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Colorado Cannabis: Soft Systems Analysis of an Emerging Industry

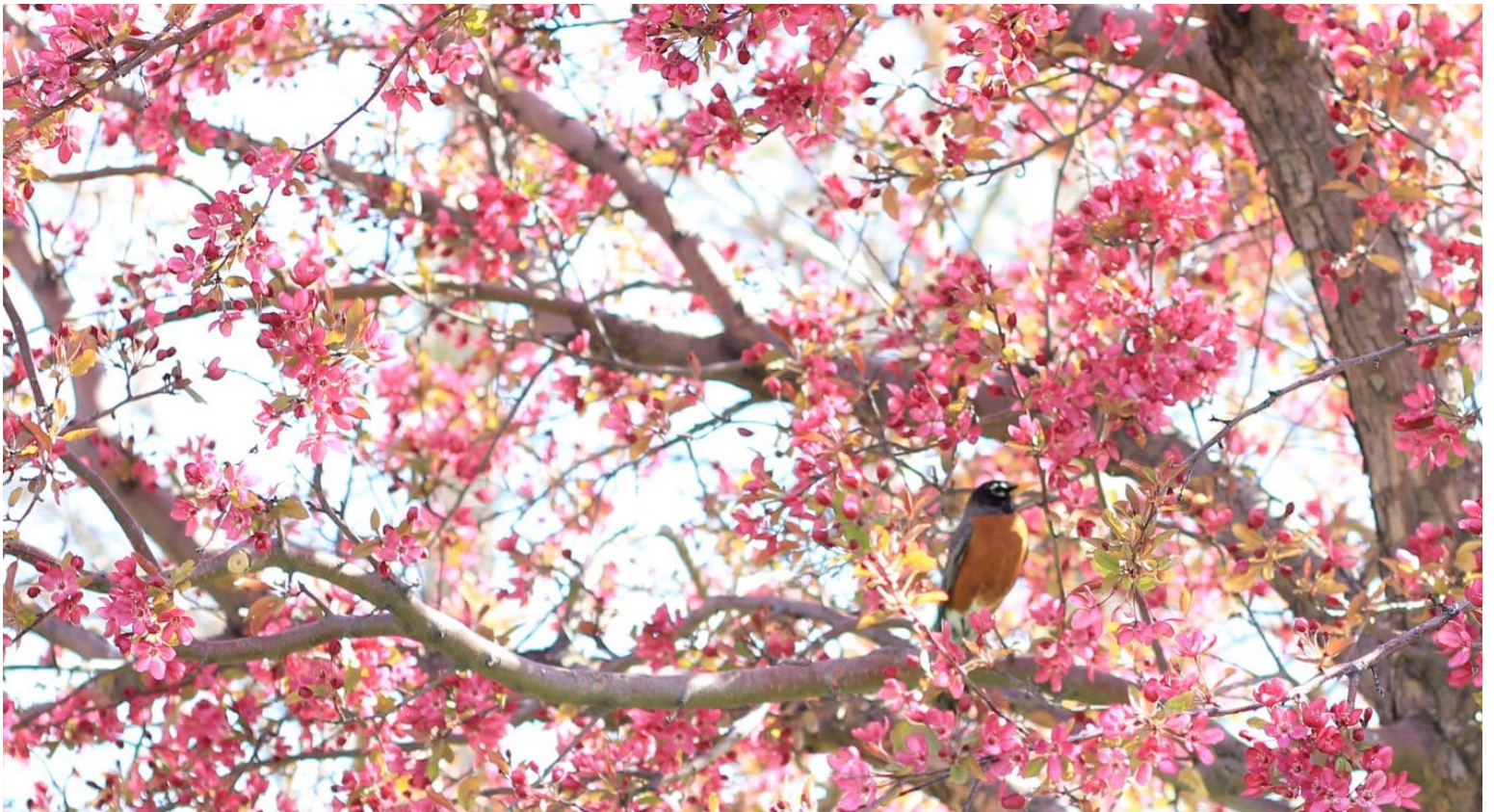
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Abstract

The objective of this study is to describe ways in which rural producers participate in the cannabis industry in Colorado. With recently changed laws permitting hemp and drug-type cannabis cultivation, cannabis could be considered a valuable cash crop for small farmers. Two case studies of growers in rural areas are presented. The first is a licensed hemp producer with a business oriented towards selling cannabidiol (CBD). The second is an organic farm producing as a “caregiver” for medical patients with a prescription for marijuana. Soft systems methodology is used to analyze the cases and situate them in their context. Access to quality planting material, stress concerning the legal situation and exclusion from the formalized industry are important themes.



Foreword

A heartfelt thank you goes out to all those involved in this project. This includes experienced workers in the industry who shared their hard-won knowledge with me and case study participants who were surprised at the depth of the study yet persisted with me anyways and allowed me the time and space for academic work in a hurried business context. It includes friends, new and old, who offered me advice, edited my work, invited me over for dinner and brought lots of laughter into my life. I have long felt that the best measure of a trip is the friends made, and I have certainly made some good ones on this trip.

I want to thank my family for encouraging and supporting my interest in science. I could never do this without so much help.

Finally, I would like to extend a special thank you to my supervisor, Charles "Chuck" Francis for allowing me the freedom to pursue my interest and being fully supportive of the difficulties I faced along the way. You were always able to see apparent difficulties as a chance for reflection, which is a great strength.

Summary

“What would a farmer do if they won the lottery? Keep farming until they run out of money.” – a common Canadian joke

Although repeated with laughter, the above quote underscores a grim reality. Running a small farm for food production in Canada and the USA is often financially unsustainable. This remains true despite helpful models such as Community Supported Agriculture, which has been available for decades (Wells, Gradwell, & Yoder, 1999). Small farms across North America are closing despite our best efforts. Local food systems are floundering as a result.

Small farms that do operate generally do so by using income which is not generated from the food system. Accepting this situation, this research project is oriented towards exploring one emerging option for non-food income which could integrate with and support a small farm operation: cannabis production.

Production of cannabis for chemical compounds used for recreational and medical purposes is becoming increasingly legal across Canada and the United States. Colorado has been a leader in this area, and is therefore a promising site to investigate the impact of this emerging industry. This thesis is a 4 month investigation into how small farms in Colorado are interacting with cannabis production. The central questions are:

- 1. How do small farmers participate in the cannabis industry in Colorado?*
- 2. How does this industry integrate with the surrounding ecology?*

Colorado has a legal structure involving three main sectors for legal cannabis production above the 6 plant limit for private use. Production can be licensed under the Department of Revenue’s Marijuana Enforcement Division (MED). It can be grown under a hemp license granted by the Colorado Department of Agriculture. Finally, it can be produced under an exception granted by the Colorado Constitution designed to allow medical patients access to the plant. Producers under this scheme are considered “caregivers”.

I have spent one month each in Denver, which is the dominant site for by MED-licensed production, on a hemp farm, and on a farm growing for medical

patients. The last two are presented as formal case studies. Important themes are difficulty accessing quality planting material, insecurity with regard to the legal environment, and legal barriers at the local level.

The work has been conducted using an action research framework. To aid the process of analysis, soft systems methodology is used. Photography has been an essential tool to aid the entire process.



Introduction

The marijuana industry is the largest cash crop in North America. Farms are facing an income crisis. This thesis is about connecting the two. Can the marijuana industry contribute to farm income?

The total drug-type marijuana industry has been estimated in 2006 to be worth over 35 billion dollars, representing a larger cash value than corn and wheat combined (Gettman, 2006). Estimating the size of an illegal industry is difficult, and this kind of estimate has been criticized (Thoumi, 2005). However, the legal sector is easier to track, and is demonstrably large. It has been valued at \$5.7 billion in 2015 for the United States (Arcview Market Research, 2016).

Domestic hemp production is only beginning in the USA, so production is quite small. However, importation of hemp products has been legal for some time and there is an estimate available for the size of the hemp industry based on the use of imported products. The Hemp Industries Association estimates the size of the industry at approximately \$620 million for 2014 (Hemp Industries Association, 2014).

On the other side coin, in contrast to these large numbers, is an income crisis for farmers. Farmer are quitting: the average annual gross exit rate from farms in the past three decades has been 10% per year (Mishra, Fannin, & Joo, 2014). This is not surprising, considering their financial situation.

The USDA uses a metric called Operating Profit Margin (OPM) to assess the financial viability of farms. If the OPM value is less then ten percent, this indicates potential financial problems. By this measure, well over half of the farms in the United States have financial problems. Most of this subset lose money every year and only continue to operate because they receive off-farm income which pays for their farming (United States Department of Agriculture Economic Research Service, 2016).

Farming is a large and complex sector and these statements are not meant to oversimplify that. Nor is cannabis proposed as a “magic bullet” solution. However, the figures are striking, and I believe that cannabis may be a small part of a more complex strategy for addressing this problem. Colorado has been a

leader in the cannabis industry. The following are therefore posed as the main research questions in this project:

1. *How do small farmers participate in the cannabis industry in Colorado?*

Since this thesis is conducted within the framework of agroecology, another important question is,

2. *How does this industry integrate with the surrounding ecology?*

There has been a call for research into small scale, ideologically oriented, independent cannabis operations (Decorte, 2010). Although there has not been a large amount of research on the issue, small scale medical providers of cannabis have been recognized for their contributions to the industry (Penn, 2014).

Method and theoretical framework

“Research that produces nothing but books will not suffice.” – Kurt Lewin, 1947 one of the first writers to coin the term ‘action research’.

The entire project is conducted using a framework of action research and soft systems methodology. Peter Checkland has provided some guidance for researchers using these techniques (Checkland, 1999, 2012; Peter Checkland, 1998). This guidance has been accepted and includes giving history and context due weight as well as dissemination of findings beyond those involved in the study. For dissemination of findings I have worked with a professor at the Colorado University at Denver to be interviewed about my work for broadcast on his television show about cannabis cultures (Marty Otañez, fsandgreen.org).

Checkland suggests using rich picturing and system mapping as a part of soft system methodology. Systems diagrams are used in this work as a tool to explain and understand research findings. Rich pictures were created every few days during field work. The volume of information arriving during field work can be overwhelming and taking the time to reflect and create rich pictures using

symbols with creative representation was useful. It helped increase understanding and to reflect during what was often a chaotic situation. The drawings also create a permanent record of themes which seemed important at the time, forming a valuable addition to field notes.

The action research process is often represented as a cyclic one involving reflection and action. The thesis does not exist as a stand alone work but as part of a continuing process involving such a cycle. Prior to this project I studied cannabis and built my skill in chromatography. This was a skill used during this project during my work with the cannabidiol-oriented hemp producer. In the second case, with the marijuana caregiver, I relied on my skill and experience as a farm worker to prepare the farm for the upcoming season. In future, after the reflection involved in delivering this thesis, I hope to continue work in the cannabis industry by comparing my experience in Colorado to the situation in British Columbia.

The emphasis on action research and contribution to stakeholder projects has aided access and produced a concretely valuable outcome for the stakeholders. Offering work in trade for information is an ethic instilled as valuable during my work with farmers in Ontario, Canada. As interns on an organic vegetable farm, my class would often visit farmers to learn about their farm. We would typically split the day in half, helping the farmer with whatever they wanted for half the day in exchange for them teaching us about their farm during the other half. Although balancing the time involved in both can be difficult, it has been an effective method to bring with me into more academic work. Although using a chainsaw and lifting with a straight back may seem out of place in academic work, within the context of action research on farms these activities are right at home.

Part of the pedagogy used in the M.Sc. Agroecology program at NMBU involves recognition of the Kolb learning cycle. This model of learning includes a reflective phase (Kolb, 1984). This was scheduled into the study. After the first case field work I returned to Canada to remove myself from the situation, take care of administrative details and reflect on the case by writing about it. The final writing phase can also be considered a valid reflection phase.

The chosen methodology uses two case studies for central data collection. For study design, recommendations have been taken from Yin (Yin, 2014). The depth offered by case study methodology can reveal questions or themes that were not previously imagined. Through this, mechanistic insight into the situation may be found. As Yin stresses in his description of case work methodology it is important to understand that this qualitative focus is quite different than a study formally involving many participants. Surveys, for example, involve many participants and may search for correlation. Case studies do not offer this, and cannot be expected to.

I have understood Yin's point regarding the role of case studies through an example and metaphor involving organic chemistry. Surveys in the form of studies of collective behavior of different molecules certainly have a place in chemistry. However, the deeper insight offered by a series of case studies was what was needed to develop the concept of aromaticity. Once developed, this concept was important for further work in organic chemistry. Taking place over 104 years, it began by investigating the case of an unusual compound (Newell, 1926), proposing its structure (Kekulé, 1865) and finally confirming its structure (Lonsdale, 1929). In the case of farms, detailed study may also offer the opportunity to describe qualitative phenomenon which may be missed through survey

"If your pictures aren't good enough, you aren't close enough." – Robert Capa.

Photography has been adopted as a technique throughout the study. I have found it helpful to aid accessibility for those unused to academic writing, and to keep records of my work. As an art form compatible with written works, it also brings an element of emotion into academics. Over the course of the project, 2 700 photos were collected. Only a few are presented here, but they have been carefully selected.

An underlying question to the project is, why do people use their income to subsidize farming? This is not a main question under investigation, but unacknowledged, it is an "elephant in the room". The use of photography helps to acknowledge one reason why farmers struggle to remain in a rural situation in

spite of financial difficulty: aesthetic of rural life and connection to nature (Gosling & Williams, 2010).

Photography also fits into the framework of action research because many of the resulting photos are useful for promotion of the business and building community when I share them with participants after the study.

Access and Networks

The networks used to identify case studies were the National Hemp Association (NHA), and Willing Workers on Organic Farms (WWOOF). The first case study was identified through the NHA during their monthly meeting in Denver. The second was identified when a manager at the farm contacted me through a profile posted on the WWOOF website. With limited time to identify candidates, the contribution of these networks was very important.

Context

The legal context has a very important effect in this industry. Largely banned until recently, legal action remains a source of insecurity for producers. The complex landscape is difficult to understand, filled with a mixture of unclear and strict rules which create peril for those attempting to work legally in the industry. The very concept of “legal” is challenged as policies conflict at the varying levels. In some situations the contrast between different legal levels could not be more striking, with one level considering an activity to be perfectly lawful, while another considers it worthy of imprisonment for life. Understanding the landscape is therefore very important to those in the industry.

The plant is illegal internationally, usually ignored federally, sometimes allowed on a state level, governed on a county level with additional rules on a municipal level. On the municipal and county level the landscape is further divided by zoning regulations and distance restrictions to schools and other cannabis operations. Overlap of these regimes combined with the varying attitudes concerning medical, retail and hemp sectors creates an intricate mosaic on the ground.

I will try to clarify the legal situation and overall context here in order to set the stage for the following research. More detailed reviews are available in

legal journals (Hudak, 2015; Stoa, 2016). Key non-governmental organizations have also done considerable legal work in this area and compiled histories. These include National Organization for the Reform of Marijuana Laws, Marijuana Policy Project and Sensible Colorado.

International

There are a number of UN conventions which constitute the legal framework on an international level with regards to cannabis. The United States of America and Canada are signatories to all of them. They are the Single Convention on Narcotic Drugs, 1961, The Convention on Psychotropic Substances, 1971, and The Convention Against Illicit Trafficking in Narcotic Drugs and Psychotropic Substances 1988. The 1971 convention does not specifically note cannabis, but is clearly oriented towards control of substances in it.

The history of cannabis in international law is long, with significance appearance in UN law since 1925. It was at the insistence of the United States that cannabis was added to the most restricted group of drugs and denied any medical use during the writing of the 1961 convention. At the time, the World Health Organization was unaware of medical uses of cannabis (Sinha, 2001).

Not all signatories have followed the spirit of these conventions, notably the Netherlands. They have argued that although the 1961 convention requires marijuana consumption to be illegal, it does not require enforcement of that law (MacCoun & Reuter, 2001). Subsequently, in The Netherlands cannabis sale remains officially illegal but the law is unenforced and cannabis is sold openly in permanent retail locations. However, commercial cultivation is restricted and penalized which is why Colorado has been chosen as a research site in this work instead.

Canada has stated that it intends to change its national law and permit a non-medical cannabis industry. The country must negotiate the international legal landscape in order to do so. The Canadian Minister of Health has publically announced legislation being prepared for introduction in the spring of 2017 (CBC News, 2016).

Uruguay deserves note as a country which has taken initiative and instituted its own laws allowing non-medical cannabis use, in spite of apparent conflict with international law (Pardo, 2014).

National

Many people I spoke to inside the United States, including those involved in the industry, were unaware of the UN conventions in place. In reality, they may not be important in the US context. As noted, the United States federal government is the driving force behind the illegality of cannabis on an international level. As such, although a national level may be considered a level down in the legal hierarchy, the US federal government has long been the primary international power holder. The UN does not directly enforce conventions, so federal law is of much more practical concern.

The most relevant branches of the federal government are the Department of Justice which is the parent of the Drug Enforcement Agency, the United States Department of Agriculture and the Food and Drug Administration. Each of them has associated legislature and budget allocations which inform their actions and form major parts of the soft system controlling cannabis cultivation.

The United States federal government considers all cannabis, including hemp, to be completely illegal through the Title 21 United States Code (USC) Controlled Substances Act. It is registered as a Schedule 1 “substance” (although it contains many unique compounds and varies considerably in character). In order for a substance to be included in Schedule 1 one of the criteria is,

“The drug or other substance has no currently accepted medical use in treatment in the United States.” - Title 21 United States Code (USC) Controlled Substances Act, subchapter 1, part B, 812

There is compelling evidence to show that this is incorrect. A well known example is the treatment of childhood epilepsy (Maa & Figi, 2014). Evidence of the effectiveness of medical marijuana containing cannabidiol is currently supported by a successful Phase 3 clinical trial (GW Pharmaceuticals, 2016). The Drug Enforcement Agency (DEA) has received an evaluation from the Federal Drug Administration with the purpose of re-considering this stance and will

review the scheduling. They have stated that they will release their decision in mid-2016 (Ferner, 2016).

The Agricultural Act of 2014 makes an exception from the Controlled Substances Act for industrial hemp for research and pilot programs ("Agricultural Act of 2014,"). Hemp is defined as cannabis containing below 0.3% tetrahydrocannabinol (THC) for every part of the plant. Although states currently issue licenses for commercial production, the act contains no provision for commercial production. This leaves commercial production still illegal on a federal level and considered production of a Schedule 1 controlled substance.

If the DEA chose, they could persecute any hemp grower in the United States and press for a maximum sentence of life in prison, which is the maximum penalty for the production of over 1000 "marihuana" plants (Yeh, 2015). No doubt an attempt like this would be contested in court, yet it remains a source of anxiety for growers interviewed.

Because hemp is considered "marijuana" under federal law, import of seeds is federally illegal. Only state departments of agriculture and research institutions may import seed through the exception of the above mentioned 2014 act. Practically, importers may experience difficulties as shipments are confiscated by the DEA (personal communication, Brian Campbell, Feb. 4, 2016).

A bill has been introduced into national congress which would allow commercial production of hemp on the federal level, called The Industrial Hemp Farming Act of 2015 (Haas, 2016).

This strict stance at the federal level is obviously unenforced, otherwise the current research would not be possible. The lack of enforcement of federal law is largely because of a policy decision by the Department of Justice, stating that such enforcement is simply not a priority for them. This was announced by the Department of Justice (DOJ) in a 2013 memo from the Deputy Attorney General, James Cole. The memo describes the priorities of the Department of Justice, which omit cultivation, adult recreational or medical use of the plant (Cole, 2013). It is known simply as the "Cole memo".

The act entitled, "H.R.2578 - Commerce, Justice, Science, and Related Agencies Appropriations Act, 2016" outlines the budget for the federal agencies noted in its title. It contains a number of sections which restrict funding use by

the Department of Justice. This includes a section restricting the department from spending money to interfere with medical marijuana use, distribution, possession or cultivation allowed by state laws. It also includes a section supporting the 2014 farm bill allowing hemp cultivation, but only for research and pilot purposes as outlined in that bill. This hemp amendment is redundant, since the farm bill of 2014 states that it exists in force notwithstanding the Controlled Substances Act. However the clarification is useful because the DEA has previously interfered with research programs allowed by the act (S. Nelson, 2014).

The budget has not been passed into law as of writing. According to congress.gov the version of the bill currently in effect contains a clause restricting expenditures on enforcing laws which conflict with state laws regarding cannabidiol. It is absent in the 2016 bill, leaving CBD producers less protected.

The budget does not include any such restriction for recreational marijuana or commercial hemp cultivation, leaving those engaged in these sections of the industry more vulnerable. They are protected only by the Cole memo.

An attempt has been made to use the same technique protect to banks which serve the cannabis industry, but it has failed. Currently, any bank which provides service to a cannabis-based business is in jeopardy of having federal support revoked. As a result, the industry operates largely on a cash basis (Popper, 2016).

For hemp growers interested in cannabidiol production, the Federal Drug Administration (FDA) is an important federal agency. The agency has currently given support to clinical trials of a cannabidiol medical product called Epidiolex™ (GW Pharmaceuticals, 2016). The continued ability of farms to sell cannabidiol on an open market is based on its registration as a dietary supplement, governed by the Dietary Supplement Health and Education Act of 1994. In order for cannabidiol to continue to be sold in this way, it must be shown to have been sold as a supplement before GW Pharmaceuticals applied for clinical trials.

An additional difficulty for cannabidiol producers emerged when the FDA issued warning letters to companies asking them to stop the sale of the compound. Their concerns focused on unproven medical claims made by companies. The Hemp Industry Association has taken a position supporting the sale of cannabidiol as a dietary supplement. They also suggest that companies selling it make no medical claims, in order to avoid FDA criticism. These positions, and links to the FDA warning letters are available in a press release from the association (Clark, 2016). The Hemp Industries Association has been a leader in previous legal issues involving hemp in the United States. For example, they won a court case against the Drug Enforcement Agency in 2003 in the United States Court of Appeal for the Ninth Circuit allowing hemp seed to remain a food item.

The United States Department of Agriculture (USDA) has been conspicuously absent from the situation. They deny that cannabis is an “agricultural crop” (2015). The Environmental Protection Agency also abstains from the discussion, leaving the Colorado Department of Agriculture to issue their own rules regarding pesticide policy for marijuana and hemp (2016b).

Although the lack of active interference could be seen as a blessing, it also means that there is no federal funding available for research or subsidies, except research activity allowed under the 2014 farm bill. USDA certification and federally provided crop insurance, or conservation reserve status may be put in jeopardy by producing hemp commercially (2015b). It also means that no USDA organic certification is currently available. The USDA has granted one organic certification to a hemp producer in the past and quickly changed their mind, deciding that no further certifications will be granted (Runyon, 2016a, 2016b).

There is some independent cooperation between states which helps to fill the gap left by the federal government. For example, the Clean Green certification is being used to certify cannabis instead of the USDA program (Clean Green Certified, 2016).

The Marijuana Policy Project (mpp.org) is a major political influence for changing laws, and summarizes detailed information regarding proposed and passed laws by state (Marijuana Policy in the States, 2015). A summary

published in 2015 describes a summary of the national situation by state. I have collected a summary into Table 1.

Status	Number of States
Medical marijuana legislation in place	9
No jail time for possessing small amounts of cannabis	5
Medical marijuana legislation in place and no jail time for possessing small amounts of marijuana	11
Medical marijuana legislation in place and marijuana is legal for adults.	4

Table 1: summary of state laws regarding cannabis as of 2015

The remaining states consider cannabis completely illegal, consistent with federal law. As the 26th state is (likely) added, this majority situation may further pressure federal policy.

California deserves special note with regards to the national cannabis context. The region known as the Emerald Triangle, including Mendocino and Humboldt Counties, is well known as a leading national area for cannabis cultivation. State law is not as explicit as Colorado regarding the legality of cannabis. However, the crop is informally accepted and forms an important part of the local economy (August, 2012).

State of Colorado

The Constitution of Colorado contains provisions which form the Marijuana Enforcement Division (MED), and the caregiver sectors. These were introduced into the constitution through Amendment 20 and Amendment 64.

Amendment 64 provides special provision for hemp as cannabis below 0.3% tetrahydrocannabinol (THC) (and it describes the MED sector, described below). It directed the general assembly to enact legislation regarding hemp, including the sale of it (which is not allowed under the federal laws regarding hemp, unless it can be argued that sale forms part of a pilot program). The Colorado Department of Agriculture has been charged with the task of implementing the hemp program. The National Hemp Association (nationalhempassociation.org) works together with the department and receives a list of all permit holders, which it shares in a map with members. Since I am a

member I can access the map. It shows approximately 130 licensees across the state.

Caregiver sector

In November 2000, Colorado voters passed the Medical Use of Marijuana Act through Amendment 20 (Miron, 2014). This created Article XVIII, Section 14 of the Constitution of the State of Colorado, which allows the existence of a medical sector involving caregivers who grow for their associated and registered patients. At the time, the Cole memo did not exist but a similar memo had been issued which had a similarly restrained federal interference in medical marijuana programs. It was issued in 2009 by the Deputy Attorney General at the time, David Ogden (Ogden, 2009). Administration of the medical program is overseen by the Colorado Department of Public Health and Environment (CDPHE).

More specific laws governing caregivers were introduced through Senate Bill 15-014 which was signed into law in May 18 2015.

CDPHE publishes detailed statistics on the program. As of March, 2016 there are 2,700 caregivers in the state and 107,067 patients. The vast majority of caregivers (80%) grow for only one patient. Only eight serve more than five patients. Severe pain is by far the leading cause of medical need, followed by muscle spasm. Only 3.5% of patients assign a caregiver to grow for them. Approximately the same amount assign an MED licensed medical facility to grow for them.

The department publishes regulations describing operation of the program. It clarifies points such as a waiver is required for caregivers to provide for more than five patients, marijuana should be provided on a non-profit basis. It also states that the caregiver should have other significant responsibilities for the patient. The regulations are outlined in the Colorado Code of Regulations under the title "Medical Use of Marijuana".

Section 14 of the constitution establishes a basic plant count as 6 plants allowed per patient, and contains language to allow doctors to give permission for a higher number. Although it is common practice to limit the prescribed number of plants at 99, this seems to be an informal policy since it does not appear in their official policy documentation of the CDPHE (Colorado

Department of Public Health and Environment). It is likely a cooperation effort with the federal government since growing 100 or more marijuana plants may be considered grounds for a mandatory sentence by the DEA. This is outlined in Title 21 of the United States Code, section 841, "Prohibited acts A".

Marijuana Enforcement Division (MED) Sector

In 2012 Colorado passed the Amendment 64: Regulate Marijuana Like Alcohol Act of 2012. This changed the Constitution of the State of Colorado, creating Article XVIII Section 16, which allows personal use and regulation of marijuana. It makes marijuana consumption and growth legal for adults 21 and over. The Marijuana Enforcement Division was created under the Department of Revenue to administer the program. It is this sector which dominates the industry commercially, resulting in retail stores.

This sector of legal cannabis is much more structured and clearly regulated than the caregiver sector. Because the sector has a short history and is more organized, much fewer legal questions arise and the description here can be brief. The structure is clearly and publically explained by the Division (Colorado Department of Revenue Marijuana Enforcement Division, 2016). Licenses for cultivation, sale, testing and processing are issued. The medical and retail sector are kept separate on a license basis, but often coexist in cultivation and retail facilities.

The MED publishes statistics regularly on their website. In March, 2016 the MED collected \$12.8 million in tax revenues from marijuana sales, an increase of 63% over the same month in 2015. There are approximately 2500 licenses issued, 60% of which are focused on medical production. In order to work in the industry, employees must be issued license by the MED. There are multiple kinds available, depending on which duties are required. Currently there are over 25 000 employees possessing valid occupational licenses.

The caregiver and MED sector cross over to some extent, and may do so increasingly in future. For example, the MED now accepts voluntary registration of caregivers.

Municipal and County

Colorado is organized into counties, inside of which municipalities claim their own political space. Amendment 64 allows counties to create their own

policies on whether to allow marijuana operations or not. The municipalities are incorporated regions and may choose their own policies, which do not necessarily agree with those of the county.

Colorado has a reputation as a place where cannabis is “legal”, but in many areas business activity is disallowed on the county level. There are 322 counties in Colorado, and 68% do not allow any cannabis businesses under the MED regime. Of the rest only 23% allow both medical and recreational cannabis businesses. 7% allow only medical marijuana businesses and 3% allow retail business but not medical ones (Brohl, Kammerzell, & Koski, 2015). A hemp permit may be held and used in any county but some have distance restrictions in effect in order to keep male plants away from sensimilla operations (Brohl et al., 2015; Fuego, 2015). Municipalities and counties are not able to ban the existence of caregiver facilities since there is no provision made for that in the constitution. However, some counties do limit plant count (Tucker, 2015).

The counties and municipalities are responsible for defining land use using a zoning code. They work with the MED on this issue in the sense that they may deny MED permits based on local zoning rules.

Results and Discussion

I entered the situation by going to Denver. Some initial time in Denver was required to search for case study candidates and write the research proposal. However, Denver is a political center for the cannabis industry and I was also able to visit a number of sites which offer insight into the state of the industry. My experience in Denver to not only helped to understand the context of the following case studies, but also led to finding them.

It was during the time in Denver that I began to create a list of industry stakeholders to construct an overall map of the cannabis industry. The Indo Expo was helpful as a cannabis focused event which took place Jan. 28-29. I attended for one of these days. Throughout the rest of my time in Denver, and periodically during case studies, I added to and constructed the conceptual map shown in Figure 1 (next page).

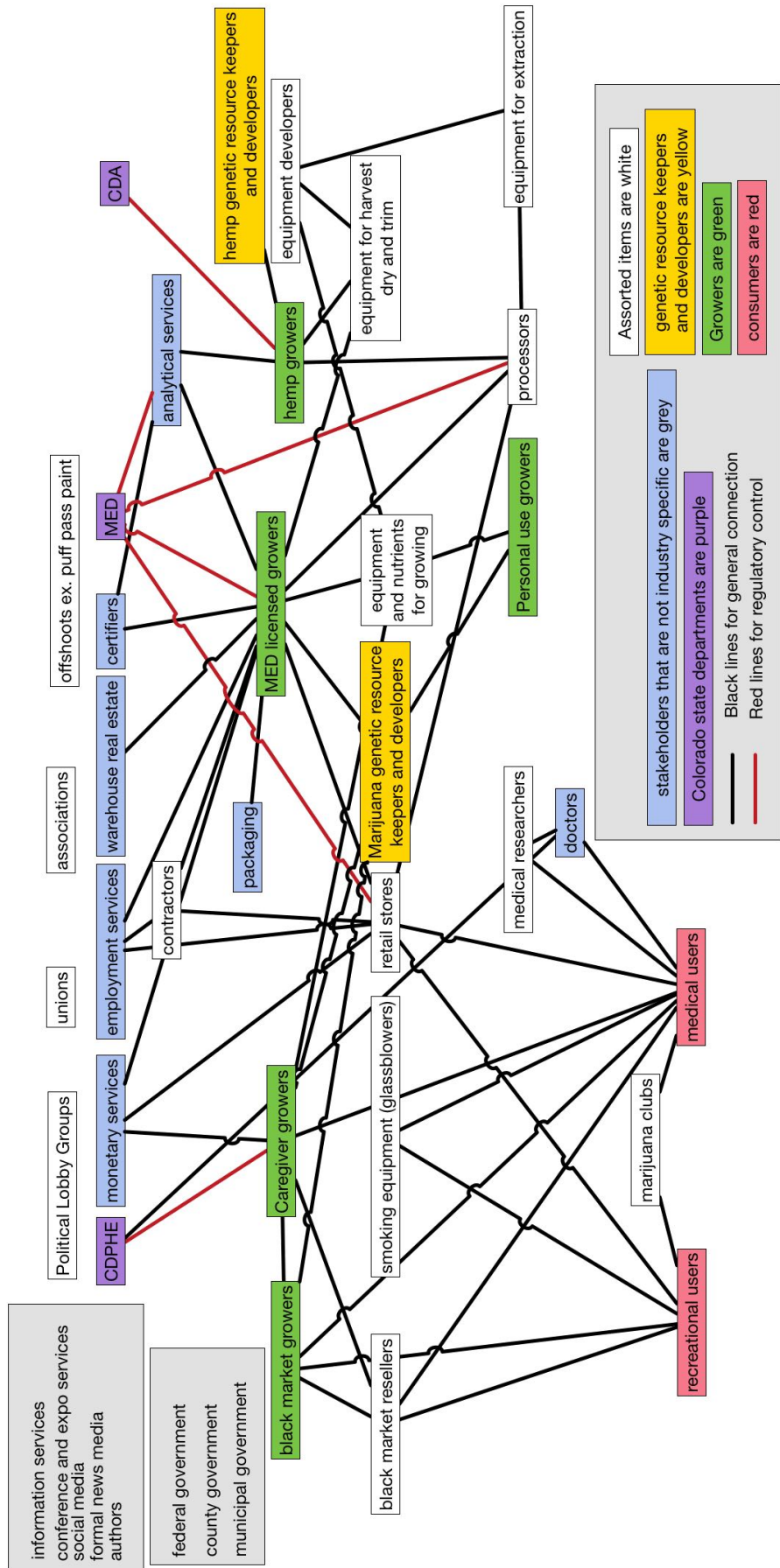


Figure 1 Conceptual map of cannabis industry in Colorado

As with any conceptual system map, the one presented is a simplification of the real world. However, it is grounded in reality with each connection representing a real observation, and each box represents a stakeholder group with at least one real organization in that group observed. Examples are provided in Appendix 1 to aid recoverability.

Observations on the black market and informal sector were possible partly through the decision to live in multiple locations in Denver, changing housing approximately every week to see more of the city. A black market seller was active at one of the hostels. For marketing they simply wrote their name and phone number on the wall of the hostel and undercut retail stores by a significant margin. During interviews, one experienced grower claimed to be able to produce marijuana for \$100 per pound. Lower end retail price in Denver from a MED licensed location is approximately \$6 per g (\$2724/lb). Based on my experience, and interview testimony, black market product is offered at approximately \$100-\$150 per ounce (28g) (\$1200-\$1800/lb). With these figures, it is clear that the black market remains a profitable industry with consumers receiving a substantial discount and growers making a considerable profit.

As an emerging industry, there are many industry events being held in Colorado. During my time in the state there was a Women GROW conference held (womengrow.com). As the name suggests the conference focuses on women leading the cannabis industry. The Northern Colorado Hemp Expo (nocoheмпexpo.com) was also held during the study period. The study contained no time or budget to attend either of these events (the Women GROW conference did have a section set aside allowing men to participate). However, the online video, agendas and personnel involved in each have been reviewed to search for themes affecting the industry. This data has been added to the conceptual map.

During my time in Denver I was able to conduct some informal interviews and one formal interview with an experienced cannabis contractor identified through the United Food and Commercial Workers union. He raised concerns about addiction with those working inside the industry and consumers, especially as high concentration products become more popular (shatter, dabs

etc.). Air quality inside grow operations was a concern, especially in the presence of mold or trichomes suspended in the air. Interesting trends in the industry include heat-press rosin, which is a material made by heating cannabis bud and pressing it to exude the resin. Research into the effect of terpenes was noted as an emerging interest.

I attended a NORML meeting in Denver and was able to ask questions about the political situation. NORML presented its strategy and is clearly taking on a role as a consumer advocacy group in Denver, representing patients and recreational users. This provides an important political counterweight to the power that businesses in the marijuana industry are developing.

I was also able to attend a meeting of the Cannabis Research Group in Fort Collins. Colorado State University is just now beginning its development of hemp varieties. They expect to be able to offer seed for the 2017 season (Colorado Department of Agriculture, 2016a). Whether this seed will be amenable to cannabidiol production remains to be seen. Because hemp research has been illegal in the United States, they largely depend on the European collection. In fact, for the 2015 field trials the University imported varieties involved in the Multihemp project. This includes extremely low THC varieties such as Santhica 27 and promising CBD producers. The Multihemp project is the same European project for which I assessed cannabinoid levels when I studied in the Netherlands. Funding for the research was expressed as a concern, but since research is legal on a federal level, the possibility is open for USDA grant programs such as the Hatch program.

Sector 1: Marijuana Enforcement Division (MED)

I was able to tour through an MED licensed medical and recreational grow operation in Denver. Although the detail gathered is not sufficient to qualify as a case study, the description is offered here and is enough to provide some contrast and points of comparison to case study operations.

The visit began by donning microporous coveralls to prevent infection of the grow area. I then walked alone with the head grower through the operation for approximately 45 minutes. He gave a very practiced description of the growing process from maintenance of the mother plants and cloning to vegetative stage and finally flowering. No photography was allowed. The plants

were remarkably clean, and disease free, although the grower expressed concern that things will remain this way, using the expression “knock on wood” repeatedly. The operation has maintained a no-synthetic-pesticide policy since it was started a number of years ago. He also stressed that the grow is unremarkable in the sense that it uses exclusively off the shelf products, and industry standard growing practices.

The facility consists of three separate rooms. One contains the “mother plants”, cuttings, and plants in the vegetative phase. The other two rooms receive 12 hours of light per day and are used for the flowering stage. The facility is licensed to grow 3000 plants, positioning it in the smallest category under MED regulations. Their goal is to grow 2200 plants. This practice of under-growing to a license is common, with operations typically only growing half the amount of plants allowed (Brohl et al., 2015). In this case it likely is related to physical planning for production: the facility is simply full at 2200 plants, but a license has been granted for slightly more. Plants grow for 16 weeks until harvest.

Production begins with cuttings taken from the mother plants. This provides clones which are nurtured in a “clone machine” (a common cloning technique is described in the Case 2 study). The clone machine is a box holds the cutting above a pool of water after they have been coated with 0.31% indole-3-butyric acid cloning gel. The machine sprays them with water at regular intervals to encourage rooting. The eZclone machine by EZ-CLONE Enterprises is an example. It is very similar to the cloning box used in the Case 1 study, manufactured by Botanicare. At this point the cuttings are not legally considered plants.

The next stage is to transplant the cutting into a medium composed of half black potting mix (containing expanded mica) and half coir which begins the vegetative growth phase. Not all of the cutting are expected to successfully root. The mix is not sterilized in this facility. After transplantation cuttings are legally considered plants and are given a color coded radio frequency identifier tag (RFID tag). The facility is licensed to grow both medical and recreational marijuana, and there is no effort to physically separate these two types during the production process. The MED issues the RFID tags to track the number of

plants grown by every licensed operation, and facilities are regularly inspected. Recreational tags are blue, and medical ones are colored yellow.

A fertigation system is used to deliver nutrient solution to the plants, with one tube leading to each plant. The plants are held on tables with edges and slight inclines, which allow excess solution to run to one end and be collected then held in an open tank underneath the table for re-use. Each table contains a computer operated pump to perform this fertilization. T5 fluorescent lights are used in this room. At an early stage of growth the top of the plant is removed to make them shorter and bushier.

The plants are moved to the flowering room after the vegetative phase. I did not gather data on the timing used at this facility, but flowering normally takes 12 weeks so they are likely moved at the 4 week stage (Cervantes, 2006). Nitrogen content of the fertilizer may be reduced for flowering (Ibid). The flowering room in uses GAVITA e-series improved high pressure sodium lighting, which provides a more yellow color than the T5s used for vegetative growth.

Air intake and output is filtered by a HEPA system. Reciprocating fans are installed on the walls and periodically used to provide air circulation and a physiological response which strengthens the stem of the plant. The plants are also held in place with PVC piping and plastic netting. They grow through this netting as they rise higher, and at some stage are quite entrenched in it as it supports the heavy developing flower buds. Carbon dioxide tanks were visible in the flowering room, and are likely used to inject carbon dioxide into the room to speed growth.

For harvest, the plants are cut at the base and hung upside-down by a naturally occurring branch. The stems are not clipped or pinched as the grower believes that this interferes with cannabinoid production. After 10 days of drying on wires the leaves around the buds are removed, and the buds are removed from the stem. In the past the facility trimmed by hand using scissor since automatic trimmers were considered to offer only poor quality trimming. In the past 2 years automatic trimmers have been improved, and the grower now uses them. These machines save a large amount of labor. It should be noted that trimming by hand is still very common in the industry.

After trimming and drying the buds are “sweated” by putting them in a large drum and closing the drum for 3-4 days. The drum may be opened periodically (“burping”), turned to mix the buds, or simply left alone. This process is believed to change the taste of the marijuana when smoked, making it less “grassy”, which may represent a change in the terpene profile.

Dominant contaminants of concern are grey mold, spider mites, and male pollen. Neem oil, citrus oil, and mineral oil are on hand. Although having operated the grow for years the grower has never seen a male flower present in this grow. The only pest monitoring performed is a visual checklist.

The facility does not process any of its own product after bud preparation. Instead, it contracts to Mahatma and The Lab, which are able to perform propane, butane and supercritical carbon dioxide extractions.

The business intends to construct a greenhouse this summer for production purposes. The facility guide also testified that further south in Colorado there are grow operations that are completely outdoors, protected by double razor wire fences.

Cinderella 99 (“Cindy 99”) was identified as a common parent for many currently used cannabis plants in Denver. The breeding strategy for the creation of this variety is described briefly in Appendix 2.

Sector 2: Hemp Producer Case Study (Case 1)

Cannabidiol Hemp Production Co.

The name of the company involved in this case study is confidential. For the purposes of the description, it will be referred to as Cannabidiol Hemp Production Co. (CHP). This business is very much focused on hemp production, in contrast to Case 2, which is a mixed organic farm. For this reason, the case study report follows a slightly different form than the next. More detail is given regarding production of cannabis.

The farm is located in Delta County, which is in Western Colorado, on what used to be a river delta. The landscape is composed largely of “mesas”, which appear as if they were giant tables dotting the landscape. The farm is located on one of them that borders larger hills, forming a southern shelf. The property itself is 57 acres in total, and includes a number of outbuildings for a total of 9 buildings comprised of a house, 4 sheds, 2 very small greenhouses, and

an indoor cannabis grow facility. Most of the land used to be in orchard, as many surrounding properties still are. Many of them are under organic management and the age of them is mixed, some trees newly planted and some quite old. After removing the orchard due to its old age the land has been used for hay. From the owners perspective as a successful real estate manager and reseller, orcharding has not been considered a business worth pursuing.

With a good yield, the hay crop is expected to be worth approximately \$20 000. An arrangement with a neighbor has been made for them to produce the crop, sell it and keep half of this revenue. However, a history of recent years shows that the hay crop often sells for less and may not be harvested at all if a skilled individual cannot be arranged to operate the irrigation. In recent years the owner has voluntarily forfeit the arranged 50% of any revenue, considering the income too marginal to pursue. The property has often been occupied by cows from a neighbor during the winter months (Figure 2) which is not seen as a significant source of revenue.

As noted in the Context discussion, hemp permits were first available in Colorado in 2014. A permit was obtained soon after. At the time, the owner was engaged with the county and neighbors in a struggle to subdivide the property. This subdivision process has since been successfully carried out. But the process was a long one and during the struggle, a hemp business was started in order to gainfully use the time spent waiting.

Delta County is one of the many counties in Colorado which does not grant permits for cultivation of THC containing cannabis. For this reason, CBD production was chosen although there is expressed interest in drug type cannabis production. The initial business plan was to produce high CBD varieties indoors and extract the CBD with butane. An existing barn was converted into a grow facility for this purpose.

However, it became obvious that butane extraction carries a significant explosion risk. Also, the business experienced challenges removing the butane from the extract. Although as a farm property and business it would be possible to take care to set up a safe operation, the effort may not be worthwhile considering other available options. The business now focuses on ethanol extraction instead.

Producing a good CBD yield while remaining under the THC limit of 0.3% has been a challenge. One way to cope with this has been to harvest the plant early, before full cannabinoid production is complete. This lowers yield but remains within the legal parameters of the hemp permit. Other challenges include relationships with staff. By the end of the study period, the business was in a state of significant flux, with a strong interest in outdoor production of CBD containing hemp flower.



Figure 2 Cows inhabit the field in the winter months.

Physical

The soil in the area is fairly deep, with an initial horizon over 30 cm. It is naturally quite rocky but the rocks have largely been removed. The alluvial mesa formation is gently sloped to the south, with slightly rolling topography.

A former nearby research station provides a reliable description of the area. The soil type is clay loam, elevation is approximately 1 700 meters, with an average annual precipitation of 30 cm. There are 150 days of frost free growing per year. Average highs are 30°C in July, 3.3°C in January, average lows are 13.3°C in July and -8.3°C in January (Godin et al., 2006).

Because the area is irrigated using surface water, the water table is not used for agriculture and the aquifer is not discussed here.



Figure 4 *Artemisia tridentata subsp tridentate*, Basin Big Sagebrush, distinguished from Mountain Big Sagebrush (subsp. *Vaseyana*) by a rounded rather than flat top.



Figure 3 Juniper (*Cupressaceae*) flower. Junipers tend to exist on the edge of sagebrush landscapes.



Figure 5 A milkvetch, *Astragalus*, likely a native nitrogen fixer

Ecosystem

Sagebrush Ecosystem

The farm is situated in a “Big Sagebrush” ecosystem, inside the Gunnison basin. This type of ecosystem is named for the presence of taller sagebrush species, particularly *Artemisia tridentata* (shown in Figure 4). Although the area receives an average of only 30 cm of precipitation per year, this type of ecosystem supports a vibrant array of life. Many species find sagebrush to be a useful food. Basin Big Sagebrush can be distinguished from the similar Mountain Big Sagebrush by a rounded rather than flat top (Shultz, 2012).

There are a number of threats to this ecosystem, and agriculture is one of them. However, invasive species, particularly flammable grasses, are a considered a more serious threat (Rowland, Suring, & Wisdom, 2010). Although the sagebrush has generally been removed by machine it is still visible in some areas. It occurs together with juniper (Figure 3) in this area, the encroachment of which is considered a threat to

the sagebrush ecosystem (Ibid). The wet conditions caused by irrigation do not allow sagebrush to re-establish itself in farm fields (Schlaepfer, Lauenroth, & Bradford, 2014).

There are areas of the farm which are difficult to irrigate, and could be returned to sagebrush. However, sagebrush habitat can be very slow to establish and the additional diversity added by it to the farm may not be significant for decades.

Inclusion of native species of plants

Inclusion of native vegetation in the crop plan is desirable as a technique to integrate with the surrounding ecosystem and potentially useful plants to exist, for example plants belonging to the nitrogen fixing milkvetch family (*Astragalus*, shown in Figure 5) (Decker & Anderson, 2004). However, the natural vegetation is adapted to low water conditions, and is unlikely to survive in irrigated agricultural conditions. Even returning areas of the farm which are difficult to irrigate to native vegetation could be difficult because removal of rocks from the soil has permanently changed the area. Rocks can have an important role in concentrating rainfall during revegetation (Buckner et al., 1998).

Birds and Bats



Figure 6 Mountain Bluebird

As wildlife that eats insects, some birds and bats can be a valuable part of a farm, stabilizing insect populations. Notable in this case are Mountain Bluebirds (*Sialia currucoides*). These birds are insectivores, which positions them as a particularly helpful bird on a farm (Herlugson, 1982). Unlike other birds, which may eat seed, increasing the population of insectivores is not expected to cause problems with establishment of a crop, or with yield. On a research scale, field trials at Colorado State University have noted problematic consumption of seeds at the harvest phase by birds, including blackbirds (Brian Campbell, personal communication, February 4, 2016). Mountain Bluebirds were noted on site at this case study, and their population may be encouraged by providing housing.

Bat houses were in use on neighboring orchards. The case study farm contained none, and could consider joining in housing efforts for bats.

Mammals, passage and movement



Figure 7 red fox (*Vulpes vulpes*) crossing the farm field



Figure 8 skunk (*Mephitidae*) living in an unused irrigation pipe

The mesa is home to many animals, although my own sightings were limited to common ones such as skunks and red foxes. Habitat loss is a major impact of agriculture in general, and I believe that strategizing around reducing this loss is an important part of agroecology. One issue evident in this case study is fencing.

A number of deer species live in the area including mule deer, *Odocoileus hemionus* (Chapman, 2006). Fruit cultivation is popular in the area and deer fencing has been erected around many properties in order to prevent the deer from eating tree leaves. The neighboring properties contain orchards, so deer fencing is in place around the entire border of the farm, with the exception of some areas bordering the road. This is fortunate because deer can be expected to eat hemp, since it is a palatable leafy green. Other farmers have reported problematic consumption (The Associated Press, 2015).

Feces on the ground and visual confirmation of their presence indicates that deer are comfortable using the southern section of the property, which is fairly open to the road. However, there are very few signs of deer using the northern section of the property for passage or browsing. The northern land area is separated from the southern one by a gate, and the lack of traces indicates that deer are uncomfortable or unable to use it even when their presence would cause no harm (as in the winter months).

The northwest corner of the property borders a non-orchard area which connects to a potential corridor. Passage through the property could be useful for deer or other animals. With this situation in mind, the wildlife habitat potential of the property may be improved by using a (lower) southern gate which allows deer traffic, and a northwest exit. These entrances may be opened only during some parts of the year. Using a specific timing strategy rather than complete exclusion can help to balance

wildlife needs for movement during calving and migration with the need to protect crops (Hanophy, 2009).

Inside the property, short barbed wire fence suitable to contain cattle is present. Since that is no longer the intended use of the land, removal of the fence is possible. This could facilitate movement across the property, and reduce danger from entanglement in the ageing fence (Ibid).

The deer fence reaches to the ground, but the observation of the movement of a red fox (*Vulpes vulpes*) through the property has been observed. Some beneficial small holes must exist, permitting some movement of some smaller, non-target species. In the case of red fox access, an obvious potential benefit is mouse and vole population control since these small animals are typically part of the red fox diet and may eat freshly sown grain seed. The presence of burrows and runways likely belonging to voles but perhaps to shrews, mice or moles was noted in the field. Long tailed voles (*Microtus longicaudus*) are expected in the area (Andelt, Ahmed, & Jones, 2015).

Social

Historically, the region was inhabited by the Southern Utes. In fact, the entire west state was considered Ute territory in 1868. They were confined to smaller and smaller areas until the present situation, where they reside on the Southern Ute Reservation in southwestern corner of the state (The Southern Ute Indian Tribe, Unknown year).

A cornerstone of this case study is a feminist worldview. Several times the owner expressed that motivation for the project was to raise money to donate to feminist organizations, although such donation is not currently practiced. Patriarchal attitudes were viewed as an extreme problem in the organization, and there was much heated discussion about attitudes with respect to this.

The labor situation on the farm was such that many people whom I spoke to expressed concerns about job insecurity. The organization was going through considerable reorganization and the number of employees changed quickly with five core individuals and multiple short term informal employees.

The project is supported by the owner's family, who live nearby. Organizational support is given, with the name of the project being registered in the name of a parent.

The owner has no intention of keeping the business, and would rather sell it in order to be free to move to California. In the interim, the preference is to find a manager

to build the business enough to sell it. Having been unable to identify a manager willing and trusted to do this, the owner feels forced to stay to work on the project.

The business owner has collected considerable capital from success in purchasing, selling and renting real estate in California, Colorado and Oregon. Interest in cannabis originated from both personal medical need for cannabidiol and experiencing the cultural acceptance of the plant while living in California and Oregon. Although the property is now successfully subdivided, the owner has kept the property and intends to build the cannabis business to a point where it can be sold, and then sell the project as a package. There are no specific motivations regarding sustainable agriculture, but there is interest in organic certification because of a perception that the medical cannabis market demands a product clean of toxic chemicals. Although there is a large kitchen garden on the property, the owner has expressed no interest in any crop other than cannabis.

Economic

The economic context of the area involves coal mining as a core economic activity. The industry has decreased recently, leaving Delta County searching for new industrial activity to encourage (Harmon, 2014).

At the time of the case study period, the business was experiencing a cash flow difficulty, which causes stress around payment of salaries and subsequent job insecurity. This will likely be resolved later in the season as properties owned in Oregon are re-mortgaged.

Given the history of this case, it seems clear that the economic potential of hemp has offered a counterbalance to suburb development. If this were not the case, the business would simply be closed and the property sold off in subdivided units as planned. This may still happen, depending on the success of the business and the prices available in the local real estate market.

An illustration of the potential revenue of the business is not difficult to show, and will be provided as a comment. Cannabidiol oil was observed for sale in a Denver dispensary at \$80 per gram. The concentration was unstated on the product. For the purposes of estimation let us assume the concentration was very high, and cannabidiol can be valued at retail for \$80/g. The number of plants produced by this operation was still under planning, but selecting a reasonably small number of 500 plants, modest yield of 200 g per plant, and 6% CBD in the flower, 6kg of cannabidiol is a reasonable estimate for an annual crop. At the retail level this represents a revenue of \$480 000. At

least one company is available for contract processing, charging \$40/lb and representing a processing cost estimate of approximately \$8 800 (Carpio, 2016). The market demand for volume of cannabidiol is more difficult to estimate, but 6 kg of the compound clearly does not represent a large enough amount to impact the state market. As noted, removal of tetrahydrocannabinol from the material may represent a challenge. Although it may require some investment, from a technical point of view this is not difficult, through the use of vacuum distillation and column chromatography (Adams, Hunt, & Clark, 1940; R. A. Nelson, 2000).

Material Based System Map

Accurate diagrams of the farm may be drawn from many perspectives. However, the production of cannabidiol is a fundamental component of the operation. A rich picture showing material flow focusing on cannabidiol is presented in Figure 9. As an emerging business CHP is actively making changes to its process but this is a description showing the situation and immediate plans at the end of the case study.

March 25 2016

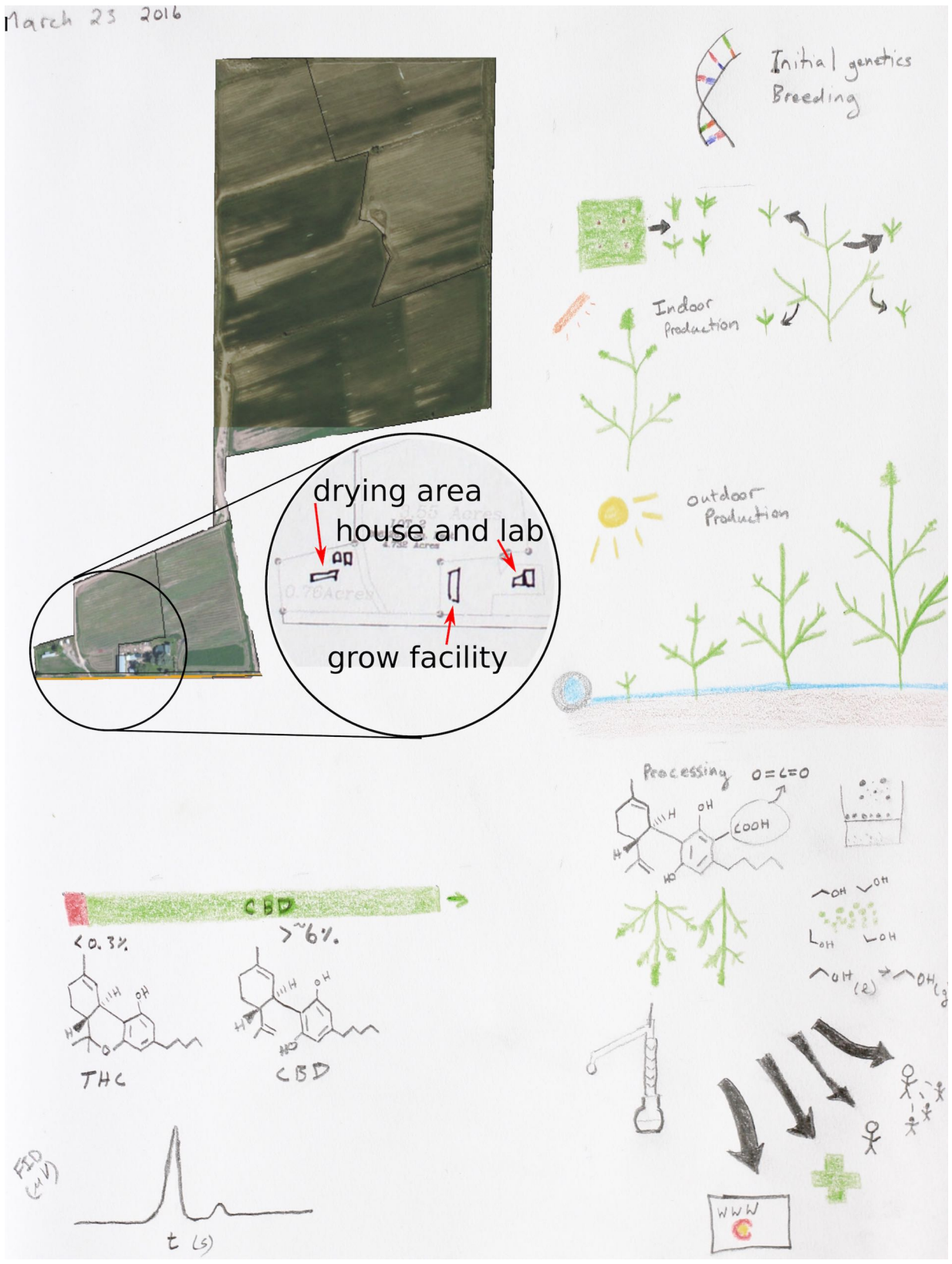
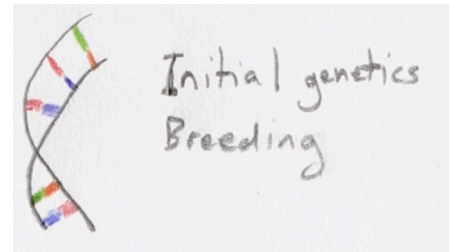


Figure 9 A rich picture of CHP based on the creation and flow of cannabidiol. Material flows from the top right to the bottom right.

Initial Genetics

Obtaining quality seed is one of the primary challenges facing CHP. Other nations, such as France and Canada, have fairly well developed seed industries and are able to produce quality seed (Bouloc, 2012). However, importation of viable hemp seed into the United States is federally illegal except for research use by an approved institution (CDA, 2016).



CHP has obtained seeds from many sources inside Colorado, and imported seed as food from the United Kingdom which apparently does not render the seed as non-viable as Canada does. Many of these seeds have been grown to maturity to assess the source. However, upon growing the seed the cannabinoid content has often been disappointing. The plants typically contain THC levels above the legal limit, even when pollinated. Although influenced marginally by environmental factors, THC level is broadly considered to be a genetic factor (Pacifico et al., 2006).

CHP has therefore initiated its own breeding program. However, breeding is complex and long-term work complicated further by the fact that hemp is a wind pollinated crop with large isolation distance required. Marijuana growers typically cope with this fact by basing production around clonal propagation of female plants. Because cannabidiol production can currently sustain a high market price, this laborious technique is also possible for hemp production.

In-house clonal propagation for the 2016 season may be impossible for CHP because key mother plants owned by the company were killed this past winter by an accident which froze the plants. In response to this, \$2000 was invested in a number of new transplants which were purchased from a grower assuring that the THC content was low. Upon analysis, this was found to be misleading. The transplants will not provide sufficient quality material for clonal propagation. At the time of finishing the case study, the business was searching for available options.

Seeds available ultimately originate from illegal import. Much of it has been informally bred on a very small scale by nearby growers. No quality source had been confirmed for this season for CHP. The Colorado Department of Agriculture recognizes seed (un)availability as an important challenge for the industry. They have issued a statement to this effect (CDA, 2015a). Colorado State University (CSU) is working to vet varieties from a European source but will not be able to provide seeds for the 2016 season (Brian Campbell, personal communication, February 4 2016). Patents have been applied for regarding promising local Colorado varieties (Lowe, Curran, & Franz, 2016).



Figure 10 Indoor grow facility



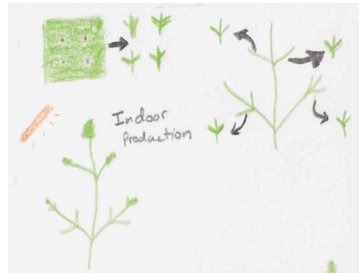
Figure 11 12 hour photoperiod bloom area



Figure 12 18 hour photoperiod vegetative area



Figure 13 left: powdery mildew right: whitefly trap



Indoor Production and Propagation - The Barn

Regulators allow a grace concentration of THC content for this emerging industry, and CHP has been able to attempt production despite their difficulty sourcing ideal genetics.

The business has invested \$200 000 to construct a 2500 square foot indoor grow facility (Figure 10). The facility is split in half for two grow areas. One is programmed for 12 hours of light per day (Figure 11). The other is programmed for 18 hours of light per day and includes a cloning area and workspace (Figure 12). The longer photoperiod area is used for growing plants in the vegetative period, and the shorter photoperiod area for flowering the plants. Design of the facility very much follows the normal design of a THC-based cannabis operation. It has been designed to produce mature plants, but in future may be used for nursery and breeding operations as focus moves towards outdoor production.

Indoor production is based around a hydroponic system. Seeds are grown in a rock wool medium, and regularly fed by flooding with liquid food, shown in Figure 16, which then returns to the tank under the table. The liquid food is considered expensive and rarely discarded, but when cleaning is necessary material is discarded into an outdoor garden area.

There is an area of the building dedicated to vegetative propagation from cutting. When plants outgrow the rock wool medium or vegetative propagation area they

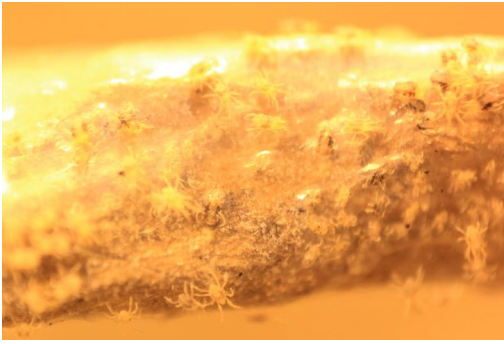


Figure 14 Mites, which have completely encased a leaf



Figure 15 Pesticides in stock



Figure 16 nutrients used

may be planted into a potting mix in preparation for outdoor transplantation.

Or, they may be moved to a pot containing coarse rock medium for further indoor growth by the hydroponic system. During the winter season growth is confined to indoor growth, and the building is heated with a pellet stove. During summer production is moved outdoors and the building becomes hot enough that air conditioning would be required for continued indoor use. A small greenhouse is under construction to complement the facility.

Plants in soil medium, in preparation for outdoor transplanting, are watered manually because the pumps involved in the hydroponic system cannot endure abrasion from dirty water.

Control of the ecology inside the facility is a challenge. There has been considerable damage from two spotted spider mites, *Tetranychus urticae* Koch (Figure 14) and one or more powdery mildews, perhaps *Podosphaera macularis* (Figure 13, left). Whiteflies, likely *Trialeurodes vaporariorum*, are a minor pest and yellow traps are used to control them (Figure 13, right). The business does not operate according to organic principles, and stocks a number of pesticides, including Eagle 20, Serenade, and Avid as shown in Figure 15.

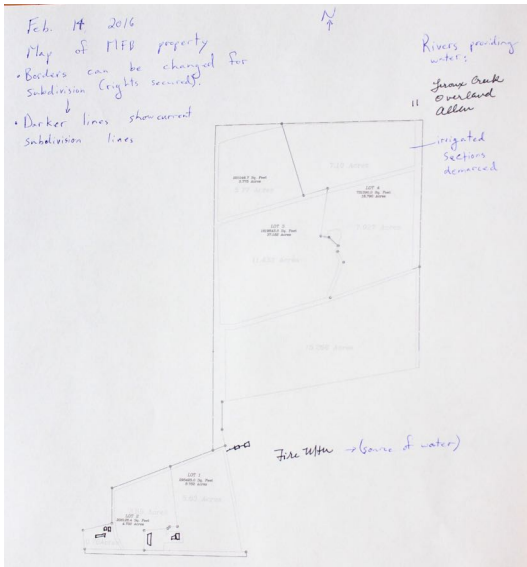


Figure 17 Map of CHP property



Figure 18 Satellite image of the property, from Delta County GIS system



Field Production

During the summer months, CHP raises hemp outdoors, and controls 57 acres of land (Figure 9). June 7 is the goal date for all hemp to be planted out from the indoor facility. This was done for a very small area with transplanted clones during the 2015 season. Some transplants plants are available for planting out this season. If seed can be secured for the 2016 season then a much larger outdoor area can be planted

Pollen production is a major concern. When planted by seed half of the plants can be expected to be male. Illegal operations involving production of sensimilla marijuana may be disturbed by this pollen. In addition to normal levels of neighborly discontent, CHP perceives a genuine risk of being a target of violent attacks, including arson, should pollen disturb illegal growers. One potential strategy is to plant at spacing large enough to remove male plants as their sex becomes noticeable. This represents a significant labor requirement. In this scenario nearby plants will likely be pollinated but pollen output will be limited.

The irrigation system used is one common in the mesa. Underground pipes and ditches carry water to headpipes, which dispense the water by flooding. Shallow trenches at centers of approximately 60 centimeters guide the water along the ground, known as “furrow irrigation” (Godin, Larsen, & Pearson, 2006). Water is dispersed unevenly, which is visible in the satellite imagery (Figure 18). The field is greener uphill, near the headpipe. Also, the land has a natural gradation which interferes with even flow. The visible



Figure 20 Deer fence surrounding the property.



Figure 21 furrows to guide irrigation water



Figure 22 The upper soil horizon in the center of the north field. The leatherman tool shown is 15 cm long.

pattern follows both gradation and distance from headpipe fairly closely. Realistically, this type of irrigation necessitates a certain amount of runoff in order to adequately water the far end of the field. However, total runoff from the farm is limited because trenches at the end of the field guide the water into a downstream headpipe. Depending on the starting point, excess water may enter and be dispersed from a headpipe up to three times before leaving the property.

Water is supplied from a number of sources, both canals and creeks. The northern area receives water from the Overland, the Allen and Leroux Creek while the southern one is watered by the Fire Mountain Canal. Delivery is managed by a mixture of privatized and state companies, some requiring a telephone request for delivery, and others flowing freely. They distribute water in varying amounts throughout the season, for example the Leroux is plentiful in the spring but less volume is available later in the season and the reverse is true from other sources. Manual gates and valves on the property result in a complex system requiring a knowledgeable operator and considerable labor. The volume available is generally not interpreted as a limiting factor in production.

Since production of hemp is federally illegal, irrigation water from federally managed sources must be mixed with other sources in order to be legally used to irrigate a cannabis crop.

As noted, the land is a former river delta, deposited from the Rocky mountains. A substantial amount of rocks have been removed from the field, and while a significant amount remain, it is possible to use disks and other cultivation equipment. Digging a hole in one of the main fields shows an A horizon over 30 cm deep (Figure 22).

The Colorado Department of Agriculture has clear policies on sampling required to enforce the 0.3% THC limit. Growers pay for an inspection visit if selected, and if the THC levels rise over 1% they may be reported to law enforcement. Farmers must give notice to harvest 30 days beforehand, and may be notified by the CDA within the next 20 days if they are selected for inspection (CDA, 2015b).

Technically the harvest date must be announced by the farmer. However, the notification window is large enough to harvest early and salvage a crop if a crop is approaching the legal THC limit. This is a strategy used by growers, and no penalty seems to be incurred from harvesting early than announced.



Figure 23 Hemp hanging to dry

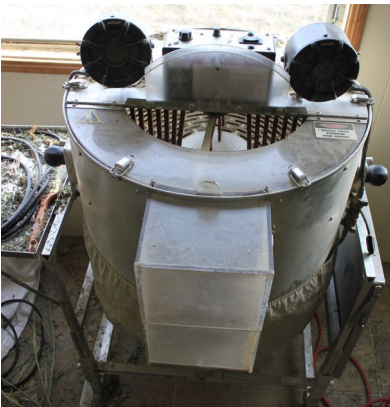
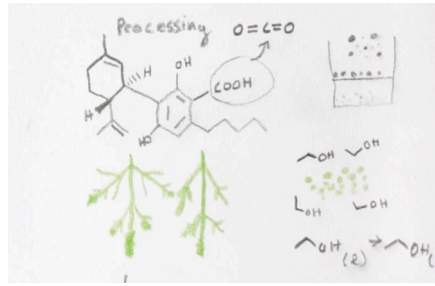


Figure 24 Automatic trimmer



Figure 25 Fractional distillation apparatus (not set up for vacuum use)



Harvest and Post Processing

A crop which is brought to maturity using the indoor facility has typically been processed by cutting the plant and hanging it to dry in a building made from a portable trailer, as shown in Figure 23. For the 2016 season, harvest and process procedures are still to be decided.

In the past, after drying a crop in the portable trailer, CHP has then processed the plant by removing the flowers by hand from the stem and feeding the material into an automatic trimming machine (Figure 24). The machine currently in use is called The Satellite, manufactured by EZ Trim (eztrimming.com) and retailing for approximately \$7000. As used, output from the machine consists of three different particle sizes. The finest of these can be expected to contain the largest amount of cannabinoids since the trichomes are small and contain the largest concentration of cannabinoids. A transition may be made to a simpler shredding machine able to grind stem.

The material is then decarboxylated, if desired, by heating in an oven. Some non-decarboxylated products are offered. Heating must be carefully controlled as excessive heating will decompose CBD. Decomposition of THC to CBN also occurs during heating. Experimentation was done as a way to reduce the THC content using heat. Unfortunately decomposition under these conditions occurs in approximately a logarithmic fashion, and destruction of THC in the material by heating is not a promising technique because CBD is also destroyed excessively. The plant material is bulky and decarboxylation at this stage is not strictly necessary. It can also be performed after the extraction stage.

The material is extracted once with food grade 90-95% ethanol. Cannabinoids are very soluble in ethanol, and minimal solvent is necessary. Contact time tends to be long, over ten minutes. The liquid is separated from the plant material and the planned process is to remove the ethanol with a D4AB Megahome Dual Water/Essential Oils home distiller.



Figure 26 Extraction and product preparation space



Figure 27 example of a finished container of salve approximately 10 ml in volume (logo and name removed for anonymity)

Previously, slow cookers have been used, and the ethanol not recovered. The distillation device noted is a stainless steel one-plate distillation apparatus with air-cooled condenser and thermostat which shuts off the device just below the boiling point of water. It has a liquid capacity of 4 liters and as a consumer device it retails for approximately \$200. Once the ethanol is removed, the solvent can be re-used for another extraction.

The remaining material is a thick paste containing a high percentage of cannabinoids in addition to waxes, proteins and sugars. Legal sale of the material requires that the THC content be below 0.3%, so it must either be diluted, purified, or the starting material must be very low in THC. Experimentation with atmospheric pressure distillation shows that it is unsuitable (apparatus shown in Figure 25). Without the boiling point depression provided by a vacuum cannabinoids may be thermally degraded, heat required is excessive and degradation of sugars leads to compounds which require further effort to remove.

CHP initially planned to use butane extraction, but found that the hazards associated with residual butane present in the material were excessive. The state of Colorado independently corroborates this finding and has banned this extraction method for use on marijuana in a home setting (Kennedy, 2015).

After extraction and any necessary purification or dilution, the next step in the production process is mixing desired formulations and packaging (in the space shown in Figure 26). CHP creates a number of products such as gelatin capsules, preparations for sublingual ingestion, and topical salves (Figure 27). Additives focus on natural ingredients, including beeswax, tea tree oil, and other essential oils.



Figure 28 analytical laboratory with GC on the left

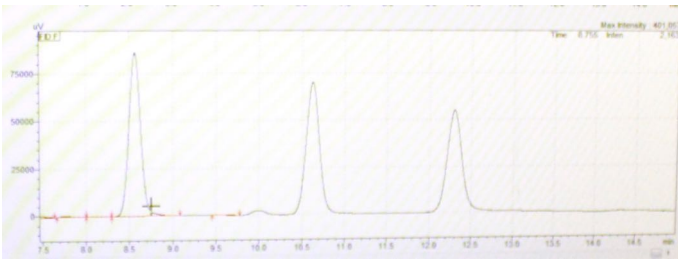


Figure 29 chromatogram of standard solution containing THC, CBD and CBN

Analytical Monitoring

CHP has invested considerably in the ability to monitor cannabinoid content. The central piece of equipment in the effort is a Shimadzu GC-2010 gas chromatography machine with an MXT-35 column and flame ionization detection. This main piece of equipment retails for approximately \$25 000.

This setup represents an acceptable industry standard in analytical technology for neutral cannabinoid assay. The plant material is first extracted with methanol, then injected using an autosampler and autoinjector. A small laboratory supports this procedure, providing space for sample and standard preparation (Figure 28). Results are gathered from the chromatogram (example shown in

Figure 29) and compared with a linear calibration curve made from standard solutions.

A home laboratory is denied full support by some laboratory supply companies, such as Sigma Aldrich, since it exists at a residential address. However, despite this challenge the laboratory is able to operate with support from other analytical companies and smaller chemical and equipment retailers. Online sourcing and postal delivery of equipment and materials is essential.

Analysis is performed at multiple stages in the production process. Breeding efforts are supported by sampling young leaflets of plants, as well as more mature plants. Legal compliance is supported by sampling plants during production to ensure that they do not accumulate excessive amounts of THC. The final harvest material is tested for THC and CBD content. Finally, the evaporated ethanol extract may be subject to quality control.

Operation of analytical equipment has been a challenge for the business. Initial training on equipment was provided by the manufacturer. However, it was received by a staff member who has subsequently left the organization. A standard operating procedure for analyzing plant material has been developed, but other testing procedures have not been recorded in writing.

Marketing

CHP has sold very little product to date. Marketing of CBD is legally complex, and they are currently deciding their strategy. As with other farm products, the point at which the goods are sold with regard to wholesale vs retail is an important strategic decision. Another key element of a strategy is the targeted client, which may be a number of different types of organizations or individuals. Geographically, CHP intends to sell only within Colorado, avoiding confrontation with the federal government over interstate commerce.

Wholesale Vs. Retail

The sale of CBD containing material can take place at many points between a sufficiently mature plant and a finished retail product. Sale of dry bracts harvested on a field level is possible immediately after harvest. At this point the product is not ready for ingestion and wholesaling to a company which will process it further is the most obvious option. However, selling the product this early in the supply chain may result in only a small portion of the potential net from the full retail value from reaching the farm. For a company far removed from any final market, or with well developed production capabilities this may be a good option. CHP is neither. In fact, CHP is considering the converse; purchase bulk material and carry out the rest of the process to make a final retail product.

The dry flower bud may be saleable if it is sensimilla, and can therefore be consumed directly by smoking. However, CHP perceives that Colorado currently contains no well developed market for high CBD sensimilla.

The most likely strategy at the moment is therefore to process the material at least to the point of an evaporated ethanol extract before. However, at this point the product has been concentrated and until CHP can obtain plants which produce a lower THC content, it cannot be legally sold because the THC content is above the 0.3% legal limit. It must be purified or diluted before sale, and CHP must either contract the job or develop a procedure for this.

Correct dilution and dose control an important part of manufacturing a final product. After this is complete, CHP intends to package the product in a manner useable for retail distribution.

Branding, Advertising and Distribution

The FDA has issued statements to a number of retailers stating that CBD does not qualify as dietary supplement. The letters demand that the companies stop the sale of their product. This occurred in late February in both 2015 and 2016. Despite warnings the companies continue to operate. The FDA has taken no significant action to enforce their demand, yet may in future. The letters issued focus on retailing CBD through websites, and the existence of medical claims. Successful clinical trials of Epidiolex™ would place cannabidiol more strongly under FDA management, leading to concerns that the FDA may enforce a monopoly on behalf of GW Pharmaceuticals.

An online presence is perceived by CHP as how the FDA identifies targeted companies. Partly because of this, some companies have chosen the strategy of selling CBD containing material only as wholesalers with no consumer interaction. For example, CannaVest has reported selling 150 t CBD containing hemp concentrate annually as of 2014, and does so as a wholesaler only (Cantú, 2014).

A restriction on online marketing represents a potentially valuable lost market segment. Yet marketing online may risk closure of the company by the FDA. CHP has therefore discussed partnering closely with a different company, one which does not have significant capital investment. CHP would provide unbranded product, and the other company would handle online retailing.

Alternative channels include sales directly to individuals via referrals, as well as sales through larger purchasers such as medical dispensaries. Marketing of cannabis products is further complicated by the fact that federal mailing services are unavailable. The United States Postal Service has made it clear that their service is not to be used to advertise cannabis (USPS, November 27, 2015). Customers may include recreational or medical dispensaries, individuals, processors and medical professionals such as homeopathic doctors.

Future Changes

The description presented here attempts to give a useful illustration of the operation. However, the production model is far from fully decided. As an emerging business, CHP is still deciding both details and overall strategy for its operations. The business does intend to upscale operations to the field level, but

quality seed is critical to this. There are reasonably large quantities of seed available, but the cannabinoid content which final plants will contain is uncertain. This content has critical implications for downstream operations.

If transition to outdoor production is possible, and quality CBD containing material can be produced, then the indoor growing facility may be transitioned to another use such as breeding. The owner of the company has permission, based on medical need (chronic fatigue) to grow 24 cannabis plants with any cannabinoid content. This permission may allow the freedom to legally explore breeding options which do not conform to hemp qualifications during the breeding program. Or, the facility may be rented out or directly used for THC containing cannabis if legal permission can be arranged.

The company has considered expanding its operations to other properties in order to produce multiple varieties of hemp and maintain isolation distances. Naturally, this strategy could accommodate breeding efforts.

Sector 3: Marijuana Caregiver Case Study (Case 2)

The origin of a caregiver

The area that this particular grower is base in has traditionally been a productive shortgrass prairie, inhabited by species such as bison and blue grama grass (*Bouteloua gracilis*). The ecoregion is Front Range Fan, an unusual mixture of prairie and a considerable amount of aquatic space (Chapman, 2006). A number of indigenous groups inhabited the area going back approximately 12 000 years (according to the land bridge theory, which is refuted (McGhee, 1989)).

Those living in the area included the Ute people. Permanent European colonization in the area began in 1858 with the establishment of what is now LaPorte. This was followed by increasing colonization marked by the 1864 massacre of local Cheyenne and Arapaho, led by Colonel Chivington. By 1867 ranching practices had destroyed the wildlife to the extent that traditional subsistence was impossible. Remaining indigenous people were removed by colonists in 1878 (Fort Collins Museum of Discovery and Poudre River Public Library District, year unstated).

Interviewing the current owner has given the following account of the farm.

The family which currently owns the homestead moved Larimer County to become established on the land in the 1960s. The impulse to transition to organic methods came after a family pet was poisoned by pesticide. The farm was an early adopter of organic practices, with an important role in formalization of organic certification in the area.

The farm was inherited by a son, having graduated in the 1980s with a degree from the nearby Colorado State University in agriculture and finance. In the early 1980's the family also purchased a retail store which they still possess and operate as a garden store. It is located in a city to the north. The store has never been perceived as profitable, but contributes to brand image and community building efforts.

Farm production focused on wholesale vegetables and some grain for many years. Products were supplied widely, with customers sometimes located on distant points of the globe. Experiments with community supported agriculture were not successful, although they were attempted. Given the timing, this may have been because of lack of public awareness necessary for acceptance of an unusual marketing model.

In the early 2000's the farm began a survey to explore the market for home delivery of food and experimented with other products. In the mid 2000's the farm began a Community Supported Agriculture operation (CSA), which is now recognized as one of their most successful decisions. However, the CSA was insufficient to raise the farm out of accumulated debt. The farm experienced financial difficulty, entering chapter 11 bankruptcy. At the same time, it was drawn into a lawsuit involving abusive treatment of migrant laborers by one of the middle managers. By the end of the decade both issues had been resolved and the CSA was operating with strength.

At this point the farm controlled over 500 acres, placing it in the largest category of farms outlined by the United States Department of Agriculture (USDA).

After its inauguration the CSA grew quickly, and its offerings evolved with it. By the start of the next decade the CSA was one of the largest in the nation. In the early 2010's the farm hired a new farm manager. Early in the growing season the owner of the farm was diagnosed with cancer. During the hiatus necessary

for treatment the farm was subject to a “hostile takeover” by a combined effort of family members, a competitor and the newly hired manager.

The struggle resulted in millions of dollars of unsold crops by the end of the year. This led to again entering Chapter 11 bankruptcy. After returning from successful treatment, the farm owner searched for an investor and identified a chapter of the local Slow Food movement. After considerable fundraising, the organization was able to offer a substantial investment with the condition that it be repaid at the end of the season.

In return for the loan, financial control of the operation was given to the loan agent in 2012. 2012 and 2013 were difficulties for the farm because of weather: hail, drought, nearby fire and subsequent flood. The fire caused a water shortage the following year (Ingold, 2012; Oropeza & Heath, 2013; Stormersite.com, 2012; Taylor, 2012; Thomas, 2012). In addition, there was a nationwide recall of spinach over concerns of e. coli contamination (News Desk, 2013).

This coincided with problems on the farm of a more human nature. During 2012 the owner perceived that the agency which lent the farm money did so with predatory intent. Having lost control and overview of the finances of the farm, the owner came to be under the impression that money was deliberately being removed from the farm for the private benefit of the individuals newly involved in financial management. As a technique to stop this from progressing, chapter 7 bankruptcy was declared in an effort to involve a trustee and request an audit.

As a result, assets of the farm business were liquidated, including the land which was sold to a different organic farm and the intellectual property. Intellectual property lost included the customer list, which was sold to a competitor, and the name of the farm. The farm was reduced to a homestead of 19 acres.

The following year, 2013, the name of the farm was re-acquired along with some other critical intellectual property. The CSA business was able to continue on a smaller basis, leasing land for production and reselling food from other growers. The farm shifted their business strategy and began to focus exclusively on a CSA model for the sale of food.

The following two years were difficult ones for the CSA, with limited infrastructure and poor staff retention. As a result, the reputation of the CSA suffered, with poor customer reviews. However, strong sales strategy and efforts to manage public relations were able to grow the CSA membership significantly.

The farm is currently reorganizing into a corporate structure, and is searching for investors by offering stock. The new farm strategy involves a move towards more collective ownership and community building.

Physical

No map of the property is supplied because the information is considered too specific, and could easily lead to the identification of the stakeholder. The participant in this case study expressed particular concerns over anonymity. Having recently lost control over almost all of the property that used to compose the farm, the farm is in the process of re-acquiring space to produce food with. The homestead of 19 acres can supply only a small fraction of the food for the planned CSA. For this reason, a physical map is less useful than one would normally be.

The soil type on the farm has been characterized by a laboratory at Colorado State University as similar to Altvan. Altvan is recognized as particularly susceptible to wind erosion (United States Department of Agriculture, 1962). A wind event observed was observed during field work on April 5. Figure 30 shows reduced visibility caused by soil eroding from land previously controlled by the farm owner, before losing it through bankruptcy. As a result of different management practices, similar surrounding fields did not experience this erosion. In addition to permanent soil damage, the dusty conditions caused by erosion reduce the quality of the cannabis crop by coating it with dust.



Figure 30 wind erosion event

The homestead has a well. It is outside the nearby alluvial aquifers, placing it in an area tapping into the Dakota-Cheyenne aquifer. Well water is an important source of irrigation in the area but approximately $\frac{3}{4}$ of the county's water use is surface water (Ground Water Atlas of Colorado, 2003). There is a water shortage expected for municipal and industrial in many areas of Colorado. Larimer County is expected to be one of the most water stressed areas (Camp Dresser & McKee Inc., 2010). This can be expected to cause shortage in available irrigation water from surface sources since the municipality owns most of the water in the area, and currently leases extra to agricultural use (Colorado Water Conservation Board, 2010). This priority which the nearby municipality takes over the water supply is what led to the irrigation shortage after the wildfire noted above.

Ecosystem

The natural ecosystem type of shortgrass prairie has been almost entirely displaced by agriculture. Rabbitbrush (*Ericameria nauseosa*) exists on field edges. This notable as a native plant with an important ecological role for pollinators and as wildlife forage (USDA NRCS, 2016).

Observation of birds indicate that the population is composed of those that establish themselves in human dominated environments. Photographs and subsequent identification indicate the presence of the dark eyed Junco (*Junco hyemalis*), house sparrow (*Passer domesticus*), white crowned sparrow (*Zonotrichia leucophrys*), red winged blackbirds (*Agelaius phoeniceus*), yellow headed blackbird (*Xanthocephalus xanthocephalus*), brewer's blackbird (*Euphagus cyanocephalus*) and Swainson's hawk (*Buteo swainsoni*). The website

allaboutbirds.org, organized by the Cornell Lab of Ornithology, was used for identification. The area has been subjected to considerable survey efforts and is identified as important habitat for many species, including the federally threatened Bald Eagle (*Haliaeetus leucocephalus*) (Doyle, Neid, & Rondeau, 2005).

A short survey of grasses growing in non-lawn areas of the farm, such as the orchard, indicate that native grasses have been displaced. Grasses observed are twitchgrass (*Agropyron repens*), domestic wheat (*Triticum spp.*) and brome grass (*Bromus inermis*). One of the native varieties still present and observed was bluebunch wheatgrass (*Pseudoroegneria spicata*) (USDA NRCS, 2016).

Trees planted on the property include lilac (*Syringa vulgaris*), decorative cedars, pines (*Pinacae* family), fruit trees (*Rosaceae* family) and quaking aspen (*Populus tremuloides*). As a prairie area, these trees seemed to have trouble surviving, killed by wind, drought and cold. They currently have a role in sheltering the birds and acting as windbreaks. Native trees still present include prairie willow (*Salix humilis*) and eastern cottonwood (*Populus deltoides*) (USDA NRCS, 2016). Both of them clearly have a role in providing habitat, judging by the number of birds frequenting them.

Although the comments here are critical because the farm clearly displaces native prairie, as an organic farm it compares favorably to other likely land area uses such as chemically based farming and suburb development. This is underscored by observations such as bird nests built in the plum orchard trees and dark eyed juncos feeding on insects in the fields.

Social

The farm has both permanent, seasonal and migratory staff, using both visiting Mexican labor and US citizens. Permanent staff has a role in caring for animals on the farm and the cannabis crop. Seasonal labor, both visitors and citizens, are employed during the growing season. CSA shareholders are invited to have only a very minor role in farm labor, receiving a small discount for a small amount of work. They are more welcome to join the commission based sales system for selling shares.

One of the major outputs, perhaps the main one, of cannabis production is considered to be social. The owner takes a political stance that medication should be free, and distributes CBD product for free. For this reason, the option of obtaining a hemp license and producing income with it is not entertained here.

There are many other positive social outcomes from the farm. Understanding them adds important weight to the argument that the farm should be supported, possibly from legal cannabis income. Community building is a major social outcome. At this time it is composed of a number of components, including inviting local schools to visit the farm (for a small fee), education of interns (who aid in running the farm), and the hosting of concert events and dinners, both in exchange for ticket prices. Many of these community building efforts return value to the farm because they raise its public profile and encourage new members to join the CSA.

The farm is in the process of refocusing on community building. In the past they have focused on food production with a privatized model. Regrowth of the farm after a difficult period will be conducted by instituting a board of directors and issuing stock enabling stockholders to vote on management of the farm. Relinquishing management control of the farm in this way represents a fundamental change in the future of the operation. One expressed reason for this is social sustainability. A collective structure allows the farm to operate when one day the current owner is no longer part of it.

An obvious social outcome of the farm, and one emphasized by the owner, is providing livelihoods to those employed by it. Expressed principles include support for a higher minimum wage, and recognition of the need for collective action on the matter.

Economic

Obviously, the farm has experienced a considerable amount of recent financial difficulty. Given the data presented from the USDA in the introduction, this is not surprising. The CSA model has been in operation at the farm for long enough to make an assessment of it, and it has been identified as the most profitable section of the farm. This, combined with a re-orientation towards community building, are why the CSA is now the main focus of the farm.

Each weekend during the case study period the farm conducted dinners in which invitees viewed a presentation about the farm and were asked to invest in it. The requested investment is locked in for a period of time, a (generous) dividend offered and stock issued in exchange. The stock forms part of a Securities and Exchange Commission supported corporation. In the strategy of the farm, this investment is seen as replacing a bank loan.

The CSA and commitment from members is viewed as a substitute for crop insurance. It was repeatedly stated that vegetable growers are not offered insurance. Crop insurance of various types is available, but may not be satisfactory or well known. Existing programs are offered by the United States Department of Agriculture's Risk Management Association (USDA-RMA) for both organic growers and vegetable growers. However, policies are usually based on records from previous years. They can also be highly specific, for example insuring one type of chili pepper but not another (USDA RMA, 2011a, 2011b). Both represent challenges for a quickly growing CSA intending to grow "unusual" crops.

The farm has an economic strategy of specialization which I have found to be unusual in small scale organic farms. An example of this is that they purchase all of their young plants ("starts") from a nearby company. This specialization makes them highly dependent on the nearby company.

Cannabis

The farm recently began growing as a caregiver registered with the CDPHE, with a waiver for permission to grow up to 99 plants. Operations are still in the learning phase, and during my visit a highly experienced outside consultant (who used the pseudonym "Dutch") was visiting on a regular basis to help. This particular individual was evicted after the house they were renting changed owners. They ran a small growing and breeding operation in the home. Now without a place to grow, their plants were transferred to the case study farm and a temporary joint operation was started. The plants were carefully raised, with no significant sign of common pest problems, and in much better condition than those found in Case 1. Two spotted spider mites, scale, russet mites, root aphids and mold were noted as concerns. All plants were

unpollinated females. The lack of infection on the plants was largely attributed to only permitting clean plants to enter the growing space.

As noted in the Context discussion, the caregiver framework does not allow sale of cannabis to anyone other than the prescription holder. The intention of the legislation is to provide medical cannabis at cost. It is therefore not legal to sell cannabis and generate significant income. The economic role of cannabis on this farm is considered theoretical, and discussion of legal barriers is an important theme. The cannabis efforts are distinctly separate from other farm operations, since the CSA and retail store are both legally for-profit operations.

The operator of the farm specifically asked that no photos of cannabis plants be shown. In the spirit of voluntary participation, and understandable concern about an uncertain legal environment, this request will be honored even though it conflicts with the planned methodology.

I first entered the growing area with Dutch in order to see the pruning process. The first pruning performed is to cut off the apical section of the plant after approximately 5 nodes are formed. This causes a shorter plant to develop with multiple leaders. However, at the time that I entered the grow the plants had been growing for approximately 13 weeks and were in the process of flowering. At this time a second pruning is performed in order to remove leaves from the center of the plant, improving air movement and preventing mold formation. After pruning the plants are physically supported with stakes, zip ties and where necessary wrapped with tape to prevent branches from splaying outwards. The day was April 9, bringing almost exactly 13 hours of daylight each day. This is over the 12 hour recommended amount for causing plants to flower (Cervantes, 2006). The longer light regime was expressed as a concern. With extended daylight, the concern is potential reversion to the vegetative phase. Even partial reversion may lower the quality of the crop.

On April 19 I was welcomed to sit in on a cloning session to create 100 clones. Dutch showed the common cloning method used by larger MED licensed growers, having worked for one for years. Cloning is done by cutting larger branches from the “mother” plants, bringing them to a work table and cutting this branch into smaller pieces. Each piece contains a length of the main stem and a single node containing leaves. The leaves are gathered into one hand and

trimmed with scissors to approximately half their size in order to limit transpiration and avoid dehydration. Cuttings produced are approximately 10 cm tall. If the stem is older and stronger (from lower on the branch), rooting is encouraged by scraping the stem. The apical section is also used as a clone, and of course contains multiple nodes. In this case, a “cloning machine” was not used, but instead the cuttings were dipped in Clonex (indole-3-butyric acid) gel before inserted into peat moss plugs, watered well and enclosed in a plastic case to maintain humidity. In approximately seven days the cuttings are expected to have visible roots extending from the plug, can be removed from the high humidity environment and transplanted into soil (unused potting mix).

The previous year, young cannabis plants were included in the vegetable operation, simply being given a row of their own. For me, this practice highlights the similarity between cannabis and vegetable cultivation, and the common skillset that they share. Growing inside a greenhouse provides more privacy and may address concerns over theft of the crop. A diagram of the greenhouse used is presented in Figure 31. The sides were painted with a thin white paint which blocked direct view of the plants. The floor was made with pebble, no air filtration system or supplemental lighting was installed. The sides are made of sheet plastic and roll up for additional ventilation when required. The plants were placed in large (approximately 100 liter) pots filled with potting mix. After cannabis production there was intention to use the soil for tomato production, but having participated in filling pots for tomato production I can say that a different material was used this season. Although the pots were quite large, they were also provided with soluble nutrients on occasion. No permanent fertigation system was installed, fertilization was delivered with a watering can by hand. Grow Big™, made by Fox Farms was stocked, as was Cocos A and Cocos B by Humboldt Wholesale. The latter two are intended as fertigation ingredients for a coir grow medium. A lemongrass, castor oil and agricultural soap mixture (“Pure Kapow!” by Pure Nutrients) was also stocked for pest control, but after discussion it was clear that it was not considered good practice to spray developing buds with anything that could alter their flavor.

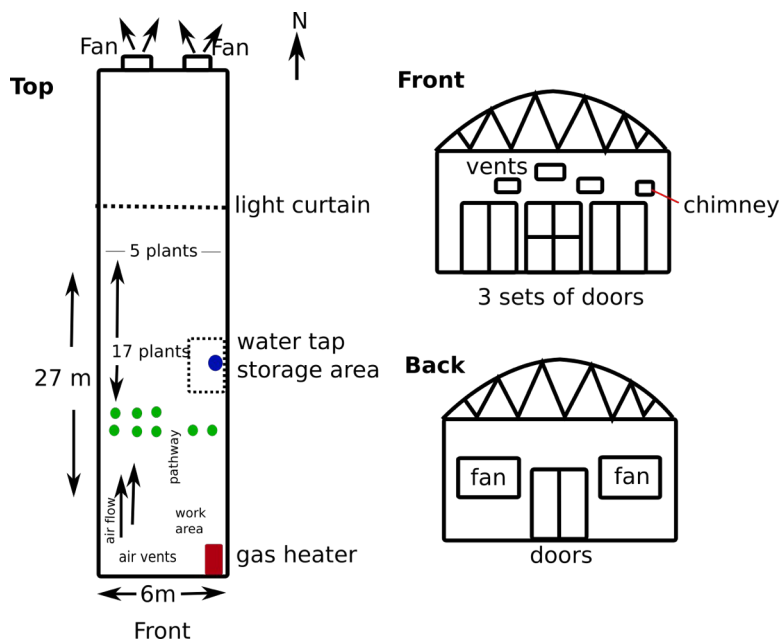


Figure 31 Diagram of greenhouse used to produce cannabis. Photos are omitted upon request of case study participant.

During my stay I was also welcomed to participate in the trimming process. This was performed by cutting the plants away from their root, and bringing them into a room with a table for further processing. From here, we cut the excess leaves off the buds with garden scissors, stopping periodically to clean the scissors with isopropanol to prevent resin buildup (which causes the scissors to stick). Dutch was very clear that using gloves is a necessity, and nitrile gloves were used to prevent absorption of compounds through the skin. After cutting excess leaves off, the bud is cut off of the stem. The unpollinated flowers trimmed in this way are placed on a screen to dry, with electric fans used to ensure that the process proceeds in a timely manner. Drying is carefully timed, and can affect the final quality considerably.

Leaves which are removed contain a considerable amount of cannabinoids and are kept. They are dried and may be used processing into extract. Although still under discussion, there was interest in an ethanol based process for extraction. This was referred to as “Rick Simpson Oil” or RSO, although Rick Simpson actually uses a hydrocarbon based extraction (Simpson, 2014). Ethanol extraction may be a safer option since the process using hydrocarbons may contain toxic residual solvent (Luigi. L. Romano, 2013).

Varieties in use included Blue Dot, noted for its high CBD content and LA Ultra, a cross between MK Ultra and LA Confidential.

When asked about the long term plans for cannabis cultivation, the farm owner expressed lack of long term interest, affirming that focus of their activity is on food production. Nevertheless, in the past inquires have been made about establishing a grow operation under the MED framework. The county denied a license because of zoning restrictions. In Larimer County, MED licensed cannabis production is zoned as industrial or commercial (Larimer County, 2013). The farm under study is considered zoned as “open” (Larimer County, 2014).

System maps

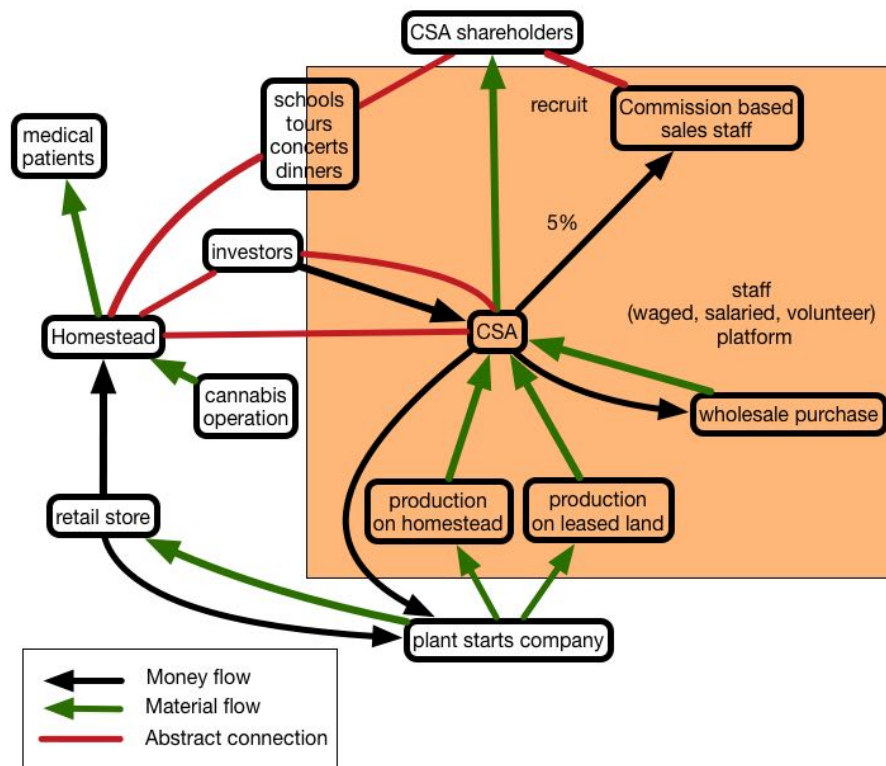


Figure 32 representation of the current situation at the Case 2 farm.

The preceding description and discussion form a background. This could be interpreted metaphorically as underlying layers of a system map, or lying outside the borders of a map. Figure 32 representation of the current situation at the Case 2 farm. It is built on a labor perspective, with the central component being a staff “platform”. Operations may be envisioned as moving on and off of this platform, either supported by staff efforts or not. Some activities such as school tours are partially supported by farm staff, but largely run by others. Obviously, there are many pieces of the farm that are not shown including obvious details such as incoming material flow to the wholesale purchase. The

plant starts company is not, strictly speaking, part of the farm but it is unusually critical to its function. Abstract connections shown refer mostly to management influence.

Using this constructed map, I have envisioned a legal cannabis operation as part of the farm, proposed in Figure 33. Income from a viable operation could be used in many ways, but it is drawn here specifically to support desires expressed during interviews. The cannabis operation is also moved to receive more support from the farm staff, and away from connection with the homestead. This follows farm strategy to plan for long term social sustainability by moving management and ownership to a more collective system. Profit from the cannabis operation is shown as being donated to the CSA, used to raise wages, save seed and repurchase lost land.

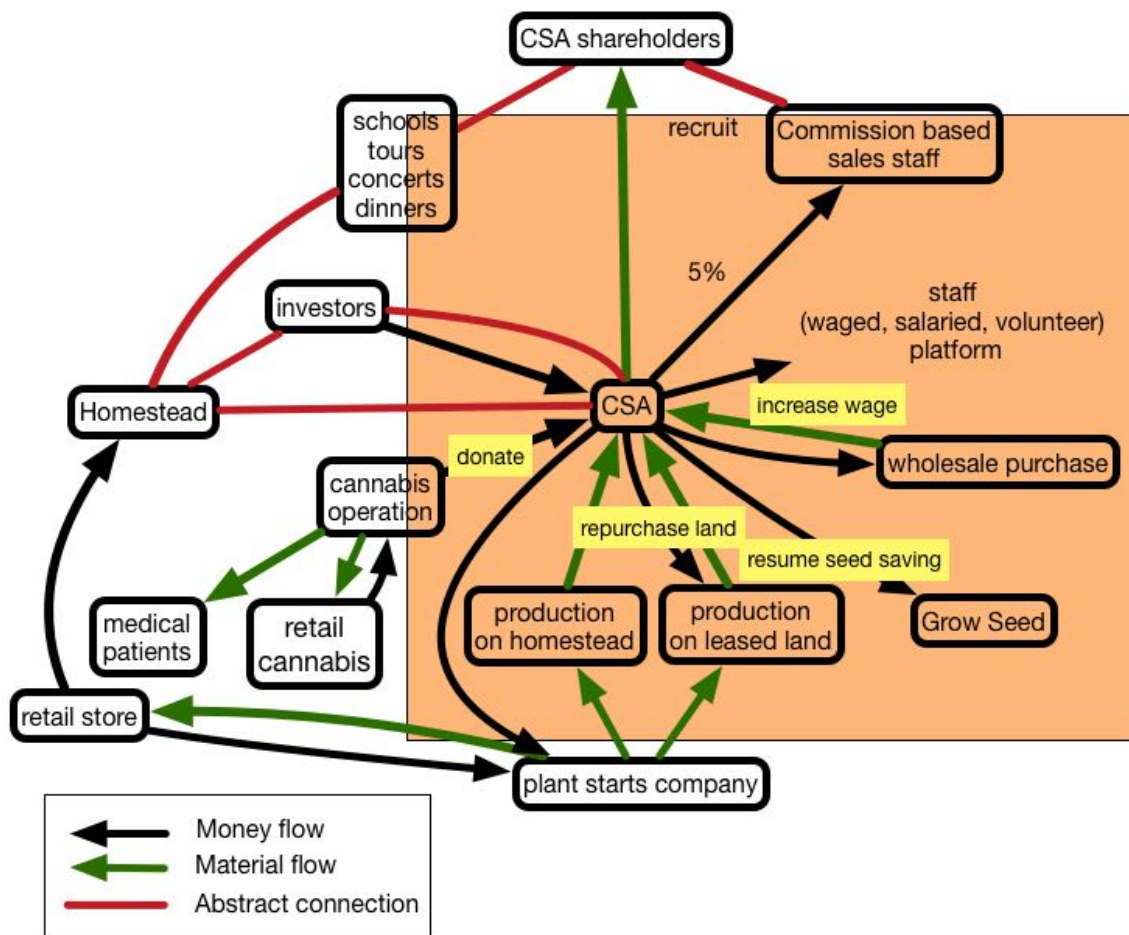


Figure 33 Conceptual map of the Case 2 farm, envisioning a legal cannabis operation

In addition to qualitative drawings, it is also possible to give a basic revenue estimate of the retail value of a cannabis crop. I will focus on the sale of THC since the farm owner has expressed opposition to selling CBD. The

monetary value of THC is higher as an edible, and for the sake of example I will envision that the business has been granted both a license for production and also edible preparation. For values reference are available (Gettman, 2006) but since this is just an illustration they are not offered extensively. Using the current greenhouse to produce 100 plants, a low yield of 200 g per plant and 15% THC content gives a regular crop size of 1.5 kg THC. Processed into an edible, which I would say can be a process approximately as difficult as home canning or baking, THC is sold at dispensaries at a value of approximately \$180 per gram (flower for smoking is much cheaper, approximately \$35 per g THC). Assuming a wholesale price of 1/3 retail, a crop may be sold from the farm gate after processing for \$93 000. Leaving out the coldest winter season, raising three crops per year is reasonable, giving an estimated annual revenue of \$279 000. Each crop costs approximately \$10 000 to raise, and would cost a modest amount more to process. The MED requires a payment of \$2 200 for each license with at \$2 500 fee for each license application (Marijuana Enforcement Division, 2015). They may require installation of security cameras and additional fencing.

Because the main barrier to this appears to be zoning restrictions of Larimer County, I looked deeper into this issue. Zoning restrictions originate from the Sept. 16, 2013 zoning amendment to restrict cultivation to commercial and industrial zones (Myers, 2013). The only justification recorded in meeting minutes from the County is that staff believes the decision is consistent with the Master Plan for Larimer county. After looking through the Master Plan, this justification did not seem clear to me. I was able to discuss this with the Planner II staff member at the time and he clarified that a statement of consistency with the master plan is approved if the proposal does not seem to conflict with the Master Plan. That is, a statement of consistency for adoption of a motion does not need to reference a piece of the plan.

I argue that this motion for restricting cannabis operations to these zones should not have been passed because the Master Plan contains clear language opposing development of open land, and an intention to maintain the open character of land in rural areas (Larimer County, 1997). Regarding this case study, it is a reasonable assumption that were a cannabis license issued, as requested by the farmer, it could have contribute to the income of the farmer. In

a context of financial stress this would have supported land tenure and helped to maintain the open character of the land.

As it is, the land has been lost due to financial difficulties. There has been concern expressed during interviews that the new land owner intends to build suburbs. However, this will likely take many years. It is still possible to reverse the situation if the land can be repurchased. The land could then be protected by a land trust and used for farming activities, contributing to seed production or food for the CSA. This scenario would protect the open character of the land.

During correspondence, the previous Planner II staff expressed concern that marijuana should be enclosed, and locked, with 24/7 surveillance and should be located where law enforcement times are short. He expressed concerns about electricity use, water use (residential wells cannot be used for commercial use) and distance requirements meant to keep cannabis operations away from residential areas.

The current facility used for cannabis cultivation is locked at all times, and a camera system would not be difficult to install. The Wellington police station is very close. No significant electricity is used, since production is based on a greenhouse. The property has a well used for agricultural use. The residential distance requirement originates from concerns over smell disturbing neighbors, and has been waived for one of the two current grow operations in Larimer County (Duggan, 2014). Smell is not a legitimate concern in this case because very little smell comes from the greenhouse, any of which very much pales in comparison to the smell of the chicken operation nearby. In other words, concerns expressed are based on a misunderstanding of the situation. The fact of the matter is, quality cannabis is already being safely and legally produced. An MED license represents only permission to sell it, with only minor modifications to the physical situation

Discussion

The ways in which the two cannabis growers participate are radically different. In the first case there is a piece of land which was going to be turned into a subdivision. The very same person who was going to do that turned it into a hemp farm instead. It appears to be a successful example of economic impact from a cannabis crop supporting the ideological goal of preserving farmland. In the second case we have a farm which has clearly experienced financial difficulty. They have absolutely everything in place to safely and legally create quality marijuana, but they do not have permission to sell it. Zoning laws do not allow it. Nevertheless, they continue to grow it and find social value in producing it for those who need it. Both operations have an interest in cannabidiol production and medical need, but interact with that need in very different ways. Will the hemp business work out well enough that the land continues to be preserved as farmland? Will zoning laws change to support the rural economy?

In the second case study the farmer clearly sees a CSA as a good financial strategy, and is more interested in the CSA than cannabis production. Will it be enough, or will profit margins from food continue to be too thin? The political context of both case studies is actually very similar since retail marijuana cultivation is not allowed at county level in both cases. Hemp cultivation is. One main difference between the two cases is the ideology of the farmer. One views cannabidiol as a legitimate sale item, and one views it as a medical item which should not be sold for profit. This informs their respective decisions on which sector of the cannabis economy they join. The operation that provides cannabidiol for free may be viewed as engaging in a gift economy.

In both cases, the pollen conflict was an outstanding issue. It represents a potentially strong conflict between those who wish to grow unpollinated sensimilla and growers who may release large amounts of pollen into the air. The first case was a candidate for releasing pollen, and the second stood on the opposite side as a sensimilla operation which may be destroyed by errant pollen. One main reason that this conflict has not emerged more strongly is lack of seed, but as the hemp industry develops seed will become available.

During field work I saw no discussion of solutions to this potential conflict, other than isolation distances which can be quite large. The standard

Canadian hemp isolation distance is 5 km (Small & Antle, 2003). Currently, sensimilla production is taking place in urban areas, and hemp is organizing mostly in the rural areas. Dividing into two areas like this could work out well, provided air filtration and isolation distances are used. A technical strategy may also involve unisexual female hybrids or feminized seed. The latter is simply seed produced from a female plant induced to make male flowers and pollinating itself. The technique is commonly used in the sensimilla industry. The former is more complex involving the cross of a monoecious with a diecious variety. For example, the F1 from crossing Kompolti and Fibrimon 21 produces an almost unisexual female population (Ranalli, 2004).

The hemp case study had a very strong focus on exclusively hemp. This monoculture focus could be a problem for the farm. No crop, no matter how profitable can be expected to be proof against normal crop rotation needs. I expect that over the long term the farm will have to adapt a more complex farm management plan.

Contrast between cases with regard to organic management has been interesting. The only one of the three operations toured which has significant problems with pests stocks and uses chemical pesticides. The other two operate according to organic principles and at the time of investigation are producing product relatively free of common pest problems. This has highlighted the importance of building design and cleanliness in production.

Reflection

Reflection is an important and recognized part of the suit of methodology used in this study, with writers involved in soft systems methodology, action research and Agroecology commonly supporting reflection of the researcher. As a personal reflection space, this section contains less referenced support than may often be seen in academic writing. It should be considered a section containing the personal opinion of the author.

The cannabis industry is strikingly vertically integrated, even legislated as such in the beginning of the MED licensed regime. Initially, it was a requirement that retailers produced the cannabis products that they sold. This has been relaxed as a requirement, but the industry remains highly integrated with many of the commercial growers selling a high proportion of the product they have grown. This emphasis is striking to me because it means that from an economic model standpoint the industry shares a strong resemblance to economic logic being adopted by small organic growers. One of the main strengths of a CSA model is that the grower is paid the full retail price of what they grow, yet they do not have the spoilage and high labor overhead required for a farmer's market (to set up, take down and tend the stand). The fact that marijuana production seems to combine this vertical integration with a high intrinsic utility, suggests that it will be a profitable industry for growers for years to come.

The ultralocal nature of the cannabis industry is also striking, given the interest in the organic movement in local supply. Cannabis in Denver is a product which is literally often grown in the same store it is sold. Yet rhetoric in the cannabis industry does not particularly acknowledge or celebrate it. And why should they? Ultralocal normally means that it was grown under electric lights, which can hardly be supported as a low impact growing method. It is possible to have a greenhouse on top of the building, but few operations do so. It seems to me that the cannabis industry is extreme in many ways, and it provides an interesting contrast to the food movement. The fact that tender cannabis leaves are also edible as a green seems mostly lost as a fact, but it is perfectly true and leads to a situation worth contemplation. For example, could a former cannabis

retail location be turned into an ultralocal organic salad restaurant? And if it did, would this be a desirable development, to grow salad under electric lights? Similar efforts are underway already (smartgreen.co). Should such enormous energy use even be certifiable as organic?

My experience in Australia with farmers interested in crops grown for their chemical content, like California Poppy, Ginseng and Radium Weed (*Euphorbia peplus*) alerted me to the hazard that extension agents may do some quick calculations, see a crop as profitable, and encourage farmers to grow it. If many do, then the market can be flooded with product, dropping the market price and leaving farmers back where they started: with a vanishing profit margin. I hope that this will not happen for cannabis growers, but only time will tell. Certainly, the control is tightly controlled for THC containing cannabis which could lessen this impact.

On a personal level, this study was definitely a growth experience. Although I have visited many farms before, being a visiting researcher was very different. It required the same patience and close quarters living, but collided much more with the tendency of farmers to be private and withdraw. It was a constant challenge to honor the spirit of voluntary participation, and not ask too hard for more information and to dig deeper. Perhaps this conflict could be negotiated by a longer study time, more thorough candidate screening and more extensive discussions before arriving on a farm. On the other hand, careful screening will introduce a systematic bias into who becomes the case study partner.

More careful screening also could have allowed closer work with farmers to draw system diagrams in a more collective fashion. In a business environment, this kind of participation would require a high level of commitment and interest, ultimately informed by faith in the researcher and the utility of any outcome.

During my work on the systems diagrams, I began to view them through two metaphors to try to include different dimensions. The first is a multidimensional situation projected in two dimensional space, as used in Principle Component Analysis (PCA). This kind of analysis is being used to characterize cannabis varieties. It is a way of reducing and simplifying a complex situation so that it can be shown on a sheet of paper. However, it is meant for use

in hard systems and is based on quantitative analysis so each component requires a coefficient. This kind of mathematical modeling could be used in a farm situation and although deciding on coefficient values becomes extremely specific it can be considered a normal part of modeling. Probability ranges could be used to “soften” the system. The other metaphor is that the 2D model shown represents a snapshot of an organization in time. Sheets could be envisioned as existing below it, representing the past, and new ones drawn on top to envision the future. This metaphor has been used during Case 2 analysis as the drawn model is adapted to envision a future scenario.

Occasionally, throughout the study I was struck by the apparent molecular confusion that still exists in this industry, even from well known companies. For example, I have seen companies label both 20% THC and 20% THCA on their cannabis flower labels (this is far higher than reasonable since the two combine to 40% THC). I have seen claims to possess cannabis varieties that produce cannabidiol (CBD) without tetrahydrocannabinol (THC) (CBD is formed when THC degrades from heat, not biosynthetically). One well known and respected company claims that other plants are able to produce cannabinoids. All of these examples come from leaders in the industry and official, inspected labels. I hope the industry can grow out of this confusion, or that they are only surface mistakes from public relations staff rather than scientific staff.

Something that action researchers do not seem to often acknowledge, but I saw in this industry is the possibility of research doing more harm than good. As an action researcher, who is supposed to help participants yet share their results, a secretive industry with troubled legal past is full of conflicts. People vividly remember the days that their activity was illegal, and harshly punishable. Given the political situation the US has faced in the past, demonizing marijuana or dark chapters like the communist witch-hunts, how can we as researchers guess at how much use will come from sharing findings? How can we guess what legal hazards people may one day face from having spoken to us? Surely anonymity is key to this, but then there a place for case study methodology? The more detail is given, the easier it must be to identify the interviewee or case study participant.

In the end I remember the philosophy of the Theravada, Mahayana Buddhists and Masanobu Fukuoka: we should at least keep in mind the possibility that non-doing may be the most useful thing of all. In a shortgrass prairie, a productive natural area damaged during the dustbowls by human action, Fukuoka's advice rings especially true.

Finally, I wonder if working in an industrialized nation was a good choice. The field of Agroecology seems to have a focus on non-industrialized nations. Perhaps this is justified if their economy is based more heavily on agriculture, or if the academic-farmer divide is larger and shows a higher need for action research. But working there can also run the danger of being colonial. I chose to work in an industrialized country with the understanding that the food system is largely connected anyways, and farms in industrialized countries are closing. Problems in one area will inevitably spread quickly, for example a wheat shortage in the US will quickly raise the price of wheat in India. During this study I became aware that the legalization of cannabis in the United States also means the collapse of livelihood for many Mexican farmers. Moralizing aside with regard to the illegal nature of their activity, many small Mexican farms have been making a living exporting cannabis. Anecdotal information suggests that the financial gain of warehouse owners in Denver may be the loss of rural Mexican farmers (Bonello, 2015). As action researchers who often fund ourselves or receive public funding, we should ask ourselves if we are working for those who truly need it. Of course, Mexico may also legalize marijuana, leading to quite a wicked situation to enter as a researcher.

Closing Remarks

The cannabis industry is set for an enormous amount of change to occur. In the US, the number of states supporting legalization could reach majority in 2016. Legal policies on the local level may follow this trend, or perhaps they will remain barriers to the industry supporting rural livelihoods. For the hemp industry, quality varieties are sorely needed, and research programs around this have just begun.

Future work could include a survey and more extensive interviews of National Hemp Association members. The association seems very open and

welcoming. Furthermore, cannabidiol production under a hemp license may be the most accessible way to enter the cannabis industry for employment and income generation. If Colorado focuses on supporting this industry, including developing quality planting material, they could position themselves as a strong leader.



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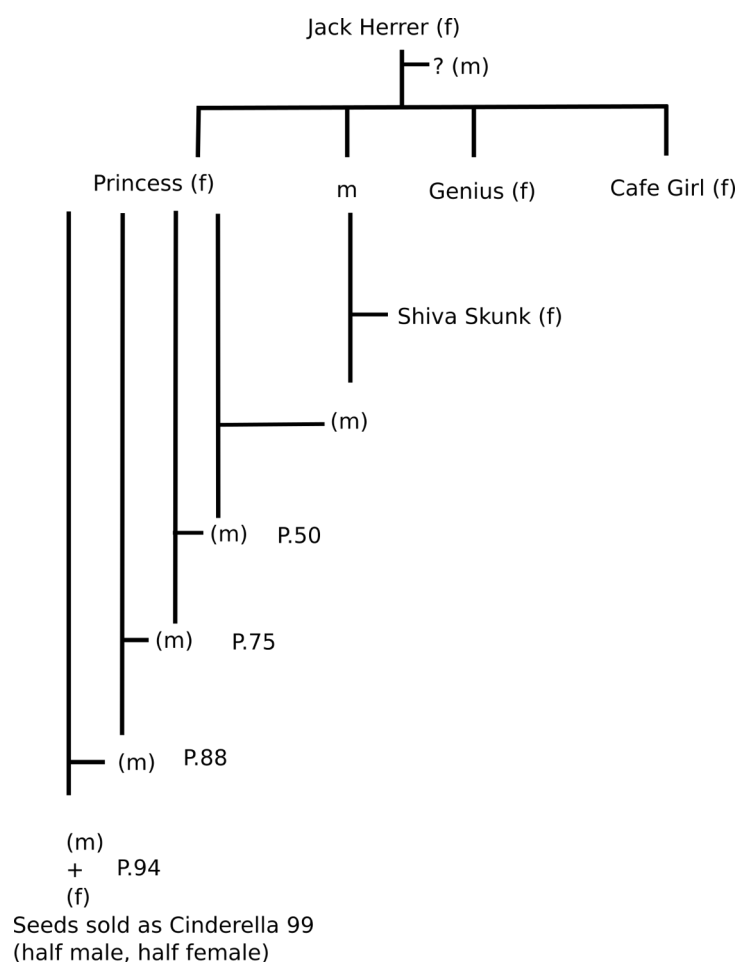
Appendix 1: Examples for system map of the cannabis industry in Colorado.

- Monetary services: Cash handling businesses such as Western Union. Attempts not yet viable such as the Fourth Corner Credit Union. Larger growers such as Livwell have access to services, although they keep their strategy for obtaining this a secret.
- Employment services: Hemp Temps, Ms. Mary Staffing, includes job fair organizers such as the Cannasearch job fair.
- Warehouse real estate: Most grow operations in Denver are located inside warehouses.
- Certifiers: Clean Green (based in California) for organic certification, Certified Kind for organic equivalent, Emerald Test for laboratory certification
- Analytical services: Steep Hill Labs, Phytatech, attached management software like CannaSys which produces CannaLIMS.
- Packaging: Specific packaging has been designed for child proofing cannabis sold at MED retail locations, especially edibles. Many growers package the material before I leaves their control, although it is possible for retail locations to do this.
- Black market growers: The hostel I stayed in had a black market grower selling to guests.
- Caregiver growers, MED licensed growers, hemp growers are all illustrated in the results section.
- Hemp genetic resource keepers and developers: Colorado State University is the most obvious.
- Equipment Developers: Greenhouse Tech Surna Inc. Grow Generation.
- Marijuana genetic resource keepers and developers: Brothers Grimm, New West Genetic, United Cannabis Corp, Cannabis Genomic Project,
- Information services: Youtube (not to be underestimated as a source of information for the small grower), Indo Expo, Women GROW, MassRoots social media platform, newspapers including The Cannabis by the Denver Post and a variety of cannabis specific magazines such as High Times, cannabis specific authors such as Ed Rosenthal, Jorge Cervantes.
- Contractors: independent individuals are employed on a contract basis to clean, harvest, trim. I interviewed one of them.
- Unions: UFCW which runs Cannabis Workers Rising. The campaign was largely dormant, but they did have staff who spoke with me and were helpful.
- Associations: National Hemp Industry Association, Hemp Industries Association, National Cannabis Industry Association.
- Political lobby groups: Marijuana Policy Project, National Organization for Reform of Marijuana Laws (NORML).
- Offshoots: Puff Puff Pass is a business which teaches people painting while they are high. There are a number of small businesses like this which have arisen in the wake of legalization.
- Retail stores: There are hundreds. Botanico is the first I visited in Denver.

- Smoking equipment: Glass blowing is a viable career because of the demand for smoking equipment. A well known store in Denver is Illuzion.
- Equipment and nutrients for growing: This is a large industry with many stores, and little detail is described because it is not the focus of this thesis. Nutrient manufacturers include Dutch Pro, General Hydroponics and Fox Farms for organic producers. Equipment sellers include growersupply.com and botanicare.
- Equipment for harvest dry and trim: This process can be quite simple for THC and CBD based operation, using garden cutting tools (as seen in Case 2). However, this box is considered specific to the industry because there are many automated pieces of equipment which have been developed. Examples include EZTRIM The Satellite which appears in Case 1.
- Equipment for extraction: companies include Precision Extraction Solutions. They are broadly divided into supercritical carbon dioxide, ethanol and butane extraction technologies.
- Processors: Mahatma, Purity Labs, The Clear are well known ones in Denver. There may be a project which is a travelling processor for hemp producers. I have found no public announcement or confirmation of this.
- Personal use growers: adults over 21 are allowed to grow up to six plants themselves in Colorado
- Medical researchers: Those involved in clinical trials nationally, such as for Epidiolextm. Also, there is an expanding state program for research sponsored by the CDPHE.
- Doctors: Issue prescriptions for medical users. They are regulated by CDPHE.
- Marijuana clubs: There are only a few, such as iBake. They are simply locations to go smoke with other people, and may sell pipes, snacks etc.
- Recreational users: May be tourists or residents of Colorado
- Medical users: Must be residents of Colorado. They often grow their own marijuana.

Appendix 2: Creation of Cinderella 99, a common parent of drug type cannabis plants used in Denver

As noted, Cinderella 99 was created by Brothers Grimm (a company) and Dr. Soul (pseudonym for an individual). Neither has formal breeding education. Dr. Soul has significant education as a former nuclear engineer. The Brothers Grimm are considered highly experienced, having bred for many years. The following diagram was reconstructed from a verbal account by both at the Indo Expo, Jan. 29, 2016 in Denver. The letter m denotes male, f female.



The P.50, P.75 label indicates the % genetics existing in the seeds from Princess (50%, 75% etc). The backcrossing process involving the creation of a male and crossing it with a female three times is referred to in the industry as “cubing”. Comments on selection criteria are as follows:

Princess was considered a good plant, with low “hermaphroditism” (low incidence of male flower production, no marijuana plant is a true hermaphrodite with flowers able pollinate themselves), good smell, good high upon ingestion

and fast maturation. However, stalk strength was lacking; during maturation it would lodge. Males selected after crossing with Shiva Skunk, which has a strong stalk, were selected for improved stalk strength.



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