Effects of White-tailed Deer (*Odocoileus virginianus*) Browsing and Prescribed Burns on Seedlings and Saplings in Itasca State Park, Minnesota.

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ABSTRACT

The purpose of the study was to determine if white-tailed deer browsing or prescribed burning had an effect on seedlings and saplings in Itasca State Park. There were four study sites located in the park: Mary Lake Unburned Exclosure, Wildness Drive Burned Exclosure, Wildness Drive Burned Area and Wildness Drive Unburned Area. It was hypothesized that the highest abundance of seedlings and saplings would be at the Wilderness Drive Burned Exclosure and the lowest abundance at Wilderness Drive Unburned Area. The data showed no correlation between abundance of deer scat and abundance of seedlings but there is a positive correlation between deer scat and abundance of saplings. This could be due in part to the fact that the deer exclosures did not completely exclude deer. The data showed no correlation between seedlings and saplings between burned sites and between unburned sites. Pine regeneration was not significant in the study transects but it was noted that there were white pine seedlings present at each site.

INTRODUCTION

Itasca State Park, located in north central Minnesota, is classified as a northern coniferous forest. The park was established in 1891 in an effort to protect remnant pine (*Pinus spp.*) stands (Zenner and Peck 2009).

Between 1920 and 1945, Itasca State Park served as a wildlife refuge, and the effects of deer browsing were immense. In 1945, a deer-hunting season was implemented to control the population (Zenner and Peck 2009). Currently, there are approximately 33 white-tailed deer per mile^2 in Itasca State Park (Dunbar and Grund 2007).

Fire in Itasca State Forest

Wildfire has been suppressed in the park since 1922. Between the years of 1650 and 1922, wildfires occurred, on average, every 8.8 years. This is associated with the large numbers of fire-tolerant tree species such as red pine (*Pinus resinosa*), white pine (*P. strobus*) and Jack pine (*P. banksiana*; Frissell 1973). No new pine stands have been established to replace mature stands as they decline; this will likely result in succession to northern hardwoods (Zenner and Peck 2009).

In the late 1990's, Itasca State Park Management prescribed a program of extensive understory surface fire to restore the natural disturbance regime of the forest. Many areas of the park have been burned multiple times. The objective was to restore conditions necessary for pine regeneration under the existing canopy (Zenner 2009). In addition, controlled burning provided more browse for deer (Dills 1970).

White-tailed Deer (Odocoileus virginianus)

White-tailed deer inhabit most of southern Canada and nearly the entire mainland United States, including Minnesota. Deer feed on a variety of vegetation, depending on what is available, which includes buds and twigs of deciduous trees and shrubs. Conifers are often utilized in winter when other foods are scarce (Dewey 2003). Deer can cause reduced plant survival, especially of seedlings and saplings. Intense browsing may result in the forest plant species' composition moving towards species not preferred by deer, which may lead to local extinctions of favored species. In areas with high deer densities, deer can affect size distributions of populations of favored plant species by preventing plants' ability to grow to sapling and small adult size (Russell et al. 2001). Thus, in areas with high deer populations, simplification of forest structure, altered patterns of secondary succession, and reduced diversity of woody plants are likely to result. On a landscape level, abundant deer population may promote dispersal and establishment of herbaceous plants in forests. Deer disperse seeds through three methods: ingestion with the seeds being passed through the digestive tract, seeds attached fur or in hooves; or by the deer spitting seeds after feeding (Holmes et al. 2007). The relationship between deer density and the total impact upon plant populations is important for management (Russell et al. 2001).

Deer Exclosures

The first deer exclosure was constructed in Itasca State Park in 1937 in an attempt to establish new pine stands by eliminating deer browsing. Many studies have documented fewer saplings and small adult trees outside exclosures than inside them (Russell et al. 2001). In one study conducted in Itasca State Park, densities of pine seedlings and saplings were found to be higher in one exclosure than outside, yet no new mature stands have been established (Zenner 2009).

However, deer exclosures do not always prevent browsing. The leaping ability of deer can make effective deer exclosures difficult to maintain (Russell et al. 2001). Also, exclosures have been shown to have no impact on small mammal densities, so herbivory still may occur (Zenner 2009).

Objectives

The objectives for this study were to determine if: (i) deer browsing has an effect on abundance of seedlings and saplings in forests of Itasca State Park (ii) prescribed burns have an effect on abundance of seedlings and saplings in forests of Itasca State Park (iii) deer browsing or prescribed burning have a stronger effect on the abundance of seedlings and saplings (iv) deer exclosures enable pine regeneration.

Predictions

(i) Since deer populations in Itasca State Park are managed by hunting, we expect to see some effects of deer browsing on seedlings and saplings outside of deer exclosures, but not extreme browsing effects.
(ii) Since the objective of prescribed burns is to restore the natural disturbance regime in a forest, we expect to see an abundance of seedlings and saplings in areas where burns have been prescribed.
(iii) We expect to see stronger negative effects on abundance of seedlings and saplings in relation to deer browsing and stronger positive effects on abundance of seedlings and saplings in relation to prescribed burns.
(iv) Since deer exclosures in Itasca State Park historically have failed to establish new pine populations, we do not expect to see significant abundance in pine seedlings and saplings.

METHODS

Study Site

During the month of June 2009, four sites were chosen in which to conduct the research. Mary Lake Unburned Exclosure (MLUE) is approximately 0.25 miles east of Lake Mary, in the southeastern quadrant of Itasca State Park and was erected in 1943. MLUE is the smaller of the 2 exclosures that were studied. A 2.1 m-high welded wire fence surrounded the exclosure. A small hole in the north side of the fence existed where deer may have the ability to enter. The last wildfire in this area occurred in 1911 (Frissell 1973).

Wilderness Drive Burned Exclosure (WDBE) is located approximately 1.25 miles west of the north arm of Lake Itasca in the northwest quadrant of Itasca State Park, next to the Landmark Interpretive Trail and is the larger of the 2 exclosures studied. An approximately 3 m-high welded wire fence surrounds the exclosure. A section of the fence where a tree had fallen, and an open gate may have provided access for deer. Itasca State Park managers prescribed a burn in this area five years ago and the last time there was wildfire in this area was 1911 (Frissell 1973).

Wilderness Drive Burned Area (WDBA) is located directly west and adjacent to the Wilderness Drive Deer Exclosure on the Landmark Interpretive Trail. Itasca State Park officials prescribed a burn in this area five years ago and the last time there was a wildfire in this area was 1911 (Frissell 1973).

Transect Methods

Wilderness Drive Unburned Area (WDUA) area is located approximately 0.5 miles west of the southernmost point of the west arm of Lake Itasca and the last time there was a wildfire in this area was 1891 (Frissell 1973).

At each site we plotted 5 transects with 4 plots each, for a total of 20 plots and each transect was 50 m long. Transect starting points were chosen using a random number table. Using the random number chart, we chose four plots along each transect. We used “rock paper scissors” to determine which side (left or right) of the transect we would plot. Each plot was marked with flags at 3 x 3 m, with a 1 x 1 m plot within. The 3 x 3 m plot was used to count saplings (trees over knee-height but under 10 DBH). The 1 x 1 m plot was used to count seedlings (trees below knee-height). Trees species were determined by using a tree identification guide, and recorded; unidentified species were recorded as “unknown.” We looked for deer scat along the entire 50 m transect: approximately 3m on both sides of the transect. Each mound of deer scat was tallied.

RESULTS

Seedling Densities

MLUE had the least amount of seedling vegetation, overall (Fig. 1). Most of the seedling population was made up of hazel (HZ) with a small presence of other shrubs (OTH), black ash (BA), paper birch (PB), and white pine (WP). WDBE had the second least amount of seedling vegetation, overall (Fig. 1). Most of the seedling population was made up of HZ and OTH with a small presence of black cherry (BC), red maple (RM), sugar maple (SM), and mountain maple (MM). WDUA had the second most overall seedling vegetation (Fig. 1). Most of the seedling population was made up of sugar maple (SM) and HZ with a small presence of OTH, ironwood (IW), WP, MM, Douglas fir (DF), and Elm. WDBA had the most overall seedling vegetation (Fig. 1). Most of the seedling population was made up of SM and HZ with a small presence of OTH, PB, and MM.

There were more tree seedlings in the non-exclosures, most of which was made up of SM. There is a fairly even amount of HZ seedling distribution between the sites but there are more total shrub seedlings in the burned sites than the unburned sites but the difference is quite small. White Pine seedlings were only found in the unburned sites. There also seems to be more vegetation in the burned exclosure than the unburned exclosure and more vegetation in the burned area than the unburned area.

Sapling Densities

MLUE had the least amount of total sapling vegetation equal with WDBA (Fig. 2). Almost all of the sapling population was composed of HZ and some PB with a relatively very small amount of BA, balsam fir (BF), green ash (GA), ironwood (IW), red oak (RO), SM, and WP. WDBE had the most overall vegetation with over double the amount of HZ than any other site with some OTH, BC, and cottonwood (CW), and very few SM, basswood (BW), IW, RO, and MM (Fig. 2). WDUA had the second to most sapling vegetation overall with the second most tree sapling vegetation (Fig. 2). WDBA had the least amount of total sapling vegetation with almost half of that vegetation being tree saplings (Fig. 2). WDBA had the least amount of HZ but HZ was still the primary species of sapling found (Fig. 2). There were also OTH, BW, IW, PB, QA, WO, MM, DW, and SM.

There was, overall, an abundance of HZ, especially in WDBE. There was an equal amount of total saplings between MLUE and WDBA and that is mostly do to a fairly equal amount of HZ at each site. WDBE, WDUA, and WDBA seem to have an almost equal amount of total tree sapling growth. MLUE has the least amount of tree saplings and they were mostly all PB.

Scat Prevalence

WDBE had the most deer scat (average of 17.25 per replicate), WDBA had the second most deer scat (average of 4.4 per replicate), WDUA had the third most deer scat (average of 2 per replicate), and MLUE had the least amount of deer scat (average of 0.6 per replicate) (Fig. 3). The two sites with the most deer scat were the two burned areas (including the one exclosure).

No correlation was found between the total mean seedling density and scat prevalence between all of our replicates. Analysis determined an R^2-value of 0.018 and a p-value of 0.584 (Fig. 4). There was a correlation between the total mean sapling density and scat prevalence between all of our replicates. Analysis determined an R^2-value of 0.654 and a p-value of 2.810E-0.5 (Fig. 5).

There was statistical variation found between the mean amounts of scat between each site (Fig. 3) (ANOVA, $F_{(3)}$=24.427, P-Value=5.037E-06); this is likely due to WDBE having such a large prevalence of deer scat. There was statistical variation between the mean amounts of scat between MLUE and WDBA ($T_{(8)}$=2.897, P-Value=0.020). There was no statistical variation between MLUE and WDUA ($T_{(8)}$=-0.762, P-Value=0.468). There was no variation between WDUA and WDBA ($T_{(8)}$=1.698, P-Value=0.128). WDBE varied a lot from all three other sites; WDUA seemed to be similar to both WDBA and MLUE; and WDBA and MLUE varied between each other.

DISCUSSION

Effect of Deer Browsing on Abundance of Seedlings and Saplings

There appears to be no correlation between abundance of deer scat and abundance of seedlings. This could be due in part to the fact that the deer exclosures did not completely exclude deer. Originally, we expected to see a correlation between deer scat and seedlings, since seedlings are a favored food source. In fact, the deer exclosures had the least abundance of seedlings (Dewey 2003).

There does appear to be a correlation between abundance of deer scat and abundance of saplings. MLUE had the least abundance of saplings, whereas WDBE had the highest. Again, we assume this is a result of faulty deer exclosures. We are uncertain if deer have an effect on the abundance of seedlings or saplings, but there is a positive correlation between abundance of deer scat and abundance of saplings. It is interesting to note that WDBE had more deer scat than all other sites, and deer fur was found in the exclosure.

Effect of Prescribed Burns on Abundance of Seedlings and Saplings

There are no strong trends between seedling and sapling abundance between burned areas and between unburned areas in our study. This is surprising, since other studies have found strong correlations between burned areas and seedling and sapling abundance (Frissell 1973, Zenner 2009). Our results are most likely due to the small number of sample sites.

The most dominant seedlings overall were hazel and sugar maple. Hazel saplings were by far the highest in density. There were very few pine seedlings, and even less pine saplings; this may suggest that the forest is making a transition from coniferous to deciduous and is currently in an early successional period, which explains the abundance of hazel in all areas, especially WDBE (Frissell 1973).

Deer Browsing and Prescribed Burning Affects on Abundance of Seedlings and Saplings

Our results are inconclusive in determining whether deer browsing or prescribed burns have a stronger effect on seedling and sapling abundance. Although species richness can be a useful tool for describing ecosystems, results are highly sensitive to the analytical approach (Holmes et al. 2007). In this case, lack of time and resources absolutely limited our study. Ideally, we would have studied a deer exclosure that was truly free of deer to use as a control. We also expect that sampling of more burned versus unburned sites would show a correlation, since other studies have shown strong correlations (Frissell 1973, Zenner 2009).

Deer Exclosures and Pine Regeneration

Our data showed little abundance of pine seedlings and saplings at all four sites. More transects at each site could have given a stronger representation of the seedlings and saplings. For example, we saw several white pine seedlings at some sites, but did not include them in our data because they were not within the transects. It is difficult to determine from our data if deer exclosures enable pine regeneration, since the deer exclosures we studied did not completely exclude deer.

Hazel Distribution

The most abundant seedling and sapling at all four sites was hazel, an early successional plant. More hazel saplings than seedlings were found most likely because hazel has reached its local carrying capacity and is shading out new seedlings especially in WDBE (Frissell 1973). Deer generally avoid hazel, which could also contribute to the abundance of hazel in all sites (Zenner 2009). Also the shade intolerant hazel will slowly be killed off when mature trees fill the over-story and outcompete them.

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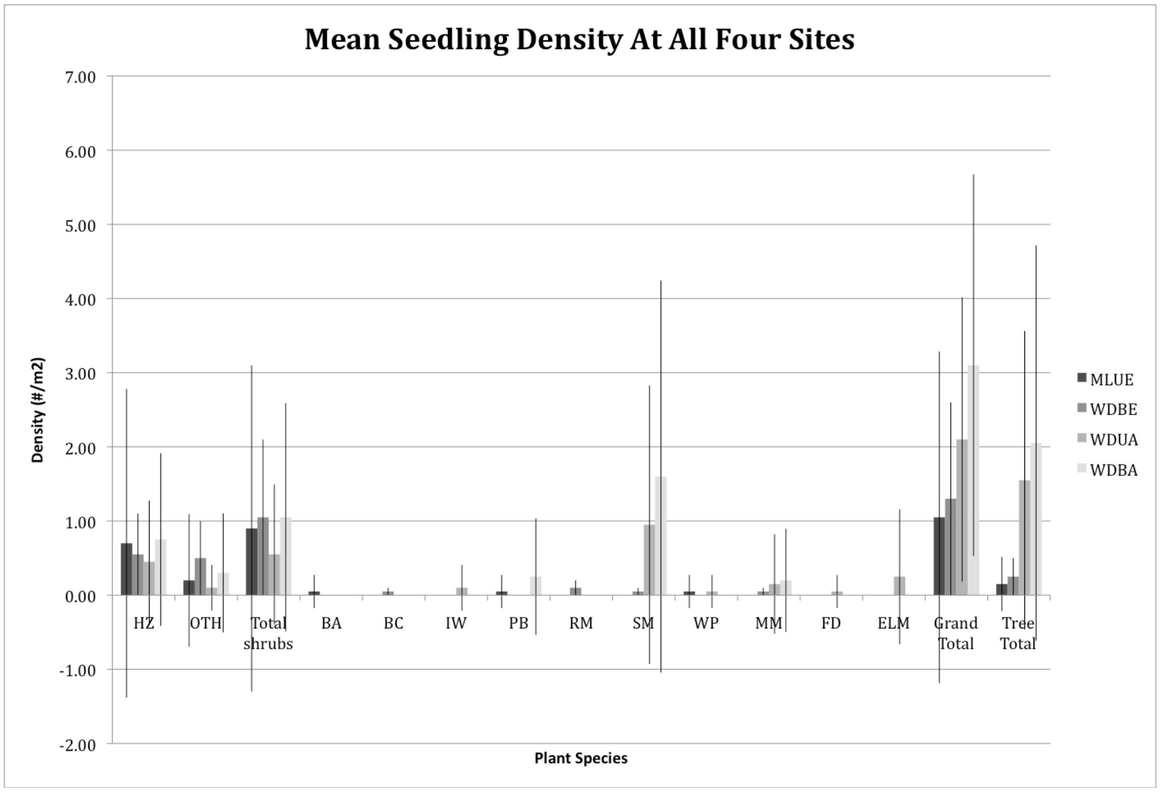

Figure 1 – Mean seedling density at all four study sites listed by plant species with standard deviation lines included for each bar.

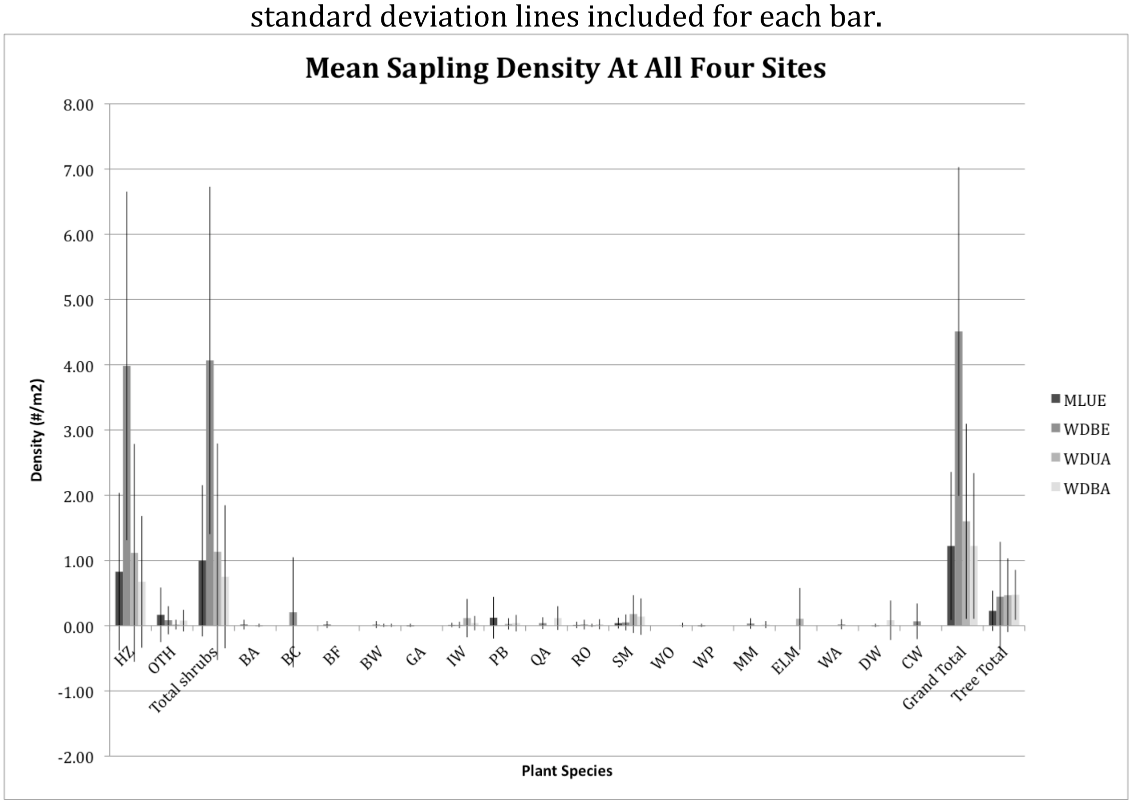

Figure 2 – Mean seedling density at all four study sites listed by plant species with standard deviation lines included for each bar.

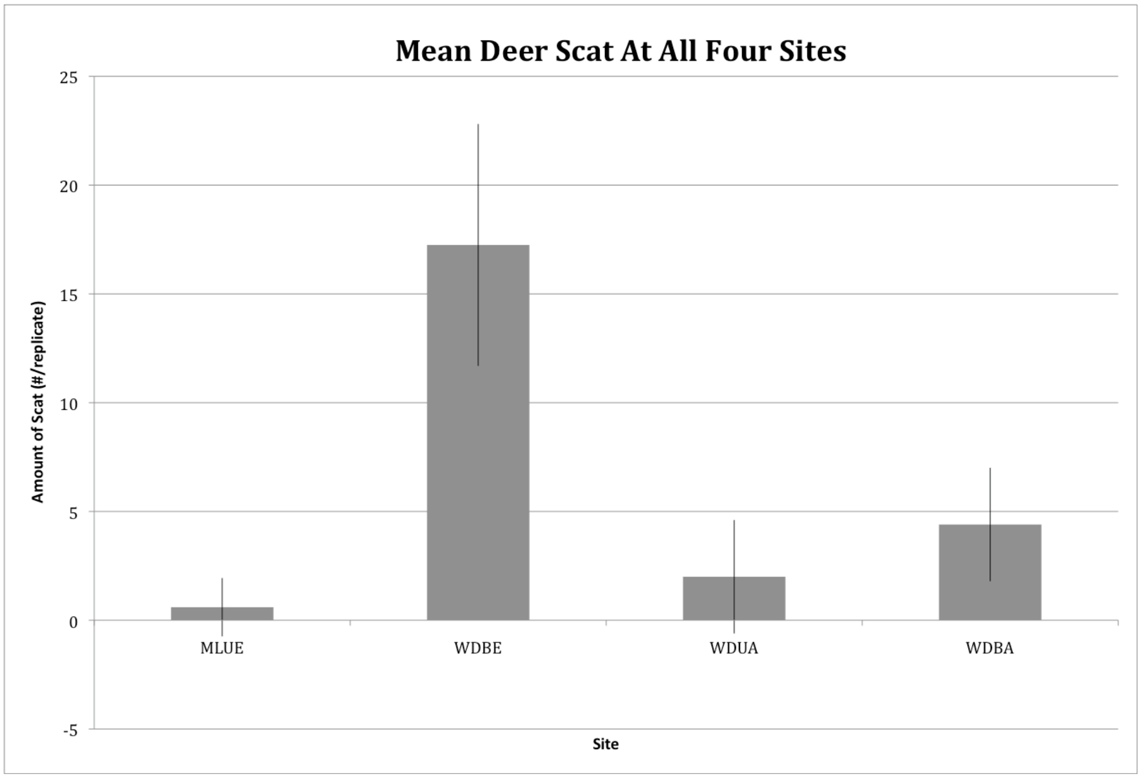

Figure 3 – Mean deer scat found at all four study sites with standard deviation lines included for each bar.

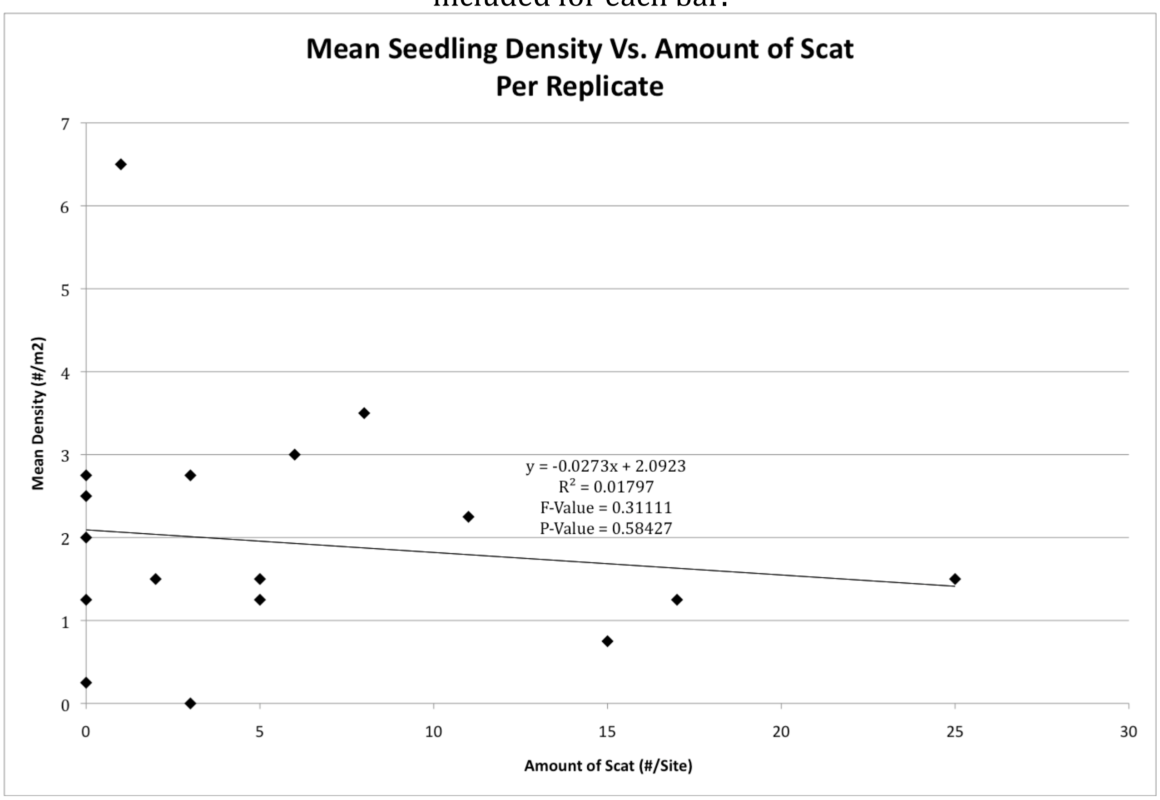

Figure 4 – Correlation of the mean seedling density and the amount of scat found at each replicate

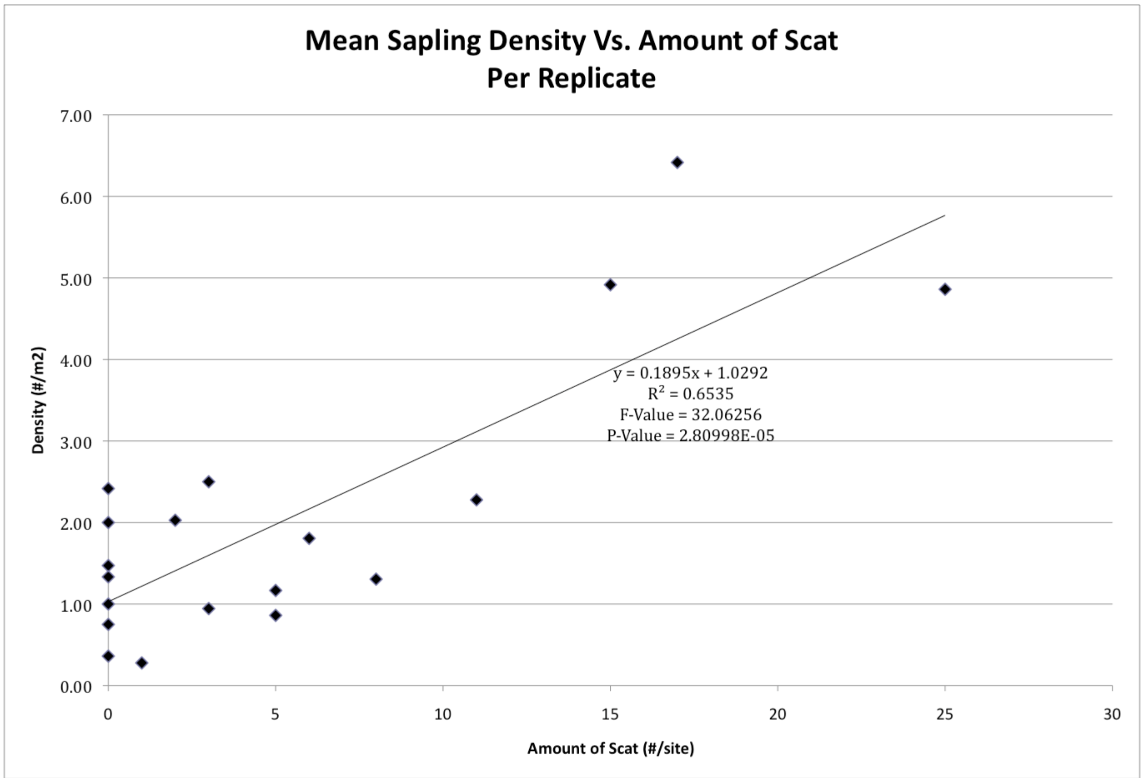

Figure 5 – Correlation of the mean sapling density and the amount of scat found at each replicate