A Guide to Reducing the Cosmetic Use of Herbicides in Saskatchewan

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Saskatchewan Ministry of Environment

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This reference guide includes helpful information on herbicides and weed control with detailed suggestions for alternatives to commercial herbicides. The information has been compiled from many sources. No scientific research was conducted by the Saskatchewan Ministry of Environment for this publication.

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1. Introduction

Weeds are plants growing in places where they are not wanted and are able to compete with the desired species. They can be unsightly and can cause hay fever and other allergies. Using chemical herbicides is one of the most common methods for controlling them. Some Canadian health organizations, however, are concerned about health risks associated with excessive use of these chemicals.

Currently, the sale and use of pesticides is regulated at the federal level by the Pest Management Regulatory Agency of Health Canada. Some provinces are banning the cosmetic use of herbicides, however, the Ministry of Environment's policy is to increase the awareness of the public and encourage the use of alternative methods for weed control while allowing the responsible use of herbicides.

Saskatchewan, being a major agricultural province, uses one third of all pesticides sold in Canada. According to Crop Life Canada, the sales of herbicides in both 2005 and 2006 accounted for 78 per cent of all pesticides used in Canada. Although, the agricultural industry is the primary user of these chemicals in the province, the herbicides are also used widely to manage weeds in urban areas. Therefore Saskatchewan's efforts have initially been focused on reducing the cosmetic use of herbicides only. Cosmetic use means using chemicals to control weeds for aesthetic purposes.

Basic information about common weeds is important in selecting the most suitable method of control. This guide covers the growth habits, life cycles, means of reproduction, and methods of controlling weeds. The guide also outlines the effects of using chemical herbicides on the environment and public health and provides some alternative methods that are available to control weeds. It does not include information on pesticides for controlling insects, rodents and fungi and does not deal with agricultural use.

The Saskatchewan Ministry of Environment has prepared this document to increase public awareness of this issue. It is hoped that the information herein will help reduce the use of herbicides in the province.

2. Weeds and their Growth Habits

2.1 What is a Weed?

A weed is a plant growing in a place where it is not wanted and is able to compete with other desired plants.

This definition leaves a lot of room for interpretation. For example, dandelions (*Taraxicum officinale*) growing in lawns are considered weeds and people can sometimes spend a lot of money and time trying to get rid of them. However, they are also considered a delicacy by some people who use them in salads, soups and other foods.

2.2 Why Control Weeds?

There are many reasons why people want to control weeds. Some of the main reasons for controlling weeds are as follows:

- There is a general perception that weeds growing in an urban lawn or garden are unsightly and may even reduce the value of a property.
- Weeds may compete for nutrients with the plants that are supposed to be growing in the lawn or garden.
- Weeds may cause allergic reactions such as hay fever and sinus congestion in some people.
- Weeds can compete with, or even displace the useful plants in our lawns, gardens and parks. As weeds invade areas, they take over the habitat that other plant species need.

2.3 Categories of Weeds

Weeds generally fall into two main categories: native and exotic.

Native weeds grow naturally in Canada but are not welcome in areas such as lawns, gardens and flowerbeds. Although these weeds usually don't pose a significant threat to the surrounding ecosystem they can compete with desired plants and are often considered unsightly.

Exotic weeds were brought to Canada either inadvertently as a result of human activities or intentionally as pretty garden plants. They later spread into other areas posing a significant threat to the surrounding ecosystems. Some of these exotic weeds push out the native plant species.

Exotic plants usually lack natural control agents such as insects and diseases that would normally keep them in check in their native area. Controlling exotic weeds that have no natural predators has contributed to the increased use of chemical herbicides over the last few decades. There are currently many exotic plants in Canada. Words such as restricted, noxious, and nuisance are

commonly used to describe exotic weeds that are aggressive, difficult to manage and invasive.

2.4 Life Cycles

Weeds can be classified under the following three life cycles:

- *Annual*

An annual weed sprouts, flowers, produces seeds, and dies within the same year. The seeds are stored in the soil and sprout the following spring.

A winter annual goes through its lifecycle in one year, but instead of germinating in the spring, it begins growing in the fall, over-winters, and continues growing in the spring. Seedlings of weed species that over-winter are often very hardy and can be difficult to destroy.

- *Biennial*

A biennial weed goes through its lifecycle in two years (two growing seasons).

- *Perennial*

A perennial weed continues growing year after year. Perennial weeds may appear to die in the fall, however, their roots remain alive in the soil and sprout new shoots in the spring.

2.5 Growth Forms

Weeds generally belong to one of two categories: broadleaf or grass-like.

- *Broadleaf*

As the name implies, these weeds have broad shaped leaves. Examples include: dandelion (*Taraxicum officinale*), creeping bellflower (*Campanula rapunculoides*), creeping Charlie or ground ivy (*Glechoma hederacea*), plantain (*Plantago major*) and white Dutch clover (*Trifolium repens*).

- *Grass-like*

Grass-like weeds share similar characteristics to cultivated grasses that are used in lawns; however, they are generally courser in texture. Some grass-like weeds are tough to control as they intermingle with desired grass species. Examples include: quackgrass (*Elytrigia repens*) and foxtail barley (*Hordeum jubatum*).

2.6 Common Weeds of Saskatchewan

Canada Thistle
Cirsium arvense

Canada thistle is a perennial that can easily be identified by its flowers and leaves. The flowers are white to purple and form several dense flower heads at the end of each branch. The leaves, which slightly clasp the stem, have jagged edges tipped with spines. Although the plant has a hollow stem, it can grow to be over on metre tall. It reproduces by seed and creeping horizontal roots. A two-week-old plant can have a root that goes 15 centimetres deep into the soil. Canada thistle is native to Europe and Asia and was accidentally introduced to North America in the 1600s.

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Canada thistle is relatively difficult to control once it is established because of the extensive root system. Individual Canada thistle seedlings can be easily picked, pulled or hoed as long as the plants are less than three-weeks-old. With older plants, if the complete root is not removed, new plants will emerge from the roots left in the soil. Frequent cutting of the new growth will slowly starve the root system and the plant will eventually die. Also, young seedlings do not tolerate shade very well so good ground cover may prevent Canada thistle from growing. Improper control, however, can encourage the spread of the plant.

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Mary Ellen (Mel) Harte, Bugwood.org

Common Groundsel
Senecio vulgaris

Common groundsel is generally found in lawns, gardens and flowerbeds. Although it is usually an annual or winter annual, it has been known to live as a biennial. Common groundsel can grow to 50 centimetres tall. The flowers are small, yellow, tube-shaped and grow in clusters at the end of each branch. The leaves are somewhat fleshy and are usually irregularly and deeply lobed. They can be variable and sometimes the edges barely have any indentations. The green bracts surrounding the flower cluster have conspicuous black tips that distinguish groundsel from other weeds in the thistle family. It reproduces by seeds, which it produces in copious amounts.

Common groundsel is a poor competitor against other plants which can be used to control it. Keeping good ground cover will prevent the seedlings from maturing. Older plants should be removed before they produce seed. This can be done by hand, hoeing or shallow tilling. Tilling an area containing these plants in the fall will also reduce what comes up in the spring.

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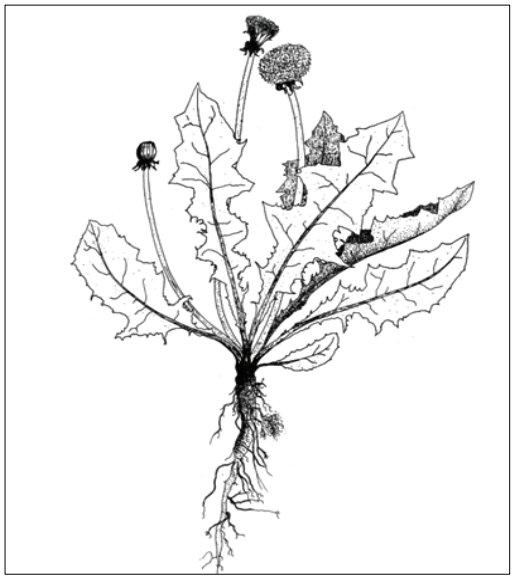
Dandelion
Taraxicum officinale



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The dandelion is one of the most common weeds found almost everywhere. It is a perennial species that grows a strong taproot. Dandelions can be identified by the characteristic single, yellow flower on a stalk that arises from a basal rosette of leaves. The leaves are irregularly toothed and grow very close to the ground. Dandelion seeds have white pappus (fluff) attached to them, which aids in their dispersal by wind.

Dandelions are best controlled by removing their seedlings. Care should be taken to remove the whole root of the plant as dandelions can reproduce from root pieces. Try to remove the plants before they produce seed. Tilling is sometimes effective with this plant but it is not always reliable. Tilling may also help the plant spread. Other methods of control include using a thick mulch to shade plants or other alternative methods described in Section 4.2.5.

Parts of the dandelion are edible. Dandelion leaves are used in salads and the plants are also used for jellies, soup and wine. If the plants are going to be consumed, care must be taken to make sure the plants are not contaminated with chemicals.

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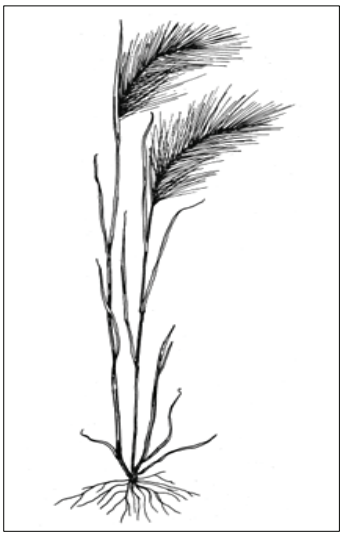
Foxtail Barley
Hordeum jubatum

Foxtail barley is another very common weed especially in the countryside where it grows around saline and alkaline sloughs. This plant tolerates high salinity in soils and thrives in high temperatures. It is a perennial grass that reproduces by seeds. It typically grows in a cluster and is 30 to 60 centimetres tall. It has very narrow leaves and long bristles (awns) that make it look like a tail. The awns are often purple to green and turn a straw colour as the plant matures.

Foxtail barley can be removed by hand or through tilling, however, it may move back into the area. There are options to remediate alkaline soils, which would allow other vegetation to colonize the area and reduce the availability of that space for foxtail barley.



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University of Manitoba Plant Science Dept.

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Lamb's Quarters
Chenopodium album

Lamb's quarters is an annual weed that colonizes bare soil and waste places. The species reproduces by seeds which can survive long periods in the soil before sprouting. The inconspicuous, tiny green flowers are clustered near the top of the stem. Although the leaf shape varies, it is usually a triangular or arrowhead shape with wavy edges. A covering of mealy, white particles is obvious on the underside of the leaves. The plant has a ridged stem that grows up to one–metre-tall and is often streaked with red or purple. Although a majority of the plants will germinate in the spring, this species can grow and flower throughout the year.

Lamb's quarters can be controlled by tilling, mowing or hoeing with the best results occurring before the plant produces seed.

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Purslane
Portulaca oleracea

Purslane is an annual that reproduces by seeds, pieces of stems or roots. It grows low to the ground, often forming circular mats. Its inconspicuous yellow flowers usually open in the morning. The leaves are smooth, thick and somewhat fleshy with a smooth, rounded tip. The reddish stems are also fleshy.

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Purslane grows well in rich, bare soil and is often found in gardens. It flowers in the late summer and produce seeds in the fall. It often flowers around the time that gardens are yielding produce. Many gardeners let maintenance and weeding slide at this time of year so purslane is able to distribute its long-lived seed. As the plant also reproduces by root and stem cuttings, cultivation can spread it. Because of its excellent capability to store nutrients, it can produce flowers and go to seed even if it has been pulled out of the ground.

Purslane weed can be controlled by pulling or hoeing when it is young. Make sure it does not re-root somewhere or continue to mature and produce flowers. It is also very important to continue controlling and removing this weed well into the late summer and fall. Purslane is a poor competitor and does not tolerate shade, so good ground cover is also an effective means of preventing it from growing.

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Quackgrass
Agropyron repens

Quackgrass is a perennial grass species that is considered as a noxious weed in Saskatchewan. Quackgrass can be very difficult to identify as a young plant. Its flat leaves are usually hairless. The appendages, called auricles, on the leaf base clasp the stem. The seed head is flattened, with two rows of seeds on either side of the stem. Its roots (rhizomes) are slender, sharp pointed at the end, and very long. Quackgrass likes cool and moist conditions for its growth. One of the reasons that it is so competitive is that its rhizomes produce and release a chemical in the soil, which suppress the growth of other plants. Quackgrass reproduces through roots and seeds, which makes it difficult to control.

Competitive cover species can help suppress its growth. Although mowing and tilling initially reduce the density of the plant they also stimulate rhizome growth and encourage the weed to spread. Rhizome fragments created through cultivation can grow into new plants. These fragments often get stuck in cultivation equipment and get spread when the equipment is used in a new location. For this reason, any equipment used to till an area where this weed is present should be cleaned thoroughly after use before it is moved out of the affected area.

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Scentless Chamomile
Matricaria maritima

Scentless chamomile is a noxious weed. It can be an annual, biennial or perennial and reproduces by seed. One plant can produce from 10,000 to 200,000 seeds. It is also very aggressive and out-competes other plants for resources. It can be identified by its white and yellow daisy-like flowers. The leaves are very finely divided into thin segments and are often described as being 'feathery' or 'fern-like'. The plant does not smell at all, when the leaves are crushed (hence "scentless"). If left uncontrolled it will often grow into a large bunch.

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The plant must be removed before it flowers because the seeds are already mature once the flower has formed. The best way to control this species is to pull it out by hand, before it flowers. Shallow tilling will destroy it, but only if the plant has not flowered. Seeds that become buried in the soil through tilling can remain viable for up to 15 years.

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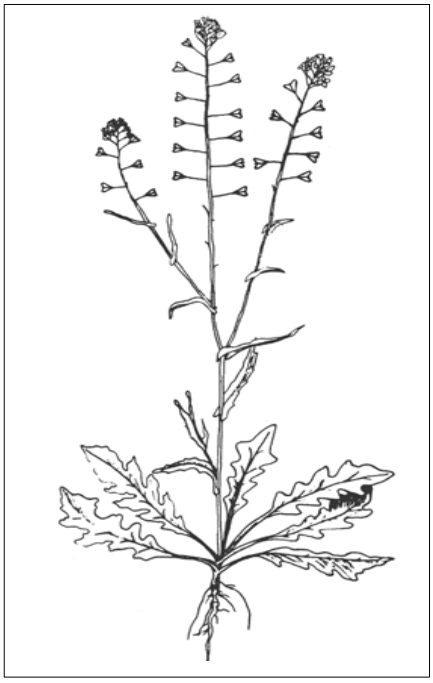
Shepherd's Purse
Capsella bursa-pastoris

Shepherd's purse is an annual (or winter annual) weed that reproduces by seed. It can flower anytime throughout the growing season and often germinates in the late summer. The plants that germinate late in the growing season are more difficult to destroy if they are left until the following spring.



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The plant is most easily identified by its characteristic seedpods, which are flattened, triangular in shape and have a broad cleft at the top (sometimes described as being heart-shaped). The small, white flowers are found at the top of the plant. Shepherd's purse has two different types of leaves: stem leaves and basal leaves. The stem leaves clasp the stem and are smaller and simpler than the basal leaves. The lobed basal leaves form a rosette around the stem. Bare soil including gardens and fields, are often colonized by this plant.

Plants should be removed before they produce seed. Seedlings can be removed by hand or hoeing and should be especially controlled in the fall. Control can also be achieved by shallow tilling.

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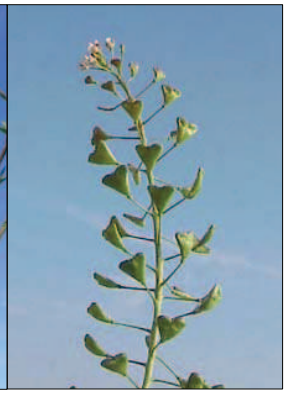

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Irene Lindsey

Stinkweed
Thlaspi arvense

This species is an annual or winter annual that is considered noxious. The weed reproduces by seeds which can remain viable up to 20 years in the soil. The small, white flowers produce distinct seed pods that are somewhat flattened, round and have a notch at the tip. The leaves have an offensive odour when crushed, giving this species its common name. Leaves on the stem clasp it with ear-like lobes. Other leaves form a basal rosette. This species can germinate throughout the growing season so control must be ongoing. Seedlings that emerge in late summer should be removed as they will be much more difficult to destroy in the following spring.

Pulling, tilling or hoeing stinkweed must be done before the plant produces seed.

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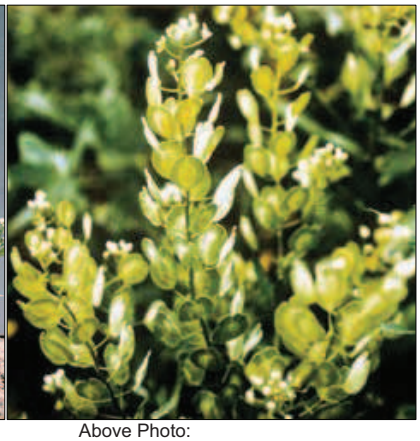

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3. Why Should We Reduce the Use of Herbicides?

The value of chemicals in weed control is established and recognized. However, while chemicals have benefits they also cause problems such as ecological disruptions, pest resurgence, secondary pest problems, herbicide resistance and possible risk to public health and the environment. Reducing the use of herbicides will lead to a reduction in problems associated with their use.

Dr. Sheela Basrur, Medical Health Officer of Toronto Public Health carried out a comprehensive review of various studies related to the effects caused by exposure to herbicides (Basrur 2002). The results of these studies on public health and the environment are summarized in the following section.

3.1 Effects of Using Herbicides on Public Health

Cosmetic use of herbicides in urban areas constitutes a relatively small proportion of the overall volume of herbicide used throughout the province. The likelihood of more direct exposure to people and pets, however, may be greater when these chemicals are used in urban landscapes. The impacts of all chemicals used in Canada are evaluated or re-evaluated at the time of their registration by the Pest Management Regulatory Agency.

Herbicides containing 2,4-D are some of the most widely used. As a result, there have been many more scientific studies devoted to researching the effects of 2,4-D than any other herbicide. Several scientific panels have evaluated the effects of 2,4-D and have described the results that link cancer effects on humans as limited, inconclusive, inconsistent and weak (US EPA 1997; WHO 1996; European Commission 2001).

There are some studies such as those by Arbuckle et al (1999 and 2001) and Garry et al. (1996 and 2001) that have looked at the effects of using herbicides containing 2,4-D and glyphosates on humans. These studies have shown that there is an increased risk to the health of those applying the herbicides commercially. Dr. Basrur (2002), in her review of the literature on human exposure and health effects, suggested that these findings warranted further research.

More recently in May 2008 the Pest Management Regulatory Agency of Health Canada concluded that 2,4-D could be used safely on lawn, turf, agricultural, forestry and industrial sites, when product label directions are followed.

Although, some of the research on studying the effect of herbicides on public health that has been reported here is related to herbicides containing 2,4-D and glyphosate, they are by no means the only chemicals in use for domestic weed control.

In view of the above information, cosmetic use of herbicides should be avoided or reduced as much as possible. In cases where it is essential, they should always be used with caution and the directions on the product label should be followed.

3.1.1 How do Herbicides get into our Bodies?

There are a number of ways that herbicides can enter the human body. They can be absorbed through the skin by direct contact, ingested by accident, or inhaled through the air (most harmful). When a chemical is ingested or inhaled, it enters the blood stream and affects the body much faster than when it is absorbed through the skin. Even walking through an area that has been recently treated with herbicides can track the chemical into the home or school.

Children are highly susceptible to herbicide exposure because they often play on the lawn or in the garden and have a very high incidence of hand to mouth contact. This is the major cause of herbicide exposure in children (Basrur 2002). The U.S. Environmental Protection Agency conducted tests to measure the amount of herbicides found within a home after a herbicide was applied to turf grass nearby. It was found that the exposure of herbicides was ten times higher indoors than before the application. Herbicide residues last longer indoors because they are not subject to conditions that break them down or disperse them quicker, such as air movement (Toronto Public Health 2002).

3.2 Effects of Using Herbicides on the Environment

Chemical herbicides are formulated to kill a broad spectrum of weed species. When they are applied to an area with weeds or even to one plant, they may also affect surrounding plants and soils. Residue from chemical herbicides can remain on plant material or in the soil for varying lengths of time. Pets and people can potentially pick up chemical residue from herbicides and track it indoors.

The chemical herbicides used to kill weeds can also potentially enter the water system. This could affect aquatic life and potentially taint drinking water. Herbicides can drift in the air, affecting air quality and damaging plants, birds, public health and/or the environment in other areas. Rick Relyea (2005) studied the impact of two herbicides (2,4-D and glyphosate) on the productivity of aquatic communities. He found no effect of 2,4-D on tadpoles, however, glyphosate completely eliminated two species of tadpoles and nearly eradicated a third species.

In view of the literature available to us and for the long-term safety of the environment and public health, chemical herbicides should be used only as a last resort for controlling weeds. Alternative, safe chemical methods should be encouraged.

4. How to Control Weeds

Understanding the biology, including the growth pattern and life cycle of weeds is very important for effective weed control. Controlling weeds should be an on-going summer activity. Knowing the life cycle of the weed and monitoring weed growth will help determine the best time to use different methods of weed control (cultural, mechanical, biological and chemical including the use of alternative/safer chemicals). Pest Management Regulatory Agency has published small booklets on various aspects of lawn care and their maintenance (Health Canada 2002). This information is also available on their website (www.healthylawns.net).

4.1 General Considerations in Selecting the Method of Weed Control

- When considering what type of weed control suits your needs, one must first learn to identify the weeds that are causing the problem. Refer to section 2.6 on "Common Weeds of Saskatchewan" for general features, identification and a good understanding of their growth habits.
- Another consideration is the size of the weed infestation. If there is a weed or two in your lawn you may wish to simply pull or dig it out. However, if there are a lot of weeds you may need to look into using a large-scale mechanical control method such as rototilling or one of the alternative methods of weed control (section 4.2.5). Chemical herbicides should only be used as a last resort.
- Timing is another consideration. Most control methods are more effective on the earlier stages of weed growth. Some weeds can only be treated with certain methods at certain times of the year. For example, if there is a large infestation of dandelions that has already gone to seed, using a method such as rototilling may spread the seeds around that area. In such cases, hand picking the weeds might be the preferred option to prevent seed dispersal. Similarly, weeds such as scentless chamomile (*matricaria maritime*), that reproduce by seeds should be controlled by pulling them out in the early stages of their growth before they produce seeds. Details of various methods of weed control are found in the following sections.
- The concept of IWM or IPM as described in section 4.3, should be used in the selection of appropriate methods while reducing the risk to public health and the environment.

4.2 Methods of Weed Control

The various methods of weed control can be categorized as cultural, mechanical, biological, chemical and alternative methods. The description of these methods along with their advantages and disadvantages are discussed further in this section.

4.2.1 Cultural Methods

Cultural methods of weed control refer to altering management techniques to prevent weeds from establishing and becoming a problem. Prevention is an important component of cultural method of weed control. The methods include proper planting, maintenance of lawn and mulching (Health Canada, 2002 and University of California, 2008).

Common methods of cultural weed control

Proper Planting
Proper planting techniques are an important part of preventing weed growth and encouraging the growth of desired plants. The following five things should be done before planting anything in your yard:

1. *Assess the site* – know the landscape and weeds;
2. *Prepare the site* – tilling soil and remove weeds;
3. *Avoid introducing weeds* – use weed-free topsoil;
4. *Encourage rapid establishment of desirable plants* – handpick weeds around young plants at least until they are established;
5. *Pick suitable grass types for lawns*

1. Site assessment
Examine and record *landscape characteristics* before preparation for planting to determine drainage, soil compaction, shading, and water infiltration. Identify weeds and make a note if the weeds are annual, perennial, or biennial .

2. Site preparation
Prepare the soil for the plants by tilling but wait until summer annuals have emerged. Alternative methods of weed control may also be used. Remember to use chemical herbicides such as glyphosate as a last resort..

3. Avoid introducing weeds
Make sure that the topsoil, potting soil, and compost that you use is weed-free to prevent introduction of weed seeds into your yard. Also ensure that you are using weed-free seeds.

Seeds placed in bird feeders may also be a source of weeds and it is important to pick weeds beneath the bird feeders to control this problem.

4. Encourage rapid establishment of desirable plants
It is important to hand-weed around young plants right after planting so that the plants have time to grow old enough to become competitive with weeds. Make sure that weeds are removed before they produce seeds so that you can prevent the spread of the weeds.

5. Suitable grass types for lawns

Choosing the correct grass type ensures that the grass is suited to the environment and will be able to compete with weeds. The grass type will depend on the purpose and the aesthetics of the lawn in urban environments.

Cool season turf grass is most commonly used for lawns in Canada. There are many different plant species that are cool season grasses but all grow the most in the spring and fall. Cool season grasses are able to withstand some mowing but they are not always native species. Common grass species include: Kentucky bluegrass (*Poa pratensis)*, fine fescues (*Festuca rubra L.*), ryegrass (*Lolium perenne*), bentgrass (*Agrostis stolonifera*), or a mix of many different grasses. Areas where there is steep topography (slopes) or shade may require a different type of grass that is more suited to those growing conditions. The following table shows various grass species and the maintenance required for each.

Grass Type	**Maintenance**
Kentucky Bluegrass	Needs more sun than many other grasses
Fine Fescues	Best in more shaded areas (4-6 hrs of sunlight)
Ryegrass	Require full sun, highly competitive with weeds, very good tolerance to wear (i.e. play areas)
Bentgrass	High maintenance, highly competitive with weeds

Proper Care and Maintenance of Lawns

Proper care of plants is important in the prevention of weeds because healthy plants are able to out-compete many weeds for available water and nutrients. Weeds often grow when the desirable plants are not as healthy and are more difficult to eradicate when they have well-established roots.

Reseed with same variety of grass in lawns with visible bare patches. It will ensure that weeds do not find those bare patches a favourable area for growth. In areas where there is high traffic there may be noticeable decrease in plant growth and even bare soil in some areas. The soil becomes compacted from continuous traffic from people walking; therefore it may be necessary to replace plants with mulch, stones, or a cement sidewalk.

The following are the main steps for proper care and maintenance of lawn:

1. *Watering* – soak deeply but infrequently;
2. *Mowing* – use a sharp blade and mow high when it's dry;
3. *Aeration* – late summer especially in compacted areas;
4. *Healthy soil* – ensure proper texture, nutrients, and pH.

1. Watering
Water the plants deeply ensuring an adequate soaking. Do not water often. It is best to water lawns in early morning when there will be lower evaporation of water so that water can be conserved. Apply at least 2.5 cm (1 inch) of water each watering event and only water when your lawn needs it (Health Canada 2002).

2. Mowing
Ensure that the mower blade is sharpened at least once a year in the spring. Grass recovers more quickly from a clean cut than when it is torn with a dull blade. The height of the mower blade should be set at 6 to 8 cm (2.5 to 3 inches). When the grass is allowed to grow at this height, a more extensive root system is able to develop and more moisture will be retained (Health Canada 2002).

3. Aeration
Aerating the lawn is important especially in areas that are compacted due to high traffic such as playing fields or playgrounds. Soil compaction decreases soil pore spaces and require aeration to ensure that the grass roots are able to access air and water. Aeration works best when done in late summer. A sign that your lawn needs aeration is when water does not infiltrate into the soil quickly after watering or a rainfall (Health Canada 2002).

Two types of mechanical aerators include a solid-tined machine that drives spikes into the ground and a core machine that removes small plugs of thatch (dead plant material) and soil. Removing thatch may be necessary if it is more than 1 cm thick on top of the soil. When the thatch becomes that thick the water may not infiltrate as well into the soil (Health Canada 2002).

4. Healthy Soil
Soil is the basis for growing healthy plants because the soil provides a growing medium, nutrients, and holds water. Three main components of healthy soil include texture, fertility (nutrient status), and pH.

Mulching
Mulch is a protective covering overlaid on the ground. Mulches can be the easiest and most effective way to control annual weeds in the garden. They may also suppress perennial weeds. Light is required for the germination of certain weeds as well as for the growth of all green plants. Mulches control weeds by preventing sunlight from reaching the soil surface.

Mulch reduces the moisture loss from the soil, helps in improving soil structure and regulating soil temperature by shading in summer and insulating in winter months. Mulch enriches the soil as it breaks down by releasing nutrients back into the soil. Un-decomposed or partially decomposed mulches will encourage microbial organisms, which helps in increasing the availability of various nutrients

and plant growth. Mulch also helps to keep fruit clean (such as strawberries and tomatoes) by reducing muddy splash-ups during rainstorms.

Materials used for mulching can be organic or inorganic. Some of the organic materials used for mulching include softwood or hardwood bark, compost, hay, hulls, lawn clippings, leaf-mold, manure, pine needles, sawdust and wood chips. Inorganic mulches include black plastic, shredded tires and landscape fabric made of polypropylene or polyester materials. The inorganic mulches do not decompose readily while most of the organic mulches decompose over time.

Pine trees are a good example where the tree naturally controls the growth of weeds by shedding and creating a layer of needles at its base. The needles of pine trees not only make nice mulch, they also lower the pH of the soil thereby restricting the ability of some weeds to grow.

Black plastic, a solid sheet of polyethylene, effectively controls annual weeds. The disadvantage of black plastic is that, water and oxygen cannot pass through this material. Always check the soil under black plastic during the growing season to ensure that the soil contains adequate moisture. Landscape fabric, on the other hand, allows water and gases to pass through the fabric. They are quite effective in controlling weeds. However, certain weeds such as large crabgrass are able to germinate below and push their shoots through holes in these fabrics.

The depth of organic mulch is an important factor in controlling weeds. An appropriate depth of mulch varies with the type and intensity of weeds. In general, more layers and tightly packed mulch is better. A loose layer of 5-8 inches and 3-4 inches of settled layer of mulch is generally effective in keeping most weeds under control (Sakovich, 2009). Try different depths of mulch and use what works for the type, amount of weeds and the environmental factors (moisture and temperature) in your area or consult your local garden centre.

Advantages of Cultural Weed Control:

- Low cost
- Effective
- Healthy for humans and the environment

Disadvantages of Cultural Weed Control:

- Takes time
- Commitment to continued weed control

4.2.2 Mechanical Methods

Mechanical methods are some of the oldest methods of weed control. The mechanical method is defined as the removal of weeds either by physical means (hand pulling) or by using some mechanical tools such as shovel, hoe, fork, mower or a rototiller.

To properly determine whether a weed can be mechanically controlled, it is important to understand how it reproduces, how it grows and the habitat it prefers. You may also need to determine whether it is worth spending the time and money needed to mechanically control the weeds. Mechanical methods are quite effective on controlling annual weeds.

It is important to understand that mechanical weed control is not a quick fix. In some cases, mechanical weed control will actually spread roots around. It is important to monitor the site to see if the weeds are coming back; if the area needs to be tilled again or if another method needs to be used.

The soil moisture can also affect mechanical weed control methods. In extremely wet conditions mowing and tillage systems are not very effective. Tilling equipment can become stuck. Mowers can become plugged and stall or even over-heat causing a risk to safety.

Common methods of mechanical weed control

Some of the common methods of mechanical weed control include hand pulling, mowing or tilling the soil. These methods are described as follows:

Hand pulling
It refers to the removal of weeds by hands. It is particularly effective when dealing with isolated annual weeds. Some of the important aspects of hand pulling are as follows:

- Requires a large amount of volunteer labour to be effective.
- Can be improved with the use of simple or specialized tools.
- Simple tools such as hoes and shovels are not very effective for all types of weeds.
- While most parts of the weed are removed, roots of some plants are often left viable in the soil, which allows the weed to regenerate.
- Although this is very effective method of controlling annual weeds it seldom controls perennial weeds.

Mowing
It refers to mechanical removal of the above ground portions of plants.

The main tool utilized in this method is a mechanical mower, which removes plant vegetative parts of plants at a uniform height. Removing the top portion of a weed reduces its ability to gather food and forcing the weed to utilize food stored in its roots. The weed will eventually deplete its stored food and will die.

Tilling
It refers to using a machine like a rototiller that has wheel-like tines to mechanically turn the soil and the plant material. The turning of weed plants in soil blocks the light and eventually starves them to death. The method also desiccates the roots causing a reduction in the viability and vigour of the plants. Rototiller is generally used for larger garden areas. For small garden areas tilling can be done by using a shovel, fork or hoe.

Precautions when using mechanical methods:
- Protect eyes, hands, feet and exposed skin.
- Use approved safety glasses that cover the eye completely while allowing air to circulate.
- Wear gloves that are sturdy enough to protect your hands.
- Wear snug fitting boots that provide ankle support.
- Long sleeves and long pants to help protect your arms and legs.
- Be careful when using machinery and/or digging tools. Make sure that everyone involved is familiar with their operation and has access to emergency contact information.

Advantages of mechanical method:
- Can be beneficial over the long-term.
- Good for controlling annual weeds
- Only selected areas are impacted

Disadvantages of mechanical method:
- Allergens may be released.
- Desired plants may be damaged or disturbed especially through rototilling.
- The method requires lot of labour.
- Mechanical weed control will often disturb the soil exposing new weed seeds.
- Weed seeds can spread when seeds imbedded in dirt or debris on machines drops to the ground. It is advisable to wash machinery and tools after use.

4.2.3 Biological Control

Biological control or bio-control is defined as the use of living organisms to destroy, or inhibit the growth of weeds, decreasing their ability to compete with the plants that are desired to grow in an area (Frick et al. 2002).

There are generally three types of biological control:
- *Classical bio-control:* Classical bio-control employs a small number of control agents. The agent will reproduce gradually and suppress the target weed as they grow. Arthropods are generally used for this method (Cole 2000).

- *Inductive bio-control:* This method often employs organisms such as fungi and bacteria to weaken the plant. This technique is usually applied through the use of a liquid spray or spread over the soil near weeds in granular form.
  - Fungi are plant like organisms. They infect plant material by boring into plant tissue and disrupting key functions and weakening the plant.

- *Unconventional bio-control methods:* Unconventional biological control methods such as grazing by animals are used in some areas to control weeds. It is not a common method in urban areas and can be used only where grazing animals are allowed.

  Sheep have been used to control several different species such as leafy spurge. Goats are another animal extremely effective at weed control.

The examples of some inductive biological control methods are as follows:

Sarritor (A selective bio-control method)
The active component of this product is *Sclerotinia minor,* a naturally occurring fungus that is native to Canada. When applied to a broadleaf weed, the fungus will grow into the weed and absorb the plant tissues until the weed is completely gone. Once the weed is gone, the fungus dies and no residues are left. The picture below shows a test plot where the product was applied in a healthy weed infested field. This product is presently available to lawn care companies through their professional distributor. Sarritor will not be available to retail outlets for home use until 2010.

Use of Sarritor as a selective herbicide to control Dandelions weeds

http://www.sarritor.ca/faq.html

Newly emerging selective bio-control method
Dr. Karen Bailey of the Dept of Agriculture and Agri-Food Canada has also developed a selective bio-control method to control Canada thistle. She used an indigenous fungus (*Phoma macrostoma)* to control broadleaf weeds. This fungus was also found to affect other weeds including dandelion, scentless chamomile and white clover. *Phoma macrostoma* has limited mobility in the soil and stays mostly where placed. It is rarely detected in the soil after one year and no carryover effects were found to other susceptible non-target plants. This product is not presently available on the market. Dr Bailey is working with a company and is in the process of registering its sale and use in Canada. The pictures below show the effect of this fungus in controlling weeds.

Untreated Treated

Sample plots untreated and treated with *Phoma macrostoma*

(Bailey 2007)

- Habitat is very important to consider when dealing with biological controls. In other words, the organism needs a specific range of temperature, amount of moisture, soil pH and the host weed for it to grow and function. Without these the organism will move to an area that can support it or else the organism will become inactive or die. Use the label and directions to use for effective weed control.

Environmental impact of biological control: There is very little environmental impact from biological control as in general the control agent is species specific. This means that the organism will only attack the targeted plant and will not negatively impact other species (Weeden et al.). In addition, unlike other methods of pest control there is no impact on ground water resources (Weeden et al.). Some of the advantages and disadvantages of using biological methods are as follows: (Jackman, 1999)

***Advantages of using Biological methods**:*

- It poses little threat to non-target organisms/weeds.
- Once established, biological control agents are self-perpetuating and can spread on their own.
- Little effort is required once a biological control organism is established.
- The adverse effect on the environmental or public health is generally low.

Disadvantages of using Biological methods

- There is always some risk and concern with introducing an exotic organism into the environment.
- Biological control agents are not available for all target weeds.
- It generally takes years of research and testing before agents are released.
- Biological control takes time in most cases, which may not satisfy public opinion.
- It relies on population of the weed and the biological agent to maintain the system. In some situations, biological controls do not seem to work well.

4.2.4 Chemical Methods

Methods where chemical herbicides are used to either selectively or non-selectively kill a wide variety of weeds are called chemical methods of weed control.

Herbicides are widely used chemicals that are designed to kill a wide variety of weeds. The Pest Management Regulatory Agency (PMRA) of Health Canada assesses all new herbicides and reviews old herbicides for their impact on public health and the environment before they are allowed to be sold for use in Canada by general public.

If people are using herbicides around the home, chances are that they are doing so for the aesthetic or cosmetic value to keep the weeds under control. This has driven the use of herbicides up in the last few decades.

Consult the staff at your local nursery or garden store to find out which herbicide is the best to treat the weeds in your yard. Consider environmentally friendly techniques including alternative methods as described in this document. Use a herbicide that is designed for that type of weed only as a last resort and use it properly.

Types of Herbicides

- *Broad spectrum*: these chemicals work on a variety of plants.
- *Selective*: these chemicals work on a narrow range of plants.
- *Non-Selective*: these chemicals kill all plants they come in contact with.
- *Contact*: these chemicals kill plant tissue on contact. They require even application.

- *Systemic*: these chemicals move through the plants' circulatory system.
- *Residual*: Such herbicides remain active in the soil for a length of time killing seeds as well as young seedlings.

  Some of these herbicides work on *pre-emergent* weeds (before weed sprouts) while others are good for *post-emergent* weeds (after the weed has sprouted) where the chemical is absorbed and transported through the plant.

***Advantages of using herbicides**:*

- Fast and easy
- Availability (numerous brands)
- Can treat almost any weed

Disadvantages of using herbicides

- Costly
- May have adverse effects on public health and the environment.

- Can kill non-targeted species
- Weeds can build up resistance to herbicides, if improperly applied.

Precautions for Using Herbicides

ALWAYS READ THE LABEL BEFORE OPENING A HERBICIDE CONTAINER!!!

When Using a Herbicide:
- Make sure people and pets are away from the area that is to be treated.
- Wear protective clothing such as long sleeved shirts, rubber gloves, coveralls, mask, rubber boots and goggles.
- Never mix different herbicides unless the instructions say to do so.
- Never use herbicides indoor that were intended for outdoor use.
- Make sure to use the correct dose; under-applying can lead to resistance in the weeds, over-applying can kill non-targeted species.
- Do not use herbicides on windy days.
- Do not eat, drink, smoke or touch your face at any time while using herbicides (PMRA 2004).

After Using a Herbicide:
- Keep humans and pets away from treated area for 12-96 hours depending upon the chemical. Read the label for their time of restricted entry interval.
- People with known allergies should stay away from treated area for 96 hours.
- If using an indoor herbicide, make sure to provide adequate ventilation. Keep the ventilation in place for a few hours after treatment.
- After you have finished the application wash your hands and face with hot soapy water. A shower would also be a good idea.
- Wash all protective clothing and safety items before re-using.

Accidental Poisoning:
- If herbicide poisoning is suspected consult your family physician immediately or call the poison centre at 1-866-454-1212.
- Bring the herbicide container or the label to help the doctor diagnose and treat the patient (PMRA 2004).

Herbicide Storage:
- Refer to the label for storage requirements.
- Always store herbicides out of the reach of children and pets and away from all food or water sources.
- Herbicide containers should be stored in a locked cabinet. That will help to ensure that they are not mistaken for a common household product.
- Do not expose to excessive heat, cold or humidity.
- Discard any herbicides if they are passed their expiry date (PMRA 2004).

Herbicide Container Disposal:

- Do not re-use empty containers.
- Herbicide containers should be rinsed thoroughly, wrapped up and disposed of properly as directed.
- Unused domestic herbicides should be disposed of at a provincial hazardous waste disposal site or at the household hazardous waste day collection events in the province (PMRA 2004).

4.2.5 Alternative Methods

In addition to the methods already described, some alternatives have been developed and are commercially available to assist in reducing the use of harsher chemical herbicides. Some of these methods are basically home made solutions while others have been developed and commercialized by private companies.

Home Made Weed Killers

There are several natural chemicals that can be used to control problem weeds in lawns and gardens. Use of these chemicals/materials would compliment mechanical, cultural and biological methods and help to reduce the cosmetic use of chemical herbicides. Some of the home made weed killers are as follows:

Vinegar, Salt and Soap Weed Killer

What you need:

-	1 gallon	or 3.8 litres	of Vinegar
-	1 cup	or 240 ml	of salt
-	1 Tbsp	or 15 ml	of dish detergent

Directions:

Mix all ingredients together until the salt is dissolved. Put the liquid in a spray bottle and spray the weed all over. Try not to get much on the soil or other plants as it can cause salinity problems in the soil. This mixture is a **non-selective** herbicide. It will kill all plants it comes in contact with.

Boiling Water

Using boiling water is a safe and effective method of controlling weed growth. It is a popular method for killing weeds that grow in cracks on sidewalks or driveways; however, it should be limited to these areas as it is **non-selective** and will kill all plants that it touches. Boil a kettle of water and slowly pour the water on the targeted weed.

Boiling water is extremely efficient in killing annual as well as perennial weeds. This method is labour intensive and may have to be repeated to kill the roots of perennial weeds.

Controlling weeds using boiling water
http://faq.gardenweb.com/faq/weeds/2002105058024260.html

Important Note: *Careful!!! Use oven mitts or gloves when handling boiling water. Pour a few inches above the plant to avoid splashing.*

Salt
Salt can be used on a small scale to kill weeds. Drop a small amount of table salt at the base of the undesirable plants. It will kill the plant and the salt will dilute down to harmless level in the next few rainfalls. This method would be more effective on weeds such as Dandelion that form a rosette of leaves near the ground. On a larger scale, one can cover the gravel driveway with a good amount of salt and nothing will grow there for months. (Remember: It is illegal to salt another person's property).

Killing weeds using salt

http://www.bycentrum.dk/garden

Rubbing Alcohol
Alcohol can be used to kill weeds. Use a spray bottle to spray the rubbing alcohol on the weeds. Rubbing alcohol draws water from the plant and evaporates it quickly. It is a **non-selective** weed killer i.e. it will kill any vegetation it comes in contact with.

Bleach
Although bleach is a toxic chemical, it can be used to kill weeds if used with care. Take some bleach in a spray bottle and spray on the weed you wish to remove. The bleach chemical will evaporate or dissipate in about two days, making the

area safe for planting. Again bleach will work as a **non-selective** herbicide and kills all type of plants. If you do get some on a plant you want to keep, wash the plant off as soon as possible.

OTHER COMMERCIAL PRODUCTS

Fatty Acids
Formulations that are made with fatty acids can be used as a, naturally safe, **non-selective** weed killer and can control weeds such as lamb's quarters (*Cheneopodium album*), red root pigweed (*Amaranthus retroflexus L.)* chickweed (*Alsine media)* and moss on roofs, walks, woodwork, stucco, fences, lawns and in greenhouses. Talk to your local garden specialist to find out more about products that contain fatty acids. PMRA of Health Canada has proposed full registration for the sale and use of 'Finalsan' and two associated end-use products (Finalsan concentrate, and Finalsan ready-to-use) containing the active ingredient 'ammonium soap of fatty acid to control weeds, moss and algae.

Acetic Acid (Horticultural Vinegar)
Acetic Acid can be used for the **non-selective** treatment of broadleaf and grassy weeds in and around the garden, on patios, sidewalks, driveways and fences. Check your retailer for products such as:

- EcoClear
- President's Choice Weed Controller Herbicide
- Scott's EcoSense Weed Control

Dandelion foliage withering just 24 hours after a vinegar application

http://landscaping.about.com/od/weedsdiseases/qt/vinegar_weeds.htm

It is important to note that most of the alternative methods described above are non-selective herbicides. The only selective method that is presently known and is commercially available is Sarritor (a biocontrol method).

Corn Gluten Meal
This product is a good **pre-emergent** natural control method. It inhibits seed germination of select weeds and adds fertilizer to the soil due to its nitrogen content. It should be applied early in the season (3-5 weeks) before seeds start sprouting. The product lasts for approximately six weeks in the soil. It can be used throughout the summer in gardens where weeds are constantly germinating and popping up. Spread the product evenly over the area to be treated (avoid using on newly seeded plants and lawn) and rake lightly. Spray water to allow

the gluten to dissolve slightly. If it rains heavily after the product is applied it may have to be re-applied. This product is safe and inexpensive and can be purchased through your local garden center or ordered online. Here are a few examples of corn gluten products: BioWeed®, Earth Friendly®, Safe N' Simple®, W.O.W®, or WeedBan®. See the following website for more details on using corn gluten for weed control http://www.uwex.edu/ces/wihort/turf/CornGluten.htm.

Controlling weeds using Corn gluten meal
http://www.uwex.edu/ces/wihort/turf/cornGluten.htm

4.3 Integrated Pest Management (IPM)

Integrated Pest Management (IPM) is an ecologically based approach to managing pests by using a combination of methods (cultural, mechanical, biological, chemical and alternative/safer methods) in a way that minimizes potential economic, health and environmental risks.

Integrated Pest Management includes the control of weeds, insects, rodents, fungi and viruses. When the objective is to control or manage weeds only, the IPM can be referred to as "Integrated Weed Management" or IWM.

Integrated Weed Management can be used to manage weeds by selecting the most suitable method of weed control (see section 4.2) and using alternative/safe chemical methods to minimize the risk of using chemical herbicides.

For further reading on the topics mentioned in this paper please see section 5.

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6. Glossary

Acidity - A measure of the amount of acid (hydrogen ions).

Alkalinity - A measure of the ability of a liquid to neutralize acids.

Annual weed - Reproduce solely by seed; they germinate, flower, and die in one season. Prevention and control is easier, since they usually reproduce only by seed. Controlling the seeds helps eliminate future weed problems. Some of the examples include purslane and lamb's-quarters.

Biennial weeds - Reproduce by seed, they typically germinate in one year, flower in the next year and then die. Biennials use two full seasons to produce seeds. White clover (*Melilotus alba*) is a biennial weed.

Biological Control - The use of living organisms (parasites, predators, pathogens) to eliminate, reduce or maintain pest populations to acceptable levels.

Chemical Control - The use of a chemical product such as a herbicide to suppress or control a weed.

Community - Consists of all the populations of different plants and animals in a given area. Also relates to a group of individuals living within a legal or political boundary.

Clay - is a type of mineral soil with particles of less than 2 microns in size.

Cultural Practices - Management practices that focus on the prevention of pests by maintaining healthy hosts through proper planting, pruning, mulching and sanitation practices (also referred to as Plant Health Care (PHC).

Diversity - The variety of species, vegetation communities, habitats or landform in a given area.

Ecology - The study of relationships between living things, with each other and with their environments.

Ecological Approach - An approach to prevention and management where control strategies are determined based on the relationship between the target organism's life cycle and its environment.

Ecosystem - A community of organisms and their physical environment.

Environmentally Sound Methods - Strategies and/or methods that provide a desired result with minimal impact on the general environment and non-target organisms.

Evaporation - Conversion of liquid water into water vapors.

Fabric barrier - A type of mulch which utilizes fabric to prevent weed germination.

Fungicide - A chemical substance or cultured biological organism that is used to kill, suppress or prevent the development of fungi.

Germinate - to sprout or grow seeds.

Grass - Any monocotyledonous plant or plants belonging to Gramineae family with bladelike leaves and hollow circular stems.

Gravel - is any loose rock that is at least two millimeters and no more than 75 millimeters in size.

Herbicide - A chemical substance or cultured biological organism used to kill or suppress the growth of plants. Also defined as chemical compounds used to kill or inhibit undesirable plant growth.

Infiltration - The slow movement/passage of a liquid through soil or any other filtering medium.

Inorganic – Materials that are made without organic life or its products, typically made from minerals.

Insecticide - A chemical substance or cultured biological organism used to kill or suppress the growth of insects.

Integrated Pest Management (IPM) - Integrated Pest Management is an ecological approach to suppressing pest populations (i.e. weeds, insects, diseases, etc) in which all necessary techniques are consolidated in a unified program, so that pests are kept at acceptable levels in effective, economical, and environmentally sound methods. Since pest problems are often symptomatic of ecological imbalances, the goal is to attempt to plan and manage ecosystems to prevent organisms from becoming pests.

Integrated Weed Management (IWM) - Refers to an ecological based approach to manage weeds by using a combination of methods (cultural, mechanical, biological, chemical and alternative methods) in a way that minimizes potential economic, health and environmental risks.

Introduced species - a plant that is not native to the area; i.e. a plant that has been brought to an area by humans.

Invasive - Species that out-compete and displace other plants by competition, lack of predators and pathogens, or direct chemical antagonism.

Mechanical aerators - Machines used to increase pore space in soil allowing air to infiltrate into the soil profile.

Monitoring - Involves the regular surveying of sites and/or features to understand and identify the location and extent of potential pest (including weed) management problems.

Mulch - A protective covering, usually of organic matter such as leaves, straw, or peat, placed around plants to prevent the evaporation of moisture, freezing of roots and growth of weeds.

Native - Species of plants that have been growing naturally in an area over long periods of time that have not been introduced by people from other areas.

Noxious (weed) - Plants which have potential for rapid spreading and major economic impact. Weeds in this category are to be controlled to prevent their spread. They are well established in some areas of the province. Efforts must be undertaken to prevent their spread to other locations within the province.

Non-target Organism - Any plant or animal other than the intended target of a pest management strategy.

Organism - An individual living thing such as animal, plant, fungus, bacterium, or one of the single-celled creatures called protists.

Organic - Materials made from living organisms (plants or animals) or their products and involving carbon-based compounds.

Park - An area which is managed to provide opportunities for recreation, education, cultural or aesthetic use. The main types of parks include: national, provincial, city, regional, community or neighborhood parks

Pathogen - A disease-causing organism.

Perennial - Plants which grow each year despite losing all above ground growth to frost. Most perennials reproduce both by seed and vegetative parts. They have tap roots (like a carrot) or underground tubers, bulbs or rhizomes. Examples include Dandelion, Purple loosestrife, Canada thistle, Creeping Charlie and Quackgrass.

Pest - Any injurious, noxious or troublesome insect, fungus, bacterial organism, virus, weed, rodent or other plant or animal which interferes with the aesthetic, health, environmental, functional, or economic goals of humans.

Pesticide - A chemical/substance that is intended, sold or represented for use in preventing, destroying, repelling or mitigating any insect, nematode, rodent, predatory animal, parasite, bacteria, fungus, weed or other form of plant or animal life or virus.

pH - pH is the measure of the acidity or alkalinity of a solution.

Pore space - The spaces within a rock or soil that are unoccupied by solid material.

Preventative Measures - Management practices that are directed towards preventing the establishment of pests (e.g. site design, genetic materials, optimal site selection for plant materials).

Rhizome - A horizontal, usually underground stem that often sends out roots and shoots from its nodes. Also called *rootstalk* or *rootstock*.

Rodenticide - A chemical substance or cultured biological organism used to kill or used to control or prevent the development of rodents.

Root systems - A set of roots consisting of the main taproot and fibrous roots that develop underground as a part of the plants.

Rosette - A circular cluster of leaves that grow from the center at or close to the ground, as in the dandelion.

Sand - Mineral soil particles ranging in diameter from 0.0625 (or $1/16$ mm) to 2 millimeters.

Shrub - a short multi-stemmed woody plant similar to trees.

Silt - The mineral soil particles raging between $1/256$ and $1/16$ mm.

Soil compaction - compression of the soil resulting in reduced soil pore space.

Soil texture - a soil property used to describe the relative proportion of different particles (sand, silt and clay) in a soil.

Species - A genetically distinctive group of natural populations that share a common gene pool that are reproductively isolated from all other such groups.

Timing - Involves a treatment action during the most vulnerable time in the life cycle of the vegetation or pest with the least impact on natural predators and/or other non-target organisms.

Topography - Detailed or precise description of a place or region.

Weed - A plant growing at a place where it is not wanted or desired.

Winter annuals - Plants that grow as annual and are able to survive over the winter conditions due to a thickened storage root. Typically they germinate in late summer or fall. Some common winter annual weeds are shepherd's-purse (*Capsella bursa-pastoris*), and stinkweed (*Thlaspi arense*).

Websites for Definitions
http://en.wikipedia.org
http://encyclopedia.thefreedictionary.com/