An Alternative Planting Approach at Acreages South of Saskatoon, Saskatchewan

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Abstract

In the past 25 years, acreages around Saskatoon, Saskatchewan have been increasing, where stakeholders plant turf grass and tree rows of non-indigenous species, further reducing the remnant range of biodiverse grasslands historic to the region. In the Hamlet of Beaver Creek, 12 kilometres south of Saskatoon, however, remnant prairies and their trophic webs still exist within a stabilized dune complex. Working with local community members at three separate lots in Beaver Creek, we are developing habitat plantings of indigenous plants using propagation methods and locally sourced plant material to: 1) enhance biodiversity through habitat creation and better practices, 2) increase habitat connectivity, and 3) engage and inform stakeholders of natural ecosystems in their local region. Implementation trials were completed as plantings of native plants, including shrubs, coarse woody debris, and direct seed plantings to a treed shelterbelt, a biodiverse shrub community using live stake cuttings, and an invaded grassland community treated with live stake cuttings and direct seeding. The plantings addressed absent vegetative layers of previously established plantings for improved local ecosystem functioning, and consist of 5-10 carefully selected species at each site based on availability, suitability to site conditions, and applicability for each of the planting methods. Recognition of grassland species struggling after habitat destruction is increasing in our partners with participation and education, such as through learning about associations between birds and the invertebrates they forage on for reproduction. We discuss the collaborative and on-ground methods here, and review the development of community engagement and education as pivotal aspects of ecosystem restoration.

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This year long capstone project turned out to be a roller coaster of learning and experiencing what a restoration project can be, from interacting with and learning from landowners, to learning from and barely scratching the surface of what an interesting ecosystem the sand hills south of Saskatoon is, to how plants grow from the smallest of plant material known as meristem and germ plasm, to intense ecological interaction between severe drought and plants and animals that evolved with them. I would like to thank the participants, Judy and Jeff Montgomery, Zak Waldner and Dr. Cherie Westbrook, and Sharon Leach and Yvan Lebel for being great, supportive landowners allowing me on their land to try my ideas, which I had many. Also, I would like to thank my professor, Dr. Nancy Shackelford, Academic Director for the Restoration of Natural Systems Program, Continuing Studies Division at the University of Victoria, Dr. Tusa Shea, Program Director for the Restoration of Natural Systems Program, Continuing Studies Division at the University of Victoria, and the professors and students I met and learned from and with along the way.

1.0 Introduction

Acreages around Saskatoon, Saskatchewan in the Rural Municipality of Corman Park have been on an increasing trend the past 25 years, where converted grasslands through agriculture have been parceled off and sold as acreages. These lands are then commonly planted to trees, often introduced or native species out of their normal range and large areas of mown lawn, following traditional landscaping practice. However, these acreage lands were once a part of the most endangered ecosystem now recognized on most continents, the temperate grassland ecosystem (IUCN, 2021).

At the same time, worldwide there is a biodiversity crisis with insects being found in decline, including a report by Wagner et al (2021) estimating 1% -2% decline over the earth in insects per year a result of the many human caused stressors, including agricultural intensification, pollution, nitrification, etc. Similarly, the grasslands of Saskatchewan have declined roughly 6% in the past 20 years to ~14% remaining (Sawatzky and Piwowar, 2019). If combined with another estimation given by Tallamy (2009) for a 1:1 ratio in decline of wild animals to habitat loss world wide of over time, then the grassland community is on a gradual process toward extinction. But, as Tallamy has presented in books "Nature's Best Hope" and "Bringing Nature Home", planting native plants can reverse this. Or, also the approach by Rosenzweig (2003), and what he called "reconciliation ecology" to stop this earth wide 1:1 ratio of species decline to habitat loss by altering our landscape practices and instead design to accommodate the broader environment.

Instead of utilizing traditional landscaping practices, acreages have the potential through ecological restoration, "the process of assisting the recovery of an ecosystem that has been damaged, degraded or destroyed" (SER, 2004), to become part of a rewilding of sorts before the "ecological memory" is pushed further beyond resilience thresholds able to allow some form of the former community back (Schaefer, 2018). It can be a stop to the process of pushing wildlife further and further outward from our cities. But, at the same time these lands have become pinched inward by satellite cities, such as Warman, Martensville, and Osler, within an hours drive of Saskatoon are now expanding cities.

Recently, however, there was an announcement from the federal government for opportunity of an urban national park in Saskatoon between the Parks Canada Agency and Meewasin Valley Authority (Star Phoenix, 2021, Aug 4). Additionally, the Wanuskewin Heritage Park, a big part of the natural and cultural history of the area, too, has expanded with a big $40 million dollar renewal recently, and even accepted a small herd of Bison (*Bison bison*) to a designated area (McDonald, 2020, August 31). And, there is an increasing knowledge base of interested gardeners in urban environments to provide for biodiversity incorporating better practices and plantings for pollinators, as seen in numerous articles on the web, including the Smithsonian Magazine article on Douglas Tallamy's work to encourage landowners to allow more wildlife back to their properties and to plant native key stone plants, especially for insects, which he emphasizes through E. O. Wilson's saying they're "the little things that run the world" (Adler, 2020).

The opportunity exists then, with the basic idea offered by Tallamy (2019), for example, to plant native plants as landowners, like himself that can form what he calls your own "Home Grown National Park", where populations can be connected by expanded habitat between isolated functioning ecosystems. In addition, it may be possible for the general population to learn to recognize through "listening" to where ecological memory exists in some historical, current, or future state as landscape layers, such as an aspen bluff or xeric stabilized dune among the expanding cultural layers of acreages, for example (Schaefer and Tillmanns, 2018).

This project looks at an approach for landowners of the Hamlet of Beaver Creek, Saskatchewan to alter their landscaping practices by planting communities of plants that resemble those of nearby functioning natural ecosystems. The location of this project borders significant unconverted prairie ecosystem in the Dundurn Sand Hills to the south, and still shows significant "ecological memory" which is acting as resiliency (Schaefer, 2018).

Therefore, the main recommendation with plantings is to start small, establish, and repeat over successive years (Scalise, 1996), then collaborate as a Hamlet together to restore the local ecological integrity, even if it means invasive species are present. And, a key element is that the understanding that 10,000 years of evolution will never be replaced is required after conversion and that these are long term developments (Nernberg, 1995).

For this project, three stakeholders provided assistance and work locations toward achieving project goals and objectives through implementation trials to establish small habitat plantings in scenarios representative of common acreage owner vegetation plantings. Smaller areas were chosen with several appropriate species selected to give the best chance for achieving goals and objectives through the plantings. Three structural forms of vegetation communities for the habitat plantings were chosen, including treed, shrubby, and prairie, where existing key ecological characteristics remain such as hydrology, habitat quality, and biotic integrity in attempt to assist the recovery process.

1.1 Goals and Objectives

Project goals include:

1) Enhance biodiversity through small, manageable habitat plantings to establish as communities.
    a. Objective - establish 3-7 select locally adapted plant species as communities at each site with plant material propagated and/or purchased, preferably as young as possible to establish together.
    b. Objective - select habitat type and prepare a base design (i.e. grassland, shrub or treed) at each trial site that supports ecological function of nearby habitat.
    c. Objective – create habitat for as many organisms as possible that supports ecosystem function, including from Orders *Lepidoptera, Passeriformes,* or

Carnivora by planting their associative vegetation, such as *Salix spp* as *Lepidopteran* host plants.

2) Connect remaining natural ecosystems through plantings and better practices that increase habitat range for wildlife, such as pollinators
   a. Objective - survey for and research faunal species both local and migratory utilizing remnant habitat (i.e. ecological memory).
   b. Objective - encourage better practices, such as reduced mowing and no pesticides that further increase biodiversity throughout the Hamlet.
   c. Objective - minimize spread of invasive plants through mechanical treatments to remove seed source to encourage native plant establishment.
3) Engage and inform Hamlet stakeholders through easily applied protocol for ongoing habitat creation.
   a. Objective - develop a thorough and concise protocol for each habitat type, and present a simple and straightforward reference as a brochure.
   b. Objective - encourage participation through on-line sources, such as NextDoor or an already created Hamlet Facebook page.

2.0 Study Area and Methods

2.1 Regional Description

This project took place within the Prairies ecozone of Canada (Figure 1), which covers the lower third of the Prairie Provinces, from just west of the Rocky Mountains in Alberta to the Red River valley of Manitoba (ecozone.ca, n.d.). The primary ecoregion of the study area is the Moist Mixed Grassland of Saskatchewan, but transitions with influence from the Aspen Parkland ecoregion ~50km north of the project area (Thorpe, 2007). Furthermore, the drier Mixed Grass ecoregion can be found ~150 kilometres south of Saskatoon extending south across the border into the United States (ecozones.ca, n.d.). Overall, the Moist Mixed ecoregion is highly altered by agriculture, with ~20% remains uncultivated grassland (SaskAdapt web-site, 2021).

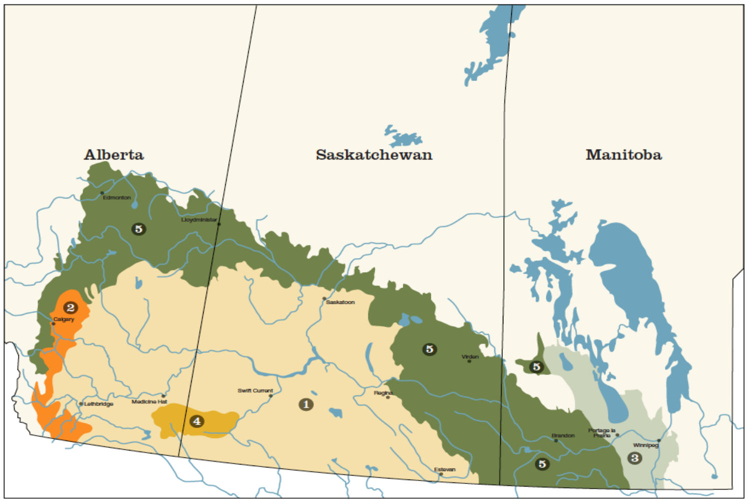

Figure 1: Prairies ecozone, containing the Mixed Grass Prairie (1), Fescue Prairie (2), Aspen Parkland (Tall Grass Prairie) (3), Aspen Parkland (Fescue Prairie) (4), Aspen Parkland (Fescue Prairie and Mixed Grass Prairie) (5) (Prairiepolination.ca, 2014).

2.2 Local Description

In general, Saskatchewan is a moderately dry climate, partly due to being on the lee side of the Rocky Mountains of Alberta, with resultant high pressure systems providing many sunny days, and where majority of precipitation comes as rain from May to September (Cote, n.d.). Annual average precipitation for Saskatoon using data from 1995 to 2020 was calculated at 344.5 mm, which includes two strong drought periods seeing annual precipitation to as low as 159.7 mm one year (2001), and during wetter periods as high as 642.5mm (2010). Precipitation records of the past year from August 2020 to August 2021 averaged 175.4 mm, similar in volume to the 2001 drought (weatherstats.ca, 2021) Other major dry periods were in 1930's and late 1980's (Thorpe, 1992).

The Hamlet of Beaver Creek is located approximately 12 kilometres south of Saskatoon, Saskatchewan within the Rural Municipality of Corman Park. There are ~47 dwellings with a population of a little over 100 people and a boundary encompassing 2 km2 ("Beaver Creek, SK", 2021) (Figure 2). It borders the Canadian Forces Detachment Dundurn to the south, which contains unconverted stabilized dune ecosystem and the Brightwater Creek flowing west before entering the South Saskatchewan River approximately 1km from the Hamlet. Immediately to the west are the Brightwater

Science, Environmental and Indigenous Learning Centre of Saskatoon Public Schools, and the Beaver Creek Conservation Area managed by the Meewasin Valley Authority, which the Brightwater (or Beaver) Creek also flows through before entering the South Saskatchewan River. East of the Hamlet, are more aspen bluffs, small pot-hole wetlands, and agricultural lands.

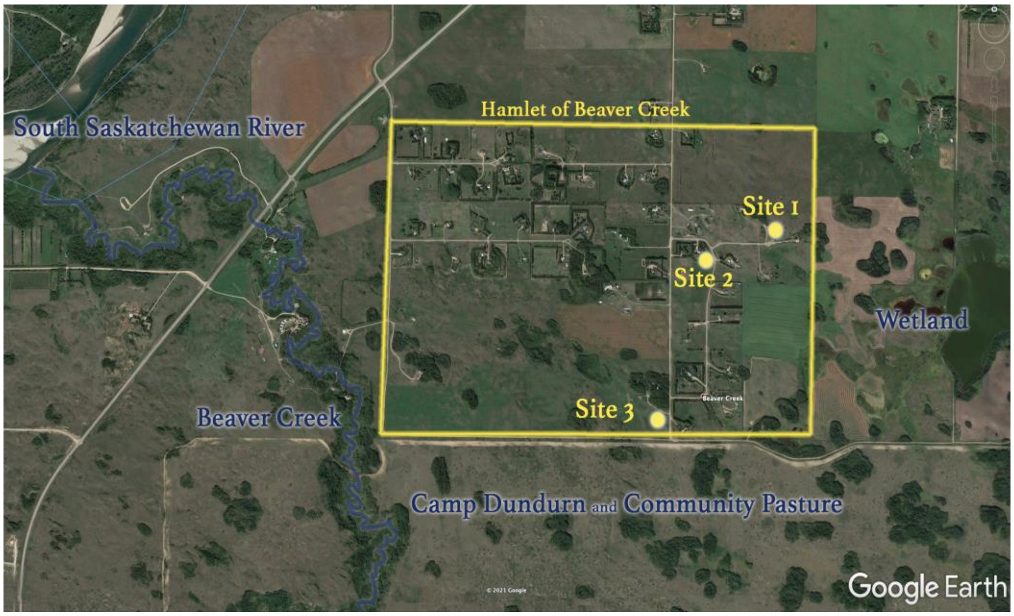

Figure 2: Hamlet of Beaver Creek and area. Project Sites highlighted within the Hamlet. (Google Earth, 2021)

The Dundurn Sand Hills encompass ~312km², and extend from the Hamlet of Beaver Creek ~40 kilometres south and ~10 kilometres across (Wolfe et al., 2002). A smaller sand dune complex exists on the opposite side of the South Saskatchewan River called the Pike Lake Sand Hills (~130km²) (Wolfe et al., 2002). They are glacially derived from a tributary that fed the ancient "Lake Saskatchewan", which deposited sand at the delta 10000 or so years ago (Harms, 1990) Areally, about 40% of the Dundurn Sand Hills has been converted to cropland, which is primarily in the northern portion where soil tends toward sandy loam (SNC Lavalin, 2020). The remainder is stabilized dune complex among the provincially run community pastures, the "Canadian Forces Detachment Dundurn", and Whitecap Dakota First Nation to the south.

Soils of the ecoregion are commonly Dark Brown Chernozemic due to accumulated grass material as organic matter (Thorpe, 1992). According to Acton et al (1970) the Dundurn Sand Hills' predominant soil is wind-worked glacio-fluvial formed Orthic Regosol, with coarse to moderately coarse grain and a knob and kettle landform, which include active complexes, stabilized blowouts, stabilized dunes, dune depressions, and sand flats (Hullet, 1966). For more on soil and vegetation see Hullet (1966).

The varied landscapes of the stabilized dunes helped create a variety of vegetation types, such as xeric grassy upland, shrubby lowlands and mesic woodlands containing ~415 species (Harms, 1990). Some of the dominant species within the stabilized dune complex include *Hesperostipa comata*, *Artemisia frigida*, *Selaginella densa*, and *Koeleria macrantha* on stabilized dunes, *Juniperus horizontalis, Carex heliophila*, *Agropyron spp*., and *Solidago missouriensis* in dune blowouts, and, *Carex heliophila, Artemisia ludoviciana*, *Agropyron spp.,* and *Symphoricarpos occidentalis* in dune depressions. Common mid height and taller shrubs include *Amelanchier alnifolia*, *Elaeagnus commutata*, *Prunus virginiana, Rosa woodsii,* and *Shepherdia argentea* (Hullet, 1966; Harms, 1990).

Woody vegetation and deeper rooting species, such as *Populus tremuloides*, *Prunus virginiana* and *Betula fontinalis* persist among stabilized dune systems in the coarser soils due to a reserve of water created by percolation to depths providing reliable moisture (Thorpe, 1992). *Rosa arkansana*, for example, common throughout the stabilized dune system, was found to extend roots 2.4-3.7m deep in sand hills of Nebraska (USDA website, 2021). However, on the finer textured soils of the more common stabilized sites, grasses persist from shallower matting and dividing roots able to make use of the limited rainfall held mostly in the surface soil (Thorpe, 1992).

Many introduced tree species, such as *Pinus sylvestris* and hybrid poplar (*Populus sp*.), or native species outside their range, such as *Picea glauca,* are planted in rows among large tracts of mown tame grasses and pastures.

2.3 Site Assessment

Brief biophysical assessments of the three properties determined which best suited either ecosystem type. Existing plant communities were surveyed for the following characteristics: root and shoot structure of similarly formed communities, their species composition, associating landforms (slope, aspect, and elevation), locations of potential sources of plant material, potential depth to water table, and observations of local fauna as potential indicators of habitat use.

Properties at Sites 1 and 3 contained both converted and unconverted prairie, whereas Site 2 was almost entirely converted and surrounded by planted trees. Sketches of existing habitat with species lists were created of existing plant communities at Sites 1 and 3, including well established areas of invasive species *A. cristatum* and *B. inermis*. Nearby unconverted mesic and xeric prairie, aspen bluffs, wetlands and streams are expected to provide for and benefit from habitat created.

Aspen bluffs were found in depressions or north facing slopes, natural shrubby outcrops were often found in depressions or north facing slopes, where snow drifts might accumulate or an elevated water table exists (Thorpe, 1992; Hullet, 1966). Grassland communities were observed on more stabilized dune but often contained invasive grasses, such as *B. inermis* or *A. cristatum*.

2.3.1 Site Selection

Traditional landscaping practices were observed throughout the Hamlet, and thought to provide opportunity to incorporate native species. For example, tree rows of hybrid *Populus spp.* with missing understory structural layers can be planted to shade tolerant shrubs, such as *C. stolonifera, Rosa spp, S. argentea* or *Salix spp* as well as associating herbaceous species to emulate an aspen bluff community.

At Site 3 (Fig. 3 - above left), an existing tree row planted to *Fraxinus pennsylvanica* with missing shrub and forb layers was chosen as the woodland planting type. Site 2 (Fig. 4 – right), was selected to fit the shrubland type as a discrete community among many planted trees. This site was to test reliability of soil

moisture where snow accumulated due human development. Finally, Site 1(Fig. 5– left) contained significant invasive C3 *A. cristatum* and *B. inermis* along a driveway also where snow accumulates.

Overall, planting sites were chosen with consideration of proximity to unconverted natural ecosystems, to increase likelihood of connections between the surrounding habitat and wildlife and the restoration. Nearby water sources, including tap water, snow accumulation and the water table were considered to aide during the establishment period.

2.3.2 Species Selection

Walking surveys of existing natural ecosystems in summer 2020 provided a list of potential plant species, sources of plant material, their growth habits, and site conditions (i.e. slope, aspect, elevation). Species were primarily selected based local availability, either by plant material (seed or cuttings), or from local producers. Both were somewhat limiting to an extent, however, because native plant production is not well established as practice in Saskatchewan, and local seed production summer 2020 became unreliable due to ongoing drought. However, enough plant material was found able to meet the objective of small, manageable community plantings of 3-7 species by including propagation methods, such as live stake cuttings, direct seed, and seedlings of locally adapted species from the provincially run Shand Greenhouses as free seedlings for rural landowners. Plant material was also sourced from online private sales.

Attempt was made to select keystone plants, such as *Salix spp.*, *Fraxinus spp*. or *Solidago spp*., that have been determined high importance for supporting food webs (Tallamy, 2019). These plant communities will take many years to evolve, and this project took the approach by Tallamy (2019) to start plants together as young as possible so their roots can intertwine and support one another over many years. Therefore, selected plant material was as close to the same growth stage as possible.

Follow-up research was conducted through websites by the USDA – Native Plant Network for propagation protocol, EFlora – University of British Columbia for botanical inventory, and potential root zone compatibility of species through the USDA – Fire Effects Information System website (FEIS). The following table summarizes selected species in descending order of frequency:

Table 1: Shrubs and forbs used in various forms (seed, seedlings, cuttings, and juvenile) in descending frequency planted.

Shrubs – Seedlings	**Shrubs – Cuttings cont'd**	**Forbs - Seed**
Shepherdia argentea - 20	*Rubus idaeus*	*Astragalus canadensis*
Cornus stolonifera - 15	*Rosa woodsii*	*Thermopsis rhombifolia*
Shrubs - Juvenile	*Shepherdia argentea*	*Dalea purpurea*
Shepherdia argentea - 5	*Elaeagnus commutata*	*Solidago canadensis*
Shrubs - Cuttings	*Ribes spp.*	*Asclepias speciosa*
Symphoricarpos occidentalis	*Viburnum opulus*	*Solidago missouriensis*
Cornus stolonifera	**Shrubs - Seed**	*Oenothera biennis*
Rosa acicularis	*Rosa acicularis*	*Anemone canadensis*
Salix spp.	*Symphoricarpos occidentalis*	*Liatris punctata*
Crataegus chrysocarpa	*Crataegus chrysocarpa*	*Artemisia ludoviciana*
Amelanchier alnifolia	*Elaeagnus commutata*	*Smilacina stellata*
Prunus pensylvanica	*Rosa woodsii*	*Agoseris glauca*

2.4 Site Plantings

Dormant plant material was planted to all three sites in fall of 2020 using known and experimental planting methods in attempt for in-situ development. Protocol was followed for fall live staking by Delanoy (2015), and spring live staking following various protocol found on-line. The fall live stake planting sites were saturated with a soaker hose to supply a moisture reserve in very dry soil. Stim-Root No. 2, 0.4% IBU rooting hormone was applied just prior to planting. Small amounts of Gaia Green 0-14-0 bone meal and Maya Gold Biochar were spread throughout sites, and at the base of each cutting. Soil was firmed back around each stem, followed by deep waterings. Fall plantings took place mid-October just prior to the upper soil layer freezing with overnight temperatures trending below 0℃, and just prior to an ~30cm snowfall in early November. Spring live stake plantings were conducted early April with dormant cuttings stored no more than one day. The live stake planting areas were lightly aerated using a spading fork.

Seeds of shrubs and forbs were pressed into soil among planted seedlings and juvenile shrubs to supplement community development. These methods will demonstrate how shrub plantings, such as hardwood cuttings can establish to shade invasive grasses from current existence (Site 1), seeded forbs can enhance regenerating disturbed stabilized dune for enhanced integrity and wildlife habitat (Site 1), live staking to help establish a compatible shrub community as structural habitat among planted trees (Site 2), and a shrub and forb understory to promote habitat under a planted tree row (Site 3).

2.4.1- Site 1: Spring and Fall Procedures

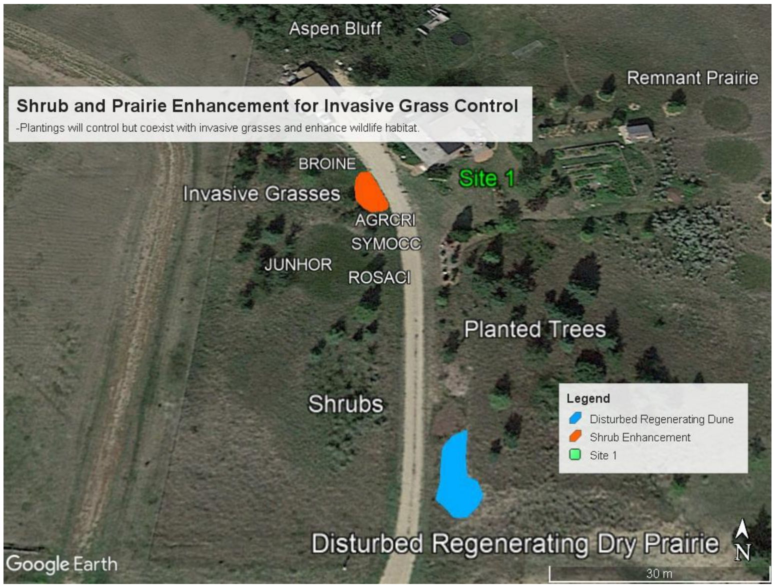

Figure 6: Site 1 has three work areas. The naturally regenerating stabilized dune (blue polygon) planted to seed was abandoned after continued drought. Live staked shrubs and native flower seed were placed among invasive grasses (red polygon). Species abbreviations: BROINE: *Bromus inermis*, **AGRCRI:** *Agropyron cristatum*, **SYMOCC:** *Symphoricarpos occidentalis*, **ROSACI:** *Rosa acicularis* **, and JUNHOR:** *Juniperus horizontalis* **(Google Earth (2020)).**

Site 1 consists of three work areas along a driveway subject to disturbance and encroachment by invasive grasses, but also with native plants among diverse plantings of introduced species. It has west facing aspect with ~6% slope. At the Shrub Enhancement (red polygon), ~65 dormant hardwood *S. occidentalis* live stake cuttings were planted in fall and spring; seeds from same the species were planted at microsites to supplement. *C. stolonifera* hardwood cuttings were planted fall 2020 and spring 2021 at the base of the slope ~0.5m apart. Large *A. cristatum* plants with large seed heads were trimmed from the area July 2020 and again in July 2021.

The disturbed dune area received seed late October 2020 collected summer 2020, randomly spread and pressed in. However, that area was discontinued due to a dry warm spring 2021 requiring a heavy watering schedule. Instead, the adjacent *B. inermis* dominated area was planted to several species of aggressive forbs to see if they might co-exist, including *Asclepias speciosa*, *Astragalus canadensis,* and *Anemone canadensis,* as well as a 1.5 month old seedling of *Asclepias speciosa* grown in a coco coir pellet.

2.4.2 Site 2: Spring and Fall Procedures

Figure 7: Site 2 is enclosed by many planted trees but with plenty of light and moisture that accumulates as snow drift in winter. Live stake cuttings were planted in fall with mulch and seed of forbs and shrubs. Coarse woody debris and wood mulch will provide habitat elements such as perches and moisture retention. (Google Earth, 2020).

Site 2 is ~ 3m x5m on the leeside of a 'height of land' with a south aspect and ~1% slope. Snow accumulates over winter from the north-west wind partially captured by dense *P. glauca* approximately 5m to the east. Shrub species were selected based on ability to root as live-staked hardwood cuttings and for varying shade tolerances. For a list of species planted refer to Table 1, which also exemplifies order of frequency.

Additionally, seed collected in summer and fall from stakeholders' land was laid flat to dry, and stored in a cool location in Ziploc bags with small desiccant packs until planting fall 2020. These included species: *Crataegus sp.*, *Rosa spp.*, and understory forbs *Maianthemum stellatum*, *Anemone canadensis*, *Anemone cylindrica*, *Oenothera biennis*, *Galium boreale*, and *Agoseris glauca*.

Live stakes less tolerant of shade were planted on the eastern half and more tolerant towards the western half. The site receives full sun mid-day until late afternoon, increased when leaves have not flushed. Cuttings were planted to 30cm depth using half inch rebar, and spaced .5-1.0m apart. Leaf mulch from nearby trees was placed at the base of each cutting followed by a 15cm layer of wood mulch in fall 2020. In spring 2021, more cuttings were placed for a total of ~65 live stakes, followed by complete coverage to ~15cm of compost and wood mulch acquired from the City of Saskatoon's Compost Depot. Finally, coarse woody debris was spread throughout to add structure and habitat. In addition, the cuttings were cut shorter in spring 2021 prior to bud flushing, and then painted with a 50% acrylic latex 50% water mix to seal the ends and further reduce moisture loss.

2.4.3 Site 3: Spring and Fall Procedures

Figure 8: Site 3. Approximate locations of CWD (red), *S. argentea* **(SHEARG),** *P. pennsylvancia* **and** *R. acicularis.* **Forb community plantings of species appropriate to low moisture conditions. CWD to capture snow, create beneficial soil conditions, create microsites for understory species and habitat for animals.** *S. argentea* **planted fall 2021 received additional plantings in spring 2021 to form communities, along with seed of several forbs and shrubs nearby and around CWD. (Google Earth, 2020).**

Site 3 is ~120m x 3m along an exposed ridge of a stabilized dune, which runs parallel to a driveway with a southern aspect and ~2% slope. The site experiences dry windy conditions. Five ~1 metre tall dormant *S. argentea* in 1 gallon pots were planted late October 2020. Planting sites were away from drip lines in attempt to minimize competition, and toward northern edge of the tree row understory. Holes were dug slightly bigger than the root ball, filled with water, and allowed to absorb to ensure a reserve in spring. The shrubs were planted no deeper than their stem collar, back-filled, watered deeply once more, and surrounded by a layer of wood mulch.

In spring 2021, 20 *S. argentea* seedlings were planted around the five *S. argentea*, and *C. stolonifera* were planted at either ends in shade of the larger trees. Five *J. horizontalis* seedlings were dug from the mown lawn along the driveway and transplanted spring 2021, as well as an ~150cm *P. pennsylvanica* and *Rosa arkansana* were transplanted late fall 2020 from a flower bed.

Four 1m by 3m areas (in blue; Figure 8) at the eastern end of the tree row were seeded to forbs collected in summer and fall from the surrounding prairie. Two consisted of dry, exposed surface, and two with more shade and established vegetation. The seed bed was prepared by raking debris free from the soil surface. Remaining vegetation was trimmed with a string trimmer close to the surface and covered by 1m x 3m burlap to improve germination. Selected forb seed was separated between site conditions, and either sprinkled or pressed-in depending on the species.

Coarse woody debris (CWD) was obtained locally from recent construction, consisting of several approximately 3-4m long, 20-30cm diameter *P. tremuloides* stumps and branches. The CWD was placed at randomly chosen locations in the understory, and are expected to attract snow drifts, accumulate debris, seeds from plants, and eroding soil to create conditions for volunteer understory vegetation, as well as perches for birds or refuge for small animals.

2.5 Better Management Practices

Mowing frequency, increased height (10cm) and extent mown were the main treatments proposed in the trials, based somewhat on findings by Watson et al (2019), found to potentially decrease pest species of insects and pollen producing plant species, decrease overall impacts to the environment, as well as increase invertebrate and plant diversity.

Mowing to 10cm in late spring, midsummer, and late fall is the approach considered but drought limited its application to basically no mowing needed.

Additionally, less frequent mowing as well as reduced extent will lessen impact on biota, such as arthropods, reduce compaction due to riding mowers, and improve groundwater recharge by better absorption (Darke and Tallamy, 2014). More creativity in mowing practice will be promoted through the brochure, such as only in areas used frequently, while focusing on the functions of various layers through as habitat, especially (Darke and Tallamy, 2014). Fall mowing at increased height will allow more snow accumulation, increased soil temperature through snow insulation, and potentially better absorption in spring thaw for groundwater recharge.

Through the brochure, further best management actions will include, reducing chemicals or no chemicals, instead for manual removal, and considering a native plant in place (Tallamy, 2019), leaves, stems and twigs will be left through fall till spring to harbour insects, volunteer native species will be allowed with management but not maintenance (Rainer and West, 2015), plant material collected from roadsides/disturbed areas before natural ecosystems, and turning off lights at night.

3.0 Results

Habitat plantings using locally collected plant material and propagation involving live stakes and seed struggled to show potential as propagation methods. Poor survival was discovered by mid July 2021 at all Sites primarily to a significant drought and associated extreme heat. Other than a large snow event early November 2020 which had melted, and possibly percolated, by late March 2021, there was very little precipitation since early summer, 2020.

The larger potted *S. argentea* planted October 2020 were successfully established with initial thorough soakings in spring 2021 and thick layers of wood mulch. The six month old seedlings from Shand Greenhouses planted early May 2021 required continued watering to keep alive during relentless heat, which eventually became too much for the landowners to continue due to fact the soil takes water very slowly at the surface when dry, requiring considerable effort to reach the root zone.

April was unseasonably warm and very dry causing added stress for all plantings, especially live stake cuttings. The effectiveness of wood mulch and compost applied along with soaker hoses at Sites 1 and 2 to maintain soil moisture at the rooting zone was difficult to ascertain due to uncertainty of soil moisture in a Regosolic soil presumed to percolate rapidly.

3.1 Site 1- Live staking and seeding to control invasive grasses.

Invasive grasses were controlled to an extent at Site 1 by the expansion of *R. acicularis,* which was previously established among the *A. cristatum.* The wood mulch, extra watering and invasive plant management are presumed to have helped retain enough soil moisture to provide for lateral growth to become the dominant species (Figures 9 and 10 – Spring and Summer). *A. cristatum* were benefitting from the added moisture too, but in mid July during intense heat and drought, were cut to the surface disallowing regeneration into August, but during a significant drought. All the approximately 30 *S. occidentalis* live stakes presumed to root by early May had died. However, suckers of the *S. occidentalis* were seen moving into the treated area. The discontinued or altered watering by the landowner also meant one of the two *C. stolonifera* had died at the lower portion of the slope.

Figures 9 & 10: Site 1 spring 2021 (left) and summer 2021(right) *S. occidentalis* live staked with *R. acicularis* in-growth.

In the neighbouring *B. inermis* area, seed from the select aggressive forbs (*Astragalus canadensis* and *Anemone canadensis*) did not germinate. One planted *A. speciosa* seedling propagated to 1.5 months in coco coir pellets is establishing to expand through the *B. inermis* with future management to remove seed and above ground material.

Seeds of *A. speciosa* were planted with the clay ball method from Audubon.org, and germinated, showing potential as a method for establishment among highly aggressive invasive grasses. However, with continued practice this approach will enhance this sites local biodiversity, especially for pollinators.

3.2 Site 2 – Live staked biodiverse shrub community

Site 2, was partly planted in late October 2020 and followed up in April 2021 with more live staking struggled to start as the snow had dissipated by late March and a warm, very dry April meant a reversal of what could have been a great start. The site was also found to be trapping mid-day heat, estimated at 10-15C more than air temperature, which was thought to be caused by *Picea spp.* ~5m from the site and introduced *Acer sp.* without leaves to the west (Fig. 11 – Site 2 in spring). The ~30 cm of snow would likely have absorbed to greater depths than realized making live staking a difficult method, but a thick layer of mulch and compost with soaker hoses and 2L pop bottles to watering spikes was hopeful to maintain at the root level, similar to Site 1.

It was hoped that with spring rain, sufficient moisture could be maintained at the rooting zone to provide that initial presumed dependable moisture reserve each spring from snow accumulation and, along with a thick layer of wood mulch and supplemental watering until established could be left to itself anywhere from 1-3 years later. Rain in spring is usually reliable and the porous soil within the Dundurn Sand Hills, is thought to create a reliable reserve of water in areas to deep rooted species (Thorpe, 1992).

Several species did well, with half or more of the cuttings planted surviving into July, even after a significant heat and drought period that continued through to August. However, more have perished through the drought with only cuttings by the hose surviving from ~3hr/ week soakings (Fig. 12 – Site 2 Salix sp. live stake). These include mainly *Salix spp,* and *C. stolonifera,* with a few as singles, such as *A. alnifolia, S. argentea*. Additionally, two *Anemone canadensis* forbs established along the western edge, as well as a *Rosa spp.* seedling. The community will be a connection between the lilac shrubs to the south and the treed/shrub volunteer community to the north as habitat supplying breeding or migratory birds.

3.3 Site 3: Woodland tree row community

The understory shrub layer was planted with focus on *S. argentea* forming communities along the length of the tree row, which consisted of one or two seedlings around one juvenile plant (Figure 13 – Site 3 after planting). CWD and thick mulch layers surrounding each planting were placed to aide and provide habitat. The *C. stolonifera* were placed at either end in shaded areas and if survive will become a part of the established *P. sylvestris* plantings as added wildlife habitat. They were vulnerable as 6 month old seedlings and needed regular watering, however. The transplanted *J. horizontalis* at the windier exposed area of the western end will help capture drifting snow along with the CWD to replenish soil moisture locally. They required significant watering initially to regrow their tap root and transplants were not thought to be successful. The *P. pensylvanica* at the eastern end survived the winter after fall transplant and the drought too after considerable attention was given to watering. It will provide beneficial habitat as an understory shrub and potentially fruit to migrating birds.

As a community, along the extent of the tree row there will eventually be a layered environment from the canopy to herbaceous layer. Additionally, the adoption of intermittent mowing will provide extended shelter and resources for associating smaller animals, such as rodents and numerous arthropods, especially with proximity to natural ecosystems with the aspen bluff ~5m to the north and the army base ~150m south.

4.0 Discussion

4.1 Site 1

At Site 1, as a result of *R. acicularis* becoming the dominant species and shading out the *A. cristatum* the objective has been attained for control of the invasive grass at this time. However, the *A. cristatum* might have been dormant, and once the moisture returns will return. Invasive plant management is expected to be an ongoing process with those robust grasses, at least until more shrubs and aggressive forbs establish. Trimming at a dry period to remove seed may have stressed or killed the plants, but given *A. cristatum* has shallow roots it may be better to dig them out and recover or plant with associating shrubs.

Removal of invasive grass seed will minimize the impact to the surrounding unconverted prairie by seed spreading, especially over snow by *A. cristatum*. Local habitat will be improved through low shrubs common to the mesic prairie on their property with opportunity for establishing from seed along the driveway. *S. occidentalis* and *Rosa acicularis* among the *Populus tremuloides* and planted trees nearby provide plenty of habitat, shade and resources as a coexistence community, which the landowners can continue adding to.

Live staking showed promise with approximately 50% striking roots by mid May, but perhaps the better approach may have been propagate in pots for 1-2 years. Also, occasional deep soaking waterings seem to be the necessary application to maintain soil moisture at the rooting zone. However, that is not what happened, and instead the landowner opted to water by hand rather than soaker hose, which does not reach the intended rooting zone as easily because the water tends to run off in this soil type when surface is dry, especially during drought conditions.

Another planting option noted is replication of conditions that aided a dense stand of *Solidago canadensis* at the far end of the driveway that started among brush piles created by the landowner. Tallamy (2019) stated *Solidago spp.*are important for pollinators as a late season nectar source, but also have intertwined roots that allow better absorption of precipitation. This species along with other aggressive forbs are hoped to be an option to establish among the *B. inermis* to co-exist and perhaps suppress growth by landowners in similar situations.

4.2 Site 2

The community as it is will need supplemental plantings in following years, possibly of seedlings through Shand Greenhouses, or more mature individuals to reach reliable soil moisture. Possibility of a tree or two exists at either end of the site that would change the structure from shrub stand to treed with shrubs below. This alternative planting technique of tree with shrubs and herbaceous layer was considered later in the project for ease of application for landowners in the brochure. This method is rather than planting individual trees that do not provide shelter for *Lepidopterans,* for example, to complete their life cycle (Tallamy, 2019). Also, with suggestion by Darke and Tallamy (2014) and findings by Pickles and Simard (2016), if a tree is going to be watered anyway, it makes sense to have vegetation surrounding it that will compete for moisture at first but also eventually interlock roots and potentially become less susceptible to drought through mycorrhizal association.

4.3 Site 3

Site 3, with a highly exposed understory along a 120m row of ~5m *F. pennsylvanica* with primarily surface spreading roots (Gucker, 2005), and planting young seedlings turned out to be another risk taken depending on rain fall. The drought was/is so severe and this site is so exposed the most likely way to further establish understory habitat will be with more mature plants as suggested by Darke and Tallamy (2015) for planting shrubs of "modest size" to develop together through intertwining roots to help them sustain through drought.

5.0 Management Recommendations

In future years, if the practice of planting locally adapted native plants becomes more popular on acreages more options will become available from local producers. As of this project, however, options are limited, especially for cost effectiveness. There are options of bundles of 10 seedlings for approximately $60, however, from a local grower. The Shand Greenhouse option with free seedlings is reliable but they produce only select species every year, which limits the communities as far as the objective for 5-7 species, is concerned.

Wood mulch can be expensive too, with option for mulch for free from the City of Saskatoon Depot, which is limited to City patrons unfortunately. Water from under ground aquifers is another risk when drought is increasing, as well as the dependence of existing large trees in an otherwise low consumptive environment of native species adapted to low water conditions. But it is also a potential impetus for landowners if the realization is there, such as wells becoming more expensive to dig and further down to reach. This project takes the approach suggested by Tallamy (2019) to plant a native plant when an introduced or invasive species is removed, which can be another application for landowners going forward in their changing landscaping practice.

Mowing has many potential applications in management for enhancing biodiversity but in general a less-is-more recommendation will be made through the brochure to landowners and perhaps the Hamlet maintained roadsides. This includes a general recommendation of mowing three times a year (spring, mid-summer and late summer), with elevated height to ~10cm, and to reduced areas. 1) encourage forb production by mowing in spring then allowing reproduction of forbs by providing pollinators a resource and a home by also elevating the height to ~10cm, then 2) again once reproduction is complete, cutting mid-summer, advancing a process of potential regeneration, but by this time growth is slowing but sun is high and rays will dry the soil rapidly so it is a way to retain soil moisture and potentially reduce evapotranspiration while allowing some forbs opportunity for continued growth to seedling stage, especially when dealing with tame cool season grasses that get a jump-start on other species in spring as the ground warms quickly filling in ground and using resources. Finally, 3) mowing in fall to a similar height (~10cm) to maintain that sheltering environment from sun and wind that will potentially retain more snow over winter and more moisture on the landscape.

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