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Agroforestry & Woodlot Extension Society

MANUAL FOR

RIPARIAN FOREST BUFFER ESTABLISHMENT IN ALBERTA

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Copies of this Manual are available for download from the website of the Agroforestry and Woodlot Extension Society, http://www.awes-ab.ca/

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A healthy riparian area in central Alberta.

Photo by AWES.

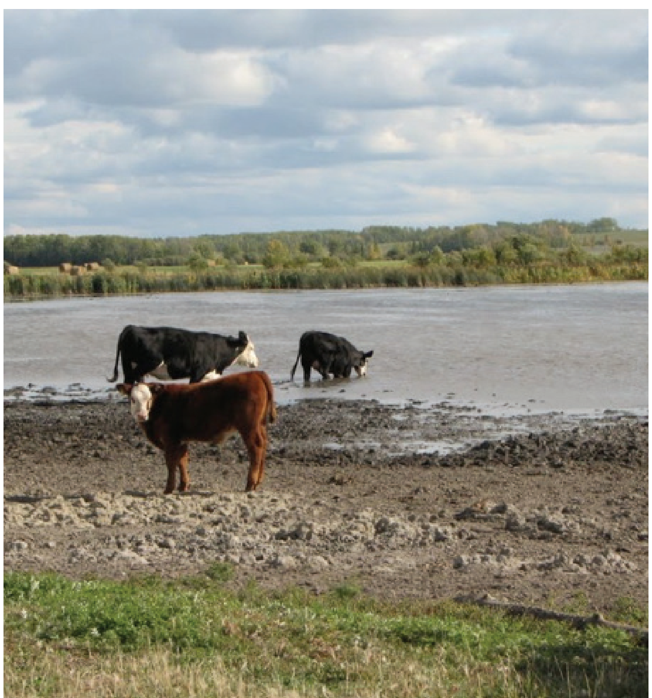

Figure 2

This riparian area in Grande Prairie County has been heavily degraded by cattle use.

Photo by County of Grande Prairie No. 1.

INTRODUCTION

The presence of fresh, clean water is easily taken for granted – few go through their day consciously attempting to alter it. Yet diverse human practices across sectors, landscapes and regions continue to cumulatively impact water quality in Alberta (Casey, 2013; Government of Alberta, 2016). In certain instances, this has reduced drinking water quality and quantity, recreational opportunities, and habitat availability for fish and other wildlife.

One of the main causes or catalysts for these impacts is the degradation of riparian areas. Riparian areas are lands adjacent to streams, rivers, lakes, ponds, and other water bodies **(Figure 1)**. "Healthy" riparian areas — comprised of diverse, resilient communities of plants and animals — can trap and absorb nutrients and sediments, reduce bank erosion, recharge groundwater, decrease water temperatures, and provide habitat for aquatic and terrestrial biodiversity (Fitch and Ambrose, 2003). These functions are quickly lost if riparian vegetation is degraded or removed **(Figure 2)**, which may occur due to changes in land-use or management practices.

STEPS TO ESTABLISHING RIPARIAN FOREST BUFFERS

STEP 1
SITE ASSESSMENT

STEP 2
PLANNING YOUR PROJECT

STEP 3
OBTAINING PLANT MATERIALS

STEP 4
PREPARING YOUR SITE

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MONITORING & MAINTENANCE

Fortunately, there are many opportunities for landowners and managers to restore or enhance the health of their riparian areas. One of these is establishing a "riparian forest buffer". Riparian forest buffers are plantings of woody and herbaceous species within riparian areas that protect water bodies from adjacent human activity. In just a few years following establishment, a well-designed riparian forest buffer can begin to provide many or all of the functions that were described above, contributing in a small but significant way to improved water quality downstream.

Establishing riparian forest buffers is complex and site-specific. The number of factors to consider and decide on – from species selection to budgets to sourcing stock – might seem slightly overwhelming to landowners and managers. This Manual is intended to guide landowners and managers through all of these decisions, while teaching them the technical skills needed to improve project success. It does this by breaking down the process of establishing riparian forest buffers into six steps:

1. **Site assessment**
2. **Planning your project**
3. **Obtaining plant materials**
4. **Preparing your site**
5. **Planting**
6. **Monitoring and maintenance**

The following six chapters are organized in accordance with these steps. Case studies of recently established riparian forest buffers in Alberta are interspersed throughout to provide some context and inspiration. Technical resources to supplement the rest of the Manual are included in the appendices.

Note that the information in this Manual has been condensed into a series of fill-out questions within the Riparian Forest Buffer Establishment Worksheet. The Worksheet and Manual are both available for download from the website of the Agroforestry and Woodlot Extension Society, ***http://www.awes-ab.ca/****.*

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CHAPTER 1
SITE ASSESSMENT

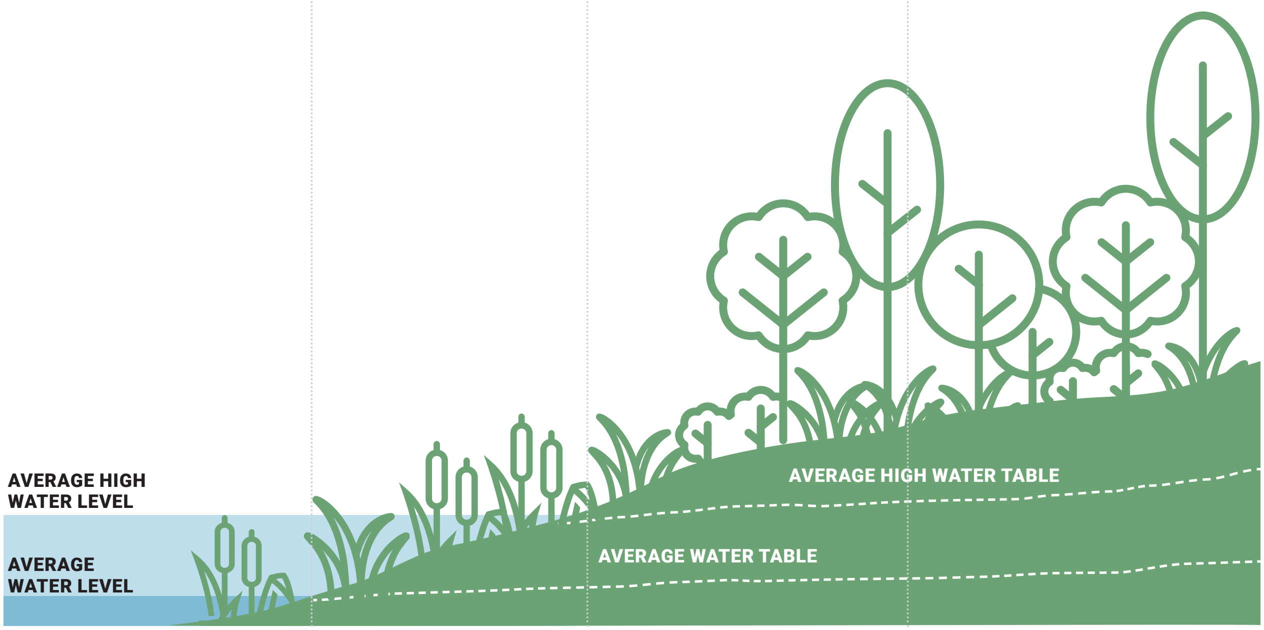
Before forming clear ideas about what should be done with your riparian area, it is important to first understand what its problems and strengths are, and what considerations should be taken when attempting to address the problems. The following chapter discusses each of these points in greater detail.

UNDERSTANDING YOUR RIPARIAN AREA

Riparian areas occur at the interface of terrestrial and aquatic environments. Due to their proximity to and interactions with surface and ground water, riparian areas have high soil moisture levels, an elevated water table, and lush, green vegetation relative to the rest of the landscape (Fitch and Ambrose, 2003).

These characteristics also vary greatly within individual riparian areas, making it useful to divide riparian areas up into four distinct zones **(Figure 3)**. These zones tend to contain slightly different vegetation communities and perform slightly different functions. Their relative widths vary greatly, and depend upon the size of the water body and steepness of the bank.

RIPARIAN AREA ZONES



	TOE ZONE	SPLASH ZONE	BANK ZONE	TERRACE ZONE
WATER EXPOSURE	This zone is completely inundated for at least 6 months of the year, and thus is subject to a range of stressors that include erosive currents, ice scouring, wave wash, and wet-dry/freeze-thaw cycles.	This zone is inundated up to 6 months of the year, and is subject to many of the same stressors as the toe zone. The water table remains close to the soil surface.	This zone is flooded once every 2 to 3 years, periodically exposing it to the same stressors as the toe and splash zone. It is often subject to relatively high amounts of human and animal traffic. The water table depth increases with greater distance from the toe and splash zones, but remains less than that of the surrounding landscape.	This zone is usually not subject to erosive actions of the water body, except in rare cases of flooding. The water table depth continues to increase until it is similar to that of the surrounding landscape.
VEGETATION	A few herbaceous plants, such as rushes *(Juncus spp.)*, bulrushes *(Scirpus spp.)*, cattails *(Typha spp.)*, and sedges *(Carex spp.)* may be present in this zone if water currents are slow (e.g. in a lake, pond, or wetland). These plants help to absorb nutrients from the water and provide habitat for aquatic species.	Rushes, sedges, cattails, grasses, forbs, and a few wet-loving shrubs such as willow *(Salix spp.)* can be found in this zone. These plants take up nutrients from the water, slow and absorb floodwater, armour the bank against scouring, and provide habitat for aquatic and terrestrial species.	Willow, balsam poplar *(Populus balsamifera)*, red-osier dogwood *(Cornus sericea)*, river alder *(Alnus tenuifolia)*, water birch *(Betula occidentalis)*, plains cottonwood *(Populus deltoides)*, and tamarack *(Larix laricina)* frequent this zone in different parts of Alberta, in addition to forbs, sedges, and grasses. This vegetation slows and absorbs floodwater, traps and filters sediments and nutrients, stabilizes the bank, and provides habitat for wildlife.	A diversity of trees, shrubs, forbs, and grasses can be found in this zone. This vegetation traps and filters sediment and nutrients; reduces soil moisture content and weight (and thus its erosive potential); stabilizes the upper portion of the bank; provides wildlife habitat, shade and wind protection for the rest of the riparian area; and is the last line of defense to slow and absorb floodwater entering upland areas.

Figure 3 Riparian area zones.

Adapted from Li and Eddleman, 2002.

WHAT ARE THE PROBLEMS?

If you have read this far, you probably have at least some idea of a problem in a riparian area that you would like to address. However, it is good to be specific about the nature of the problem(s). The following "Yes/No" checklist can help you assess the health of a streambank riparian area (adapted from Cows and Fish, 2008):

- Statements that you answer "No" to are potential problems, or symptoms of problems, in your riparian area.
- If you answer "No" to four or less of the statements, then there is a good chance that your riparian area is resilient enough to continue providing most ecosystem functions.
- Any more than four negative answers and the problems may be undermining the riparian area's functionality, and could lead to others if left unaddressed.
- For more information on assessing riparian health on both streambanks and lakeshores, visit **www.cowsandfish.org.**

Problem		Y	N
1	85% or more of the riparian area is covered with vegetation (of any kind).		
2	More than 50% of the riparian plants are taller than knee height.		
3	Shrubs are growing along or near the stream edge, and are NOT heavily browsed.		
4	There are young trees and shrubs that will replace existing older woody vegetation over time.		
5	Native plants dominate the riparian area, with invasive species such as Kentucky bluegrass *(Poa pratensis)*, clovers *(Trifolium spp.)*, smooth brome *(Bromus inermis)* and creeping red fescue *(Festuca rubra)* representing less than 15% of all plants. For help with invasive species identification, refer to the Invasive Weed and Disturbance-caused Undesirable Plant List by Cows and Fish (2007), or other guides provided in Appendix B.		
6	Noxious weeds such as Canada thistle *(Cirsium arvense)*, scentless chamomile *(Matricaria perforata)* and leafy spurge *(Euphorbia esula)* make up less than 15% of the plants growing in the riparian area.		
7	There are no exposed and eroding soils or slumping banks.		
8	The stream channel is narrow and deep, not shallow and wide.		
9	The stream does NOT appear ditched or entrenched and is able to overflow its banks most years.		
10	Water in the stream is clear and NOT cloudy or full of sediment.		
11	There are NO retaining walls, rip-rap or other bank stabilizing structures.		
12	Wildlife are often seen in the riparian area and fish live in the stream.		
13	Plants are vigorous, there is carryover of plant litter, and forage production is stable.		

WHAT HAS CONTRIBUTED OR IS CONTRIBUTING TO THESE PROBLEMS?

Once you have a clear idea of the problems facing your riparian area, the next step is to figure out their root cause(s). These might be ongoing or historical, located at the site itself or further upstream or upland (Government of Alberta, 2014). Causes may include:

1. **Land-use activities at the site.** These may cause mechanical damage (e.g. soil compaction and erosion, vegetation removal, or channel slumping), or contribute to nutrient loading of waterways, spreading of invasive species, sedimentation, or other pollutants entering the site. Examples include livestock grazing, recreational use (e.g. all-terrain-vehicles, dirt bikes, equestrian, or motorized boats), and lakeshore development.

2. **Dams, diversions, culverts, or artificial water inputs upstream of the site.** These can prevent natural moisture replenishment through seasonal flooding or create high or low water fluctuations at times of the year they would not naturally occur.

3. **Land-use activities upland of the site.** Intensive management practices, particularly those that result in the removal of forest cover, can reduce the ability of upland areas to absorb and slow down the flow of surface water runoff. This increases the speed and volume of runoff during high flow events, which can collect and carry sediments and pollutants to the site. Examples of such activities include road and housing developments, livestock feeding areas, annual cropping, logging, and mining.

If your site problems are due to ongoing land-use activities or management practices that you have control over, your first step should be to address these directly. Failing to do so could compromise the success of potential planting activities or the ability of the area to regenerate naturally.

IS A RIPARIAN FOREST BUFFER AN APPROPRIATE SOLUTION FOR MY SITE?

Establishing a riparian forest buffer is not always the most effective way to address problems in riparian areas. Before planting, consider the following questions:

1. **Will the site quickly revegetate naturally?** Natural revegetation can occur quite rapidly (<10 years) when there is a pre-existing supply of viable native seeds and root mass in the soil. This supply may have

built up in the soil pre-disturbance, or may be provided by nearby natural areas. Often, a good practice is to address the cause of the problem and then wait 1-3 years to see what will grow, as this might surprise you.

2. **Is planting practical?** Heavily compacted sites may be difficult to plant in with any success. A better option might be to address the cause of the compaction and allow for natural revegetation and freeze/thaw cycles to gradually loosen up the soil (see Chapter 4 for more details on this option). Meanwhile, actively slumping banks or those that have a steepness of greater than 4 vertical to 1 horizontal may need to be bioengineered using willow fascines, logs, rocks, or other materials. Refer to ***The Practical Streambank Bioengineering Guide*** by Bentrup and Hoag (1998) for more information on bioengineering, and consult with Alberta Environment and Parks **(http://aep.alberta.ca/)** before undertaking construction or bank modification activities.

3. **Can the site support trees and shrubs?** It may be difficult or impossible for trees and shrubs to grow in sites with certain issues, such as high levels of compaction, slumping, flooding, and salinity. These characteristics may be natural to your site, or may have been caused by previous management practices. More information on these characteristics is provided in the following section. However, a good way to get an idea of whether your site has the potential to support trees and shrubs is to find nearby undisturbed riparian areas with similar characteristics, and make note of what is growing there.

SITE CHARACTERISTICS TO CONSIDER WHEN ESTABLISHING A RIPARIAN FOREST BUFFER

The final part of the assessment process is to identify factors that might influence the design of your riparian forest buffer. To account for variability, this may need to be done at multiple locations within your planned planting area and at different times throughout the year. Consider the following in an assessment:

1. **Plant Hardiness Zone (PHZ).** Canada's PHZs are regions with similar climatic conditions (e.g. average frost free days, minimum and maximum temperatures, seasonal precipitation, etc.) that define where certain species can survive. PHZs range from 0 to 8, with 0 being the harshest climate and 8 the mildest. Zones are further divided into subzones such as 3a and 3b, where "a" is harshest. Appendix A includes recommended minimum PHZs for the species listed. For more information on PHZs or to find the PHZ of your site, visit **http://www.planthardiness.gc.ca/index.pl?** or download Natural Resources Canada's *My Tree* app.

2. **Moisture regime.** The moisture regime of your riparian area depends on amount and frequency of precipitation, flooding, and surface water runoff (particularly snowmelt). Local site conditions are also important:

north-facing slopes tend to be wetter than south-facing slopes, while wetter soils are found closer to the water's edge (i.e. the Toe and Splash Zones). These variables should influence species selection **(see Appendix A)** and drought management practices **(see Chapter 6)**. For more information, refer to:

» Seasonal precipitation data for your region, which are available through the Alberta Weather Station Data Viewer **(http://agriculture.alberta.ca/acis/alberta-weather-data-viewer.jsp)**

» Topographical maps, which contain contour lines (i.e. lines of equal elevation — see **Figure 4**). They can be used to determine how water flows across the land, making it possible to estimate the amount of surface water runoff your site is receiving (based on its "catchment area") and what sorts of materials (e.g. manure, fertilizers, etc.) the water might be carrying. Topographical maps can be found for certain areas through County websites, or privately purchased.

» In-situ assessments of soil dampness and high-water level — often a visible mark on bank vegetation **(Figure 5)**.

Figure 4

Aerial photo of a property in Parkland County, AB with contour lines outined in white.

Parkland and several other counties in Alberta offer free online GIS programs that include contour line data. Photo reproduced with permission from Parkland County.

Figure 5

The highwater level (shown by the yellow arrow) is clearly visible on the bank of this riparian area in Grande Prairie, County, AB.

Photo by AWES.

3. Soil conditions. Soil texture, compaction, drainage and salinity are important factors to consider when selecting species (see Appendix A). Soil texture can be estimated by following the instructions provided in Figure 6. Highly compacted soils may require special site preparation or planting techniques that are outlined in Chapters 4 and 5 respectively.

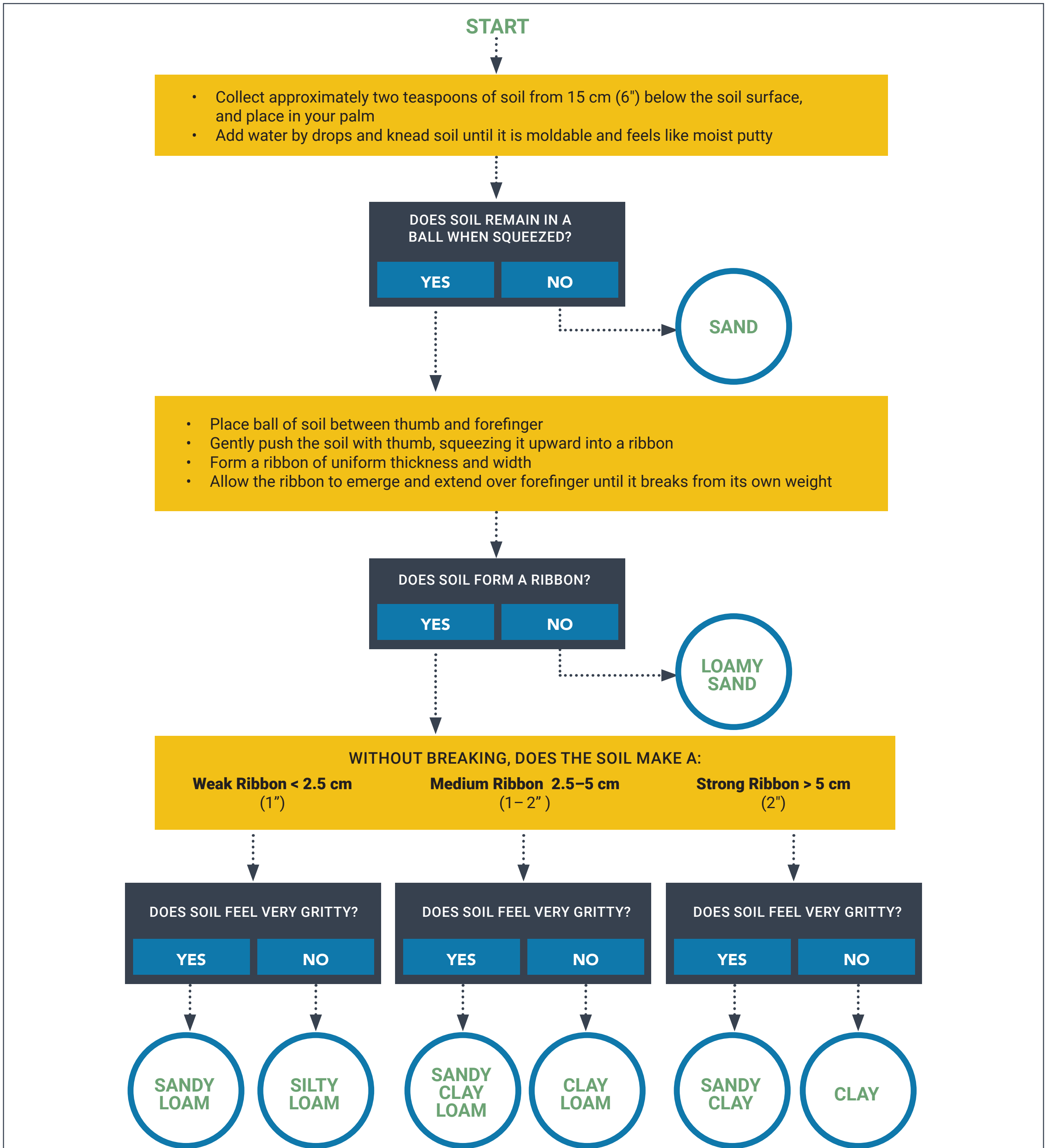


Figure 6 Follow these step-by-step instructions to estimate the soil texture at your site.

Adapted from WOW! The Wonders of Wetlands, copyright Environmental Concern Inc. 201 Boundary Lane, St Michaels, MD 21663. For more information contact Environmental Concern Inc. at 410-745-9620 or visit www.wetland.org.

Figure 7 This site has been overrun with the noxious weed Canada thistle *(Cirsium arvense)*.

Photo by AWES.

4. **Presence of invasive species and/or noxious weeds.** Invasive species and weeds such as smooth brome, Kentucky bluegrass and Canada thistle can compete with seedlings for nutrients, light and moisture. Various site preparation techniques (described in Chapter 4) may be required if any of these species are prevalent. Identification guides such as *A Field Guide to Common Riparian Plants of Alberta* (Hale et al. 2005) can help you determine which invasive species are present at your site **(see Appendix B)**.

5. **Light.** The aspect of your site will influence the amount of light it receives, with north-facing slopes being more shaded than south-facing. Large obstacles such as trees and buildings may also shade out your site. Both of these factors are important to consider when selecting species, as some are more shade tolerant than others **(Appendix A)**.

6. **Wind.** Wind is an important and often underestimated factor in the success of seedling establishment. Strong winds can cause desiccation and mechanical damage to seedlings, reduce moisture availability, and decrease winter temperatures (i.e. windchill). Using existing barriers (e.g. larger, established trees, or infrastructure) or planting fast-growing, stress-tolerant species (e.g. balsam poplar, trembling aspen, or Manitoba maple) on the windward side can help protect seedlings. Prevailing winds for each season in your region can be found through the Government of Alberta's maps, **http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sag7019**.

7. **Native plant communities.** Understanding which plant communities are native to your area is helpful for identifying species that are adapted to its conditions. This starts with knowing the natural region of your

site, as each of Alberta's five natural regions contains different native plant communities (Figure 8). Completing an inventory of existing native species around your area will provide more specific insight into what grows well there. Refer to Appendix B for a list of native plant identification guides.

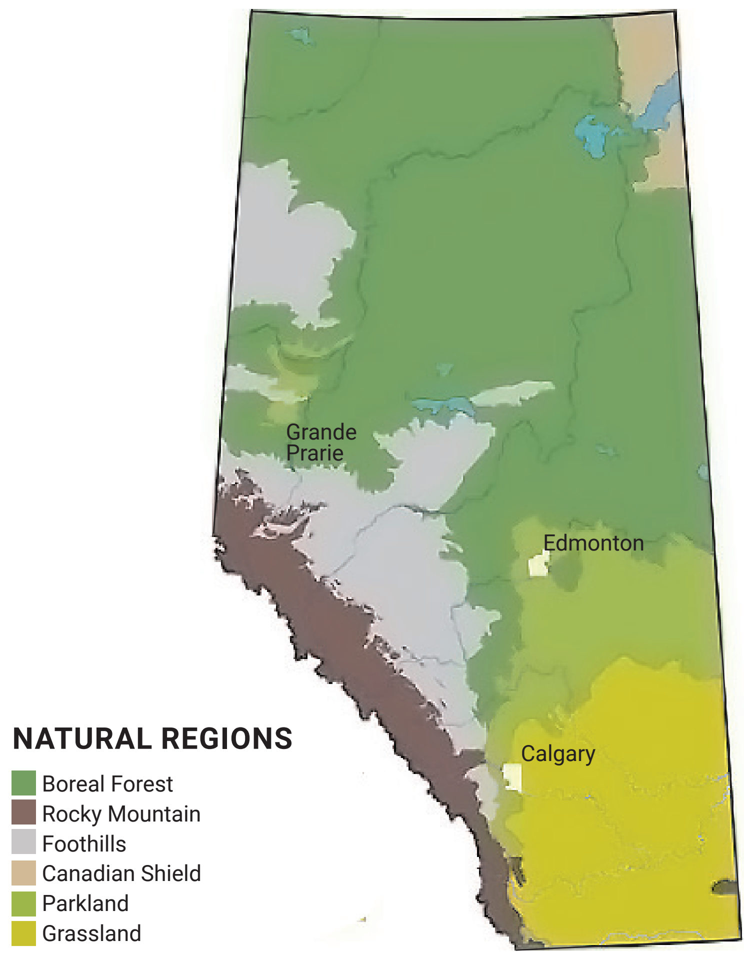


Figure 8 Natural regions of Alberta. Appendix A provides information on which species are native to each area.

Adapted from Science 7 RVLC Sandham.

As you can appreciate, there are a lot of site factors to consider when establishing a riparian forest buffer. These factors will continue to shape how the rest of the process unfolds, from planning to site preparation to planting. They will also provide a useful baseline to compare against when monitoring and evaluating the success of the project. Overall, being aware of these factors as early as possible increases the chances that the buffer will end up functioning as desired.

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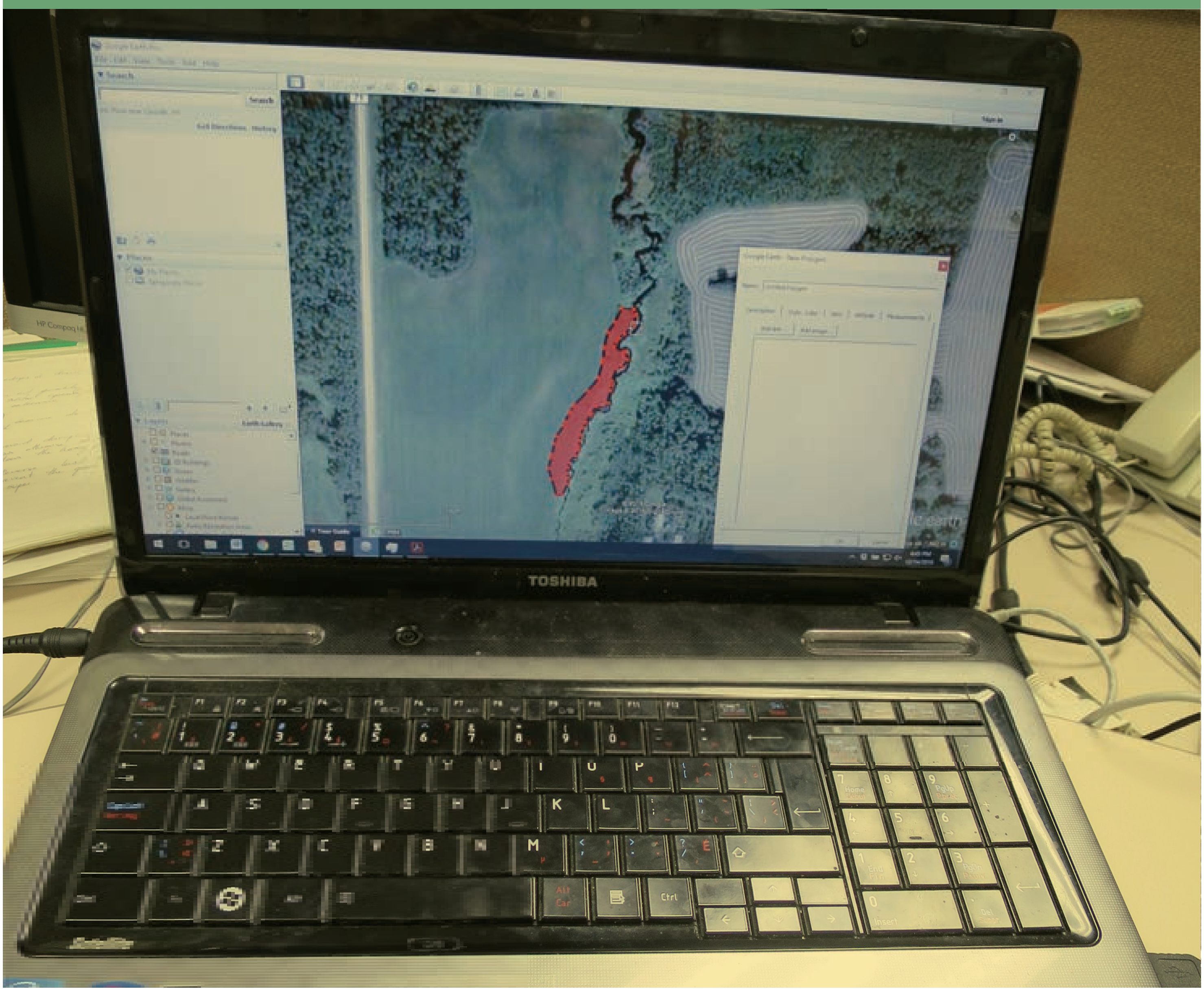
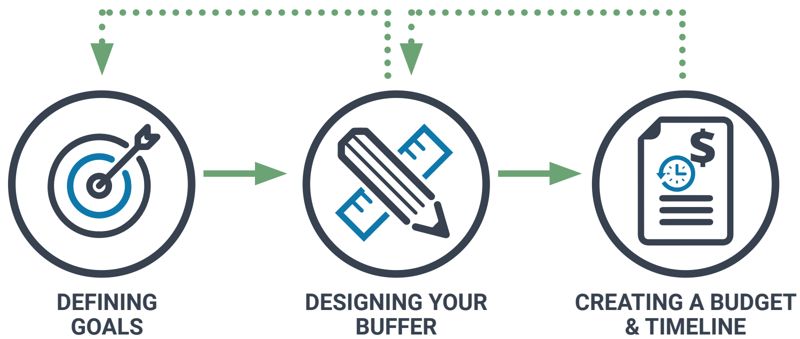
CHAPTER 2
PLANNING YOUR PROJECT



Once you have a good understanding of your site, the next thing to do is to plan your project. Planning involves:



These steps are not necessarily sequential, but instead may loop back on each other as your plan unfolds.

DEFINING GOALS

Having clear goals is essential both for riparian buffer design and evaluation of planting success. **Table 1** outlines some of the many possible functions a riparian forest buffer can provide. These functions are not necessarily mutually exclusive, and a well-designed riparian forest buffer should be able to provide many of them at once. Clear goals will also provide you with sufficient direction to determine the resources required to complete this project.

Table 1. Examples of possible functions and design recommendations. Latin names are provided in Appendix A.

Function	Recommended Composition	Recommended Layout
Bank stabilization and erosion control	• Plants with deep binding roots (i.e. trees, shrubs, and sedges).	• Dense vegetation cover should be achieved in the bank zone and any other erodible areas. Vegetation cover above the bank zone is also beneficial, as it will slow down runoff.
Water temperature cooling and evaporation reduction	• Taller trees and shrubs, ideally including some with high foliar density such as spruce.	• Vegetation on the south and/or west side of the water body should be dense, wide, and tall enough to maximize shading.

Function	Recommended Composition	Recommended Layout
Water quality enhancement through absorption and filtration of sediments, nutrients and other pollutants	• Plants with deep binding roots (i.e. trees, shrubs, and sedges). • Plants that absorb large amounts of nutrients (i.e. fast-growing trees and shrubs, along with sedges, bulrushes, and cattails) • If pollutants have a high salt content (e.g. road salts), include salt tolerant species such as silver buffaloberry or wolf willow.	• Minimum buffer widths from activities with high potential to contribute nutrients (e.g. corrals, feeding areas, cropland, roads, housing, pits) are 20m (65') for permanent water bodies with glacial till substrate, 50m (165') for permanent water bodies with alluvial substrate, and 6m (20') for ephemeral water bodies (AESRD, 2012). • Larger buffers are required in slopes greater than 5%, and where groundwater is shallow (<1.8m). Refer to AESRD (2012) for more information.
Flood risk reduction and groundwater recharge	• Plants with deep binding roots, especially those with a physical aboveground structure (i.e. trees and shrubs).	• Buffer should ideally be as wide as the 100-year floodplain.
Production of fruits and nuts	• Fruit/nut bearing species. • Sheltering species – i.e. tall, hardy, and fast-growing trees and shrubs. • Nitrogen fixing species.	• Fruit/nut-bearing species are growing above the highwater level in a favourable micro-climate (typically southern exposure, sheltered from winds). • Fruit/nut-bearing species are arranged to facilitate their harvest (e.g. in rows). • Sheltering species are providing protection from prevailing winds, while nearby nitrogen fixing species are increasing soil fertility for growth and fruit/nut production.
Shelter for livestock or farmyards, and/or snow management	• Taller trees and shrubs.	• Long, continuous areas or rows of trees and shrubs, oriented perpendicular to prevailing winds (AAFC, 2010) • Shrubs are favoured along the windward edge of the buffer, while trees are favoured within the buffer and along its leeward edge • If area is narrow (i.e. <30m wide), canopy porosity is 40-60% • If area is narrow, roads and/or infrastructure are NOT downwind within 2X the height of the tallest trees.
Production of biomass and timber	• Species with timber/biomass value.	• Timber/biomass species are growing in an area that can be safely harvested with minimal environmental impact (i.e. avoid steep slopes, wet spots, and areas within 30m of water body). • Space is left for harvest access-ways. • Timber/biomass species can be arranged to facilitate their harvest (e.g. in rows for willow biomass operations).
Pollinating or pest suppressing insect habitat	• Native flowering trees, shrubs, and forbs with flowers of different heights, shapes, sizes, colours, and bloom periods. • Hollow-stemmed plants, decadent trees and shrubs, and bunch grasses for nesting and overwintering sites.	• Sunny, sheltered sites are ideal. • Flowering species are clumped together in small groups. • Area is structurally diverse, with plants of varying heights interspersed together. • Area is connected to other habitats.
Fish habitat	• Trees, shrubs, and herbaceous riparian species (e.g. cattails, bulrushes, sedges).	• Dense, deep-rooted buffer to stabilize streambank/shoreline and filter out sediments and nutrients. • Vegetation is within the seasonal floodplain to provide off-channel refugia. • Woody vegetation is overhanging the channel to provide debris for creating resting pools and gravel beds.
Habitat for other wildlife (e.g. ungulates, birds, small mammals).	• Diversity of native coniferous and deciduous species, of different ages, shapes, and sizes. • Native species producing diverse fruit/seed types throughout the year (for birds and small mammals).	• Patches of coniferous trees are providing thermal cover and seeds. • Patches of deciduous species are providing browse, berries, and seeds. • Area is structurally diverse, with plants of different ages, shapes, and sizes interspersed together or in adjacent patches. • Area is connected to other habitats.

Generally, riparian forest buffers are planted within the ***bank and terrace zones*** *of riparian areas. These zones are less likely to be subject to destructive floods, can support the most diverse communities of woody species, and usually take longer to revegetate naturally.*

DESIGNING YOUR RIPARIAN FOREST BUFFER

Thus far, you have identified a riparian site of concern; catalogued its problems, strengths and characteristics; and defined goals for your riparian forest buffer. The next step is to integrate all of this into a buffer design. This involves determining project location, potential species, and planting density.

WHERE DO I PLANT?

Generally, riparian forest buffers are planted within the **bank and terrace zones** of riparian areas **(see Figure 3)**. These zones are less likely to be subject to destructive floods, can support the most diverse communities of woody species, and usually take longer to revegetate naturally. However, including willow and certain herbaceous species in the splash and toe zones can be highly beneficial, particularly if these zones are degraded.

Riparian forest buffers also need to be of a **minimum width** to function properly. Recommended buffer widths vary significantly, as they depend on desired functions **(see Table 1)** and site characteristics. Keep in mind that wider buffers may be required in the following areas:

- Areas with relatively impermeable soils (e.g. compacted, alkaline, or high clay content), as surface water travels more quickly over these soils.
- Flood-prone areas, or where the channel is likely to migrate to in the future (e.g. low-gradient areas along the outside bend of the stream)
- Steep slopes, as these areas will have more rapid surface water runoff.
- Areas with high-intensity management activities occurring upland (e.g. feedlots or annual cropland)

Based on all of this, it is sometimes advisable to design a "variable width buffer" – a riparian forest buffer with varying widths along the waterbody as required.

One final consideration to make when deciding on where to plant is **access requirements.** Can the equipment required to plant and maintain your site access it safely and efficiently? Seedlings planted in regular rows are often easier to maintain with larger equipment such as tractors or ATVs (Withrow-Robinson et al., 2011).

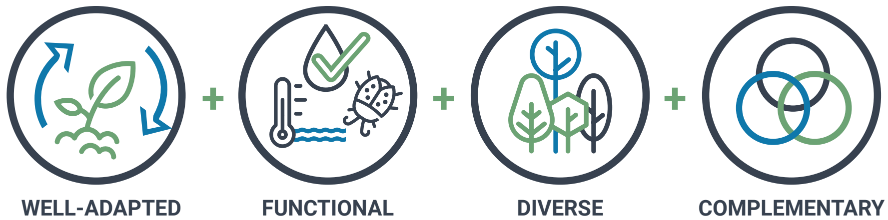
Figure 9

Shade tolerant species such as white spruce *(Picea glauca)* are well-adapted to understory environments.

Photo by AWES.

WHAT DO I PLANT?

Different species can have vastly different growth patterns and requirements in terms of moisture, soil, light, nutrient, spacing, and temperature. Some are tolerant of shady conditions or saline soils; some fix nitrogen, adding fertility to the soil. Appendix A provides information on these and other characteristics. While looking through Appendix A, it is recommended that you choose species that are:



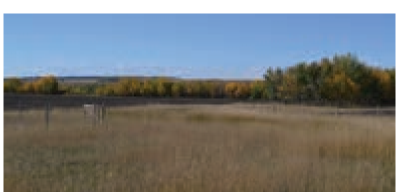
Well-adapted: Favouring species that are adapted to the conditions of your site, as identified in your site assessment, will minimize the amount of effort needed to keep your planting alive.

Functional: Choose species that will help you meet your functional goals (see Table 1).

Diverse: Diverse vegetative communities tend to grow in riparian areas, in part due to varying moisture regimes and soil conditions (see Figure 3). Planting a variety of species increases the resilience of your project, as different species thrive in different site conditions, or are able to weather unexpected events such as pest or disease outbreaks.

Complementary: Choosing species with different characteristics (e.g. height, speed of growth, ability to fix nitrogen, etc.) increases the likelihood that they will complement each other, rather than compete. For example, shade tolerant, nitrogen fixing shrubs such as green alder or Canada buffaloberry can be planted near fast growing trees such as balsam poplar to increase soil fertility and form a future understory.

Case Study 1: Selecting the best species for different site conditions in Grande Prairie County, 2016



Site context

- Site with two distinct sets of conditions: a mature aspen stand and a grassy open area
- Grassy open area had below and above ground competition, and was very exposed
- Aspen stand had an open and well-shaded understory

Strategy

- In grassed area, we planted balsam poplar — a fast-growing and sun-loving species
- Balsam poplar seedlings were planted in a large container plug size (415D) to increase stress tolerance and growth rate
- In aspen understory, we planted white spruce — a shade-tolerance species

Result

- Overall high (>90%) survival rates
- Seedlings in grassed area doing well with some signs of stress

HOW DENSELY DO I PLANT?

The final decision to make in your design is how close together you should plant your seedlings (i.e. density). There is no fixed number to go on for this, and plant spacing may vary greatly even within the same project – anywhere from 1– 3 m (3 – 6 ft) for shrubs and 2 – 5 m (6 –15 ft) for trees (USDA, 2010). This is due to differences in desired functions **(Table 1)**, site conditions, plant characteristics, and site preparation and maintenance plans (Withrow-Robinson et al., 2011). Planting at higher densities (e.g. 2–3 m between trees) is generally recommended on erodible hillslopes, when the site has minimal vegetative cover, when long-term weed control is a challenge, or when rapid functionality is desired.

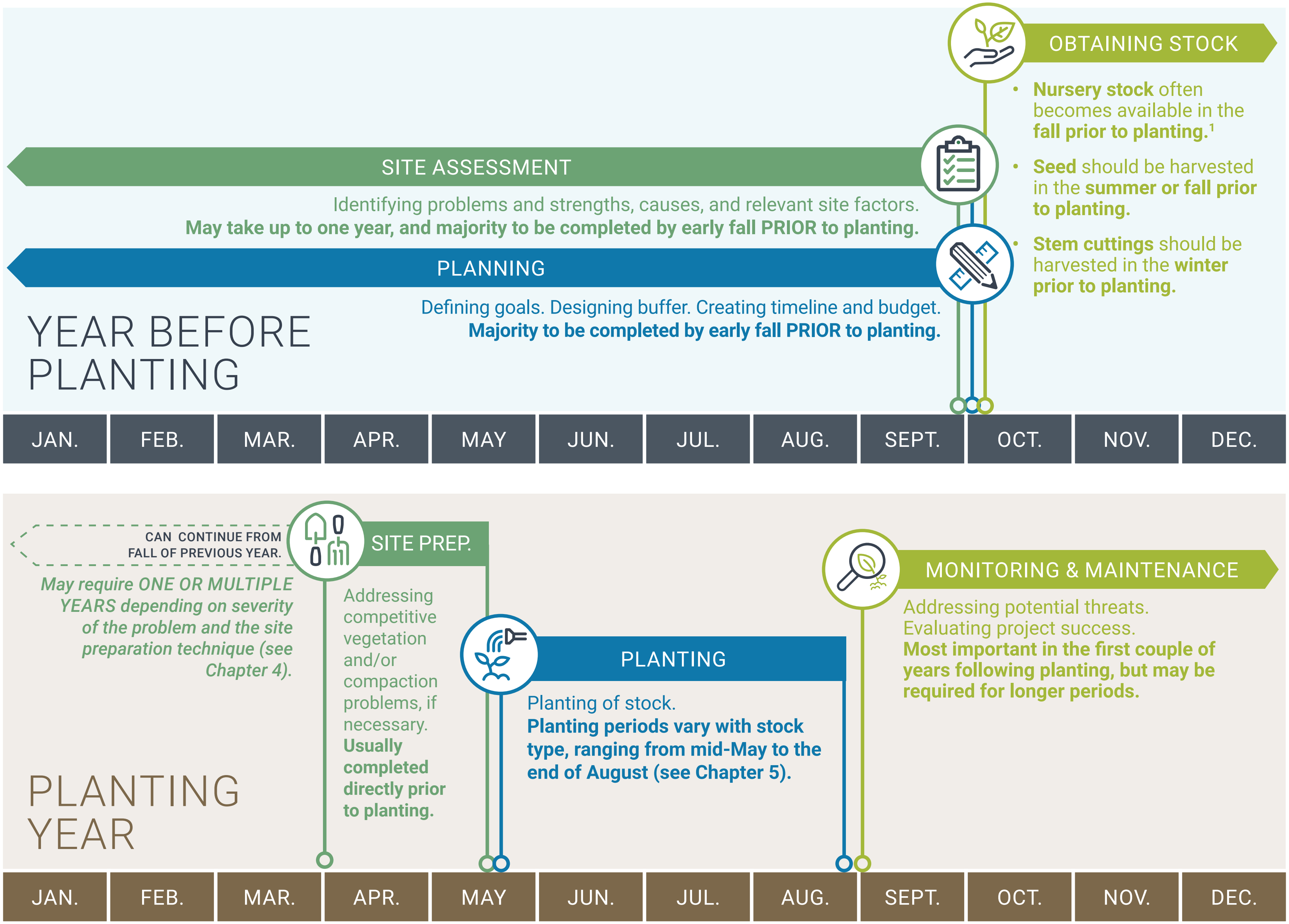
Once completed, your planting design should include a map of your site with section(s) outlined that indicate species and planting density. **Appendix C** provides a tutorial on how to create such a map using Google Earth Pro, including steps for using Microsoft Excel to calculate the number of seedlings you will need given the size of your area and planting density.

Your planting design should also include additional notes that outline the management activities required for each section. Management activities may include methods to prepare the site for planting, reduce competition from weeds, and ensure the seedlings receive adequate moisture. These are outlined in Chapters 4 and 5, but are important to consider early on in the process.

TIMELINE AND BUDGET

A crucial, often neglected part of the planning process is coming up with a timeline and budget. Establishing a buffer generally happens over two calendar years, beginning with assessment, planning, obtaining stock, and site preparation later in the first year and then planting in the spring/summer of the second year. This is not counting monitoring and maintenance, which may be required particularly in the first two years following establishment. **The timeline on the next page shows the approximate time periods of the different steps necessary to establish a buffer.**

Project budgets are even more variable than timelines, as they depend on the scale and management intensity of the project, as well as the availability of resources (e.g. volunteer labour, machinery, mulch materials, etc.). A basic budget template is provided in **Appendix D**. Note that grants to support project costs may be available through counties, the provincial government, or other organizations (e.g. industry groups, corporations, conservation agencies).



[1]Some nurseries do not open ordering until the calendar year of planting. In such cases, stock should be ordered by the end of February.

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CHAPTER 3
OBTAINING PLANT MATERIALS

To achieve necessary functionality, riparian forest buffers involve planting far more trees, shrubs, and/or herbaceous species than a simple landscaping project. For this reason, stock types that are relatively inexpensive and easy to plant are generally preferred. These include container plugs, bare root seedlings, stem cuttings, and seeds.

These stock types can be sourced from a nursery (for a native plant nursery database refer to http://anpc.ab.ca/), or, in the case of cuttings and seeds, harvested yourself. Each stock type has different storage requirements, planting windows and techniques, survival rates, size and cost ranges, and even terminology. This information is summarized in Table 2 and the following paragraphs.

Table 2. Characteristics of different stock types for riparian forest buffers (based on Scianna et al., 2005; Withrow-Robinson et al., 2011; Hoag, 2007; Tannas and Tannas, 2016).

Stock Type	Height	Stem Diameter	Unit Cost	Possible storage time (under ideal conditions described below)	Planting Window
CONTAINER PLUGS	15–50 cm (6–20”)	0.1–0.8 cm (0.05–0.3”)	$1.00–$5.00	One week	Overwintered stock: mid-May to mid-June Hot-lifted stock: mid-June to end of August
BARE ROOT	20–60 cm (8–24”)	0.3–1.3 cm (0.1–0.5”)	$1.00–$5.00	One week	Mid-May to mid-June
STEM CUTTINGS	Minimum 40cm (16")	Minimum 2cm (3/4”)	$0.40–$0.60/m ($0.20–$0.30/foot) (calculated as harvesting labour and transport)	Dormant stock: 2–6 months Actively growing stock: 1–3 days	Ideally when the soil is thawed and plants are dormant (usually April and October). Can be planted during growing season with reduced success
SEED	–	–	Vary greatly. Contact local native seed vendor.	1 year to several decades, depending on the species.	Spring or fall

Figure 10

White Spruce *(Picea glauca)* container plug stock.

Copyright Tree Time Services Inc. 2016.

Figure 11

Container plug bundles (left) and an opened box of container plugs (right).

Photo by AWES.

CONTAINER PLUGS

Container plugs are seedlings grown in small containers and planted with the roots contained in soil **(Figure 10)**. They are relatively simple to handle and plant, are more likely to survive drought conditions than bare root stock or non-rooted cuttings, and can be used to plant trees, shrubs, and herbaceous species. These factors make container plugs a versatile and reliable choice for almost any planting project.

Container plugs usually come plastic-wrapped in bundles of 5–20 that are fit into cardboard boxes, which can hold anywhere from 90–450 plugs **(Figure 11)**. Plug quality can be highly variable, and is important to assess when you receive your order. Check that the roots are moist and not tightly packed or "root bound" (ie. forming a solid mass that encricles the outside of the plug), as this will decrease root growth. Ideally, seedling roots will bind the soil or peat of the plug just enough to facilitate extraction from the wrapped bundle, and handling without soil falling off the roots.

There are two types of container plugs with different planting windows and storage requirements. **"Overwintered container plugs"** (spring stock) are in winter dormancy and should be planted after last frost (typically after mid-May in Alberta) but before mid-June. If planting immediately is not feasible, they can be stored for up to one week in a cool, dark place (between 2–4°C), such as a refrigerator or root cellar (Scianna et al., 2005). Watering every few days may be necessary if the seedlings begin to dry out. Ensure that seedlings are thawed out completely before planting.

"Hot-lifted container plugs" (summer stock) are actively growing and should be planted between mid-June and late August within a few days of receipt. They can be temporarily stored for up to one week in partial shade between 4 and 21°C (Dunroese and Barnett, 2004). Watering every 1–2 days may be necessary to prevent them from drying out.

Figure 12

Lodgepole pine *(Pinus contorta)* bare root stock.

Copyright Tree Time Services Inc. 2016.

BARE ROOT STOCK

Bare root stock is typically grown in a nursery bed for about two years, and then dug up and sold when dormant **(Figure 12)**. This type of stock is widely available and can perform well with proper care, but is vulnerable to drying out both in storage and after planting (Kiiskila, 2004). It also has a relatively narrow planting window (between mid-May and mid-June), and cannot be used for herbaceous species.

Bare root stock usually comes in small bundles bound together with an elastic band and laid horizontally in cardboard boxes. Check to see if roots are moist when you receive them, as this will greatly affect seedling success. Like overwintered container plugs, bare root stock may be stored for up to one week in a cool, dark place (between 2–4°C), if roots are kept moist.

STEM CUTTINGS

Stem cuttings are segments of mature, dormant, woody stems or shoots with intact lateral buds (Darris 2006, **Figure 13**). Stem cuttings of certain species of trees and shrubs will grow into new individuals, if harvested, stored and planted appropriately **(Figure 14)**. Although harvesting stem cuttings is relatively labour-intensive, with a team of volunteers it can be an inexpensive and enjoyable way to acquire stock for a planting project.

Figure 13

Recently harvested willow stem cuttings.

Photo by AWES.

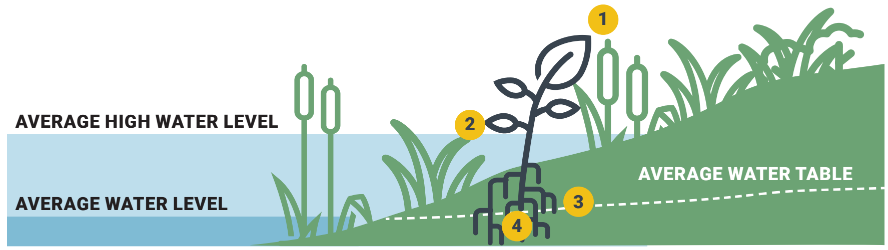
Figure 14

Stem cuttings of species such as willow will begin to grow new roots and leaves soon after they are planted during the growing season.

Photo by AWES.

SELECTING STEM CUTTINGS FOR HARVEST

In Alberta, the best species to select stem cuttings from are willow, red osier dogwood, plains cottonwood, and balsam poplar, as these will root with the highest rates of success when planted[2] (Darris, 2002; Hoag 2007).



In general, cuttings should be a minimum height of 40cm (16") and a minimum diameter (at the top end) of 2cm (3/4"). Specific recommended cutting sizes for different sites depends on the following factors:

1. **Height of surrounding vegetation.** The tops of cuttings should not be shaded out by surrounding vegetation when planted
2. **Height of high water level.** The tops of cuttings should be above the annual high water level when planted
3. **Depth of water table.** Cuttings should be long enough to reach the water table when planted, so longer cuttings are often used in more upland areas (i.e. the bank and terrace zones)
4. **Desired speed of establishment.** Longer cuttings will provide more rapid bank stabilization and erosion control

Case Study 2: The vulnerability of stem cuttings to drought in Red Deer County, 2015

Site context

- Low lying, wet area with moderate grass competition
- Drought-like conditions in region

Strategy

- Harvested 1m long willow stem cuttings during dormancy
- Bundled up and stored cuttings for 6 months at -2°C, and then presoaked them for four days prior to planting
- Used a mallet to pound the cuttings into the planting area at 1 m spacing

Result

- Drought-like conditions continued over the growing season
- Very low (<5%) survival rates
- Cuttings put on very little growth after planting

[2]*Common snowberry (Symphoricarpos albus), currants (Ribes spp.) and red elderberry (Sambucus racemosa) may also root with moderate success when planted in favourable conditions (Darris, 2002).*

The best time to harvest stem cuttings is during the winter "dormant season" - that is, when the "donor" plants are without green leaves.

Figure 15

Scratching away the bark of this willow stem reveals green underneath, indicating that the stem is alive.

Photo by AWES.

When considering these factors, keep in mind that at least three quarters of the cutting should be in the ground when planted, while 3-4 buds should be aboveground (Hoag, 2007).

Furthermore, it is important to take cuttings from healthy stem material, avoiding stems that are covered in lichen, rigid or easily breakable, or abnormally light. Scratching away a bit of bark from the stem can reveal whether the stem wood is green and thus alive **(Figure 15)**. Also avoid using the tips of stems for cuttings, as these have relatively low energy reserves (Hoag, 2007).

HARVEST TIMING

The best time to harvest stem cuttings is during the winter “dormant season” – that is, when the “donor” plants are without green leaves. Stem cuttings harvested during this time transpire less water and consequently are less likely to dry out. Harvesting stem cuttings from actively growing donor plants in the spring or summer is possible, provided the cuttings are planted within 1-3 days with their rooting ends soaking for that period.

HARVESTING PREPARATION

Select a harvesting site that has a healthy stand of desired species, is close to your planting site, and can be legally accessed (contact Alberta Environment and Parks before harvesting cuttings from public land, **http://aep.alberta.ca/**).

Ensure that you have the necessary Personal Protective Equipment, which should include gloves, rubber boots or at least closed toe shoes, eye protection and a hat. The latter two items help to protect the eyes and face from scratches as you navigate through the stand.

The following tools are also recommended:

- Loppers;
- Hand pruners or a machete;
- Commercial stretch-wrap, bale twine, or large zip ties to tie bundles of cuttings together;
- Flagging tape and a sharpie pen for marking down species and site information;
- If cuttings are actively growing and there is no standing water on site, 5 gallon buckets filled with water may be used for soaking.

HARVESTING

1

Once you have located a desired stem cluster, cut near the bottom of the stem at a 45-degree angle with loppers. Cutting at this angle makes it less likely that water will pool on the wound left by the cut, reducing the risk of infection for the donor plant. No more than a third of a donor plant should be harvested (Hoag, 2007).

2

Cut the tips and side branches off of the harvested stems. Make sure to measure out the desired height of the cutting.

3

Temporarily pile the cuttings in a cool, shady place. If cuttings are actively growing, place immediately into standing water.

Figure 16

Snow caches such as this one are an easy way to store willow cuttings until planting.

Photo by AWES.

STORING

Actively growing cuttings may be planted up to 3 days after harvest, as long as their rooting ends are kept soaking in water. Dormant cuttings can be stored for far longer – up to 6 months under the right conditions (Crowder, 2005).

To store dormant cuttings, bundle them in something that will keep the moisture in, such as heavy duty garbage bags or moist burlap.

Bundles of dormant stock must be placed in cold storage (between -5 and 4°C; colder is preferred[3]) or a "snow cache" over winter (Tilley and John, 2012). Snow caches should be located in fairly shaded areas where cuttings can be evenly buried with at least two feet of snow (Figure 16). Covering snow caches with reflective insulated tarps helps maintain cool temperatures.

When the soil is thawed and ready for planting, remove cuttings from cold storage and soak them completely in water for two to six days (Sotir and Fischenich 2007; Darris 2006). Plant cuttings directly after they have finished soaking, using techniques that are described in Chapter 5.

[3]*Note that dormant cuttings can only be stored for 2-3 months if temperatures are above freezing (i.e. 0-4°C) (Tilley and John, 2012).*

Seed can be used to provide a temporary cover crop, or to establish a long-term herbaceous layer of native grasses, sedges, rushes, and/or forbs.

Figure 17

This riparian area was seeded with native grasses, forbs, sedges and rushes to provide long term functionality as trees and shrubs become established.

Photo by North Carolina State Unviersity, 2013.

SEED

Seeds can be used in riparian forest buffers for two purposes. The first is to provide a **temporary cover crop** to alleviate soil compaction or to reduce potential of soil erosion. Typically, this involves using fast-growing, readily available agronomic grasses or legumes that are later removed through tilling, mowing or spraying after their function is fulfilled. More information on cover crops is provided in Chapter 4.

The second potential purpose of seeding is to establish a **long-term herbaceous layer** of native perennial grasses, sedges, rushes, and/or forbs **(Figure 17)**. As highlighted in Chapter 2, many of the functions that riparian forest buffers can provide are enhanced by including herbaceous species in addition to trees and shrubs. Seeding these areas may be particularly necessary when existing herbaceous cover has been significantly damaged, removed, or outcompeted by invasive species.

Native seeds can be purchased from certain specialized nurseries listed on the Alberta Native Plant Council website, **http://anpc.ab.ca/**. Try to ensure that the seed you purchase has been harvested locally (i.e. in Alberta or Saskatchewan), as some seed companies source from across North America. Another option is to harvest the seed yourself. For more information, refer to ***Restoring Canada's Native Prairies: A Practical Manual*** by Morgan et al. (1995).

Seeding can occur in either spring or fall. If seeding is not possible immediately, then seeds should be stored in a cool, dry location that is well-protected from rodents. In such conditions, seeds can retain their viability anywhere from a year to several decades, depending on the species.

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CHAPTER 4
PREPARING YOUR SITE

Plants need four basic elements to grow: sunlight, water, nutrients, and air.

Different species require different quantities of these elements, which is why it is important to select species that are adapted to the conditions of your site. For example, moist, poorly drained sites should be planted with wet-loving species such as willow or red osier dogwood.

However, in sites with issues such as excessive vegetation competition or soil compaction, it may be difficult for any planted species to survive. In these situations, some sort of site preparation may be required. The following chapter will outline consequences of these site issues, how to determine the necessity of site preparation, and various site preparation techniques.

EXCESSIVE VEGETATION COMPETITION

THE PROBLEM

Fast growing plants such as invasive weeds and spreading grasses are common in and around disturbed sites. This vegetation can take up much of the available nutrients, moisture, light, and space at a site. Research has shown that even moderate infestations of annual weeds can decrease seedling survival by 50 to 75% (AAF, 2007). Spreading grasses such as smooth brome or Kentucky bluegrass can be particularly detrimental to seedling establishment and growth by forming a thick sod mat with a dense root system that chokes out most other plants.

Something should be done if:

1. Over 50% of light that would reach the seedlings is blocked by other plants
2. Over 50% of the topsoil is made up of the roots of sod-forming grasses

Figure 18

Rototilling.

Photo by USFWS Southwest. Ottine Dam Revegatation 2016.

Figure 19

Scythes make it possible to cut weeds and grasses close to seedlings.

Photo by Jerry Dicker, Filnore Woods Blog.

POSSIBLE SOLUTIONS

Tillage breaks up existing vegetation and sod clumps, creating favourable beds for planting. However, unless it is done repeatedly over a growing season, it is not a long-term solution for perennial weeds or spreading grasses, which will sprout back up from root fragments and existing seeds (Withrow-Robinson et al., 2011). Furthermore, tilled areas are susceptible to erosion and recolonization by fast-growing weedy species.

Various techniques can be used to address these shortcomings. For example, using a rototiller to **till in small strips** where seedlings will be planted can help to reduce the likelihood of erosion (Figure 18). Additionally, planting a fast growing cover crop such as winter wheat or fall rye into a tilled area can decrease rates of weed recolonization and erosion. If possible, the cover crop should be mowed before it goes to seed.

Mowing can reduce aboveground competition for light, and reduce populations of annual weeds if it is done before they set seed. Mowing does not reduce populations of invasive grasses and perennial weeds unless it is repeated frequently over multiple seasons before and after planting. Hand tools such as scythes make it possible to cut close to seedlings (Figure 19).

Herbicides are generally less expensive than most other site preparation techniques for large scale projects, are less likely to cause erosion than mechanical techniques such as tilling, and can be done in sites with challenging topographies. Many herbicides (e.g. Glyphosate) are transported through the plants to the root system, making them effective at killing perennial weeds and grasses. Mowing prior to spraying helps to ensure contact between chemical and the living, targeted vegetation.

However, most herbicides do not kill seeds, so repeated applications are required in the growing season prior to planting to address germinating vegetation. Furthermore, herbicides can be taken up by non-targeted organisms or run off into waterbodies, posing a risk to riparian and aquatic health. For this reason, the Alberta Government's (2010) Environmental Code of Practice for Pesticides contains strict regulations about herbicide use within 30m of water bodies.

Based on these regulations, it is recommended that if used, herbicides should be sprayed in meter-wide circles where each seedling will be planted at least 1m from the water's edge by a certified pesticide applicator. Note that less than 10% of any given 100m^2 area can be sprayed per year 1–5m from a water body, while less than 30% of any given 100m^2 area can be sprayed per year 5-30m from a water body. Be sure to consult the Environmental Code of Practice for Pesticides in full before planning any spraying.

Solarization involves covering an area with transparent greenhouse plastic for an extended period of time to heat-kill all vegetation within it **(Figure 20)**. For best results, the following 5-step process should be followed:

1. Till the area, or mow it close to the ground. This will make it possible to spread the plastic as close to the soil surface as possible.
2. Irrigate the area. This will stimulate the germination of weeds that might otherwise survive the heat as a seed.
3. Cover the area with transparent greenhouse plastic (UV-treated if possible). Ensure that the edges of the plastic are buried or stapled down to eliminate airflow.
4. Leave the plastic in place for an entire growing season – for example, from mid-May until early September. This allows time for most weed seeds to germinate and be heat-killed.
5. Plant or seed early the following spring.

Solarization can be extremely effective on relatively small scales, but the costs of UV-treated greenhouse plastic quickly become prohibitive for larger areas. The plastic may also suffer damage from rodents or ungulate hooves, decreasing its effectiveness.

Figure 20

Rolling out plastic to solarize an area.

Photo by Regents, University of California.

Figure 21

Hand weeding.

Photo by AWES.

Figure 22

Grazing a riparian area.

Photo by AWES.

Hand pulling competitive vegetation can be an effective but labour-intensive strategy, recommended for small sites or projects with committed volunteer groups (Figure 21). Efforts should be focused on microsites of a meter in diameter where seedlings will be planted.

Grazing an area prior to planting can beat back certain palatable weeds and grasses to give seedlings a head start (Figure 22). However, achieving an appropriate amount of grazing can be a delicate balance, as overgrazing can increase soil compaction, particularly when the ground is saturated (e.g. spring or during sustained summer wet-periods). Even with optimal management practices, further maintenance will likely be required to slow the growth of perennial weeds and grasses (see Chapter 6 for more information).

Mulching involves spreading a material around where seedlings are planted to starve competing vegetation of light, and can be done prior to, during, or shortly after planting. Mulching can also provide a number of other benefits to seedlings that are described below, depending on the type of material used.

Plastic mulch can be purchased in rolls that are easily applied in relatively flat areas, either by hand or with the use of a tractor prior to planting – many counties in Alberta offer plastic mulch applicators for rent (Figure 23). Plastic mulch is relatively inexpensive and extremely effective at blocking sunlight to prevent weed growth. Dark coloured plastics also keep the soil temperature high, facilitating a longer growing season (Pollock, 2012).

Figure 23

Plastic mulch can be efficiently applied in straight rows either before or after planting using a tractor-pulled applicator.

Photo by Robert Decker.

Figure 24

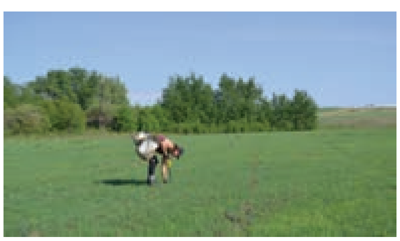
Pulp mats are an effective, biodegradable mulching option.

Photo by AWES.

The downsides of plastic mulch include the fact that it needs to be collected and landfilled as it gradually breaks apart over a period of 5–10 years. Further, plastic mulch can reduce root suckering of planted species (e.g. wild rose, raspberry), limiting their ability to colonize a site.

Pulp mats, cardboard, and **newspaper** are biodegradable alternatives to plastic mulch that offer similar functionality and are generally applied shortly after planting **(Figure 24)**. However, they can be labour intensive to apply, and can provide habitat for voles that might browse seedlings. It is important to ensure that these mulches are attached to the ground in some way (e.g. using field staples) so that they are not blown over onto seedlings.

Case Study 3. The promise of pulp mats — Parkland County, 2015



Site context

- Area with well-established weed cover that was recently sprayed with herbicide and tilled, and then seeded to grass
- Open planting area with an existing forest stand on the west side that protects it from winds

Strategy

- Planted a high density of white spruce and lodgepole container plugs (2 m x 2 m spacing)
- Each seedling had a 30 cm x 30 cm pulp mat placed over it and secured with field staples

Result

- Overall high survival rates (>85%) of both species planted
- Pulp mats continue to suppress weeds a year and a half after planting

Figure 25

Spreading straw mulch with a bale processor.

Photo by AWES.

Organic mulches such as straw, wood chips, or grass clippings can also be a cheap and effective weed control method that may be applied prior to or following planting. These mulches provide the additional benefits of reducing soil moisture losses by up to 50% and enhancing levels of soil nutrients (particularly carbon) as they decompose (CSU, 2015). They also help to insulate the soil, which can be beneficial for seedling growth (by reducing their exposure to cold snaps), or detrimental to it (by preventing the ground from warming up in the spring).

Although organic mulches can be time consuming to apply by hand, machinery such as bale processors, wood chip spreaders, and spinning rakes can greatly speed up the process if seedlings are planted in rows **(Figure 25)**. When applying, ensure that the mulch is not piled up on the stem of seedlings (as this may cause it to rot), but rather in a doughnut shape around it **(Figure 26)**. Note that organic mulches also provide excellent vole habitat, and reapplications will likely be required over the first couple of seasons as they decompose.

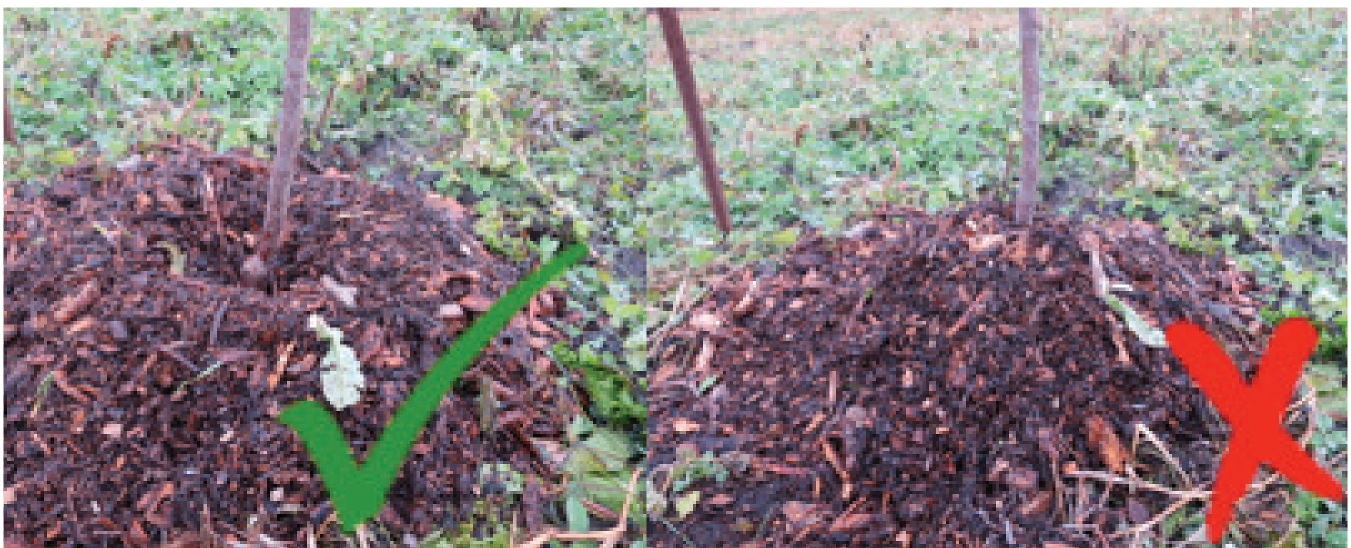


Figure 26

Apply mulch in a doughnut shape around seedlings (picture on left) rather than piled up against their stem (picture on right).

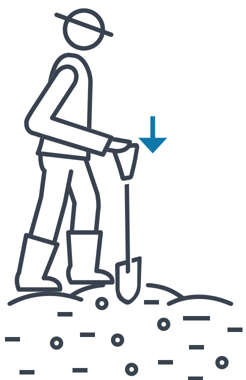
Photo by AWES.

SOIL COMPACTION

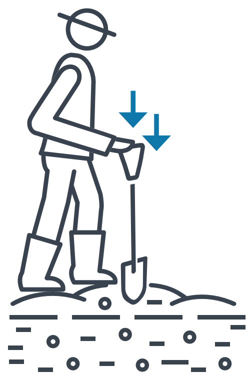
THE PROBLEM

Soil compaction is common in riparian areas due to relatively high moisture levels and livestock or machinery use. Compacted soils are more challenging to plant in and more difficult for seedling roots to penetrate. They can lead to stunted or horizontal root growth, leaving seedlings susceptible to drought or uprooting during high winds and freeze/thaw cycles. ***Some form of site preparation is required if soil is moderately to highly compacted.***

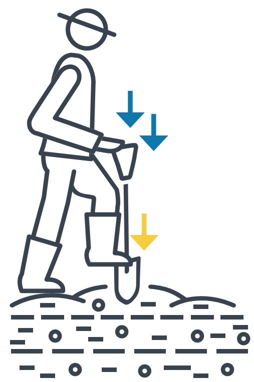
To determine the severity of soil compaction, use a planting shovel to administer the following test:



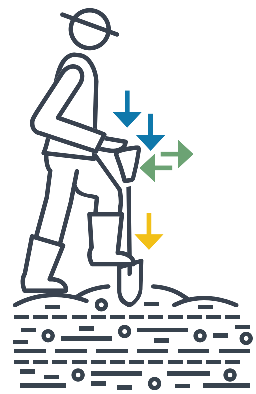
LOOSE
Shovel will penetrate easily with own weight



NOT COMPACTED
Shovel can penetrate soil with arm force only



MODERATELY COMPACTED
Shovel kicker must be stood on with one foot to create the force needed to penetrate soil



HIGHLY COMPACTED
Shovel kicker must be stood on and rocked back and forth to penetrate the soil

Figure 27

Freeze/thaw cycles can open up crevices and ridges in the soil.

Photo courtesy J.Brew/National Snow and Ice Data Centre.

POSSIBLE SOLUTIONS

Waiting a year or more, while taking away the cause of compaction (e.g. livestock or machinery), is the simplest and least expensive option. For sites that are difficult to seed or access with machinery, it may be the only option. Over time, freeze/thaw cycles will gradually loosen up the surface of compacted soils (Figure 27), allowing for roots, fungal hyphae, and other soil life to begin to burrow in and rebuild soil structure. This activity may make it possible to plant in the site in a year or more. Note that certain weedy species (e.g. Canada thistle, dandelions) grow well in compacted soil, and waiting may leave the site open to their invasion.

Figure 28

Daikon radishes can be used as an effective deep-rooted cover crop.

Photo by Marie Ruzicka, Sunrise Farms.

Figure 29

Chisel-plow attachment.

Photo by Athens Plow Company.

Planting a deep-rooted cover crop can help alleviate soil compaction over one or multiple seasons while reducing the risk of weed colonization. The roots of cover crop species such as alfalfa or Daikon radish are often robust enough to penetrate the compacted layer, creating pore space for air, water, and other plant roots to fill (Chen and Weil, 2009, **Figure 28**). Once the cover crop has done its job, it can be killed by mowing before it goes to seed if it is an annual or by tilling. Its residue will increase the soil's organic matter content, making compaction less likely in the future (Soil Quality Institute, 2003).

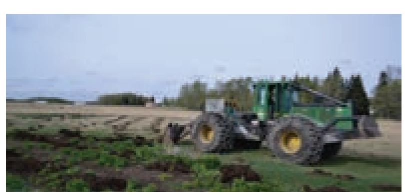
Mounding involves flipping over discrete patches of soil to create a series of small depressions and mounds capped with mineral soil **(see Case Study 4)**. Depending on soil moisture levels, seedlings can be planted within the wet depressions, on top of the drier mounds, or somewhere in between. In addition to alleviating soil compaction, mounding creates small protected micro-habitats for seedlings to grow in without excessive competition from weeds. However, mounding equipment is relatively uncommon and thus may be difficult to access. It is also not suitable for challenging topographies.

Deep tilling techniques such as chisel plowing or subsoiling can mechanically break up and loosen highly compacted soils (Soil Quality Institute, 2003, **Figure 29**). They are best done in the summer or fall when soils are relatively dry, and can quickly improve soil aeration and water-holding capacity for planting the following spring. However, these techniques are not suitable for steep slopes or wet areas, and thus may have limited application for many riparian sites.

Case Study 4: Site preparation with a mounder along an ephemeral stream in Red Deer County, 2016

Site context

- Compact, clayey soils
- Thick sod mat and grass competition



Strategy

- Used a mounder to flip sod over, creating discrete mounds capped with mineral soil
- White spruce, black spruce, tamarack, lodgepole pine, white birch, balsam poplar, and willow container plugs were planted on mound "hinges"

Result

- Overall high survival rates (>95%)
- Willow and balsam poplar were heavily browsed by voles, but most managed to recover
- Mounding also stimulated suckering in adjacent balsam poplar stands

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CHAPTER 5
PLANTING

Planting on a broad scale may seem like a daunting task, both in terms of the labour involved and the importance of getting it right. Yet when done with appropriate technique and tools, it can be an enjoyable form of exercise, the results of which will be visible for decades to come. This chapter outlines some best practices for planting to help you achieve your desired results.

Figure 30

Seedlings can be planted much more efficiently with a tree planting shovel (left) compared to a generic shovel or spade (right).

Photo by AWES.

Figure 31

Professional tree planters planting into a recently seeded cover crop.

Photo by AWES.

WHEN TO PLANT

Different stock types have different planting seasons, which are outlined in **Table 2** in Chapter 3. In general, avoid planting on days that are windy, dry, or warmer than 30°C. Instead, plant when soil conditions are favourable – that is, drained of any standing water, thawed, and moist.

HOW TO PLANT

CONTAINER PLUGS AND BARE ROOT STOCK

Tool

Tree planting shovels **(Figure 30)** are small spades designed to efficiently plant container plugs and bare root stock by creating "slits" in the ground rather than “holes” for the seedlings. Most landowners have basic shovels and spades **(Figure 30)** that will do the job, but at a far slower rate than tree planting shovels.

Technique

Proper planting technique is outlined in **Figure 32**, while common planting faults are shown in **Figure 33**. For large scale projects (i.e. >500 seedlings), consider contracting professional tree planters. A single professional tree planter can plant 1,000 to 3,500+ seedlings per day depending on the site **(Figure 31)**. Another option is to rent a mechanical tree planter, which are available through certain counties in Alberta. These tractor attachments make a trench as they go along, into which trees are placed. However, they are unwieldy in challenging topographies or areas of high moisture, and thus are usually not recommended for riparian planting projects.

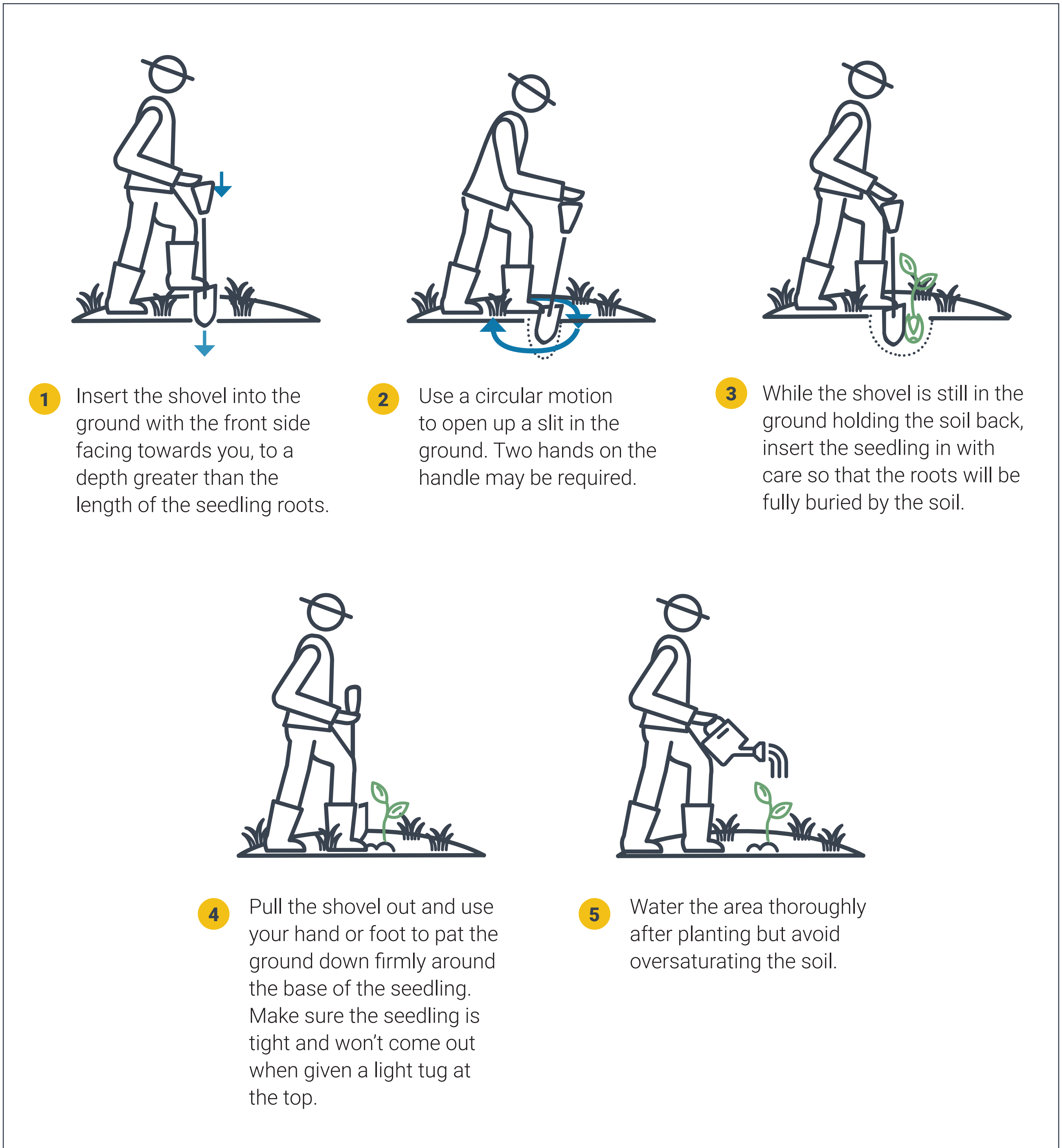

Figure 32

Proper planting technique.

Created by AWES.

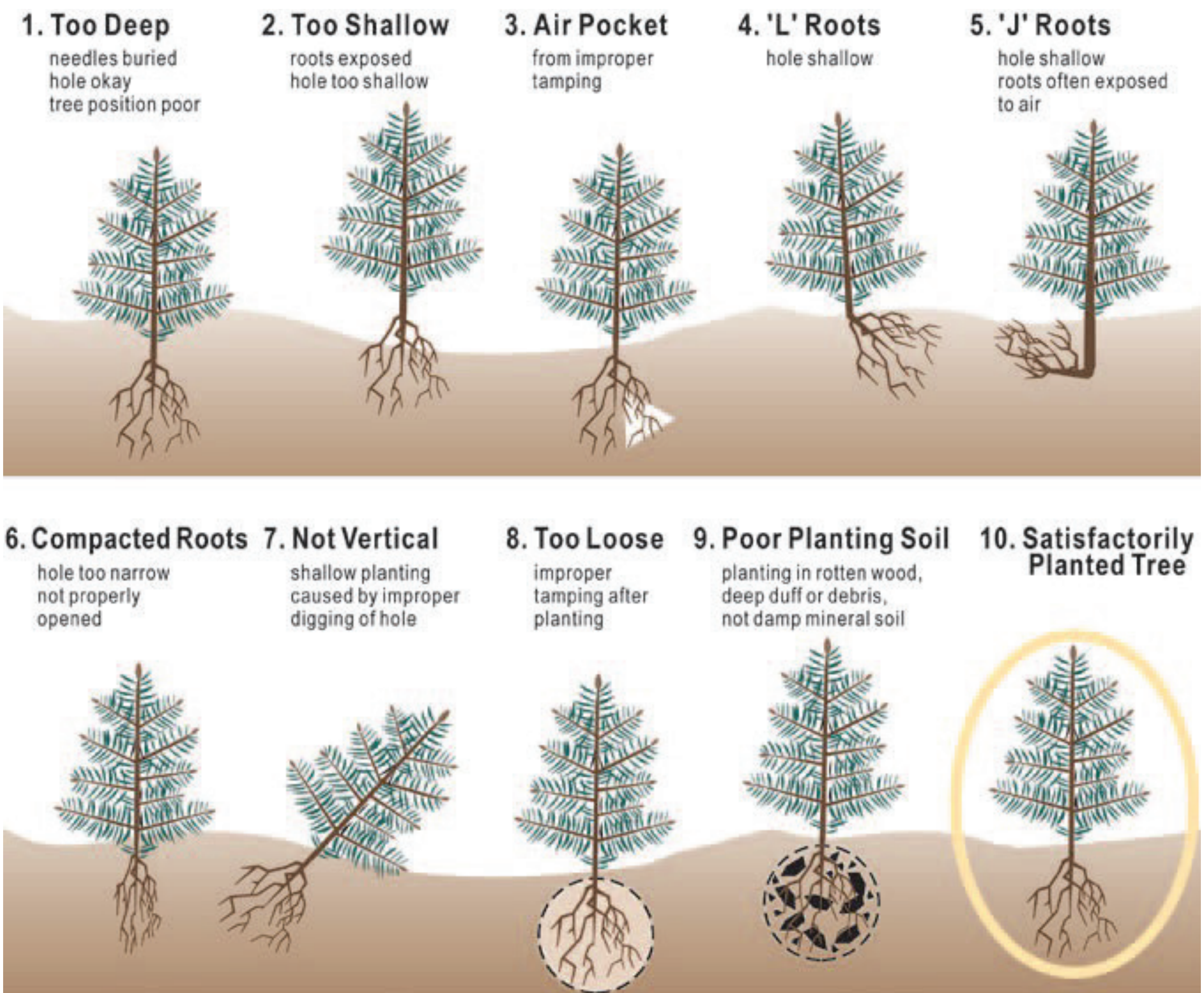

Figure 33

Common tree planting faults.

Created by Rose and Morgan, 1992.

Figure 34

Planting a cutting into a relatively loose soil.

Photo by AWES.

Preventing injury

Planting seedlings is a repetitive task – similar to shovelling snow – that can lead to strain injuries if proper care is not taken to prevent them. Injuries commonly occur to the muscles, tendons and ligaments of the wrists, shoulders, back and knees. The best defense is to wear appropriate Personal Protective Equipment (i.e. steel toe boots, work gloves, and a sun hat), stay well hydrated, and take regular breaks. Selecting a shovel of the appropriate length allows you to maintain a healthy posture. Be sure not to grip the shovel handle too hard, as you run the risk of vibrations in the wrist when contacting hard ground or rock.

STEM CUTTINGS

Tools

Depending on the technique you choose, you may need a rubber mallet, a piece of rebar, an auger, or a shovel.

Technique

Stem cuttings should be planted right-side up, to a depth where their bottom can reach the water table and their aboveground portion has at least 3 buds that are not overly shaded by surrounding vegetation (Hoag, 2007). At least three quarters of the cutting should be buried underground to make it less susceptible to drying out.

- In loose soils, it may be possible to push cuttings into the ground by hand (Figure 34).
- In more compact soils, cuttings can be pounded into the ground using a rubber mallet. Avoid pounding too hard, as this will damage the cutting's rooting end as it is forced in. If the pounding damages the top of the cutting, simply cut away the damage with a pair of pruners.
- In highly compact soils or with relatively thin cuttings, a pilot hole can be made by pounding in a piece of rebar or using an auger. The cutting can then slide into the hole relatively easily.
- An alternative, slightly more time-consuming option is to dig holes with a shovel. When filling in the holes, ensure that the soil is tightly packed around the cutting.

1. Stem cuttings should be planted right-side up, to a depth where their bottom can reach the water table
2. Their aboveground portion should have at least 3 buds that are not overly shaded by surrounding vegetation
3. At least 75% of the cutting should be buried underground

SEEDS

Seeding is usually the most efficient way to plant herbaceous species. There are several ways to seed, each of which has its advantages and equipment requirements. **Broadcast seeding** is relatively simple and can be done with minimal specialized equipment, but is generally thought to require twice the amount of seed as seed drilling to achieve proper coverage (Morgan et al., 1995).

For small sites, seeds can be simply scattered by hand. Larger areas require broadcast seeders, which range from hand cranked versions that you can strap to your chest **(Figure 35)** to ones that are pulled by ATVs or tractors. Lightly incorporate broadcasted seed into the soil using a rake or pack roller – heavy harrowing is not advisable for native seeds, which germinate near the surface.

Seed drilling is an efficient way of seeding over large areas, but requires expensive, specialized equipment: namely, a seed drill **(Figure 36)**. Seed drills are typically pulled by tractors, and make small furrows in the ground into which a specified amount of seed is dropped and then covered up. They require careful calibration, as native seeds come in a variety of different sizes and weights. Although no-till native seed drills are gradually becoming available, most drills require exposed, packed mineral soil.

Hydroseeding involves mixing seeds in a mulch/water slurry and spraying them across a site using a high-pressure hose **(Figure 37)**. It has particular utility on steep slopes that are difficult to access for machinery. Hydroseeding equipment is expensive, but may be available for rent from landscaping companies.

Figure 35

Hand-cranked broadcast seeder.

Photo by The Xerces Society for Invertebrate Conservation, 2013.

Figure 36

Native seed drill.

Photo by the Ohio Pollinator Habitat Initiative.

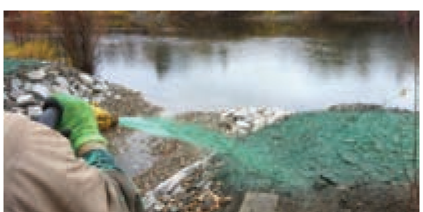

Figure 37

Hydroseeding.

Photo by Sagebrush Nursery.

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CHAPTER 6
MONITORING & MAINTENANCE

Even the most well planned-out projects should be monitored carefully.

This is most crucial during the first couple of years after establishment when seedlings are most vulnerable, but can be highly beneficial to continue after that. Good monitoring practices will help you to:

- Identify potential threats to the seedlings and appropriate responses
- Evaluate the success of your project at meeting its desired goals

These benefits are discussed in greater depth over the rest of this chapter.

POTENTIAL THREATS TO SEEDLINGS

COMPETING VEGETATION

A forest naturally develops over time in stages. Fast-growing annual "pioneer" species are usually the first ones to germinate in disturbed areas with exposed mineral soil. These are quickly followed by fast-growing perennials, starting primarily with herbaceous and then moving into woody species. Eventually, slower growing trees and shrubs will grow through the vegetation and begin to shade other species out, forming a "climax forest" **(Figure 38)**.

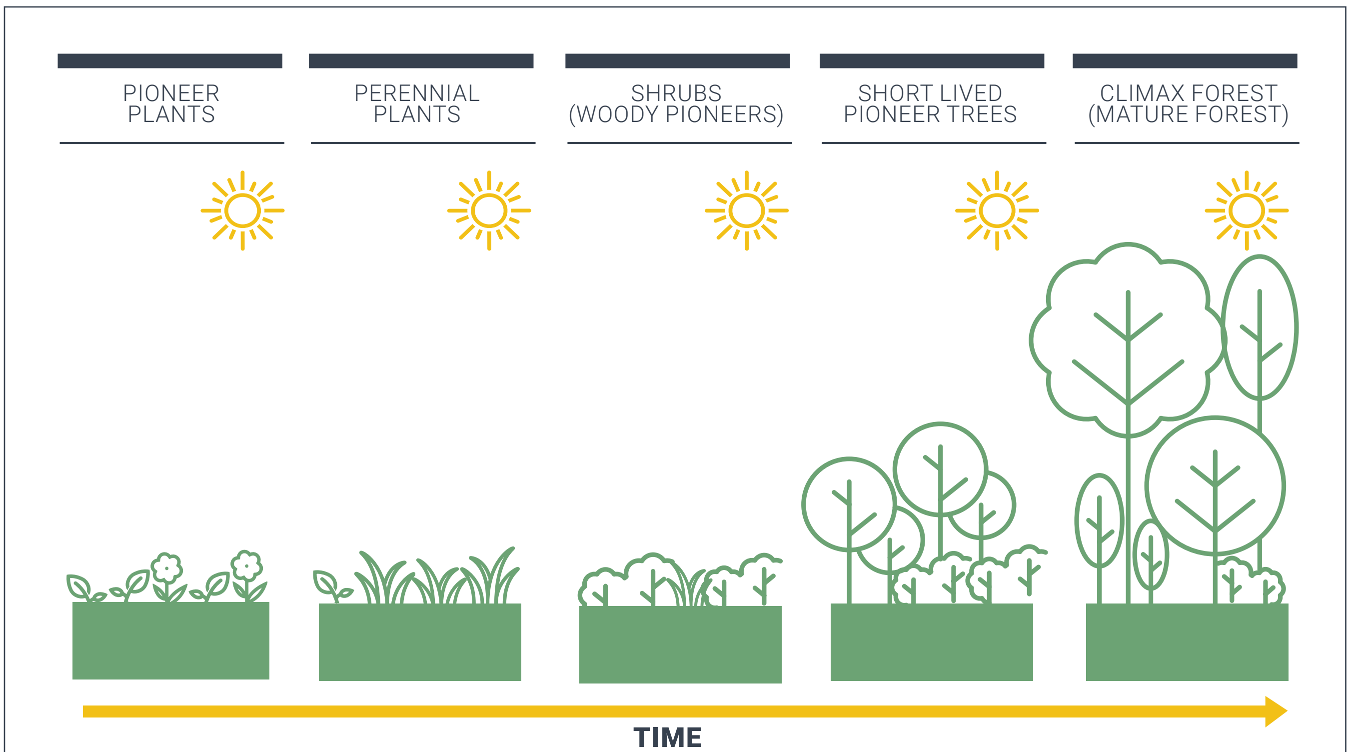

Figure 38

Stages of forest succession.

Adapted from the Permaculture Research Institute.

Figure 39

Drip irrigating seedlings.

Photo by Sherwood Botsford, Sherwood's Forest Tree Farm.

Establishing a riparian forest buffer is a way of "fast-forwarding" this process. Forest cover is usually desired quickly so that riparian functionality can be restored, and woody species may begin to dominate a well-designed, densely planted site in less than 5 years (Schroeder et al., 2009). The downside of this is that even with the best site preparation techniques, repeated efforts are usually required to address early successional species (i.e. weeds), particularly on sites that are highly disturbed.

These efforts may involve continuing with many of the site preparation techniques described in Chapter 4. However, special considerations need to be made to protect the growing seedlings. For example, care should be taken to avoid mowing or spraying herbicides on seedlings, with deciduous species being particularly susceptible to commonly used herbicides such as Glyphosate. Further tilling deeper than 5 cm (2") or too close to seedlings can damage roots[4]. If significant ongoing weed control is required, mark out seedlings with pin flags or flagging tape to avoid losing or accidentally damaging them.

DROUGHT

Periods of low moisture in the first few years post-planting can seriously compromise planting success. Different seedlings have different tolerances, and so what exactly counts as "low moisture" may vary. However, seedling health is likely being affected if the soil at a depth of 10–20 cm (4–8") feels dry to touch (Cerny et al., 2002).

There are two things you can do to reduce drought stress on young seedlings. The first is **irrigation**. This is generally done using mobile irrigation equipment such as sprinklers and hoses or water trucks (Fischenich, 1999). Drip irrigation systems can also be set up and used temporarily (AAFC, 2015, Figure 39). Concentrate efforts on areas within 0.5 m (2') of seedlings, as their roots will be unable to access moisture from further away until they have grown longer. It is also better to begin irrigating before the seedlings develop high levels of moisture stress.

A more long-term, preventative solution that can be combined with irrigation is spreading a thick layer of **organic mulch** (e.g. wood chips, straw, grass clippings) around the seedlings (see Figure 25 and 26). This will keep the soil cool, reducing evaporative losses. It will also, over time, add organic carbon to the soil, which increases its water-holding capacity (CSU, 2015).

BROWSE

Animals can quickly and effectively destroy a riparian forest buffer. Young deciduous species are particularly palatable to wildlife and livestock, but any seedling may be browsed if it is the most palatable forage in the area. Monitor for bark scrapings, girdling, or nipped off branches.

[4]Note that balsam poplar, trembling aspen, willow, red-osier dogwood, chokecherry, pin cherry, raspberry, rose are all examples of species that produce root suckers. Lightly damaging the roots of these species through occasional shallow tilling (<5 cm deep) for the first two growing seasons will actually stimulate suckers to emerge, increasing the overall capture of the site (Schroeder et al., 2009).

Figure 40

Deer browsing.

Photo by Grand Canyon National Park: Mule Deer Winter Browse 1602.

Figure 41

Plastic tree tubes (left image) and rolled up sections of window screening (right image) can protect seedlings from browse.

Photo (left) by A.M. Leonard Horticultural Tool and Supply Company, (right) by Takota Coen.

Deer, elk, and moose can nip young shoots off trees and shrubs, and completely eat or uproot small seedlings **(Figure 40)**. Installing fencing or tree guards (e.g. plastic tubes, hardware cloth or rolled up window screening) can prevent this from happening **(Figure 41)**. However, deer can browse up to 1.75 m (6') on a tree and jump 2.5 m (8') (Henigman and Martinz, 2002; Clevenger and Huijser, 2011), while moose can browse and jump up to 2.5 m (8') (BC Parks, 2000). Thus, the amount of material required for long-term seedling protection can be prohibitively expensive.

Other temporary options include deer repellents and scaring devices. However, deer repellents generally only stop light browsing, and need to be reapplied at regular intervals over the growing season (different products have different recommended application frequencies). Meanwhile, scaring devices, which include motion-triggered noisemakers or sprayers, often lose their effectiveness over time as the deer become accustomed to them.

Beavers eat young succulent seedlings and can fell full-grown trees to build their dams and lodges. Tree guards can protect seedlings from damage when they are young, while fencing, cages, or 12–16 gauge wire with a 2.5 cm (1") mesh size can be wrapped around larger trees and shrubs up to a minimum height of 1.2 m (4') (Fitch, 2016). These barriers are effective, but, like in the case of deer and moose, are expensive and time-consuming to apply.

Another strategy is to deter beavers from the general area. Options for doing this include inserting a long pipe (pond leveler) through their dam to undermine its effectiveness, or creating narrow channels up or downstream of the site to encourage them to dam there. For more information on these and other options, refer to the recent publication put out by the Cows and Fish Program titled *Caring for the Green Zone: Beaver – Our Watershed Partner (Fitch, 2016).*

Case Study 5: Planting unpalatable species to avoid browsing in Ponoka County, 2016

Site context

- Limited vegetation competition
- Substantial deer and beaver browse had prevented existing woody vegetation (i.e. rose, willow, and young aspen) from surviving or reaching mature height.

Strategy

- Planted white spruce - an unpalatable species - in areas of highest wildlife traffic

Result

- Overall high survival rates (>90%)

Figure 42

Stem girdled by voles.

Photo by Mary Holland, https://naturallycuriouswithmaryholland.wordpress.com/.

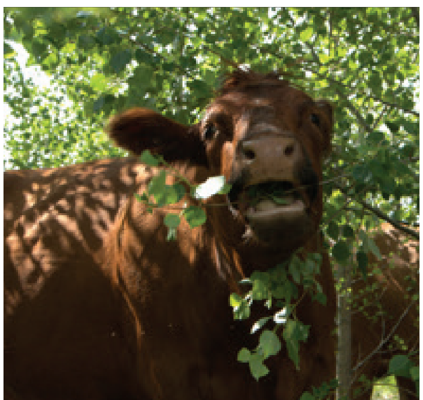

Figure 43

Cattle browsing trembling aspen stems.

Photo by AWES.

Figure 44

Yellowheaded spruce sawfly is a common pest of white spruce *(Picea glauca)*.

Photo by Toso Bozic.

Voles and hares are often underestimated browsers of young seedlings. They can cause significant mortality by scraping away a ring of bark around the base of seedlings (girdling) **(Figure 42)**. This often happens in the winter months, when food sources are scarce.

Tree tubes can protect seedlings from voles and mice, but, as discussed above, are expensive and labour-intensive to install in larger planting projects. Mowing thick grasses and weeds in the areas surrounding the seedlings is an effective alternative, as it deters the rodents by reducing their available cover. Another option for the winter months is to drive an ATV or small tractor on the snow adjacent to seedlings. This will collapse any snow tunnels that the rodents might use to access the seedlings.

Livestock can browse or trample seedlings and older trees and shrubs, and should be kept out of planting areas at the very least until seedlings are well-established (2+ years after planting) (Amonson, 2008; Kaufmann et al., 2014; **Figure 43**). At this point, grazing may be possible, but should be monitored closely to ensure that it is not causing significant damage to seedlings. Proper grazing management can reduce the likelihood of this occurring, and involves:

- Balancing stocking rates with the amount of available forage
- Distributing livestock evenly across the landscape (for example, by rotating them through different areas over the season)
- Avoiding or minimizing grazing of areas during vulnerable times such as during high moisture, or when seedlings are the most palatable food source (i.e. during spring bud-out or in late summer/fall after the grasses have cured and woody plants are still green)
- Providing adequate rest periods for areas to 'recharge' after grazing

For more information on grazing in riparian areas, consult the Cows and Fish publication *Caring for the Green Zone: Riparian Areas and Grazing Management – Third Edition (Fitch et al., 2003).*

DISEASE AND PESTS

Disease and pests such as fungal infections, forest tent caterpillars, woolly aphids and others **(Figure 44)** can have devastating effects on seedlings and are difficult to predict and control. The best thing you can do is prevent widespread infection, by:

- **Reducing general seedling stress.** Stressed seedlings have weakened immune functioning, and can attract diseases and pests. Reduce stress by selecting seedlings that are adapted to your site's conditions, and responding to other threats that were described above (i.e. competitive vegetation, drought, or browse).
- **Choosing a diversity of species,** as a single disease or pest is less likely to specialize in multiple species.

Certain fungicides, insecticides and organic treatment options can be used to control certain diseases and pests. However, these are generally more suitable for backyard use than larger scale riparian plantings.

Figure 45

The area of a survival assessment plot can be estimated by laying out a rope of a known distance from a point and then using the formula πr^2.

Photo by AWES.

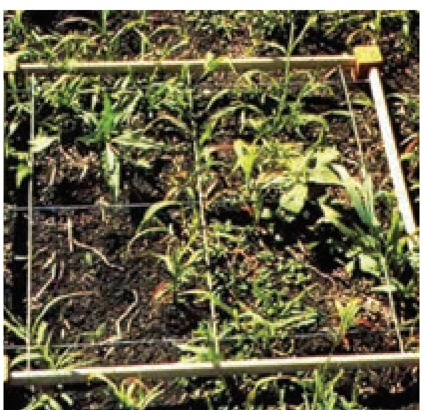

Figure 46

A quarter meter square quadrat for estimating survival rates of seeded herbaceous species.

Photo by John P. Morgan, Prairie Habitats Inc.

EVALUATING THE SUCCESS OF YOUR PROJECT

Effective project evaluation involves a lot of monitoring. This does not have to be in the form of formalized scientific techniques, but it is a good idea to have consistent ways of monitoring indicators of project success. These indicators might include:

- **Survival rate of plants.** This should be estimated each spring in the first few years following planting.
  - » The survival rate of tree and shrub seedlings can be estimated by walking to random points in your planted area, and then counting the number of alive and dead trees/shrubs within a certain distance (e.g. 5 m) of your point **(Figure 45)**. Replanting may be necessary if sufficient vegetative cover will not be achieved with the surviving seedlings once they have matured.
  - » The survival rate of seeded herbaceous species can be estimated by placing a quarter meter square quadrat (50 cm X 50 cm) **(Figure 46)** at randomly assigned points and counting the number of surviving plants within it (multiply by four to get a density value per m^2). Reseeding may be necessary if the plant density drops below 20 plants/m^2 for grasses, or 5 plants/m^2 for wildflowers (Morgan et al., 1995).
- **Changes in riparian functioning and health.** Every few years, repeat the 13-question riparian health assessment that you initially conducted in Chapter 1 to identify problems at your site. Make note of the number of questions you answer “Yes” and “No” to and see if it changes over time.
- **Unexpected problems and opportunities.** Keeping track of unforeseen events allows you to adapt your management activities accordingly, and adapt future projects to avoid or take advantage of them.

With a few exceptions, the majority of this monitoring can be done through simple visual sweeps of the area while making notes in a project logbook. This can be supplemented by taking repeated photos of a certain part of the area over time. Consider taking these photos at the same times each year, using GPS coordinates or something stationary as a reference point (e.g. a well-established tree or piece of rebar stuck in the ground).

CONCLUSION

Establishing a riparian forest buffer is an effective way to improve the health of a riparian area, while adding beauty and functionality to the surrounding property.

To help you realize these benefits, this manual has outlined six steps for riparian forest buffer establishment: site assessment, planning, obtaining stock, site preparation, planting, and monitoring and maintenance. This "recipe for success" has been created using the most up-to-date research and experience available related to riparian forest buffers.

That being said, riparian forest buffers are inherently site-specific, and we continue to learn more about best practices for each of the steps described above. By establishing one and sharing your experience with neighbours, community groups, local governments, and organizations such as the Agroforestry and Woodlot Extension Society or Cows and Fish, you will be able to contribute to this learning process while potentially inspiring others to do the same. In such a way, forest buffers of different sizes, patterns, and compositions may gradually begin to populate riparian areas across Alberta, helping in a small but significant way to enhance the vitality and resilience of our watersheds.

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APPENDICES

APPENDIX A: SPECIES OPTIONS FOR RIPARIAN FOREST BUFFERS

Table 3. Trees and shrubs. Sources: AAF, 2016; ABMI, 2016; Hale et al., 2005; Manitoba Naturalists Society, 2006; NRCan, 2016; PFAF, 2016; Royer and Dickinson, 2007; USDA, 2016; USFS, 2016.

* Note that forage value may vary significantly for different species of livestock and wildlife
** Hardiness zone data were not available for all species. For more information on species distributions, visit http://www.planthardiness.gc.ca

Scientific name	Common name	Height (m)	Width (m)	Growth rate (F fast, M medium, S slow)	Flower period (Ap April M May Jn June Jl July Au August)	Fruit/seeds available (type) (Sp spring, Su summer, F fall, W winter)	Forage value* (G good, F fair, P poor, T toxic)	Traits (N nitrogen fixer, Sp spreads fast, St salt tolerant, Su suckering)	Soil texture (C clay, L loam, S sand)	Moisture tolerance (D dry, A average, M moist, W wet)	Exposure (F full sun, P partial shade, S shade)	Natural region (B boreal forest, C Canadian shield, F foothills, G grassland, P parkland, R rocky mountain)	Minimum hardiness zone**
Abies balsamea	Balsam fir	15-25	6-8	S	n/a	(cone) F, W, Sp	P		C, L, S	M	F, P, S	B, F	1a
Acer negundo	Manitoba maple	12-20	10-15	F	M	(samara) F, W	P	Sp, St	C, L, S	D, A, M	F, P	G, P (eastern)	2b
Alnus incana ssp. Tenuifolia	River alder	2-8	2-4	F	Ap, M	(nutlet) F, W	P	N	C, L	M, W	F, P	B, C, F, R	1b
Alnus viridis ssp. Crispa	Green alder	3	4	F	Ap, M, Jn	(nutlet) F, W	P	N	C, L	M, W	F, P	B, C, F, P, R	1a
Amelanchier alnifolia	Saskatoon	2-4	2-3	M	M, Jn	(pome) Su	G	Su	C, L, S	A, M	F, P	B, C, F, G, P, R	2b
Andromeda polifolia	Bog rosemary	0.1-0.4	0.1-0.4	S	M, Jn	(capsule) Su, F, W	T	Su	L, S	M, W	F, P	B, C, F	
Arctostaphylos uva-ursi	Common bearberry	0.1-0.2	0.8-1.5	M	M	(drupe) Su, F, W	P	St	L, S	D, A	F, P	B, C, F, P, R	1b
Artemisia cana	Sagebush	0.4-1	0.4-1	F	Jl, Au	(achene) F, W	F	Su	L, S	D, A, M	F	G, P	
Betula occidentalis	Water birch	3-9	2-4	F	Ap, M	(nutlet) F	F		C, L, S	M, W	F, P	B, F	2a
Betula papyrifera	White birch	10-20	8-15	F	Ap, M	(nutlet) F	F		C, L, S	D, A, M	F, P	B, C, F, P	2a
Betula pumila	Dwarf birch	2-3	2-3	M	M, Jn	(nutlet) S, F	F		C, L, S	M, W	F	B, C, F, P, R	2a
Chamaedaphne calyculata	Leatherleaf	0.2-1	0.2-1	M	M, Jn	(capsule) Su, F, W	P		C, L, S	M, W	F, P	B, C	
Clematis ligusticifolia	Western clematis	3-6	(vine)	M	Jl, Au	(achene) F	P/T		L, S	D, A, M	F, P	F, G	
Clematis occidentalis	Purple clematis	1-3	(vine)	S	M, Jn, Jl	(achene) Su, F	P/T		C, L, S	D, A, M	F, P	F, R	3a
Cornus sericea	Red osier dogwood	1-3	3-4	F	Jn, Jl	(drupe) Su, F	G	Su	C, L, S	A, M	F, P, S	B, C, F, P, R	2a
Corylus cornuta	Beaked hazelnut	2-3	1-3	S	Ap, M	(nut) Su, F	F	Su	C, L, S	A, M	F, P	B, F, P	2a
Crataegus chrysocarpa	Round-leaved hawthorn	3-6	3-6	M	M, Jn	(pome) F, W		St, Su	C, L, S	D, A, M	F	G, P	
Dasiphora fruticosa	Shrubby cinquefoil	0.6-1.5	1.5	M	Jn, Jl, Au	(achene) F, W	P		C, L, S	D, A, M	F, P	B, F, G, P, R	1a
Elaeagnus commutata	Wolf willow	0.5-4	0.5	M	Jn, Jl	(drupe) Su, F, W	F	N, St, Su	C, L, S	D, A, M	F	B, F, G, P, R	3a
Empetrum nigrum	Crowberry	0.1-0.4	0.1-0.4	M	M, Jn, Jl	(drupe) Su, F, W	P		C, L, S	D, A, M	F, P	B, C, F, R	
Fraxinus pennsylvanica	Green ash	12-20	10	F	M	(samara) F, W	P	St	C, L, S	D, A, M	F	G, P (eastern)	2b
Juniperus communis	Ground juniper	0.3-1.5	1.3	S	n/a	(cone) Sp, Su, F, W	P	St	C, L, S	D, A	F	B, C, F, P, R	1a
Juniperus horizontalis	Creeping juniper	0.1-0.3	5	M	n/a	(cone) Sp, Su, F, W	P	St	C, L, S	D, A	F	B, C, G, P	2a
Larix laricina	Tamarack	6-20	6-10	M	n/a	(cone) F, W	P		L, S	M, W	F	B, C, F	1a
Lonicera dioica	Twining honeysuckle	1-3	(vine)	M	M, Jn	(berry) Su	P		C, L, S	D, A, M	F, P	B, C, F, P	
Lonicera involucrata	Bracted honeysuckle	1-2	1	M	M, Jn, Jl	(berry) Su, F	P		C, L, S	M, W	P	B, F, P, R	
Picea glauca	White spruce	15-25	4-6	M	n/a	(cone) F, W, Sp	P		C, L, S	A, M	F, P, S	B, C, F, P, R	1a
Picea mariana	Black spruce	7-20	3	S	n/a	(cone) Sp, Su, F, W	P		C, L, S	M, W	F, P	B, C, F, R	1a
Pinus banksiana	Jack pine	20	3-6	F	n/a	(cone) Sp, Su, F, W	P		L, S	D, A	F	B, C, F	1a
Pinus contorta	Lodgepole pine	12-25	6	F	n/a	(cone) Sp, Su, F, W	P		L, S	D, A	F	B, F, P, R	1a
Populus balsamifera	Balsam poplar	20-25	12	F	Ap	(capsule) Su	F	St, Su	C, L, S	M, W	F	B, C, F, G, P, R	1a
Populus deltoides	Plains cottonwood	20-30	20	F	Ap, M	(capsule) Sp, Su	F	Su	C, L, S	M, W	F	G	2b
Populus tremuloides	Trembling aspen	25	3	F	Ap	(capsule) Sp, Su	G	Sp, Su	C, L, S	A, M	F, P	B, C, F, G, P, R	1b
Prunus pensylvanica	Pin cherry	1-10	3-8	F	M, Jn	(drupe) Su, F	F	Sp, Su	C, L, S	D, A, M	F	B, F, G, P	1a
Prunus virginiana	Chokecherry	3-10	2-8	F	M, Jn	(drupe) Su, F	F/T	Sp, Su	C, L, S	D, A, M	F, P	B, F, G, P	2a

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Scientific name	Common name	Height (m)	Width (m)	Growth rate (F fast, M medium, S slow)	Flower period (Ap April M May Jn June Jl July Au August)	Fruit/seeds available (type) (Sp spring, Su summer, F fall, W winter)	Forage value* (G good, F fair, P poor, T toxic)	Traits (N nitrogen fixer, Sp spreads fast, St salt tolerant, Su suckering)	Soil texture (C clay, L loam, S sand)	Moisture tolerance (D dry, A average, M moist, W wet)	Exposure (F full sun, P partial shade, S shade)	Natural region (B boreal forest, C Canadian shield, F foothills, G grassland, P parkland, R rocky mountain)	Minimum hardiness zone**
Rhamnus alnifolia	Alder-leaved buckthorn	0.5-2	0.5-2.5	M	M, Jn	(drupe) Su, F			C, L, S	M, W	P, S	B	
Rhododendron groenlandicum	Common labrador tea	0.4-1.5	0.4-1.5	M	Jn, Jl	(capsule) Su, F	P		C, L, S	M, W	F, P, S	B, C, F, R	1a
Rhus trilobata	Skunkbush	1.5-2	1.5-2	M	M	(drupe) Su, F, W	P	Sp, St, Su	C, L, S	D, A, M	F	G	
Ribes americanum	Wild black currant	0.9-1.2	1.5-2.5	M	M, Jn	(berry) Su	P		C, L, S	M, W	F, P, S	B, F, P	
Ribes aureum	Golden currant	1-2.5	1-2	M	M, Jn, Jl	(berry) Su	P		C, L, S	D, A, M	F, P	G	
Ribes glandulosum	Skunk currant	1	1.5-2.5	M	M, Jn	(berry) Su	P		C, L, S	M	F, P	B, C, F, P, R	
Ribes hirtellum	Smooth gooseberry	0.9	1.5-2.5	M	M, Jn	(berry) Su	P		C, L, S	M	F, P	B, F, P	
Ribes hudsonianum	Northern black currant	0.5-1	1.5-2.5	M	M, Jn	(berry) Su	P		C, L, S	M, W	F, P	B, F, P, R	
Ribes oxyacanthoides	Wild gooseberry	0.3-1.5	1.5-2.5	M	M, Jn	(berry) Su	P		C, L, S	M	F, P	B, C, F, G, P, R	
Ribes lacustre	Bristly black currant	0.5-1	1.5-2.5	M	M, Jn	(berry) Su	P		C, L, S	M, W	F, P	B, C, F, P, R	
Ribes triste	Wild red currant	1	1.5-2.5	M	M, Jn	(berry) Su	P		C, L, S	M, W	F, P	B, C, F, P, R	
Rosa acicularis	Prickly rose	0.5-2	0.5-2	M	Jn	(hip) Su, F, W	P	Sp, Su	C, L, S	D, A, M	F, P	B, C, F, G, P, R	1a
Rosa arkansana	Prairie rose	0.3	0.3	M	Jn, Jl, Au	(hip) Su, F, W	P	Sp, Su	C, L, S	D, A, M	F	G, P,	
Rosa woodsii	Wood's rose	0.5-2	0.5-2	M	Jn	(hip) Su, F, W	F	Sp, Su	C, L, S	A, M	F, P	B, C, F, G, P, R	1a
Rubus idaeus	Wild raspberry	1-2	1-2	M	Jn, Jl	(berry) Su	P	Sp, Su	C, L, S	A, M	F	B, F, G, P, R	
Salix athabascensis	Athabasca willow	0.6-1.3		M	M, Jn	(capsule) Su	G		C, L, S	M, W	F	B, F, R	
Salix bebbiana	Beaked willow	0.5-10		F	Ap, M	(capsule) Sp, Su	G		C, L, S	A, M, W	F, P	B, C, F, G, P	2a
Salix candida	Hoary willow	0.3-1		M	M, Jn	(capsule) Su	G		C, L, S	M, W	F	B, C, F, P	
Salix discolor	Pussy willow	2-6		F	Ap, M	(capsule) Sp, Su	G		C, L, S	M, W	F	B, C, F, P	2b
Salix exigua	Sandbar willow	4-6		F	M, Jn	(capsule) Su	G	Sp, Su	C, L, S	M, W	F, P	B, C, F, G, P	2a
Salix lasiandra	Shining willow	4-11		F	M	(capsule) Su	G		C, L, S	M, W	F	B, C, F	
Salix maccalliana	Velvet fruited willow	1-5		F	M, Jn	(capsule) Su	G		C, L, S	M, W	F	B, F, R	
Salix myrtillifolia	Myrtle leaved willow	0.1-0.6		M	M, Jn	(capsule) Su	G	Sp, Su	C, L, S	M, W	F	B, C, F, R	
Salix pedicellaris	Bog willow	0.2-1.5		M	M, Jn	(capsule) Su	G	Sp, Su	C, L, S	M, W	F	B, C, F, R	
Salix petiolaris	Meadow willow	1-6		F	M, Jn	(capsule) Su	G		C, L, S	M, W	F	B, C, F, G, P	
Salix planifolia	Flat leaved willow	0.2-4		F	M, Jn	(capsule) Su	G		C, L, S	M, W	F	B, C, F, P	
Salix pseudomonticola	False mountain willow	1-6		F	M, Jn	(capsule) Su	G		C, L, S	A, M	F	B, C, F, P	
Salix pseudomyrsinites	Firmleaf willow	1-7			M, Jn	(capsule) Su	G		C, L, S	M, W	F	B, C, F, P	
Salix pyrifolia	Balsam willow	0.4-4			M, Jn	(capsule) Su	G		C, L, S	M, W	F	B, C, F, P	
Salix scouleriana	Scouler's willow	3-20		F	M, Jn	(capsule) Su	G		C, L, S	D, A, M	F	B, C, F	
Salix serissima	Autumn willow	1-5			M, Jn	(capsule) Su	G		C, L, S	M, W	F	B, C, F	
Sambucus racemosa	Red elderberry	3-4	2.5	M	M, Jn	(drupe) Su, F	F		C, L, S	A, M	F, P	F, R	2a
Sarcobatus vermiculatus	Greasewood	0.5-2	0.5-2	M	Jn, Jl	(achene) F, W	T	St	C, L, S	D, A, M	F	G	
Shepherdia argentea	Silver buffaloberry	2-4	2-4	M	M	(berry) Su, F	P	N, Sp, St, Su	C, L, S	D, A	F	G	2a
Shepherdia canadensis	Canada buffaloberry	1-3	1-2	M	M, Jn	(berry) Su, F, W	P	N	C, L, S	D, A, M	F, P	B, C, F, G, P, R	1a
Sorbus scopulina	Western mountain-ash	1-4	1-4	M	Jl	(berry) F, W	F	St	C, L, S	A, M	F, P	B, F, R	2a
Spiraea alba	Narrow-leaved meadowsweet	1	1	M	Jn, Jl, Au	(follicle) Su, F, W	P	Su	C, L, S	A, M	F, P	B, F, G, P	
Spiraea lucida	White meadowsweet	0.2-0.8	0.2-0.8	M	Jn, Jl	(follicle) Su, F, W	P	Su	C, L, S	D, A, M	F, P	B, F, P, R	
Symphoricarpos albus	Snowberry	0.5-1	1-1.3	M	Jn, Jl	(drupe) Su, F, W	P	Sp, St, Su	C, L, S	D, A, M	F, P	B, F, P, R	1a
Symphoricarpos occidentalis	Buckbrush	1	1	M	M, Jn	(drupe) Su, F, W	P	Sp, St, Su	C, L, S	D, A	F, P	B, F, G, P, R	
Vaccinium myrtilloides	Velvetleaf blueberry	0.1-0.6	0.1-0.6	M	Jn, Jl	(berry) Su, F	P	Su	L, S	M	F, P, S	B, C, F, R	1a
Vaccinium vitis-idaea	Bog cranberry	0.3	1	M	Jn, Jl	(berry) Su, F, W	P	Su	L, S	M	F, P	B, C, F, R	2a
Viburnum edule	Low-bush cranberry	0.5-2	0.5-2	M	M, Jn	(drupe) Su, F, W	P		C, L, S	M, W	F, P, S	B, C, F, P, R	2a
Viburnum opulus	High-bush cranberry	2-4	2-4	M	M, Jn	(drupe) Su, F, W	P		C, L, S	A, M	F, P, S	B, C, F, P	

Table 4. Common riparian herbaceous species. Sources: AAF, 2016; ABMI, 2016; Hale et al., 2005; Manitoba Naturalists Society, 2006; PFAF, 2016; Royer and Dickinson, 2007; USDA, 2016.

*Note that *Sium suave* (water parsnip) has a similar appearance to *Cicuta maculata* (water hemlock), which is highly poisonous to humans and livestock

	Scientific name	Common name	Flower period (Ap April M May Jn June Jl July Au August, S September)	Fruit/seeds available (Sp spring, Su summer, F fall, W winter)	Forage value (G good, F fair, P poor, T toxic)	Traits (Sp Spreads fast, N nitrogen fixer, St salt tolerant, Sf sod-forming, Bf bunch-forming, Co cool season, Wa warm season)	Soil texture (C clay, L loam, S sand)	Moisture tolerance (D dry, A average, M moist, W wet, Aq aquatic)	Exposure (F full sun, P partial shade, S shade)	Natural region (B boreal forest, C Canadian shield, F foothills, G grassland, P parkland, R rocky mountains)	Bank/shoreline protection: G good, F fair, P poor
Grasses	*Agropyron smithii*	Western wheat grass	Jn, Jl	Su, F	G	St, Sp, So, Co	C, L	D, A, M	F	B, F, G, P	F
	Agropyron trachyaulum	Slender wheatgrass	M, Jn	Su	G	St, Sp, Bf, Co	C, L	D, A, M	F, P	B, F, G, P	G
	Beckmannia syzigachne	Slough grass	Jn, Jl, Au	Sp, Su	G	Bf, Wa	C, L	M	F	B, F, G, P	F
	Calamagrostis canadensis	Marsh reed grass	Jn, Jl, Au	Su	F	Sp, Sf, Co	C, L	M, W	F, P	B, C, F, R	G
	Deschampsia cespitosa	Tufted Hair grass	Jn, Jl	Su	G	Bf, Co	C, L, S	A, M, W	F, P	B, F, G, P	G
	Glyceria grandis	Tall manna grass	Jn, Jl, Au	Su	G		C, L, S	M, W	F	B, G, P	G
	Hierochloe odorata	Sweet grass	M, Jn, Jl	Su, F	F	Sp, Sf , Co	L, S	D, A, M	F, P	B, C, F, P, R	F/G
	Phalaris arundicacea	Reed canary grass	Jn, Jl	Sp, Su	G	Sp, Sf, Co	C, L, S	A, M, W	F, P	B, F, G, P	G
Grass-like Species	*Carex aquatilis*	Water sedge	M, Jn, Jl	Su	G/F	Bf	C, L, S	W, Aq	F	B, C, F, G, P	G
	Carex atherodes	Awned/Slough sedge	Jn, Jl		G/F	Bf		W, Aq	F	B, F, G, P	G
	Carex lanuginosa	Woolly sedge	Jn, Jl		G/F	Sf		M, W, Aq	F	G, P	G
	Carex utriculata	Beaked sedge	Jl	Sp, Su	G/F	Sp	C, L, S	W	F	B, C, F, G, P	G
	Eleocharis palustris	Creeping spike rush	Jn, Jl, Au	Su, F	G	Sp, St	C, S	W, Aq	F , P	B, F, G, P	G
	Equisetum arvense	Common horsetail	n/a	Sp, Su	P/T	Sp	C, L, S	A, M, W	F, P, S	B, C, F, G, P	F
	Juncus balticus	Baltic rush	Jn, Jl	Su	F	N, Sp	C, L	M, W	F, P	B, F, G, P	G
	Scirpus acutus	Hardstem bulrush	Jn, Jl, Au	Su	F		C, L, S	W, Aq	F , P	B, C, F, G, P, R	G
	Scirpus microcarpus	Small-fruited bulrush	Jn, Jl		G		C, L, S	M, W	F , P	B, F, G, P	G
	Scirpus validus	Great bulrush	Jn, Jl	Su	F		C, L, S	W, Aq	F, P	B, C, F, G, P, R	G
	Typha latifolia	Cattail	Jn, Jl	Su	P	Sp, St	C, L, S	M, W, Aq	F, P	B, C, F, G, P	G
Forbs	*Achillea millefolium*	Common yarrow	Jl, Au	Su, F	P/T	Sp	L	D, A	F, P	B, C, F, G, P, R	P
	Galium boreale	Northern bedstraw	Jn, Jl		P		C, L, S	D, A, M	F, P	B, C, F, G, P, R	
	Glycyrrhiza lepidota	Wild Licorice	Jl	Su, F	G	N, Sp	C, L	A, M, W	F, P	G, P	G
	Heracleum lanatum	Cow parsnip	Jn, Jl	Su, F	G		C, L, S	M	F, P, S	B, C, F, P	
	Mentha arvensis	Wild mint	Jn, Jl, Au	Su, F	P	Sp	C, L, S	M, W	F, P	B, F, G, P	
	Monarda fistulosa	Wild Bergamot/ Bee balm	Jn, Jl, Au	Su, F	F		C, L	D, A	F	B, F, G, P	
	Polygonum amphibium	Water smartweed	Jn, Jl, Au	Su	P	Sp	C, L, S	M, W, Aq	F, P	B, C, F, P, R	
	Scutellaria galericulata	Marsh skullcap	Jn, Jl, Au		P		C, L, S	M	F	B, P	
	Sium suave	Water parsnip	Jl, Au	F	P		L, S	M, W	F	B, C, P	
	Smilecina stellata	Star-flowered solomon's seal	Jn	Su, F	F/G		C, L, S	A, M	P, S	B, F, G, P	
	Solidago canadensis	Canada goldenrod	Au, S	F	F/G	Sp	C, L, S	A, M	F, P	B, C, F, G, P, R	F
	Stachys palustris	Marsh hedgenettle	Jl, Au	Su, F	P		C, L, S	M, W	F, P	B, F, G, P	
	Vicia americana	Wild vetch	Jn, Jl	Su, F	G	N	L, S	D, A	F	B, C, F, G, P, R	

APPENDIX B: IDENTIFICATION GUIDES FOR NATIVE AND INVASIVE SPECIES IN ALBERTA

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7. Royer, F., and R. Dickinson. 2007. ***Plants of Alberta: Trees, Shrubs, Wildflowers, Ferns, Aquatic Plants, & Grasses.*** Lone Pine Publishing: Edmonton AB.

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APPENDIX C: USING GOOGLE EARTH PRO AND MICROSOFT EXCEL TO CREATE A PLANTING DESIGN

The following is a step-by-step tutorial on how to use the free Geographic Information System (GIS) program “Google Earth Pro” and the spreadsheet program “Microsoft Excel” to create a planting design. These particular programs have been selected because they are widely available at little to no cost. Similar steps would be followed using other GIS programs (e.g. many counties provide free online GIS software) or spreadsheet programs.

FINDING YOUR SITE

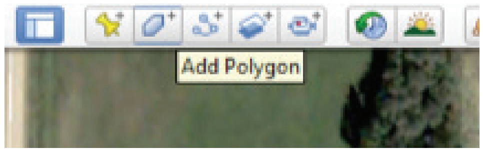
1. Calculate the latitude and longitude of your property by entering your legal land description into **https://www.lsdfinder.com/map**

2. Open up Google Earth Pro, paste your latitude and longitude into the “Search” bar in the top left corner, and hit “Enter”

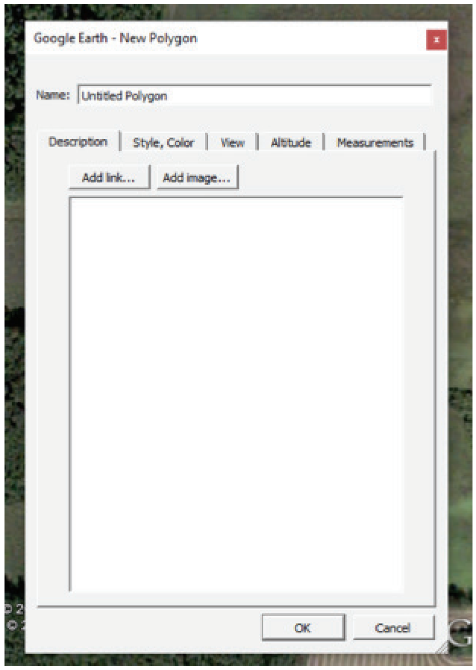
3. Move to your planting site on your property by clicking and dragging the map along. Zoom in using your mouse scroller, or by clicking on the zoom in/out icons on the right hand side of the page (shown by the red circle).

CREATING PLANTING AREAS AND LINES

1. To define a planting area, click on the "Add Polygon" icon at the top left corner of the map.

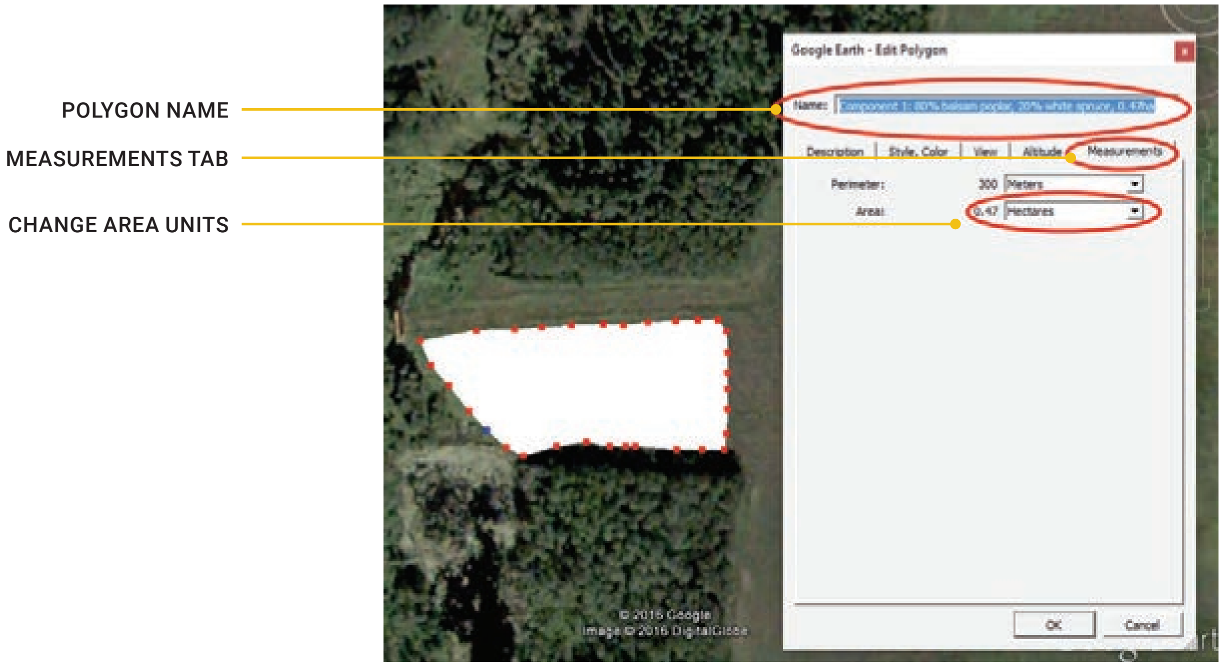


This will open up a window titled "Google Earth – New Polygon".



2. Define a planting area by clicking repeatedly along its borders. A polygon will gradually take shape as you do so. If you are unhappy with the position of one of the points, you can click and drag it to adjust it or right click to undo it. Note that the point that you clicked on last will be what the new point connects to, so if you make edits to previous dots make sure you click on the correct dot before making a new one!

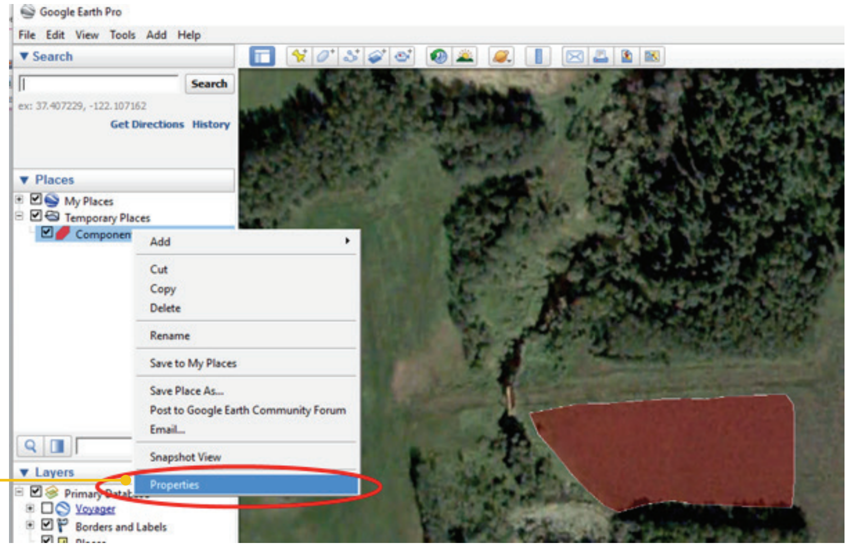
3. When you are satisfied with the size and shape of your polygon, click on the **"Measurements"** tab in the "Google Earth – New Polygon" window. Change **Area** units to Hectares or Acres according to your preference using the drop-down menu. You can then see the area of the polygon that was created. Change the **name** of the polygon to something that describes what is in it and how large you want it to be. For example, the polygon in the picture has been renamed "Component 1: 80% balsam poplar, 20% white spruce, 0.44ha".



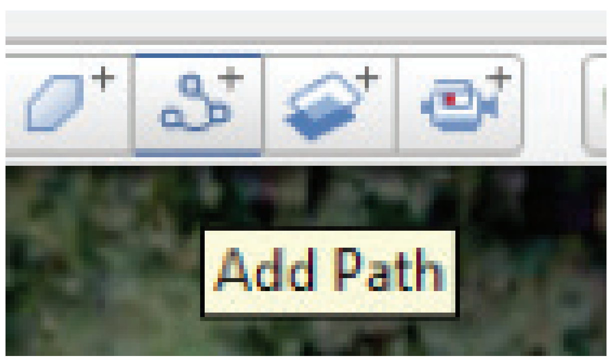
4. You can also change the style and colour of the polygon by clicking on the **"Style, Color"** tab. In addition to changing the **colour** of the area, it is recommended that you change its **opacity** to ~40%. This will allow you to see the land covered by the polygon.

5. When you are satisfied with your polygon, click **"OK"** on the **"Google Earth – New Polygon"** window. You can find the polygon item under **"My Places"** on the bar to the left of the map. To edit the polygon, right click on it and select **"Properties"**. This will bring back the **"Google Earth – New Polygon"** window.

PROPERTIES

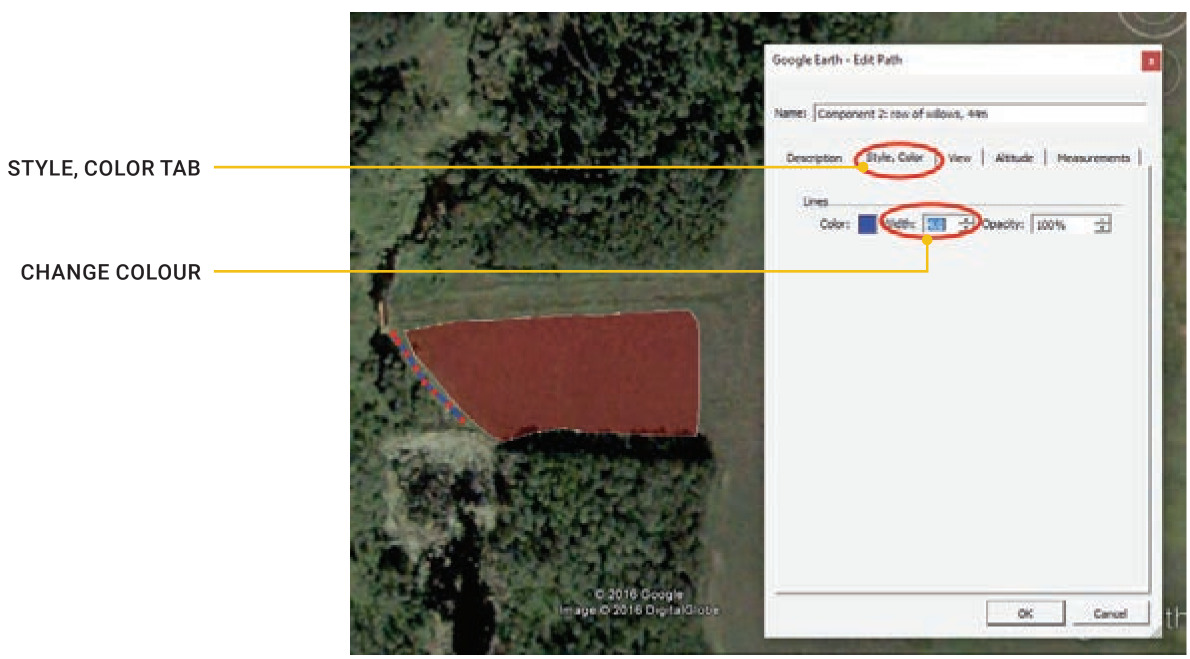


6. You may also wish to create a linear planting, if for example you are planting along a streambank. To do so, click on the **"Add Path"** icon on the top left corner of the map.



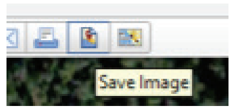
7. This will open a **"Google Earth – New Path"** window. The instructions are very similar to making a polygon. After you have defined your line on the map, click on the **"Measurements"** tab and change the units to meters or feet. Then change the name of the linear planting into something that describes its species and length.

8. Edit the style and colour of the linear planting by clicking on the **"Style, Color"** tab. You may wish to increase the width of the line to make it more visible. When you are satisfied with the planting, click **OK**.

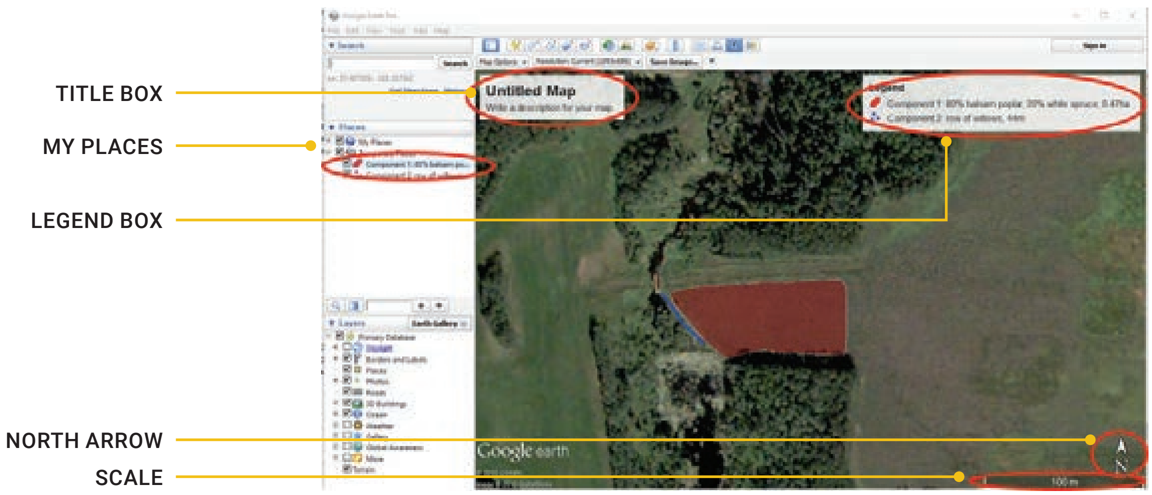


SAVING AN IMAGE OF YOUR SITE

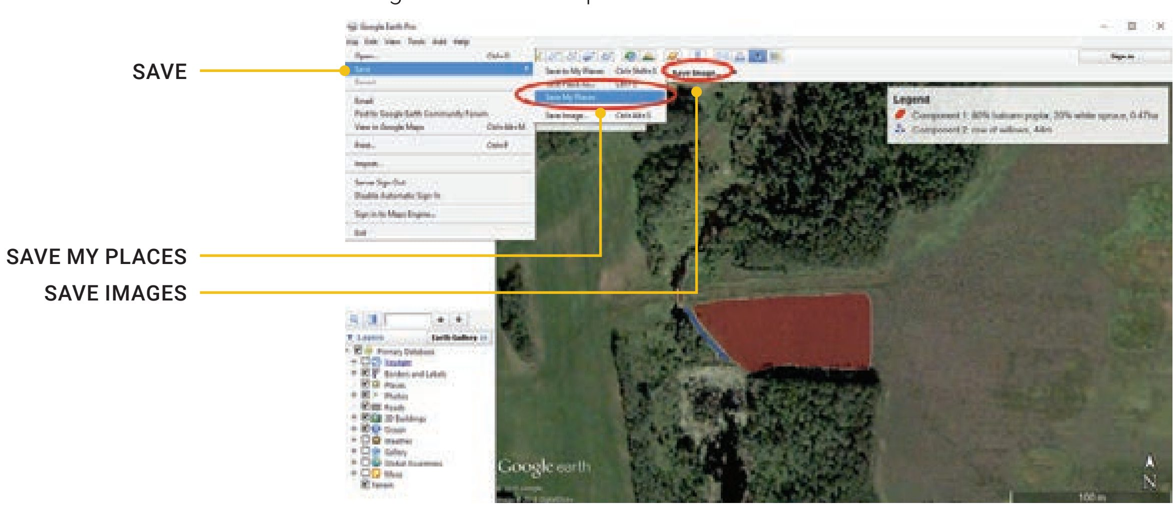
1. Once all your planting areas and lines have been created, it is time to save an image of your site. Click on the **"Save Image"** icon directly above the map.



2. A Title Box, Legend Box, North Arrow, and Scale Line should appear on your map. You can move any of these features around by clicking and dragging them. Click on the **Title Box** to edit it. Editing the text of the legend is more difficult — to do so, you need to edit the names of the planting polygons and paths that you made. As described above, this can be done by right clicking on each item under **"My Places"** on the bar to the left of the page, and selecting **"Properties"**.

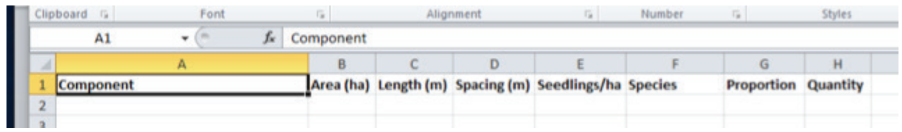


3. When you are satisfied with the contents of your image, click **"Save Image"**. Clicking **"File>Save>Save My Places"** is also recommended, as it will make it possible to access and edit planting items next time Google Earth Pro is opened.

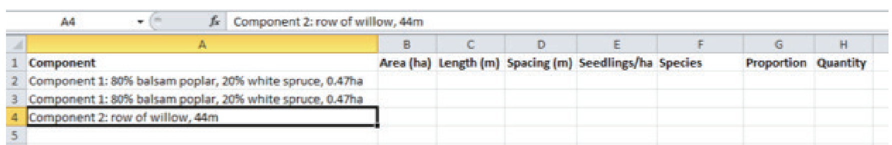


CALCULATING THE NUMBER OF SEEDLINGS REQUIRED FOR YOUR PLANTING DESIGN

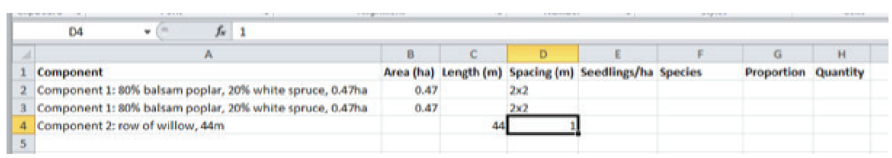
1. Open up **Microsoft Excel**. Fill in the first eight columns with the headings: **"Component", "Area (ha)", "Length (m)", "Spacing (m)", "Seedlings/ha", "Species", "Proportion",** and **"Quantity".** Use Imperial units if you are more comfortable with them.



2. Fill in the names of the planting components that you created in Google Earth Pro under the **"Component"** column. Make multiple rows for components that have multiple species within them, as it is necessary to calculate the quantity of each species separately. For example, in the demonstration planting design, Component 1 has both balsam poplar and white spruce, and therefore will have two rows in the spreadsheet.



3. Fill in the **Area** values (if the planting is an area) or **Length** values (if the planting is a line) of each component. Fill in the desired plant spacings.



4. For the area plantings, fill in the number of seedlings per hectare/acre at the spacing you have chosen. Use the reference table **(Table 5)** to convert common spacing values to number of seedlings per hectare or acre.

Table 5. Conversions of common spacing values into seedlings per hectare and acre.

Seedlings per hectare		Seedlings per acre	
Spacing (Meters)	Number of seedlings	Spacing (Feet)	Number of seedlings
1.0x1.0	10,000	3x3	4,840
1.5x1.5	4,444	5x5	1,742
2.0x2.0	2,500	6x6	1,210
2.5x2.5	1,600	8x8	681
3.0x3.0	1,111	9x9	538
3.5x3.5	816	11x11	360
4.0x4.0	625	12x12	303
4.5x4.5	493	14x14	222
5.0x5.0	400	15x15	194

5. Fill in the species names and their proportions in each component. For example, Component 1 in the demonstration has 80% balsam poplar and 20% white spruce, so 0.8 and 0.2 were put in the Proportion column beside each species respectively.

G4 fx 1

	A	B	C	D	E	F	G	H
1	Component	Area (ha)	Length (m)	Spacing (m)	Seedlings/ha	Species	Proportion	Quantity
2	Component 1: 80% balsam poplar, 20% white spruce, 0.47ha	0.47		2x2	2500	Balsam poplar	0.8	
3	Component 1: 80% balsam poplar, 20% white spruce, 0.47ha	0.47		2x2	2500	White spruce	0.2	
4	Component 2: row of willow, 44m		44	1		Willow	1	
5								

6. The formulas for calculating the quantity of species in each component are:
    a. For area plantings: Quantity=Area*Seedlings/ha*Proportion
    b. For linear plantings: Quantity=Length*Spacing*Proportion

SUM fx =C4*D4*G4

	A	B	C	D	E	F	G	H
1	Component	Area (ha)	Length (m)	Spacing (m)	Seedlings/ha	Species	Proportion	Quantity
2	Component 1: 80% balsam poplar, 20% white spruce, 0.47ha	0.47		2x2	2500	Balsam poplar	0.8	940
3	Component 1: 80% balsam poplar, 20% white spruce, 0.47ha	0.47		2x2	2500	White spruce	0.2	235
4	Component 2: row of willow, 44m		44	1		Willow	1	=C4*D4*G4
5								

7. **Congratulations!** You have calculated the quantity of seedlings of each species required for your planting design. It may be advisable to round your quantities to the nearest 10 or 15, as seedlings often come in bundles of these numbers.

APPENDIX D: BUDGET TEMPLATE FOR A RIPARIAN FOREST BUFFER PROJECT

The following is a budget template for a riparian forest buffer project. It is not necessary to fill out all of the blanks provided, as certain costs may not be relevant for your riparian forest buffer. For example, small-scale buffers (<500 seedlings) may not require hiring professional tree planters.

Table 6. Budget template for a riparian forest buffer.

Step	Item	Quantity	Unit Cost	Cost
Site assessment	Labour time	___ hours	$ __ /hour	$ _____
Planting design	Labour time	___ hours	$ ___ /hour	$ _____
Obtaining Stock	Labour time	___ hours	$ ___ /hour	$ _____
	Travel to nursery	___ km	$ ___ /km	$ _____
	_____ seed(lings)	___seed(lings)	$ __ /seed(lings)	$ _____
	_____ seed(lings)	___seed(lings)	$ __ /seed(lings)	$ _____
	_____ seed(lings)	___seed(lings)	$ __ /seed(lings)	$ _____
	_____ seed(lings)	___seed(lings)	$ __ /seed(lings)	$ _____
	_____ seed(lings)	___seed(lings)	$ __ /seed(lings)	$ _____
	_____ seed(lings)	___seed(lings)	$ __ /seed(lings)	$ _____
	_____ seed(lings)	___seed(lings)	$ __ /seed(lings)	$ _____
	_____ seed(lings)	___seed(lings)	$ __ /seed(lings)	$ _____
	_____ seed(lings)	___seed(lings)	$ __ /seed(lings)	$ _____
	_____ seed(lings)	___seed(lings)	$ __ /seed(lings)	$ _____
Site Preparation	Labour time	___ hours	$ __ /hour	$ _____
	Machinery Use	___ hours	$ __ /hour	$ _____
	Materials eg. (mulch, herbicides etc.)	___	$ __	$ _____
Planting	Labour Time	___ hours	$ __ /hour	$ _____
	Professional planter contract	___ seedlings	$ __ /plug	$ _____
Monitoring and mainteance	Labour time	___ hours	$ ___ /hour	$ _____
			Total	$ _____