Sustainability and Food Security

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Final Report

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Sustainability and Food Security at Tecasy Ranch

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Cover Image: Overview of Tecasy Garden by Karie McDougall from 2022.

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What is sustainable gardening?

In 1987, the World Commission on Environment and Development defined sustainability as the ability of people in the present to meet their needs without hindering future generations from being able to meet the very exact needs. It takes on three forms, namely, environmental, economic and social sustainability. Taking this into account, one can deduce that sustainable gardening requires a whole systems approach that incorporates all three sustainability forms to promote people's health and the land.

Regarding gardening/farming, sustainability can be defined as an approach to agriculture that aims to optimize productivity, profitability, and environmental stewardship while promoting social responsibility and equity. Sustainable farming involves a range of practices, such as conserving soil and water, preserving biodiversity, crop rotation, cover cropping, integrated pest management, and supporting local food systems, that reduce negative environmental impacts and enhance the long-term health and productivity of agricultural systems (Jackson et al., 2007; Lal, 2015; Gliessman, 2015).

Tecasy Ranch has a community garden, located on a 2-acre plot, established in 2020, that brings people together through food, cultivates health, nurtures community, and creates a sense of belonging while supporting local food banks. Tecasy aims to connect people to people, people to nature, and a greater cause within the community. However, the Ranch faces challenges in terms of sustainability and productivity, particularly concerning the two-acre plot of sandy and acidic soil on which the community garden is located. Tecasy has tried to amend the soil using various methods and receives some funding to support the operation of the garden. The Ranch grows various crops, which are supplied to Nourish's food box program for distribution to eligible low-income households. The team at Tecasy is committed to improving the sustainability of their gardening practices, reducing their environmental impact, and increasing crop productivity while maintaining the health of the garden and land. The Ranch aspires to create a sustainable garden that can feed itself for years to come and provide a model for sustainable agriculture in the community.

The research aims of this project will address four key research questions, including what constitutes a sustainable garden, which sustainable practices are currently underway at Tecasy Ranch, how other sustainable farms in the area have been established, and what practical actions Tecasy Ranch can take moving forward. By the end of this research, practical recommendations for sustainable gardening practices at Tecasy Ranch will be provided.

It is important to note that accessible language and a narrative format are used within this report. We found it crucial for community involvement when discussing scientific topics that can be complex. For example, a person outside of the field may have a hard time understanding the terms used. Therefore, a narrative format is the most appropriate and engaging way of sharing information. This approach can foster better communication and collaboration between the students, experts in the field, and community members, leading to more effective solutions and positive outcomes. Involving the community in scientific discussions can also increase trust, participation, and ownership of the decision-making process.

Soil management

Soil is the backbone of gardening and the lifeblood of food production. When you decide to become sustainable, even the soil matters; it may be the most important aspect and certainly the top priority for Tecasy Ranch and Garden. Soil sustainability considers a multitude of factors, from quantity and quality of organic matter, various nutrients, soil type, soil health and pH. These factors work in tandem to ensure the vegetables grown in the garden reach their peak productivity and are of the highest quality possible. A popular definition of **soil health** is described as follows, "the capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health," this definition acts as a baseline when discussing soil health throughout the paper (Doran & Zeiss, 2000). Regarding sustainability, the soil must include these factors, require little intervention and only use natural or organic methods when intervention is required. In addition, the soil must remain healthy and self-sufficient for years to come. Vegetable gardens are particularly tricky as different plant species remove nutrients and add nutrients during the growing season. Under Crop Management, more explanation is offered to assess which plants should follow each other in rotation for best soil health.

Soil management is a multidimensional concept where traditional practices are becoming less effective. Soil is a living system that demands a holistic approach to fully understand its growing capacity and health (Doran & Zeiss, 2000). Our research follows this interdisciplinary approach as we considered the soil type (parent material and great group), environmental conditions (climate and location), and farming practices (fertilizer and compost). This led to an in-depth understanding of the soil before offering suggestions and recommendations for the future of their management practices.

Soil Analysis and Management History

After speaking with Tecasy's manager, Karie, during an initial interview, it was determined that maintaining sustainable soil health is the top priority for the farm. The garden's success is heavily reliant on well-nourished soil, which requires using environmentally friendly and sustainable methods to neutralize the pH levels of the soil efficiently. To ensure long-term soil health, providing the soil with the correct amount of organic matter and essential nutrients such as nitrogen, potassium, sulphur, phosphorus, and magnesium is essential.

A soil analysis conducted in 2021 revealed the lowest levels of soil nutrients, and the pH range was between 5.8-6. To improve this, heavy agriculture lime was applied to the soil in 2021, with a half tonne in the spring and 500 lbs in the fall. No fertilizer was used in the garden; only organic matter was added to the planted rows. In 2022, lime was applied to a new section of the garden to improve the overall soil pH. Karie combined a triple 15 NPK fertilizer with sea and mushroom compost to boost soil nutrients and organic matter, resulting in the best produce yield to date (see changes in Table 1.2). Moreover, the soil texture at the farm is sandy with low clay content, which affects the ability to retain water and nutrients, as seen in the small improvements between soil tests. A higher clay content contributes to a natural deficiency in the organic matter regardless of nutrient treatments. Significant research will be conducted to address these concerns and create

sustainable soil conditions to determine the best types of fertilizer, compost, and application practices.

Table 1.1. The initial soil test from 2021.

Reported Date:Apr 8, 2021 Printed Date:Apr 8, 2021 **SOIL TEST REPORT** Page: 1 / 1

Sample Number	Lab Number	Organic Matter	Phosphorus - P ppm Bicarb	Phosphorus - P ppm Bray-P1	Potassium K ppm	Magnesium Mg ppm	Calcium Ca ppm	Sodium Na ppm	pH pH	pH Buffer	CEC meq/100g	Percent Base Saturations % K	% Mg	% Ca	% H	% Na
1	79802	2.7	14 VL	28 L	11 VL	63 M	540 M	9 M	6.0	6.9	4.5	0.6	11.7	60.2	26.6	0.9
2	79803	2.9	13 VL	27 L	10 VL	66 L	600 VL	12 M	5.8	6.7	7.2	0.4	7.6	41.5	49.8	0.7

Sample Number	Sulfur S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Soluble Salts ms/cm	Saturation %P	Aluminum Al ppm	Saturation %Al	Nitrate Nitrogen NO3-N ppm	K/Mg Ratio	ENR	Field ID
1	7 L	2.9 L	13 L	76 VH	0.4 L	0.1 VL		5 L	672	1.3 M		0.05	39	
2	7 L	3.5 M	17 M	85 VH	0.5 M	0.1 VL		6 L	595	1.0 G		0.05	41	

OE VL = VERY LOW, L = LOW, M = MEDIUM, H = HIGH, VH = VERY HIGH, G = GOOD, MA = MARGINAL, MT = MODERATE PHYTO-TOXIC, T = PHYTO-TOXIC, ST = SEVERE PHYTO-TOXIC

Table 1.1 shows the acidic pH with deficient levels of organic matter, phosphorus, potassium, and boron. Low levels of magnesium, zinc, sulphur and copper. Lastly, medium to high levels of sodium, iron and calcium.

Table 1.2. The second soil test from 2022.

Reported Date: Printed Date:Apr 25, 2022 **SOIL TEST REPORT** Page: 1 / 1

Sample Number	Lab Number	Organic Matter	Phosphorus - P ppm Bicarb	Phosphorus - P ppm Bray-P1	Potassium K ppm	Magnesium Mg ppm	Calcium Ca ppm	Sodium Na ppm	pH pH	pH Buffer	CEC meq/100g	Percent Base Saturations % K	% Mg	% Ca	% H	% Na
VEG	41639	2.7	18 L	31 L	38 L	87 H	640 M	13 H	7.2		4.3	2.3	17.0	74.9	4.5	1.3

Sample Number	Sulfur S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Soluble Salts ms/cm	Saturation %P	Aluminum Al ppm	Saturation %Al	Nitrate Nitrogen NO3-N ppm	K/Mg Ratio	ENR	Field ID
VEG	7 VL	3.0 M	20 M	109 VH	0.4 L	0.4 L		7 L	592	0.2 G		0.14	39	

OE VL = VERY LOW, L = LOW, M = MEDIUM, H = HIGH, VH = VERY HIGH, G = GOOD, MA = MARGINAL, MT = MODERATE PHYTO-TOXIC, T = PHYTO-TOXIC, ST = SEVERE PHYTO-TOXIC

Table 1.2 shows small improvements to almost all nutrients except sulphur. The pH increased from 5.8-6.0 to 7.2. There is still room for improvement in potassium, phosphorus and organic matter. The lack of change in organic matter is likely due to organic matter added by crop residue, without this the matter would have been depleted.

Soil Great Group and Environmental Conditions

The farm is situated in Buckhorn, Ontario, on the border between the Mixedwood Plains and Boreal Shield Ecozone (as shown in Figure 2). The area experiences cooler and shorter summers, resulting in a shorter growing season, and the presence of large water bodies leads to varying weather conditions (Saurette et al., 2021). Along the border are two merging soil great groups (as illustrated in Figure 3), creating unique soil conditions for Tecasy's garden. The northern part of the land has coarse, acidic, and underdeveloped soils due to the metamorphic bedrock. In contrast, the southern part comprises Melanic Brunisol with extremely calcareous parent material, leading to extreme alkalinity that needs time to neutralize, resulting in underdeveloped soil and low nutrient levels (Saurette et al., 2021). The garden's main concern is sustainable soil, which means soil that can feed itself and support a healthy garden with minimal or no human intervention, and this requires high nutrients and organic matter in the soil (Magdoff, 2012).

The sandy texture of the soil causes problems with water and nutrient retention, making it less than ideal for growing conditions. As per Figure 3, the yellow zone beneath the Ranch on the map encompasses the majority of Ontario's agriculture due to optimal climate and soil type

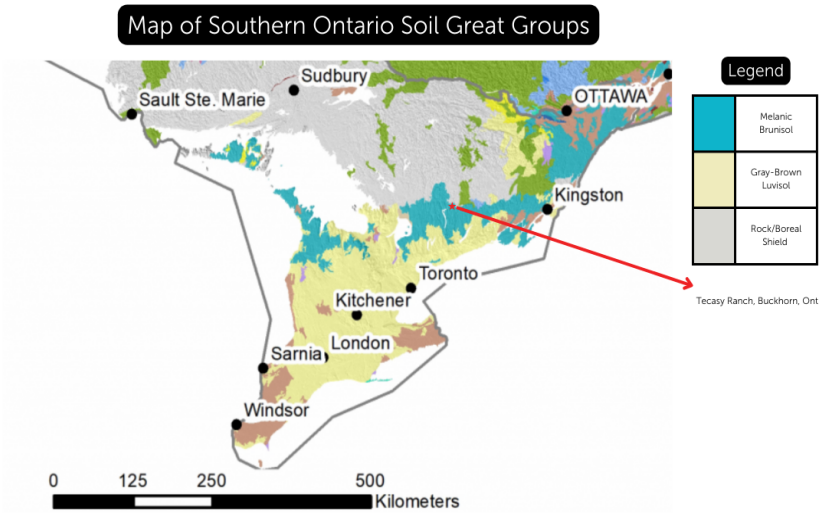
(Saurette et al., 2021). The concerns regarding the low organic matter and nutrients in the Tecasy garden can be attributed to its geography and soil type, which require more labour-intensive upkeep. Achieving sustainable soil will be more challenging due to these obstacles, as the soil necessitates interference and treatments to obtain optimal growing conditions. It may take several years to achieve sustainable soil if it is attainable at all.

Figure 1. Map of Southern Ontario Ecozones

Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Research and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch. (1995). Terrestrial Ecozones, Ecoregions, and Ecodistricts Province of Ontario [map]. 1:3,500,000.https://sis.agr.gc.ca/cansis/publications/maps/eco/all/districts/index.html

Figure 1 shows a map of the Ecozones in southern Ontario that determine the climate, precipitation, and vegetation. Tecasy Ranch is located approximately at the red star and borders the Mixedwood Plains and Boreal Shield.

Figure 2. Map of Southern Ontario Soil Great Groups



Cerkowniak, D and Agriculture and Agri-Food Canada. (n.d.). Distribution of Soil Great Groups in Ontario and Quebec [map]. (ca. 1:125000,000). https://openpress.usask.ca/soilscience/chapter/soils-of-ontario/

Figure 2 is a map of Ontario's soil great groups. Tecasy Ranch is located approximately at the red star. The soil there is Melanic Brunisol on the border of the rocky Boreal Shield.

Fertilizer and Compost Methods

Tecasy Ranch uses various natural fertilizers and compost products for the vegetable garden. The recent mixture of triple 15 NPK fertilizer and sea and mushroom compost was costly and showed a slight improvement in nutrient levels (see Table 1.1 and 1.2). Vital nutrients like Potassium, Sulfur and Phosphorus are still considered low. The investment was over CA$ 1100, not including the cost of labour. However, this may seem expensive; traditional forms of commercial compost range around CA$100 per square yard. Focusing on the NPK ratio but making slight variations to which nutrients you need an excess of can target those lower levels. In addition, adding fish or bone meal (water-soluble versions) increases P levels. While adding kelp meal can increase potassium levels.

One of the most 'hidden gem' fertilizer methods comes from a non-traditional type of companion planting. The relationship of mycorrhizal fungi to surrounding plants and trees has been well documented in the last 15 years as a critical mutualism that supports nutrient and water transfer, root health, and overall size and health of plants (Huey et al., 2020). They are found in a great variety in almost any natural soil system; their presence determines the health of anything around them (Huey et al., 2020). Home gardeners can purchase dry mycorrhizal blocks to sprinkle into the soil before planting or introduce in liquid (water) after planting (Didur, 2011). However, before planting is recommended. A study by Didur (2011) tested the effects of mycorrhizal fungi in various vegetables and fruits. Over the summer, plants with fungi grew stronger, larger and more disease resistant than those without. She also had the produce anonymously taste-tested, and the results proved plants with fungi tasted sweeter and overall better than the others (Didur, 2011).

Ideally, creating your own compost and using materials locally available is the best practice. Trent Vegetable Gardens works with a local compost company, Trent Starbucks, for coffee grinds and Trent Animal Care for manure. Establishing local connections to help mitigate waste products

into useful fertilizers and compost material is a sustainable approach to this issue. Often companies are willing to offer these byproducts at a fraction of the cost, if not for free. Tecasy can create such a system within their community, benefiting their social and environmental sustainability.

Referring to the soil analysis above (see Tables 1.1 and 1.2), there is little to no improvement in organic material. While the organic matter did not change, it likely would have if this soil was not planted; crop residue adds organic matter. This finding, more than ever, solidifies the importance of composting in the garden. A study by Kelley et al. (2020) highlights the benefits of homemade compost specifically made from food scraps or yard waste for sandy, acidic soils stating compost "addresses both waste management and soil health issues, composting diverts organic wastes from landfills and recycles nutrients into soil amendments that improve soil fertility and health." While Tecasy does not currently use animal manure as fertilizer, the study refers to manure as a comparison to other composts. This is valuable in case manure is considered as fertilizer. Food and yard waste produce more Nitrogen, less Carbon Dioxide emissions than manure, and a higher Phosphorus content than industrial compost (Kelley et al., 2020). Part of what makes home composting valuable is its societal impact on food/yard waste mitigation, diverting organic waste from landfills, and sustainably improving soil health through a circular economy. Animal manure may be costly, but Kelley et al. (2020) suggest mixing small amounts of it within compost to improve fertility and stretch the product further if desired.

Establishing a community composting program feels like a daunting task. Still, many waste products can be easily found around the neighbourhood, like leaf clippings, coffee grinds, egg shells, onion skins even clippings from the garden as your prune over the season. The hardest aspect is time and patience when developing your compost. Starting this season will give you a boost for next year; as time goes on, the compost becomes more self-efficient.

Biochar

New research is circulating in agriculture communities in the Northern Hemisphere debating using biochar over agricultural lime. Biochar is a charcoal product originating from ancient Amazonian farming practices (Isaacs, 2017). It is mixed into compost or manure, drastically improving biomass and chemistry for sandy, acidic soil and increasing nutrient retention (Isaacs, 2017). In Canada, there are limitations to this product due to a need for more scientific data, production and usage. This may be changing as research suggest Canada may soon become the fastest-growing market for biochar production as more science proves its value (Lévesque, 2022). When comparing the required amount for Tecasy to the use of agricultural lime, it is more than double the price and is primarily sold in small quantities. However, it is cost-effective in small doses and can target plants that require more nutrients, like nightshades and leafy greens. Additionally, less biochar is required for a larger area when combined with compost or manure. It is a worthy investment as biochar lasts many growing seasons and remains just as practical over time (Isaacs, 2017). Biochar is a resource many homeowners can produce given its simple qualities; you just need access to burn wood at a high temperature for the charcoal. Considering it originates from pre-industrialization, reinventing the wheel isn't necessary; we just need to maximize the efficiency of production.

Water Quality and Quantity

During the initial interview at Tecasy, water quality and quantity issues raised concerns for the team. The farm receives water from a local stream fed by a marsh and lake. During the summer months, the quality and quantity of the water become questionable due to drought. An unknown surface oil was documented on the stream during a previous growing season. Other issues are the result of a local road flanking the farm. In the winter, the road receives salt and sand treatment that has the potential to run off into the surrounding waterway and contaminate the soil. Considering the stream and current source of surface water is part of a larger water system, waste, garbage, animal, and pesticides can also run off, causing a potential threat to the produce.

Moreover, oil, gas, microplastics and other byproducts of vehicles can also make their way into the water source. Further information is required on the water quality in the surrounding area. The chemical composition of the water can alter soil chemistry during rain or garden watering, as outlined in the next section. Ensuring a clean water source is vital for the health and quality of vegetables.

Lastly, part of the sustainability model outlined in the introduction emphasizes environmental impact. If the water source cannot sustain the garden's needs and the ecosystem during summer droughts, a secondary source should be obtained for the farm to alleviate stress on the water. Stresses can occur in various ways, one of which is streamflow. Considering this source is connected to other bodies of water, impacting the water flow from pumping can cause unnaturally low levels elsewhere. Reducing water levels can decrease the dilution of nutrients to harmful levels, for example, salinity. In general, over-pumping to support a large garden in months with low precipitation will increase the risks of drought to an ecosystem that trickles down into a myriad of issues. Reducing the overall stress and harm to the surrounding water source must be taken into future consideration.

Water Testing

Understanding what is in your water matters. Local streams and rivers may present harmless on the surface or even look clean, but their chemical and particulate composition of them is invisible to the naked eye. Considering the garden uses a stream located by roadways and towns, it's important to know if the water plays a role in the garden’s health or impacts the final product. Certain contaminants are caused by runoff and can live in the soil longer than in water.

Water quality concerns range from pH imbalances, dissolved oxygen, chlorine, nitrates, salinity, and bacteria (E.coli). A few of these parameters can be tested in-home testing kits like a CA$140 freshwater kit from Water Rangers, or all except bacteria and nitrates can be tested for CA$350. Even simple pH testing strips are available at hardware stores and would work wonders during warmer months when the water is stagnant.

If the pH of the water is extremely acidic or alkaline this will alter the growing conditions of the plants due to changes to the soil pH. This test can be easily done by placing a test strip into a containter with source water, then comparing it to a graph. Other concerns like dissolved oxygen (DO) determine water heath through a concentration in a chemtric DO test (Water Rangers CA$350 test kit). Poor DO content and life cannot sustain itself, this is usually the result of excess nutrients like nitrogen or phosphorus. Their excess can relete to algae or agricultural fertilizers (nitrates).

While these two nutrients are beneficial in plant growth, their excess shouldn't be problematic, but this is not the case. Adding water with low oxygen levels will cause oxygen to pull from the soil and roots of plants (Becker, 2016). In addition, having a high saturation of DO will increase the plant health and growing efficiency. So while there may not be obvious signs of low DO, there is not a problem having too much; it is better to know if you can increase production.

Lastly, the other parameters such as chlorine and salinity can cause plant damage and hinder growth. They may dehydrate the plant, harm the roots or even cause full crop failure. These are not currently concerns nor have they been present at the garden but it is important to understand all possible ailments to your garden before they arise. Preventative measures such as testing can ensure levels are monitored before they become problematic. Testing water should occur at least five times during the growing season especially near harvest and planting (Hultberg, 2022). More information can be found on the Water Rangers website should there be an interest in testing. While the prices are steep, they are usable over multiple years and are good to have.

Another option is a specialized test from a company like Tap Score, which measures a variety of concerns for ~CA$150. They can determine E.coli, nitrates, heavy metals, petroleum, microplastics, etc. There is little concern for these parameters; however, this is an option should any issues arise. The main concern for a garden producing vegetables for charity and consumption should have a baseline understanding of E.coli levels in surface water due to the sickness resulting from accidental ingestion. Water or agriculture labs can offer cheaper alternatives just for E.coli that can be done a few times during the growing season. There is more concern when the water becomes stagnant as this allows more bacterial growth and before harvesting the produce. To avoid unnecessary contamination even without a water test, a few simple steps can be taken while watering. During irrigation, avoid having water directly touch the edible parts of a plant, like the fruit of tomatoes, and instead target it to the base of the plant (Hultberg, 2022).

Another option is drip irrigation; however, this is costly to install. Surface water can be used in bulk for plants that are not eaten raw and or have protective outer layers, like potatoes or squash (Hultberg, 2022). Next, although not fully recommended if water touches edible parts of the plant before harvesting, it is best to wait for a "die-off" to occur (Hultberg, 2022). This means leaving the plant alone for at least four days before harvesting, as the bacteria may die. If there are contaminants, this is not a guaranteed removal practice. Lastly, washing any harvested produce in the surface water is best avoided in case there is a presence of E.coli. It may not be removed before consumption.

Secondary Water Source

While the stream does sustain the garden's needs, it is recommended that a potential secondary source is included to remove unwanted stress to the ecosystem that uses the stream too. In addition, certain plants may be susceptible to drought when the water levels are too low to pump, so alleviating that stress is critical too.

A simple chart below maps out the pros and cons of different water sources that can act as a much-needed secondary source while also comparing them to the control source (the stream).

Table 2. Cross Comparison of Potential Water Sources.

Sources	Positives	Negatives

Well Water	- Sustainable off-grid source of water - Can last generations if maintained - Minimal disruption to ecosystem and surrounding area - Long-term investment - Can contain good nutrients like calcium or magnesium for plants - Payment upfront saves down the line	Expense: - Permits cost money and are required - Min. costs are CA$4500 plus potential cistern CA$2000 - Additional infrastructure needed (pumps, pipes) Contaminants: - Lacks treatments - Can contain bacteria, heavy metals - Therefore needs treating and testing (costs, time)
Rain Water (barrels)	- Contains fewer chemicals or heavy metals - Almost free minus infrastructure - Doubles as storage	- May require a permit to collect - Still requires testing, acidic rain may damage plants - Not ideal during droughts
Surface Water (current source)	- Cheaper than groundwater - When at high volumes, it is ideal and sustainable - Avoiding importing water by using what is local - Requires little infrastructure	- Open to the environment (runoff, bacteria, waste, garbage) - Susceptible to drought - Potentially taking water away from marine/terrestrial species - Requires testing and potential to be unusable

The above information is courtesy of Holley (2023), Seismic Waterfinder (2012) and Hultberg (2022).

Pest management

When starting a large-scale garden, pests and insects interest the farmers because they can make or break the outcome of your produce. At Tecasy, little insect or pest impact has plagued the farm since the start of 2020. There are some concerns for squash bugs (*Anasa tristis*), potato beetle (*Leptinotarsa decemlineata*), cabbage worms/moths (type unknown) and tomato hornworm/five-spotted hawkmoth (*Manduca quinquemaculata*). In 2021, squash bugs destroyed the garden's squash and cucumber plants. After attempts to remove the insects with neem oil, all the cucurbit plants were eventually uprooted. In 2022, row covers were used to cover the planted cucurbits to avoid any harm from squash bugs. After the plants flower, the row covers are removed.

This method was successful, and there were no squash bugs in 2022. As for the remainder of the documented pests, a 'pick and squish' (physical control) method is practiced for targeted removal. However, cabbage worms are unharmed and left alone. Finally, there must be more focus surrounding larger pests like rabbits, squirrels and deer on the farm, as their current presence is minimal but indefinite. While this remains true and good now, there is no telling what the future impact of these creatures will be. Without proper prevention tools like fences, their impact will be inevitable.

The sustainable interests of Tecasy Ranch focus on low-impact pest mitigation strategies. Various methods are practiced, but all align with natural and organic values. As we advance, preventative and passive pest management practices will be discussed below to further aid their low-impact plan. An Integrated Pest Management (IPM) study will be outlined and compared to Tecasy's goals.

Figure 3.

Figure 3 shows the tomato hornworm (left) and some cabbage worms (right). Photos were taken by Karie McDougall in 2022.

Integrated Pest Management

Insects, rodents, birds and bears can all be classified as 'pests' in a garden. However, there are benefits to a robust ecosystem surrounding your garden filled with such pests. Not all pests are harmful, and not all will fully damage your garden. Working with the environment, not against it, to improve the growth of your garden is essential in a sustainability model. The use of any harmful practices in pest removal for the personal benefit of the farmer is an ethical consideration of moral value. We often remove, trap or terminate unwanted critters without considering their role in the ecosystem; as the farm or garden is often an artificial and intrusive addition to the landscape, it is hardly justified to remove the natural fauna strategically. Despite this, many insects threaten vegetable gardens. Integrated Pest Management (IPM) combines strategies to prevent insect pest damage in gardens and works on various scales. Non-toxic and natural methods are considered before synthetic or chemical methods to ensure minimal impact on the surrounding ecosystem

(Diffenderfer, 2021). Part of this approach requires a system to identify the risks and their location (Diffenderfer, 2021).

The **IPM Triangle** from Diffenderfer (2021) goes as follows:

1. Create a detailed list of all the items grown in the garden (vegetables, cover crops, flowers).
2. Consider what insects or ailments are common in each item, regardless of their presence in the garden.
3. Familiarize yourself with each life stage of the insect and its mouthparts to identify its presence through plant damage.
4. Associate non-toxic, natural and targeted treatments to each insect and life cycle. Document results.

This list is highly detailed but practical as a training guide for new workers and acts as a master list for years to come. It works best when constantly updated with treatment results and new additions. The Triangle method works best with other gardening methods like cover cropping, crop rotation and disease management (Diffenderfer, 2021).

A significant section of IPM involves Push-Pull strategies and predatory insects. Push-Pull strategies refer to strategies that shift behavioural patterns in insects (Cook et al., 2007). This includes placing specific plants to distract the insects away from the garden while drawing them in with a plant they prefer, where controlled pest removal can occur (Cook et al., 2007). Some of the best natural deterrents are lavender, basil, herbs, marigolds, chrysanthemums, and more (Kanuckel, 2022). It is used in tandem with 'ghost crops': favourable insect crops are grown away from the garden to trap unwanted pests, so it becomes an effective, non-toxic insecticide (Cook et al., 2007). Distraction crops also improve pollinator frequency and health. Comparatively, predatory insects such as lacewings, hoverflies and ladybirds naturally prevent aphids in gardens (The Orchard Project, 2022). These insects can be attracted to various distraction plants mentioned above (The Orchard Project, 2022). One documented instance of ladybirds at Tecasy illustrates the garden's current health and use of strategic plants. Lastly, physical barriers such as row covers dominate gardens around the area and are used at Tecasy. These allow enough light to reach the plant while protecting it from insects and smaller mammals.

Figure 4.


Figure 4 illustrates that the row covers over cucurbits on the left to prevent squash bugs. While to the right is a ladybird insect commonly used as a predator insect to prevent aphids. Photos were taken by Karie McDougall in 2022.

Crop management

Table 3 shows the crops planned to be grown for the 2023 farming season. The number in brackets indicates the number of types of each plant grown. Furthermore, a description of the plant's behaviour with the soil and Karie's plans for planting most of them.

Table 3. A sample of Tecasy's 2023 gardening plan

Name of the plant	Describer (Giver, taker, moderator)	Projected planting schedule
Beans (1)	Givers	June
Beets (2)	Moderator	Optimal soil temperature: 10-26°C (cool vegetable)
Brussel sprouts (1)	Taker	Spring - plant seeds once the soil is workable or 45-60 days before first hard frost
Cabbage (3)	Taker	After last frost
Carrots (3)	Moderator	When soil temps rise above 8 degrees C (cool

		vegetable)
Cucumbers (3)	Taker	Sow seeds in spring when ground is warm - Mid-June
Kale (2)	Taker	June
Lettuce (3)	Moderator	
Peas (3)	Givers	Plant in early spring and late summer for fall
Potatoes (3)	Takers	
Peppers (2)	Taker	Plant in mid-June
Winter squash (4)	Takers	Plant in June
Sunflowers (5)	Moderator	
Swiss Chard (1)	Takers	
Tomatoes (4)	Takers	Wide variety of plants- spring once the last frost is gone
Onions (2)	Moderator	Cold soil- 5-10 degrees (do not plant in summer). Early spring or End July/August
Summer squash (5)	Takers	Plant in June
Flowers (3)	Cover crops	
Eggplant (1)	Takers	

Crop management is essential if not the most important, farming component. It includes the timing of the plantation, the cocktail of plants chosen to be grown, attention paid to the tendering of the crops and other things like crop rotation (Shah & Wu, 2019). As detailed in Table 1, Tecasy ranch offers many plants with wide-ranging management requirements. Despite continued attempts to develop a system that works, Tecasy is still challenged by its acidic and sandy soils, making it especially difficult to maximize the land's potential. Considering that all the produce from Tecasy goes to a food bank, they are faced with having to deliver on the promises they offer to these food banks. A good way to improve yield is through methods that promote soil improvement and are economical, such as crop rotation.

Crop rotation is a method of management that entails swapping planting between two different crops in a section to make the most out of the section. For example, if you plant a taker of nutrients such as tomatoes, the next one would be beans to restore the nutrients in the soil. With for-profit farmers, it is a great way to balance between cash crops, cover crops and filler crops. If Tecasy can develop a crop rotation system that works for them, they will save on experimenting year in and out where the risks are high and rewards are unclear (Manual, 2009). Henceforth, as a

method, it is encouraged to assist with Tecasy's nutrient-deficient soils that are not costly and helpful in the long run. Moreover, it increases the productivity of the land, which is beneficial for what they get to donate to the food banks.

Community Connections

Nautical farms (Todd Noble)
Todd Noble of Nautical farms, upon hearing about our research, recommended the primary focus should be to research methods of building up organic matter in Tecasy's soil.
Biochar was discussed as a possible way to balance the soil's pH levels. Noble recommended visiting the Peterborough farmers market as he recalls a local farmer has begun making biochar, and holding workshops to teach other local farmers how to create biochar. Our peer-reviewed research fell short of finding information about the use of biochar in Canadian agriculture, but Todd's local information provided us with important options and connections.

Further, he recommends connecting with local cattle farmers to purchase their manure. This is a good way to provide financial support to other local farmers, create community connections, and build up the chemical and biological composition of the soil. Manure can increase soil quality by adding nutrients, including nitrogen, phosphorus, potassium, sulphur, magnesium, and calcium, which are lacking in Tecasy's sandy and acidic soil (refer to soil analysis). Another option is connecting with the Buckhorn townsite in the fall when leaf collection occurs. Collecting community members' yard matter is an excellent and inexpensive (potentially free) way to build a mutually beneficial relationship with the community. Moreover, when leaves are decomposing, they attract worms and microbes, which assist in the release of carbon, nitrogen, phosphorus, potassium, and other important nutrients and minerals (Ma, 2016). However, this practice's downfall is potential garbage in leaf litter.

Todd recommends using a three-year plot rotation where every third year, the plot is mulched (with hay, leaves, ash, etc.) and left to naturally recover itself. He says, 'weeds are guardians of the soil; they are nature's response to recovering soil nutrients'. Plants that are well adapted to growing in this area often have deep tap roots. When these 'weeds' grow, their roots reach deep within the soil and bring nutrients and minerals to the surface. When the plant dies, it becomes biological matter and replenishes the surface soil. This practice requires very little human interference and is a simple way to maintain a sustainable garden.

Regarding human labour, volunteering, and creating sustainable social relationships, Todd uses a program called WWOFF (worldwide organic farming franchise). He highly recommends using WWOFF (or other work-away programs) that involve volunteering in exchange for boarding. WWOFF finds people from all over the world who are interested in learning about global agricultural practices. Many farms across Canada use this organization as an approach to financial sustainability, and as a way to provide agricultural education to people who are interested in someday having their own farms/ gardens. The major downfalls of this option (as expressed by

Janis and Debbie of Cielo farms) are that some volunteers are inexperienced and require extensive training and oversight. Further, it does not necessarily contribute to local community building as many individuals come from all over the country/ and the world. However, many individuals are repeating volunteers and will return to the same farm for multiple seasons. Thus, over time can build important relationships with the local community and the land.

One of the most important takeaways from Todd is that agriculture is linear and nature is not. In order to create a sustainable farming system, practices cannot be linear but constantly evolve to find innovative and sustainable solutions. These practices require local resources and local connections and relationships if they are to be truly sustainable.

Cielo Farm (Janis and Debbie)

Janis and Debbie of Cielo Farm have been farming the soils of Cavan, Ontario (located 15 minutes south of Peterborough) for the past ten years. Through trial and tribulation, the sisters have successfully established a sustainable framework that provides them and their nearby communities with organic local produce. Using non-GMO, untreated heirloom seeds, and low-impact methods of agriculture such as low till and organic/ 'green' insecticides (safer soap, Chrysanthemum, Diatomaceous earth), they are able to maintain their garden using the least invasive tools, aids, and strategies. Practicing polyculture through crop rotation, they can produce a wide variety of fruits, vegetables, and herbs that are of high nutritional value and can withstand extensive transportation and storage. Utilizing hoop houses, greenhouses, and indoor seed-starting methods, they are able to extend their growing season significantly to make up for the relatively short growing seasons that this region experiences. Janis and Debbie provided us with valuable local and experiential knowledge on the success and failures they have encountered over the past ten years. Their main recommendations for sustainable operations include: utilizing raised garden beds, composting, and using preventative/ preparative methods such as fencing, rain barrel collection, and the 'pick and squish' method for insects and their larvae.

Abbey Gardens (Cara and Misty)

Abbey Gardens is a garden in the Haliburton area which focuses on ecological restoration and building sustainable communities. The goals of Abbey Gardens include: restoring and protecting landscapes, creating a charity business model that can sustain itself, and food security via growing their own food and teaching others. Cara and Misty (employees of Abbey Gardens) provided important advice from their experiences with sustainability-based practices.

Financial sustainability is maintained by:

- Using and modifying onsite resources such as turning a garage into a seed-starting nursery and utilizing pond water when necessary
- Resources are shared with other operations (borrowing farm equipment)
- Collaborating with local partners (spent grains from the Brewery for soil building)
- Partnering with local universities and colleges on research projects

Attracting community through a variety of options

- Providing a hub for shoppers to buy locally grown fresh produce and locally made meals
- Hosting educational events
- Free and paid experiences and programs for visitors
- Volunteering that build relationships of reciprocity

Building relationships with Indigenous communities

- They contract a knowledge keeper to teach about local Indigenous history, knowledges, and issues
- Employees take Indigenous studies courses
- They are working with Creator's Gardens to install a healing garden: Anishinaabe knowledge holder and environmental science masters student, Joseph Pitawanakwat teaches land based education in the great lakes region, assists in environmental restoration, and builds gardens composed of native plant species that have traditional medicinal uses
- They are provide a home to two Ojibwe Horses (formerly known as Lac La Croix Pony), which are an endangered breed with strong historical and cultural importance to Ojibwe peoples

The Seasoned Spoon and Trent Vegetable Gardens (TVG)

Learning from the community is a vital component of our research because it is important to understand the connections needed to create and maintain local food security. As we discussed earlier, sustainability goes beyond the realm of environmental practices and involves social and economic factors. Meeting social and economic needs in food production requires extensive collaboration and cooperation between producers and beneficiaries. Our group met with employees of the TVG and the Seasoned Spoon (an on-campus plant-based restaurant) to further our understanding of the many steps involved in this process. We learned that maintaining a sustainable garden takes considerable resources (people, information, materials and tools, energy, capital, and time). The seasoned spoon has worked in collaboration with TVG for 17 years; the two organizations can coordinate efficiently enough that 80% of the restaurant's total food comes from TVG. The Seasoned Spoon feeds approximately 75-100 people daily and requires around 30 hours of combined labour from restaurant staff. For this system to function sustainably, it requires constant collaboration and communication between departments; this relationship is built on trust and respect. Furthermore, other project informants mentioned the importance of maintaining knowledgeable and experienced help because it reduces unnecessary mistakes and the consistent resource strain of training.

The World Commission on Environment and Development (1987) states that in order for a project/ organization to be socially sustainable, it must have 1) an accurate understanding of the positive and negative social impacts and 2) it requires commitment and ongoing interest of all participants. The seasoned spoon has specific methods in place to maintain staff and customers, and these include:

- Providing fair wages and annual wage increases (even though they are non-profit and rely on grants)

- Maintaining a compassionate workplace environment (showing kindness, acceptance, and understanding towards individual needs)
- Promoting individual interests by allowing staff to choose their roles
- Encouraging creativity and believe everyone's ideas matter equally
- Value feeding people over profit (will provide food regardless of payment)
- Hosting educational and community building events (soap making, seed saving,

We think Tecasy Ranch does a good job in regards to maintaining community by:

- Providing fair wages ($22 an hour, which is $6.5 more than minimum wage)
- Promoting individual interests (allowing employees the freedom to choose daily tasks)
- Valuing people over profit (donate produce and allow employees to take home extras

For more information on the economic and social aspects of sustainability, we recommend referencing Maia Sitzer's community-based resource management project (#CBR Number: #5092) titled *Sustainable Garden: Socioeconomic Impact*. Maia has done in-depth research on the impacts Tecasy Ranch has on food banks in their community for her project in FRSC4890Y - FRSC Community Based resource management course at Trent University.

Indigenous Food Security

In recognition of our role in the Williams Treaty of 1923 and Rice Lake Treaty #20 of 1818, and in respect of Indigenous peoples' place in current and historical times on this land, and the teachings, ceremonies, languages, and practices that are tied to this land, we think it is vital to incorporate Indigenous knowledge, practices, and interests, into our research and final report. Tecasy ranch is situated on the traditional territory of the Michi Saagiig Nishnaabeg that, includes Curve Lake First Nations, Hiawatha First Nations, Alderville First Nations and the Mississaugas of Scugog Island. We also recognize the Burleigh Falls Metis and nearby Haudenosaunee communities. Before colonization and industrialization, hunting and gathering were the predominant methods of acquiring food for the Anishinaabeg people. Aside from hunting and gathering, many communities in this area also had an important relationship with Manoomin (wild rice). Manoomin continues to be maintained by Anishinaabeg peoples for its important role in the diet of both humans and wildlife and as a culturally significant element in ceremonies and spiritual practices (Whitney, 2015). We want to recognize the many generations of relationships that have existed between Indigenous peoples and this land, and we hope to learn from the reciprocity and methods of sustainability that were historically and are currently used by the original stewards and caretakers of this land.

We would like to encourage going beyond a simple land acknowledgment and begin taking steps to engage in reconciliACTION. Tecasy Ranch can engage in this by learning about the different types of land use, including for the purpose of hunting (if there is an interest/ need). The main goal of this project is to aid in food security; we are curious about what factors are preventing sustainable hunting practices from taking place on this property. Considering the geographic

location and habitat connectivity, it is reasonable to believe Tecasy Ranch is home to a healthy population of deer, moose, bear, and rabbits, all of which are common game species for hunters looking to secure wild meat. Upon speaking with a local hunter (who chose to remain anonymous), we learned that an average deer harvest provides approximately 50 pounds of meat. The average serving for one portion of meat is 4 oz per person. With this information, we can calculate that one deer can provide 200 meals, which is 50 days of meat for a single family of four. An American hunting association called 'Hunters Wholesale' says one serving of venison contains around 150 calories and 30 grams of protein, which is significantly higher than other affordable meat options. Common store-bought meat options have lower caloric value and protein per serving: Ground beef contains 125 calories, and 21 grams of protein and chicken breast contains 108 calories and 25 grams of protein (Hunters Wholesale, n.d.). With 550 acres of land and the goal to increase local food security, foster nature connection, provide a place for education, and nurture the community, we think Tecasy Ranch has a unique opportunity to make a difference in the food security of their community and to challenge conventional perceptions and rules of land use and private land ownership. We would like to consider the many possibilities this project could have and the many different relationships and outcomes that could come from a comprehensive and culturally-inclusive understanding of food security, sustainability, and community.

The lands and waters surrounding Lake Ontario are currently and historically home to multiple Haudenosaunee communities. We believe it is important to recognize the different knowledge systems tied to these lands and consider and incorporate them in our research where appropriate. Multiple agricultural methods were used by the Haudenosaunee people that can be used to help plants succeed in different soils and climates, and we believe could be beneficial for Tecasy Ranch. For example, Wampanoag corn and bean mounds can be created to help maintain adequate water filtration in challenging soils while simultaneously promoting the benefits of companion planting (this method was created by the Wampanoag people of what is now known as coastal Massachusetts and was adopted by Haudenosaunee people and used in this region for many generations) (Eldredge, n.d).

Figure 1: Circular Wampanoag Garden

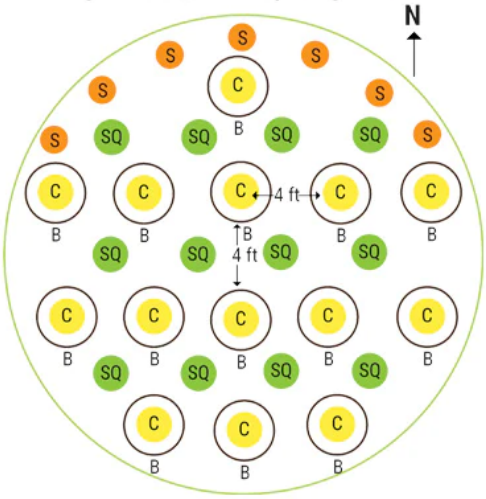
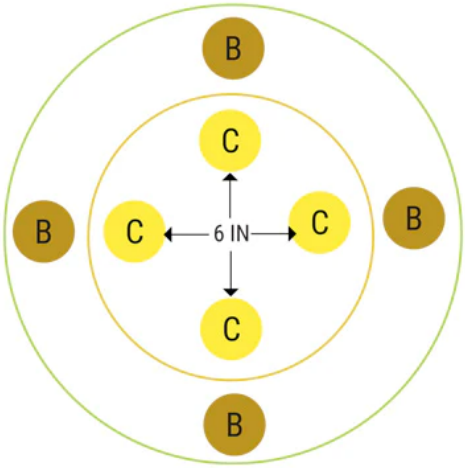


Figure 2: Wampanoag Corn and Bean Mound



(https://www.groworganic.com/blogs/articles/three-sisters-companion-planting-method)

These mounds can be created by piling compost or organic matter (fish, ash, leaves, etc.) and adding soil on top to create a slow-leaching nutrient mound. Corn seeds are planted in the center of the mound, and later beans are planted on the exterior of the mound. Corn acts as the pole for the beans; in return, the beans act as nitrogen fixers for the soil; Squash can be planted last to retain moisture and act as ground cover to prevent weeds and insects from affecting the other plants. Lastly, sunflowers or bee balm can be planted at the garden's north end to attract pollinators. Using a mutualistic relationship, these plants are able to work together to produce abundant nutrient-rich produce while utilizing the most sustainable practices (Kimmerer, 2013).

Geographically specific land-based knowledge and methodologies are important to this project and were noticeably lacking when research focused only on Western science. We think this project could benefit greatly from employing and/or respectfully consulting with Indigenous knowledge holders and land stewards, such as is practiced at Abbey Gardens. Furthermore, we noticed that Tecasy Ranch supplied multiple food banks (Nourish program, Women's shelter in Peterborough, YWCA, One Roof, Millbrook Senior Center, and Kawartha Food Share), which are anywhere from 30 min to an hour away from the gardens; meanwhile the food bank at Curve Lake is merely a 20-minute drive. We believe it is important to minimize storage and transportation times to maintain the highest quality products and limit unnecessary expenses (gas) and time. More importantly, we want to recognize the disproportionate number of Indigenous peoples who struggle with food insecurity due to the historic disruption of food systems (both intentionally (as a weapon by governments) and as a byproduct of industry and development). As of 2021, a study by the Faculty of Health at the University of Waterloo, Cambium Indigenous Professional Services, and Ontario Ministry of Food, Agriculture and Rural Affairs stated the rate of food insecurity for Indigenous peoples was 41.6% which compares to 11.7% for the general population in Ontario (Domingo, 2021). Similar to many Indigenous communities across Canada, Curve Lake has been subject to constant inequities from settler infringement of treaties. Degraded quality and quantity of traditional food systems have led to a reliance on processed foods, thus, a major health crisis for Indigenous peoples across Ontario (Domingo, 2021). For this reason, we highly recommend seeking a relationship with all of the local communities surrounding Tecasy Ranch and reaching out to see if there is an expressed interest/ need to enhance food security in local Indigenous communities.

Suggestions & Recommendations

Community Knowledge and Recommendations: Overview

Each respondent expressed the importance of trial and error because each of their landscapes is different and poses various obstacles in agriculture. Although they have had (and continue to have) various successes and failures, certain failures can be expected; Adequate knowledge and research can help avoid these failures. Cara from Abbey Gardens provided important insight:

> "While experimenting within is good, the basics have long been established, people have been growing their own food for a long time, we do not need to reinvent it, just curate it to suit our targets, our own vision and missions. Great things come from stepping outside of our comfort zones." (Cara, 2022).

We found common ground among all respondents on the importance of building up organic matter in soil; Our formal research (peer-reviewed) strongly supports these recommendations. There are various methods practiced by community members to begin this process:

- Personal kitchen compost
- Collecting compost from community (ex: coffee grinds from local cafes, vegetable and fish scraps from local restaurants)
- Collecting community leaf litter
- Making own biochar/ buying from local source
- Mulching with hay, wood chips, grass clippings, forest matter (needles, twigs, leaves, etc)
- Winter cover cropping (maintain soil structure and retain moisture)
- Three year crop rotation, with every third year left fallow (allow weeds to take over to naturally restore soil fertility)
- Practicing Hügelkultur/ mound culture: using raised beds with buried log and tree matter (for slow and long term nutrient leaching)

Making connections with people who provide the resources, services, or skills you need is important, moreover, it is vital to have a reciprocal relationship where you can provide something for them, whether that is financial compensation, food reimbursement, or opportunities for education. Each respondent/ participant recommended visiting the Peterborough farmers market, participating in local agricultural events, or hosting volunteers and events in order to build these community relationships and connections. *The Market Gardener: a successful grower's handbook for small-scale organic farming'* by Jean-Martin Fortier was recommended by multiple respondents as the 'ultimate guide' in their operations. We analyzed the book and agree that it is an invaluable resource to have on hand.

Future Areas of Research

Our research team has a unique opportunity to make informed recommendations for future student-led projects at Tecasy Ranch. Sustainability is a broad topic, and we found the project to be overwhelming in the beginning. We want to narrow it down for the benefit of future students because there are many different research opportunities, and we would like to contribute to the continuation of this important university-community relationship by recommending a few areas of interest:

1. <u>Forest Gardening/ Orchard</u>

The host expressed an interest in creating an orchard for fruit and nut tree species. We think this is an excellent idea to prepare for future food security, relocalize more food options, engage in the planting of native species, and revitalize traditional forest gardening knowledge/ techniques. Most tree species take around ten years to produce fruit and nuts, so we think it is beneficial to begin research as soon as possible (if this is a significant point of interest).

2. <u>Agriculture and Wildlife</u>

We think it is important to look further into options of deterring wildlife from entering Tecasy's gardens. Multiple community connections agreed that it is not a matter of if, but a matter of when, animals will discover and begin utilizing the plot as a regular food source. The host mentioned an inability to grow certain foods (ex: corn and blueberries) due to bear activity. Once animals become reliant on a food source, it is extremely challenging to change this behaviour. Food conditioning and habituation of wildlife often lead to human-wildlife conflict and are the main cause of wildlife mortality. We think getting ahead of this expected issue is important by looking into Tecasy's wildlife populations and researching options to deter conflict.

3. Infrastructure: Greenhouse, Well, Food Cellar

We recognized the lack of infrastructure as a significant barrier preventing maximum food production. Our research has shown that greenhouse or hoop houses would be beneficial investments to lengthen growing seasons and increase produce quantity and quality. We recognize the host's interest in building a food cellar and think this could present opportunities to decrease food waste and preserve root vegetables to supply food banks throughout the winter months. We encourage looking into drilling a well to secure consistent access to clean water sources. We think a future student research project could assist Tecasy in finding options specific to their individual needs and creating community connections to help build this infrastructure.

4. GIS Mapping

We think an interactive data-based map would provide significant insight into understanding the landscape in order to assist in land management strategies and understanding land use opportunities. This type of map could provide information about vegetation, soils and geology, water systems, wildlife habitat use, and recreational trail use. Students with a background in Geographic Information Systems (GIS) could practice their skills while simultaneously benefiting a local organization.

5. Indigenous Connections

We think Tecasy has an opportunity to make real strides at building important connections with surrounding Indigenous communities. We think a student-led research project focusing on building these relationships would greatly benefit both students and the community.

- Creating fulfilling employment opportunities for community members
- Creating space for Indigenous knowledge and public education opportunities
- Contribute to food security through produce programs
- Support Indigenous environmental issues

For example a project aimed at recognizing the original languages and place names of the buckhorn region. For instance, the trail names at Tecasy are based on local wildlife: moose (mooz), beaver (amik), bear (makwa), fox (waagosh) timberwolf (ma'iingan) (found on the Ojibwe people's dictionary: https://ojibwe.lib.umn.edu/). Consider consulting with an Anishinaabe knowledge holder and language speaker to see if this is an appropriate way for Tecasy to recognize the cultural heritage.

6. Garden Box Programs

We think Tecasy could look into biweekly/monthly produce subscription boxes. Programs like 'the good food box' have been immensely successful in nearby regions (visit: https://ggfb.ca/about-us/). We think this would be a great way to make direct connections with families in need (while also reducing stigma against utilizing food banks), and reach families interested in eating local food and supporting local farmers This program presents opportunities for a 'pay if/what you can' system, which could contribute to economic sustainability from excess produce.

Resources

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