262
						Total Seeds in Sample	592

Table B.30: BioLogic, Perfect Plot seed mix germination data (Plate B-10).