Effects of Redcedar (*Juniperus virginiana*) on Understory Components at Various Stages of Invasion

Figure 1. Eastern redcedar tree. Photo taken by Jim Mason of the Great Plains Nature Center

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Introduction

They seem harmless at first glance. Stands of trees dot the landscape, adding character to an otherwise smooth horizon line, breaking up the monotony of grassland. In the beginning, this was desirable. In the beginning the fields of Kansas were desolate wastelands of ravaging winds and merciless sun, uninhabitable to our pioneer forefathers. Hailing from a coastal haven of forests and valleys, the first European settlers made it their business to plant trees, and lots of them. Legislation was passed that encouraged would-be landowners to devote large portions of their land to trees, and row after row was planted to act as windbreaks on the harsh prairie (Rodgers (date of publication?).

Of particular note among the many tree species then encouraged under the new legislation is the eastern redcedar, or *Juniperus virginiana*. A native species to Kansas, and the only evergreen of this status, redcedar trees are useful in many contexts. They make excellent wind breaks, and it is for this that they were coveted in the early years of settlement in Kansas; they provide habitats for a variety of animal species, especially birds; and, when harvested, provide the perfect material for novelty chests and wood crafts (Kansas Forest Service, 2004). In its mature stages, in fact, eastern redcedar are considered to be aesthetically pleasing trees, and are often sought out for landscaping in suburban and developing areas.

While the species initially provided many benefits to Kansans, at present we may have gone beyond the point of diminishing returns. In recent years, the increase in redcedar cover has occurred at an alarming rate across the Great Plains. In a 2002 study of redcedar in Oklahoma, the species was found to be encroaching at a rate of

762 acres a day, and projected economic losses by 2013 are $447 million (Oklahoma Department of Agriculture, Food and Forestry, 2002). Here in Riley County, the amount of redcedar coverage has increased by an alarming 382% in the last 21 years (Price and Grabrow, 2010). It is not simply the presence of redcedar, but its invasive nature and the speed with which it spreads that has created concerns among a growing number of land resource managers. A great portion of Kansas citizens rely heavily on the grasslands and the forage they produce, and so anything that causes land cover to change as rapidly as redcedar invasion has is a cause for alarm. We are a state that depends on agriculture for 20% of our total economy (Polanksy, 2009). With an industry valued at $3.8 billion, Kansas ranks 6th in farm product exports and first in "wheat flour milled", "sorghum grain produced", and "cattle slaughtered" in 2007 (Polansky, 2009). If this precious farmland is fragmented and eventually overwhelmed by evergreen forests, countless people's livelihoods will be negatively impacted. Of possibly greater concern is the rate with which grass and rangelands are being lost. From a purely economical view, losing rangelands will cost more money. Further 2007 data shows that "cattle revenue exceeded crop revenue by 1.9 times," and "represented 59.3% of total agricultural sales for [Kansas]" (USDA NASS Census of Agriculture, 2007).

Furthermore, the increase of redcedar in residential areas is a safety hazard. According to research by Zhang and Hiziroglu, "eastern redcedar has volatile oil in its anatomy which increases the fire risk" to tree stands and everything that surrounds them (2010). Additionally, "The increased juniper infestation within the areas where humans interact with environment has resulted in a potential increase of catastrophic wildfires" (Zhang and Hiziroglu, 2010). Zhang and Hiziroglu continue:

> "Economic loss and the cost of suppressing these fires are immense and can cause considerable losses to the government and the public. Educating rural and urban interface residents about junipers and their increased risk to wildfire is a real challenge. Homeowners who appreciate the greenery and believe that "tree is good", mostly do not recognize the increased fire risk from these highly flammable trees growing near them" (2010).

And it is not only the economics that have Kansans worried, but also the simple preservation of landscape. Kansas rangelands offer us "high quality air and water, open space, and recreation" (Vallentine,1989). At one point in our history "tallgrass prairie covered 140 million acres of North America" (Polanksy, 2009), while today, a meager 4% of tallgrass prairie remains in North America, with the majority of it here in our very own state, in the Flint Hills of Kansas (2009).

According to Dr. Clenton Owensby, current Kansas State professor, this unusual increase in redcedar cover has been going on since the 1960s (Owensby *et al.*, 1973). In an early study published in the Journal of Range Management in 1973, Clenton Owensby *et al.* discovered that 96% of the redcedar trees in their study area were less than ten years old. The authors suggested that one of several reasons may have caused the increase: an increase in the presence of the starling birds that are reported to spread redcedar seeds; a decrease in some small mammal species that damage redcedar seedlings, or the promotion of redcedar for use in windbreaks (Owensby *et al.*, 1973).

The trouble with the redcedar invasion is that, like any sort of epidemic, its onslaught is slow and it appears harmless in its initial stages. If a few new trees crop up on grasslands now and again it is unlikely that anyone will worry, and it is only when we are faced with full-fledged forests where there was once prairie and open rangeland that we acknowledge that there may be a problem. By then, however, it is often too late to implement control measures that are not extremely costly. Without that ounce of prevention, the necessary cure can be daunting. There are a few fool-proof control methods, but often they are costly and time consuming, and while the topic remains relatively unsupported by research the cause goes mostly unknown.

Our research, then, attempts to provide a better understanding of just how redcedar is affecting the land it invades. It visibly fragments rangelands, yes, but it is also said to decrease plant biodiversity, increase soil erosion, and change soil pH. Soil pH can be easily measured, and we decided to use ground cover data as an indicator of soil erosion potential. Through a series of field excursions to sites of varying degrees of redcedar invasion, we collected data to measure tree cover, type and percent ground cover, and soil pH.

We hypothesize 1) that there will be a negative relationship between redcedar cover and living ground cover; i.e. as redcedar cover in an area increases; living ground cover in the general vicinity will decrease. We also hypothesize 2) that there will be a difference between the pH of soil found under redcedar stands and that of soil found outside the cover of redcedar.

Methods

Study Areas

Three areas around Manhattan, KS were chosen for the study and permission was sought and granted from the landowners. The goal was to find three stands of *Juniperus virginiana* at varying stand ages and densities. The three sites were chosen to be at different stages of invasion with the youngest site having trees between 8 and 10 feet tall and the two more advanced sites having trees around 40 feet tall with one site more densely populated than the other. Soil types varied between all sites. The lowest stage of infestation is situated on a soil composition of Dwight-Irwin complex, 1 to 3 percent slopes. At the intermediate and most advanced site, clime silty clay loam, 20 to 40 percent slopes, stony soils predominate. These soils are typical of the tall grass prairie, and will support the plants and grasses associated with them (Web Soil Survey).

Figure 2. Site 1, primary invasion site located just north of Manhattan

Figure 3. Site 2, secondary invasion site, located south of Manhattan.

Figure 4. Site 3, most advanced invasion site, located north of Manhattan near Tuttle Creek.

Understory Cover Measurements (Daubenmire Quadrat)

Figure 5. The Daubenmire quadrat was laid a 5m intervals along the transect and was used to estimate amount and type of ground cover.

At each site two 50 meter transects were established in as straight of a line as possible and in a manner perpendicular to the slope of the area. Beginning at the 0 meter mark quadrants and moving along in 5 meter intervals the Daubenmire method was used to estimate ground cover composition. Two sticks were used to lay the Daubenmire frame, one along the transect line and one perpendicular to the line. This method aided in working around the trees in our study area. The percent cover for bare ground, rock, plant litter, moss, forbs, and shrubs was visually estimated on a Daubenmire scale of 0%, 1-4%, 5-24%, 25-49%, 50-74%, 75-95% and >95%.(See Appendix A)

Tree Canopy Cover Measurements (Spherical Densitometer)

Figure 6. The spherical densitometer was used to determine percent tree cover using a concave mirror.

Densitometer readings were taken every 5 m along the transect lines in the same location as the Daubenmire quadrants. The device was held at waist height unless tree cover inhibited by vegetation then the densitometer was held level at ground level in a manner such that the readings were not impeded by the ground cover. Count was taken of the less prominent cover feature in the mirror, tree cover or sky, as if there were four dots in each box in the mirror. To calculate percent tree canopy cover, the count for tree was multiplied by 1.04 cover conversion factor (Lemmon 1956).

Tree Basal Area Measurements (Point Cruise Method)

To determine tree trunk basal area the Point Cruise method was used with a basal area factor of 10 with the JIM-GEM® Cruz-All, throughout all of the sites (Avery and Burkhart 2002). The scores were calculated using the following equation.

Figure 7. Point cruise method of measuring basal area of a site.

BA=(Total trees tallied/number of points) BAF

Tree Age Measurements (Core Samples)

To age the site tree core samples were extracted from the largest, and presumably the oldest trees at each site. The largest trees in proximity to the transect line were selected. Three cores were taken at the advanced site because it was clear which trees were the largest; we took more (4) at the intermediate site and the most (6) at the youngest site because all the trees were relatively similar in size.

Figure 8. Tree core extraction using the Suunto tree borer.

Cores were taken at breast height except in the cases of small trees, that were taken closer to the base, or large trees, where one had to climb between branches and the samples was taken slightly higher than breast height. The cores once extracted were stored in plastic tubes and refrigerated until they were secured to a board to dry. Tree age was taken as the average age found between the three counters.

pH Meter

Soil samples were taken both under tree canopy and in the open, two of each, for each transect. In taking the sample the top layer of organic debris was brushed aside and the top 2 cm of soil was extracted, approximately 0.25 L were collected.

In the lab, protocol and procedure was taken under direction of Dr. Ransom, Agronomy Soil Scientist at Kansas State University. From the soil samples 10 mL of soil was extracted to be tested, to each soil sample 10 mL of deionized water was added and the mixture stirred thoroughly. In the case of high organic content where the water was soaked up completely, more water was added in 10 mL increments until consistency matched other samples. After 30 minutes the samples were stirred again. After another period of 30 minutes the samples were stirred immediately before being tested with the Orion research digital pH meter.

Results

Our results generally show that as *Juniperus virginia overstory* canopy cover increases, the live understory cover decreases. Our results are not conclusive, as there were spots along our transects that were not consistent with the rest of our data. The most advanced site showed the strongest inverse relationship with a negative slope of 0.94 and an $r^2 = 0.59$.

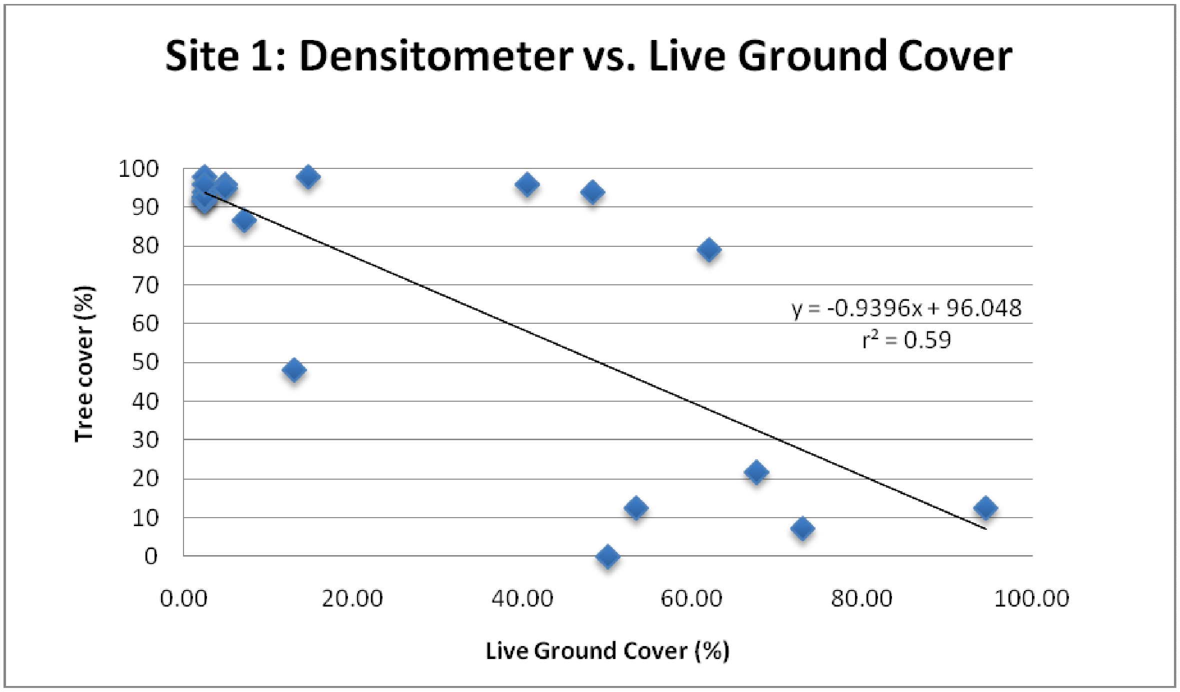

Figure 9. Shows the relationship between tree cover and understory cover in the advanced stage. The data displayed in this graph shows negative relationship indicating as tree cover increases, live understory cover.

Our intermeddiate site (Site 3) and initial stage sites showed less strong correlation results with an r^2 value for the intermediate site of 0.33 and for the low juniper density site having a value of 0.17.

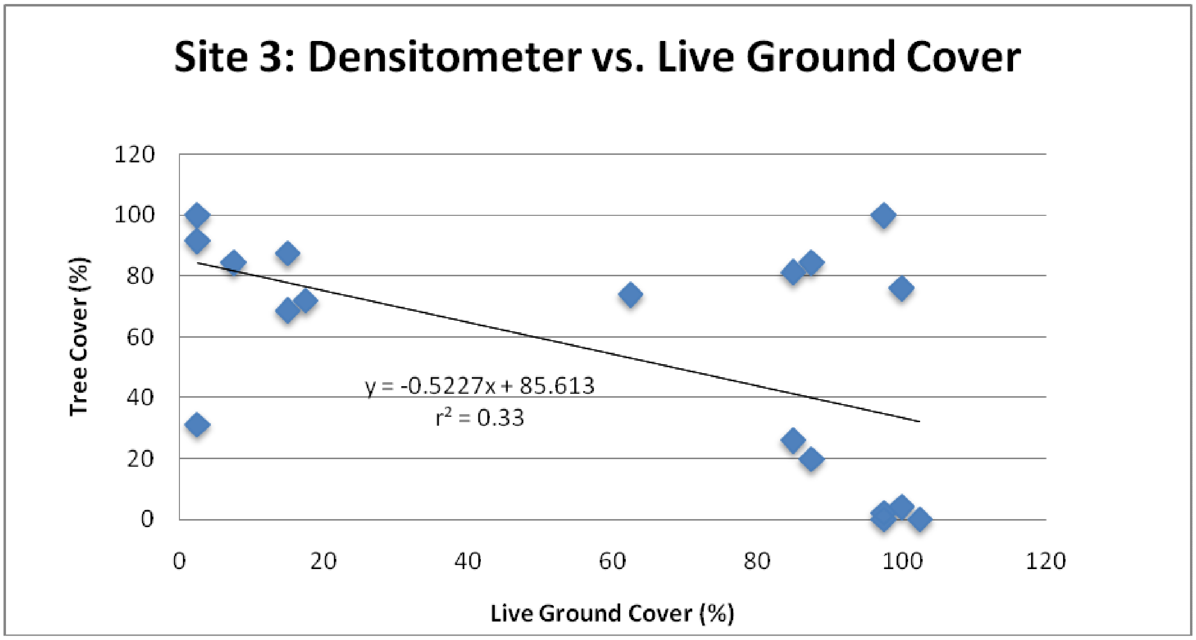

Figure 10. Shows the relationship between tree cover and understory cover in the intermediate stage. The data displayed in this graph shows negative relationship indicating as tree cover increases, live understory cover.

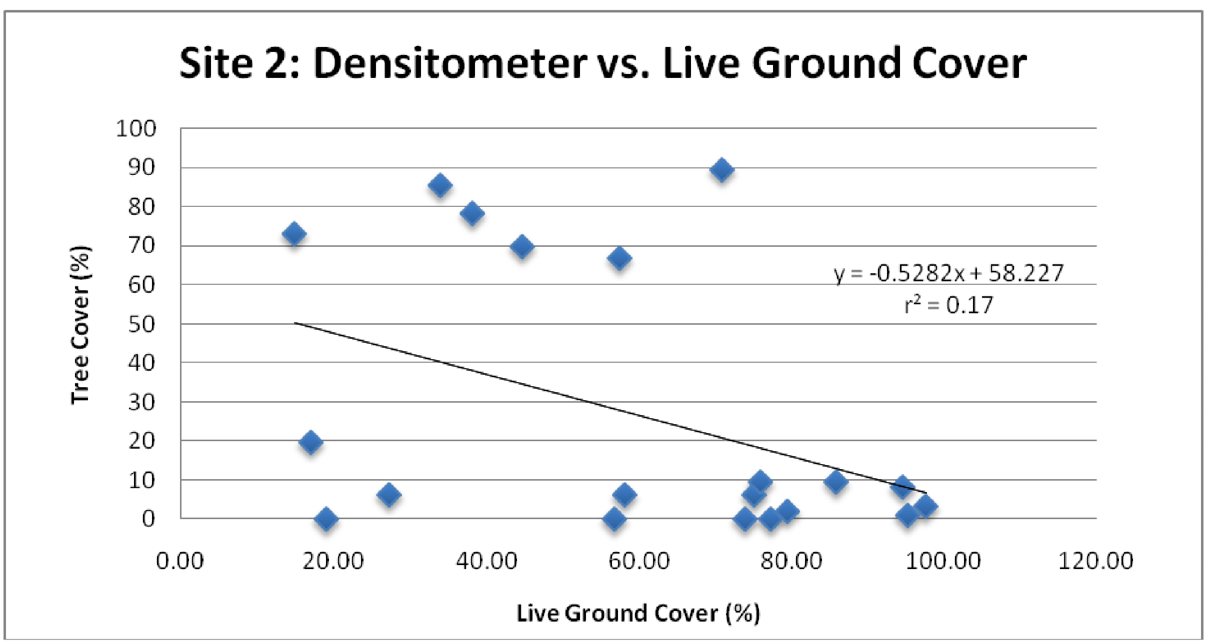

Figure 11. Shows the relationship between tree cover and understory cover in the initial stage. The data displayed in this graph shows negative relationship indicating as tree cover increases, live understory cover.

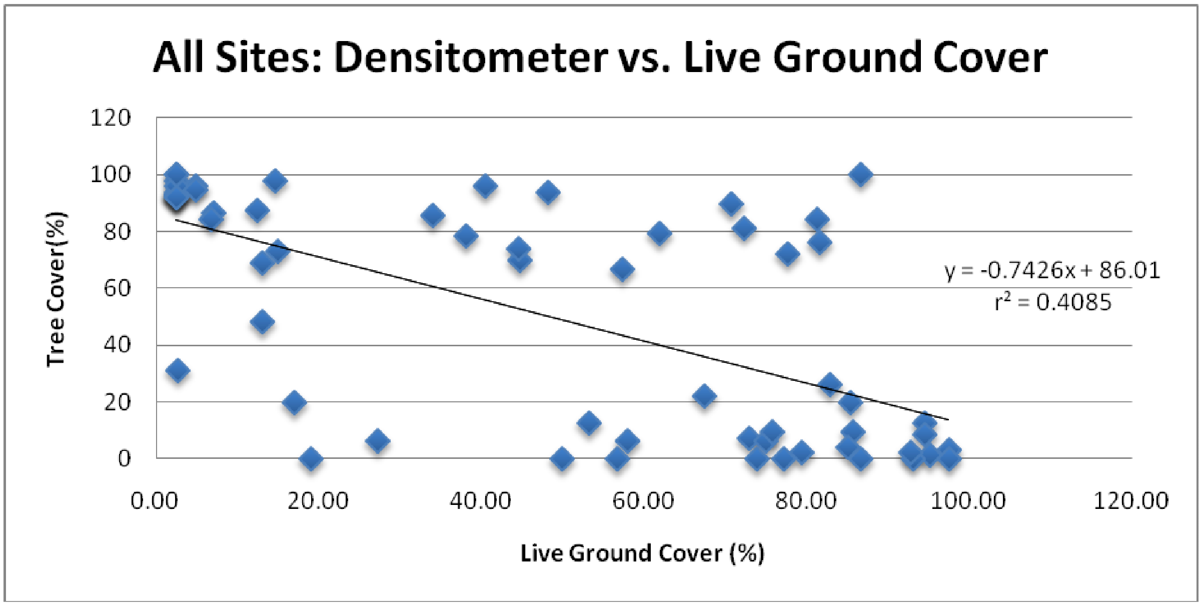

Figure 12. Shows the relationship between tree cover and understory cover combining all sites. The data displayed in this graph shows negative relationship indicating as tree cover increases, live understory cover.

This graph represents the live ground cover from all of our sites together. Because the negitive correlation is not as strong at the initial and intermeddiate stages, it makes this graph's slope weaker then our site one graph. Overall, it does support our hypothesis that as *J. virginia* increases invasion on a site, the live ground cover is lost. As the invasion stages increased, the basal area per acre also increased, effecting the live ground cover. Our initial stage site had a basal area per acre of 0, our intermeddiate stage site was 42.5, and our advanced site was 95, as calculated by the point cruise method. This supports why the initial and intermeddiate stage sites have a weaker correlation between tree cover and live ground cover then the advanced stage site.

We observed at one of our sites that there was increased rock cover.

Figure 13. Shows increased rock cover under tree canopy.

We believe that the slope of the site was a contributing factor to the exposure of rocks under the tree canopy. The slope was calculated using a climometer to get a reading of 20 percent. Our other sites either showed no correlation, or a negitive correlation. We believe this is because these sites we on level ground. This inconsistency could be because it is unknown whether the amount of rock is due to preexisting rock conditions at our sites.

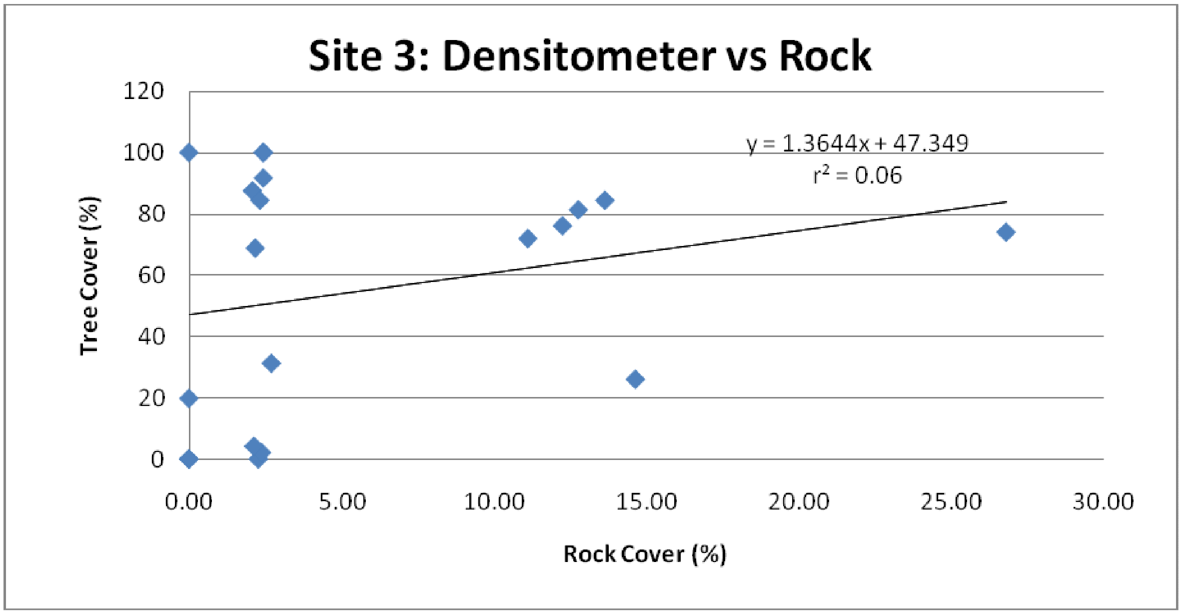

Figure 14. Shows the relationship between tree cover and rock cover. The data displayed in this graph shows positive relationship indicating as tree cover increases, rock cover increases.

Another hypothesis we tested was whether or not *J. virginia* effected the soil pH levels. These results were inconclusive. Most of our samples showed that the pH levels are lower under the trees then in open spaces.

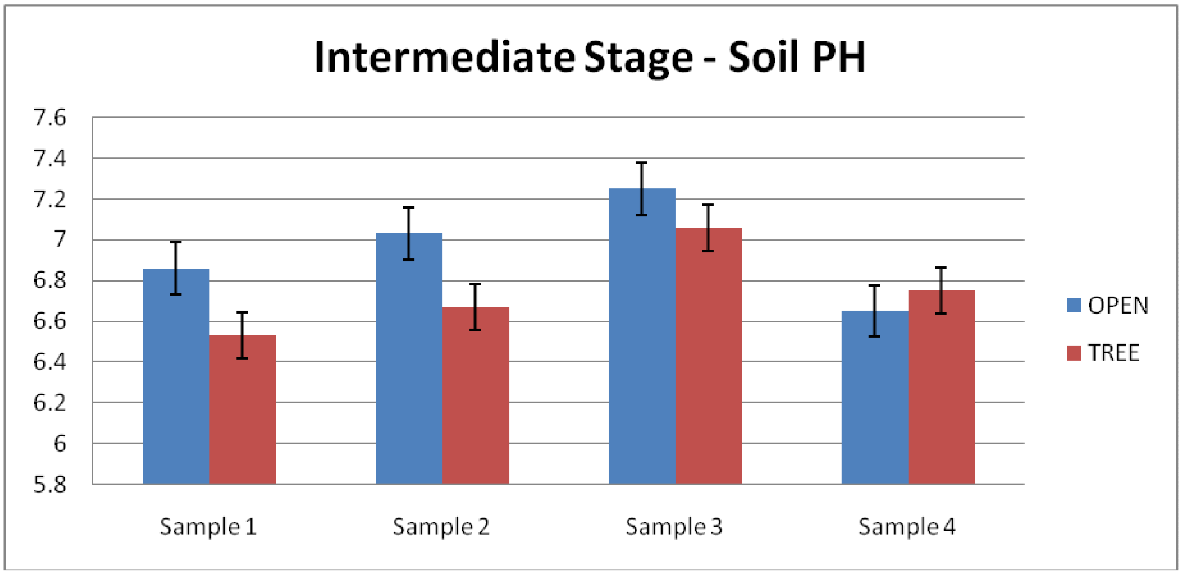

Figure 15. Shows the relationship between soil pH under tree canopy and outside tree canopy. The data displayed in this graph shows that the soil pH under the tree canopy is usually lower than that of pH levels outside tree canopy.

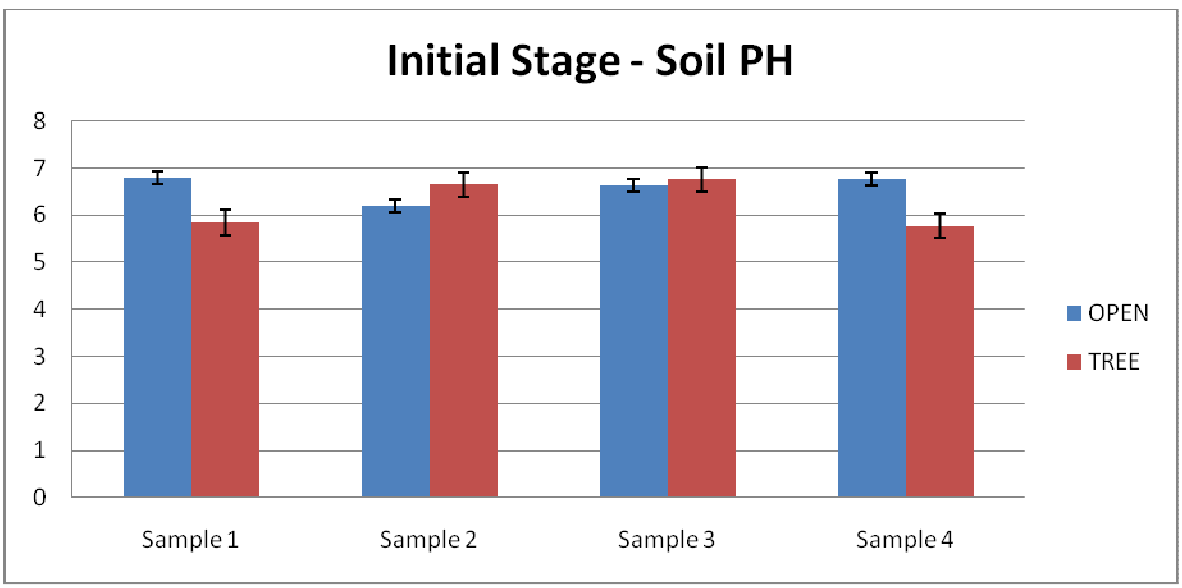

Figure 16. Shows the relationship between soil pH under tree canopy and outside tree canopy. The data displayed in this graph shows mixed results showing two samples with lower soil pH under the tree canopy.

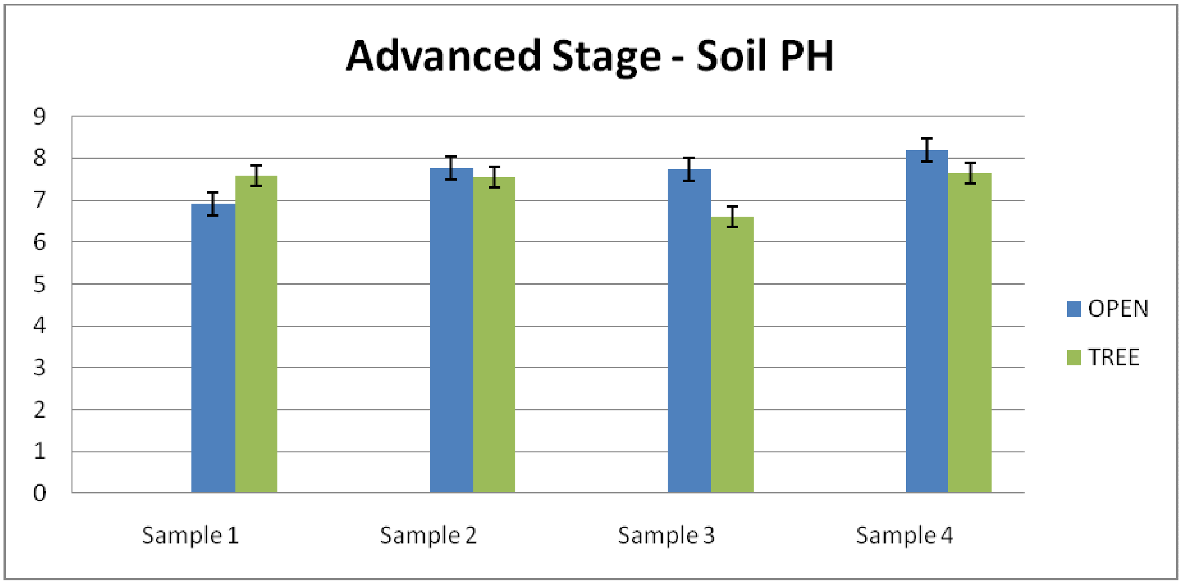

Figure 17. Shows the relationship between soil pH under tree canopy and outside tree canopy. The data displayed in this graph shows that the soil pH under the tree canopy is usually lower than that of pH levels outside tree canopy.

Discussion/Conclusion

Our first hypothesis is, there will be a negative relationship between redcedar cover and living ground cover. Our results support the acceptance of the alternate hypothesis that there is a relationship between tree and understory cover with increased tree cover reducing understory cover. The amount of understory cover decreases as the invasion site becomes more advanced. According to Pierce and Reich (2010), the presence of redcedar decreases the amount of sunlight and moisture the understory receives. This suppresses the growth of live understory around the redcedar invasions.

Our second hypothesis, there will be a difference in soil pH under redcedar when compared with soils away from the redcedar cover. Our findings show only small differences, and given the small sample size, we cannot confidently accept the alternate hypothesis and must say, there is no clear difference between the pH of soils underneath the canopy of redcedar and out in the open grass areas. Pierce and Reich also found no difference in their study, but prior studies have found the pH under the redcedar to be higher (more basic) than soils found in open areas. This may be due to "increased soil calcium and findings of higher excess-base levels (base content remaining after decomposition)," (Pierce and Reich, 2010, p 243).

The last characteristic that we observed was that the sight with the largest slope had a significantly higher amount of rock than the other two sites that had more level slopes (figure #). From this observation, we believe further studies on lands with steeper slopes would show an increase in soil erosion associated with increased cover of redcedar.

Figure 18. The steep slope of the intermediate site. This site had more rock present than the other two sites.

When assessing our research we found a few methods that we could improve. We need to standardize the way we collect our data. Different people collect data in different ways. It would have been beneficial to our research to have regulated methods with less room for human error and personal perceptions. We collected data from September until early November. We believe it would have been better to collect all of our data within the same two to three week period. As summer was changing into fall, the vegetation was changing and dying off. When we collected our data in

November it was difficult to tell what this year's vegetation was and what litter from the previous years.

When we collected soil we were under the impression that we needed a liter of soil to test the pH, when in fact we only needed 10 grams. Since we had to collect only the top few centimeters of soil it was difficult to get a liter without getting litter in our samples. If we were to retest our soil pH, we would get smaller samples of soil and make sure to keep all litter and organic matter out of the samples. When we were testing the pH of the soil, the digital pH reader seemed to be unreliable. We could have improved our results by doing a second trial of soil testing or by using a second method of testing the pH and then compared the two results.

From this research along with literature reviews it is obvious that redcedar has some negative effects on the vegetation and the soil around the site of invasion. Luckily, there are methods to control the spread of redcedar (although they can be costly and time consuming, especially if they are not controlled early on). The Wisconsin Department of Natural Resources (2004) states that the best control method for redcedar is the monitoring and prevention of spreading. It is also crucial to educate the public on the benefits of early removal. After a red cedar invasion occurs there are three main ways to eradicate the species, they include burning, chopping the tree down, and chemical control. Burning is the fastest and least expensive method for removing redcedar, but it is often only successful on trees that are less than two meters tall (United States Department of Agriculture Natural Resources Conservation Service, 2010). If trees are larger than two meters tall, the best method of removal is to cut down individual trees below any living green plant material. Herbicides can also be used to poison the invasive trees, but it is the most costly and time consuming. According to Pierce and Reich (2010) the prairie ecosystem has a strong capacity for rapid recovery once redcedar is removed. If we humans can control the spread of redcedar our prairie ecosystems are likely to recover from this invasive species.

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