Community Resource Guide

Sustainable Healthy Soils in Alberta

April 2023

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Community Resource Guide
Sustainable Healthy Soils in Alberta

Executive Summary

Soils grow plants, store, supply, and purify water, modify the atmosphere, and store various organisms. Soils are generally influenced by climate, location, and living organisms. They continually undergo various biological, chemical, and physical processes at the same time. Basically, the soil is 'a living ecosystem' given its complexity and strong internal connectedness.

It is one of our major responsibilities to keep our soils healthy as healthy soils are key to our ability to provide food, manage the available carbon and provide building blocks to our ecosystem. We cannot take them for granted. However, some human activities harm soil health, producing impacts such as compaction, erosion, salinization, loss of organic carbon, depletion or excess of nutrients, loss of biodiversity, desertification, and contamination. Therefore, each of us, both as a producer and consumers of food and a citizen, has a role to play in maintaining the health of our soils.

Food can be produced everywhere: rural or urban lands, front or backyards in rural or urban households, community areas, house/office rooftops, etc. Given the pressure on land and other natural resources, Urban Agriculture (UA) is getting popular across the globe and many countries are revisiting and revising their existing agricultural policies to incorporate necessary changes for UA. Basically, UA is a dynamic concept incorporating various livelihood systems, e.g., subsistence farming, food processing, and commercial farming. However, most urban farmers operate without any formal recognition and don't receive any structural support from municipal policies and legislation. This resource book is prepared for urban growers in Alberta to help them understand the principles and practices of UA, major issues related to soil health, and how to maintain soil health while practicing UA on urban lands. For instance, the US Department of Agriculture (USDA) outlined the five basic land and soil management principles, such as soil armor, minimum soil disturbance, plant diversity, continual live plants/roots, and livestock integration which are crucial to help maintain and improve soil health.

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1. Agricultural Development in Alberta

Alberta contributes up to 16% to Canada's agricultural Gross Domestic Product (GDP) (Statistics Canada, 2020d). Beef, canola, wheat, pork, and dairy have been Alberta's top five agricultural products for many years, while peas and pulses are emerging crops (Statistics Canada, 2020a). More recently, Alberta has emerged as Canada's largest honey producer (Statistics Canada, 2020e). Green revolution technologies emerged in the mid-twentieth century and more recently developed farm technologies such as precision agricultural technologies and digital farming helped Alberta raise its agricultural productivity by five times (up to 56 bushels/acre) between 1870 and 2020 (Statistics Canada, 2020g). On the other hand, agri-food processing is emerging as a big future opportunity for Alberta's farm enterprises as food processing and manufacturing comprised 19% of the total agricultural GDP of the province in 2019 (Statistics Canada, 2019). However, crop production is equally crucial as an input for the agri-food industry. Alberta's total farmland of 50 million acres across 40,600 farms is managed by 49,000 farmers (Statistics Canada, 2020b).

2. Why Healthy Soils are important?

Nutritious food is important for human survival and growth; in the same way, healthy soils are crucial for a healthy planet. Natural events such as heavy rainfalls and windstorms remove topsoil along with very essential nutrients which are vital for plant growth. Healthy soils provide nutritious food essential for human health and help produce the fiber we wear. More importantly, soils help clean air, purify water, and maintain the climate. Therefore, we need to understand the importance of healthy soils in our day-to-day life to protect our soils from natural and manmade events in order to create and maintain sustainable food production systems for the current and future generations.

3. What is Soil Health?

3.1 What is soil?

Soil is a naturally balanced combination of organic matter, minerals, gases, liquids, and organisms that together support life. Soils not only grow plants but also store, supply, and purify water. Soils modify the atmosphere and store various organisms. Soils are generally influenced by climate, location, and living organisms. They continually undergo various biological, chemical, and physical processes at the same time. Soil is ‘a living ecosystem’ with complexity and strong internal connectedness (www.soilhealth.ca).

3.2 Soil Health: Concept and Definition

The most widely used definition by Doran and Zeiss (2000; p. 3) says, “Soil health is the capacity of soil to function as a vital living system, within the ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health”. Generally, the terms ‘soil quality’ and ‘soil health’ are used interchangeably in the literature (Karlen et al., 2001). However, soil quality is linked to its functions while soil health presents soil as a dynamic, living, and finite non-renewable resource (Doran and Zeiss, 2000). Simply, soil can perform according to its potential and changes across time because of human use and management or unusual natural events. It is the net result of ongoing conservation and degradation processes (Halvorson et al., 1997).

Soil health is essentially a complex interplay of several physical, biological, and chemical properties (Figure 1). A soil is considered “healthy” if it can provide comparable or better ecosystem services relative to undisturbed reference soils of similar type in the same region. On the other hand, the soil would be considered “unhealthy” if it can’t perform the normal environmental functions of similar soils in the inherent ecosystem (UNFAO, 2021).

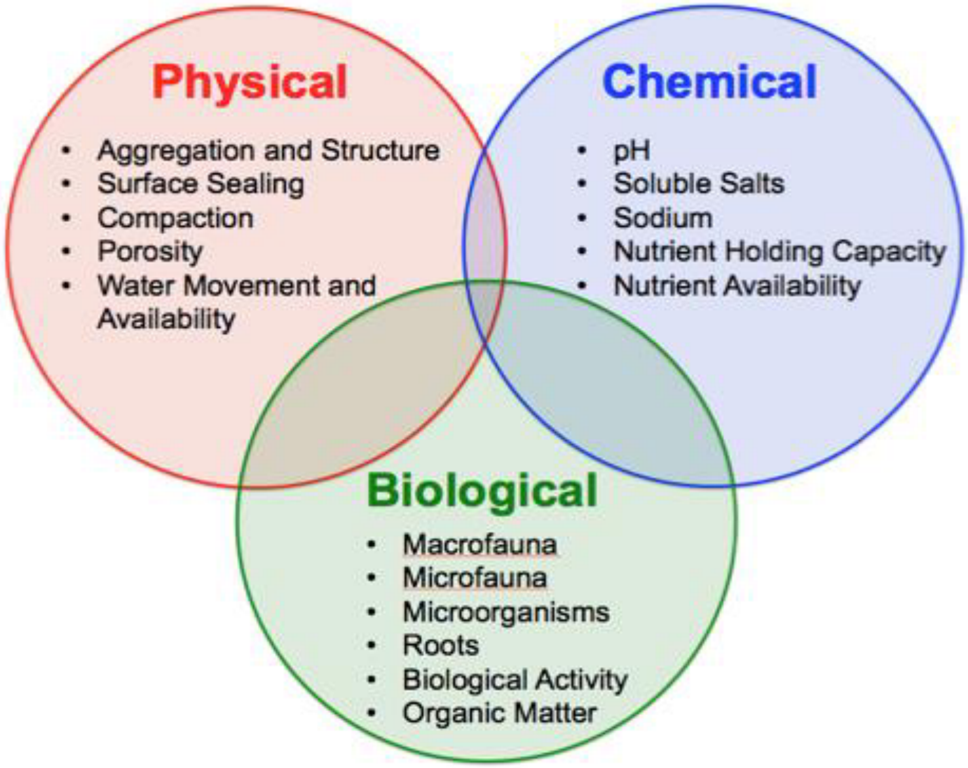

Figure 1: Physical, chemical, and biological properties of soil health (Source: North Dakota State University, n.d.)

A healthy soil largely depends on various regional factors ranging from agroclimatic conditions like soil type, crop combinations, and climate to land use for growing trees, grains, grass, and functions such as controlling water flow, transporting solute, retaining, and cycling nutrients, offering habitats for biodiversity. Therefore, soil health is fundamentally a soil's continued capacity to function and sustain living organisms over a long period of time (Groupe AGÉCO, 2020).

3.2. Principles of Soil Health

The US Department of Agriculture (USDA) outlined the following five basic land and soil management principles which are crucial to help maintain and improve soil health (NRCS, 2016):

Principle 1: Soil Armor
Soil should be kept covered as much as possible with living plants, crop residues, compost, or synthetic tarps as it helps control soil erosion, check weeds, mitigate soil temperature fluctuation, reduce soil compaction, and provide improved habitats to soil organisms.

Principle 2: Minimum Soil Disturbance
It is advisable to minimize or reduce mechanical disturbance (e.g., tillage), chemical disturbance (e.g., pesticide application), and biological disturbance (e.g., overgrazing) to the soil. Conservation tillage, integrated pest management, and rotational animal grazing can be used as effective management practices to minimize soil disturbance, reduce soil erosion, and enhance soil biodiversity.

Principle 3: Plant Diversity
A diversified farmland growing different crop species can maintain its soil health by suppressing disease and pest incidences and sustaining a fully functioning soil food web.
Principle 4: Continual Live Plants/Roots
For healthier soils, it is crucial to keep living plants or roots growing throughout the year as it improves soil biodiversity, increases microbial activity, and reduces soil erosion.

Principle 5: Livestock Integration
Animal grazing in cover crops, crop residue, and weed management can improve animal welfare, reduce herbicide uses, promote nutrient cycling, and decrease cropland nutrient export.

4. Urban Agriculture

4.1. Meaning and Scope

Urban agriculture (UA) consists of a combination of farming activities within the economic, social, and ecological systems in urban areas. Besides location, integration between urban, peri-urban, and rural agricultural systems is the major defining aspect (Figure 2). Agricultural land plays a crucial role in the economic development in Alberta. The economic development and commercial activities that consume land resources increased manyfold over the years while the total land available for all these activities did not change. A large number of such changes have been seen in the periphery of urban regions, like Calgary and Edmonton. For instance, 4.3% of agricultural land in the Edmonton-Calgary corridor was converted for economic development between 2000 and 2012 whereas this figure for the entire Alberta province was just 0.8% (Government of Alberta, 2008).

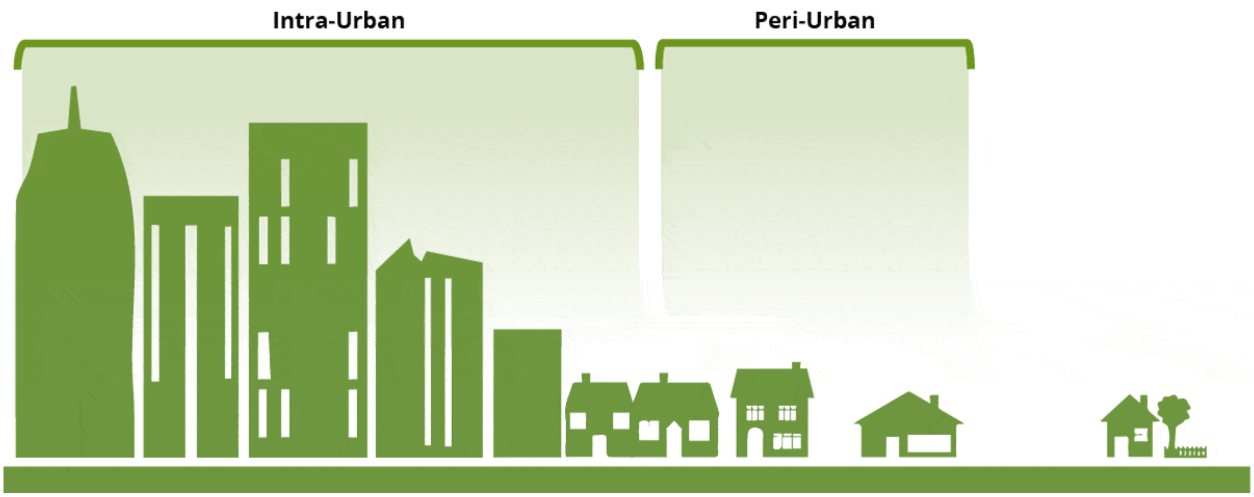

Figure 2: The spectrum of locations of agriculture in urban areas (Source: https://landusehub.ca/urban-agriculture/)

As per the Food and Agriculture Organization (FAO), "UA uses urban resources such as land, labor, urban organic wastes, water and produces for urban citizens. UA is strongly influenced by urban conditions such as policies, competition for land, urban markets and prices, and makes a strong impact on the urban system)" (van Veenhuizen and Danso, 2007). UA is a dynamic concept incorporating various livelihood systems, e.g., subsistence farming, food processing, and commercial farming. UA is becoming popular across the globe and many countries are revisiting and revising their existing agricultural policies to incorporate necessary changes for UA (van Veenhuizen, 2006).

Most urban farmers, however, operate without any formal recognition and don't receive any structural support from municipal policies and legislation. Therefore, region-specific policies and regulations might improve the potential of UA to mitigate its potential risks (van Veenhuizen and Danso, 2007). UA helps consumers to connect with local food producers and participate in the local food systems.

Primarily, UA can have the following major categories (Mok et al., 2014):

1. Small commercial farms and community-supported agriculture
2. Community /private gardens
3. Front/backyard gardens
4. Rooftop gardening/vertical farming

Appendix A discusses some prominent examples of Urban Agriculture in Alberta.

5. Soil Health in Alberta: Improvement Underway

As per the Soil Quality Compound Index (SQCI), which is a weighted average of three indicators, soil erosion, soil organic carbon (SOC), and soil salinization, the state of soil health in Canada has improved between 1981 and 2011 (Clearwater and Hoppe, 2016). The Risk of Soil Erosion Index (RSEI) increased from 65 in 1981 to 84 in 2011 which indicates reduced soil erosion in Canada. It is largely attributed to reduced tillage in Canada. The land area under no-tillage seeding increased from 7% in 1991 to 56% in 2011 (Statistics Canada, 2011). The Relative Soil Organic Carbon (RSOC) estimates the Soil Organic Carbon levels in soils. The Soil Organic Carbon Change Index (SOCCI) drastically improved in Canada from 48 in 1981 to 74 in 2011. The third indicator used to realize the SQCI was Soil Salinization which is more common in arid regions of Canada like Alberta, Saskatchewan, and Manitoba. After heavy rains in these regions, water tables rise and soluble salts travel to wet soil surfaces. These salts remain on the soil surface after soil water evaporates due to high temperatures during summer. The trends of improving soil health, particularly in the Canadian Prairies can be largely attributed to the adoption of no-tillage practices, reduced summerfallow[1] use, and more cultivation of high-residue crops like alfalfa and hay that require low tillage (Clearwater and Hoppe, 2016).

6. Best Soil Health Management Practices: What you can do for Healthy Soils

Some unintended consequences of human activities and natural processes such as compaction, erosion, salinization, loss of organic carbon, depletion or excess of nutrients, loss of biodiversity, desertification, and contamination impact soils and degrade soil health. **Figure 3** suggests six soil

[1] Summerfallow is a practice where farmers leave their field without a crop for one year to help control weeds, allowing soil moisture levels to increase (Clearwater and Hoppe, 2016).

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health management practices that can maintain or improve soil health in a field, yard, garden, or plot. They can be used individually or together depending on the type of soil and human activities carried on that soil.

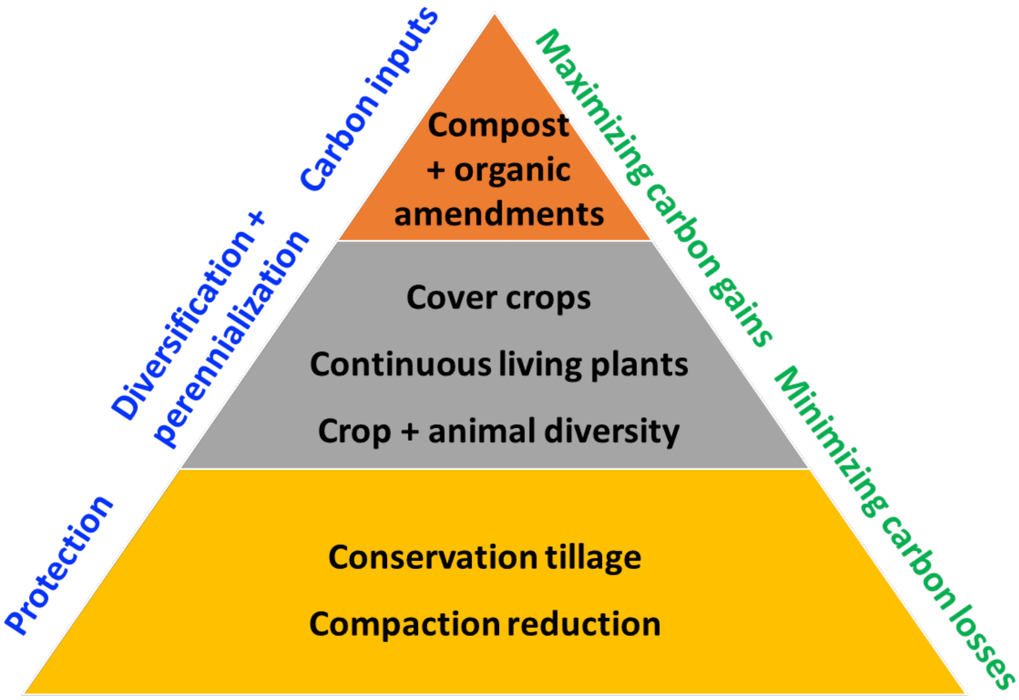

Figure 3: Schematic of the 6C practices of soil health management explaining how they enhance soil health (in blue on left) and by which mechanism (in green on right) (Source: Van Eerd et. al., 2021)

6.1 Reduce Compaction

Compaction occurs when soil particles are pressed through human activities such as regularly-used pathways or the use of heavy machinery or equipment.

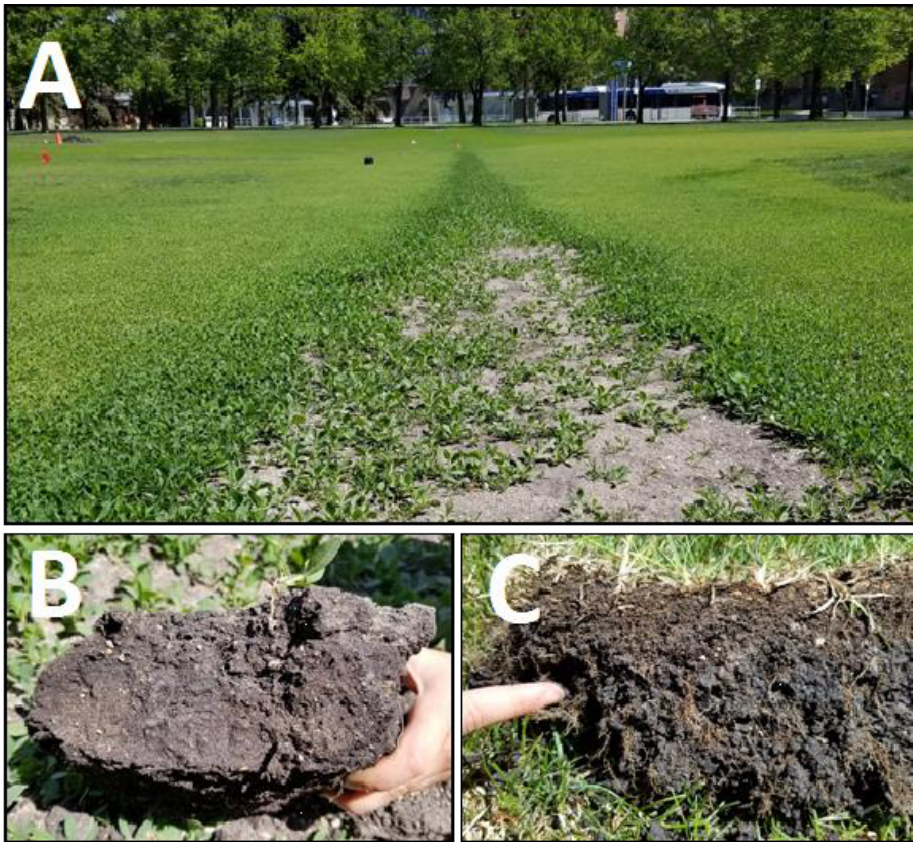

Figure 4: (A) Soil compaction from a regularly-used pathway on the grass. (B) Compacted soil has a poor massive structure with no or limited plant growth. (C) Uncompacted soil with a granular structure where plants can grow easily (Source: Van Eerd et. al., 2021)

Compaction reduces soil pores in size and number and increases bulk density. It reduces the volume of water and air in the soil which impacts plant growth. Compaction can occur in the topsoil or deeper soil depending on the intensity of human activities. For instance, the force of footsteps can cause soil compaction. Figure 4 shows the effect of regular walks on the grass. Soil compaction can be avoided or reduced by reducing traffic in fields particularly when soil is wet. However, snowing, freezing, and thawing helps reduce soil compaction in Canada. Chisel plow or subsoiling (deep tillage) can also be used to break up the compacted soil layers when soils are dry enough to be ploughed. Alternatively, biodrilling or biological tillage can also be used (Figure 5).

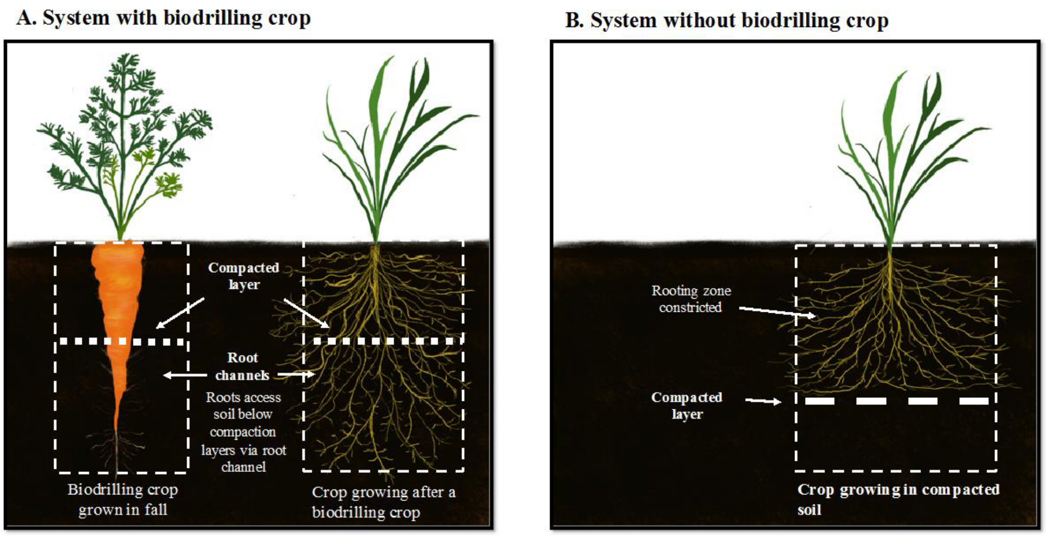

Figure 5: (A) By growing cover crops when there is adequate soil moisture, roots can biodrill channels through soil compaction layers that are used by the roots of subsequent crops to access the soil below. (B) In a system with a biodrilling crop, roots are restricted by the compacted layer. (Source: Van Eerd et. al., 2021).

Using the Global Positioning System (GPS), growers can direct farm equipment to travel on permanent tramlines on their fields (Figure 6). It helps in reducing soil compaction, saving fuel consumption, and increasing field accessibility, particularly in wet seasons. It has positive impacts on soil such as quicker water infiltration, lower bulk density, and greater crop yields.

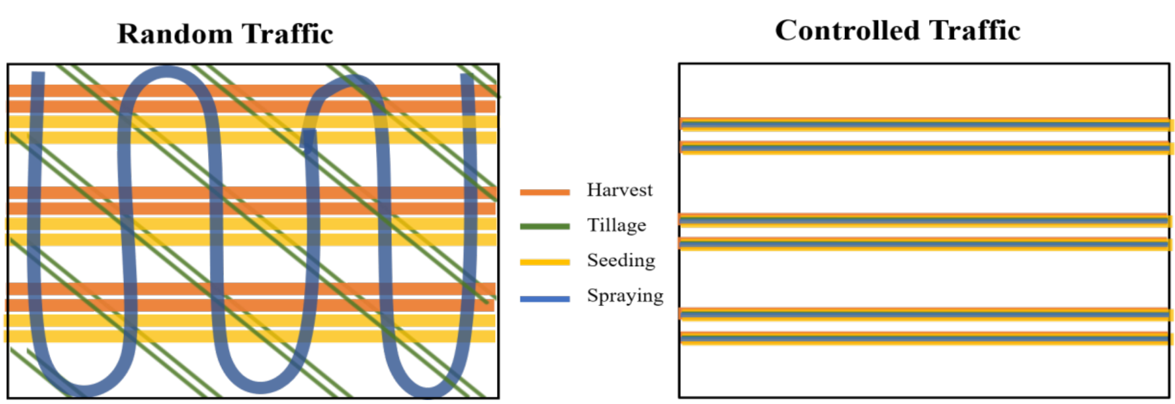

Figure 6: Random v/s controlled traffic (Source: Van Eerd et. al., 2021)

6.2. Conservation Tillage

Soil tillage is 'a mechanical act of mixing the soil to various degrees, primarily for preparing it for sowing, transplanting, or making seedbeds.' However, it is also used as a tool for controlling weeds, breaking up soil compaction, facilitating the faster decomposition of crop residues or organic amendments, and incorporating amendments and soil-applied pesticides into soil. Tillage improves soil aeration, decreases soil moisture, and promotes faster warming in the spring which leads to earlier or more uniform plant germination. It also stimulates soil microbial activity by breaking soil organic matter that helps in maintaining soil structure (Van Eerd et. al., 2021). However, there are a few negative impacts of tillage on soils and plant productivity. For instance, by dumping crop residues into the soil, tillage exposes the soil to water and wind erosion. It disrupts the connection between topsoil and soil microbes and leads to compaction when the soil is wet. Therefore, it is advised to adopt conservation tillage practices i.e., reducing the number of passes (tillage frequency) and intensity (depth) of tillage operations to maintain and improve soil health. Conservation tillage falls in between no-tillage and conventional tillage and varies with the frequency and intensity of soil disruption (Figure 7).

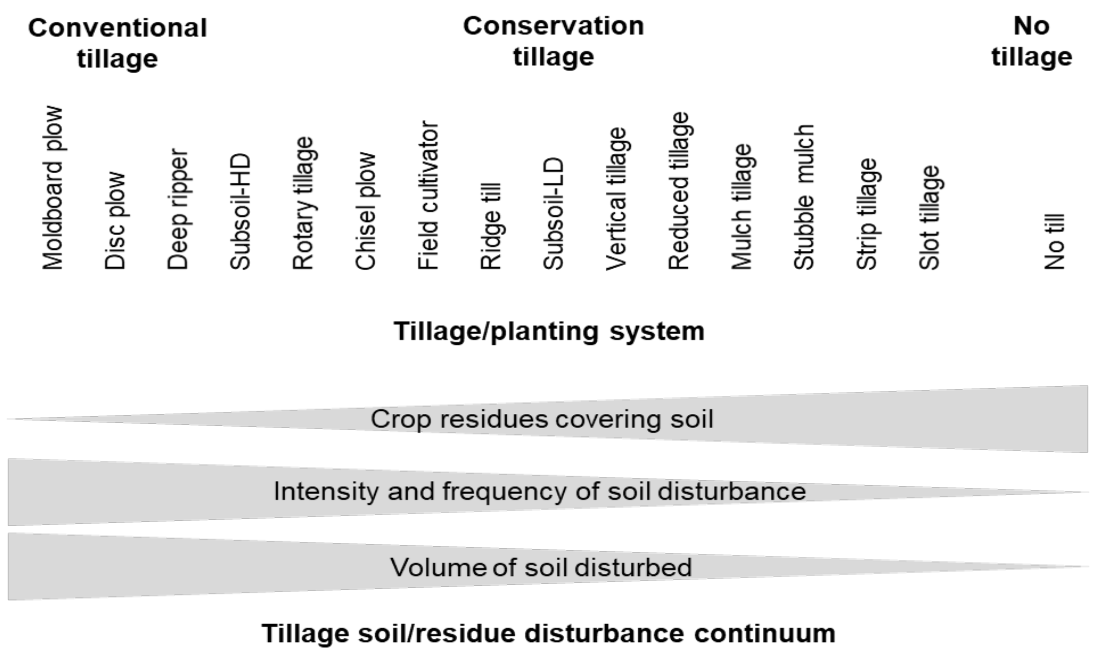

Figure 7. The frequency and intensity of soil disturbance under conventional or no/conservation tillage. There can be varying degrees of disturbance from high to low (Source: Van Eerd et. al., 2021)

Both the adoption and success of conservation tillage largely depend on climatic conditions, soil types, crop rotation, and cropping systems. For example, no-till is more suited to drier regions as it helps conserve soil moisture for plant growth, whereas, in wet regions like BC and eastern Canada, tillage helps soils to dry up quickly for planting. Conservation tillage is more popular in western Canada than in eastern regions. Over the years, no-tillage helped in improving soil health in Canada (Statistics Canada, 2016). Further, conservation tillage also depends on crop types as small grains and oilseed crops in western regions, which don't leave much crop residue as compared to grain corn in eastern regions. Conservation tillage is more suitable for cropping systems with grain and oilseeds where weeds are controlled by pesticides, whereas in organic farms weeds are managed with tillage. For instance, vegetable farms still use tillage as they need well-connected seedbeds for germination. In such cases, tillage is used to incorporate crop residue into soil and for managing weeds and insects more effectively.

Farmers, who adopt conservation- or no-tillage, have had to learn new farm management techniques and make new investments to bring out structural changes in their farm equipment in order to manage crop residue and weeds. Soils also take time to adjust to changes in microbial populations. These challenges vary with agroclimatic conditions, soil types, and farm management practices already in place. It is more challenging to transit from conventional tillage to no-tillage for poorly drained clay-textured soils. For those, who wish to transit from conventional to organic farming along with conservation-or no-tillage, this is more difficult as soil surfaces are generally acidic with ammonium-based fertilizers under conventional farming systems (Halde et al., 2015, 2017).

6.3. Continuously Living Plants

Like in forests, soils need to be covered with living plants and crop residues. Continuous living plants minimize soil disturbance, cycle nutrients, and water, and supply organic inputs through roots and litterfall to improve soil organic matter (Figure 3). Soils need to be left fallow to conserve soil moisture for subsequent crops, though it has some negative impacts on soil carbon matter (Janzen, 2001).

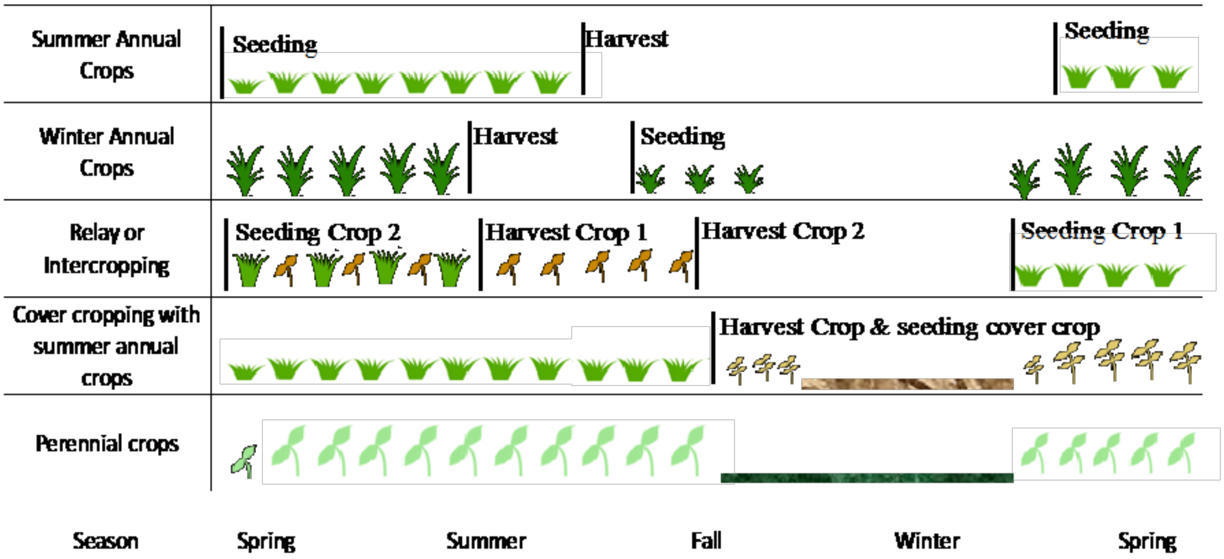

Figure 8: Schematic Gantt chart of various cropping strategies to increase living plant cover Note: Green and brown lines indicate soil coverage as opposed to bare soil. (Source: Van Eerd et. al., 2021).

The absence of living plants and their root systems make soils prone to erosion which may lead to low organic carbon in the soil which eventually degrades the soil health. Therefore, continuous living plants is the only 6C soil health management strategy that contributes to all three soil health principles, e.g., protecting soil, improving diversity, and building carbon. Perennials, such as orchards, pastures, and forages, are the best practices to increase continuous living plants on a field. In a long-term crop rotation trial in Saskatchewan, organic carbon stocks were higher in a diversified 6-year crop rotation farm when compared to a low diversity farm. In another study in Ontario, soil health scores improved by having a red clover cover crop on a farm. To note, as annual crops in Canada have living roots for 3-5 months in a year, there are very few options to keep living plants for the other months when it snows. Winter wheat or fall rye in a crop rotation is one of the options (Figure 8). Another option is to grow cover crops in the fall and early spring. Intercropping, agroforestry, and woody plants can also add duration and type of living plants as they not only help improve diversity but also provide habitats for pollinators and other fauna, store soil carbon, manage pest attacks, and regulate water and nutrient cycles (Van Eerd et. al., 2021).

6.4. Cover Crops

Cover crops are plants or alternate crops that protect soil and provide ecosystem services such as erosion control, nutrient supply, climate regulation, water quality and supply, and biodiversity conservation. Cover crops capture nutrients and supply them to the following crop. Different cover crops provide different types of ecosystem services (Table 1). It is therefore important to choose cover crop types carefully to get the desired results in terms of ecosystem services. Cover crops can be categorized into five general categories based on ecological niche, plant type, and growth form (Table 1). Legumes fix nitrogen while the other four categories of cover crops are driven by their ability to survive in warm or cold weather. It is advised to plant them in a good mix making a "polyculture" or a "cocktail" to garner maximum benefit. Cover crops can be sown anytime around the year provided enough time is given to them to grow. They take 4-6 weeks to grow given the climatic conditions. Farmers having orchards, growing high-value crops and those into organic farming grow cover crops in between two crop seasons. Alternatively, a cover crop can also be grown by underseeding directly under the main crop (Van Eerd et. al., 2021).

Table 1: Some commonly used types of cover crops with their key benefits (Source: Van Eerd et. al., 2021)

Cover crop type	Example species	Key benefits
Legumes	Red clover	Nitrogen fixation
Warm-season (C4) grasses	Sorghum	Abundant biomass and carbon inputs
Warm-season broadleaves	Sunflower	Added diversity
Cool-season (C3) grasses	Cereal rye	Rapid growth and overwinter survival
Cool-season broadleaves	Radish	Rapid growth and deep roots for nutrient scavenging

Cover crops help improve soil health by increasing carbon supply to the soil by extending plant duration. As cover crops are cultivated into the soil, they don't remove any carbon except in some cases where they are used for livestock grazing. The decomposition of cover crops enhances microbial activity which eventually builds soil organic matter which improves water-holding capacity and nutrient cycling (Chahal et al., 2020; Chahal and Van Eerd, 2018; Chahal and Van Eerd 2019). In addition, cover crops minimize carbon exports by mitigating erosion from water and wind and promoting soil aggregation which all decrease carbon losses. They also improve soil infiltration and enhance soil's soil retention capacity. On the other hand, by increasing evapotranspiration, they increase soil's capacity to receive a higher amount of rainfall. Some deep-rooted cover crops such as mustard, radish, and turnip help reduce soil compaction by penetrating hard plow pan layers. They help move macro- and micro-nutrients from deeper soil depths to surface and near-surface soil which can be used by the next crop. Further, they mitigate leaching losses of nutrients, such as nitrogen to groundwater (Van Eerd et. al., 2021). However, despite numerous benefits, cover crops are grown by only 14% of Canadian farmers as they have cultivation costs without corresponding immediate financial benefits. They do, though, bring long-term environmental benefits to soil and enhance ecosystem services.

6.5. Crop and Animal Diversity

Higher crop diversity helps reduce pest attacks, particularly from soil-borne pests, and enhances soil organic matter with different types of carbon inputs. Crop diversity encourages microbial diversity and functional redundancy as diverse communities have stable populations with resiliency to abiotic and biotic stressors. Using a combination of planting intercrops, cover crops, and perennials helps to enhance both temporal and spatial diversity (Figure 9). For instance, winter wheat can be planted in September which can provide carbon inputs and protect soil from erosion during a time of year when other rotations would be fallow. In addition, polyculture (mixture of plants) and intercropping (mixture of crops) can also be useful to enhance crop diversity. Squash and winter wheat can go together. In the prairies, chickpeas, and flax make a good intercrop mix, though special equipment is required to harvest them. Polycultures can be used as a cover crop mix or a forage crop and to support biological diversity. Farm diversity can be enhanced by having animals on the farm as they return carbon to the soil through feces and manure.

Figure 9. It is an example of spatial crop diversity within beds (many species of greens grown together) and among beds.

There are some challenges in increasing farm diversity as growing different crops needs more finances and resources to sow and harvest at different times of the year. Further, many crops require specialized planting or harvesting equipment, which requires more capital investment and higher routine maintenance. Moreover, different crops need diversified expertise and markets to sell them.

6.6 Compost and Amendments

Organic soil amendment is a process of adding any carbon-based material, such as compost, to the soil. This carbon material can be a 'waste' from humans, food, plants, and animals which are a critical source for soil health. The type of amendments can be applied to the soil directly (e.g., culls after sorting and packaging vegetables on a farm) or they can be processed through some media. Which amendment suits your soil largely depends on soil nutrients, the concentration of salt and heavy metals, and pH levels. And application rates will depend on organic matter content and nutrient levels mainly N and P.

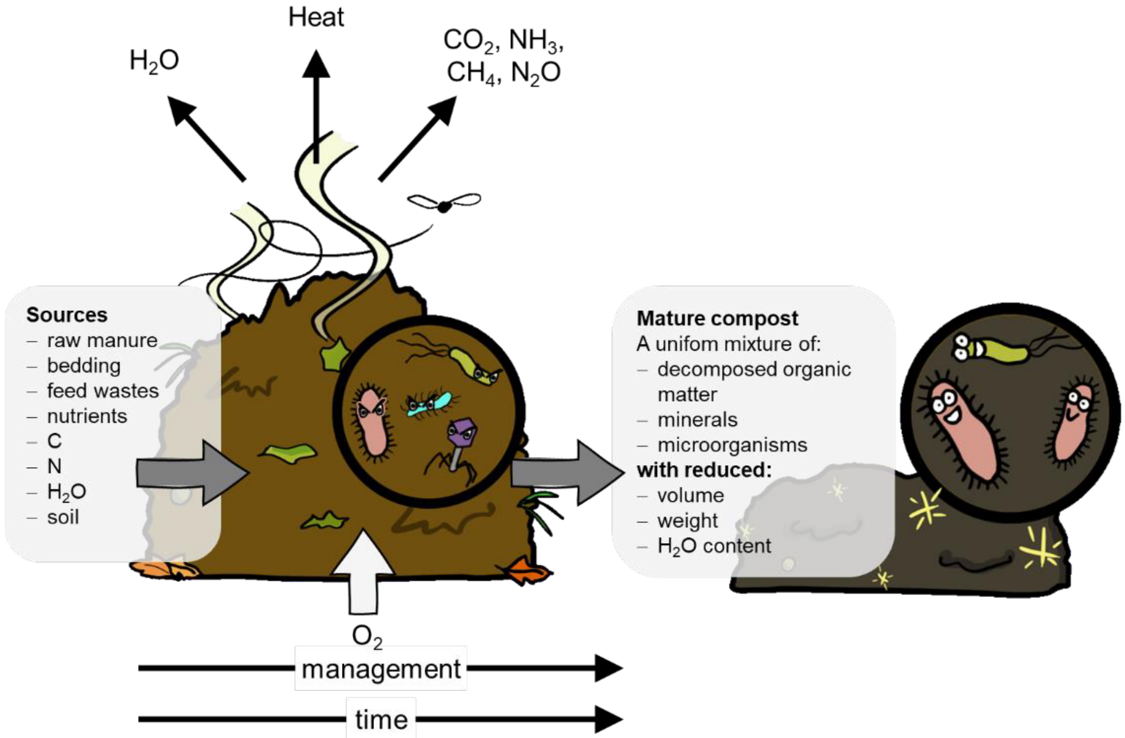

Figure 10: The composting process (Source: Van Eerd et. al., 2021)

Composting, an aerobic process of decomposition, is one common form of processing that requires the right combination of oxygen, moisture, and temperature (Figure 10). Traditional composting requires making a pile of wet organic matter made up of yard waste, food scraps, and occasionally sewage, and waiting several months for the waste to break down into humus (which is compost that's mainly used for conditioning soil). This is something you can do in your backyard.

Alberta's two major cities both encourage composting but take different approaches. The City of Calgary is successfully running a centralized composting program called 'Green Cart Food and Yard Waste Program' where the city municipality collects food and yard waste from family homes using green carts which are picked up weekly in summer (April-October and every two weeks in winters (November- March). The green carts go to the Calgary Composting Facility where this waste is converted into compost. This facility processes 145,500 metric tons of residential food and yard waste and dewatered biosolids every year. By 2025, this program will include an anaerobic digestion module where food waste will be converted into renewable natural gas. Edmonton encourages household composting, with an advisory program for city residents on 'how they can compost food and yard waste' as composting is the most effective way of reducing kitchen waste which can be used to grow food in backyards and community gardens.

Organic amendments, like adding compost to the soil, improve soil health by building soil carbon, which enhances soil infiltration, improves water holding capacity, and increases microbial activity, CEC, and nutrient availability. Organic amendments increase water and nutrient availability in soils and promote plant growth which eventually helps improve the supply of soil carbon (Wallace et al., 2009). A continuous application of soil carbon adds organic matter to soils that improve the biological, chemical, and physical properties of soil (Maillard and Angers, 2014; Norris and Congreves, 2018). Organic amendments can also mitigate the negative effects of soil erosion (Larney and Olson, 2018).

There are a few challenges in the application of amendments. First, human and animal waste-based manure contains pathogens. Provincial rules and regulations related to the application of amendments aim to minimize the risk of pathogen and nutrient movement off the field and to reduce odor. It is advised to apply amendments in the spring or fall after crop harvesting. Some farms require tillage to incorporate the amendment which disturbs the soil. A higher dose of amendments may lead to a concentration of P, K, and Zn in the soil which can pose a risk to human, animal, and environmental health. Some amendments high in salt can lead to the burning of plants and add salinity, particularly in Alberta soils. Moreover, the preparation of amendments and their application cost to farmers may bring some economic and environmental benefits in the long run.

7.Conclusions

Soils are crucial for producing food and fiber as they help grow plants, store, supply, and purify water, modify the atmosphere, and store various organisms. Soils continually undergo various biological, chemical, and physical processes at the same time. It is one of our major responsibilities to keep our soils healthy as healthy soils are key to our ability to provide food, manage the available carbon and provide building blocks to our ecosystem. However, some human activities can degrade soil health, resulting in impacts such as compaction, erosion, salinization, loss of organic carbon, depletion or excess of nutrients, loss of biodiversity, desertification, and contamination. Therefore, each of us, as producers, consumers, and citizens, has a role to play in maintaining the health of our soils.

Given the pressure on land and other natural resources, UA is getting popular worldwide, and many countries are making necessary changes in the existing agricultural policy frameworks to promote UA that can support subsistence farming, food processing, and commercial farming on urban lands. However, most urban farmers operate without any formal recognition and don't receive any structural support from municipal policies and legislation. This resource book is particularly prepared for urban growers of Alberta to make them understand the principles and practices of UA, major issues related to soil health, and how to maintain soil health while practicing UA on urban lands. For instance, the US Department of Agriculture (USDA) outlined the five basic land and soil management principles, such as soil armor, minimum soil disturbance, plant diversity, continual live plants/roots, and livestock integration which are crucial to help maintain and improve soil health.

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Appendix A: Examples of Urban Agriculture in Alberta

A. **Vacant Public Land**: In 2018, a vacant public land of 400 sq. meters in Edmonton was used to grow food and flowers for non-profit use (Figure 1). Edmonton citizens are allowed to grow food on vacant public land for non-profit use with a fee of $100 per lot.

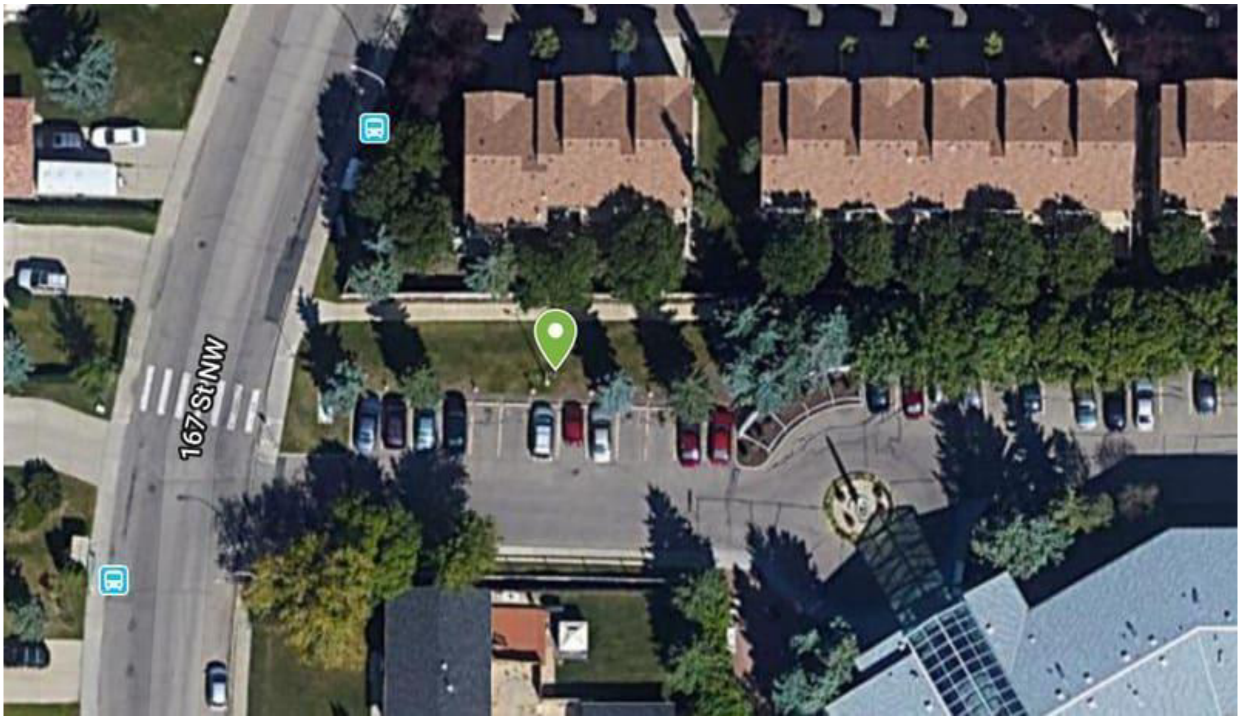

Figure 1: A vacant public lot in Edmonton used for gardening (Source: https://landusehub.ca/urban-agriculture/)

B. **Northlands Urban Farms**: It is a non-profit urban farm with vegetables, bees, hens, and a tree nursery. It is run by local communities of the Northlands (Figure 2). Some communities here use underutilized private yards, backyards, and front yards for growing vegetables and fruits for personal or community use.

Figure 2: Northlands Urban Farm in Edmonton (Source: https://landusehub.ca/urban-agriculture/)

C. **Grow Calgary**: Started in 2013, Grow Calgary is Canada's largest urban farm on 11 acres of public land that grows food for donation (Figure 3). It is run by a non-profit organization of volunteers.

Figure 3: Grow Calgary (Source: https://landusehub.ca/urban-agriculture/)

Municipality plans for Urban Agriculture in Alberta

A. **Calgary Eats:** It is a Food Action Plan initiated by the City of Calgary in 2011 with the sole aim of providing local, accessible, secure, sustainable, and healthy food to local communities in Calgary ensuring community development and economic growth. With the help of non-profit and pop-up markets, the Municipality aims to turn vacant public land into urban farms to encourage local food production through developing community gardens and promote waste management and sustainability through composting and renewable energy sources. To feed the increasing urban population, the Municipality aims to locate more vacant public lots and convert them into community gardens while experimenting with more innovative food production methods such as aquaponics and vertical farming. Between 2012 and 2017, the number of community gardens increased from 111 to 149 in the city of Calgary. Urban farms, farmer markets, breweries, food processors, and hunger relief services also increased significantly between 2012 and 2017. More recently, Alberta Health Services released the Community Gardens Handbook to guide communities on "how they can start a community garden" (Calgary, 2017).

B. **Fresh:** In 2012, under the title Fresh, Edmonton developed a Food & Urban Agriculture Strategy to respond to the growing awareness about urban agriculture and local food systems in urbanized areas. Municipalities want to tap the enormous opportunities by engaging local communities in food production locally. Resultantly, the sustainability of food production systems and quality of life will improve among local urban communities. This strategy aims to convert residential, vacant, or underused plots into urban farms and community gardens. This plan ensures urban growers that their investments and contributions to local food systems will feed them permanently over multiple seasons (EDMONTON, C. O., 2012).

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