Restoring Aspen Parkland at Riverlot 56 in Central Alberta

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Abstract

The Aspen Parkland ecoregion occurs within Canada and the United States of America between boreal forest and prairie grasslands. Large scale clearing and cultivation of this region has left very little of it in a natural state. Riverlot 56 is a protected area that contains unaltered, natural aspen forest as well as some cleared areas that have been cultivated for hay. In 2014 the Riverlot 56 Natural Area Society, as designated stewards of the site, initiated a project with the aim of reforesting the cleared section in order to restore habitat and control the invasive plant species that had colonized the cleared area in the absence of native vegetation. Plantings of native trees and shrubs were conducted utilizing three methods; within fenced "exclosures" to prevent grazing, within "islands" of unmowed areas, and transplanted from the forest edge into a row. The intention was that these plantings would provide cover eventually outcompeting the invasive species onsite.

By 2018, when this current project was initiated, there had been limited follow up and it was unknown whether the plantings had been successful. The goal of this project is to assess the three techniques that were utilized in order to answer the question, what is the most effective way to reforest a site within the Aspen Parkland while controlling invasive species? All of the plantings that were conducted in the study area were assessed for their rate of survival, both by species and propagation method. Within the three planting areas and the open field the amount of invasive plants per m^2 was assessed in order to understand the effectiveness of the plantings in controlling them.

The intention of conducting this new project was to understand what had been effective in order to continue applying the principles of adaptive management. As there is limited information available on restoration projects within Aspen Parkland adaptive management offers the most effective way of managing the site while simultaneously gaining a greater understanding of the site. Over the long term reviewing what methods have been effective on site and adjusting management plans accordingly it will be possible to effectively and efficiently reforest Riverlot 56.

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Introduction

The Aspen Parkland ecoregion is the largest and northernmost of the prairie ecoregions within Canada (Ecozones, 2014). Characterized by a continental climate of short, warm summers and long, cold winters with continuous snow cover the Aspen Parkland ecoregion represents the intersection of the boreal and prairie biomes in North America making it a zone of constant competition between grassland and forest species (St. Clair, Cavard, & Bergeron, 2013). Trembling aspen *(Populus tremuloides* Michx*)* and balsam poplar *(Populus balsamifera)* constitute the majority of the treed stands that delineate this ecoregion from the Moist Mixed Grassland Ecosystem to the south (Shorthouse, 2010). As is the trend with prairie ecosystems worldwide it has been heavily altered by humans and is disproportionately underrepresented within the system of protected areas (Hoekstra et al, 2010). Less than 5% of Aspen Parkland remains in a native state (Rasmussen, 2017). Riverlot 56 Natural Area is one of the rare sites within this ecoregion that has been largely preserved in a natural state and has been formally protected from development.

As an island of protected land surrounded by both farmland and suburban housing managing Riverlot 56 in a way that promotes native species biodiversity is inherently challenging. A number or areas within the riverlot were cleared for farmland and are now idle which has created challenges with invasive plant species. Ongoing management of these species through mowing, while necessary to control their dispersal, is both expensive and inhibits the reforestation of the site with native species (D. Stoker, personal communication, September 13, 2018).

Reforestation was identified by the Riverlot 56 Natural Area Society as a method to control invasive species while maximizing the use of the site for a variety of user groups, especially cross-country skiers. In 2014 the Riverlot 56 Natural Area Society initiated a project, spearheaded by Dan Stoker, to revegetate the site using three different techniques. These were: planting native species in fenced exclosures (see Appendix 1 for exclosure image) to keep out browsing ungulates, planting native species in unfenced "islands" that were not mowed, and relocating naturally regenerating, on-site saplings from the forest fringes to a location within the open area (see Figure 1).

This project will evaluate the efficacy of these different techniques based on the survival rate of the plantings as well as their ability to control the site's two most significant weed species in order to answer the question; What is the best way to reforest an open, disturbed landscaped in Aspen Parkland ecoregion in a cost-effective manner while managing noxious weeds? A lack of finances is often a limiting factor for projects such as this. The financial cost of each method will be weighed against its efficacy in controlling weeds through reforestation. This investigation will serve to guide further restoration and management in Riverlot 56. Furthermore, this project is intended to help groups and agencies with similar intentions to that of the Riverlot 56 Natural Area Society make decisions regarding their efforts to restore and manage sites in the Aspen Parkland ecoregion.

In addition to quantifying the results of the 5 Year Plan the goal of this project was to understand the site better and to provide suggestions for restoration. For this reason, a soil pit was included in the site analysis.

Figure 1.) Map of Riverlot 56's northern section (53.65972N, 113.5894W)

Ecological Context

The site of the restoration project within Riverlot 56 is comprised of Aspen Parkland forest (hereafter referred to as parkland) and cleared, disturbed land vegetated with bearded wheat grass (*Agropyron subsecundum)* and invasive species; of greatest concern is the two most common, noxious weeds on site, field scabious (*Knautia arvensis)* and Canadian thistle (*Cirsium arvense*) (Achuff & Talbot, 1971). A legacy of the glaciation that occurred in this region are the undulating plains that comprise the parkland region. Riverlot 56's terrain rarely exceed a slope angle of 5% (Knapik & Pettapiece, 1971). This is evident at the restoration site itself where there is almost no discernible slope. The surficial material of parkland is moderately fine textured, moderately calcareous glacial till (Natural Regions Committee, 2006). The soil on the site is comprised of Dark Brown Chernozems (Appendix 2 for images).

To supplement the information found in the literature and to provide a site-specific analysis a soil pit was dug onsite. The pit was dug until the clay layer was reached and then analyzed according to the methodology suggested by Klinka and Green in *A Field Guide to Site*

Identification and Interpretation for the Vancouver Forest Region (1994). The result of this soil pit indicates that the site has a silty-clay loam soil type with streaks and gleying (mottling resulting from soil saturation) beginning at 35cm of depth and a clay layer and significant gleying at 70cm of depth (Appendix 2a, 2b). The result of analyzing the soil pit alongside the onsite vegetation indicates that the site has a mesic moisture regime with a moderate to rich nutrient regime (DeLong, Banner, MacKenzie, Rogers, & Kaytor. 2011).

Climactically the Aspen Parkland ecoregion is consistent with a typical continental climate featuring cold winters and warm, hot summers (see Appendix 3 for temperature and precipitation data).

The moderately dry continental climate of Riverlot 56 influences the vegetation onsite but in a transitional zone such as the parkland the disturbance regime plays a significant role in determining whether Aspen Parkland, Boreal Forest, or Prairie is dominant (St. Clair, Cavard & Bergeron, 2013). Before large scale settlement at the start of the twentieth century and the land clearing and fire suppression that accompanied this settlement, fire was a significant presence on the landscape (Stockdale, 2014). Some of this fire would have been deliberately started by the Indigenous people of this region for the purpose of creating ungulate browse while the rest would have been from natural causes (lightning strikes) that the Indigenous peoples would have allowed to burn (Lewis, 1978). Due to intense fire suppression fires of any significant size within this area are now very rare (Natural Resources Committee, 2011). It is likely that this alteration of the historical disturbance regimes contributes to the challenge of managing invasive species on site (Figure 2) (Johnson, DiTomaso, Brooks, 2009).

When discussing the vegetation of Riverlot 56 it is logical to divide the site into two sections based on the degree of human intervention. There is the cleared area, used as a hayfield, which until the initiation of the restoration project in 2014 was comprised almost entirely of bearded wheat grass (*Aqropyron subsecundum*) and the noxious weeds field scabious (*Knautia arvensis*) and Canada thistle (*Cirsium arvense).* This is in contrast to the relatively natural areas surrounding the open field. This natural area is characteristic of parkland in that it includes a forest canopy dominated by deciduous trees such as balsam poplar (*Populus balsamifera,* hereafter refferred to as poplar*)* and trembling aspen (*Populus tremuloides)* with saskatoon (*Amelanchier anifolia)* red osier dogwood (*Cornus sericea)* and wild rose (*Rosa acicularis)* common in the shrub layer (Natural Resources Committee, 2011). Appendix 4 contains a more complete list of the species present on site.

In sections of the open hay field that are not mowed there is substantial encroachment of native species, especially trembling aspen, into the hay field. This is especially evident where the hay field is to the north of the native forest, possibly due to the important role that the shade of the established forest plays in moderating the effects of the summer heat and drought (St. Clair, Cavard, Bergeron, 2013). It is possible that this natural regeneration may continue and cover the field. However, due to the need to accommodate a variety of site users and the need to control the aforementioned weeds from spreading into nearby lands (discussed in the next section, Historical Context) it has not been possible to take a completely hands-off approach to the management Riverlot 56's vegetation.

Historical Context

The area that is today referred to as Riverlot 56 is within the traditional territories of the Cree, Ojibway, Assiniboine and other peoples covered by Treaty 6 (Taylor, 1985). Hunting and gathering of plants would have been commonplace activities on the banks and in the forest of the area (Taylor, 1985). The region was also a trade corridor through which Indigenous peoples would travel in order to access the North Saskatchewan River from the north and vice versa (Simonson & Johnson, 2005). This pattern of movement was amplified by the establishment of a Hudson's Bay Company trading post at what is now Edmonton (known as *Amiskwaskahegan* to the local Cree) in 1795 (Heritage Community Foundation, 2010a). The nearby city of St. Albert was founded in 1861 as a Metis settlement leading to the division of surrounding lands into farm parcels in the long, narrow style typical of French-Canadian farm parcels (Heritage Community Foundation, 2010b). In 1876 Treaty 6 was signed between the Government of Canada and the Cree, Ojibway and Assiniboine peoples of the region leading to further settlement of what is today central Alberta (Taylor, 1985). Riverlot 56 was parceled and divided but unlike much of the farmland bordering the site was never intensively farmed (T8N, 2017). The site was vacant until 1920 when it was purchased by the Government of Canada to be used as the site of the Edmonton Indian Residential School (T8N, 2017). The residential school only occupied the far southern extent of the parcel leaving most of the parcel relatively untouched until it was eventually sold to the Government of Alberta (Ma, 2013). The lower portion of the site, where the Riverlot 56 Natural Area Society initiated its restoration project was used recreationally by nearby residents but had no official designation until 1987 when it was made a provincial *Natural Area* (Government of Alberta, 2014). This designation is intended to "protect sensitive or scenic public land or natural features on public land from disturbance, and to maintain that land or those features in a natural state for use by the public for conservation, nature appreciation, low intensity outdoor recreation or education, or for any combination of those purposes" (Government of Alberta, 2014). To this end, the Riverlot 56 Natural Area Society and the St. Albert Nordic Ski Club (STANSKI) continue to manage the site for both public use and the preservation of the site's natural characteristics.

Project Outline

The role of this project was to assess the success of the Riverlot 56 Natural Area Society's *Five-Year Plan to Renaturalize and Partly Reforest Riverlot 56* and to make recommendations for future efforts to renaturalize and reforest the site. The Riverlot 56 Natural Area Society advocated for Riverlot 56 to gain protected status and have been stewards of the site since its designation as a *Natural Area*.One aspect of stewardship is the control of invasive weeds on site. Field scabious (*Knautia arvensis*) and Canadian thistle (*Cirsium arvense)* are widespread on site and are both provincially designated as a "noxious weed" meaning that legally they must be controlled (Government of Alberta, 2010). As Riverlot 56 is in close proximity to farm and range land the responsibility to manage these weeds is significant and for this reason the Riverlot 56 Natural Area Society contracted the mowing of the site to a local farmer (D. Stoker, personal communication, September 13, 2018). By 2014 there was a decreased interest in harvesting the hay onsite as it had become less economically viable. The imperative need for weed control, coupled with the opportunity to create new habitat for wildlife and the availability of funding through a grant impelled the Riverlot 56 Natural Area Society to envision and begin working on a plan to reforest the open space in 2014 (Riverlot 56 Natural Area Society, 2014).

While the Five-Year Plan included work within the southern, upslope area of Riverlot 56 this assessment focuses on the lower (northern) area which saw the most significant investments of time, energy, and finances. There were three major stages in the reforestation efforts.

In 2014 three hundred spruce (*Picea glauca)* trees were planted in ten "islands" (Figure 1, Appendix 5). These plantings were supplemented with trembling aspen, red osier dogwood, wild rose, wild raspberry, balsam poplar, honeysuckle, and pin cherry (Appendix 5). After initially being mowed to discourage plants that might compete with the new plantings these islands have been untouched.

2014 also saw the establishment of 4 "exclosures", areas that were surrounded with six foot high wire fencing high to deter browsing ungulates (Figure 1, Appendix 5,6,7). This strategy has been effective in other suburban and urban areas with high ungulate populations and limited natural predators (Larson, 2017). Evidence of ungulate browsing in the form of damaged saplings is abundant in the vicinity of the restoration site.

The third method of renaturalization utilized the abundant on-site stock of aspen and balsam poplar saplings that have naturally started to reforest the field from the forest margins. Using a skid steer with a tree spade attachment trees were relocated from the periphery of the forested areas into a row in the middle of the field (Figure 1, Appendix 9). This method allowed for larger trees to be relocated than would have been possible with hand planting.

When the Riverlot 56 Natural Area Society began this project there was a high degree of uncertainty on how best to reforest the site as few similar projects had been undertaken in this region (D. Stoker, personal communication, September 18, 2018). The answer to this uncertainty was the specific, detailed, and documented method for reforesting that the Society used including detailed planting lists and gridded, mapped planting schemes (Appendix 5,6,7). Utilizing the framework of adaptive management (Plan, Do, Evaluate and Respond) (Appendix 8) the intention was to study the site while simultaneously reforesting it (California Department of Fish and Wildlife, 2018). Despite this intention the site had been left unstudied since 2016.

The intention in undertaking this new project was to update the Riverlot 56 Natural Area Society's records on plant growth on the site and to study which of the three methods had the greatest level of success. In order to do this two metrics were assessed within each of the three distinct planting areas. Survival rates of the planted species and the quantity of the two most significant invasive species within the area (field scabious and Canada thistle) were evaluated. The success of the areas in regard to planting survival and weed control was assessed relative to the cost of each method.

Figure 2.) Margin of forested area in Riverlot 56, pink flowers are field scabious (*Knautia arvensis*)

Methods

Quantifying the survival rate of the plantings was straightforward due to the recordkeeping of the initial planters. The planting lists, as well as the stratified method of planting (Figure 5,6,7) aided in this. With the help of volunteers all of the islands were visited and the white spruce (*Picea glauca,* hereafter referred to as spruce) as well as any other species planted within that island were counted. By standing shoulder to shoulder and walking in a straight line, "sweeping" each island, it was possible to be confident that all the spruce still living within each island were counted. It was more challenging to locate and count the other species that had been planted. Spruce naturally occur far more rarely within the parkland than the other native species that had been planted making them visibly distinct. (Environment Canada, 2014). In all cases the utmost effort was made to locate the other plantings and to differentiate between individuals that were planted and those that had spread naturally. When it was not possible or realistic to locate them, they were presumed dead.

The exclosures were originally mapped and planted utilizing a row system (Appendix 6,7). As the spruce were the easiest to locate they constituted a point of reference for locating and identifying the other species planted within the exclosures.

There was less documentation of the trees that were relocated using the skid steer (Appendix 9). Fortunately, as the trees that were relocated were bigger, it was simple to identify where a tree that had been relocated had died. Each tree, living or dead, was identified as aspen or poplar and counted.

The prevalence of invasive species on site was evaluated using a quadrat and randomly sampling each of the three planting areas. The open field, where no work was conducted, was also sampled to provide some measure of a control variable. The purpose for sampling the area that had not been restored was to understand if there was a reduction in the quantity of the invasive species that was correlated to the planting of native species. For this survey the 4.51-hectare site was gridded and divided up into ninety-nine 619 m^2 squares using Google Earth. All of the squares were numbered. For the assessment of the open, unplanted field, 20 of the 99 squares were selected using a random number generator. Each square was located in the field using GPS coordinates and on the ground landmarks. In order to eliminate bias, the south east corner of each square was located, and from there the quadrat was thrown as far as possible towards the north west corner. If the quadrant's landing position overlapped an island or exclosure it was moved as little as possible so that it was entirely off of the island (Appendix 10).

To sample the island areas all the squares on the gridded map with any amount of island within them were assigned a number. From this new set of numbers twelve numbers were randomly selected. The selected grids and the southeast corner of each square were located. From here the quadrat was blindly thrown into the portion of the square that was island (evident from the length of the uncut grass and weeds) (Appendix 11, 13). If the quadrat was not entirely within the island area it was shifted as little as possible until it was.

Each exclosure was surveyed separately. The three larger exclosures were planted with 170 plants in rows. Building off this system, which was already mapped, six numbers were randomly generated from the set of 170 numbers. While sampling 6 out of 170 plants would appear to be a low number the plantings are tightly spaced. Based on this spacing six seemed to be adequate for getting an understanding across the exclosure. Within each of the three larger exclosures the species planted were in a grid formation, but the species order was random that the sampling was not affected by being conducted adjacent to the same species in each exclosure (Appendix 6). At each selected plant the south east corner of the quadrat was placed at the stem of the plant and then invasive species were counted within it (Appendix 12). Exclosure 1, being smaller and differently shaped, had less plants within it. To compensate for this a set of six random numbers was generated from the 101 plants within it. These were sampled in the same manner as in the three larger exclosures.

The row of trees relocated by the skidder was sampled by sampling every sixth tree. As the trees were planted linearly this method was decided upon as it offered a way to obtain a sample of the entirety of the planted row with as little bias as possible. Moving from east to west, at each of the six trees the quadrat was placed so that it was centered within the row as much as possible.

After obtaining the data from the plantings and the data from the weeds onsite averages were calculated for both data sets, for each location. This allowed two comparisons; survival of plantings and the quantity of noxious weeds. The three methods could then be assessed based on their cost effectiveness. While total rates of planting survival and weed counts comprised the main methods of analysis the rate of survival of aspen and poplar in the island plantings, exclosures, and the row of skidder plantings was also conducted. A wide variety of native plants was used in the original plantings and the varying rates of survival between species within the same island or exclosure reflects the varying conditions required for growth by each species. By looking at one species that was consistently planted across all sites it may be possible to draw conclusions that were otherwise not possible when looking at rates of survival as a whole.

Results

The summers of 2014 and 2015 were atypically hot and dry in the region around Riverlot 56 (Government of Canada, 2018b). This multi-year drought continued until the summer of 2016 with decreased spring and summer precipitation and a lower than average snowpack (Government of Canada, 2018b).

The total survival rate after 4 years, of all plantings over all three methods, is 65.28% (1574 planted, 1026 survived). Within this number is a high degree of variability of species that survived and where these species survived (Table 1, Chart 1).

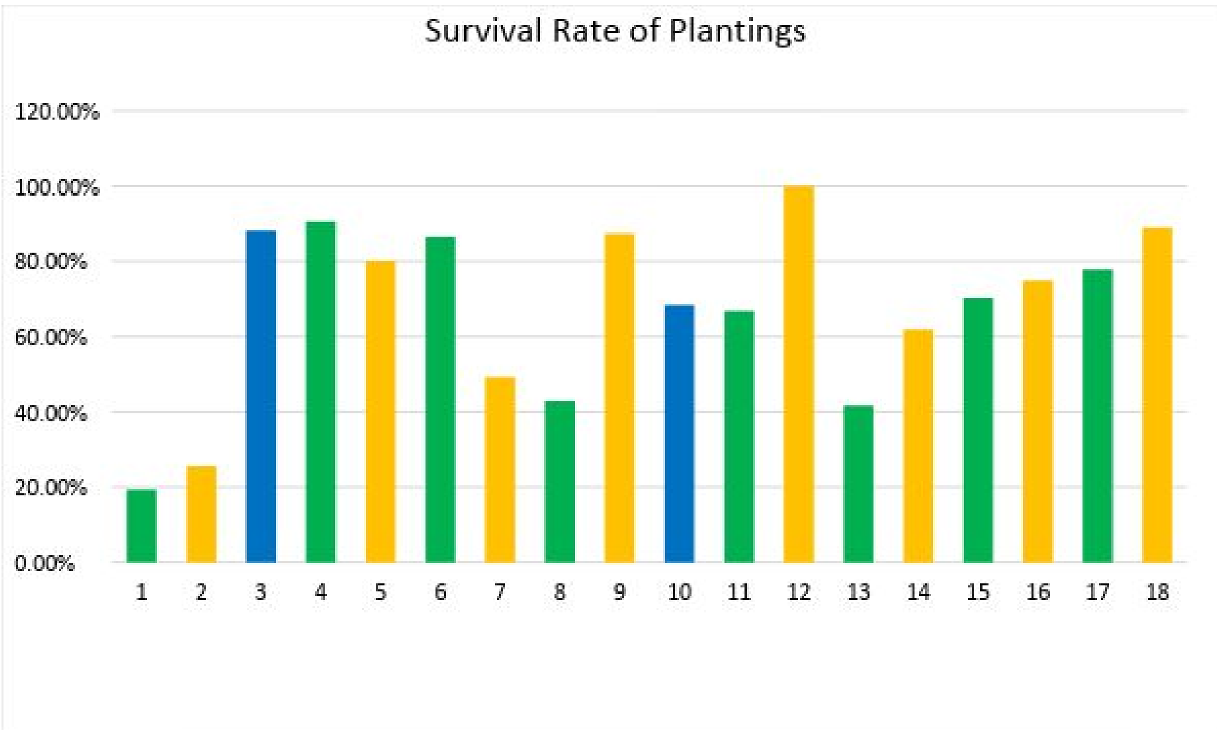

Chart 1.) Species Survival Rates by Location

Species	Location	Survival Rate
Trembling Aspen	**Island**	**19.30%**
	Exclosure	25.50%
	Skidder Row	**88.20%**
White Spruce	Island	90.60%
	Exclosure	**80.10%**
Dogwood	Island	86.70%
	Exclosure	**49.20%**
Balsam Poplar	Island	42.90%
	Exclosure	**87.50%**
	Skidder Row	68.40%

Honeysuckle	**Island**	**66.70%**
	Exclosure	100%
Pin Cherry	**Island**	**41.70%**
	Exclosure	62%
Wild Rose	**Island**	**70.20%**
	Exclosure	75%
Wild Raspberry	**Island**	**77.80%**
	Exclosure	88.90%

Planting Survival

Survival of white spruce seedlings (*Picea glauca*) was significantly higher than any specific area total averages and higher than the average of any other species. The white spruce rate of survival was fairly consistent across the areas in which it was planted. On the other end of the spectrum, the average rate of survival for aspen was lower than the overall average in all locations except the row of trees transplanted by the skidder. The exclosure system appears to have had mixed results. While some species clearly benefitted and had higher rates of survival within the exclosure (balsam poplar *Populus balsamifera*, honeysuckle *Lonicera glaucescens*, wild raspberry *Rubus ideaus*, and wild rose *Rosa acicularis*) other species such as spruce and dogwod (*Cornus sericea)* had higher rates of success outside of the exclosures. Disregarding variability between species the total survival rate in the islands was 77.51%, in the skidder row was 77.78%, and in the exclosures was 40.54%. While some species within the exclosures thrived and had high rates of survival the overall average rate of survival was lowered by the large number of aspen trees

Table 1.) Planting Survival Rates

that were planted and the very low number that survived.

Trembling aspen and balsam poplar were the only species planted across all three areas. Trembling aspen had very low rates of survival within the islands (19.3%), low rates within the exclosures (25.5%), and high rates of success in the skidder row (88.2%). Balsam poplar was most successful within the exclosure (87.5%), moderately successful in the skidder row (68.4%), and least successful in the islands (42.9%).

The effectiveness of the different areas in suppressing weeds is difficult to assess as the results are not significantly different. For example, the variation between some exclosures was more significant than between the total exclosure average and the open field (Table 2, Chart 2). The islands averaged a total weed count of 15 per m^2 compared to a total of 23/m^2 in the exclosures, 20/m^2 in the open field and 18/m^2 in the skidder row. While there was variation between the exclosures the lowest exclosure still had a count of 18 weeds per m^2.

Table 2.) Weeds per m^2 in Restoration Areas

Area	Species	Number	Total

Exclosure 1	Thistle	18	28
	Scabious	10	
Exclosure 2	Thistle	16	20
	Scabious	4	
Exclosure 3	Thistle	18	27
	Scabious	9	
Exclosure 4	Thistle	13	18
	Scabious	5	
Exclosure Total	Thistle	16	23
	Scabious	7	
Island	Thistle	10	15
	Scabious	5	
Open Field	Thistle	14	20
	Scabious	6	
Skidder Row	Thistle	14	18
	Scabious	4	

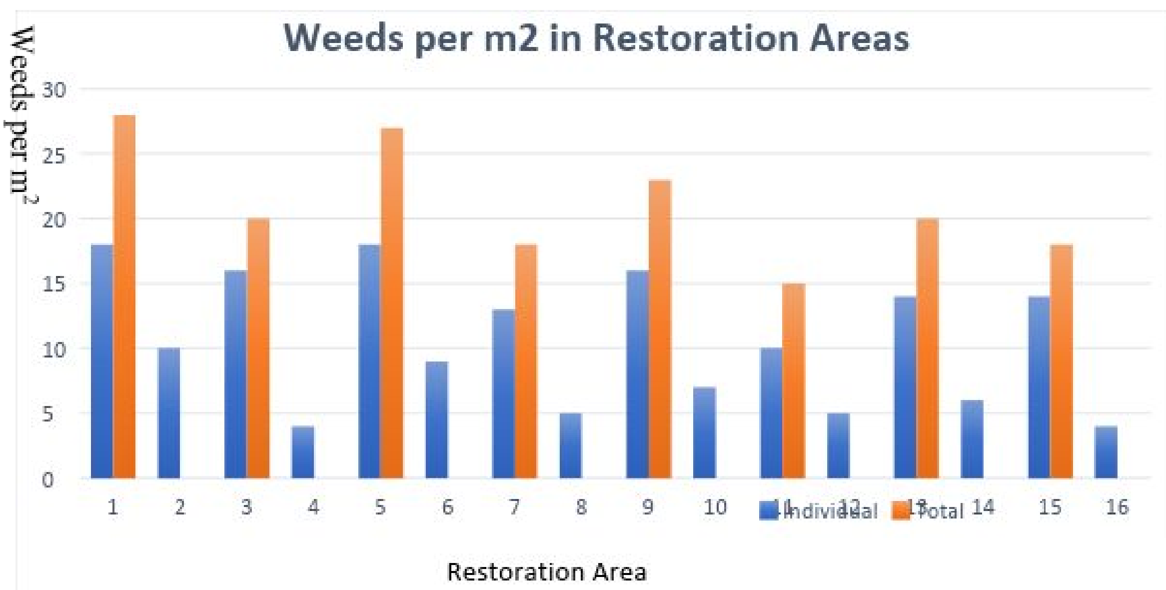

Chart 2

Discussion

The findings of this project suggest certain species are more effective than others for the purpose of reforestation. White spruce has had by far the highest success rate of the species on site. If the intention is to change the structure of the open, deforested field the spruce clearly offer an effective option. However, in a typical parkland ecosystem white spruce occurs rarely and there is little natural precedent for it on site. (Environment Canada, 2014). In cases where long term fire exclusion occurs parkland may naturally give way to spruce (Bird, 1961). However, relying on white spruce to reforest the site where there is almost no naturally occurring white spruce in the vicinity may be akin to creating a novel ecosystem; one that would provide valuable ecosystem services but may not necessarily have a historical precedent on site (Morse et al, 2014).

If the goal of reforesting and renaturalizing Riverlot 56 is to be achieved, and if the goal is to create an ecosystem that is analogous to the forested areas currently on site then it is clear that trembling aspen should be prioritized. The survival rate of trembling aspen on site was highly variable but was highest by a margin of over 60% in the row of trees that was relocated from onsite. This may be due to two important factors; the saplings being relocated on site are already adjusted to the restoration site and local conditions and they are also taller than the smaller, nursery grown plantings. Being conditioned to the site and being genetically optimal for the specific location are important factors for a successful planting (Landowner Resource Manual, 2000). In addition, the size of the aspens that were relocated made them better able to compete for resources like sunlight and water. In the islands, where trembling aspen survival rates were lowest, there were a number of dead aspen saplings that thistle and grasses had grown completely over top of. Financially, relocation is also the most effective option. The costs of purchasing the trees from the nursery (varies, between $6-$12 per tree) and the cost of paying for tree planters ($20.00/hour) compared to the cost of the tree skidder ($140.00 per hour) seems low but when the sums of each is divided by the number of trees left living after four years the cost for the skid steer trees is almost half that of the planted saplings (Riverlot 56 Natural Area Society, 2014).

Almost all of the shrub species survived better within the exclosures than outside. These species provide valuable diversity onsite, especially within the exclosures which, planted in the middle of the field, may have a lower likelihood of native species colonization without human intervention. Honeysuckle and wild raspberry were also seen to be colonizing the sites with a number of individual plants that had clearly spawned naturally.

Dogwood was the one shrub that was more successful in the islands than in the exclosures. This may be due to its low drought tolerance; the exclosures were located in the middle of the open field, compounding the drought effects of the initial two years of the project, while the islands were for the most part more sheltered from the sun along margins of the forest (Government of Alberta, 2017).

It is more challenging to draw conclusions of the effectiveness of the plantings in suppressing the growth of weeds on the site. The results were not significantly different between locations onsite. Interestingly, the lowest number of weeds per m^2 was found in the islands. This may be due to a number of factors. Many of the islands are contiguous to the natural forest leading to an abundance of native plants that can compete with the weeds. These islands are also more shaded than the exclosures or open field areas; sunlight is an important limiting factor for thistle growth (<20% sunlight will lead to mortality) (Elpel, 2017). It is also possible that there may be some amount of grazing when the thistle is young and edible in spring as compared to in the exclosures where any grazing is restricted.

Recommendations

In the interest of continuing to employ adaptive management at Riverlot 56 the project should be continued and monitored. The effectiveness of the different renaturalization methods will become more obvious as the plantings mature and begin to shade out the weeds. Based on the observations thus far a couple of new techniques could be employed that may be effective.

The most cost-effective method for producing trembling aspen trees that are viable over the long term has been demonstrated to be using a skid steer to relocate aspen from forest edges. Combining this method with an exclosure to prevent browsing may increase the survival of these species beyond the 88.2% seen without any protection. It will almost certainly increase the survival of relocated balsam poplar, which did well in the skid steer row (68.4%) but also benefitted from the exclosure (87.5% survival rate).

With the ongoing and increasing impact of climate change it is widely anticipated that species, and the ecosystems that they comprise, will shift their range northwards (Schneider, 2013). Riverlot 56 occupies what is currently the boundary between boreal forest to the north and parkland to the south (Environment Canada, 2014). As the climate warms this boundary will shift north making boreal species like white spruce less adapted to the site while making the site more conducive to aspen and other parkland (although some projections suggest that by 2100 the area will be grassland) (Schneider, 2013). The effects of climate change will likely amplify the drought effects that were seen when the original 5-Year Plan was implemented in 2014. Therefore, if reforestation is to occur in a lasting, meaningful way on site it will be most effective to maximize the sheltering benefit of the established aspen forest (Campbell & Cambell, 2000). Natural Areas such as Riverlot 56 will be critical to the preservation of the parkland ecosystem as climate change causes species of the parkland ecosystem to disappear from the southern extent of their range (Worrall et al, 2013).

It may be effective, and interesting from an adaptive management perspective, to set up exclosures in areas where poplar and aspen are naturally regenerating. This may combat the browsing of these trees by ungulates and hasten the natural process of regeneration.

Areas in the field on the north side of the forested areas demonstrated more effective natural regeneration than areas to the south of the forest (Appendix 11). This indicates that the sheltering effect of the trees plays a significant role (Campbell & Campbell, 2000). Exploiting this effect may hasten the reforestation of the site and contribute to a higher rate of planting survival.

Conclusion

Riverlot 56 has seen substantial change over the years but fortunately natural aspects of it have been preserved. These attributes provide an opportunity for members of neighbouring communities to understand what their region was like before settlement, agriculture and development and provide a subtle reminder that nature exists both outside and within seemingly urban communities. The work that Riverlot 56 has done to capitalize on opportunity has been invaluable to the ongoing preservation of the site. The most important part of adaptive management is to be constantly observing, assessing, and adapting management plans and that is the intention of this report. One important aspect of the restoration project is the opportunity that it provides for community engagement. The long-term stewardship of Riverlot 56 will require the ongoing commitment of organized volunteers. The Riverlot 56 Natural Area Society helped

to provide the impetus for protecting Riverlot 56 initially and has stewarded the site for multiple decades.
As the community of St. Albert grows, and use by multiple user groups increases, so too will the pressures on the site increase. Preservation of the values in the Riverlot will require the buy in of visitors and community members. Opportunities to take an active role in site management, such as plantings, provide a valuable opportunity to engage the community and can increase the amount of connection that local residents feel towards the site (Shandas & Messer, 2008). Efforts should be made to find the most effective balance between efficiently carrying out restoration on site and finding ways of engaging community members.

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Appendix

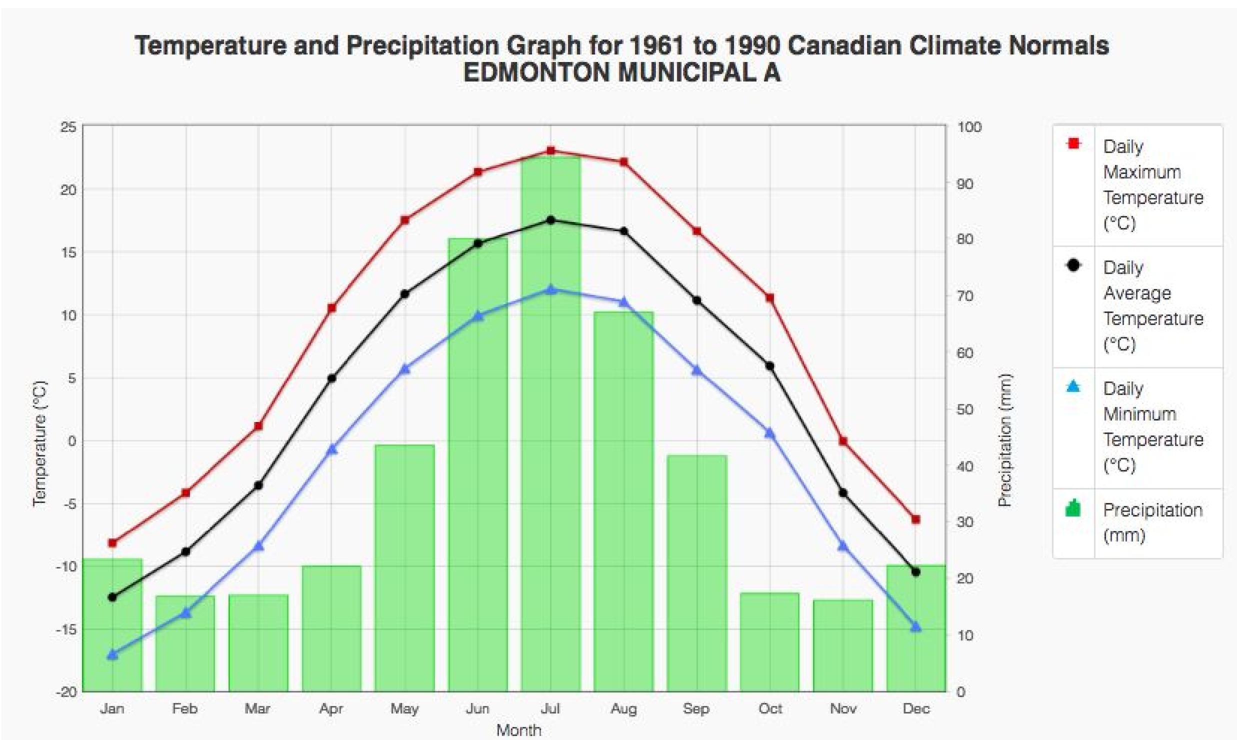
Appendix 1.) Exclosure 3 at Riverlot 56. Exclosures allow native vegetation to regenerate in degraded areas by restricting the ability of grazing species to access the site (Aerts, Nyssen & Haile, 2008).

Appendix 2a.) Soil pit; notice dark soil and mottled gleying below ~20cm

Appendix 2b.) Soil test; soil was easily rolled into casting that held shape

Precipitation													
Rainfall (mm)	2	0.8	2	9.9	40.5	79.8	94.3	67	39.9	10	2.2	0.9	349.3
Snowfall (cm)	25.6	19.6	17.7	12.8	2.8	0	0	0	1.9	7.4	16.3	25.5	129.6
Precipitation (mm)	23.3	16.8	17	22.1	43.5	79.9	94.3	67	41.6	17.3	16.1	22.2	461.3
Snow Depth at Month-end (cm)	21	20	8	0	0	0	0	0	0	1	6	17	
Extreme Daily Rainfall (mm)	9.4	4.1	6.6	27.2	43.9	80	114	59.7	51.3	23	8.9	5.8	
Date (yyyy/dd)	1965/ 14	1977/ 16	1955/ 30	1940/ 20	1939/ 19	1974/ 26	1953/ 31	1976/ 01	1969/ 04	1981/ 08	1956/ 05	1951/ 10	
Extreme Daily Snowfall (cm)	29	18	23	38.1	13.5	1	0	0	7.4	22.3	39.9	25.8	
Date (yyyy/dd)	1989/ 30	1962/ 03	1982/ 11	1955/ 19	1963/ 02	1967/ 09	1990/ 31+	1990/ 31+	1971/ 29	1984/ 18	1942/ 15	1979/ 09	
Extreme Daily Precipitation (mm)	29.6	19.1	21.3	38.1	43.9	80	114	59.7	51.3	24.4	39.9	21.1	
Date (yyyy/dd)	1989/ 30	1962/ 03	1972/ 23	1955/ 19	1939/ 19	1974/ 26	1953/ 31	1976/ 01	1969/ 04	1970/ 25	1942/ 15	1955/ 26	

Appendix 3a.) Precipitation Averages for Edmonton Area (Government of Canada, 2018a)



Degree Days													
Above 18 °C	0	0	0	0.3	4.1	14.6	32.1	27.6	2.8	0.1	0	0	81
Above 5 °C	0.2	0.3	3.9	59.1	209.2	318.8	388.9	358.9	190.7	77.1	3.6	0.1	1611
Below 0 °C	395.7	264.3	148.4	17.9	0.1	0	0	0	0.4	11.3	157.7	334.4	1330
Below 18 °C	948	761	671.4	393.4	201.3	85.7	46.1	71.7	208.9	374.2	668.1	886.9	5317

Appendix 3b.) Temperature Averages, Edmonton Area (Government of Canada, 2018a)

Species	Mean Cover (%)	Frequency (%)
TREES		
Populus balsamifera	29	100
P. tremuloides	43	100
SHRUBS		
Amelanchier alnifolia	15	100
Cornus stolonifera	27	100
Corylus cornuta	11	60
Lonicera involucrata	3	20
Populus tremuloides saplings	11	20
Prunus virginiana	4	60
Ribes triste	1	40
Rosa acicularis	9	60
R. woodsii	11	40
Rubus strigosus	4	40
Salix bebbiana	1	20
Symphoricarpos albus	9	60
S. occidentalis	3	20
Viburnum edule	3	20
HERBS		
Aster ciliolatus	4	60
Equisetum arvense	1	40
Fragaria virginiana	5	100
Galium boreale	2	60
G. triflorum	2	60
Lathyrus ochroleucus	1	20
Maianthemum canadense	1	20
Mertensia paniculata	1	20
Rubus pubescens	4	60
Sanicula marylandica	4	60
Taraxacum officinale	1	40
Vicia americana	1	20

Appendix 4.) Plant List for Riverlot 56 (Achuff & Talbot, 1971)

1 15

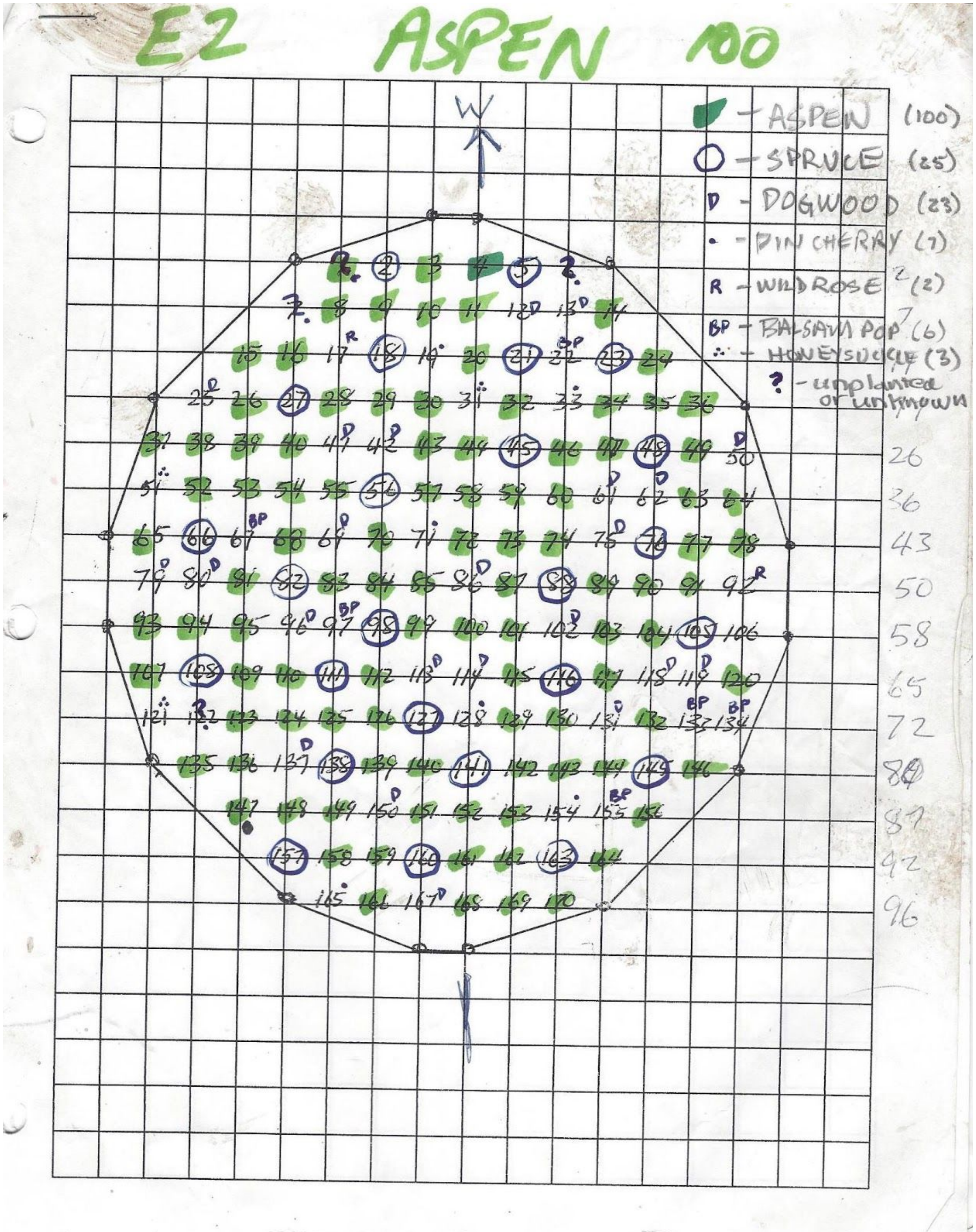
Starting Planted Trees

	TA	WS	DG	BP	HO	PC	WR	RA	BU	GO	SK
Totals Island #1	8	40	3	0	6	0	7	1	0		
Totals Island #2	8	40	3	0	0	0	6	1	0		
Totals Island #3	8	40	3	0	0	0	0	1	0		
Totals Island #4	8	40	3	0	0	0	0	1	0		
Totals Island #5	8	72	3	0	0	0	0	1	0		
Totals Island #6	8	40	3	0	0	0	0	1	0		
Totals Island #7	8	39	3	0	0	0	0	1	0		
Totals Island #8	28	60	3	0	0	0	0	1	0		
Totals Island #9	28	76	3	0	0	0	0	1	0		
Totals Island #10	28	71	3	0	0	0	0	1	0		
Totals Island #11	0	40	0	7	0	12	0	0	0		
Totals Island #12	0	60	0	0	0	0	0	0	0		
Totals Island #13	0	50	0	0	0	0	0	0	0		
Totals Island #14	0	63	0	0	0	0	0	0	0		
Exclosure #1	61	14	0	3	0	4	1	18	0		
Exclosure #2	93	25	22	6	3	7	2	0	12		
Exclosure #3	96	27	24	6	6	2	6	0	3		
Exclosure #4	100	19	24	6	0	8	4	9	0		
Beach DS	0	112	0	0	0	0	0	0	0		
Beach MS	0	32	0	0	0	0	0	0	0		
Big Trees	20	70	0	0	0	0	0	0	0		
Sunstar 14.09.25	45			45						20	20
Arrowhead 14.09.24	71				20					10	
Arrowhead 14.09.25	25		19								
Species Totals	651	1030	119	73	35	33	26	37	15	30	20

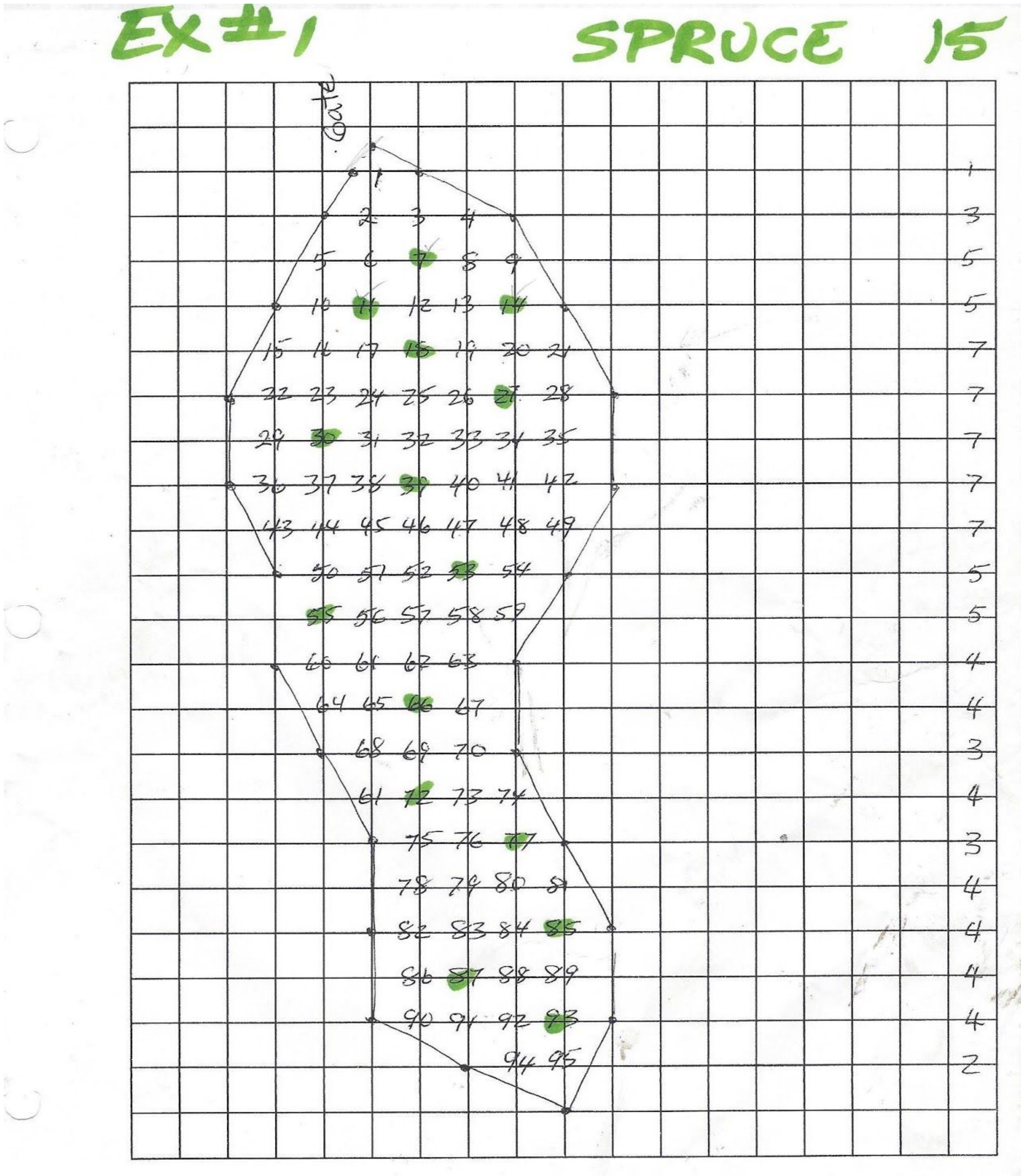
Grand Total

TA	Trambling Aspen
WS	White Spruce
DG	Dogwood
BP	Balsam Poplar
HO	Bracted Honeysuckle
PC	Pin Cherry
WR	Wild Rose
RA	Wild Raspberry
BU	Buckbrush
GO	Gooseberry
SK	Saskatoon

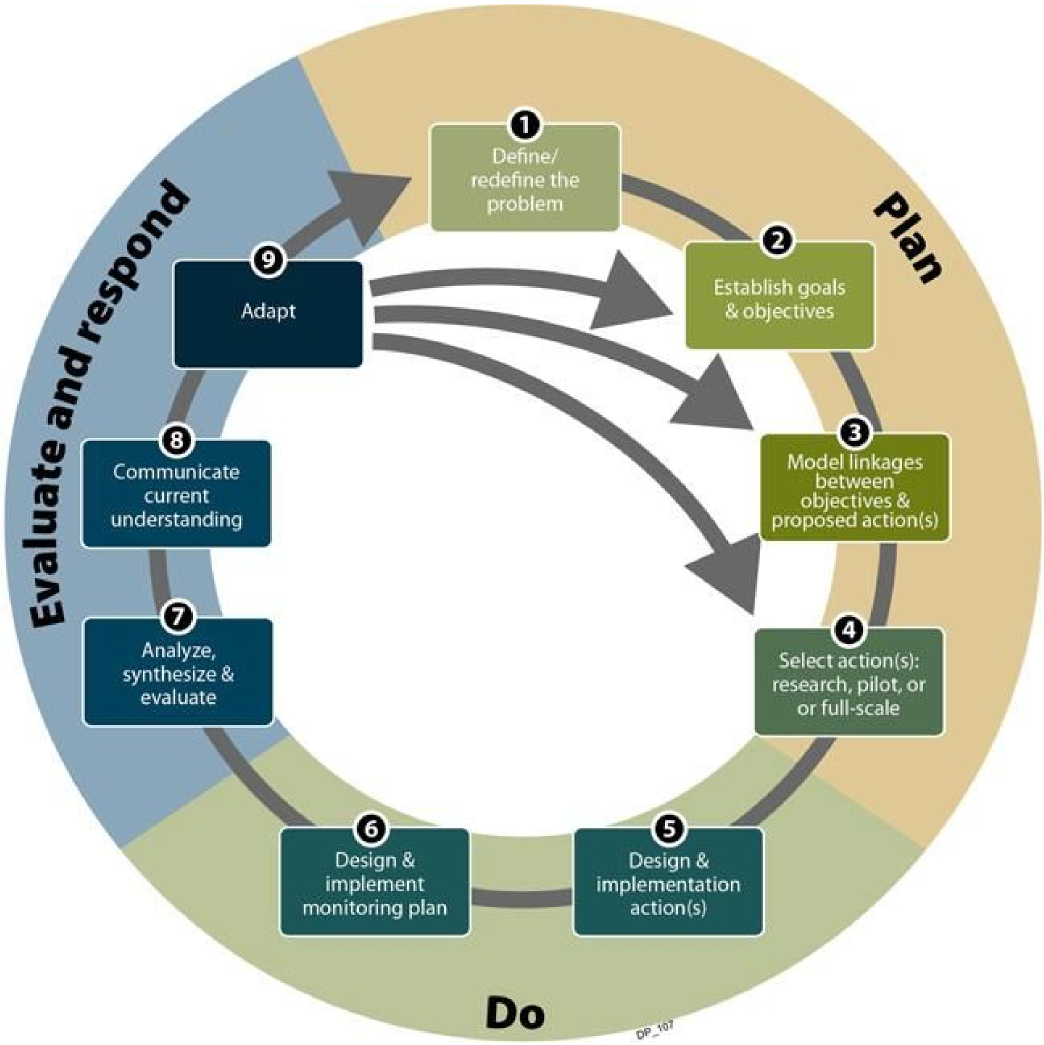
Appendix 5.) Planting List (Credit: Riverlot 56 Natural Area Society)



Appendix 6.) Planting Map for Exclosures 2-4 (Credit: Riverlot 56 Natural Area Society)



Appendix 7.) Planting Map for Exclosure 1 (Credit: Riverlot 56 Natural Area Society)



Appendix 8.) Illustration of Adaptive Management process (California Department of Fish and Wildlife, 2018)

Appendix 9.) Skid Steer Relocating Trees (Credit: Mary Schafer)

Appendix 10.) Quadrat in open field

Appendix 11.) Island planting area

Appendix 12.) Quadrat in Exclosure Appendix 13.) Quadrat in Island