Are Food Plots Effective at Protecting Row Crops?
An Analysis of Ecological & Agricultural Impact by Whitetail Deer

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Abstract:

The immense damaged caused by Whitetail Deer throughout the United States to various ecosystems, as well as agricultural row crop, has brought to attention the need for more methods of management of the keystone species. Though traditional methods such as hunting are still the primary source of management, new methods such as implementing the use of supplementary food plots to alter feeding patterns could be the next breakthrough in an effort to reduce both ecological and agricultural impact.. Utilizing four test locations of similar environmental and agricultural make-up, two of which supplementary food plots present, the impact caused by Whitetail Deer was recorded periodically throughout the summer and growing season of corn. The data was then compared to see if supplementary food plots could be used a Whitetail Deer impact management method. Results showed that the presence of a supplementary food plot did not significantly affect or alter the amount of damage caused by Whitetail Deer in either forest environments or agricultural fields. However, statistical analysis of the agricultural impact without taking distance into effect as the covariant showed significantly less damage to the agricultural fields located near supplementary food plots. The use of supplementary food plot as a management method to reduce the amount of agricultural impact caused by Whitetail Deer can be seen as an effective. Ultimately, the location of the plot, along with duration of presence and plant species used, will play a role in how effective it the plot is as a management method.

I. Introduction:

Whitetail Deer, *Odocoileus virginianus*, are a native species of the Cervidae (deer) family in North America, Central America, and South America. The species has been able to survive and thrive in many different types of ecosystems and environments. In North America, the current deer populations exist at higher densities in access of 120 percent of what they have been in the past few centuries (Rooney & Waller, 2002). This constant population growth is partially due to the breeding behavior of the species and the high rate of fecundity. As a result of the population growth, the need for food throughout the population grows thus resulting in an increased impact on the areas inhabited by Whitetail Deer. The increased demand for food by Whitetail Deer has not only led deer to eat more in prairie and forest environments, but also take to agricultural row crop fields as a food source as well as using these field as routes to other food sources away from the deer's home range. In areas where agriculture has a significant presence, the impact is felt at both an ecological level and agricultural level. Various management methods have been used in an effort to try and control the amount of damage that Whitetail Deer have caused to these areas. The use of supplementary food plots by farmers is one of the methods that is gaining more interest, though it is unclear if this method is effective or if it is having further effects both to the crops and forested areas near agriculture fields. Expanding on the seminal work of Kilpatrick and Stober (2006), we will be exploring how Whitetail Deer will react to the presence of an alternative/supplementary food source and the ecological impacts caused..

In comparison to many other animals, most Whitetail Deer breeding occurs during a considerably short period of time from mid-late November into early December. Not all breeding activity occurs during this span, however this is the period of time when the highest percentage of females breed. During this time period it was found that male deer, bucks, testes have the greatest volume while female deer, does, simultaneously showed the least amount of resistance to attempts at copulation and the highest frequency of urination onto their metatarsal glands, resulting in pungent substance known to attract males (Illige, 1951). Does reach sexual maturity at 1-1.5 years old, with mating commonly beginning at 1.5-2 years old and continuing through 7.5 years old (Verme, 1965). Successful fertilization of does ranged from 77-80 percent in multiple studies (Illige, 1951; Haugen, 1975). Depending on the diet of the pregnant doe, each doe is able to birth one to two fawns per year with a gestation period averaging from 198-206 days (Verme, 1969). Several studies done throughout the United States have shown that the average success breeding rate ranges between 65-74 percent with multiple areas in the Midwest averaging 80 percent success rates (Illige, 1951; Haugen 1975). In Illinois it was found the average breeding success rate for all age deer was 84 percent (Nixon & Etter, 1995). This ability to reproduce so successfully has led to what can be seen as an almost exponential growth in the Whitetail Deer population. Through archaeological, anthropological, and historical data it had been estimated that the species has an average density of 3.1-4.2 deer per km^2 in their North American range, but have also been recorded in different habitats with densities as low as 2-4 deer per km^2 and as high as in excess of 10 deer per km^2 (Rooney & Waller, 2002). Studies performed in the state of Illinois have shown statewide that deer densities were estimated at 4-5 deer per km^2 of total area and 30-37 deer per km^2 of forest (Roseberry & Woolf, 1998). This rising population in combination with the foraging habits of Whitetail Deer brings upon a serious crisis in the impacts these deer are having on their habitats.

Foraging habits of the Whitetail Deer show that there is no true structure as to what plant species and size are preferred for the entire population, but rather a variance in plant species preference based on the regions they inhabit. This foraging habit, or rather lack thereof, has caused dramatic ecological impacts to the forests, grasslands, swamps, and prairies that Whitetail

Deer populate. In Texas it was found that Whitetail Deer diets varied by plant availability in the areas of focus rather than by plant species. It was seen that through the duration of one year, Whitetail Deer in Texas had herbaceous plants making up 90% of their diets, which included forbs (68%), grasses (22%), and browse (5%) (Chamrad & Box, 1968). This reliance on plant availability rather than by category/guild is seen in different climates and ecosystems throughout the United States. In areas of the northern Midwest and the greater Northeast it has been recorded that deer have had both negative direct and indirect impacts on various tree and plant species including Eastern Hemlock, Northern White Cedar, white-flowered trillium, and wild lily-of-the-valley. The recruitment of Eastern Hemlocks has suffered so immensely the species is no longer able to replace itself. Northern White Cedar, white-flowered trillium, and wild lily-of-the-valley recruitments were also found to have been directly affected by the foraging of Whitetail Deer although to a lesser degree of impact (Rooney, 2001). This reduction in individual plant growth and plant population growth shows a selective foraging feeding habit by Whitetail Deer in which they mainly feed upon new growth of already established saplings and plants, as well as newly sprouting trees and plants. Resulting from the constant foraging on young plants and trees, deer-caused stem morphology and reduction in plant growth rates are being seen more commonly in various forest communities in the Midwest and Northeast (Russell, 2001). In a study done by Augustine and Frelich (1998) it was also seen that in Minnesota the size of the Whitetail Deer population had a direct effect on white-flowered trillium. In areas of high deer density, grazing damage was much greater on the trillium plants resulting in much less growth, smaller leaf sizes and a lower flowering rate. Compared to protected areas, the flowering rate was 19 times lower in areas of high deer density, which correlates directly to a significant reduction in pollination and the spreading of the species.

Along with larger plant life, Whitetail Deer are found to have a profound effect on the understories of many forest environments. Understory communities are found to have the greatest damage in both direct and indirect impact. In a study by Rooney (2001) Whitetail Deer foraging completely altered two forests understories eliminating 48 and 81 percent of understory species in a couple decades. When high intensity browsing to understories occurs, reductions in vertical habitat complexity are common. This results in the reduction of nesting and feeding habitats for various shrub-nesting bird species (Rooney & Waller, 2002). As Whitetail Deer continue to browse upon the same plant species, the plant species they do not prefer, such as highly invasive garlic mustard and hay-scented fern, begin to take over the forest understory (Rawinski, 2008). Hay-scented fern causes additional negative impacts to the forests by preventing the seeding of many of tree species native to North America (Cote *et al.*, 2004). This prevention of seeding in combination with the heavy foraging on acorns in White Oak dominated forest of the Midwest resulted in the 11 percent decrease in dominance of the White Oak species (McShea *et al.*, 2003). What originated as a singular source of impact has progressed into a multilevel ecological modifier.

Along with the ecological impact Whitetail Deer have in forest environments, they have very drastic effects in cropland as well. In areas with a high percentage of the land being used for agricultural (<50%), in particular row crop farming such as in Illinois, the damage caused by deer can be extremely detrimental to both the crop itself and the farmers financially. With a strong agricultural presence in Illinois for the greater part of the past century it can be justified that Whitetail Deer have seen and still see crops in agricultural fields (10 acres or larger) as a natural food source through part of each year, that duration being the growing season until the crop is harvested. Row crop fields make up over 54 percent of Illinois landscape as well as 42 percent of the optimum-foraging landscape fit for Whitetail Deer (Roseberry & Woolf, 1998). With almost half of the optimum species feeding ground for Whitetail Deer in the state being agricultural landscape, this further backs the notion that deer see row crop in Illinois as a natural food source. In a 1993 study by Wywialowski (1996) it was found that $92 million in damage to corn crops occurred across ten states in the Midwest, with deer being one of the three primary damage causing wildlife species. While studies of Whitetail Deer movement and impact, and management forms, are extensive in forest environments throughout the United States, little information on movement, impacts and management exists in areas of intensive row crop farming.

In attempts to try and regulate the amount of impact the Whitetail Deer population causes in certain areas of the United States various management methods are practiced. These different methods include hunting, private game management, nuisance (damage) license, culling and the introduction of supplementary food sources in the form of food plots to deer populations. Hunting is the most well-known and common method for Whitetail Deer management throughout the United States. However in the past two decades the population of hunters has decreased while deer populations have increased. With an aging hunter population and low recruitment of new hunters throughout the nation, further decline in the hunting population can be expected (Riley *et al.*, 2003). From 1980 to 2000 the number of license hunters in the United States drop by 1.2 million (Grady *et al.*, 2003).

Along with the large decrease in the hunting population, the shifting interest of many in the hunting population from “meat hunter” to “trophy hunter” is taking away the management aspect of what hunting is supposed to represent (Grady *et al*,. 2003). In Illinois the total number of Whitetail Deer harvested per year from hunting alone has declined by 55,489 over the past decade (IDNR, 2015). This inverse trend has led to Illinois’s, along with many other states, Department of Natural Resources re-evaluating management methods and the quotas that are allowed for hunters. In doing so the Department of Natural Resources in multiple states along with the United States Fish and Game Service have taken steps in an attempt to motivate hunters to harvest female and antlerless deer as a feasible way to manage the ever-growing Whitetail Deer population through hunting (Decker & Connelly, 1989). Private game management along with nuisance license are used much less in comparison to hunting but are still often used in areas of new housing or commercial development and by farmers and owners of large plots of land with animals causing extended damage to their crops or property. However this method, depending on the state, can cost the farmer upwards of $300.00 as well as having to follow strict regulations at both federal and state levels, along with some county and municipality regulation (IDNR, 2015).

Deer culling is a popular form of management used by many Department of Natural Resources agencies as well as many Fish and Wildlife agencies as a way to manage Whitetail Deer herds at various levels, but most commonly at the county level. Culling is the process of controlling a herd or population size of a group of animals through the removal of certain animals by selective killing or slaughtering. Whitetail Deer culling is frequently done for two main reasons, those being to control the population size and to prevent the spread of wildlife diseases, such as Chronic Wasting Disease (CWD), within the population. From this two types of culling techniques used by management officials exist, non-selective culling and selective culling (Wasserberg *et al.*, 2009). Non-selective culling targets to remove any deer within a certain population or area depending upon the location, and is most commonly used for population control but is also used in disease control management as well. Selective culling targets to remove only certain members of the deer population, and targets only those that show undesirable traits or evidence of disease (Wolfe *et al.*, 2004). When taking the desired animals, the trained sharpshooters performing the culling are doing so in the most humane manner possible by aiming for the deer's head (brain) or neck (spine) to ensure a quick death with the least possible suffering for the animal (DeNicola *et al.*, 2000).

However the use of culling as a viable management option brings upon many risks and controversial issues. Without the proper pre-culling Whitetail Deer population density estimates compared to the amount of damage that has occurred to the locations of focus, the culling of either too many or too few animals could occur thus resulting in over-kill to the herd population or no change to the amount of damage occurring to the ecosystem (Gill, 1992). The location in which the culling is taking place plays a major role in risk factor as well. With a majority of culling occurring near suburban and developed areas, the potential of human interference is very present even with warnings given to the surrounding population and restricted access to culling areas. In culling programs such as that of the Will County (IL) Forest Preserve District, the areas of removal were all located near private land and housing communities (WCFPD, 2014). While most firearms used for culling in these suburban areas are fitted with suppressors, the public reaction to noise associated with the discharge of a firearm is often negative (DeNicola *et al.*, 2000). Along with these risks there are many controversial issues surrounding the ethics and how humane culling actually is. Animal rights groups have spoken out about the way in which Whitetail Deer are being harvested and handled post kill. In the case of the Will County culling program, the animal rights group SHARK (SHowing Animals Respect and Kindness) has made public outcry claiming that forest preserve officials are searching for animals to cull rather than taking the animals targeted at bait piles and that officials are letting animals suffer once shot (Miller CBS, 2015). With such controversy present, the search for less debatable management methods is ever present.

One method becoming progressively more common throughout the United States for managing Whitetail Deer impact in both forests and agriculture fields is the introduction of supplementary food sources. This supplementary source is primarily planted in the form of a food plot.

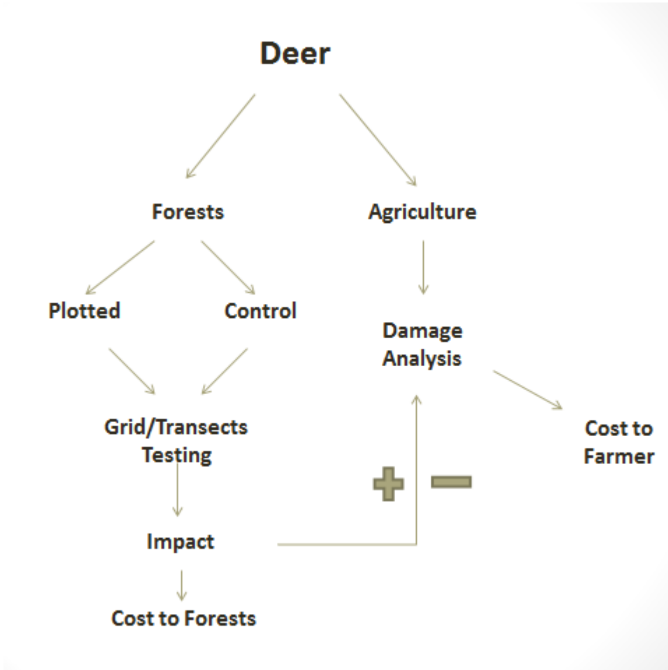
Supplementary food plots are small plots of land, usually ranging only a few acres in size, that provide an alternative food source to wildlife. Many outdoorsmen, conservationists, and farmers will plant supplementary food plots for the purpose of attracting wildlife for hunting, with use most commonly for targeting Whitetail Deer. These alternative food sources can be made up of single species or multi-species plots with plants such as alfalfa, sugar beets, clover species, chicory, or oats being used most commonly. Though some of the species of plants found in food plots are native in some regions of the country and could be considered as a present or *natural* food source, the plant population density or number of plants present per area is not naturally occurring in the areas in which they grow.

Plant preference in plots also varies with the region in which it is being planted and depends upon certain factors such as climate, soil makeup, and nutrient content of different soils (MacGown, 2002). A study by Hehman and Fulbright (1997) found that in warm season of the southern United States deer will browse more heavily on supplemental food sources due to the lack of nutrients in the food sources in the surrounding area. Various food plot plant species, such as Alfalfa and Clover, are semi-perennial plants with the ability to survive harsh winter conditions offering Whitetail Deer a food source and nutrient supply other than the leaves and fallen fruits of the surrounding plant life. This gives budding tips and seeds on the surrounding plant life a chance to grow and germinate. The availability and cost of supplementary food plots varies based upon multiple factors including, the quantity of seed needed to plant a selected area, desired density of growth, quality of seed blend and the plant species that is desired for the plot. Ready to plant three year semi-perennial alfalfa seed food plots, which are frequently used throughout the conservation and hunting community, are very affordable ranging from $9-$10.50 per pound (ImperialSeed, 2015). As a well-known implement used by sportsmen and conservationists that has the ability to withstand the various conditions present in the United States, supplementary food plots have the ability to be a cost effective deer impact management but would need to be closely analyzed to see how effective they could be in multiple habitats.

In order to properly follow the focuses of the study, Figure 1(below) breaks down the different focuses that were be analyzed along with breaking down the steps in which the study itself was ran. With the focal point of Whitetail Deer impact and the presence of both an ecological and agriculture aspect being analyzed simultaneous throughout the duration of the study, it is at the highest importance to keep the aspects separate from one another.

The ecological side of the study, labeled Forests in the diagram, shows the split in which the variable of a food plots presence would be tested against that of a non-plotted, or control area. From this the method of testing at all testing locations would be the same to eliminate any chance of another variable. Following the testing was the calculation of total damage, or impact that occurred at all test sites. The impact can then be address exclusively for the ecological damage that occurred, as well as being related over to the agricultural view of the study for further analysis.

On the agricultural side of the study, labeled Agriculture on the diagram, one perspective of total damage to agricultural row crop at each testing location was tested. Once the data was analyzed it was then compared to the ecological data to see if the presence of a supplementary near the agriculture field prevented or caused more damage to the crops. This correlation can then be interpreted as a positive or negative influence, as represented by the plus and minus symbols. In both the case of the presence of a plot being detrimental to the crop or benefiting the crop, the cost to the farmer can be analyzed. This cost would be in the form of how much seed is necessary to plant a food plot to benefit the crops, or how much more damage was done to my crops with the presence of a supplementary food plot. This breakdown of the study into two areas of focus will allow for proper analysis and collection to occur with a lesser data being confused due to the complete separation of the focal points.



<u>Figure 1:</u> *Flow chart break down of the two focuses and perspectives of the study. Following the forests path, the study is viewed at from an ecological perspective. The main concern from this perspective is whether the presence of a supplementary food plot affects the amount of ecological damaged caused by Whitetail Deer. Following the agriculture path, the study is viewed at from a farmer's perspective with the main concern being on crop damage caused by Whitetail Deer. Once total damage/impact is collected from both perspectives, the analysis of whether the presence of a supplementary food plot in a forest near an agriculture field affected the amount of damage at each location.*

With multiple points of focus present in both the ecological and agricultural aspects of the study, multiple main objectives will be focused upon as well. The main objectives are to analyze how Whitetail Deer will react to the presence of an alternative/supplementary food source, determine the degree of impact deer have on areas with both forest and agricultural make-up, and to ultimately conclude whether or not the presence of a supplementary food plot plays a role in the ecological impact that Whitetail Deer have on the surrounding area. Along with this, the study will be analyzing and concluding if the introduction of a supplementary food plot could decrease agricultural impact but increase impact found in forest, and whether the introduction of a supplementary food plot would be a cost effective management strategy. It is predicted that the introduction of a supplementary food plot will increase the amount of impact caused by the Whitetail Deer in a forest environment, while simultaneously reducing the amount of damage they cause to agricultural row crop fields near the plotted area.

III. Methods:

Site Selection:

Food plot sites and control sites with similar environmental conditions were selected to test whether the presence of supplementary food plots reduce the amount of deer induced damage to agricultural fields and woodlands. Various locations around the counties of Will, Grundy, Livingston, and Kankakee in Illinois were surveyed to find the proper locations to have areas with the most similar forest and agricultural make up. Two general locations and four testing sites with very similar agricultural and deciduous forest make-up were found win Wilmington, Illinois and Coal City, Illinois. Prior to the planting of each of the food plots preliminary photographs and documentation were taken to note the presence of any disturbance or damage that had already been present at each site. On April 3rd and 4th, 2015, the planting of two separate supplementary food plots took place, one in Will county located in Wilmington, Illinois, Simms's Plotted (A) and the other located in Grundy County in Coal City, Illinois, Grundy Bottoms (B). On June 22nd a series of tornados moved through the greater Coal City area completely destroying the Grundy Bottoms (B) test site. To replace these destroyed sites, another general location with two testing sites with similar agricultural and deciduous forest make-up was found in the township of Ritchie, Illinois, located southeast Wilmington, Illinois. Another plot and control site were planted in Richie, Illinois on July 3, 2015. This site will be identified as Ritchie Plotted (B).

Table 1: Site Information

Site	Site Name	Location	GPS Coordinates	Plotted/Contro	General Characterisics
A	Simm's Plotted	Wilmington, IL	41.314036°N, 88.179530°W	Food Plot	Deciduous, Near Natural Spring
A	Van Duyne Control	Wilmington, IL	41.309482°N, 88.205180°W	Control	Deciduous, Near man made lake
B	Ritchie Plotted	Ritchie, Illinois	41.257973°N, 88.092141°W	Food Plot	Deciduous, Near Forked Creek
B	Milton Control	Ritchie, Illinois	41.245095°N, 88.101243°W	Control	Deciduous, Near Kankakee River

Planting:

Both plots were planted using a disc, spread, cover and culti-pack method. This planting method consists of first using a disc harrower pulled behind an all-terrain vehicle to break the surface of the soil and till up soil to a depth of three inches. Following discing the selected area, five pounds of Whitetail Institute Imperial Alfa-Rack Plus Perennial alfalfa seed was spread and dragged over with a length of chain link fence to slightly cover the seeds. Lastly, a culti-packer roller was pulled over the plot to drive the seed even farther into the ground. This process was done only at the plotted areas. Each of these food plots are approximately one half acre in size. The two plots were each fertilized with three pounds of common 20/20/20 fertilizer at two weeks after planting as well as at four weeks after planting. This fertilizer is a mix of 20% Nitrogen, 20% Phosphorus, and 20% Potassium per bag and was used according to recommendations via Whitetail Institutes to ensure the maximum amount of growth for the Alfalfa plants. Experimental data collection began once the plants sprouted.

Figure 2: *Image of the planting process at Simm's Farm Plotted (A) on April 3rd, of 2015. The object on the bottom right corner of the picture is a disc-harrow which was used to cut through the present vegetation and till up fresh soil for planting.*

Control Sites:

At each test site a control test location/plot of the equivalent half-acre size was established. These sites will be referred to as Van Duyne Control (A) and Milton Control (B). The control locations were selected based upon similarities of the agricultural and ecological forest makeup compared to that of the plotted site it corresponded with as well as the other test location. The location of the Van Duyne Control plot (A) is approximately 1.37 miles southwest of its corresponding test spot Simm's Plotted (A). The Milton Control plot (B) is approximately one mile from the plotted area of Ritchie Plotted (B). Preliminary photographs and documentation of any pre-existing disturbance or damage were taken down as well for the control sites prior to the beginning of the study.

Test Site Locations:

Figure 3: *Satellite image of the Simm's Plotted (A) study site located in Wilmington, Illinois from May of 2015. This site was the first plotted are planted to begin the study.*

Figure 4: *Satellite image of Van Duyne Control (A) study site located in Wilmington, Illinois from May 2015. This site was the first of the control sites established for the study*

Figure 5: *Satellite image of the Ritchie Plotted (B) study site located just outside of Wilmington in the township of Ritchie, Illinois. This picture was also taken in May of 2015.*

Figure 6: *Satellite image of the Milton Control (B) study sites located in Ritchie, Illinois from May 2015.*

Agricultural aspect:

Each of the locations, that being Wilmington (Test Site A) and Wilmington (Test Site B), had agricultural fields making up one-fourth of the testing area of the transects. These areas exist both at the locations of the plotted areas as well as both of the control areas. These sections of agricultural row crop under analysis were located on the Eastern transect of each of the four sites. Approximately 60 meters of the 120 meter Eastern transects were located in the agricultural fields. Each of the agricultural fields being analyzed was made up of a corn crop.

The sections of these transects in the agricultural fields were further broken down and gridded off branching from the transect both north and south to extend the area of study. These extended grids ran 7.5 meters in both directions (N/S) from the transects. This expansion brought the total area of agricultural analysis to 900-meter^2. These areas were also photographed and documented prior to the beginning of the study to account for prior damage and disturbance that was pre-existing.

Data Collection:

In order to capture, document, and track the changes that had occurred at each of the sites, a timeline for recording data from the time of first sprout until the removal/harvest of the corn crop (October 25, 2015) was followed. This time period allowed for optimal data collection during many time periods including: the growth cycles of deer, the growth plotted areas, and the pre-rut stage of Whitetail Deer. The "pre-rut" is a period of time ranging only a few weeks usually beginning in early to mid-October (*Depending on region)* prior to the Rut when male deer activity begins to increase and female activity starts to decrease. The "Rut" is period ranging from 1-3 months, beginning between late October and early to mid-November (*Depending on region)*, in which Whitetail Deer mating occurs and the amount of male deer movement tends to reach its yearly high, while female deer activity reaches its low (Holzenbein & Schwede, 1989). Both sites at each location were checked every three to four days during the months of June, July and August. From September through the end of data collection on October 25, 2015, each plot was checked as often as possible, but with no true schedule due to interference with the beginning of the fall semester. The spacing in-between checking periods was done to prevent an excess of human scent contamination at each location so that the deer population would not be scared or pushed out of the areas. This allowed the deer behavior to be as close to natural as possible with as little human interference as necessary, while still being able to collect an adequate amount data. This gap between checks also helped prevent flaws in data collection and observation, such in the case that other animals of the forest feed over the areas in which deer had, thus giving a flawed observation as to how much of an impact the deer population truly had.

The use of transects to collect data was also optimized during the duration of the study. Transects at each site were established, all of which ran east and west from both the plotted and control areas and were measured out to 120 meters from a central point of reference. These transects were lines of guidance for examination away from the center point of the plots and control areas. Since the alfalfa plots will be part of the study, in terms of recording damage done to them as well, there will be no buffer zone to the edges of the plots. This kept the testing areas of both the control and plotted sites the same. Two trail cameras were placed at each location allowing for the capturing of deer feeding habits and what they are eating, along with what other wildlife species came through the testing areas and the damage in which they caused. These cameras were placed at opposite corners of the food plots with one facing the south and one facing the north. At the control sites trail cameras were also placed in the same north and south orientation. The cameras at each location were placed as close to equidistant from the center points, that being 31.8 meters. Each trail camera had 160° of capturing capability allowing for full coverage of any wildlife walking both in and out of the areas in all directions. These cameras allowed for visual way of tracking deer density and population in the greater area of each site.

On Site Data Collection:

Grid:

Along with the use of trail cameras, on site field assessments have been done at all locations throughout the duration of the study. During the field assessments multiple measurements relating to the total ecological impact caused by deer were taken. In the food plotted sites browsing damage caused by deer was calculated by utilizing a grid measurement system. Each of the plotted areas was planted in a 45-meter by 45-meter square that could be separated into nine smaller individual 15-meter by 15-meter sections sectioned off using 50 meter measuring tapes in the same orientation as the image below shows. The amount of browse in each of these sections was then measured to gather the total area effected in square meters. This measurement was then recorded and calculated as a percentage of the section in which it was in. This measurement technique was used at both plotted locations thru the entire duration of the study.

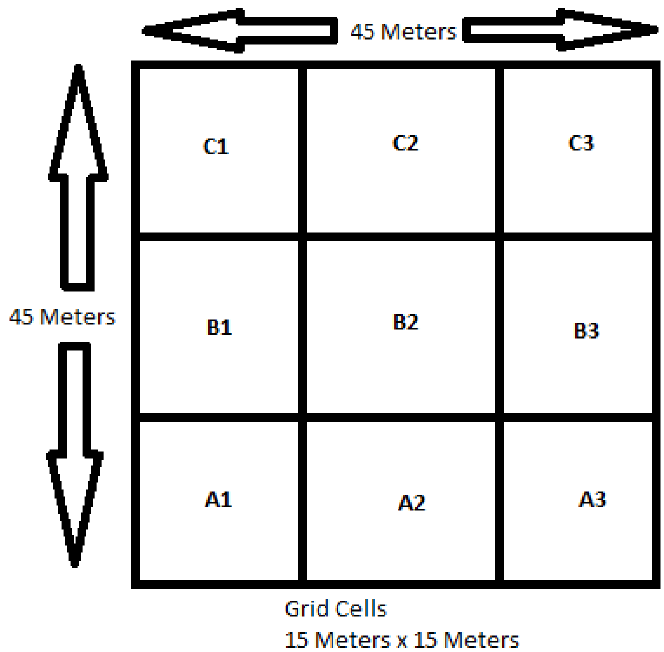


Figure 7: *Grid system used to measure the amount of damage at all four study sites*

At the control sites, this same grid measurement system was also utilized with a few modifications to establish the same amount of area around the central point as plotted sites. The same 45-meter by 45-meter square used for the plotted sites was measured out using 50-meter measuring tapes and marked off at each corner using blaze orange spray paint. Using a laser range finder the distance from each corner to the center point was measured to ensure equal distance at all points. This area was then broken down into the same nine 15-meter by 15-meter sections as the plotted sections. Measurements of the total area of browse by deer were also done using the same technique as stated in the paragraph above.

Transects:

Line transects were also utilized to test farther away from gridded areas. These transects were orientated both east and west of the center point and ran a distance of 120 meters in both directions. Theses transects were laid out using a compass, laser alignment tool, and three 50 meter measuring tapes. Along these transects were recording points located every 20 meters. These points were marked with environmentally friendly spray paint. At each of these 20 meter points of interest a circular area with a diameter of 8-meters was established as an area of focus. An 8 meter wide PVC pipe ring was used to mark each of these areas when measurements were being taken. Browse damage done to the forest floor and up to 3 feet off the ground in these areas was measured and recorded in terms of area in square meters and further calculated as percentage of the 50.27m² area of the circle. Data from the transects at both control and plotted locations was first kept as all individual recordings. Recordings at all of these areas of focus were kept individually based upon the direction of the transect it was located on as well as being further compiled for the total area of damage done along the transects for each site. The figure below is similar to the layout used when collecting data.

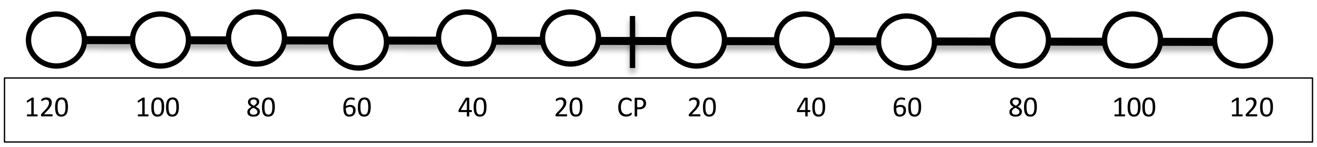


Figure 8: *Transect system with circular points of interest used to measure damage away from the grid system at all four sites. (CP=Central Point)*

Along with these points of interest, all damage and disturbance by Whitetail Deer that are in plain sight along the transects were also recorded. All damage that is located above the 3 feet from the forest floor in the areas of focus was added into this category of in plain sight. This data was all then added into the total damage for the transects in each direction as well as the total at each location. This allowed for the greater area surrounding each of the locations to be properly sampled and all data from each sight to be analyzed in the same proportion.

Complimentary to the data collected at each individual transect, the total damage and disturbance for both transects at each plot was also combined to give the total amount of impact caused by Whitetail Deer in each area as a whole. The total amount of damage at each site will be summed and categorized by its location at a control or food plotted sections.

Agricultural Damage:

At each of the test sites the eastern orientated transect from each plot ran into an agricultural field which had been planted with corn. Each of these sections of the transects stretched 60 meters into the fields. As stated previously in the section above the areas of focus for the transects will be every 20 meters, however in these sections where row crop agriculture is present a modification to the analysis was done as stated previously in detail in the *Data Collection* section.

For this stretch of the transects, the points of interest were placed every 10 meters along the transect with a focus on damage caused by Whitetail Deer to the crop. At each of these points of interest the same circular area of focus was used, however the diameter of these circles were four meter instead of the eight meters used along the rest of the transect. Along with the points of interest, the damage analysis in this area also followed a grid format explain earlier in the *Agricultural aspect* section.

Identifying Damage:

The signs of disturbance by Whitetail Deer will be the main aspect looked for on these transects as well as in each of the grid systems. These signs of disturbance include: broken branches and stems of trees higher than 3 feet off the ground, trample and deer trails, footage of deer feeding in plots via game trails, and observable feeding locations along the transects identified by comparison to feeding evidence found in plots.

In order to properly determine and analyze the damage that is done to the surrounding area and making sure that it is in fact caused by Whitetail Deer, camera evidence along with identifying signs of deer activity, such as rubs, scrapes, location of droppings, and track identification, will be used. Identifying deer tracks in locations of interest is the easiest way to determine if it was caused by a deer but also checking higher up on branches to look for marks of browsing or damage caused to plants where a deer could have either broken part of the plant with an antler or its head. Identification of damage due to feeding was analyzed comparing known feeding evidence to that of areas which were considered unidentified. These known spots will come from the plotted areas with trail cameras present to pinpoint that plants that were in fact fed upon by deer. Being able to identify signs of damage not caused by Whitetail Deer was also very important. This allowed for the ability to be able to set aside any data that is seen unfit or not related to the total impact caused by Whitetail Deer to try to keep the test as true as possible. In doing so identifying other species tracks and droppings is a high priority. This supplementary data could later be taken back into effect and compared for all 4 sites again. Along with this I must be aware of the edge effects of the forests as the transects head toward the agricultural fields. Edge effect refers to the fragmentation and changes in population or community structure that occurs at the boundary of two habitats (Alverson, 2005). Depending upon the habitat that is at hand that lasting edge effect can run into the wooded area well over 100m and as little as 40 meters (Alverson, 2005). With it known that Whitetail deer typically thrive in this edge habitat, the establishment of a boundary must be made official upon the first data collection period. The data that will be collected in the edge area must also be examined more closely to determine the true cause of damage or disturbance.

Identifying damage in the agricultural fields caused by Whitetail Deer required a more in-depth analysis of any damage found due to the dramatic change in environment from that of a deciduous forest. Trample was the easiest to distinguish whether it was caused by deer or not. Locating the path in which deer took via identifying their hove prints was the primary key to establishing if the damage was caused by deer. Identifying the areas in which Whitetail Deer had fed on the corn crop was done by comparing bite marks found in the field to a bite pattern sample provided by the Illinois Department of Natural Resources office located in Wilmington, Illinois. Along with this, feces samples throughout the areas were analyzed to determine both Whitetail Deer presence and feeding.

Statistical Analysis:

Data from each of the sites was collected in a field notebook through the duration of the study. Data was then organized and transferred into a Microsoft Excel spreadsheet file for preliminary analysis and to construct preliminary graphs.

Upon the completion of the data collection process and complete organization of all measurements, the data was then transferred and orientated properly again into IBM SPSS Statistical analysis software. The data was then analyzed using multiple ANCOVA (Analysis of Covariance) tests. These tests were ran with the presence or absence of a supplementary food plot set as the fixed factor or independent variable, the distance from the food plot as the covariant, and the total amount of damage as the dependent variable, to find if a significant correlation between the presence of a food plot and the amount of total impact existed.

The first ANCOVA test analyzed the total damage of all grids along with transects data included based on a site only analysis, to the presence or absence of a food plot. Thus meaning that all of the data was entered separately based upon the site it was from. This test also left out all agricultural damage. The second ANCOVA test analyzed only the agricultural damage collected to that of the presence or absence of a food plot on a site specific basis as well.

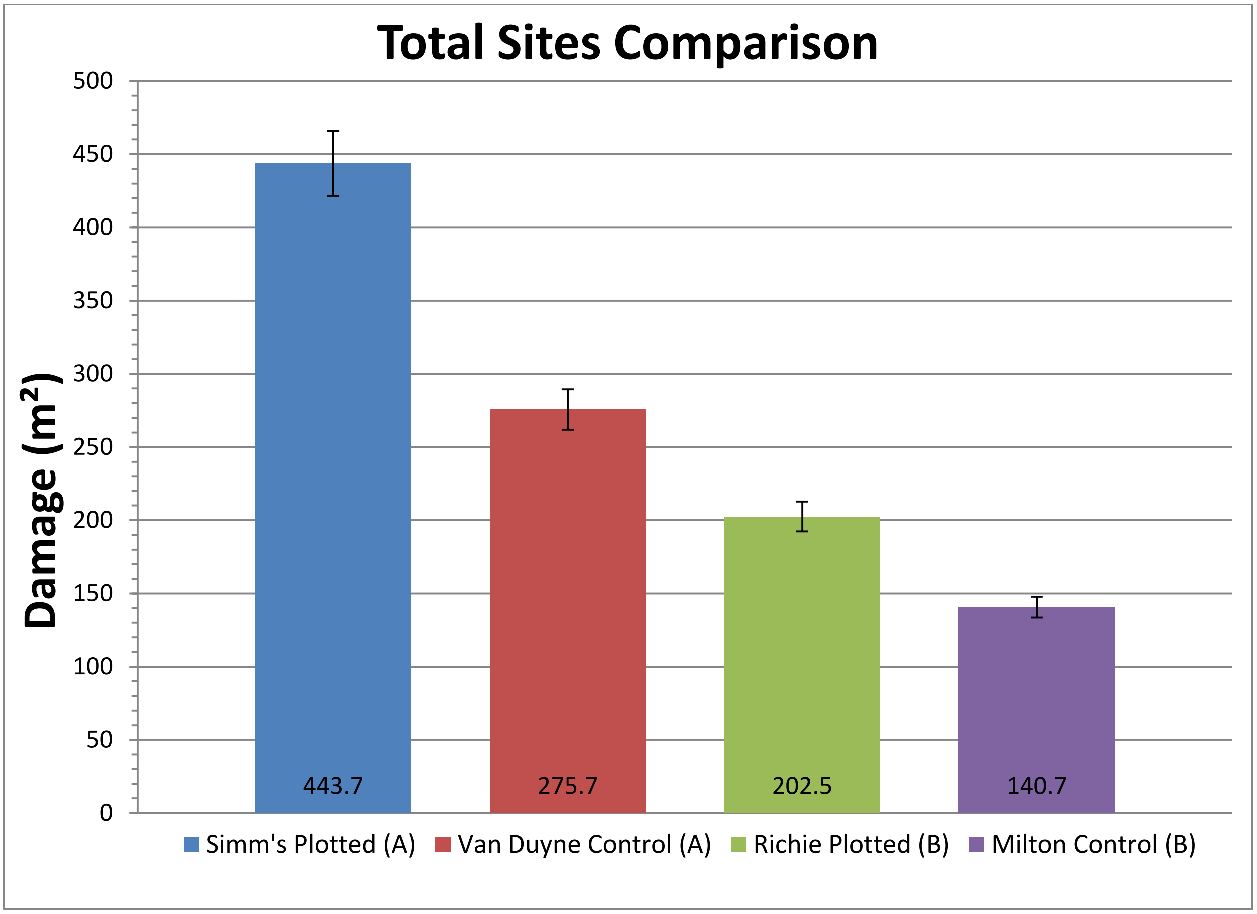
The third ANCOVA test analyzed the total impact of all grids and transects, however this time the data was combined into only “plotted” and “control” groups. Thus the transects at each location were also summed based on distance and directional orientation. This analysis was run without the input of any agricultural damage. The fourth and final ANCOVA test analyzed only the total combined agricultural damage from each “plotted” and “control” site and was organized and summed by its distance. Following the completion of the fourth ANCOVA all statistical data was ready to be reported.

IV. Results:

The main objective of the study was to determine how Whitetail Deer would react to the presence of a supplementary food plot. From the data gathered and presented in the graphs on the following pages, the trends and impacts caused by Whitetail Deer in both woodland and agricultural settings can be seen. The various statistical data ran through SPSS showed that the total impact that resulted in both forest and agricultural row crop fields were not statistically significant with a covariant present. The significance of the presence or absence of a supplementary food plot having an effect in the forest setting came out to be 0.542 and 0.648, which can be translated to a 54.2% and 64.8% chance that these results could have occurred by random error. Results found for ANCOVAs that analyzed only the agricultural damage showed data with more correlation but was still considered insignificant. The significance of the presence or absence of a supplementary food plot while just analyzing the agricultural impact came out to 0.613 and .059, or that it had a 61.3% and 5.9% chance of these outcomes occurring by random error.

In Figure 9 (below) the overall comparison of total damage is shown. This shows that both of the areas that were planted with supplementary food plots had a greater amount damage caused to them by Whitetail Deer. The control areas were still impacted greatly through the duration of the study but much less than the plotted sites they were paired with. The damage at the Van Duyne Control site (A) was 62% of that which occurred at its partner site Simm’s

Plotted (A). While the Milton Control site (B) received 69% of what had occurred at its partner site Ritchie Plotted (B). This first analysis trend begins to hint at the possibility that supplementary food plots could increase overall damage.



<u>Figure 9:</u> *Calculated total impact comparison of Control vs. Food Plots by individual site, with transect damage included for each site.*

In Figure 10 (below) the comparison of only the grids at each location is shown. It is revealed that the plotted sites suffered much more damage than that of the control sites. The trend of the plotted areas taking more of an impact is continued on this graph from that seen on Figure 9 (above). The control site grids at both testing areas showed much less impact caused by Whitetail Deer with 45% less damage at Van Duyne Control site (A) compared to the Simm's Plotted site (A) and 40% less damage at the Milton Control site (B) compared to that suffered by the Ritchie Plotted site (B).

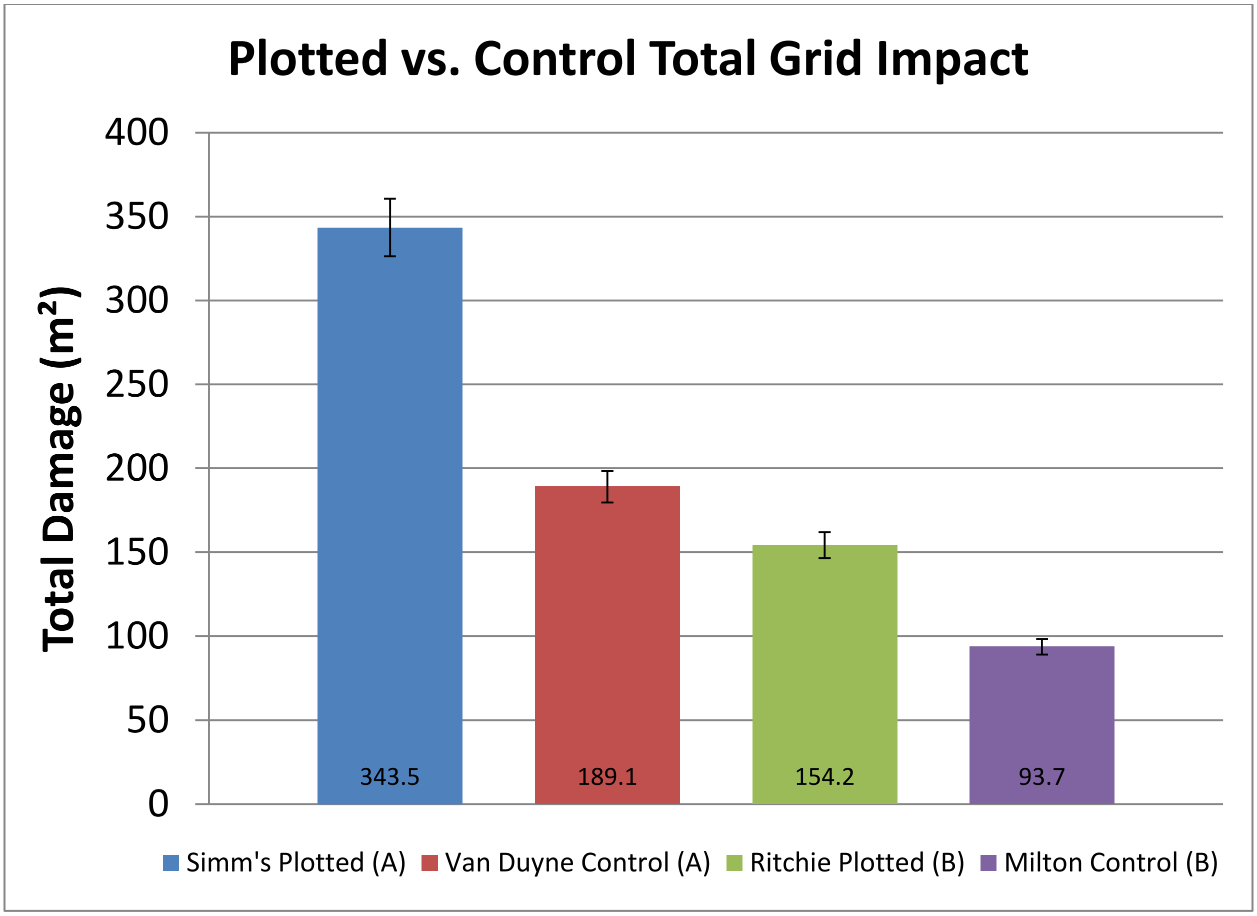


__Figure 10:__ *Calculated Grid-only impact comparison for each site. Agricultural and Transect damage not analyzed*

Figure 11 (below) presents a more in depth progressional breakdown of the constant impact that the plotted and control areas of Site (A) had during the duration of the study. This line graph gives the greatest insight from the study into how different the control and plotted areas were affected by Whitetail Deer. In the beginning of the study it can be seen that the impact to both of the sites was fairly similar. This is due to the early growth stages of the Simm's Plotted site in which little vegetation could be found on the plot. As the growing season and study progressed the amount of impact to the plotted area increased as both the amount of alfalfa and density of alfalfa plants in the plot increased. The trends found near the September 25th marker related very closely to the increased activity found by Illige (1951). That is during the beginning of the fall just prior to the "Rut" deer activity and feeding increases, especially in males. The quick jump in impact from September 7, 2015, through October 14, 2015, is explained by the increase in activity in both the control and plotted sites, though the Simm's Plotted site was a much more dramatic increase compared to that of the Van Duyne Control site.

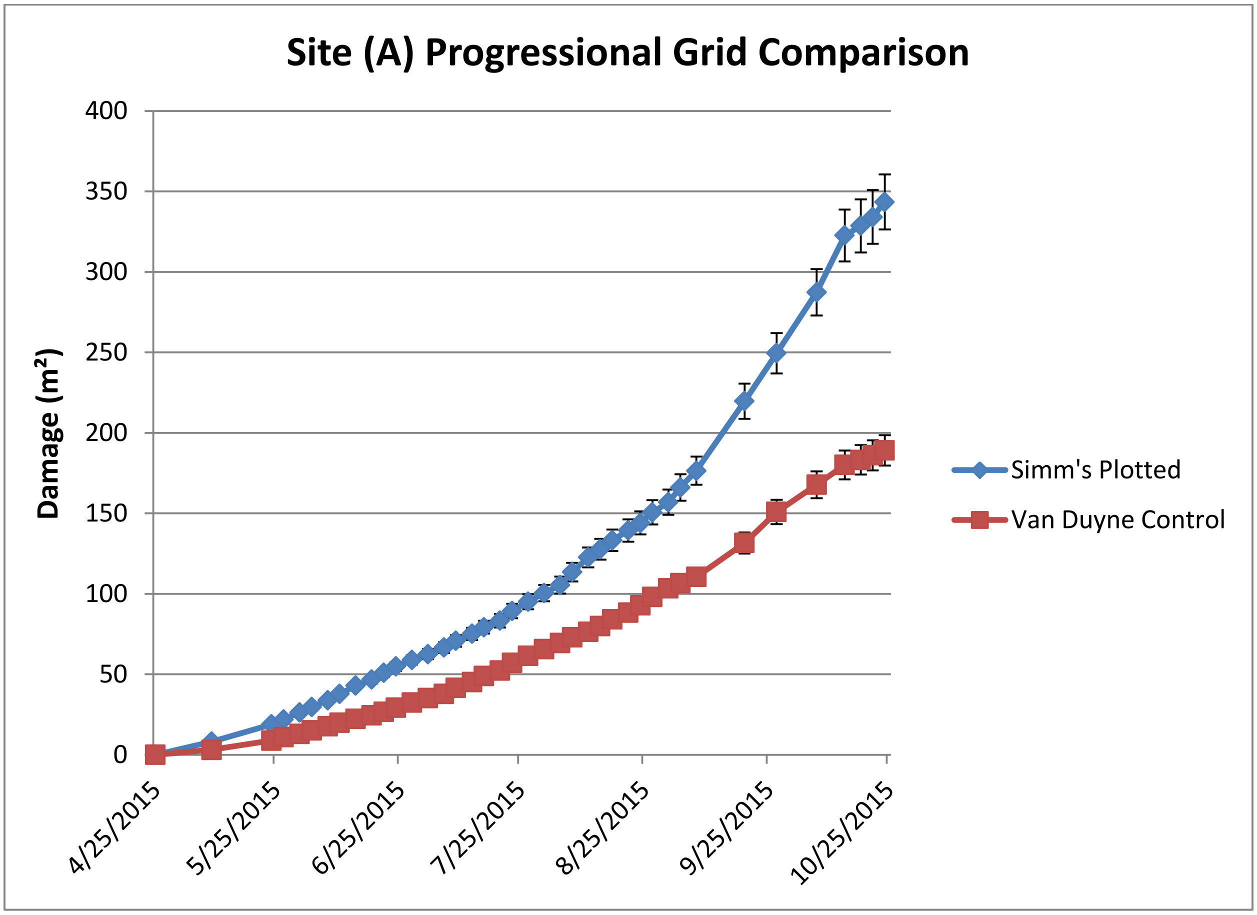


__Figure 11:__ *Calculated progression comparison of Site (A) Control vs. Plotted through the entire duration of the study. Data points broken down by days of collection.*

Similar to that of Figure 11, Figure 12 (below) shows a more in depth progressional break down of the constant impact that occurred at the Ritchie Plotted site (B) and Milton Control site (B) testing locations through the duration of the study. The trends on this graph are very much similar to that of Site (A) locations while having a much shorter duration of data collection and measurement. Again a dramatic jump in the impact from September 7, 2015, through October 14, 2015, is very easily seen at these locations as well. The intensity of damage done to the plotted area (Ritchie Plotted) compared to that of the control (Milton Control) on a shorter duration basis can be clearly seen in the graph. With the shorter growth period allowed for this area, this presents the trend that Whitetail Deer activity does not change based upon amount of growth and density but rather the time of the year.

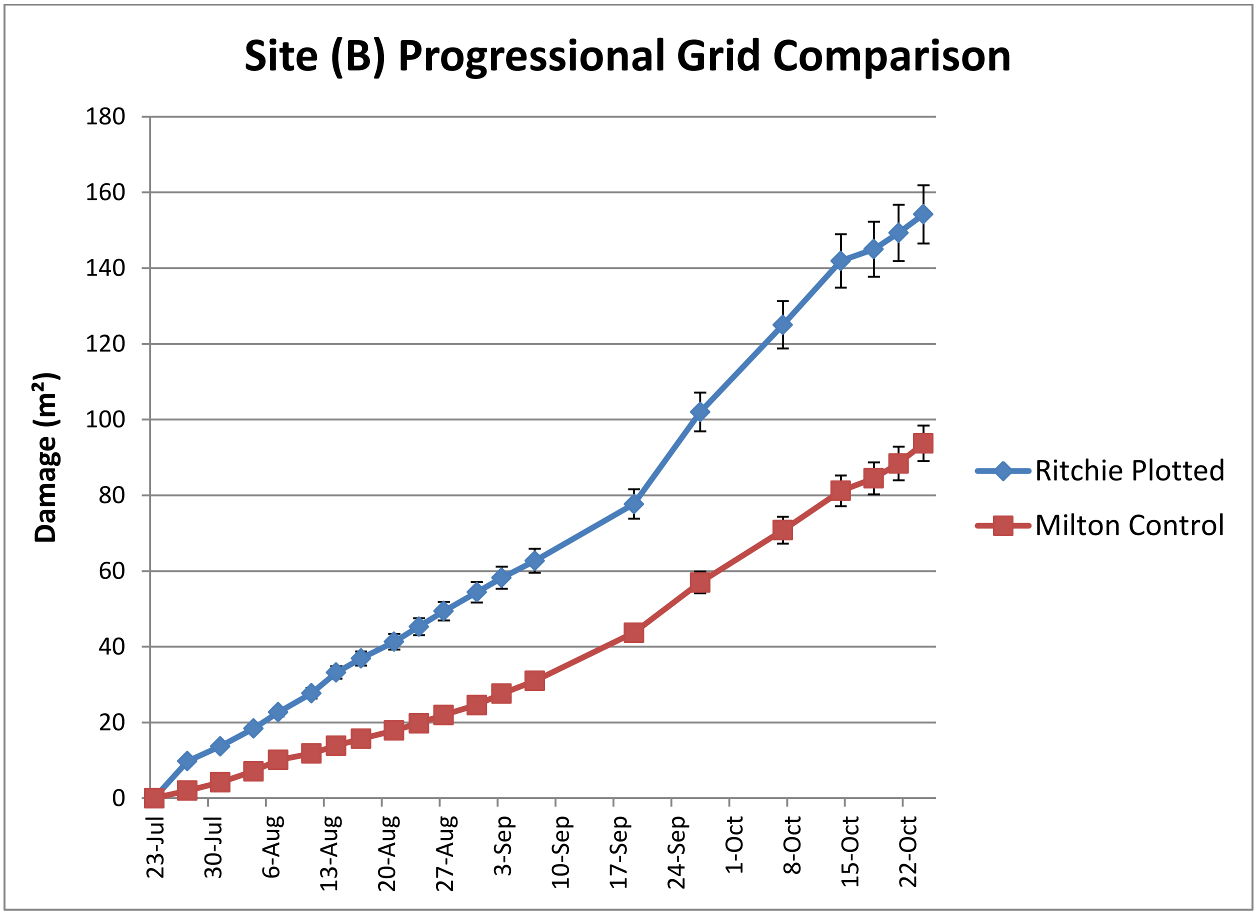


Figure 12: *Calculated Site (B) progression comparison and break down from start (replant) to the conclusion of the study. Data points broken down by days of collection.*

Figure 13 (below) focuses directly upon the damage that occurred in the agricultural field areas of the transects that extended from the plots. This reveals that the tested areas of the agriculture fields with plotted areas present had less damage done to the crops compared to that of the agriculture fields located at the control site areas. At the Site (A) locations, the Simm's Plotted site suffered 13.5% less damage compared to the Van Duyne Control site (A). At the Site (B) locations, the Ritchie Plotted site suffered 11.3% less damage compare to the Milton Control site. Duration also presented itself as a relevant factor to the amount agricultural damage with the Site (A) locations having more damage to them than the Site (B) locations which had to be replanted.

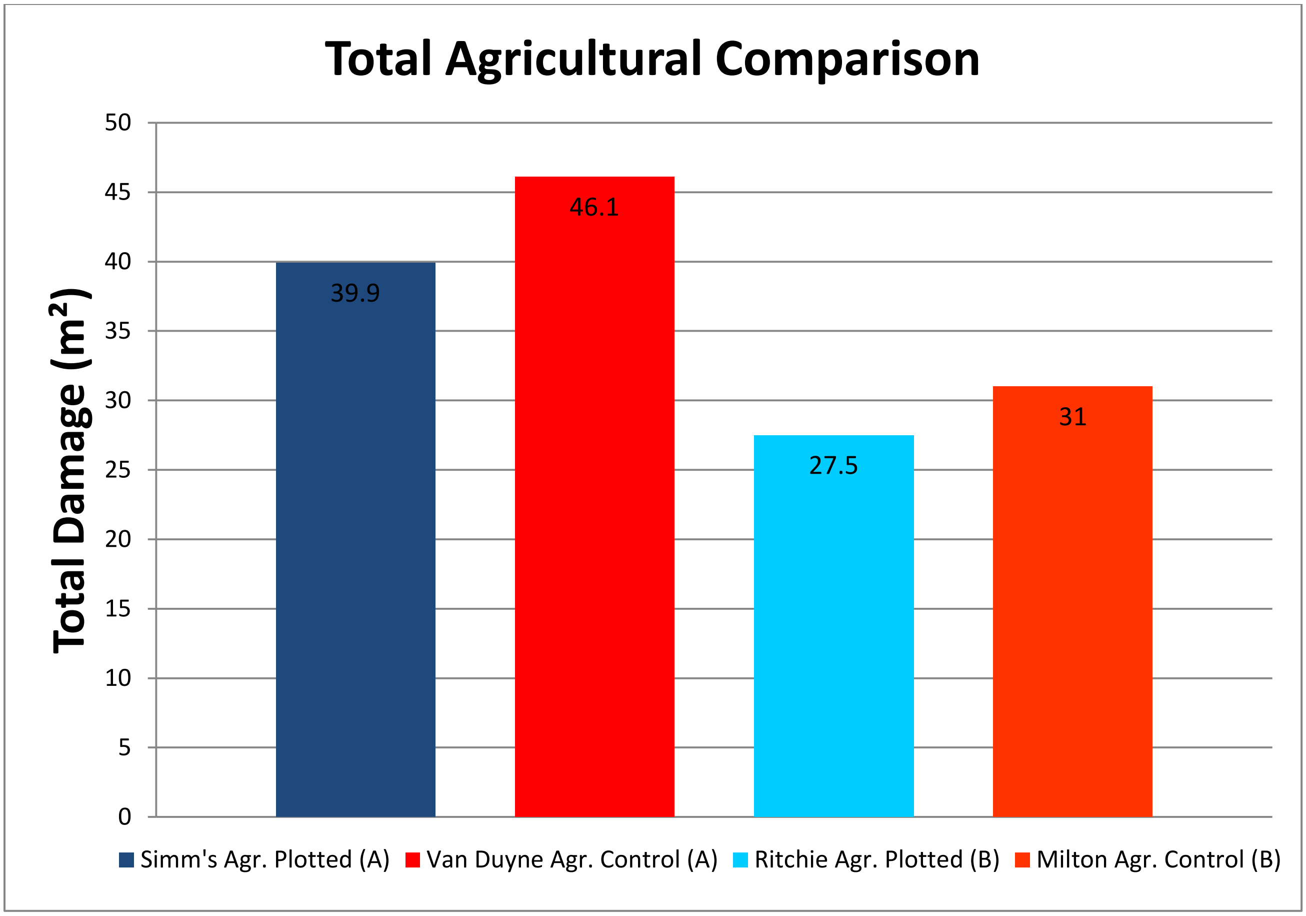


Figure 13: *Calculated total Agricultural impact found in Agricultural grid analysis. Transect data is not included in Agricultural total.*

V. Discussion:

Ecological Impact

The hypothesis that the presence of a supplementary food plot located within a deciduous forest near an agricultural row crop field would increase the amount of ecological impact caused by Whitetail Deer was not supported by the data due to statistical insignificance. The 168 m^2 difference in damage to the Simm's Plotted site than the Van Duyne Control site at the Site (A) locations along with the 61.8 m^2 difference in more damage to the Ritchie Plotted site than the Milton Control site at the (B) locations hints at the trend that the presence of a supplementary food plot could increase ecological damage but the lack of statistical significance cannot prove the findings.

However it was found that the distance from the plot did significantly affect the amount of damage with a significance of 0.001. This gives representation that the chances of the amount of ecological impact decreasing as the distance from the supplementary food plot increases have a 0.1% chance of occurring randomly. Similar results were found with Whitetail Deer at ranch in south Texas in which the amount of browse damage increased with proximity to the supplemental food source (Cooper *et al.*, 2005). Along with this, results from a baiting study done throughout Canada and the United States found that browsing increased in proximity to the location of bait piles placed for Whitetail Deer (Dunkley & Cattet, 2003).

Compared multiple ecological impact studies done by Thomas Rooney (*et. al*, 2005) throughout the Midwest, and northern Wisconsin, the duration used in this study was significantly less in comparison. The extension of the duration of study would allow for a greater ecological impact to be analyzed and for trends that were existent to be magnified with more time.

Agricultural Impact

The hypothesis that the introduction of a supplementary food plot near an agricultural field would decrease the amount of agricultural row crop damage caused by Whitetail Deer compared to sites without a supplementary food plot was also not supported due to lack of support via statistical significance. In a comparison of the total damage found between the sites with food plots present versus the control sites without food plots it was found that at Simm's Plotted site had 6.2 m^2 less damage than the Van Duyne Control site at location (A) and the Ritchie Plotted site had 3.5 m^2 less damage than the Milton Control site at location (B). Statistical significance came out show that at a site analysis there was a 58.2% chance of the results occurring by random chance.

However, when the data was analyzed when summed together with the other agricultural data of the same plot type it was found that there was only a 5.9% of the results occurring randomly by chance. When the covariant of the combined agricultural analysis was dismissed it showed that there was statistical significance between the presence of a supplementary food plot and the amount of impact caused by Whitetail Deer to row crop with a 3.6% chance that the results occurred randomly by chance. With the rather short scale of the study, this result could give insight that supplementary food plots could possibly play a role in the impact caused by whitetail deer

Further testing must be done on a larger scale both spatially and temporally in order to apprehend better data. Even larger scale tests such as that done by Nixon (*et al.*, 2007) gave only limited insight into the behavior of Whitetail Deer in agricultural environments. Based upon the statistical insignificance in the difference in damage between Plotted and Non-Plotted areas, the used of a supplementary food plant as management method to control, or lessen, the amount of agricultural row crop damage cause by Whitetail Deer cannot be recommended. However, with the trends and data found during the study, the use of a supplementary food plot near agricultural row crow showed progressive benefits leaning towards it's usage as a management method. Though its use cannot be significantly recommended as a management method, it can be seen from the data that in certain situations the use of a supplementary food plot could in fact benefit a farmer. To find significant data to support or nullify this, a longer duration study must occur.

Methodology Analysis

Though the methods used during study were very thorough in collecting as much data as possible and as often as possible without disturbing the natural patterns and behavior of the Whitetail Deer population, the sheer size of the study was a bit overwhelming for a single person to do. A team approach to this study in the future or a smaller scale of it would be able to work just as well and should be able to achieve similar data collection. Even though the time of collection lasted the entire growing season of both the deer and the corn crop and ended once the crop was harvested, a longer duration of study and data collection, either over the course of a full year or multiple years would result in much more quality information. An increase in the duration of the study would also allow for further comparison of this recent study to that of past extensive studies, such as the 10 year ecological impact study done by Horsley (*et al*, 2003). This allowance of time could also take into account different variations that occur year to year such as variations in weather patterns, crops cycled, ecological growth cycles and many other variables both natural and humanly influenced. Shifts and patterns within the constant impact caused by Whitetail Deer could then been found and analyzed more carefully, such as the perennial cycles found in the study by Illige (1951) on the peaking sexual activity of deer.

Increased duration would also allow for the possibility of full recover from natural disasters, as was the case on June 22nd of 2015 a series of severe tornados made their way through the town of Coal City, Illinois. The path the tornados took went right over both of my original Site (B) location destroying everything in its path. The plotted site located in a section of woods near a Commonwealth Edison high voltage power line was completely flattened and turned in to rubble. Restricted access called for the replanting of another test plot in a different location. This resulted in three trail cameras being destroyed and never found after the tornado. The control site which was located just over a mile away from the plotted site was also in the path of the tornados and was also completely destroyed after the storm made its way through. At this control plot two more trail cameras were lost due to the storm. The use of a multiple year study would thus allow for full recovery of test sites as well as more substantial data that could be used in the study.

Type of Plot

The type of food plot that had been chosen for this study was done so simply based on the amount of seed that was currently available and ready for immediate use. Since the funding for the study was limited, the most affordable path possible had to be taken relating to seed purchase primarily. The use of a different type of plant in the supplementary food plots could very well result in much different data and results than what was concluded through this study. Every aspect involved in the seed selection process could play a role in the way Whitetail Deer react to the presence of a food plot. In previous years while growing the same alfalfa food plots for hunting purposes, there have been years where deer would not come near the plot and other years where multiple deer would be present feeding in the plot at all times.

V. Conclusion

While the introduction of a supplementary into a deciduous near and an agricultural row crop field caused some changes to occur in the amount of impact caused by Whitetail Deer, the amount was not enough to be able to be considered significant. The increased duration of study in excess of a year or longer would be needed to further determine if the data could possibly become significant. However this study can be used as a baseline by conservationists, farmers, and landowners to run a small scale test and deter both the ecological impact cause by Whitetail Deer as well as possible management solutions.

V. References:

Alverson, W. S., Waller, D. M., & Solheim, S. L. (1988, December). Forests Too Deer: Edge Effects in Northern Wisconsin. Retrieved October, 2015, from http://www.jstor.org/stable/2386294?seq=1#page_scan_tab_contents

Brinkman, T. J., Deperno, C. S., Jenks, J. A., Haroldson, B. S., & Osborn, R. G. (2005, July). Movement of female white-tailed deer: Effects of climate and intensive row-crop agriculture. Retrieved September, 2015, from http://www.bioone.org/doi/abs/10.2193/0022-541X(2005)069%5B1099:MOFWDE%5D2.0.CO%3B2

Brown, R. D., & Cooper, S. M. (2006, June). The Nutritional, Ecological, and Ethical Arguments Against Baiting and Feeding White-Tailed Deer. Retrieved May, 2015, from http://www.bioone.org/doi/abs/10.2193/0091-7648(2006)34%5B519:TNEAEA%5D2.0.CO%3B2

Chamrad, A. D., & Box, T. W. (1968, May). Food Habits of White-Tailed Deer in South Texas. Retrieved April, 2015, from http://www.jstor.org/stable/3896137?seq=1#page_scan_tab_contents

Cook, C., & Gray, B. (2005). Effective Food Plots for White-Tailed Deer in Alabama. Retrieved November, 2015, from http://cahabariver.net/book/deerfoodplots.pdf

Cooper, S. M., Owens, M. K., Cooper, R. M., & Ginnett, T. F. (2006). Effect of supplemental feeding on spatial distribution and browse utilization by white-tailed deer in semi-arid rangeland. *Journal of Arid Enviornments, 66*(4), 716-726. Retrieved March, 2015, from http://www.sciencedirect.com/science/article/pii/S0140196305003010

Cote, S. D., Rooney, T. P., Tremblay, J., Dussault, C., & Waller, D. M. (2004, June). Ecological Impacts of Deer Overabundance. Retrieved September, 2015, from http://www.jstor.org/stable/30034112?seq=1#page_scan_tab_contents

Decker, D. J., & Connelly, N. A. (1989). Motivations for Deer Hunting: Implications for Antlerless Deer Harvest as a Management Tool. *Wildlife Society Bulletin, 17*(4), 455-463. Retrieved March, 2015, from http://www.jstor.org/stable/3782713?seq=1#page_scan_tab_contents

DeNicola, A. J., VerCauteren, K. C., Curtis, P. D., & Hygnstrom, S. E. (2000). *Managing white-tailed deer in suburban environments: A technical guide*. Ithaca, NY: Cornell Cooperative Extension.

Dunkley, L., & Cattet, M. R. (2003, January). *A Comprehensive Review of the Ecological and Human Social Effects of Artificial Feeding and Baiting of Wildlife* [Scholarly project]. In*Http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1020&context=icwdmccwhcnews*. Retrieved October, 2015, from http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1020&context=icwdmccwhcnews

Edwards, S. L., Demarais, S., Watkins, B., & Strickland, B. K. (2004). White-tailed deer forage production in managed and unmanaged pine stands and summer food plots in Mississippi. *Wildlife Society Bulletin, 32*(3), 739-745. Retrieved May, 2015, from http://mrmpros.com/wp-content/uploads/2012/06/MRRW-wildlife_society_bulletin.pdf

Fulbright, T. E., & Ortega-Santos, J. A. (2013). *White-Tailed Deer Habitat: Ecology and Management of Rangelands* (2nd ed.). Retrieved April, 2015, from https://books.google.com/books?hl=en&lr=&id=t9BGvuVx6eAC&oi=fnd&pg=PP2&dq=White-Tailed+Deer+Habitat&ots=Aqu8Ppi5s6&sig=FdMtf1V3wSH-SjEF3T_Rdboc_58#v=onepage&q=White-Tailed Deer Habitat&f=false

Gill, R. M. (1992). A Review of Damage by Mammals in North Temperate Forests: 1. Deer. *A Review of Damage by Mammals in North Temperate Forests: 1. Deer, 65*(2), 145-169. Retrieved October, 2016, from https://www.researchgate.net/profile/Robin_Gill/publication/30991640_A_Review_of_Damage_by_Mammals_in_North_Temperate_Forests_1._Deer/links/00b7d5260ea0fb8330000000.pdf

Grandy, J. W., Stallman, E., & Macdonald, D. W. (2003). The Science and Sociology of Hunting: Shifting Practices and Perceptions in the United States and Great Britain. Retrieved 2015, from http://animalstudiesrepository.org/cgi/viewcontent.cgi?article=1006&context=sota_2003

Hanson, K. D. (2004). *Soil survey of Will County, Illinois*. Washington, D.C.: U.S. Dept. of Agriculture, Natural Resources Conservation Service.

Haugen, A. O. (1975). Reproductive Performance of White-Tailed Deer in Iowa. *Journal of Mammalogy,* 151-159. Retrieved September, 2015, from http://jmammal.oxfordjournals.org/content/56/1/151.abstract

Hehman, M. W., & Fulbright, T. E. (1997). Use of Warm-Season Food Plots by White-Tailed Deer. *The Journal of Wildlife Management, 61*(4), 1108-1115. Retrieved April, 2015, from http://www.jstor.org/stable/3802108?seq=1#page_scan_tab_contents

Horsley, S. B., Stout, S. L., & DeCalesta, D. S. (2003). White-Tailed Deer Impact on the Vegetation Dynamics of a Northern Hardwood Forest. *Ecological Applications, 13*(1), 98-118. Retrieved October, 2015, from http://www.jstor.org/stable/3099953?seq=1#page_scan_tab_contents

Hurley, P. M., Webster, C. R., Flaspohler, D. J., & Parker, G. R. (2012). Untangling the landscape of deer overabundance: Reserve size versus landscape context in the agricultural Midwest. *Biological Conservation, 146*(1), 62-71. Retrieved March, 2015, from http://www.sciencedirect.com/science/article/pii/S0006320711004502

Illige, D. (1951). An Analysis of the Reproductive Pattern of Whitetail Deer in South Texas. *Journal of Mammalogy, 32*(4), 411-421. Retrieved September, 2015, from http://www.jstor.org/stable/1375789?seq=1#page_scan_tab_contents

Kilpatrick, H. J., & Stober, W. A. (2002). Effects of Temporary Bait Sites on Movements of Suburban White-Tailed Deer. *Wildlife Society Bulletin, 30*(3), 760-766. Retrieved May, 2015, from http://www.jstor.org/stable/3784229?seq=1#page_scan_tab_contents

MacGowan, B. J., & Osborne, D. (2002). Food Plots for White-Tailed Deer. *Tracks and Signs of the Animals and Birds of Britain and Europe*. doi:10.1515/9781400847921.246

McShea, W. J., Healy, W. M., Devers, P., Fearer, T., Koch, F. H., Stauffer, D., & Waldon, J. (2007). Forestry Matters: Decline of Oaks Will Impact Wildlife in Hardwood Forests. *The Journal of Wildlife Management, 71*(5), 1717-1728. Retrieved October, 2015, from http://onlinelibrary.wiley.com/doi/10.2193/2006-169/abstract

Miller, S. (2015, March 13). Animal Rights Group Wants Will County To End Deer Culling [Will County Deer Culling]. Retrieved March 28, 2015, from http://chicago.cbslocal.com/2015/03/13/animal-rights-group-wants-will-county-to-end-deer-culling/

Nielsen, C. K., Porter, W. F., & Underwood, H. B. (1997). An adaptive management approach to controlling suburban deer. *Wildlife Society Bulletin, 25*(2), 470-477. Retrieved August, 2015, from http://www.porter.fw.msu.edu/Nielsen%20et%20al%201997%20-%20Adaptive%20Mgmt%20of%20Urban%20Deer.pdf

Nixon, C. M., & Etter, D. (1995). Maternal Age and Fawn Rearing Success for White-tailed Deer in Illinois. *The American Midland Naturalist, 133*(2), 290-297. Retrieved 2015, from http://www.jstor.org/stable/2426393?seq=1#page_scan_tab_contents

Nixon, C. M., Hansen, L. P., Brewer, P. A., & Chelsvig, J. E. (1991). Ecology of White-Tailed Deer in an Intensively Farmed Region of Illinois. *Wildlife Monographs, 118*, 3-77. Retrieved 2015, from http://www.jstor.org/stable/3830680?seq=1#page_scan_tab_contents

Nixon, C. M., Mankin, P. C., Etter, D. R., Hansen, L. P., Brewer, P. A., Chelsvig, J. E., . . . Sullivan, J. B. (2007). White-Tailed Deer Dispersal Behavior in an Agricultural Environment. *The American Midland Naturalist, 157*(1), 212-220. Retrieved September, 2015, from http://www.jstor.org/stable/4500607?seq=1#page_scan_tab_contents

Rawinski, T. J. (2008). Impacts of White-Tailed Deer Overabundance in Forest Ecosystems: An Overview. *Impacts of White-Tailed Deer Overabundance in Forest Ecosystems: An Overview*. Retrieved 2015, from http://www.na.fs.fed.us/fhp/special_interests/white_tailed_deer.pdf

Riley, S. J., Decker, D. J., Enck, J. W., Curtis, P. D., Lauber, T. B., & Brown, T. L. (2003). Deer Populations up, hunter populations down: Implications of interdependence of deer and hunter population dynamics on management. *Ecoscience, 10*(4), 455-461. Retrieved 2015, from http://www.jstor.org/stable/42901555?seq=1#page_scan_tab_contents

Rooney, T. P., & Waller, D. M. (2001). Direct and indirect effects of white-tailed deer in forest ecosystems. *Forest Ecology and Management 181 (2003) 165–176 Direct and Indirect Effects of White-tailed Deer in Forest Ecosystems $*. Retrieved March, 2015, from https://www.researchgate.net/profile/Donald_Waller2/publication/222651104_Rooney_TP_and_DM_Waller_Direct_and_indirect_effects_of_White-tailed_Deer_in_forest_ecosystems_Forest_Ecology_and_Management/links/0fcfd506cfaf4e701f000000.pdf

Rooney, T. P. (2008). Deer impacts on forest ecosystems: A North American perspective. *Choice Reviews Online, 46*(02). doi:10.5860/choice.46-0986

Roseberry, J. L., & Woolf, A. (1998). Habitat-Population Density Relationships for White-Tailed Deer in Illinois. *Wildlife Society Bulletin, 26*(2), 252-258. doi:10.1007/springerreference_44567

Russell, F. L., Zippin, D. B., & Fowler, N. L. (2001). Effects of White-Tailed Deer (Odocoileus Virginianus) on Plants, Plant Populations, and Communities: A Review. *The American Midland Naturalist,146*(1), 1-26. Retrieved 2015, from http://www.jstor.org/stable/3083148?seq=1#page_scan_tab_contents

Tremblay, J., Thibault, I., Dussault, C., Hout, J., & Cote, S. D. (2005). Long-term decline in white-tailed deer browse supply:can lichens and litterfall act as alternative food sources that preclude density-dependent feedbacks. *Long-term Decline in White-tailed Deer Browse Supply: Can Lichens and Litterfall Act as Alternative Food Sources That Preclude Density-dependent Feedbacks, 83*, 1087-1096. Retrieved July, 2015, from https://www.researchgate.net/profile/Jean-Pierre_Tremblay/publication/229195350_Long-term_decline_in_white-tailed_deer_browse_supply_Can_lichens_and_litterfall_act_as_alternative_food_sources_that_preclude_density-dependent_feedbacks/links/53e8f0c20cf2fb1b9b64321f.pdf

Verme, L. J. (1965). Reproduction Studies on Penned White-Tailed Deer. *The Journal of Wildlife Management, 29*(1), 74-79. Retrieved 2015, from http://www.jstor.org/stable/3798633?seq=1#page_scan_tab_contents

Verme, L. J. (1969). Reproductive Patterns of White-Tailed Deer Related to Nutritional Plane. *The Journal of Wildlife Management, 33*(4), 881-887. Retrieved 2015, from http://www.jstor.org/stable/3799320?seq=1#page_scan_tab_contents

W. (1981). *Deer management in Will County Forest Preserves*. Columbus: The Division.

Wasserberg, G., Osnas, E. E., Rolley, R. E., & Samuel, M. D. (2009). Host Culling as an Adaptive Management Tool for Chronic Wasting Disease in White-Tailed Deer: A Modelling Study. *Journal of Applied Ecology, 46*(2), 457-466. Retrieved September, 2015, from http://www.jstor.org/stable/27695969?seq=1#page_scan_tab_contents

Wolfe, L. L., Miller, M. W., & Williams, E. S. (2004). Feasibility of "test-and-cull" for managing chronic wasting disease in urban mule deer. *Wildlife Society Bulletin, 32*(2), 500-505. doi:10.1002/9780470172377.ch11

Wywialowski, A. P. (1996). Wildlife Damage to Field Corn in 1993. *Wildlife Society Bulletin, 24*(2), 264-271. Retrieved 2015, from http://www.jstor.org/stable/3783116?seq=1#page_scan_tab_contents