HB21-1301 Cross Pollination Working Group

Technical Report

November 1, 2022

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Disclaimer

Staff from the MED and CDA helped facilitate the workgroup discussion. Staff assisted in checking the factual background material, except for the data and analytics provided by work group members. The opinions expressed, conclusions reached, and recommendations made by the report are those of the workgroup. They do not reflect the position of the MED, CDA, the Office of the Governor, or any other state agency and do not reflect potential fiscal impacts or other agency considerations that may inform any statutory changes. This report may not be used as written guidance from the MED or CDA for purposes of complying with the statutes and rules governing marijuana or hemp.

I. Executive Summary

The HB21-1301 Cross Pollination Working Group was convened to address multiple concerns around the impact of cross pollination on hemp and marijuana crops in Colorado. This issue impacts diverse producers of *Cannabis sativa* crops across the state. A collection of industry stakeholders, hemp and marijuana cultivators, and state officials worked together to discuss four critical issues mandated by state legislation. These issues included: (1) how to minimize volunteer cannabis plants growing on areas of land that are not registered or licensed, regardless of its prior status as registered or licensed; (2) how best to share data and the proximity between locations of outdoor hemp and marijuana cultivations, including information for each outdoor cultivation regarding: (a) the potential for cross-pollination and (b) property size; (3) best practices for preventing cross-pollination including: (a) An examination of the standards developed by agricultural organizations with expertise in industry-wide standards and practices; (b) Recommendations from subject-matter experts; and (c) If available, a review of practices developed by the hemp center of excellence; and (4) the feasibility of conducting and financing field studies to examine cross-pollination between outdoor cultivations and areas of land with volunteer cannabis plants.

In addition to monthly working group meetings, stakeholder members and representatives from state agencies also met in smaller focus groups for six months to develop policy recommendations based on these areas of study. Key recommendations from the working group are highlighted here:

1. Minimizing unregistered plants

The existence of unmanaged volunteer plants aggravates the issue of cross pollination. The unintended cross pollination of volunteer plants with marijuana and hemp fields cultivating female-only plants creates economic harm to both marijuana and hemp producers. The state of Colorado needs a mechanism to minimize the unwanted growth of those plants in natural and unregulated settings. The working group proposes the Colorado General Assembly run a bill appropriating funds for a grant to a research entity that would report, in a timeframe to be determined, on pollen count testing and locations around the state with concentrations of feral hemp populations. The creation of a Best Management Practices (BMP) manual has been recommended to highlight existing Good Agricultural Practices (GAP) and note where additional diligence is required due to the unique factors involving cannabis plants. Once a registrant or licensee surrenders their registration or license and either moves or goes out of business, those parties could refer to the BMP manual outlining procedures intended to prevent the growth of *C. sativa* plants on an inactivated field. It is also recommended the CDA and MED include language that states that, upon surrender or revocation of a registration or license, a registrant or licensee must sign an acknowledgement agreement that they have read and understood the BMP manual and will, to the extent possible, incur on those practices to mitigate the risk of future volunteer plants.

2. Data sharing

It was recommended that CDA/MED endeavor to produce a public resource map that includes numerous features to help reduce the impacts of cross pollination. Cultivation

locations will be mapped with approximate or exact GPS coordinates, depending on the state agency. The “pins” for each cultivation location will be color-coded by crop type with relevant data points updated on a regular and timely basis. The CDA should be responsible for the development and maintenance of the resource map while the MED will consolidate information from their records to assist the CDA in their efforts. This resource map will be password protected and made available to individuals who maintain at a minimum a CDA-HEMP Phase 1 Application and/or a MED cultivation license.

3. Best management practices

This list of ten BMPs have been informed by peer-reviewed scientific literature (see Works Cited section) and were drafted with the working group, many of whom are experienced professional cultivators in the Colorado hemp and marijuana industries.

1. Indoor cultivation, if at all possible
2. Coordination with neighbors
3. Plants with triploid genetics
4. Crop barriers for all types of growers
5. Physical and/or natural barriers
6. Proper maintenance of harvest and other farm equipment to avoid spreading seed
7. Utilizing feminized seed for cannabinoid crops, rogueing males when applicable
8. Have a good cross pollination plan
9. Using good agricultural practices when timing your *C. sativa* crop

10. Planting certain types of crops earlier/later based on local circumstances

4. Future research

There is a lack of cross pollination research between different types of hemp and marijuana crops. There are many ways to approach this gap in information - higher levels of funding may allow researchers to study the issue in a more comprehensive way. A series of approaches have been crafted to help guide the legislature.

1. $50,000 request from legislature: Pollen-capturing studies: Industry will collect pollen using pollen traps which will be counted and analyzed in a university setting.
2. $100,000 request from legislature: AI and pollen sensors will look at total pollen count by species (Pollen Sense sensors cost roughly $3,500 per machine).
3. $250,000 request from legislature: Genetic fingerprinting will be funded in a university setting and possibly further supported by grant funds or other mechanisms.
4. $500,000 request from legislature: University collaboration to fund a PI for a federal government grant for a long-term project (two or more years).

II. Introduction

A. Working Group Implementation

The HB21-1301 Cross Pollination Working Group was facilitated by the Colorado Department of Revenue's Marijuana Enforcement Division (MED) and Colorado Department of Agriculture (CDA) as part of the Department's implementation of HB21-1301 - Cannabis Outdoor Cultivation Measures. Specifically, HB21-1301 required the State Licensing Authority, in collaboration with the Commissioner of Agriculture and the Governor's Special Advisor on Cannabis and Deputy Legal Counsel, to convene a work group on or before November 1, 2021, to study and recommend options for minimizing cross pollination between *C. sativa* plants.

Working group members participated in facilitated and open discussions, presented data and helped with research, and were instrumental in drafting proposed legislation while in smaller focus groups. The MED and CDA delivered presentations on relevant topics, developed monthly meeting agendas, and shared other relevant materials with the working group throughout the series of meetings. This helped the working group prepare for meetings, draft potential questions and thoughts to guide group discussions, and guide the discussions towards science and grower-backed solutions to mitigate cross pollination in *C. sativa* crops. All meetings were open to the public, where interested parties could comment during the public comment portion of the meetings or submit written comments for the consideration of agency representatives and working group stakeholders.

This legislation requires submission of a report on or before November 1, 2022, informing the legislature of the working group's findings and recommendations. The report must be submitted to the House and Senate Agriculture committees and published on the two departments' websites. The language in the bill restricts the working group's recommendations from including mandates on the type, location, or timing of any crop planting.

B. Working Group Composition

Working Group Chairs

- Wondirad Gebru (Director, CDA Division of Plant Industry)
- Dominique Mendiola (Senior Director, CDOR Marijuana Enforcement Division)
- Danielle Henry (Senior Policy Advisor, CDOR Marijuana Enforcement Division)

CDOR MED State Licensing Authority Appointments

- Shawn Honaker (Yeti Farms)
- Jonathan McIntosh (McCanBiz LLC)
- Bia Campbell (VS Strategies)

Legislative Committee Appointments from the Chairs of the House Agriculture, Livestock, and Water Committee and the Senate Agriculture and Natural Resources Committee

- Brian Higgins, as a member from an affected licensed marijuana cultivation business
- Grant Orvis, Ph.D., to serve as a geneticist with expertise in cannabis breeding
- Thomas Dermody, as a member from a software company that services the
- agricultural industry
- Damian Farris, as a member from a business in Colorado with experience growing hemp grain and fiber varieties
- Steve Turetsky, as a member representing a company with expertise in agricultural surveying
- Eric Singular, as a member from a business in Colorado with experience in the development of seed that is certified by the Association of Official Seed Certifying Agencies
- Bill Conkling, as a member from an affected licensed marijuana cultivation business (represented by Bia Campbell of VS Strategies)

Other Participants Pursuant to HB21-1301 - Ean Seeb (Special Advisor on Cannabis, Governor's Office), * Courtney Krause (Deputy Legal Counsel, Governor's Office)

Resigned from Working Group - Rob Ganger, Scott Perez, Mike Sullivan, John McKay Ph.D., Christian Barr, Veronica Carpio, John Vaught

Technical Report Facilitator, Researcher, Writer - Brian A. Mitchell

C. Problem Statement

Two distinct Colorado state agencies manage the registration, cultivation, sales, etc. of two legally distinct crops which are produced using chemovars of the same plant species (*C. sativa* L.). This allows for sexual reproduction of this wind-pollinated plant. Cross pollination between hemp and marijuana, or between different types of hemp crops, reduces the quantity and quality of yields when the final product is derived from an unpollinated female flower. Other impacts include increased risk, reduced profits, increased labor costs, and more. Volunteer plants from unanticipated pollination and seed dispersal, both on- and off-farm, exacerbate the issue by pollinating both hemp and marijuana crops. A lack of research on pollen viability, wind dispersal, and other factors complicate the issue, as does the privacy of grower location information.

III. Relevant Research

A. Cross Pollination

Pollination occurs when a grain of pollen (male) is transferred to the ovule of a flower (female), where the egg is contained. Each component contains half the genetic material needed to produce a new seed (Browning, 2016). Cross pollination is a naturally occurring process where pollen is transported from the anthers of one individual plant to the stigma of a flower from another plant of the same species. This process helps to maintain genetic diversity and allows for new genetic adaptations to occur through genetic recombination (Pattemore, 2017). While many agricultural and horticultural crops have the ability to self-pollinate (tomatoes, peppers, peanuts, peach and sour cherry trees), other plants have features to promote cross pollination. If cross pollination is undesirable, the pollen release and receptivity of the female flower (the "pollen catcher") can be separated in time or space. This separation is crucial as some crops are very susceptible to changes caused by pollen source, e.g., sweet corn, which is cross pollinated by wind and must be isolated in some way from all other types of corn (Browning, 2016).

The same species of plant is often bred into distinct agricultural crops. For example, corn (*Zea mays*) has been bred over time to produce different types of agronomic crops, namely field corn, sweet corn, ornamental corn, and popcorn. Unlike other commodity crops like rice, barley, and wheat, corn has separate male and female flowering parts, which allows for high frequencies of cross pollination (Brittan, 2006). If grown by the

same operation during the same season, these crops are separated by location (400 yards has been recommended) or by their flowering dates (1 month apart is common). Corn pollen is spherical, viable for 18-24 hours (drastically reduced with desiccation), and is 90 to 100 μ in diameter, which is relatively large compared to other plants (Brittan, 2006). Corn pollen fresh weight is 60% water at flowering and pollen longevity drops rapidly if water content falls below 40% (Bohn, 2003). Corn pollen is also heavy and drops to the ground quite quickly after being released from the male flower. It is recognized as one of the largest, most common particles found in the air in the US.

Corn is a promiscuous pollinator, an outcrossing, wind-pollinated crop. Corn plants are monoecious, with male and female flowers on the same plant. Wind carries pollen from the tassels of male flowers to the individual silks that get pollinated, resulting in a kernel of corn on a cob. This pollen can travel miles before finding a silk, which may be in your crop, your neighbor's crop, or even farther away from the source. This causes issues with neighboring crops, especially crops where growers are trying to save pure seed from their stand. (Janson and Carlson, 2013)

How to avoid cross pollination in organic sweet corn production is explained by this North Carolina State University (NCSU) leaflet. It notes that four-row blocks are required for adequate pollination and, if sweet corn is planted downwind of popcorn or field corn, the resulting kernels will be more starchy than sweet. The same concept applies to white and yellow cultivars of sweet corn; the kernels will change colors when cross pollinated. Also, super-sweet and standard sweet corn cultivars will cross pollinate, reducing the sugar content of super-sweet cultivars of corn.

The NCSU resource notes sweet corn should be separated from different types of corn (field corn, popcorn, ornamental corn) by at least 300 yards, with 300 feet needed between super-sweet and non-super-sweet corn. Staggered planting dates is also a recommended tool, staggering planting dates of cultivars with similar days to maturity by two weeks or using cultivars with different days to maturity. This would reduce the risk of cross pollination between the different types of corn (Davis, 2020).

Pollen drift and undesirable cross pollination is a longstanding issue in certain commodity and specialty crops. The issue also presents a problem between Genetically Modified (GM) and non-GM crops, corn in particular. A literature survey (Bohn, 2003) concluded that 125,000 corn pollen grains could be expected to travel up to 500 meters from the original source. Analysis of other studies during the 20th century show the extent of pollen drift is highly dependent on multiple factors, especially wind speed and direction. Bohn noted in a 2003 talk on pollen drift that, "An adjustment of technical farm procedures can be used to avoid mixing of GM and non-GM seed, e.g., planting and harvesting conventional crops before GM crops. However, a containment of pollen employing normal farming procedures is not possible."

Efforts to separate GM and non-GM seed can be made in the supply chain in two ways, either through dedicated silos and dryers or through the definition of agricultural zones and separate harvest procedures. The definition of agricultural zones would severely reduce the impacts of cross pollination and is easier to implement, in theory, than segregation of crops further down the supply chain (Coleno et al., 2009). Cross pollination remains an issue with GM crops, as certified organic producers may lose

their certification status for a three-year period if even small amounts of GM proteins are found in their corn (Jemison and Vayda, 2001).

Consensus in the scientific literature, centered predominantly on corn production, is that one of the most effective techniques to limit exposure to cross pollination is through isolation, or a physical separation of sensitive crops (Thomison and Geyer, 2016; Bohn, 2003; Browning, 2016). For example, several state seed certification agencies require an isolation distance of 660 ft. between non-GM IP and GM corn; border rows are also manipulated in this isolation process to minimize GMO pollen contamination (Thomison and Geyer, 2016). Corn producers aim to minimize pollen drift and not mix GM and non-GM grain so seed purity standards are maintained. These producers should keep excellent records and be mindful of volunteer plants, planting order, planting date and hybrid maturity, prevailing wind direction during the outdoor production season, harvest and storage issues. Finally, they may even conduct a pollen drift risk assessment for their farm that considers surrounding operations (Nielsen, 2000; Brittan, 2006).

The spatial and/or temporal separation of GM crops has become an issue in recent decades. In the larger world, this is encouraged but not enforced by regulation. However, confined field tests of GM plants have strict regulations in terms of minimum separation distances between sexually compatible crops, managed by the USDA Biotechnology Regulatory Services. For example, regulated maize plants that are allowed to open pollinate in field tests must be 660 feet (201.17 m) away from other crops of the same species. APHIS and USDA have published this table on minimum separation distances for GM crops (USDA-BRS, 2013).

Additional science-based techniques that influence and mitigate cross pollination in agricultural crops include physical barriers and windbreaks (trees, taller crops), and covering materials. Wind direction and barrier characteristics (height, density) are very important factors in this process. In experimental and modeled studies, cross pollination has been reduced 60% with a 6-meter tall windbreak and 30% with a plant windbreak, a sorghum crop planted between to a donor pollen crop and a recipient pollen-receiving crop (Ushiyama et al., 2009). There are varying degrees of effectiveness when using different kinds of windbreaks for cross pollination concerns around IP and patented bioengineered corn crops. The additional cost of the windbreaks at scale also raises concern in large commercial fields.

Other science-based and farmer-tested solutions include deploying pollen sensors, using overhead irrigation to water crops and reduce pollen drift, coordinating crops and/or timing with neighboring operations. Participation in a “pinning” map system, as Western Oregon’s specialty crop seed industry has utilized, is a way to help plan crop locations and reduce conflict. The Willamette Valley Specialty Seed Association facilitates a fee-based, volunteer map system with color coding to help isolate numerous different crop types, including beets, radishes, broccoli, kale, onions, spinach, squash, and GMO crops. A series of concentric rings are used to indicate where sensitive crops are located. For example, one- to four-mile buffers are established to separate different types of *Beta vulgaris* species (sugar, table, and fodder beets; Swiss chard). (WVSSA, 2022)

The Association of Official Seed Certifying Agencies (AOSCA) certification for foundation, registered, and certified hemp seed utilizes land requirements such as weed management and crop rotations. AOSCA enforces field standards like isolation distances and seed impurity standards for certified seed through regular crop inspections. The certification standards for the production of certified hemp seed note, “the area, density, stage of maturity and location of any contaminating pollen source is an important factor in cross pollination… There shall not be any *Cannabis sativa* L. plants within 100 m of the crop and not more than 10 plants/ha beyond 100 m within the isolation requirement.” AOSCA certification standards for hemp (*Cannabis sativa* L. subsp. *sativa*) require 15,748-foot distances between hemp crops (3.11 mi or 5 km). There are additional considerations when producing feminized seed crops of hemp; an example in greenhouse production of feminized hemp seed is the documentation of the mechanical isolation method used to isolate clearly-labeled female plants and their flowers from undesirable pollen. (AOSCA, 2021)

The Federal Seed Act (FSA), legislation that guides the Agricultural Marketing Service (AMS) in the production of certified seed, has set minimum land, isolation, field, and seed standards (7 CFR § 201.76). Minimum land standards dictate the length of time that must elapse between crops of a similar kind. Isolation requirements are used to determine the physical distance between the crop grown for certified seed and a source of potential contamination. Field requirements exist in terms of the minimum number of plants or heads in which one plant or head of another variety is permitted.

Seed standards are provided that describe the maximum percentage of other seeds (other varieties or off-types) permitted in the final product, cleaned seed. For example, utilizing a table from the FSA, one can see that certified seed for hybrid corn has no land standard, indicated by a "0," has an isolation standard of 660 feet (201.17m), and a field requirement of 1,000. More information on the FSA and certified seed standards, including a helpful table listing many common agricultural crops and their standards, can be found on Cornell Law School's Legal Information Institute website.

B. *C. Sativa* Pollination

Pollen is both undesirable and required in *C. sativa* production, depending on the final product. Cultivators must attempt to exclude pollen when producing cannabinoid-rich female plants, as these compounds are highly concentrated in the unpollinated female hemp flower (Fig. 1). This type of production outdoors can be difficult as feral hemp populations exist throughout the country (ditches, fencelines, abandoned production sites, other disturbed habitats) leading to the potential for cross pollination from wild male plants (Hart, 2020). However, pollen is desirable for future generations of crops, as the pollen and resultant seeds contain valuable genetic information for creating new plant populations.

Figure 1. A female flower develops at the top of a hemp plant. Photo by Brian A. Mitchell.

Hemp pollen is spread by wind in large quantities and across long distances (Small and Antle, 2003). Male plants with thousands of staminate, pollen-producing flowers shed pollen several weeks prior to seed ripening on female plants (Rana and Choudhary, 2010). In Canada, the standard distance to isolate high-quality pedigreed hemp seed is 5 kilometers (km) or 3.11 miles (mi). Research shows that downwind hemp pollen distribution is six times the upwind amount, the equivalent of a 0.9 km (0.56 mi) isolation distance for upwind areas of cultivation (Small and Antle, 2003). It has also been noted

that hemp pollen dispersal decreases exponentially with distance, its range best represented with a leptokurtic curve.

In a literature survey on hemp pollen viability, Small and Antle (2003) summarized that hemp pollen has a 70-90% viability rate at anthesis, the opening of the anthers which are the pollen-bearing structures of the male hemp flower, [Fig. 2.]) with other studies confirming a range of 60-80% viability. After 72 hours, hemp pollen viability was reduced to just 5 to 10%. In storage, researchers have noted pollen viability at 50% after three days and 16% after one week, with lower humidity prolonging viability. A more recent study showed pollen viability at its highest in April in Agra, India, reaching 97%; the same study demonstrated *in vivo* that germination resulting from pollination can be very high, ranging from 78-85% (Rana and Choudhary, 2010).

Pollen collection and proper storage is vital, and research has shown that collection by hand (tweezers) and a handheld vacuum are high-yielding methods, while visible light spectroscopy is a valuable way to quantify pollen while in liquid suspension (Wizenberg et al., 2020). Finally, it is not yet known how pollen counts and seed production are correlated; numerous environmental factors are at play, in addition to cultivar selection, crop timing, and more (Small and Antle, 2003).

Figure 2. The pollen-producing male flowers of a hemp plant. Photo by Brian A. Mitchell.

It was noted in a 2019 University of Missouri Extension publicatio that cross pollination between different types of *C. sativa* crops presents a risk to producers, especially considering the numerous state programs emerging to produce medical and recreational marijuana. Male plants are common in fiber and grain production, where pollination of the female flowers is required or less of an issue, yet the pollen drift from these crops has created contention amongst cultivators. Additionally, Midwestern states like Missouri have a large number of counties with wild hemp populations, which are mixed male-female populations of *C. sativa* that produce pollen during the growing

season. One key way to reduce the risk of cross pollination is to be aware of neighboring operations and understand the different types of *C. sativa* production (UM Extension, 2019).

With all-female *C. sativa* crops, scouting for male plants (and sometimes male flowers on female plants) and physically removing ("rogueing") them from the field is another common way to reduce cross pollination. This is a labor-intensive process for cultivators producing plants for different cannabinoids, i.e., CBD, CBG, CBN, that occurs even under the best circumstances. This emphasizes the importance of planting feminized seed or female rooted cuttings (clones) when producing most cannabinoid-rich crops.

Cannabis buffer zones

"*Hybridization of high THC* Cannabis *with low THC* Cannabis *can result in crop loss for both growing operations. If genes that promote high levels of tetrahydrocannabinol (THC) are transferred by pollen from high THC Cannabis to low THC Cannabis, the resulting seed could result in subsequent generations of plants that test above the permitted THC limit of 0.3% dry weight, requiring the crop to be destroyed and result in large investment losses (Small and Antle 2003). This is probably a less frequent occurrence because high THC Cannabis growers and low THC Cannabis growers who are growing crops for cannabidiol (CBD) production normally eliminate male plants, or grow female clones, and the extent to which pollen from high THC or high CBD Cannabis cultivation represents a large pollen source is unknown and probably minimal. On the other hand, pollen from low THC Cannabis hybridizing with high THC or high CBD Cannabis cultivation who depend on unfertilized flowers for their product is a major concern, as fertilized flowers and seed production in the high THC or high CBD production fields will significantly reduce the value of the crop. Both low THC hemp growers and high THC or high CBD growers are faced with a perennial problem of ensuring that their plants are adequately protected from contaminating pollen*." (ICR, 2017)

Unpollinated female flowers are desired in cannabinoid production, as pollination of female *C. sativa* flowers impacts the yield and quality of the crop. In fact, to reach the profitable markets of smokable flower products or usable hemp flowers for extraction, growers and processors favor the production of 100% unpollinated female flowers (Nackley et al, 2020). Many critical factors influence yield and quality of a crop - cultivar selection, planting density, growing environment, harvest time, and insect/disease

pressure. Another key factor is the severity of cross pollination. Researchers have found pollination leads to significantly reduced yields of essential oil, the vessel for cannabinoids such as THC, CBD, CBC, CBN, CBV, and numerous others. A greenhouse study demonstrated that the yields of cannabinoid-rich essential oils produced by unpollinated plants was more than twice as high as pollinated plants (Meier and Mediavilla, 1998). Additionally, when pollen is absent and pollination does not occur, a prolonged period of virginity leads to the expansion and continued development of female *C. sativa* flowers. Unpollinated female flowers significantly increase in girth when compared to pollinated female flowers, an adaptation to increase the likelihood of fertilization when males are scarce in the local environment (Fig. 3) (Small and Naraine, 2014).

Common solutions to preventing cross pollination in certain crops include strategies not permitted in the working group's recommendations, such as separating certain types of production in space (buffer zones) and time (planting dates, etc.) or growing specific types of plants, e.g., triploid crops that are mostly sterile. Pollination will always be a risk due to intersexual nature of hemp. In all-female crop production for cannabinoid-rich flowers or cannabinoid extraction, female flowers can change into male, pollen-producing flowers. This pollen can easily pollinate nearby female flowers in the crop or become windborne and affect other nearby cultivations. Male flowers in dioecious crops (one with male and female plants of the same species) can also morph into female flowers, but this would only produce "extra" hempseed and have little effect on fiber production. These intersexual changes are thought to be brought on by

physiological stress or other environmental factors. Researchers have noted prevention of cross pollination outdoors in large open fields of economic relevance is nearly

Figure 3. This unpollinated cluster of female *C. sativa* flowers shows the potential for continued flower growth and development. Photo by Brian A. Mitchell.

impossible (Meier and Mediavilla, 1998) and that no known distance between a *C. sativa* crop and other production sites, in addition to wild hemp populations, that would completely eliminate the chance of wind-driven cross pollination (Nackley et al., 2020).

Pilot studies have been conducted in *C. sativa* crops on the efficacy of pollen exclusion using common horticultural materials such as insect netting and row coverings, which are woven fabrics. Data from Colorado State University (CSU) research has shown a cultivar-dependent response in improved cannabinoid yields when covered by two different types of row cover (thin and thick woven fabrics). In other words, all-female high-CBD production systems may benefit from being under cover at certain times of the year (pollen season) to minimize cross pollination and prevent seed production (Bowen, 2022). Experts have recommended that more research must be conducted, with accompanying policy created to help mitigate cross pollination risks; for now, the best way forward may be to start an open dialogue among *C. sativa* producers (DeDecker, 2019).

Pollen stays viable longer and maintains higher germination rates during the mid/mid-late flowering stages of male flowers; this developmental stage is ideal for collecting pollen (Guadet et al., 2020). Male flowers exist on “all-male” plants in dioecious populations (male and female plants in the same crop at varied ratios) or on monoecious plants, which have male and female flowers on the same plant. Pollen viability is important for numerous reasons; collecting pollen is crucial for breeding efforts, scientific research, and gaining a better understanding of pollen counts and movement in Colorado. There are many easy, straightforward ways to collect pollen, including Do-It-Yourself pollen traps (“megastigmas”) constructed from inexpensive dowel rods or other structural pieces, clothespins, and sticky cards to catch the pollen (Kevan et al., 2006). DIY pollen traps could be used at different heights, in multiple

areas, during unique weather events, and across numerous times and days to quantify pollen species and counts.

In a 2020 study, hemp pollen comprised 36% of the airborne pollen in Papillion, Nebraska in mid to late August. Hemp pollen, a potent aeroallergen, surged to over 1/3 of the wind borne pollen yet the same area, when tested again in mid-September, did not detect any hemp pollen. The peak pollination period was thought to have lasted for several weeks. The hemp pollen produced reactions when tested on sensitive individuals suffering from rhinitis and asthma symptoms in the summer. Sixty-one percent of patients responded positively to skin patch tests and 73% of those patients suffered from respiratory issues during the peak pollination window in the area (Stokes et al., 2000).

An interesting study in Tetouan, Morocco, over a three-year period (2008-2010) indicated that *C. sativa* pollen levels were highest in June and July. In general, pollen concentrations were evenly distributed during the day, with slight (5%) spikes at 12 and 4 pm. The researchers indicated that *C. sativa* pollen reached substantial levels in summer and may be a clinically important aeroallergen for sensitive people, especially when combined with previous research on skin test reactivity, respiratory symptoms, and pollination period. (Aboulaich et al., 2011)

Hemp pollen and pollen counts in general are surging, which may lead to more cross pollination, not to mention increased issues for allergy sufferers. U.S. Scientists have recently noted that, on average, pollen counts have increased 21% from 1990 to 2018, with the largest surges seen in tree pollen (compared to other flowering plants) and in

Texas and Midwestern states, where large feral hemp populations exist (Anderegg et al., 2020). The main pollen season for hemp plants varies but can last up to 155 days a year (April to September). Pollen volume has been noted to peak at different times of the year depending on the region, weather, temperature, and other factors; it also surges midday while consistently remaining in the air for sustained periods of time (Aboulaich et al., 2013). Pollen season in general starts around 20 days earlier than it did in 1990. It seems that increased pollen counts are strongly linked to warmer temperatures brought about by anthropogenic climate change (Anderegg et al., 2020). Finally, increased precipitation and relative humidity appear to lead to lower atmospheric pollen concentrations (Aboulaich et al, 2013).

C. Feral and Volunteer Hemp Populations

Feral (wild) hemp populations exist across the world, including in Colorado. The HB21-1301 legislation defines a volunteer hemp plant as “a *Cannabis* plant growing spontaneously without direct human control or supervision.” Feral populations may be considered a nuisance for cannabinoid producers, as these crops are dioecious and male plants will produce and shed pollen. There is also research potential in feral populations of hemp, as wild genomes of hemp may hold key traits for future plant breeding. This is important as *C. sativa* germplasm was destroyed or not kept up during the last century’s efforts to criminalize all components of the species in the U.S.

Win Phippen, Ph.D., is a professor at the School of Agriculture at Western Illinois University, where he runs the alternative crops program. He has been interested in

collecting samples of wild hemp plants, from seeds to pollen and more, as he sees the potential of a gene bank to store germplasm of these resilient plants (Bennett, 2020). Additionally, the University of Wisconsin Hemp Program is eager to learn more about feral hemp. They have asked the community to identify wild hemp crops and contact their program, either via an app or web browser service called iNaturalist, email, or post, with details about the plants. They aim to save seeds from plants, characterize the plant populations, and conduct studies on an insect pest (the Eurasian hemp borer) to help local farmers navigate hemp production (UW-ECALS, 2021)

From the mid-80s to the mid-2000s, the Drug Enforcement Agency (DEA) spent at least $175 M on eradicating 4.7 B wild hemp plants. South Dakota led the way with over 68 million wild hemp plants eradicated each year from 1984-2005, followed by Indiana, which eradicated 65 million wild hemp plants annually in the same period (Stansbury, 2006). Despite these efforts, feral hemp continues to dot the landscape of the country, especially in Midwestern states like Minnesota (Fig. 4). In fact, in some Minnesota counties, it has been treated as a noxious weed and listed as a Prohibited or Restricted Species (Minnesota Wildflowers, 2022). In 2012, Waseco County listed all non-licensed hemp as a County Noxious Weed (MDA, 2022). Researchers noted nearly twenty years ago that “weedy hemp” will be increasingly widespread as plants escape cultivation through various means (Small and Antle, 2003). Finally, three states have *C. sativa*, whether hemp or marijuana, listed as noxious weed seeds under the Federal Seed Act - Minnesota, Mississippi, and Pennsylvania (USDA-AMS, 2022).

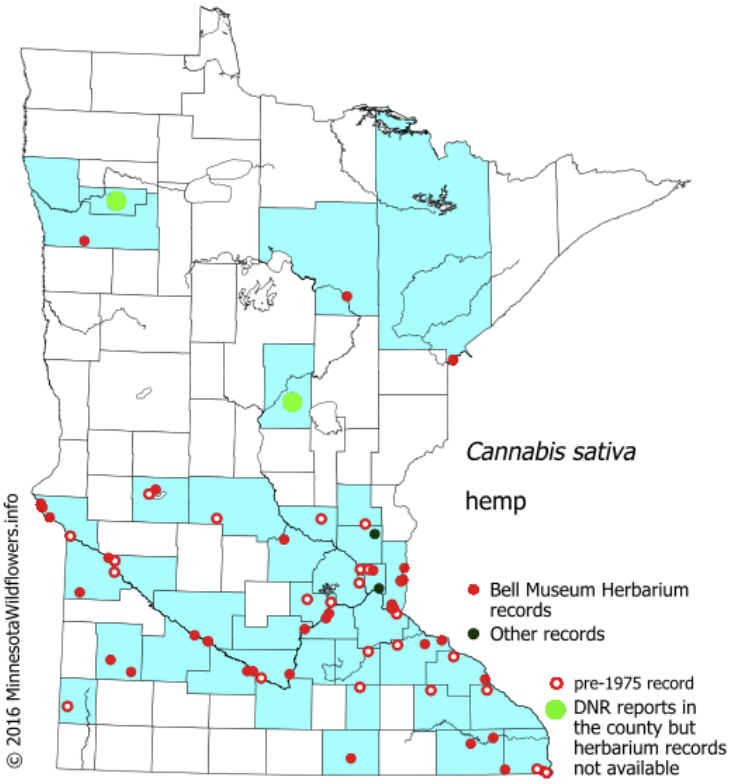

Figure 4. A map shows the Minnesota counties that have wild hemp populations which were quantified using herbarium records, Department of Natural Resources reports, and other records (MinnesotaWildflowers.info, 2016).

The North American Plant Atlas from J.T. Kartesz has mapped many plant species across the country. This national plant atlas utilizes similar maps to the one in Fig. 4, yet provides more data, covers most of the fifty states, and can be used for thousands of different species. The last maps created for *C. sativa* are dated 2 Nov. 2014, but clearly indicate the presence of wild *C. sativa* plants in most contiguous U.S. states, including Colorado. In this state, it is listed as an exotic (non-native but present and self-sustaining in nature, wild) species in Montezuma, El Paso, Denver, Larimer, Weld, Boulder, and Grand counties (Kartesz, 2015). More information on the North American

Plant Atlas and BONAP (The Biota of North America Program - North American Vascular Flora) can be found on their website.

Isolation distances between relevant farms are used to minimize the risk of cross pollination by undesirable pollen. Wild or volunteer populations of plants can also produce pollen that isn't desired on any agricultural operation. For example, non-GM maize purity is affected by volunteer maize plants, often a result of no- or minimum-till continuous corn production systems (Thomison and Geyer, 2016).

It is easy to eradicate feral hemp plants with mechanical methods (hand pulling, hoeing, tilling, etc.). In some experts' opinions, chemical methods of eradication are not advised as *C. sativa* plants are resilient and resist many herbicides. There are a complex set of regulations concerning which herbicides may be used by agricultural operations to eradicate volunteer hemp. Individual states provide guidance to their producers about which chemicals may be used in the production for the eradication of hemp and marijuana plants and in those systems, but little research is being conducted on these issues.

IV. Cultivator Survey Results

A. Cultivator and Operation Demographics

A stakeholder survey was open from January 1st through April 30th, 2022. The CDA survey received 64 responses from a diverse group of *C. sativa* cultivators and other stakeholders in the state. The survey goals were to assess the impacts of cross pollination in various ways and to seek stakeholder solutions to the complex issues surrounding *C. sativa* cross pollination.

The survey asked for respondents' contact information (name, company name, location [city, county], and phone number). Hemp and marijuana production is spread across the diverse geography of Colorado yet also concentrated in a few key areas. Most responses (58%) were from cultivators in six counties - Boulder, Denver, Larimer, Mesa, Montrose, and Pueblo. Twenty-four of 64 Colorado counties were represented (38%) (Fig. 5).

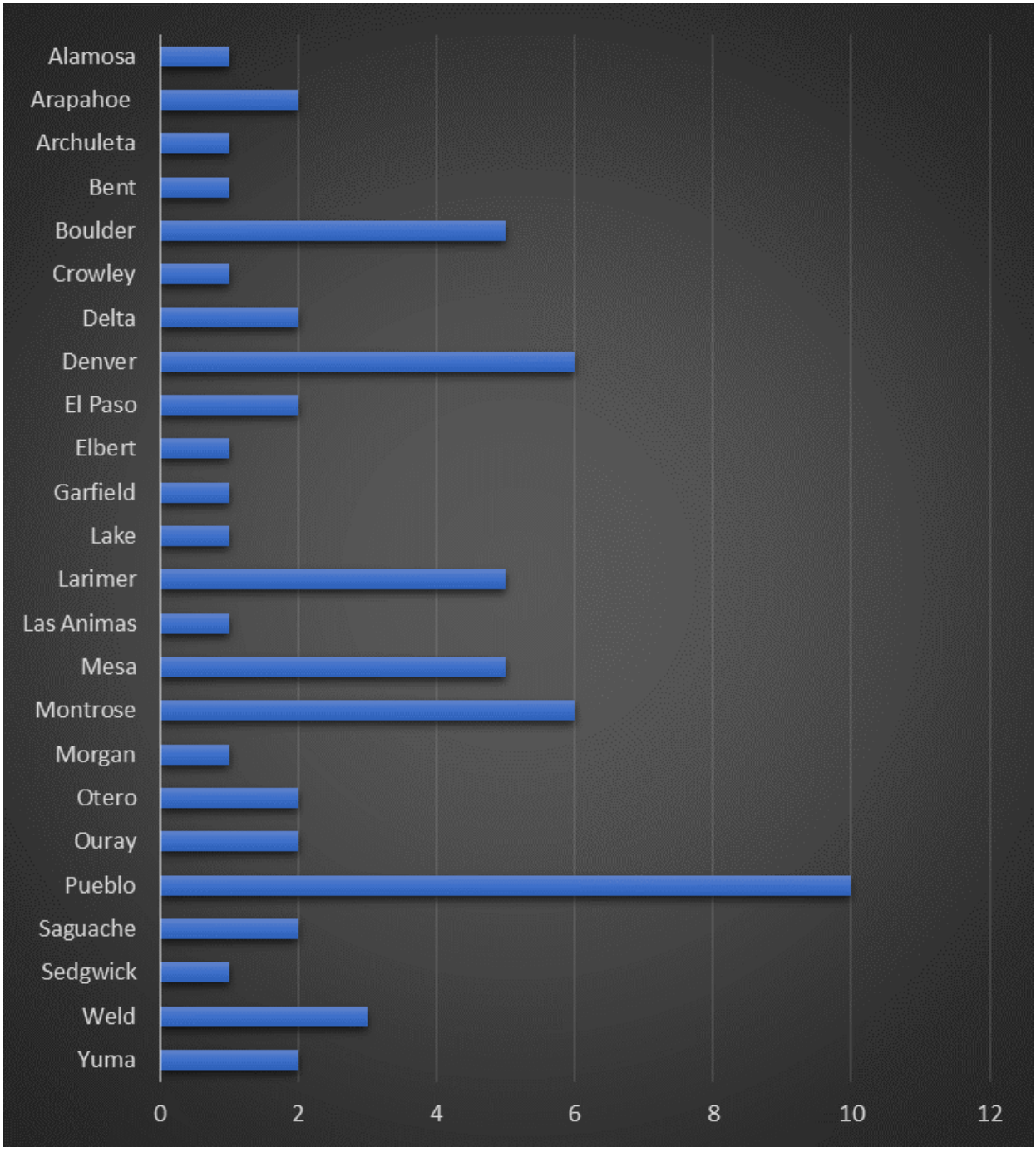

Figure 5. Twenty-four Colorado counties were represented in the hemp and marijuana stakeholder survey, with over half of the responses derived from just six counties.

Respondents were asked to describe their operation in three ways: identify the type of crop they produced, what type of production facility they utilize, and at what scale they operate. Survey questions are italicized throughout the remainder of this section.

What type of crop do you grow, e.g., CBD hemp, fiber/grain hemp, marijuana, etc.?

MED licensees cultivate recreational and medical marijuana while CDA registrants produce hemp for smokable flower and/or cannabinoid extraction. CDA registrants also produce hemp for fiber, grain/hempseed, dual-purpose (fiber and grain), multipurpose (fiber, grain, and cannabinoids), and certified seed crops. The DOR-MED provides licenses for medical and recreational marijuana cultivators. In the cross pollination survey, 28 MED licensees (45%) and 35 CDA registrants (55%) responded (Fig. 6).

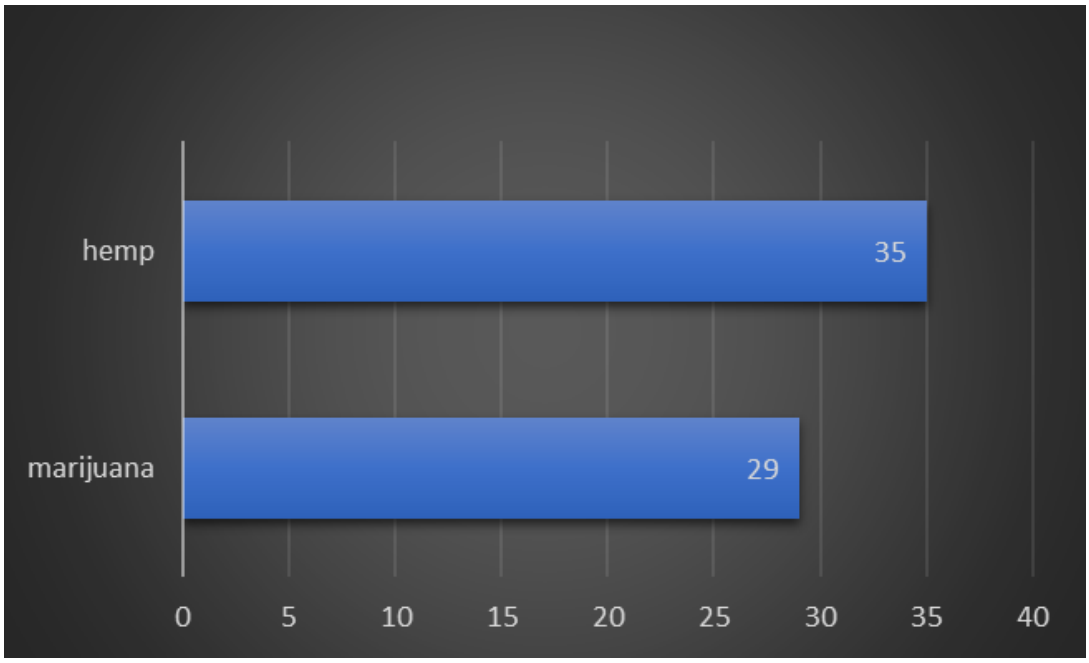

Figure 6. There was a roughly equal number of respondents when sorted by producers' main crop type, hemp or marijuana.

Is your operation indoor, outdoor, or both?

MED licensees and CDA registrants noted if they cultivated plants indoors or outdoors. Some operations had multiple locations, i.e., in two counties, and many had both indoor and outdoor cultivation facilities (Fig. 7).

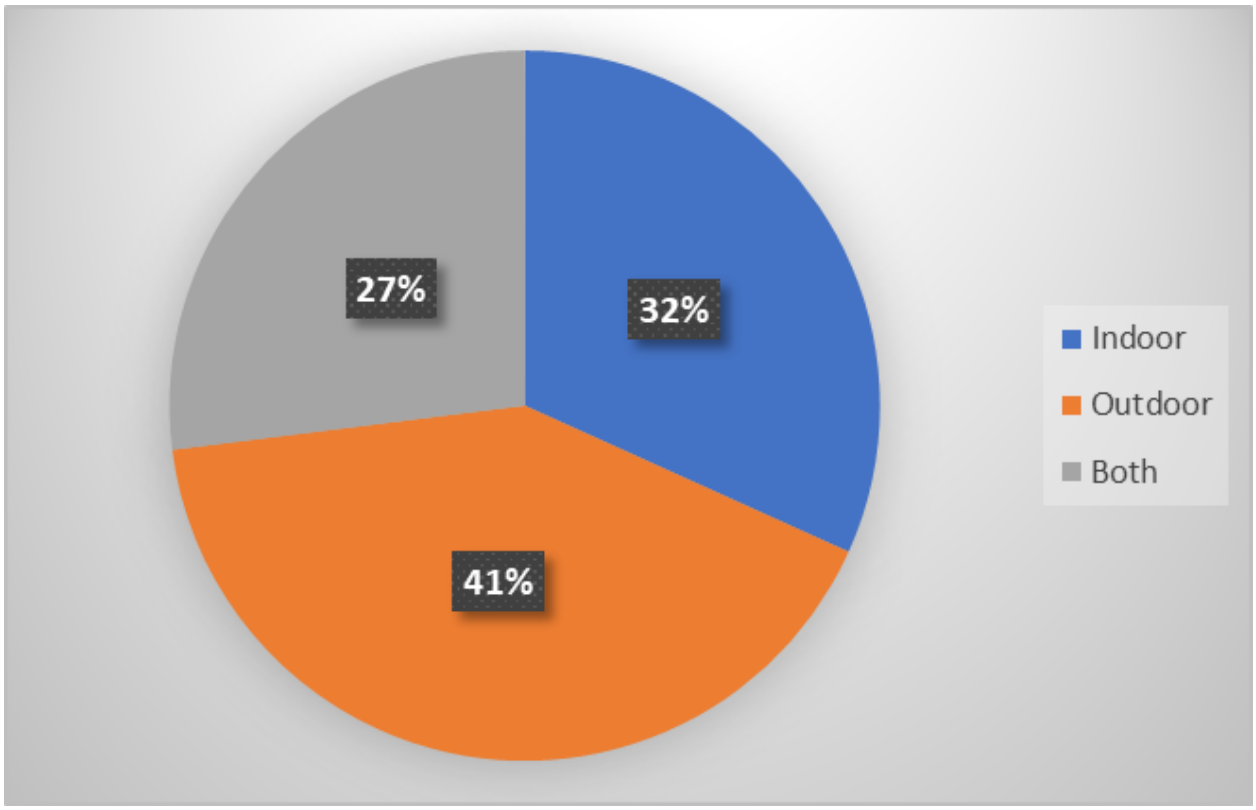

Figure 7. Cultivators produce hemp and marijuana crops indoors, outdoors, with over a quarter of respondents using both types of systems.

Of 63 responses, 26 respondents cultivated crops outdoors (41%), 20 respondents cultivated crops exclusively indoors, and 17 respondents indicated they used a combination of greenhouses, indoor spaces (converted warehouses, grow rooms), and fields. For example, one producer noted they do breeding work in their greenhouse but

produce finished plants in their fields. Another mentioned they root their cuttings/clones and grow transplants indoors before moving to outdoor field production during the growing season.

What is your square footage and/or outdoor acreage?

Scales of operations varied widely. Indoor hemp and marijuana production footprints ranged from 1,000 to 70,000 square feet (across multiple locations). The average indoor operation was 11,883 sq. ft. The largest operation was spread across different facilities – the average excluding this operation was 10,066 sq. ft. (Fig. 8).

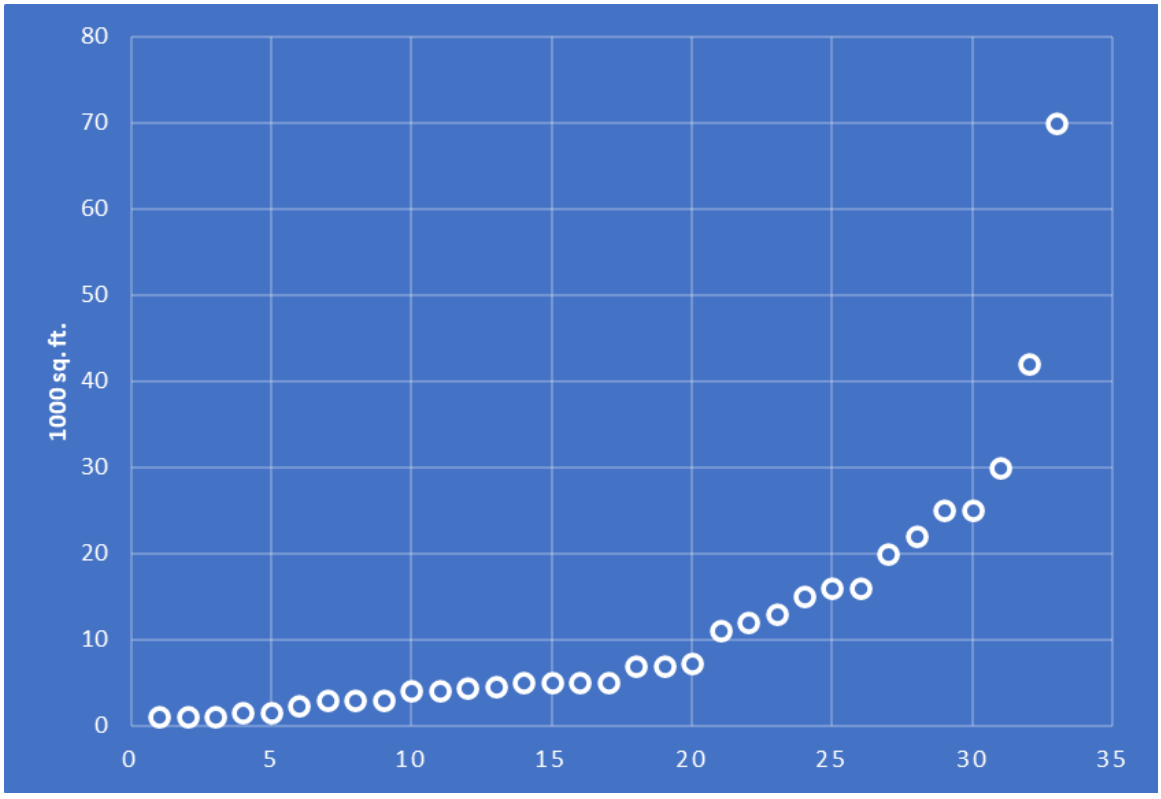

Figure 8. The scale of indoor cultivation operations, where each circle indicates the size of respondents' indoor hemp or marijuana facilities in units of 1000 sq. ft.

Cross pollination is overwhelmingly a concern for outdoor marijuana and hemp producers. In terms of the scale of outdoor operations, farms ranged from 0.1 acre to 200 acres (Fig. 9). The average outdoor production area was 32.4 acres and producers noted that outdoor acreage can vary each year. There was a notable trend towards reduced outdoor acreage over time in the responses.

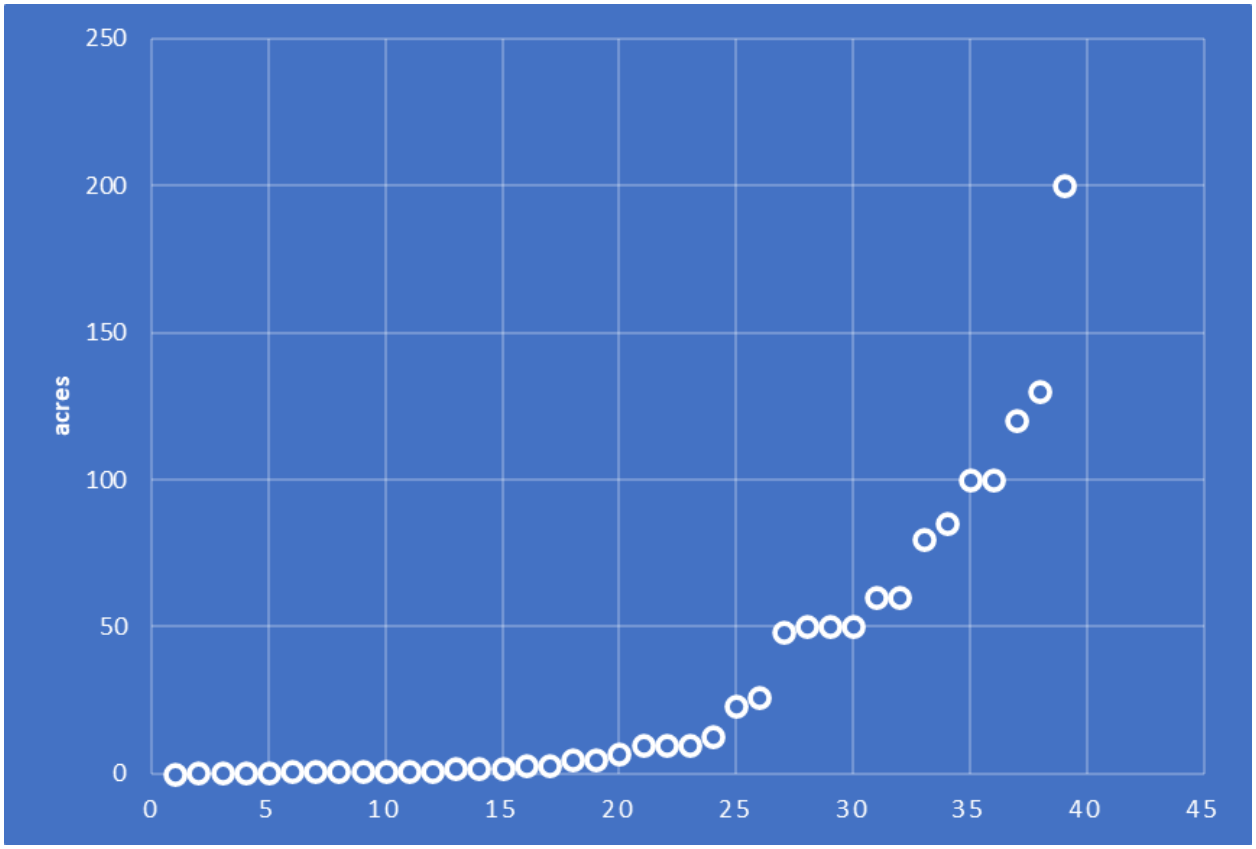

Figure 9. Each circle represents the different sizes of outdoor hemp operations in acres.

B. Impacts of Cross Pollination

Have you experienced cross pollination in your crop?

Next, the survey asked the Colorado marijuana and hemp industries if their crops had been affected by cross pollination. A majority of the 64 respondents (55%) said “yes,” their crops had been impacted by this issue (Fig 10).

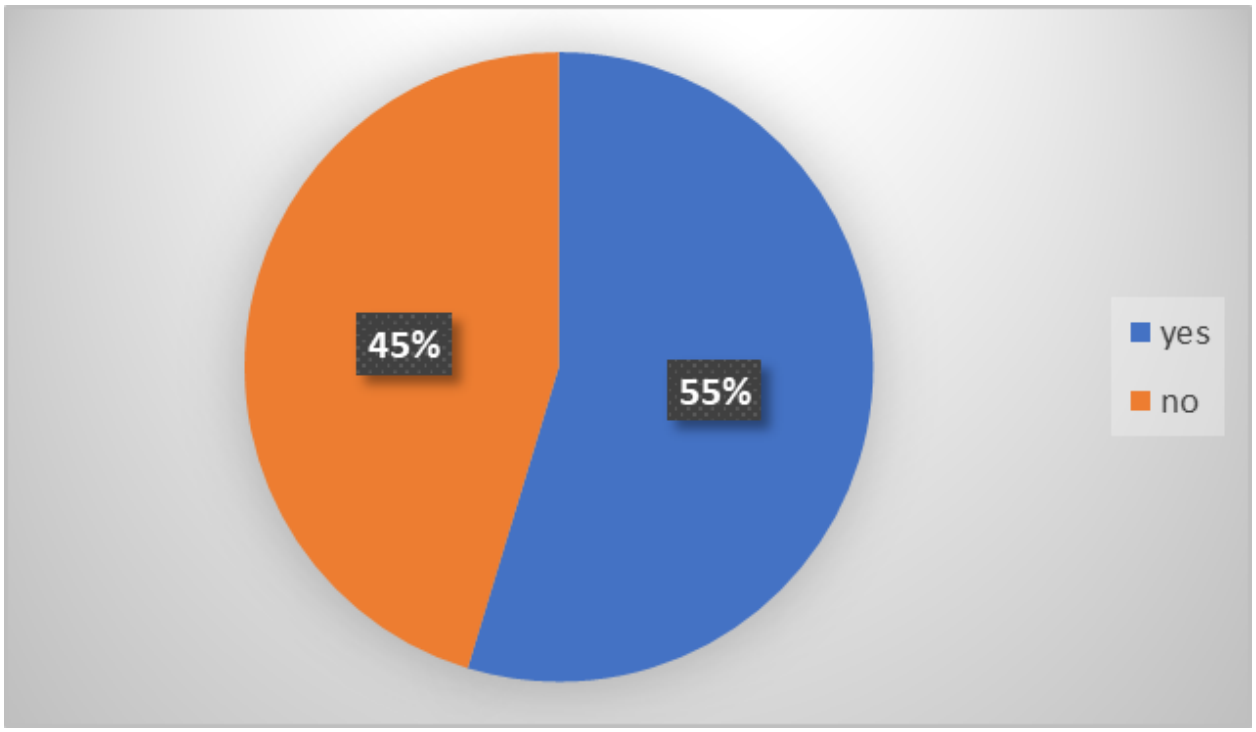

Figure 10. A majority of stakeholders in the Colorado marijuana and hemp industries stated they had been impacted by cross pollination of their crops.

If you have been affected by cross pollination, please describe the impact on your crop. For example, what percentage of your crop was affected?

Marijuana and hemp growers were asked to quantify their crop loss due to cross pollination. The survey asked, “If you have been affected by cross pollination, please describe the impact on your crop. For example, what percentage of your crop was affected?” Fifty-one responses reported their crop loss as a percentage; 35% of cultivators saw 50-100% of their crops cross pollinated during at least one growing season (Fig. 11).

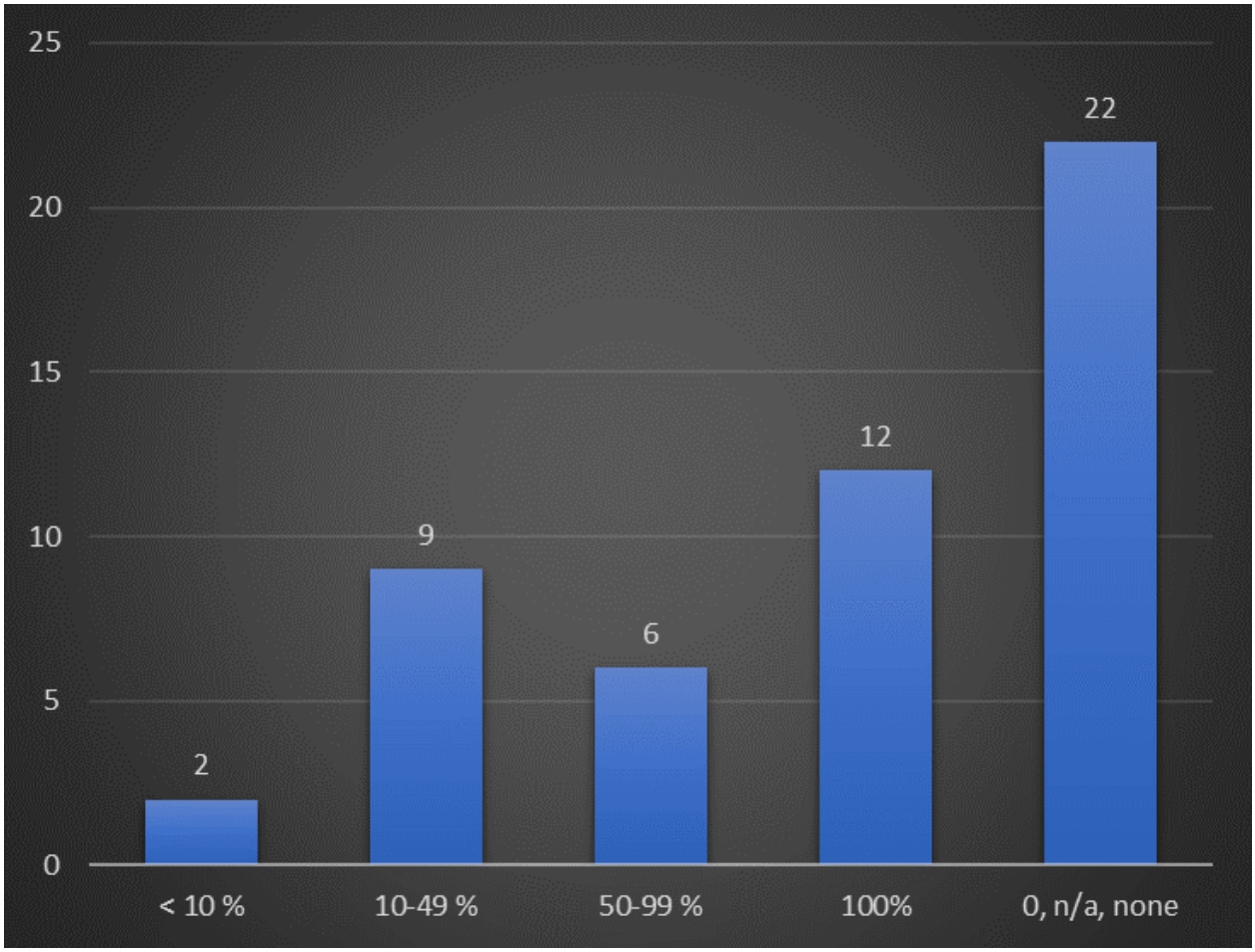

Figure 11. Survey respondents estimated the percentage of their hemp and marijuana crops that were affected by cross pollination.

In what year did this issue occur? What time during the growing season did pollination occur?

When asked about the timing of cross pollination events, growers mentioned they had issues every growing season from 2016 to 2021. A typical Colorado outdoor growing season begins in mid to late spring and ends in the first few weeks of October after a frost kills annual warm-season plants. Survey respondents mentioned that July to mid-October, August, end of summer to early fall, and fall were the times when cross pollination was the most severe at their operations.

Many hemp and marijuana producers commented on the reduction in outdoor cross pollination over time, which runs parallel to the decline of hemp production overall, as the number of registrations has declined steadily since 2019. For example, one grower stated their crops were 100% seeded in 2019, 75% of their outdoor crop was cross pollinated in 2020, yet only 10% was affected in 2021. It is important to note that growers indicated cross pollination was predominantly an issue in outdoor production. One respondent said, “In our greenhouses about 20% of the crop is affected. Our past 2019 outdoor crop was fully seeded (100%).”

What was the estimated financial impact from pollination?

Estimates of the financial impact of cross pollination ranged widely. Cultivators estimated their losses in USD: $12,000; $25,000; $200,000; $250,000; $450,000; $800,000; $1 million; millions of dollars. Other growers estimated their percentage crop loss during the affected year; these responses also varied substantially. Percentage estimates from the survey included: 10%, 30%, 50%, “at least half our crop,” and “100%

loss.” Others mentioned cross pollination had a “horrible impact,” a “huge” or “substantial” impact, or the financial impacts were “hard to estimate.”

What is the ongoing financial impact of rogueing male plants, scouting for male flowers, etc.?

Cultivators of all-female *C. sativa* crops must manage their fields differently than dioecious hemp producers - at first sight, male plants must be removed (“rogued”) from the field to avoid pollination of female plants that reduces the quality of the crop. The survey asked producers about the ongoing financial impact of rogueing male plants and scouting for male flowers (on female plants). Again, responses were highly variable. Two growers mentioned their labor costs during key times for rogueing males were $450 a month for one operation and $2000 a month for the other. Other cultivators stated the annual cost of rogueing male plants - $1,000; $3,000; $5,000; $10,000; $15,000. For some, the annual costs fluctuated over time, with expenses ranging from $10,000 to $45,000.

Some notable cultivator responses to this question include the following statements.

> “The situation will be unique for each grower/farm. If you are producing for flower, then such incidents can (be) disastrous, as in the difference between sustainable and business failure.”
>
> “Triploid sterile female varieties are available now if you don’t want seeded crops.”
>
> “We have not determined the financial impact. Culling males and/or herms is a cost of doing business.”

What is the estimated frequency of seeds produced in both indoor and outdoor production? Have you noticed differences in pollination/seed production between the cultivar/variety you have produced?

These two questions describe the differences in cross pollination between indoor and outdoor production, in addition to the differences between the cultivar (cultivated variety) of *C. sativa* produced. Notable responses describe grower observations on the differences between indoor and outdoor production.

"Incredibly heavy in hoop houses and (the) greenhouse. No seeds noticed in indoor cultivation."

"None in Indoor/greenhouse. Most strains outdoors."

"I didn't have any seeds until the farm went in next door."

Different cultivars and types of *C. sativa* may respond differently to cross pollination. Growers had a few things to say about this issue in the following responses.

"The triploid varieties are a path forward, traditional diploid varieties will continue to be seeded with the escaped feral CBD and illegal high THC plants, even if all intentional producers diligently control their male plants."

"Yes, especially with the use of triploids (i.e. lower pollination, but not totally eliminated)."

"No, except for seedless triploid varieties."

"Absolutely. Some strains create way more seed than others given the same amount of material/inflorescence size. Different sized seeds as well. This also goes for pollen and pollen grains."

"Yes, susceptibility to hermaphrodite or seed is both cultivar specific, as well as genetic stress/stability within that cultivar."

Many growers noted they only produce one cultivar of *C. sativa* at their operation. Other producers grew more than one cultivar and only noted slight differences in the effects of wayward pollen. Finally, others noted the production environment (indoor vs. outdoor) seemed to have a greater effect than cultivar selection, with indoor production substantially limiting the effects of cross pollination.

C. Cross Pollination Mitigation Strategies

The survey asked stakeholders to describe methods they have used to mitigate the effects of undesired cross pollination on certain *C. sativa* crops. They were asked how successful they had been in their efforts, in addition to what methods they are considering in future growing seasons.

What measures have you used to reduce cross pollination? Have they been successful?

"We tried to use the best genetics we could and used pollen netting on indoor"

"distance, filtration, water, crop barriers, trees, breeding," "Only success so far is the use of triploid cultivars"

"Using reliable genetics. Yes." "Corn and Sunflower Barrier Crops… Yes, successful"

"Check field with drone and spot kill, yes," "Air filtration, but not successfully"

"Filtration. HEPA and good airflow setup. Also SOPs for cleaning, workflow, etc"

"male rogueing on my acres," "Just walking fields removing as many male plants as possible"

"constant field & neighborhood patrols," "Moved into greenhouse. Yes." "Limit visitors, change filters regularly"

"Changing clothes, shoes etc before entering grow areas. Burners"

"Scouting and removal of affected plants has been the only method that has been successful"

"Weeding out male plants at their earliest point noticed male. Successful so far"

"Verifying the sex of a seed by germinating several test seeds. Yes.," "Impossible to prevent to date."

Are there other methods you are considering for use with future crops?

"Distance from other growers, row covers, triploid plants."

"Will use triploid varieties when the price reaches economically viable level, no more hemp growing until that point."

"No, I try to keep the clones feminized as best I can."

"I plan to move to indoor growing in addition to our outdoor grow plans."

"We have spoken about using pollen screens behind our fans in our greenhouses if we start seeing evidence of cross pollination."

"Outdoor you could use a large swaths of pollen fabric on tall poles like Top Golf."

D. Unregistered Plants and Other Questions

Volunteer *C. sativa* is a byproduct of cultivation and occurs when a plant is pollinated, whether intentional or not, and a seed makes its way to the ground. When the seed is in a favorable environment, it germinates and emerges from that location, e.g., the soil in a field. This often occurs at the end of the season or at the beginning of the next season. Seed can be transported long distances via mammals (including humans), birds, farm equipment and other vehicles, and other methods. Under CDA guidelines, volunteer hemp must be registered with the agency or destroyed.

What techniques have you used to manage volunteer C. sativa plants on your registered land area and beyond?

"not an issue, is an issue with abandoned fields from previous years, landowners responsibility, shame when companies go out of business, county should be responsible for volunteer plants."

"Instruct employees to spot and immediately pull them, both for compliance and best practices for controlled cultivation."

"We mow, scout and weed religiously. Tag any female wild plants and kill anything else."

"Scouting and destroying," "Weeding out males when discovered"

"Herbicides," "rotation," "tilling"

"Hand hoeing, mechanical plowing / disking, and chemically spraying ground going back to conventional crops"

"Volunteer sativa plants came up in 2021 in our field. We weed sprayed and rototilled for eradication."

"Rotation. We don't plant back onto a field used for hemp production less than 4 crop years later."

"Till and rogue early when outdoors; indoors it's about soil replacement."

"We pull the plants by hand and bag them in water filled bags."

"Volunteers have been very minimal, hand removal," "hand pull and check everyday every row,"

"Labors walking fields weeks on end"

Have you noticed feral (wild) populations of C. sativa plants, also known as ditchweed, in your region?

We asked marijuana and hemp cultivators, "Have you noticed feral (wild) populations of *C. sativa* plants, also known as ditchweed, in your region?" Volunteer hemp plants arise from seeds that are not intentionally planted, while feral hemp populations are plants that have 'escaped' cultivation and established themselves in the wild, e.g., feral hogs in

Texas or Canada. Only 25% of the respondents stated they had seen feral populations near their operations (Fig. 12). Many responses noted that uncultivated populations were confined to their outdoor fields. This indicates that volunteer hemp in cultivated fields is commonplace and is something producers are already successfully managing in their fields and outside their facilities.

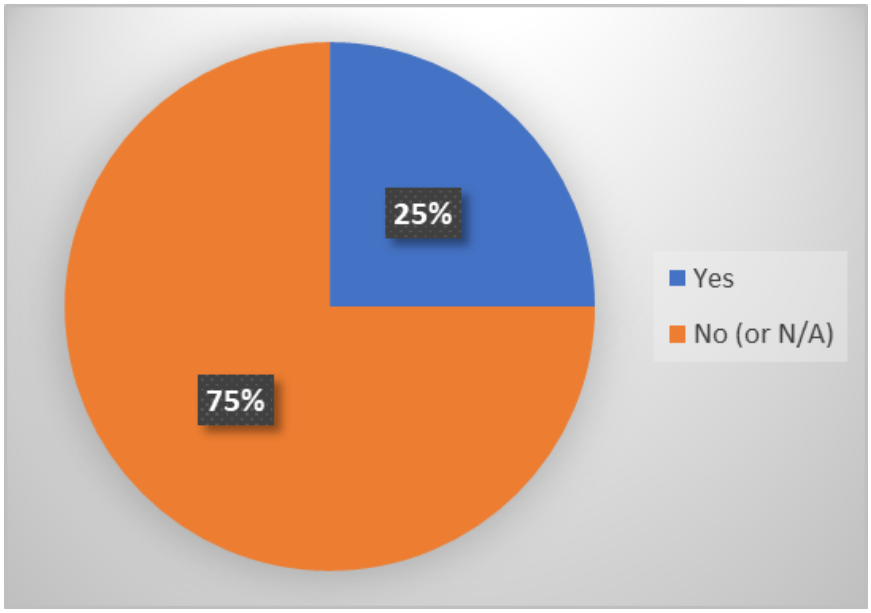

Figure 12. Feral and volunteer hemp exists in Colorado yet only 75% of respondents noticed it near their cultivation facilities.

Do you have any thoughts as to the source of pollen that pollinated your crops?

"I believe that little was done to mitigate the issue this past year and I no longer employ my grower. I am interested in using pollen sensors this year to determine how much comes from feral hemp v volunteer plants from seeds from previous years"

"Yes, we tracked the source to a hemp farm on the next road over, approximately 1/4 mi away. I have two farms in the near vicinity, that operate identically. One farm was specifically effected and the other was not."

"There are 15-20 outdoor marijuana grows within a one mile radius. I suspect that one or more of our neighbors either is growing from seeds and not doing a good job culling males, or not watching for herms"

"Our county has 30+ registered Hemp growers so likely it is from CBD varieties, making the seed useless for any possible experimentation or out planting for trials."

"Yes, the sale of the marijuana grow and the new owner eliminating males has solved our issue"

"Illegal grows, outdoor grows," "Some hemp farms right upwind."

"Yes. It is clearly coming from hemp producers that are planting large acreage of non feminized seed 30-60 miles away upwind. This needs to be restricted."

"A neighbor 3/4 mile south (upwind) made no attempt to reduce male plants in his field. He had several acres with estimated 60% male plants."

"The huge amount of uninformed farmers that tried to cut corners and used their seed they saved from plants to grow the next years crop."

"We were told by locals that there is a fiber hemp production farm nearby, as well as many other farms that do not destroy rogue plants."

"Yep, know exactly where it came from...having a heads up on an operation of that size would have been helpful."

"Right next door. Outdoor crop less than 50 yards from our fence that was licensed from the county of Pueblo."

"yes, multiple sources. Other hemp grows (pollinated & non pollinated), personal MJ grows, licensed MJ grows."

"Seed and fiber growers, farmers not killing their volunteers and Nebraska ditchweed pollen drift"

"Clearly. One grower that flippantly and irresponsibly ruined everyone's crops that year"

"Source has to be hemp stands within wind source area. Huge considering wind patterns"

"Hermaphrodites and random sources. Impossible to tell in my area."

If you have had any issues, have you contacted neighbors? State agencies? Others? What was the response you received?

"Yes, the hemp producers using non feminized seed have stated that is their business model and refuse to change (it appears to be the seed producer driving the model, giving the non fem seed to the farmers for free and splitting the crop). Agencies have stated the practice is legal and not regulated. County had a brief discussion about regulating it, but it's a bit complicated and more than the county wanted to get into, and information and resources to help with this were not available for the county."

"We have contacted our neighbors and were invited to tour their facility. We shared some information of planting and harvesting times."

"No one cares. We grew the plants without pesticides and with excellent hands on farming. The price dropped so drastically we cant keep growing. Its very sad as we do believe its a great beneficial crop for the earth and Colorado."

"We did everything we could possibly do and were completely ignored. Every neighbor wrote a letter as well and opposed the new grow. Some residential neighbors are less than 20 yards from the outdoor grow, it's not right."

"I have contacted neighbors and the county. I was part of a letter signed by many neighbors to the county. I participated in a local county Work Group to draft regulations. Nothing has been done by the county and I never received a response from any commissioner."

"We spoke to the county. They have been very cooperative."

"Yes the neighbors were willing to act. The County lacked determination, resources, or training to effectively investigate or enforce the code."

"Its been a recurring topic in Colorado but I haven't heard of any legal action or new legislature about it"

"We did contact the grower and identified the source of the pollen," "Contacted neighbors, how I found out about their crop this year."

It is important to note that a few responses discussed issues of fear, intimidation, theft, and harassment. Respondents also mentioned fear of retaliation from other producers and mentioned the potential for lawsuits based on cross pollination-related issues. Cross pollination is clearly an issue that has affected numerous producers in Colorado.

V. Working Group Recommendations

The HB21-1301 Working Group on cross pollination broke into focus groups to address four main subjects of study noted in the legislation. The key limitations of the policy recommendations were they must not mandate restrictions on hemp type, timing of crop planting, or dictate location; they also should not limit the ability of property owners from entering into voluntary agreements. The desired outcomes of the focus group process were to:

- Answer the legislative call to study the subjects of managing pollen from wild populations of *Cannabis sativa* L., hemp and marijuana cultivation operations, and sharing sensitive information related to these issues
- Discuss strategies on how to manage these issues within focus groups
- Utilize the team roles within focus/subgroups to assure high-quality interactions and transferrable information back to the large group

Focus group members were asked to participate in the process by engaging in the following roles:

- Chair/facilitator – *Assures that everyone participates in the conversation*
- Secretary/timekeeper – *Records the group responses; keeps track of time and progress, help group focus on work*
- Spokesperson – *Willing to report back to the larger group on the key outcomes*

The focus groups were tasked to study, discuss, and craft ideas on four unique but interrelated topics. Working group members were assigned a focus group, but participation in multiple groups was encouraged. The main topics and the focus groups participants are listed below, followed by the working group recommendations.

A. How to minimize volunteer cannabis plants growing on areas of land that are not registered or licensed, regardless of its prior status as registered or licensed;

- Bia Campbell, Damian Farris, Steve Turetsky

B. How best to share data and the proximity between locations of outdoor hemp and marijuana cultivations, including information for each outdoor cultivation regarding: (a) the potential for cross-pollination and (b) property size;

- Thomas Dermody, Jonathan McIntosh, Eric Singular

Best practices for preventing cross-pollination including: (a) An examination of the standards developed by agricultural organizations with expertise in industry-wide standards and practices; (b) Recommendations from subject-matter experts; and (c) If available, a review of practices developed by the hemp center of excellence; and

- Brian Higgins

The feasibility of conducting and financing field studies to examine cross-pollination between outdoor cultivations and areas of land with volunteer cannabis plants.

- Grant Orvis, PhD, Shawn Honaker

A. Minimizing Unregistered Plants

Legislative directive: How to minimize volunteer cannabis plants growing on areas of land that are not registered or licensed, regardless of its prior status as registered or licensed.

Problem Statement

Unlike marijuana and hemp, which are regulated by the Department of Revenue and Department of Agriculture, respectively, volunteer *C. sativa* plants, meaning plants that grow in nature without prompting or supervision, are currently unregulated in Colorado.

Not only that, but no state agency has authority over those plants. Different law enforcement agencies have authority over unregistered and unlicensed *C. sativa* growing in the state, but in reality, prioritization and lack of resources does not allow for an oversight level that would lead to minimizing those plants. As a consequence, control over their spread and growth, as well as tracking and containment of plants in affected areas is non-existent.

This becomes an issue because of the resilient nature of the *C. sativa* plants, which grow easily, as the nomenclature would indicate, volunteer *C. sativa* plants are also known as feral hemp. We don't know and don't have enough data to ascertain if there is native hemp in Colorado or not, therefore, we cannot make an assessment of whether those plans should be considered invasive.

> USDA's definition of an invasive plant is as follows: *Invasive Plant: A plant that is both non-native and able to establish on many sites, grow quickly, and spread to the point of disrupting plant communities or ecosystems.*
>
> From the Presidential Executive Order 13112 (February 1999): *'An invasive species is defined as a species that is 1) non-native (or alien) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health.'*

The existence of unmanaged volunteer plants aggravates the issue of cross pollination. The unintended cross pollination of volunteer plants with marijuana and hemp fields cultivating female-only plants creates economic harm to both marijuana and hemp

producers. Colorado needs a mechanism to minimize the unwanted growth of those plants in natural and unregulated settings.

The management and reduction of cross pollination is essential to maintain Colorado's position as a leader in the *C. sativa* space, both at the hemp and marijuana levels.

Policy Proposals

1. *Data Gathering*

This focus group is proposing the Colorado State Legislature run a bill appropriating funds for a grant to a research entity that would report, in a timeframe to be determined, on pollen count testing and locations around the state with concentrations of feral hemp populations.

2. *Land that was once registered or licensed*

This task force is proposing that, in coordination with other focus groups, when creating the Best Management Practices (BMP) manual, we include information about preventing volunteer hemp, including, but not limited to how to take care of land, in an effort to discourage future volunteer *C. sativa* populations that were once registered or licensed as a hemp or marijuana cultivation operation. This section should highlight existing Good Agricultural Practices (GAP) and note where additional diligence is required due to the unique factors involving cannabis plants. Once a registrant or licensee surrenders their registration or license and either moves or goes out of

business, those parties could refer to the BMP manual outlining procedures intended to prevent the growth of *C. sativa* plants on an inactivated field.

Note 1: The BMP manual will point out the different best practices for outdoor grows versus controlled environment agriculture (CEA), also known as greenhouses.

Note 2: The BMP manual will contain best practices for weed prevention and timelines and season differentiations, in addition to the best management practices to prevent volunteer *C. sativa* plants. Noting that mechanical eradication of volunteer *C. sativa* plants is the only effective way to fully remove those plants, and that burning or use of herbicides are not effective, as *C. sativa* plants can survive those processes.

Note 3: Education of stakeholders: In addition to having this information in the BMP manual, the state should also include information on the MED & CDA websites.

Note 4: The BMP manual should include a section on “info to know” to help mitigate volunteer *C. sativa* plants.

1. Until authority over unregistered *C. sativa* is determined, educate stakeholders on the current ways to identify volunteer *C. sativa* plants to verify if they are being grown on a legally registered land area.

2. Identify trouble areas for volunteer *C. sativa* plants after having been grown on a piece of land.
3. Identify areas in the State where volunteer *C. sativa* plants thrive, as well as primary locations where those plants tend to grow, such as ditches, fence lines, clusters of trees, and other areas where plants have access to water sources, etc.
4. Lessons on how to identify pathways for the spread of seed or pollen, making people aware, and increasing ability to monitor when possible. Some examples are:
    a. Seeds can be spread by birds, mice, or other small animals. Volunteer *C. sativa* plants are likely to be found where these animals live or on the way to their homes. Those areas should be monitored when possible.
    b. Pollen can be spread by wind, birds, and bees. Bees feed on the hemp pollen and take it back to their hives. The presence of those animals and insects should also be monitored.
5. The BMP manual should include information on *C. sativa* pollen itself in order to increase awareness on the characteristics and nature of it. For example, when hemp pollen starts and stops being produced by the *C. sativa* plant and the timeframe when the highest amount of pollen is likely to be present.

a. Additionally, the manual should identify the types of *C. sativa* plants that produce pollen. Including, but not limited to dioecious male plants, monoecious plants, female dioecious plants that have produced pollen. It should also include life cycle information and pictures of all types of pollen-producing *C. sativa* plants.

6. The manual should include pictures of *C. sativa* plants that have just emerged from the ground to help landowners spot volunteer hemp as early as possible. The sooner it is identified the easier it is to be removed. It is also important to note that volunteer *C. sativa* can emerge as early as the end of January or February in each year. Finally, the BMP manual should list the conditions needed for hemp to germinate and emerge.
7. Information on how to make sure that harvest equipment and trucks used are thoroughly cleaned out before moving between fields is paramount, especially in areas that may not be obvious, such as the engine compartment or roof of the cab.
8. The maintenance of clean grounds at grain and fiber processing facilities. With particular focus on roadways to the facilities, loading, unloading areas should also be considered critical information.

Note 5: Working with universities and students on a volunteer basis to develop a program is a valuable avenue to mitigate costs and access resources in order to

identify volunteer cannabis populations with the help of landowners and other stakeholders. Volunteer students could go out to those areas to sample and perform research on those populations. Having students mechanically remove the volunteer cannabis plants could present a viable avenue for a mutually beneficial program. As a result, this research would be invaluable with novel information and, at the same time, would result in the reduction of volunteer cannabis plants.

As a part of those efforts, this focus group is also recommending CDA and MED to include language that states that upon surrender or revocation of a registration or license, a registrant or licensee must sign an acknowledgement agreement that they have read and understood the BMP manual and will, to the extent possible, incur on those practices to mitigate the risk of future volunteer plants.

3. *Defining authority for action*

This task force is proposing the Colorado State Legislature run a bill to create a new Article under Title 35 (Agriculture) of the Colorado State Statute. Article 62 (Unregulated Cannabis Plants) would give the Department of Agriculture authority over unregistered *C. sativa* plants. The designation and classification of volunteer *C. sativa* plants would assist the state in coordinating efforts with counties to stop the spread of feral plants. The article would mirror the delegatory power, actions and best practices of Article 5.5 of that same Title, and help guide the state and counties on how to deal with this issue, as well as give *C. sativa* registrants and licensees an avenue to reach out to public authorities to solve related issues that arise.

B. Data Sharing

Legislative Directive: How best to share data and the proximity between locations of outdoor hemp and marijuana cultivations, including information for each outdoor cultivation regarding: (a) the potential for cross-pollination and (b) property size.

Problem Statement

While *C. sativa* pollen's vigor in Colorado's climate is not well understood, it can be surmised that the prevailing winds and proximity to commercial sources play a critical role in mitigating pollen related risk on flower-orientated production of hemp and marijuana. It is a shared concern amongst flower-oriented producers that pollinated crops will lower their returns on investment, and, therefore, it is in the public's interest to provide accurate information on the relative proximity and crop type of cannabis associated with a given location so that cultivators may make informed decisions about the risk they may face in outdoor cultivation models.

Under their current statutory and rule-based authority, MED and CDA maintain the GPS locations of all land used to cultivate hemp and marijuana, as well as the type of crop that cultivator is producing. MED presently maintains this information in a public-facing, yet underutilized, fashion. CDA, as required by the State's approved management plan, maintains this information, but is currently restricted from sharing it, except for law-enforcement related activities.

The focus group has concluded that by randomizing a hemp registrant's exact location by three (3), but no more than four (4), miles from the exact location of a Registered Land Area, the specific information the Industrial Hemp Act requires be maintained as

confidential is sufficient protected and concurrently provides enough specificity for producers to ascertain the relative risk they might face from pollen sources.

Policy Proposals

Provided that the disclosure requirements as specified above are acceptable, the Focus Group recommends that a CDA/MED endeavor to produce a public resource map that shall include the following features;

- For Registered Land Area supervised by the Department of Agriculture, the Department shall affix the GPS locations of an approximate site at a randomized distance between three (3), and no more than four (4) miles from, the exact address of the production site,
- For Licensed Premises supervised by the Marijuana Enforcement Division, the Department shall affix the exact physical address to the map. For clarity, the Licensed Premise may, or may not, be an indoor- or outdoor-based marijuana production site,
- Color-Coded by Crop Type (Flower, Grain, Fiber, Seed, or multiple crop types),
- Relevant data points shall be updated at least once per month and twice per month in April-August of a given calendar year when the occurrence of cross pollination is most likely,
- CDA should be the responsible state agency for maintaining the resource map, though MED should be responsible for consolidating information sourced from their database in a timely manner,

- With exception to when a bonafide Colorado Open Records Request is submitted, access to the resource map should be password protected and made available to individuals who maintain at a minimum a CDA-HEMP Phase 1 Application and their MED licenses.

Pending the beneficial use of this map in the first calendar year, further improvements to this map that the State may consider include, but are not limited to;

- Disclosure of the relative size of the production site in square ‘feet and, or acres depending on the nature of said production-type,
- A “report feral *C. sativa* plants” feature that would allow members of the public to report sites where feral cannabis plots reside for the benefit of producers seeking to reduce pollinated-related risk as necessary. The resulting coordinates would be superimposed on to the same web-interface as elected by the Department as a separate color-coded designation.

Defining Authority for Recommended Action

The focus group has determined that the recommendations are within the guidelines of the CDA’s Hemp Program and the MED's existing statutory authority.

Fiscal Impact Note

The focus group anticipates a minimal fiscal impact imposed by this recommendation. The required data is maintained by both agencies and the software package required to

produce the map falls within Discretionary limits. The expectation is that one full-time employee of the CDA's Hemp Program would spend no more than 1.5 hours per month accomplishing the related task, therefore no additional staffing is required.

C. Best Management Practices

Legislative directive: Best practices for preventing cross-pollination including: (a) An examination of the standards developed by agricultural organizations with expertise in industry-wide standards and practices; (b) Recommendations from subject-matter experts; and (c) If available, a review of practices developed by the hemp center of excellence.

Problem Statement

There is a lack of research on the best practices to prevent cross pollination in marijuana and hemp production. State legislation tasked the working group to develop a set of best practices to mitigate the economic impact of undesirable cross pollination in these two state agencies. Information from scientific literature, diverse agricultural organizations, Colorado hemp and marijuana producers, and other sources were utilized to craft a list of practices that may help reduce the effects of cross pollination.

Policy Proposals/BMP Manual

In March 2022, the responses from survey questions 15 and 16 were presented to the working group. These questions asked, “What measures have you used to reduce cross pollination? Have they been successful?” and “Are there other methods you are considering for use with future crops?” These cultivator-trialed techniques were discussed alongside a short list of cross pollination mitigation ideas backed by peer-reviewed scientific research.

Any measure that was successful for growers in Colorado and backed by scientific research was considered a “top-tier” idea to manage the impact of cross pollination. The next tier of suggestions were common-sense methods suggested by cultivators that were also supported by the expertise within the working group. Finally, there were good ideas suggested by producers in the hemp and marijuana industries that may or may not be successful but hold merit and may be worth considering with other tactics.

Top-Tier Ideas to Mitigate Cross Pollination

1- Indoor cultivation, if at all possible (wet walls + water filters, pollen screens, light deprivation)

2- Coordination with neighbors (e.g., "pinning" map system in W. OR specialty seed industry)

3- Triploid genetics - pollination is reduced 99%

4- Crop barriers for all types of growers (annual, perennial)

5- Physical/natural barriers (isolated field, buffer zones between different C. sativa crops)

6- Properly maintaining harvest equipment (planters, trailers, hoppers) to avoid inadvertent seed spreading

7- Utilizing feminized seed when producing cannabinoid crops, rogueing males when applicable

8- Have a good cross pollination plan (standard operating procedures)

9- Good agricultural practices (GAP) for timing your C. sativa crop

10- Planting certain types of crops earlier/later based on local circumstances

Successful measures trialed by Colorado producers (survey question #15) and future methods under consideration (survey question #16)

Indoor production of cannabinoid-rich, all-female *C. sativa* crops was discussed by numerous producers, both survey respondents and within the working group. Indoor production includes the use of greenhouses, in addition to modified warehouses and other structures. Common components utilized in indoor production include filtration with HEPA, carbon intake, and other types of filters; HVAC upgrades, sealing vents, and other building modifications; pollen screens, netting, fabrics, and wet walls (which are

also used to cool down greenhouses). Survey respondents suggested other producers create a set of Standard Operating Procedures (SOP) and use it to manage cleaning and workflow. Growers who felt successful in the management of cross pollination also limited visitors to their facilities and asked employees to change clothes, shower, and manage personal hygiene in specific ways. Similarly, cultivators reported using sanitizing stations at facility entrances, which are commonly used to manage diseases in greenhouses, nurseries, and dairy operations. These alcohol foot wipe pads, foot baths, or other types of stations are placed outside doors of facilities to avoid the spread of pollen and pathogens into sensitive production areas.

Survey respondents and working group members discussed other management practices outside of facility improvements. To maintain an all-female production system, cultivators mentioned how they only cloned female plants, rogued male plants in certain production systems, and removed individual sets of male flowers or seeded flowers from female plants. Field arrangements and crop rotations are used to manage cross pollination, as are the use of feminized seed of specific cultivars from reputable companies. Germination tests can be used to help determine the male-female ratio of a feminized seed crop indoors at a small scale before planting entire fields of a crop. Triploid cultivars produce a very minimal amount of seed and are being used by producers to bypass this issue altogether.

Spraying plants with water during peak pollen season, having a “friendly neighbor” policy and an awareness of neighborhood operations and feral hemp populations, and

the tried-and-true methods of physical barriers (e.g., wind fence, crop barrier, natural geography), distance and isolation, and crop timing were mentioned frequently in the survey and broadly discussed by the working group. Finally, producers mentioned the use of drones and other precision agricultural tools to identify and apply spot treatments of pesticides to male plants.

Helpful responses to survey question #16 described tactics Colorado producers are considering for future use in mitigating cross pollination. They are considering the use of pollen fabric as an outdoor barrier, row covers (manufactured nonwoven fabrics) to isolate crops, light deprivation, positive pressure, different types of products to de-stress, stabilize, or otherwise manipulate plant growth and production, and methods to irrigate fields, germinate volunteer seed two or three times and cultivate fields, then plant their desired crop.

Location management, like buffer zones between operations, and use of isolation distances is commonly used with other crops, as is the separation of relevant crops by flowering dates. For example, the isolation distance for AOSCA certified hempseed production and the Canadian requirements for pedigreed seed is roughly 3 miles, or 5 kilometers. Many agencies that certify seed use land requirements, weed management mandates, enforcement of crop rotations, require seed lots to meet impurity standards. Additionally, physical barriers/windbreaks are highly effective. Trees, taller “trap” crops, covering materials, and other methods can be used in conjunction with environmental information (wind speed and direction, barrier height and density, relative humidity, etc.)

These barriers minimize pollen dispersal, decrease pollen count, and can help reduce isolation distance. Finally, research has shown that the overhead watering of crops during critical times can reduce pollen drift between outdoor crops.

Volunteer hemp is easily managed with cover cropping, well-timed shallow tillage, judicious use of herbicides, and other methods. Proper and thorough cleaning of harvest and other farm equipment is necessary to mitigate the spread of hemp/marijuana seed. It is crucial to watch for volunteers around fence lines, ditches, and other disturbed and marginal areas.

D. Future Research

Legislative directive: The feasibility of conducting and financing field studies to examine cross-pollination between outdoor cultivations and areas of land with volunteer cannabis plants.

Problem Statement

We need more data on how to facilitate outdoor production of all types of *C. sativa*. Cross pollination has a negative economic impact on cultivators and other entities down the supply chain. Also, the state agencies involved in the working group should incentivize engagement with growers of all types to help with cross pollination research, i.e., more cultivators would get involved and help if they were paid for their time or incentivized in some other way.

Policy Proposals

There are numerous ways to begin closing the knowledge gap on outdoor cross pollination in hemp and marijuana crops in Colorado. The focus group created a series of progressively involved research studies. These studies are all reasonable next steps in better understanding the nature of cross pollination in this semi-arid, mountainous state. This research could be conducted through the Colorado Hemp Center of Excellence, when established, and/or in conjunction with Colorado State University.

Pollen-capturing studies - $50,000 request from legislature

Pollen traps are inexpensive and straightforward to make in a Do-It-Yourself-type manner. One type, a “mega-stigma” can be constructed from small boards, tape, and other household materials. Industry professionals would be provided financial support to collect pollen using D-I-Y pollen traps at their facilities and in their fields. The pollen would then be counted via documented scientific methods by university or other research personnel.

The budget for a small-scale project would be mostly spent on materials to construct the pollen traps and compensating industry professionals for their time and effort. If professional research or university personnel and/or facilities are deemed necessary for this study, funds would be used to compensate researchers for their time and use of university facilities and resources.

Steps required for megastigma construction (Kevan et al., 2006)

1. Make a number of wooden platforms, about 10 cm square with 45º bevelled edges and a central hole which can accept a dowel, rod or rope as an axis.

2. To each bevelled edge of the platform, affix two wooden spring-operated clothes pegs by the non-clip end with weather-resistant glue, nailing or stapling; each platform thus has eight clothes pegs. Use of water-soluble glue and plastic clothes pegs may prove to be less durable.

3. Thread these platforms onto a chosen axis which should fit through holes in the centre of each platform.

4. Make holes across the diameter of the axis to allow for stops, such as nails or toothpicks, to be inserted. These hold the platforms in place. Rope can be used instead of dowel for suspending traps, but it is important that the platforms be close to horizontal.

5. Make detachable pollen traplets from plastic horticultural labels, about 1.5 cm wide x 10 cm long x 0.1 cm thickness. Use a single-hole punch to distribute four to six holes evenly down the length of the label.

6. Apply transparent sticky tape along the underside length of the plastic labels so that the sticky surface of the tape is exposed upwards through the holes.

7. Clip the traplets to each platform with the clothes pegs. Each platform should then contain eight traplets with approximately 40 sticky pollen-trapping surfaces in total.

Steps required for megastigma construction (Kevan et al., 2006) continued

1. Choose a patch of plants in which to make the study.

2. Early in the morning (dawn) deploy one megastigma with traplets, to which tape has been most recently applied, in place.

3. Record time, height, and weather conditions.

4. At regular intervals, remove or replace the traplets from the megastigma and return them to the laboratory.

5. Record time, height, and weather conditions at each sampling.

6. Examine each hole in each traplet microscopically at a resolution of 100X or more, counting grains per hole by scanning systematically. If necessary, to ease counting, a tiny drop of Calberla's stain (or other stain) (Dafni et al, 2005) can be used in each hole. The stain should be removed after about two minutes by absorbing it with the point of a piece of filter paper or paper towel. Be sure not to dab the hole, but to use only the point of the absorptive surface which allows surface tension to absorb excess stain.

Specialized sensors - $100,000 request from legislature

Pollen sensors now have the capability of speciating and counting different types of pollen. Artificial intelligence (?) paired with environmental sensors would be utilized to measure total pollen count during different times of the year. These types of sensors cost around $3,500 per machine from Pollen Sense, for example. This level of funding would build upon the previous model, where industry professionals work with researchers to capture pollen to better understand cross pollination. Funding at this level would allow for a similar type of industry-academia collaboration but with additional technology to supplement the homemade pollen traps.

Genetic fingerprinting - $250,000 request from legislature

People can only make assumptions when identifying the source of *C. sativa* pollen. However, with help from private industry, university researchers, and possible funding from federal agencies, genetic fingerprinting of C. sativa would be conducted. This research could help hemp and marijuana producers identify the source of cross pollination.

Fingerprinting/sequencing analysis for investigating genomic origins of pollination events is a realistic option with Front Range Biosciences, a pioneering hemp company located in Boulder, Colorado. They have tools, including STR analysis (fingerprinting) and utilizing proprietary SNP chips from industry. These tools would all be helpful for looking at seeds from pollinated plants and determining their origins and if pollinated from local hemp, marijuana cultivators, or feral hemp populations. The cost of analysis per sample for SNP analysis is $35; the cost per sample for STR fingerprinting is $65, with possibilities for discounts up to $5 per test based on the quantity of samples. Note: a bank of hemp genetics must exist to compare pollen samples to during these analyses. Identification of pollen sources may be difficult without plant tissue or other samples from source plants to measure against the cross-pollinating pollen.

4) University collaboration for 3-year study - $500,000 request from legislature

Experimental research is crucial to fill knowledge gaps and build a better understanding of the natural world. Funding would be utilized to fund a university professor to act as

primary investigator (PI) on a research proposal for a federal grant. A three-year, replicated study would be executed in diverse locations across the state.

$60,950 Formal One-Year Federal Grant Budget with Justification (EXAMPLE)

Senior Personnel: $1,500 - As Principal investigator (PI), a professor/researcher would be responsible for management, organization and reporting of the project, and supervision of graduate and undergrad employees.

Other Personnel: $24,000 - Graduate Student support ($1,625/month, $19,547/year) is requested for one Ph.D. student for the duration of the proposed project. The graduate student will design and conduct the described field experiments and participate in data analysis, data interpretation, and manuscript preparation. Student hourly support ($15/hour for 10 hours/week for 20 weeks; $3000/year) will allow an undergraduate student to help graduate student with field work and data collection.

Fringe Benefits: $2,500 - Fringe benefits are budgeted at the following estimated rates for each category: Faculty and Administrative Professionals - 27.1%; Graduate Research Assistants - 9.5%; Student Hourly - 0.9%. The actual rate charged will be the federally approved rate in place at the time the salaries are incurred.

Domestic Travel: $2,500 - Funds for employee travel between locations for data collection, etc.

Materials and Supplies: $3,000 - Funds to support purchase of supplies for pollen detection and viability studies.

Equipment or Facility Rental/User Fee: $19,500 - Funds for lab analyses and outside services.

Indirect Costs: $7,950 - The sponsor allows the indirect cost rate at 15% of modified total direct cost base, computing by adjusting total direct costs to exclude tuition, equipment, participant support, etc. over $25,000.

Topics of Interest for Future Research

Airborne pollen count during pollen season in different ag/eco regions across the state, across different types of facilities (indoors, high tunnel, outdoors)

Viability of pollen at different times and distances from source (ICR, 2017)

Pollen viability and germination rates over time, based on collection dates

Pollen range/distance traveled in Colorado

Percentage of hermaphrodites in all-female crop plant populations (by cultivar)

Pollen dispersal factors - prevailing wind direction, topography, scale (large plant populations), local insects, mechanical movement (humans, clothing, tools, etc.)

Opportunities for summer+ employment via PT jobs/internships for young plant scientists (Terry Moran)

Utilize UAV (drones) to scout for on-farm volunteers and identify feral hemp populations (CSU Drone Center)

Seed set at different distances from a pollen source to predict buffer distances where tolerable level of cross pollination occurs, i.e. don't just measure pollen count (ICR, 2017)

Size and shape of buffer zones, especially with lack of prevailing winds and semi-arid, low humidity climate of Colorado, where pollen travels further, stays viable longer (ICR, 2017)

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VII. Appendices

A. Colorado House Bill 21-1301

https://leg.colorado.gov/bills/hb21-1301

HOUSE BILL 21-1301 - Cannabis Outdoor Cultivation Measures

BY REPRESENTATIVE(S) Esgar and Holtorf, Bernett, Bird, Boesenecker, Duran, Gray, Hooton, Lontine, McCormick, McLachlan, Michaelson Jenet, Ricks, Snyder, Valdez A., Woodrow, Jackson, McCluskie, Ortiz, Titone; also SENATOR(S) Coram and Moreno, Ginal, Gonzales, Holbert, Jaquez Lewis, Rankin.

CONCERNING THE REMOVAL OF IMPEDIMENTS TO CANNABIS FARMING, AND, IN CONNECTION THEREWITH, PERMITTING CONTINGENCY PLANS TO REDUCE CROP LOSS BASED ON ADVERSE WEATHER AND CONVENING A WORKING GROUP TO EXAMINE MEASURES TO REDUCE CROSS-POLLINATION, AND MAKING AN APPROPRIATION.

SECTION 2. In Colorado Revised Statutes, add 35-61-110.3 as follows:

35-61-110.3. Cross-pollination - working group - reporting - repeal. (1) ON OR BEFORE NOVEMBER 1, 2021, THE COMMISSIONER, IN COLLABORATION WITH THE STATE LICENSING AUTHORITY, THE GOVERNOR'S DEPUTY LEGAL COUNSEL, AND THE GOVERNOR'S SPECIAL ADVISOR ON CANNABIS, SHALL WORK WITH A

WORKING GROUP CONVENED TO STUDY AND RECOMMEND OPTIONS FOR MINIMIZING CROSS-POLLINATION BETWEEN CANNABIS PLANTS, INCLUDING:

(a) HOW TO MINIMIZE VOLUNTEER CANNABIS PLANTS GROWING ON AREAS OF LAND THAT ARE NOT REGISTERED OUTDOOR HEMP CULTIVATIONS OR LICENSED OUTDOOR MARIJUANA CULTIVATIONS, REGARDLESS OF WHETHER THE PROPERTY WAS PREVIOUSLY REGISTERED OR LICENSED;

(b) HOW BEST TO SHARE DATA AND THE PROXIMITY BETWEEN THE LOCATIONS OF REGISTERED OUTDOOR HEMP CULTIVATIONS, LICENSED OUTDOOR MARIJUANA CULTIVATIONS, AND THE PROPERTIES OF APPLICANTS FOR REGISTERED OUTDOOR HEMP CULTIVATIONS OR LICENSED OUTDOOR MARIJUANA CULTIVATIONS, INCLUDING INFORMATION FOR EACH OUTDOOR CULTIVATION REGARDING:
(I) THE POTENTIAL FOR CROSS-POLLINATION BETWEEN THE OUTDOOR CULTIVATION AND OTHER OUTDOOR CULTIVATIONS OR AREAS OF LAND WITH VOLUNTEER CANNABIS PLANTS; AND
(II) PROPERTY SIZE;

(c) THE BEST PRACTICES FOR PREVENTING CROSS-POLLINATION INCLUDING:

(I) AN EXAMINATION OF THE STANDARDS DEVELOPED BY AGRICULTURAL ORGANIZATIONS WITH EXPERTISE IN INDUSTRY-WIDE STANDARDS AND PRACTICES;

(II) RECOMMENDATIONS FROM SUBJECT-MATTER EXPERTS; AND

(III) IF AVAILABLE, A REVIEW OF PRACTICES DEVELOPED BY THE HEMP CENTER OF EXCELLENCE; AND

(d) THE FEASIBILITY OF CONDUCTING AND FINANCING FIELD STUDIES TO EXAMINE CROSS-POLLINATION BETWEEN OUTDOOR CULTIVATIONS AND AREAS OF LAND WITH VOLUNTEER CANNABIS PLANTS.

(2) IN CONVENING THE WORKING GROUP, THE APPOINTING AUTHORITIES SHOULD STRIVE TO INCLUDE REPRESENTATION OF A DIVERSE CROSS-SECTION OF MEMBERS. MEMBERS OF THE WORKING GROUP SHALL BE APPOINTED ON OR BEFORE OCTOBER 15, 2021, AS FOLLOWS:

(a) THE CHAIRS OF THE HOUSE AGRICULTURE, LIVESTOCK, AND WATER COMMITTEE AND THE SENATE AGRICULTURE AND NATURAL RESOURCES COMMITTEE OR THEIR SUCCESSOR COMMITTEES SHALL JOINTLY APPOINT:

(I) TWO MEMBERS FROM AFFECTED LICENSED MARIJUANA CULTIVATION BUSINESSES IN THE STATE;

(II) ONE GENETICIST WITH EXPERTISE IN CANNABIS BREEDING;

(III) ONE SCIENTIST OR AGRONOMIST WITH EXPERTISE IN CROSS-POLLINATION;

(IV) Two MEMBERS FROM SOFTWARE COMPANIES THAT SERVICE THE AGRICULTURAL INDUSTRY;

(V) Two MEMBERS FROM BUSINESSES IN THE STATE WITH EXPERIENCE GROWING HEMP FROM FEMINIZED SEEDS OR CLONES PRIMARILY FOR CANNABINOID PRODUCTION;

(VI) TWO MEMBERS REPRESENTING COMPANIES WITH EXPERTISE IN AGRICULTURAL SURVEYING;

(VII) TWO MEMBERS FROM BUSINESSES IN THE STATE WITH EXPERIENCE IN THE DEVELOPMENT OF SEED THAT IS CERTIFIED BY THE ASSOCIATION OF OFFICIAL SEED CERTIFYING AGENCIES; AND

(VIII) Two MEMBERS FROM BUSINESSES IN THE STATE WITH EXPERIENCE IN GROWING HEMP GRAIN AND FIBER VARIETIES; AND

(b) THE STATE LICENSING AUTHORITY SHALL APPOINT FOUR MEMBERS AS FOLLOWS:

(I) TWO EACH WITH EXPERTISE IN LICENSED MARIJUANA CULTIVATION REGULATIONS; AND

(II) TWO EACH REPRESENTING A LICENSED MARIJUANA OUTDOOR CULTIVATION BUSINESS WITH EXPERTISE IN CANNABIS GENETICS.

(3) THE WORKING GROUP'S RECOMMENDATIONS MUST NOT INCLUDE MANDATES ON THE TYPE, LOCATION, OR TIMING OF ANY CROP PLANTING; HOWEVER, THIS WILL NOT LIMIT THE ABILITY OF PROPERTY OWNERS TO ENTER INTO VOLUNTARY AGREEMENTS.

(4) ON OR BEFORE NOVEMBER 1, 2022, THE WORKING GROUP SHALL SUBMIT A REPORT OF ITS FINDINGS AND RECOMMENDATIONS TO THE HOUSE OF REPRESENTATIVES AGRICULTURE, LIVESTOCK, AND WATER COMMITTEE AND THE SENATE AGRICULTURE AND NATURAL RESOURCES COMMITTEE, OR THEIR SUCCESSOR COMMITTEES. THE DEPARTMENT AND THE STATE LICENSING AUTHORITY SHALL POST THE REPORT ON THEIR PUBLIC WEBSITES.

(5) THIS SECTION IS REPEALED, EFFECTIVE JANUARY 1, 2023.

B. Glossary of Terms

Cannabinoids are secondary metabolites produced by *Cannabis sativa* plants; cannabinoids of interest in this report are tetrahydrocannabinol (THC) and cannabidiol (CBD), though scientists have identified ~ 150 diverse cannabinoids produced in the plant. Cannabinoids are found in different plant parts but are predominantly located in the glandular trichomes of unpollinated female flowers. These unpollinated female flowers are often necessary to produce a high quantity of cannabinoids (a high-quality crop).

Cannabis sativa is an anemophilous (wind-pollinated) plant that was domesticated roughly 10,000 years ago in China. Hemp and marijuana are both *C. sativa* crops, i.e., they are the same species and are compatible in terms of sexual reproduction. This means that pollen from male flowers in either crop can successfully pollinate the separate female flowers in either crop.

Hemp is legally defined as "the plant *Cannabis sativa* L. and any part of that plant, including the seeds thereof and all derivatives, extracts, cannabinoids, isomers, acids, salts, and salts of isomers, whether growing or not, with a delta-9 tetrahydrocannabinol concentration of not more than 0.3 percent on a dry weight basis (7 U.S. Code § 1639o). Many hemp production systems (oilseed, hempseed/grain, and dual-purpose [hempseed and fiber]) require pollination and the presence of local male plants, or they produce pollen that isn't required for a successful crop (e.g., textile fiber systems). *C. sativa* pollen is problematic for cannabinoid crops (CBD, CBG, etc.), as high-yielding crops require a lack of pollination (and, therefore, seed production).

Intersexual plants, like *C. sativa*, have sexual plasticity and the capacity for flowers to change sex during the season or life cycle of plant. The male flowers then shed pollen, which would cause localized pollination. Male flowers can also change morphology and become female flowers, but this does not affect cross pollination.

Marijuana is legally defined as "all parts of the plant *Cannabis sativa* L., whether growing or not; the seeds thereof; the resin extracted from any part of such plant; and every compound, manufacture, salt, derivative, mixture, or preparation of such plant, its

seeds or resin. (B) The term “marihuana” does not include (i) hemp, as defined in section 1639o of title 7...” (21 U.S. Code § 802).

Pollen from either C. sativa crop has the potential to be problematic in the production of cannabinoids, especially for smokable flower products. Pollen can be shed by male flowers of feral (wild) hemp plants, volunteer plants from cultivation operations, and legally cultivated plants, i.e., licensed marijuana or registered hemp production facilities and farms. Pollen is deliberately used for plant breeding purposes, rewilding efforts, and other uses.

C. Additional information on Data Sharing

Cross Pollination Mapping Tool Discussion
Prepared by Jonathan McIntosh, Humble Farms
June 1, 2022

Background

- Task Group #2 is investigating options to map sources of pollen
- Cannabis pollen can travel hundreds of miles, but generally the risk is most relevant for pollen released within a range of 5-15 miles.
- Pollen will be from one of five sources
  - Feral cannabis plants
  - Legal/Sanctioned Hemp farms
  - Legal/Sanctioned Marijuana farms
  - Illegal marijuana grows (no data available)
  - Unregistered hemp grows (no data available)
- There are regulatory constraints prohibiting the release of hemp farm locations
- It would be helpful for both hemp and marijuana farmers to know if there is a potential risk to their crop
- It would be helpful to prospective farmers to know if there is a potential risk for pollen when assessing potential farm locations.

Solution Notes

● Provide a self-service tool that would allow farmers to see, within the constraints of privacy regulations, if there are potential sources of pollen nearby
● There are multiple online mapping services that can display locations
○ Most map the address to a map image. Many can accept lat/long
○ Leverage mapping expertise when it is readily and cost effectively available
● A big question for both the CDA and the MED is how accurate is the data?
● This issue is not unique to Colorado. As more states legalize marijuana, this tool could be helpful for other states.

Proposed Solution

● Manipulate the CDA Hemp farm locations randomizing the lat/long of the actual locations by +/- 0.5 to 1.5 mile
● Load the randomized hemp locations and the MED marijuana locations into a mapping system.
● Make the tool available through either the MED or CDA websites.
● The tool would answer the proximity question for the vast majority of prospective users.
● Could also create a self-service add-on feature (or perhaps a separate tool) that could be used to crowd-source feral populations

Prototype

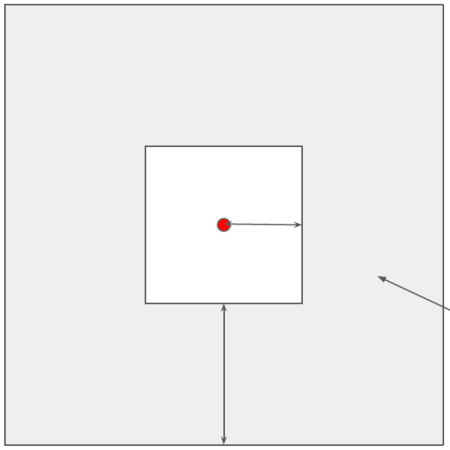
● Recreational and Medical cultivation licensee addresses pulled from the MED website
○ This data includes all cultivation locations including greenhouse and indoor operations that are
unlikely to be a significant source of pollen. Can the MED provide just OD locations?

● Hemp locations based on the zip-codes provided by the CDA
○ It would be a trivial matter to randomize the actual locations
● The addresses were loaded into an excel spreadsheet and then uploaded to the tool. Cannabis and hemp locations are color-coded.
● No feral cannabis locations mapped
● The system could display whatever information is desired associated with the location. E.g., the number of acres at a given location.
● Used on-line tool BatchGeo for prototype

● Maptitude has also expressed interest in providing this service

Randomizing Actual Locations

The actual latitude and longitude coordinates would have a random number equivalent to between 0.5 miles and 1.5 miles added (or subtracted) from each dimension. Or some other range that sufficiently changes the location to meet the privacy restrictions. Since pollen can effectively travel 5-15 miles, being off by a mile or two still provides meaningful information to a prospective user.



If a user is interested in knowing a more precise location, could another detailed inquiry be made to the CDA to determine a more precise location?

Reported location, somewhere in this area

● Actual location

Questions

● Can the MED confirm the addresses are actual licensed facility locations?
● Can the MED flag outdoor grows? Can the MED provide tier information?
● Does the CDA know the type of operation? Seeds? Fiber, etc.?
● Would the randomized data be sufficient to address the privacy requirements for hemp locations?
● How often is new location data compiled/updated?
● Who would manage the data for MED? CDA?
● Who would own this tool?
● Is there a budget available to develop and maintain the tool?
● What data should/could be provided in the tool?

Next Steps

● Create a prototype using actual hemp locations, but randomized. Assess usefulness/utility within the working group.
● Collaborate with possible solution providers regarding other capabilities that may already exist
● Address questions

D. Cultivator Survey

HB21-1301 Cross Pollination Working Group
Survey of Hemp and Marijuana registrants and licensees

Introduction
The Colorado Department of Agriculture (CDA) and Marijuana Enforcement Division (MED) seek responses from registered hemp and marijuana (Cannabis sativa L.) producers concerning the impact of cross pollination in their crops. Currently, the CDA and MED do not track specific incident reports from stakeholders related to unwanted pollen and pollinated crops, including both outdoor and indoor operations. Your response will provide valuable information to the Cross Pollination working group created by Colorado HB21-1301. Please reach out to Brian Mitchell at the CDA (brian.mitchell@state.co.us) with any technical issues or questions about the survey. Thanks!

1) Personal information:
a) Name
b) Company
c) City and county
d) Phone number
e) Email address

2) Describe your operation:
    a) What type of crop do you grow, e.g., CBG hemp, retail MJ, etc.?
    b) Indoor or outdoor?
c) Square footage and/or outdoor acreage

3) Have you experienced cross pollination in your crop?

4) If you answered yes to Question 3, please describe the impact on your crop. For example, what percentage of your crop was affected?

5) In what year did this issue occur? What time during the growing season did pollination occur?

6) What was the estimated financial impact from pollination?

7) What is the ongoing financial impact of rogueing male plants, scouting for male flowers, etc.?

8) What is the estimated frequency of seeds produced in both indoor and outdoor production?

9) Have you noticed chemovar/cultivar/variety/strain differences in pollination/seed production?

10) What measures have you used to reduce cross pollination? Have they been successful?

11) Are there other methods you are considering for use with future crops?

12) What techniques have you used to manage volunteer C. sativa plants on your registered land area and beyond?

13) Have you noticed feral (wild) populations of C. sativa plants, also known as ditchweed, in your region?

14) Do you have any thoughts as to the source of pollen that pollinated your crops?

15) If you have had any issues, have you contacted neighbors? State agencies? Others? What was the response you received?

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