Following the smell: terpenes emission profile through the cannabis life-cycle

Supporting Information

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14 Tables, 63 Figures, 70 pages

Note: Throughout this document 'CCF' refers to the Cannabis Cultivation Facility while 'CPF' refers to the Cannabis Processing and Extraction Facility.

S1. Methods

S1.1 Questionnaires:

We developed two sets of questionnaires. The first was an 'Intake survey' and it served the purpose of screening cannabis cultivation facilities that would participate in the study in case we had received numerous replies.

The second was a 'Full survey' and it was designed to obtain the maximum information from a selected facility ahead of sampling, so researchers could strategize the best use of time, instruments, and other resources.

These questionnaires were developed based on a former review investigation[1] and did not consider the inclusion of cannabis processing and extraction facilities. The inclusion of the CPF in our study occurred after a few months without sufficient response to our calls and e-mails inviting other cultivators.

Figure S 1 to **Figure S 13** show the questions in each survey.

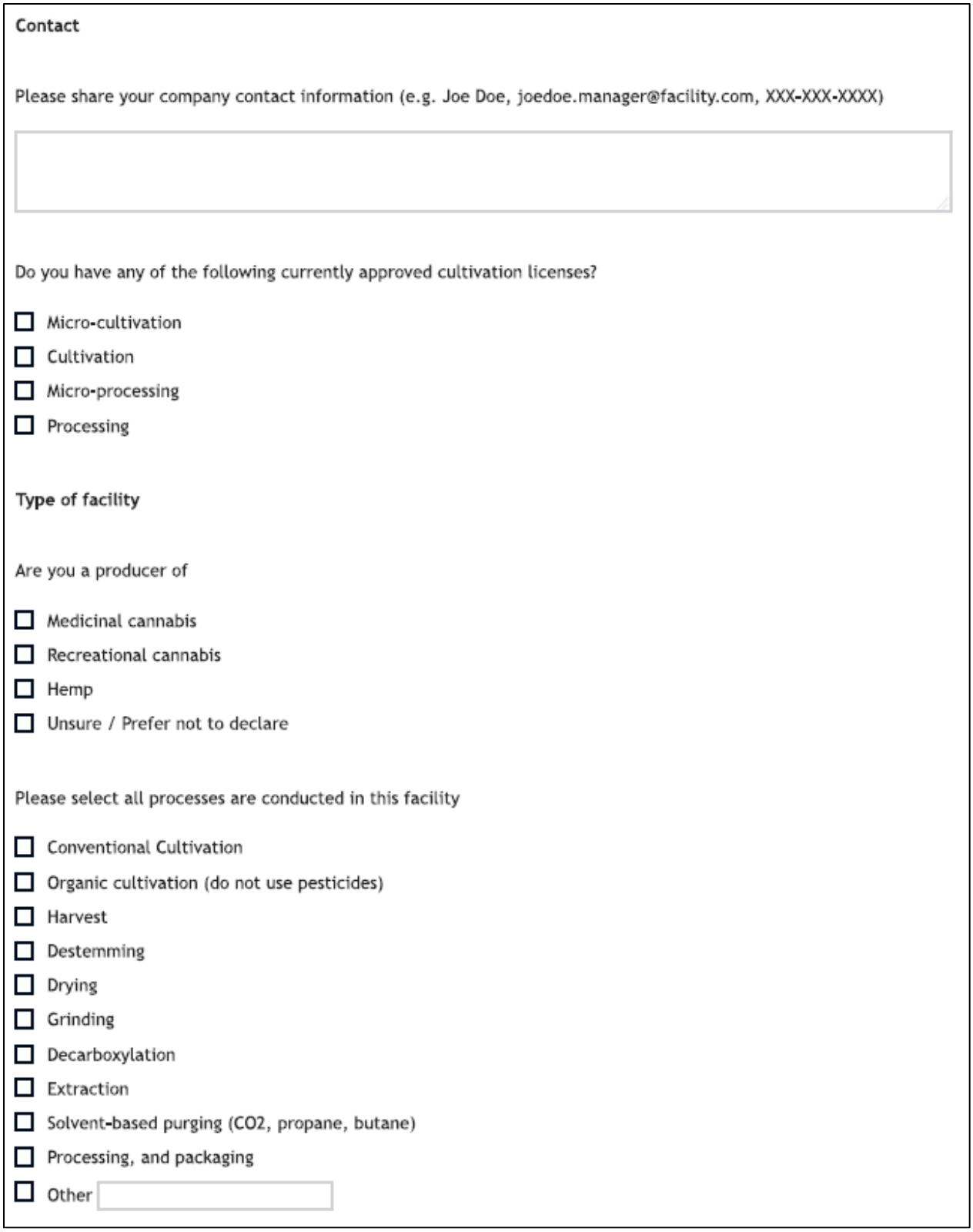
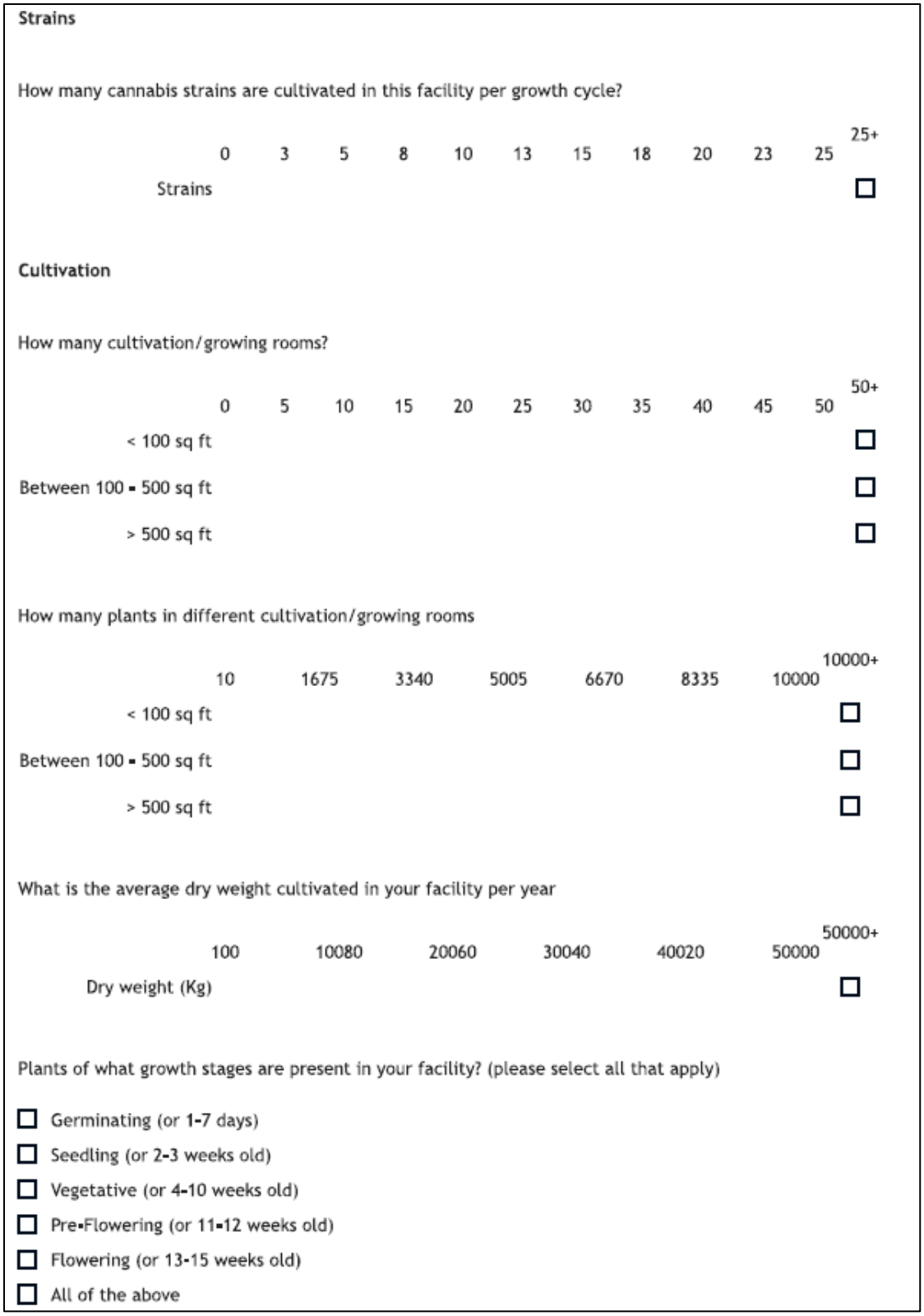


Figure S 1. Intake survey – contact questions.



Strains

How many cannabis strains are cultivated in this facility per growth cycle?

	0	3	5	8	10	13	15	18	20	23	25	25+
Strains												☐

Cultivation

How many cultivation/growing rooms?

	0	5	10	15	20	25	30	35	40	45	50	50+
< 100 sq ft												☐
Between 100 - 500 sq ft												☐
> 500 sq ft												☐

How many plants in different cultivation/growing rooms

	10	1675	3340	5005	6670	8335	10000	10000+
< 100 sq ft								☐
Between 100 - 500 sq ft								☐
> 500 sq ft								☐

What is the average dry weight cultivated in your facility per year

	100	10080	20060	30040	40020	50000	50000+
Dry weight (Kg)							☐

Plants of what growth stages are present in your facility? (please select all that apply)

- ☐ Germinating (or 1-7 days)
- ☐ Seedling (or 2-3 weeks old)
- ☐ Vegetative (or 4-10 weeks old)
- ☐ Pre-Flowering (or 11-12 weeks old)
- ☐ Flowering (or 13-15 weeks old)
- ☐ All of the above

Figure S 2. Intake survey - strains questions.

Controls

What type of emission controls are applied in the facility (please select all that apply)

- ☐ Carbon/charcoal filter
- ☐ Biofilter
- ☐ Ozone generators
- ☐ UV lights
- ☐ Odor neutralizer
- ☐ HEPA filters
- ☐ Air quality monitors (odors, particles, VOCs...)
- ☐ None
- ☐ Other

Management

Does the season of year affect any of the following for cannabis cultivation at your facility? (select all that apply)

- ☐ Types of strains cultivated
- ☐ Temperature in growing room
- ☐ Ventilation in growing room
- ☐ Lighting in growing room
- ☐ Humidity in growing room
- ☐ Carbon dioxide in growing room
- ☐ Other
- ☐ None of the above

Is there a time that control equipment is turned off?

- ○ Yes (please explain when below)
- ○ No
- ○ Depends on (please mention details in the box)

Do people smoke in the facility indoors?

- ○ Yes
- ○ No

Figure S 3. Intake survey – Controls and Management pt.1 questions.

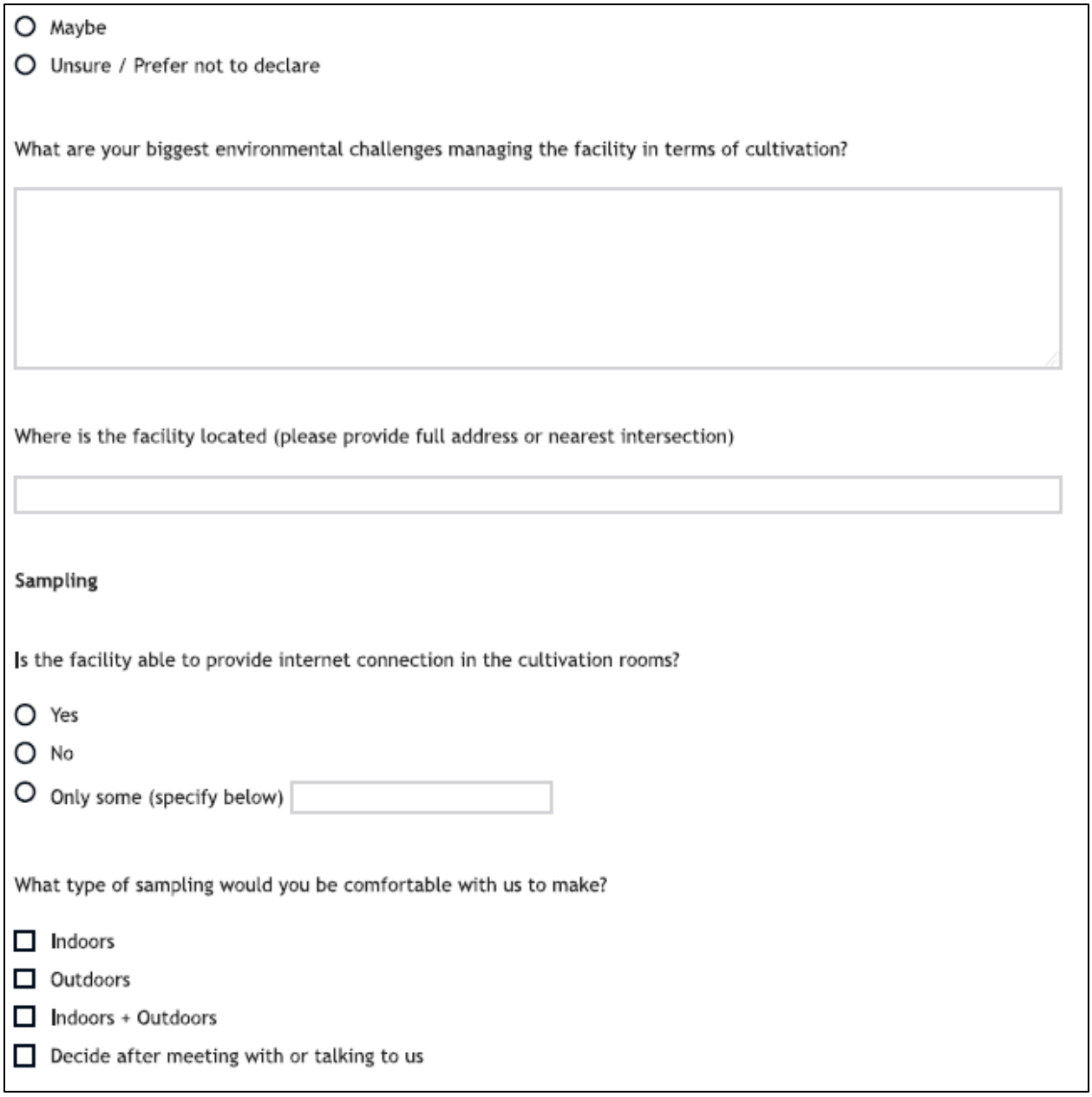


Figure S 4. Intake survey – Management pt. 2 and Sampling questions.

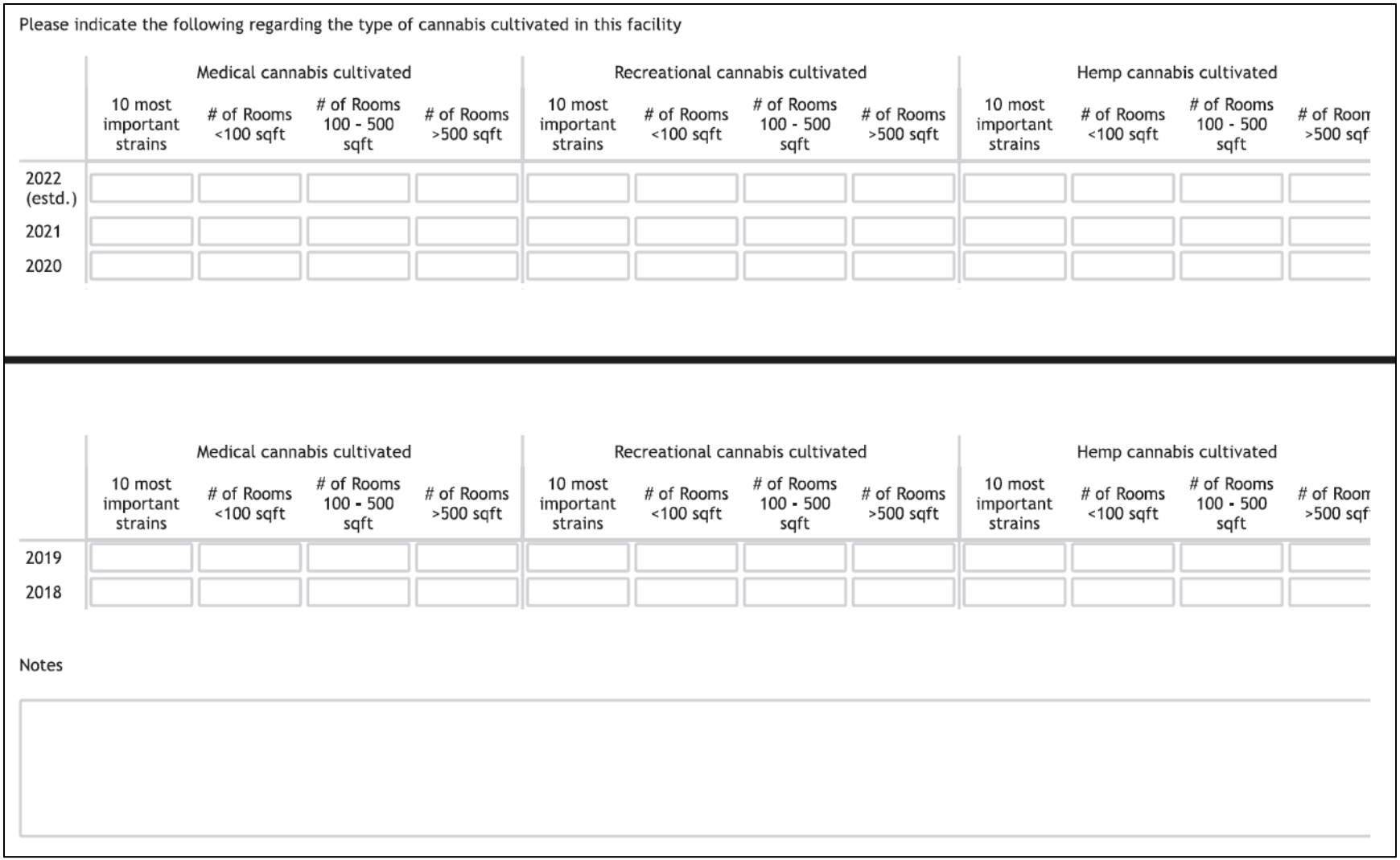
Cultivation history

Can you provide an estimation for the following categories and years?

	Medical cannabis cultivated		Recreational cannabis cultivated		Hemp cannabis cultivated	
	# of Plants (in steps of 100)	Dry weight (Kg) (in steps of 10)	# of Plants (in steps of 100)	Dry weight (Kg) (in steps of 10)	# of Plants (in steps of 100)	Dry weight (Kg) (in steps 10)
2022 (estd.)						
2021						
2020						
2019						
2018						

Notes

Figure S 5. Full survey - Cultivation history, pt. 1.



Please indicate the following regarding the type of cannabis cultivated in this facility

	Medical cannabis cultivated				Recreational cannabis cultivated				Hemp cannabis cultivated			
	10 most important strains	# of Rooms <100 sqft	# of Rooms 100 - 500 sqft	# of Rooms >500 sqft	10 most important strains	# of Rooms <100 sqft	# of Rooms 100 - 500 sqft	# of Rooms >500 sqft	10 most important strains	# of Rooms <100 sqft	# of Rooms 100 - 500 sqft	# of Roon >500 sqf
2022 (estd.)												
2021												
2020												

	Medical cannabis cultivated				Recreational cannabis cultivated				Hemp cannabis cultivated			
	10 most important strains	# of Rooms <100 sqft	# of Rooms 100 - 500 sqft	# of Rooms >500 sqft	10 most important strains	# of Rooms <100 sqft	# of Rooms 100 - 500 sqft	# of Rooms >500 sqft	10 most important strains	# of Rooms <100 sqft	# of Rooms 100 - 500 sqft	# of Roon >500 sqf
2019												
2018												

Notes

Figure S 6. Full survey – Cultivation history, pt. 2.

Current cultivation

Can you share the facility floor plan with us?

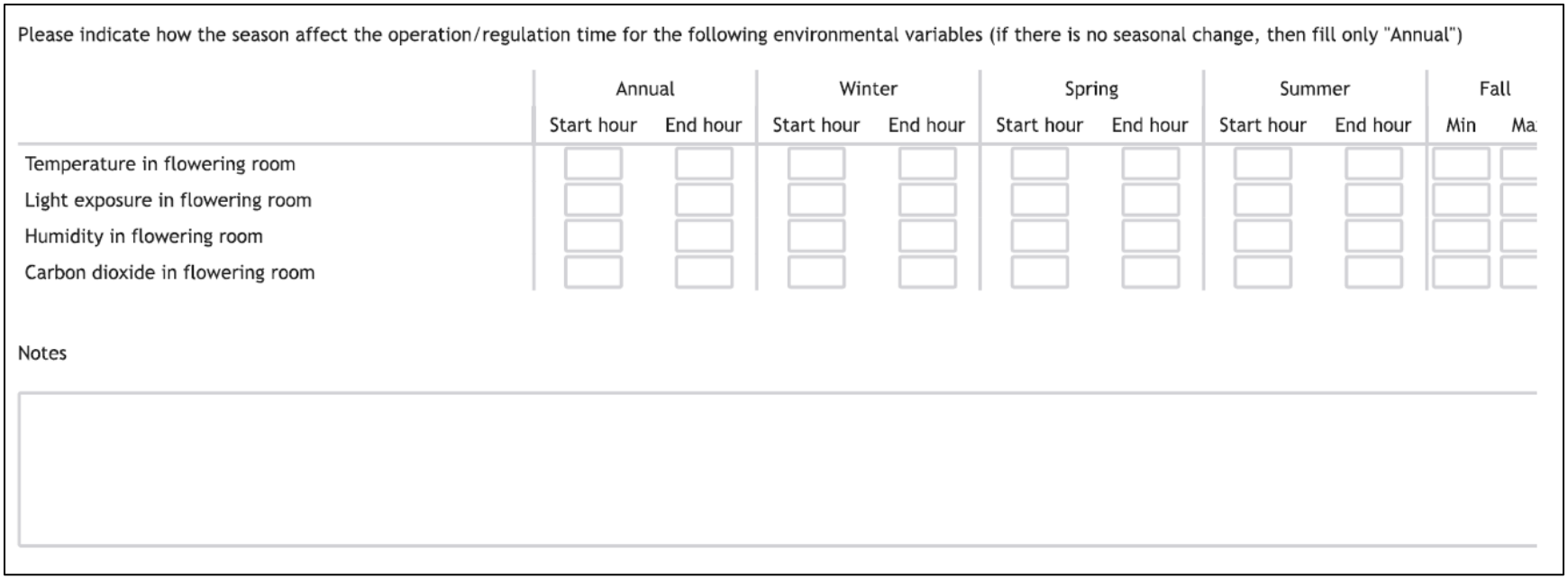
- ○ Yes
- ○ No

Please indicate how the season affect the minimum and maximum values for the following environmental variables (if there is no seasonal change, then fill only "Annual")

	Annual		Winter		Spring		Summer		Fall	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Temperature in flowering room (Degrees celsius)										
Light exposure in flowering room (# hours)										
Humidity in flowering room (% percentage)										
Carbon dioxide in flowering room (parts per billion - ppb)										

Notes

Figure S 7. Full survey – Current cultivation pt. 1.


Please indicate how the season affect the operation/regulation time for the following environmental variables (if there is no seasonal change, then fill only "Annual")

	Annual		Winter		Spring		Summer		Fall	
	Start hour	End hour	Start hour	End hour	Start hour	End hour	Start hour	End hour	Min	Ma
Temperature in flowering room										
Light exposure in flowering room										
Humidity in flowering room										
Carbon dioxide in flowering room										

Notes

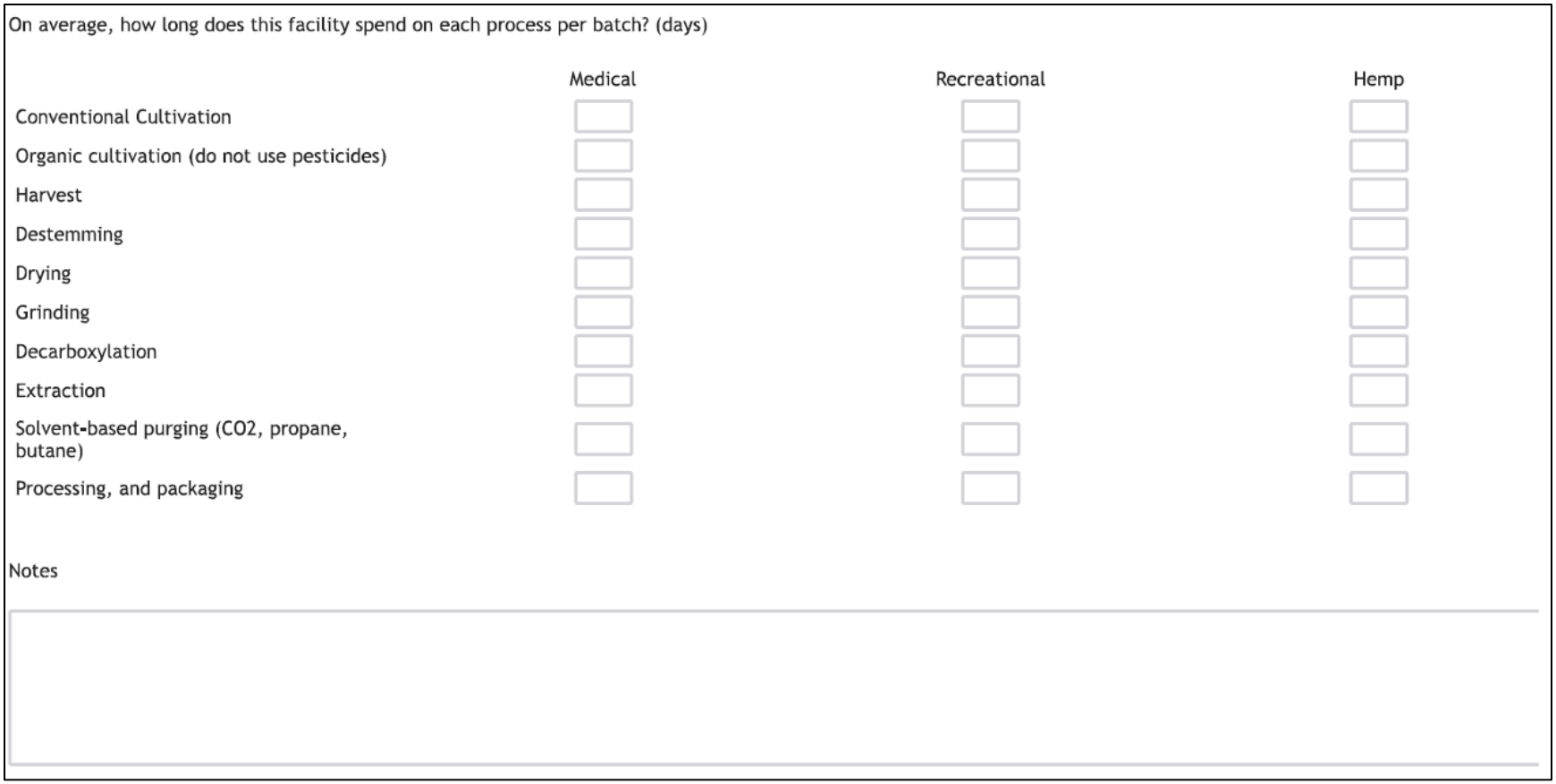
Figure S 8. Full survey - Current cultivation pt. 2.

Can you provide an estimation for the following categories and cultivation stages?

	Cultivation weeks		# of Plants			Air exchange per hour (ACH/CADR)		# of carbon/charcoal filter working		# of Biofilter working		# of Ozone generators working		# of UV lights working		# of Odour neutralizers working		HEPA filters working	
	Min	Max	Room <100 sqft	Room 100 - 500 sqft	Room >500 sqft	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Immature (Germinating + Seedling)																			
Vegetative/Pre-Flowering																			
Flowering																			
Processing																			

Notes

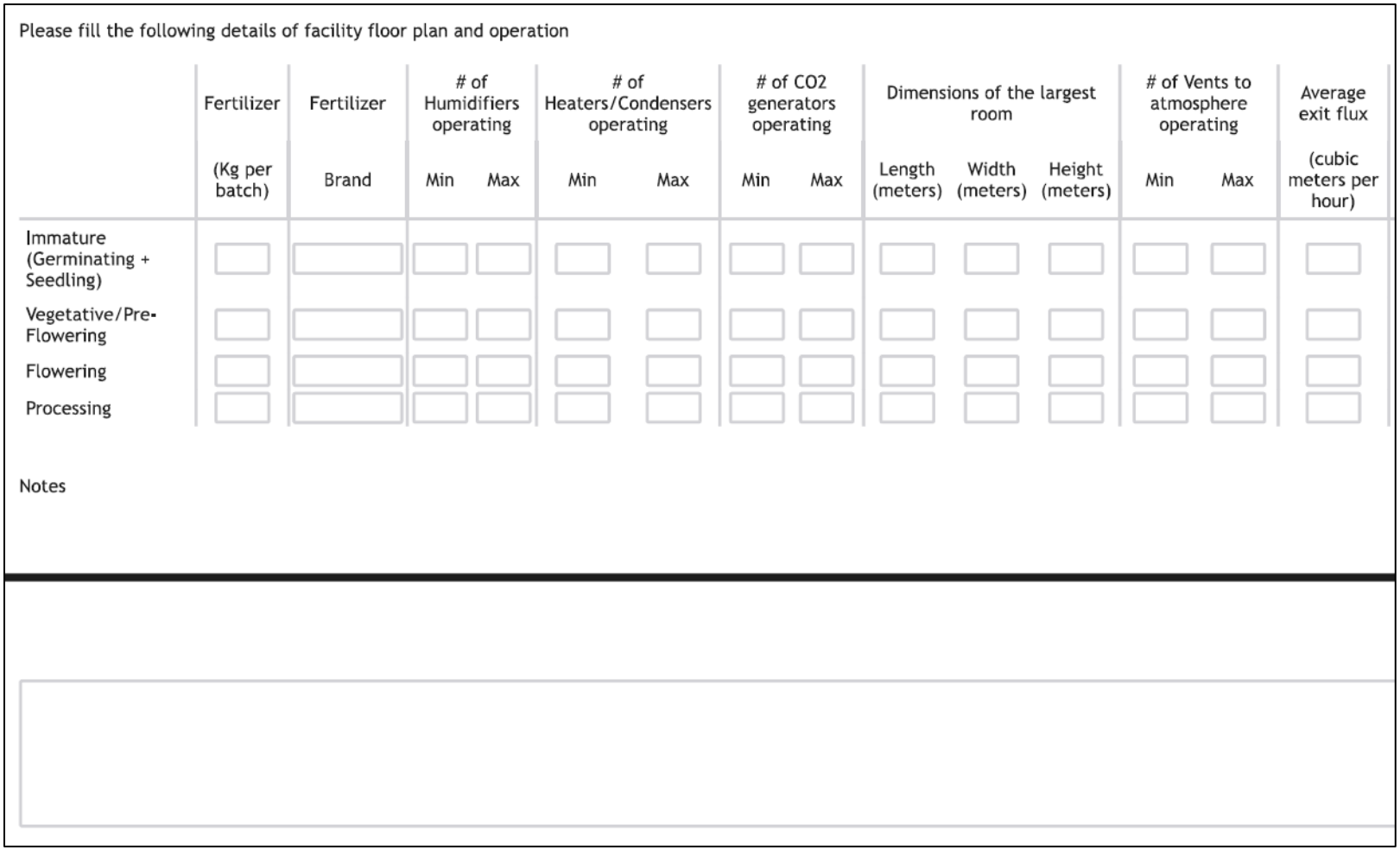
Figure S 9. Full survey - Current cultivation pt. 3


On average, how long does this facility spend on each process per batch? (days)

	Medical	Recreational	Hemp
Conventional Cultivation			
Organic cultivation (do not use pesticides)			
Harvest			
Destemming			
Drying			
Grinding			
Decarboxylation			
Extraction			
Solvent-based purging (CO_2, propane, butane)			
Processing, and packaging			

Notes

Figure S 10. Full survey - Current cultivation pt. 4.



Please fill the following details of facility floor plan and operation

	Fertilizer (Kg per batch)	Fertilizer Brand	# of Humidifiers operating Min	# of Humidifiers operating Max	# of Heaters/Condensers operating Min	# of Heaters/Condensers operating Max	# of CO2 generators operating Min	# of CO2 generators operating Max	Dimensions of the largest room Length (meters)	Dimensions of the largest room Width (meters)	Dimensions of the largest room Height (meters)	# of Vents to atmosphere operating Min	# of Vents to atmosphere operating Max	Average exit flux (cubic meters per hour)
Immature (Germinating + Seedling)														
Vegetative/Pre-Flowering														
Flowering														
Processing														

Notes

Figure S 11. Full survey - Current cultivation pt. 5.

Please fill the following details of facility floor plan and operation

	Light for bacteria disinfection brand	Age of lighting (months)	Lights for growing brand	Age for lighting (months)
Immature (Germinating + Seedling)				
Vegetative/Pre-Flowering				
Flowering				
Processing				

Notes

Figure S 12. Full survey - Current cultivation pt. 6.

Control technologies and practices

Please indicate the following for the control technologies listed that are used in your facility

	What is the treated flow capacity of one unit of the following control equipment? (in cubic meter per hour)		What is the average efficiency of each emission control per room? (% percentage of BVOCs treated or particulate matter for HEPA filters)				How the efficiency is measured?	When did you make the last change/maintenance operation?
	Min	Max	Immature (Germinating + Seedling)	Vegetative/Pre-Flowering	Flowering	Processing	Describe method	(Date: yyyy-mm-dd)
Carbon/charcoal filter								
Biofilter								
Ozone generators								
UV lights								
Odor neutralizer								
HEPA filters								

Notes

Is there are stage of cultivation carried outdoors?

- ○ Yes
- ○ No

Figure S 13. Full survey – Control technologies and practices.

S1.2 Facilities details:

Details of each room of the CCF are provided in **Table S 1** to **Table S 4** and for the CPF details are given by **Table S 5**. This information was used to establish correlation between emission patterns with environmental variables, and estimate emission factors.

Table S 1. Strains and capacity of the CCF at the time of sampling.

ROOM ID	**Strains**	**Key info: # of plants or dry weight (kg) processed per day of activity**
VEGETATIVE	Same as Mothers	Up to 20,000 plants
MOTHERS	Critical super silver, Tangerine dream, Blue dream, Sensi star, Tropical sherbet, C-velvet, Gomgi, Girl scout cookies	Immature plants: up 500 Mother plants: up to 100
GROW ROOM (PROPAGATED)	Blue dream	Up to 600 plants
GROW ROOM (FLOWERING)	Girl scout cookies	Up to 300 plants
DRYING	Blue dream	Up to 1000 plants
TRIMMING	Blue dream	Approx. up to 50kg per day
VAULT / STORAGE	Numerous	Up to 2,000kg
PACKING ROOM	Blue dream	Up to 200kg

Table S 2. Controls of the CCF at the time of sampling.

ROOM ID	Air Filters (Charcoal, Bio, HEPA, other)			
	Type	**#**	**Model**	**Replaced every**
VEGETATIVE	Charcoal	1	Techsorb Pleated Filter	Each year
MOTHERS	Charcoal	1	Techsorb Pleated Filter	Each year
GROW ROOM (PROPAGATED)	Charcoal	1	Techsorb Pleated Filter	Each year
GROW ROOM (FLOWERING)	Charcoal	1	Techsorb Pleated Filter	Each year
DRYING	Charcoal	1	Techsorb Pleated Filter	Each new drying event
TRIMMING	Charcoal	1	Techsorb Pleated Filter	Each new trimming event
VAULT / STORAGE	Charcoal	1	Techsorb Pleated Filter	Each year
PACKING ROOM	N/A	0	0	N/A

Table S 3. HVAC capacity of the CCF at the time of sampling.

Room	Area (m^2)	Height (m)	Volume (m^3)	HVAC type	Flow Capacity, (m^3/h)	HVAC (#)	Total (m^3/h, HVAC)	Time* (h)	AER (h^{-1})
VEGETATIVE	119.2	5.0	595.9	5 ton Trane AC's	3,400	5	17,000	0.035	28.5
MOTHER	105.4	5.0	526.8	5 ton Trane AC's	3,400	5	17,000	0.031	32.3
GROW (PROPAGATED)	71.8	5.0	358.8	5 ton Trane AC's	3,400	4	13,600	0.026	37.9
GROW (FLOWERING)	48.1	5.0	240.4	5 ton Trane AC's	3,400	2	6,800	0.035	28.3
DRYING	39.3	5.0	196.5	5 ton Trane AC's	3,400	2	6,800	0.029	34.6
TRIMMING	39.0	5.0	195.1	5 ton Trane AC's	3,400	2	6,800	0.029	34.8
VAULT / STORAGE	40.4	5.0	202.0	5 ton Trane AC's	3,400	2	6,800	0.030	33.7
CCF PACKING	42.0	5.0	210.1	5 ton Trane AC's	3,400	2	6,800	0.031	32.4

*for complete room air to be replaced

Table S 4. Lights of the CCF at the time of sampling.

ROOM ID	Light		
	Type	**Model**	**Schedule (ON)**
VEGETATIVE	LED	Spyder 2x	6am – 3am
MOTHERS	LED/Fluorescent	Spyder 2x	6am – 3am
GROW ROOM (PROPAGATED)	High Pressure Sodium	Pro 1000dl	11p.m. - 11a.m.
GROW ROOM (FLOWERING)	High Pressure Sodium	Pro 1000dl	11p.m. - 11a.m.
DRYING	Fluorescent	2 Lamp 32W T8 Outdoor Vapor Tight Fluorescent Fixture	Lights OFF unless for checking T and RH
TRIMMING	Fluorescent	2 Lamp 32W T8 Outdoor Vapor Tight Fluorescent Fixture	7am - 3.30pm
VAULT / STORAGE	Fluorescent	2 Lamp 32W T8 Outdoor Vapor Tight Fluorescent Fixture	7am - 3.30pm
PACKING ROOM	Fluorescent	2 Lamp 32W T8 Outdoor Vapor Tight Fluorescent Fixture	7am - 3.30pm

Table S 5. the CPF average production, controls, and air circulation information

ROOM ID	Details				
	Production capacity (average day)	**Controls**	**HVAC (m^3/h)**	**Volume (m^3)**	**AER (h^{-1})**
PACKING AREA	8000 packages	N/A	9065	458.6	19.76
DISTILLATION	40-60kg in bulk extract	HEPA	1870	66.3	28.2
ETHANOL EXTRACTION	150kg mixture	Fume Hood	1275	70.3	18.1
FORMULATION	5-15kg in bulk extract w/ terpenes added	HEPA	510	49.5	10.3
HYDRO EXTRACTION	40-50kg in bulk biomass (mesh bags)	N/A	10,285	267.5	38.4
PRE-ROLL*	10,000-15,000 units of either 0.5g or 1g	N/A	N/A*	74.3	19.76*

* This room is located inside the packing area. It is a glass house that remains closed when pre-rolling activity is performed and open otherwise.

S1.3 GC-FID calibration curves

We used 1µL injections of concentration 2,500 µg/mL, 1,000 µg/mL, 100 µg/mL, 10 µg/mL, 1 µg/mL, and 0.1 µg/mL. Peaks from solutions of 1 µg/mL and 0.1 µg/mL could not be distinguished from background noise, thus they were excluded from the calibration curve fitting. **Figure S 14** gives the Area *vs.* Internal concentration points for each terpene investigated, as well as the calibration function and R^2 value. **Figure S 15** provides the chromatograms of each injection, and **Figure S 16** the blanks.

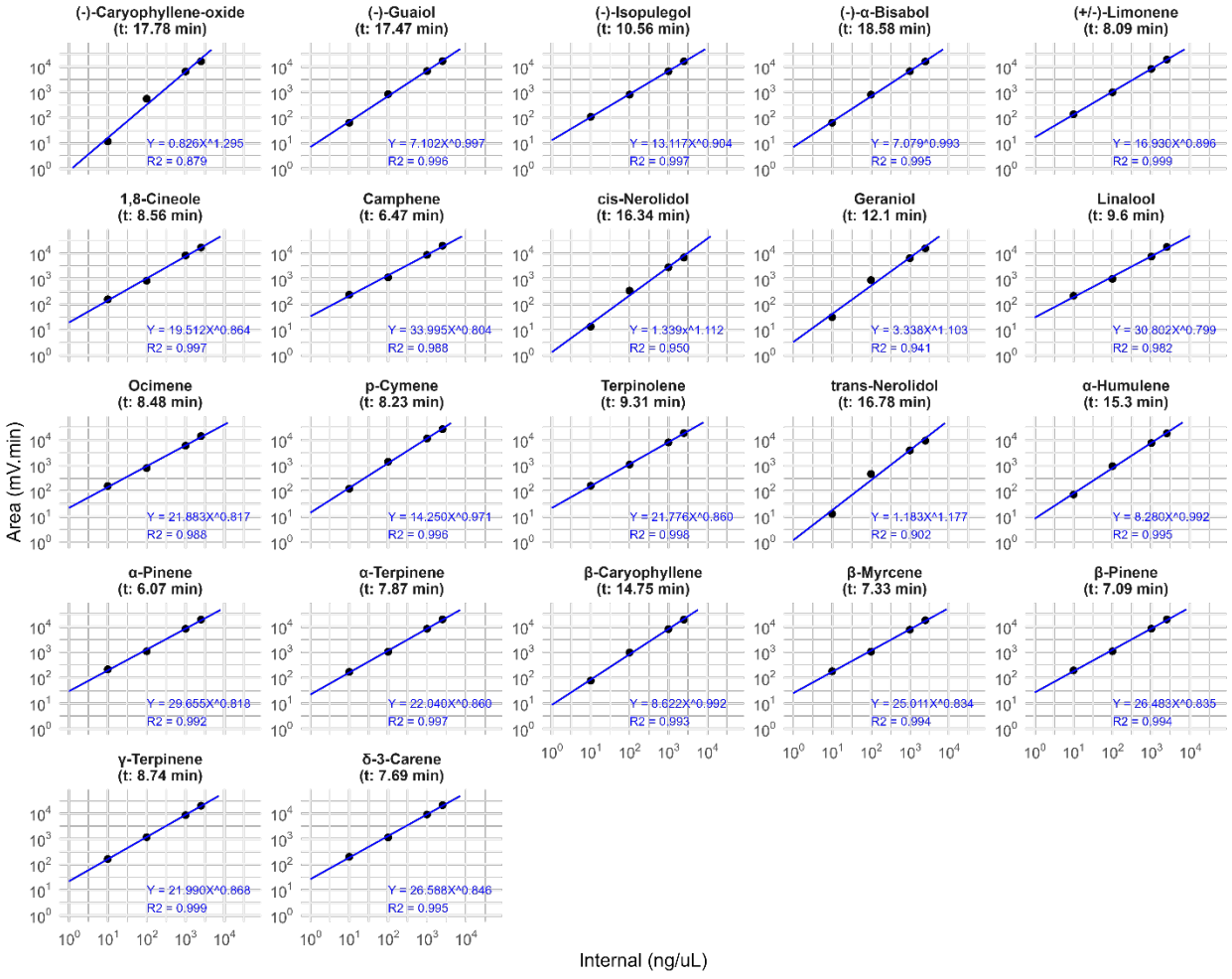


Figure S 14. Calibration fit for the 22 terpenes investigated in this study. Under each terpene name there is the corresponding average retention time of peaks.

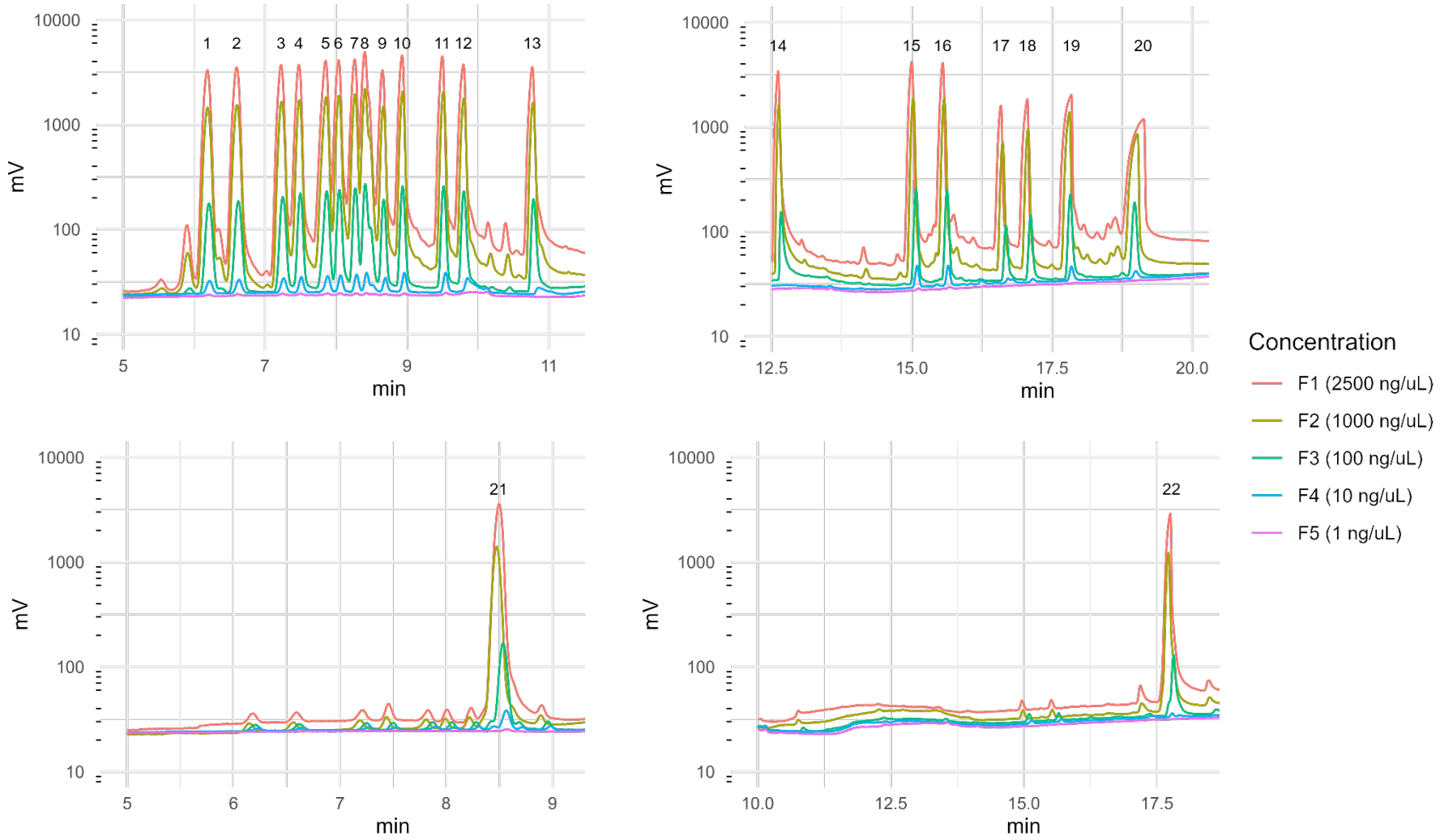
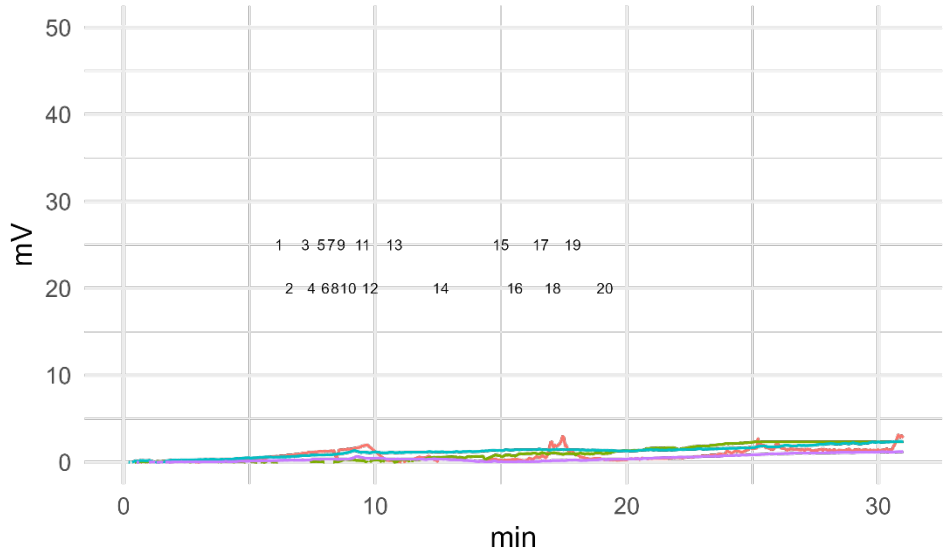
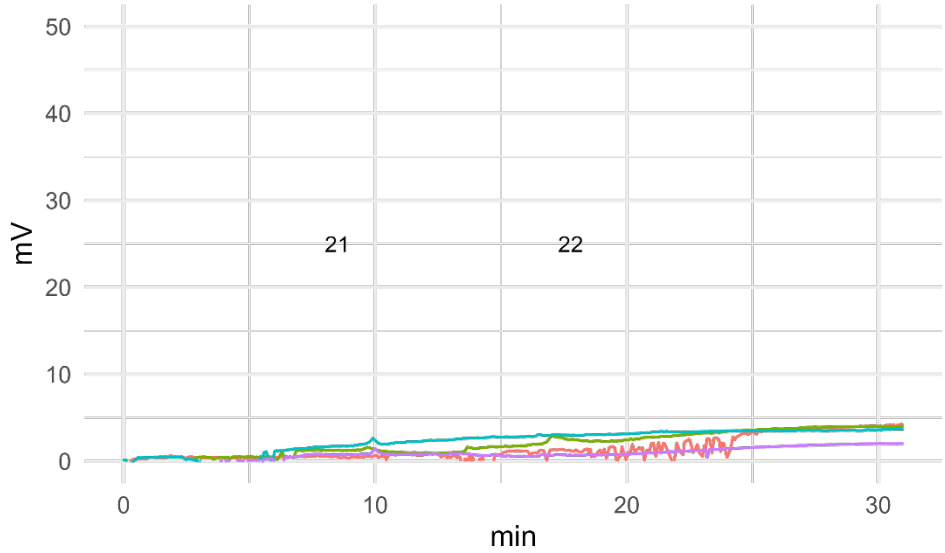


Figure S 15. GC-FID signals used to calibrate the 22 terpenes: (1) α-Pinene, (2) Camphene, (3) β-Pinene, (4) β-Myrcene, (5) δ-3-Carene, (6) α-Terpinene, (7) (+/-)-Limonene, (8) p-Cymene, (9) Ocimene, (10) γ-Terpinene, (11) Terpinolene, (12) Linalool, (13) Isopulegol, (14) Geraniol, (15) β-Caryophyllene, (16) α-Humulene, (17) *cis*-Nerolidol, (18) *trans*-Nerolidol, (19) (-)-Guaiol, (20) (-)-α-Bisabol, (21) 1,8-Cineole, and (22) (-)-Caryophyllene-oxide.



(a) Blanks of Standard #1



(b) Blanks of Standard #2

Figure S 16. Chromatograms of blanks in between injections of each calibration solution.

S1.4 Improvement of the fieldwork temperature program

Figure S 17 shows the difference in peak resolution after the injection of 1µL of Standard #1 at concentration of 2,500 µg/mL using two different temperature programs. In the top panel, the GC oven starts at 40 °C, holds that temperature for 1 minute, then ramps up to 280 °C at 10 °C min^{-1}. In the bottom panel, after reaching 200 °C, the ramping doubles to 20 °C.min^{-1}. In both cases the carrier flow pressure was 11 psi (20 mL/min).

The second temperature program improved the peak resolution of less volatile terpenes, reducing the chances of misplacing Guaiol and α-Bisabol retention time window, as well as peaks overlaps (with other chemicals) in the field.

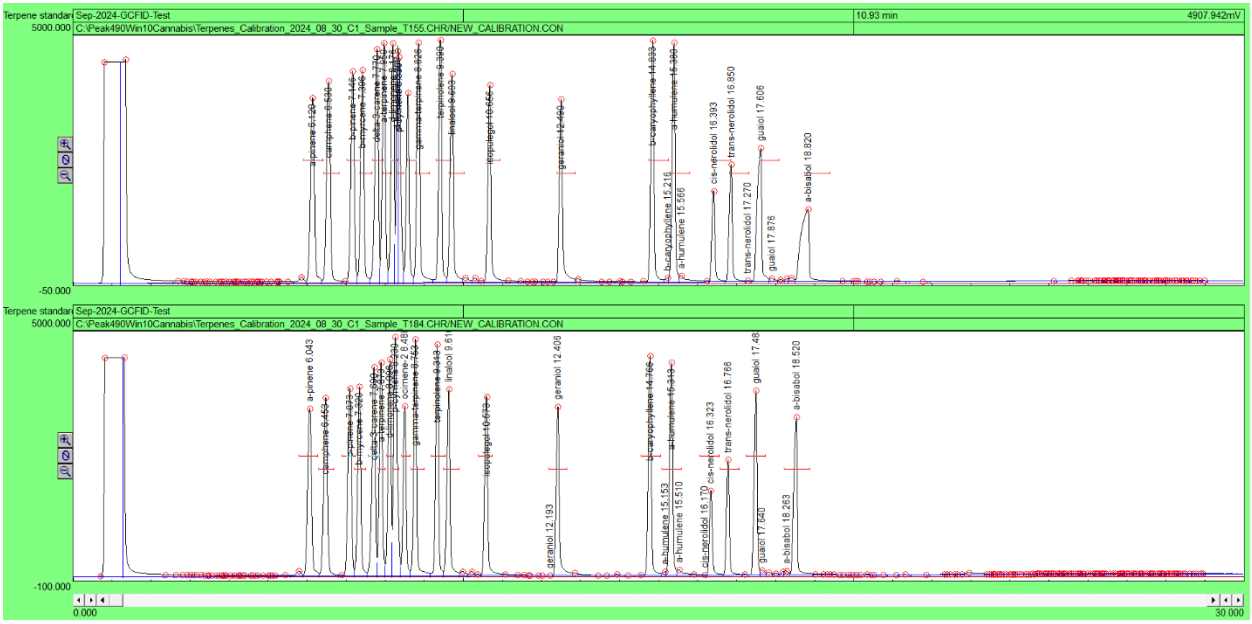
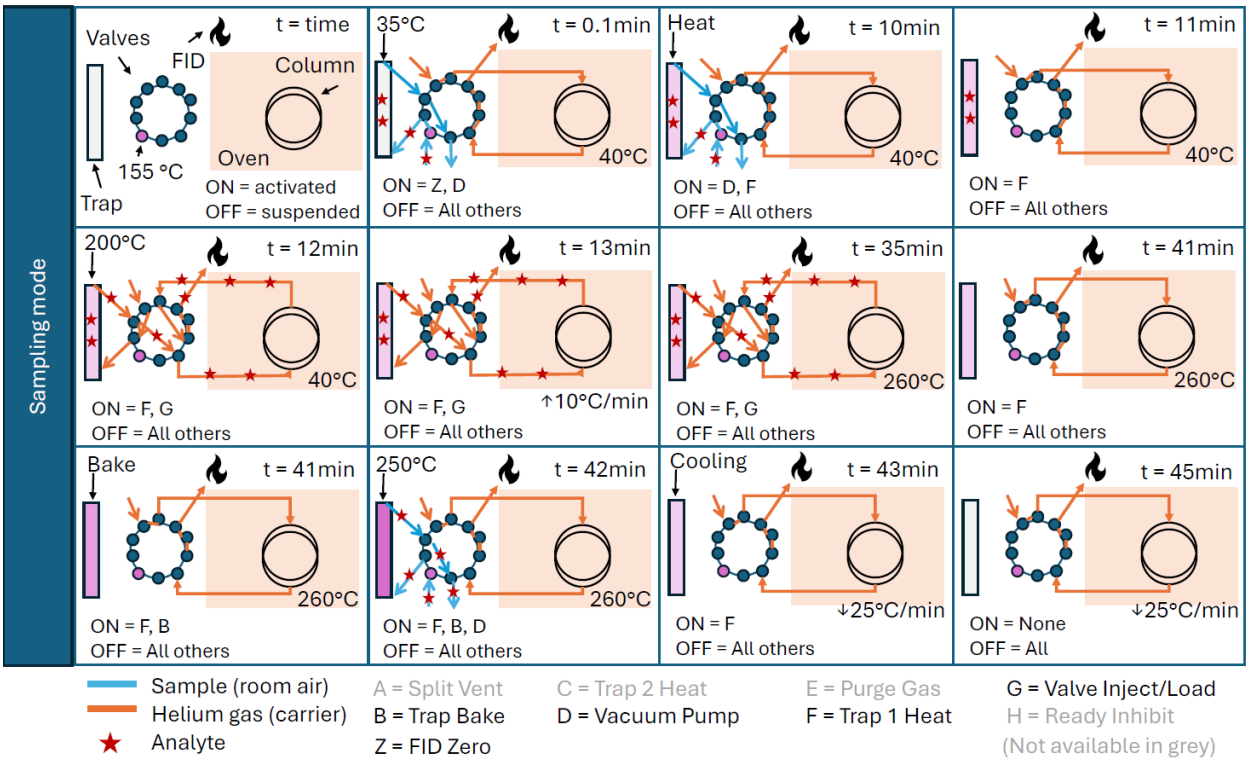
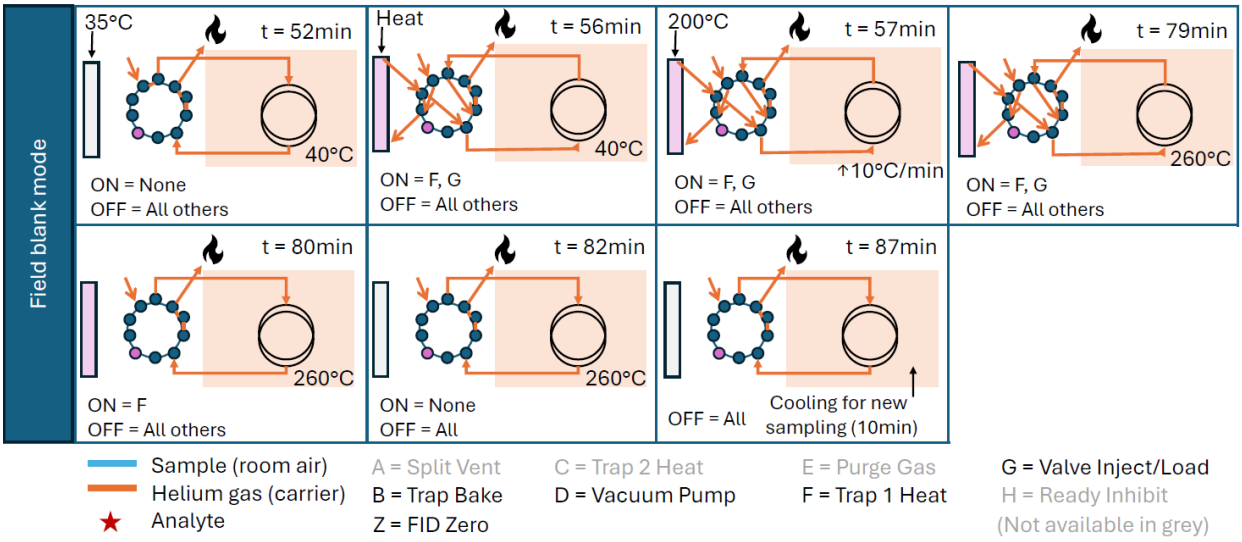


Figure S 17. Improvement in the resolution of later terpene peaks due to faster temperature ramping.

S1.5 GC-FID Protocols



(a)



(b)

Figure S 18. GC-FID protocol used in this study during (a) sampling mode and (b) field blank mode when using 11 minutes trapping. For the 1-minute trapping, the heat and pump are turned on at the same time, the G valve opens at minute two instead of twelve, and all other events are equally spaced.

S1.6 Conversion between FID signal, area integration, and parts per billion (ppb)

$$C_{ppb} = I \times V_{cal.inj.} \times K_{ng\to g} \times \frac{1}{MW} \times \frac{1}{F.t} \times K_{L\to mL} \times \frac{1}{4.09 \times 10^{-8}} \times K_{ppm\to ppb}$$

- C_{ppb}: Concentration in parts per billion (ppb)
- I: Standard equivalent concentration in nanograms per microliter (ng/μL^{-1})
- $V_{cal.inj.}$: Volume of standard used during calibration (μL)
- $K_{ng\to g} = 10^{-9}$: Conversion factor from nanograms to grams (g·ng^{-1})
- MW: Molecular weight of the chemical in grams per mole (g·mol^{-1})
- F: Flow rate in milliliters per minute (mL·min^{-1})
- t: Trapping time in minutes (min)
- $K_{L\to mL} = 1000$: Conversion factor from liters to milliliters (mL·L^{-1})
- 4.09×10^{-8}: Conversion factor from moles per liter to ppm (ppm·L·mol^{-1}) at 1 atm and 298 K.
- $K_{ppm\to ppb} = 1000$: Conversion factor from parts per million (ppm) to parts per billion (ppb)

Notice that:

$$\frac{p}{RT} = \frac{n}{V}$$

At 1 atm and 298 K (~25°C):

$$\frac{1}{0.08206 * 298}\left(atm * K * \frac{mol}{L} * \frac{1}{atm} * \frac{1}{K}\right) = 0.0409\left(\frac{mol}{L}\right)$$

$$0.0409\left(\frac{mol}{L}\right) * \frac{1}{1000}\left(\frac{L}{cm^3}\right) * 6.02 * 10^{23}\left(\frac{molecules}{mol}\right) = 2.46 * 10^{19}\left(\frac{molecules}{cm^3}\right)$$

Also:

$$1\ ppm = \frac{\frac{1}{10^6} molecule_x}{molecule_{air}} = 2.46 * 10^{13}\left(\frac{molecules}{cm^3}\right)$$

Then:

$$4.09 * 10^{-2}\left(\frac{mol}{L}\right) = 2.46 * 10^{19}\left(\frac{molecules}{cm^3}\right) = 10^6\ ppm \equiv 4.09 * 10^{-8}\left(\frac{mol}{L}\right) = 1\ ppm$$

S1.7 Low-cost sensor data

In this work, we used a Real-time Affordable Multi-Pollutant (RAMP) Low-Cost Sensor (LCS) to measure several gas pollutants, Particulate Matter with less than 2.5 micrometers ($PM_{2.5}$) plus Temperature (T) and Relative Humidity (RH), in the rooms of the CCF and the CPF. The RAMP has a detection range of 0.02 ppm to 25 ppm for NO, NO_2, and O_3, 0.1 ppm to 25 ppm for CO, 100 to 2000 ppm for CO_2 and 1 $\mu g.m^{-3}$ to 1000 $\mu g.m^{-3}$ for $PM_{2.5}$.

The sensor was calibrated following the available best practices [2–5]. In short, we collocated the RAMP with reference instruments in an outdoor (Jan/2023 – Apr/2023) and indoor setting (Sep/2023). We used a hybrid approach of Linear Regression and Random Forest Models to adjust the RAMP raw values. Ninety-three days (88 at outdoor, 5 indoor) were used to train the model and 22 days at outdoor were used to test the model. **Table S 6** provides the statistics result from this calibration, showing good adjustment, except for the environmental variables and $PM_{2.5}$. **Equations 1 to 5** explain each indicator used.

$$r = \frac{\sum(x_i - \bar{x}) * (y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \ \sum(y_i - \bar{y})^2}} \qquad Eq.(1)$$

$$R^2 = \left(\frac{\sum(x_i - \bar{x}) * (y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \ \sum(y_i - \bar{y})^2}}\right)^2 \qquad Eq.(2)$$

$$RMSE = \sqrt{\overline{(x_\iota - y_\iota)^2}} \qquad Eq.(3)$$

$$MAE = \overline{|(x_\iota - y_\iota)|} \qquad Eq.(4)$$

$$CvMAE = \frac{\overline{|(x_\iota - y_\iota)|}}{\bar{y}_\iota} \qquad Eq.(5)$$

where,

x_i = values of the x-variable in a sample

$\bar{x}$ = mean of the values of the x-variable

y_i = values of the y-variable in a sample

$\bar{y}$ = mean of the values of the y-variable

Table S 6. RAMP calibration: statistical results.

	r	R^2	RMSE	MAE	CvMAE
CO (ppb)	0.97	0.94	41.25	29.24	0.09
NO (ppb)	0.98	0.96	4.41	3.04	0.16
NO2 (ppb)	0.92	0.85	3.00	2.26	0.12
O3 (ppb)	0.97	0.94	2.92	2.17	0.13
PM ($\mu g.m^{-3}$)	0.74	0.55	3.09	1.71	0.30
T (°C)	0.59	0.35	3.30	2.38	0.40
RH (%)	0.66	0.44	13.64	10.54	0.13

Figure S 20 to **Figure S 22** provide the hourly averaged time series of NO, NO_2, and O_3 in each room of the CCF while **Figure S 23** to **Figure S 25** show the same analysis for the CPF. One thing to note is the clear difference in the order of magnitude of NO concentrations compared to NO_2 and O_3. We suspect this could be a) biased due to the Linear Regression component in the upper limit of calibration data or b) caused by an interference of another pollutant in the electrochemical process (e.g., HONO).

Bias:

In our calibration model, 96.37 ppb was the split value between applying Linear Regression and Random Forest Model in the upper end of the data (see **Figure S 19**).

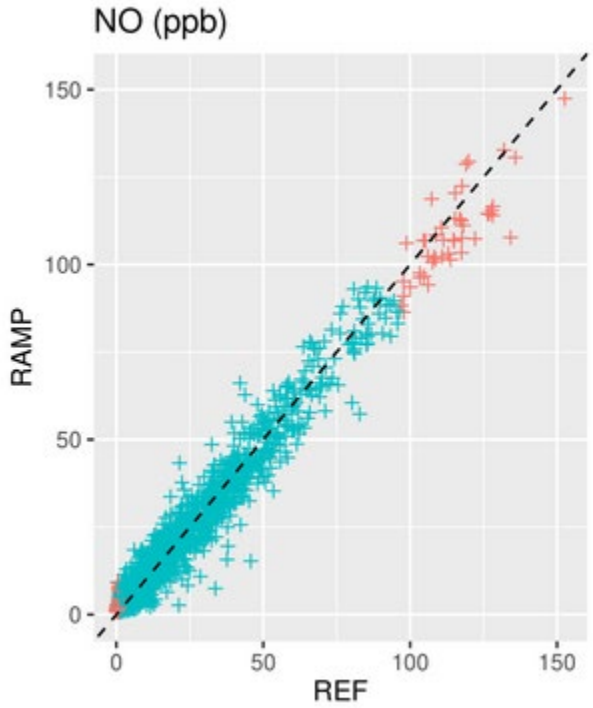


Figure S 19. Calibration of the NO signal in the Low-cost sensor showing the model splitting where Random Forest Model was applied in the middle (+) section, and Linear regression at the extremities (+).

Because the raw signal from the LCS was higher than the raw signal and the reference values used for calibration (see **Table S 7**), it is less likely that the Linear Regression is not extrapolating the calibration, but rather attempting to adjust a value that is already high.

Table S 7. Statistics summary of the NO signals from the low-cost sensor in the field, during collocation, and reference monitor.

	NO (raw, LCS Field)	**NO (ppb, LCS Field)**	**NO (raw, LCS collocation)**	**NO (ppb, Reference)**
Minimum	-245.55	78.03	-14.80	0
1st Quartile	22.32	299.53	10.39	2.89
Median	83.09	590.42	14.34	9.69
Mean	307.95	1045.57	18.85	18.31
3rd Quartile	295.25	1348.32	23.35	24.44
Maximum	3485.47	5995.83	148.57	248.48

Interference:

Our NO sensor is composed of a cell containing three electrodes, namely working, reference, and counter electrodes, which are separated by hydrophilic filters that enable ionic connection. In the working electrode oxidation or reduction reactions occur ideally only for the specific gas of interest. This is achieved by coating the electrode surface with a catalyst chosen to maximize surface area and enhance reaction with the target gas. A redox pair is created through the counter electrode, promoting electrons transference, and the potential difference between working and counter electrodes is measured. Finally, the reference electrode secures the potential of the working electrode (see more in Mead et al. (2013)[6]).

Past investigations already indicated that nitrous acid (HONO) might affect NO_2 electrochemical sensors by increasing the output one order of magnitude[7] and that HONO is readily available indoors[8,9]. Others have found cross-sensitivity of NO electrochemical sensors with Ethanol[10]. In our study, we observed a strong correlation between terpenes concentration and NO calibrated signal for the instantaneous concentrations in some rooms (**Figure S 26**). This effect is more noticeable in when plotting the correlation of the minimum, mean, and maximum values in each room (**Figure S 27**). This is not to imply that terpenes are affecting the electrochemical reaction directly, but rather the products formed by reaction in the indoor atmosphere could. Without the possibility of further investigation, we assumed that the sensor accurately estimated NO concentration inside the rooms.

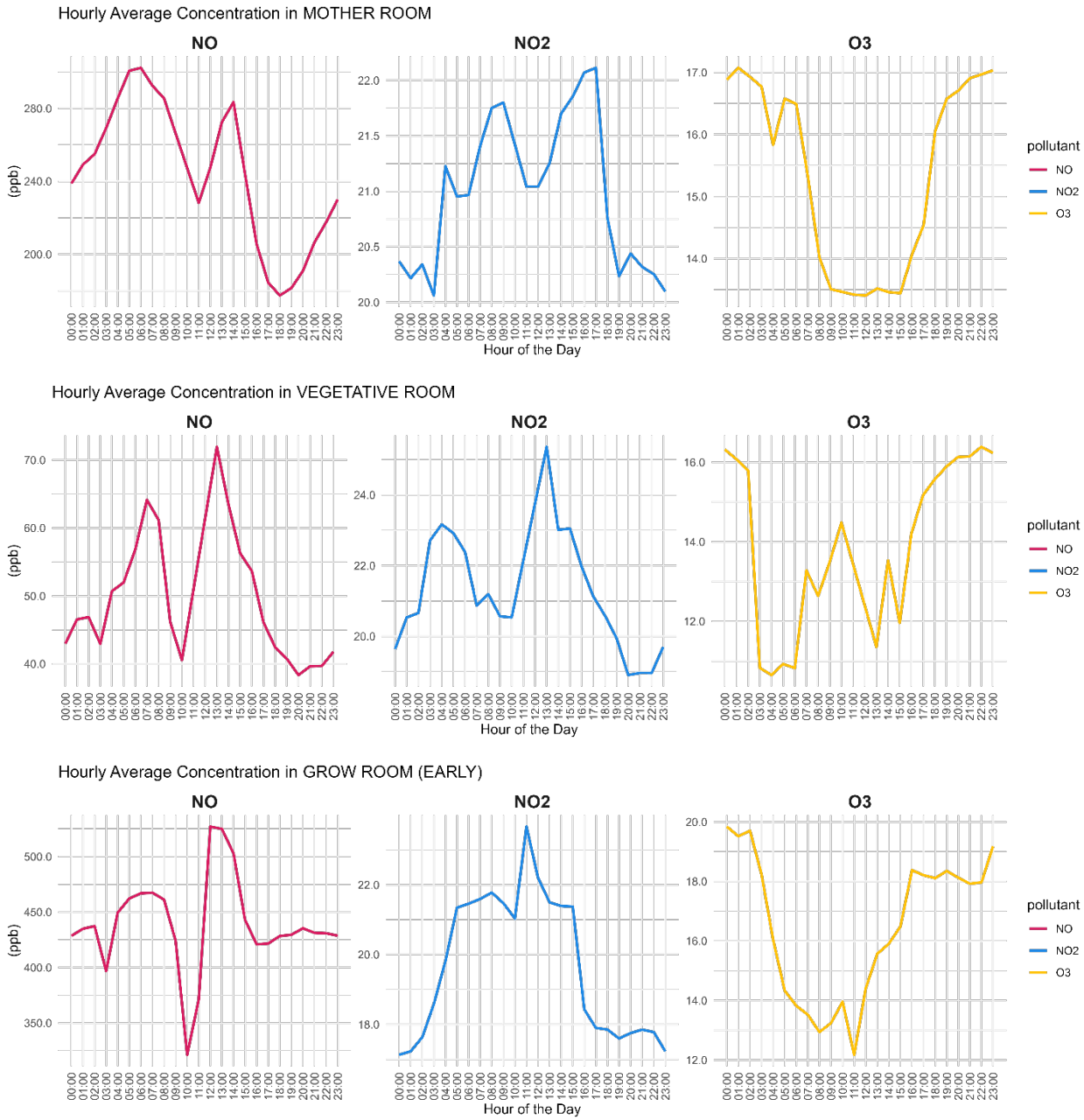


Figure S 20. NO, NO_2, O_3 hourly average variation in the rooms of a cannabis cultivation facility (CCF). – pt. 1. "Early" refers to recently propagated cannabis plants.

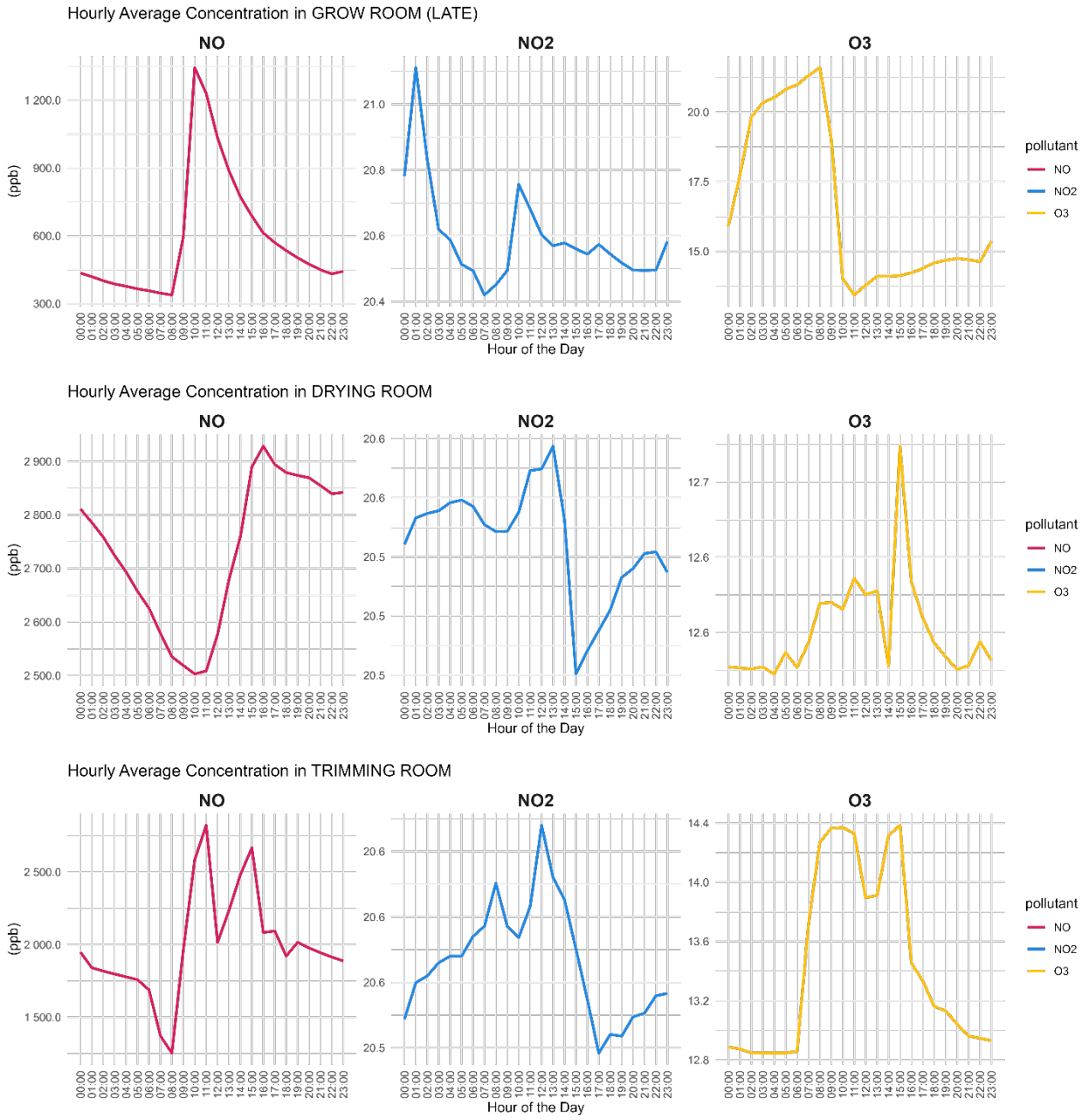


Figure S 21. NO, NO_2, O_3 hourly average variation in the rooms of a cannabis cultivation facility (CCF). – pt. 2. "Late" refers to flowering (mature) cannabis plants.

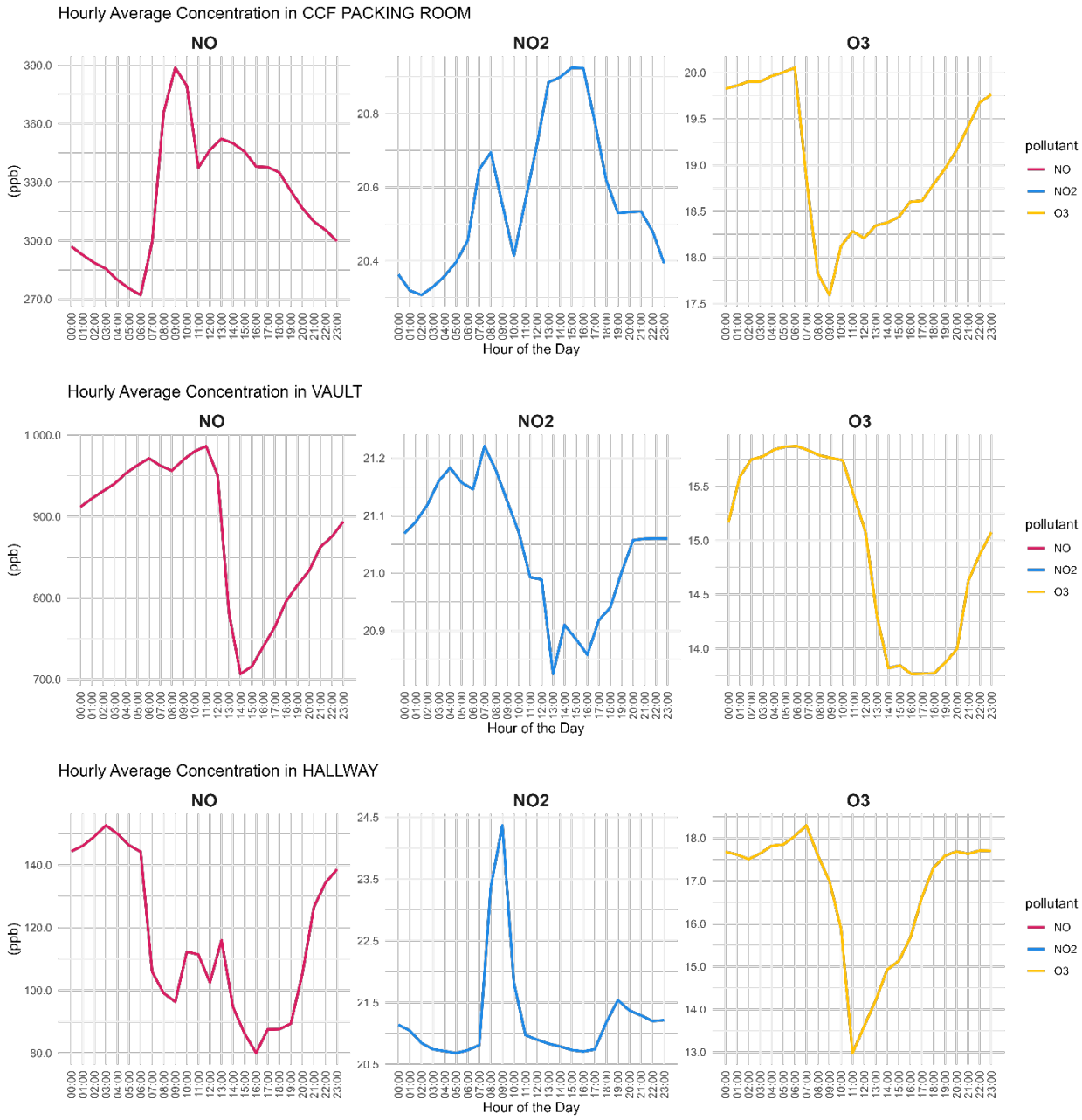


Figure S 22. NO, NO_2, O_3 hourly average variation in the rooms of a cannabis cultivation facility (CCF). – pt. 3.

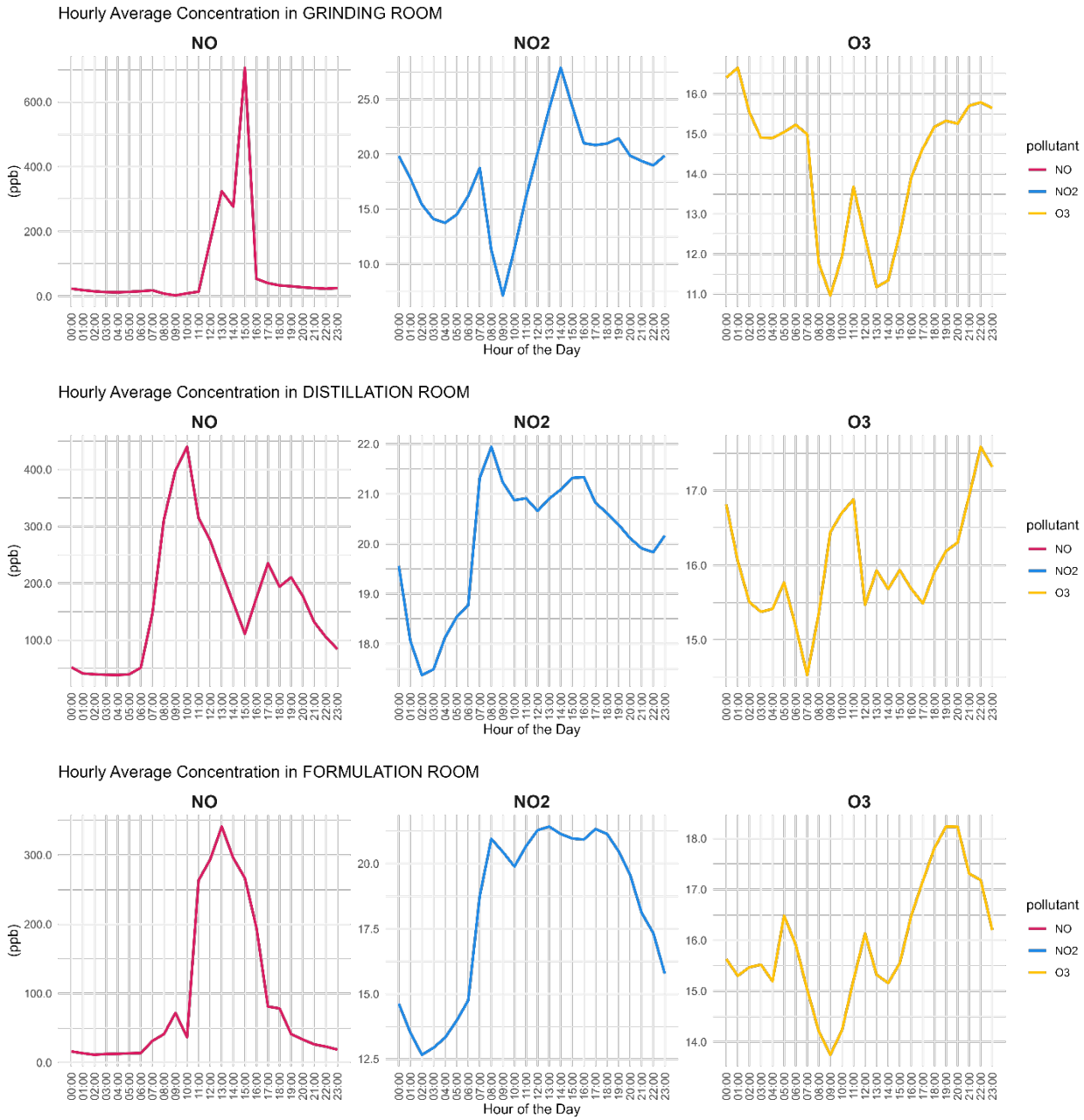


Figure S 23. NO, NO_2, O_3 hourly average variation in the rooms of a cannabis processing facility (CPF). – pt. 1.

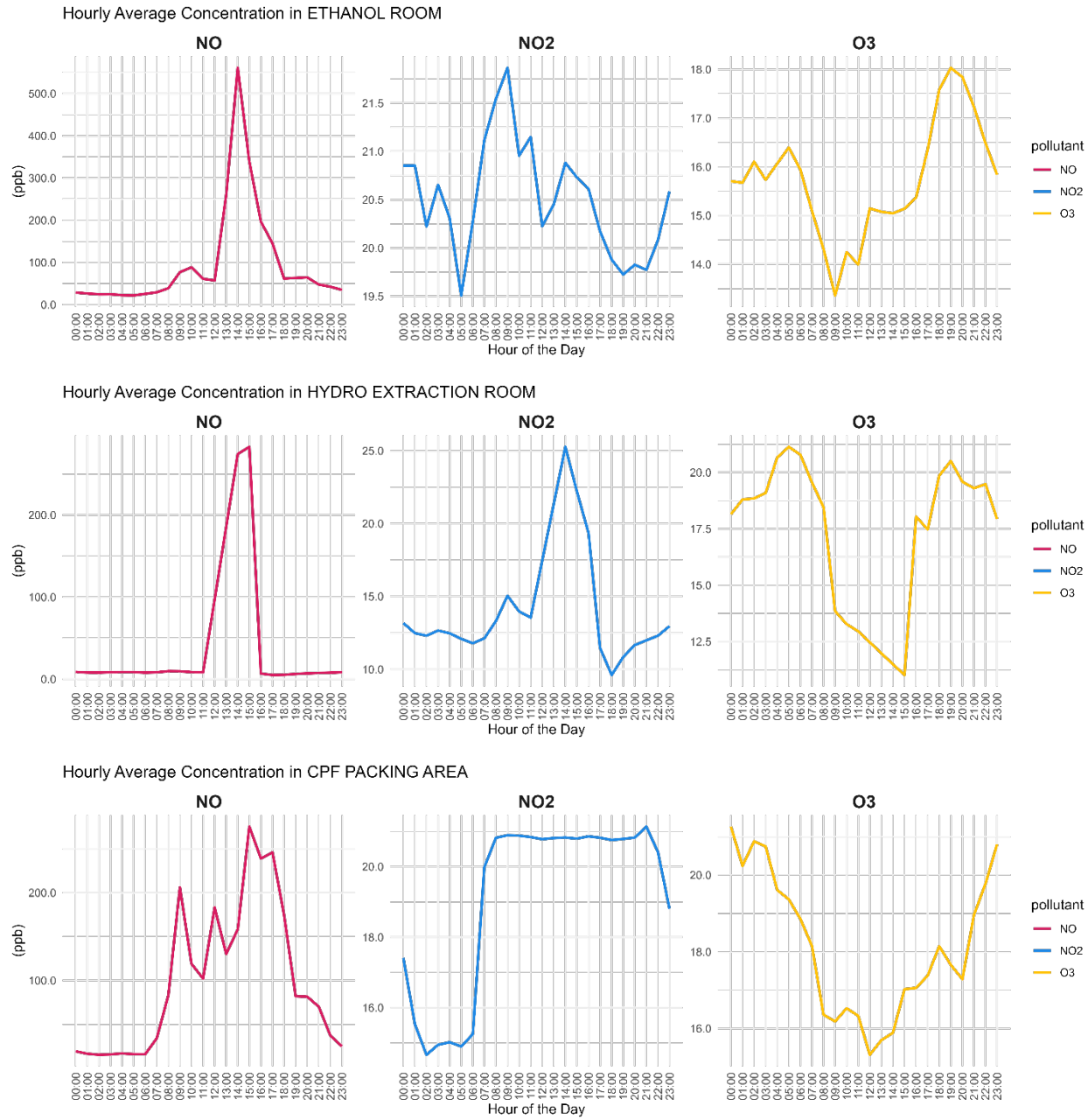


Figure S 24. NO, NO_2, O_3 hourly average variation in the rooms of a cannabis processing facility (CPF). – pt. 2.

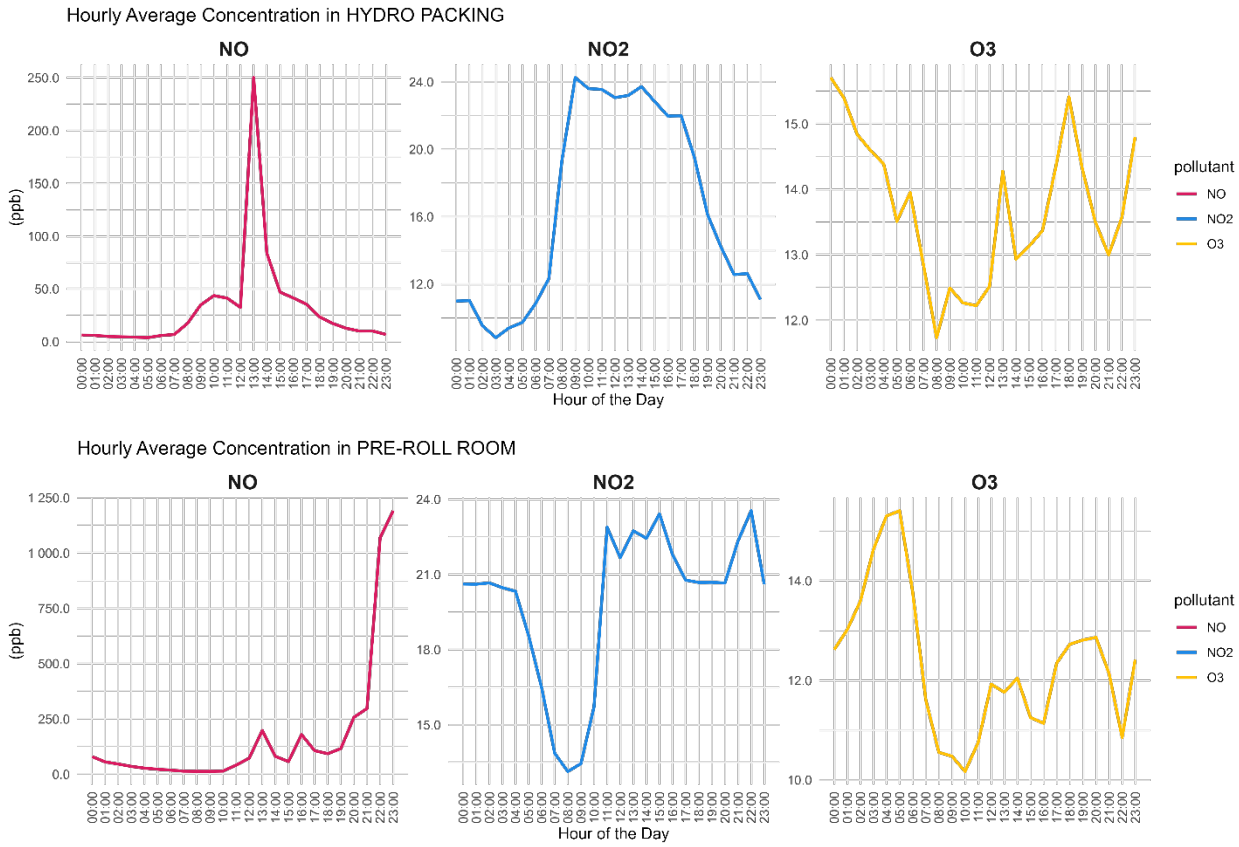


Figure S 25. NO, NO_2, O_3 hourly average variation in the rooms of a cannabis processing facility (CPF). – pt. 3.

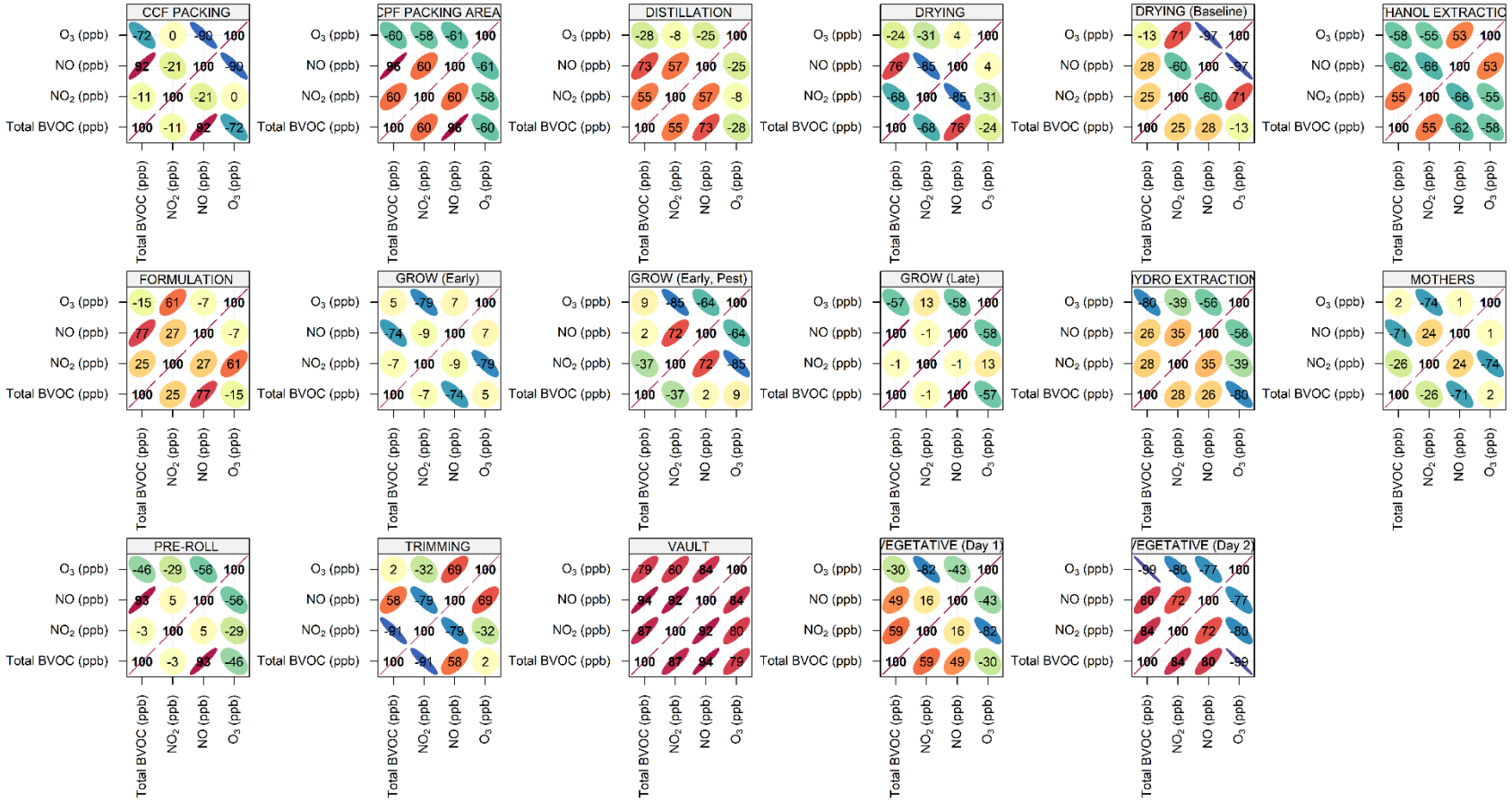
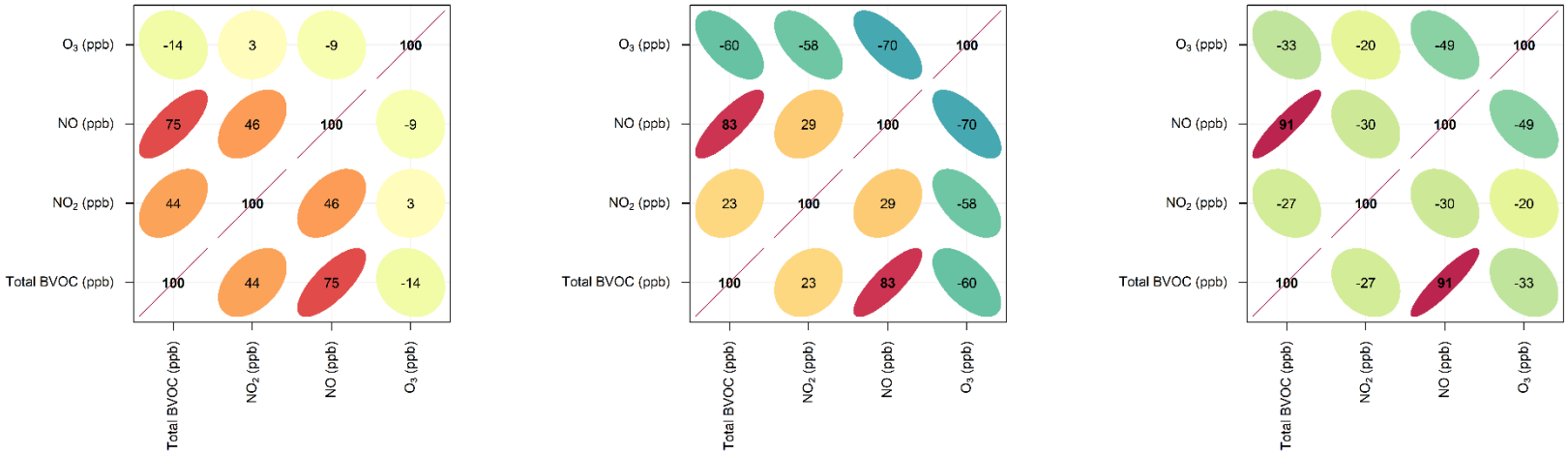


Figure S 26. Correlation of the 15-min averaged values of NO_2, O_3, and NO with the Total BVOC measured in each room of this study.



(a) Minimums (b) Means (c) Maximums

Figure S 27. Correlation of the minimums (a), means (b), and maximums (c) 15-min averages of NO_2, O_3, and NO with the Total BVOC measured in each room of this study.

S1.8 Light spectrum

The wavelength in the rooms of the CCF and the CPF was scanned using an OCEAN INSIGHT FLAME Miniature Spectrometer (model FLAME-S-RAD). This instrument can scan light in the ultraviolet, visible, and infrared spectra between 190 and 1100 nm. During deployment, we made one scan every minute in each room. However, because each facility has a schedule for when the lights are ON and OFF, here we show the light conditions at specific minutes that are representative of each period, rather than the entire collection of 1-minute scans. **Figure S 28** to **Figure S 35** show the measurements for the CCF and **Figure S 36** to **Figure S 39** for the CPF.

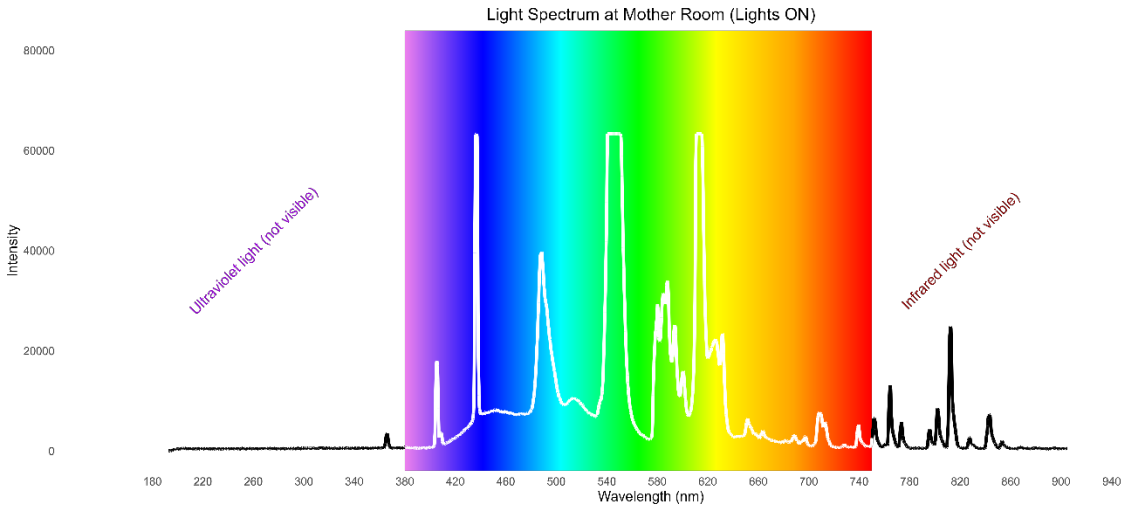


Figure S 28. Light spectrum in the CCF Mother room with the sensor facing the plants.

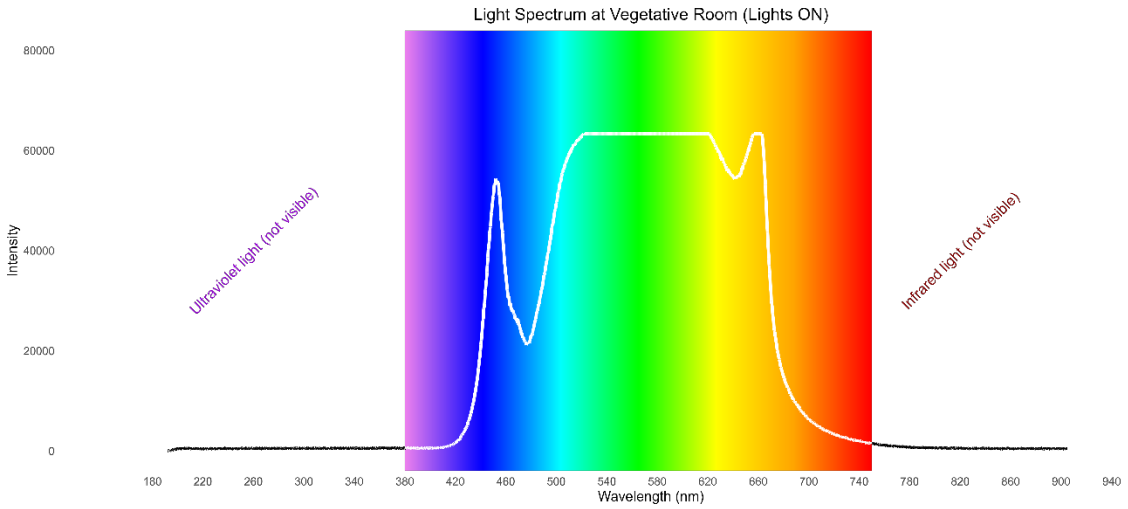


Figure S 29. Light spectrum in the CCF Vegetative room with the sensor facing the plants.

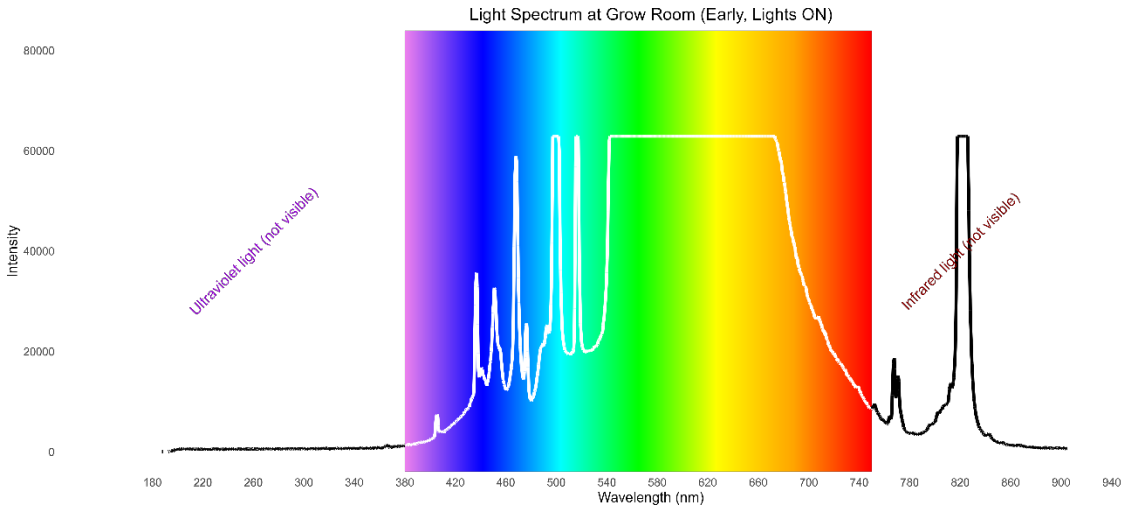


Figure S 30. Light spectrum in the CCF Grow room (early plant development) with the sensor facing the plants.

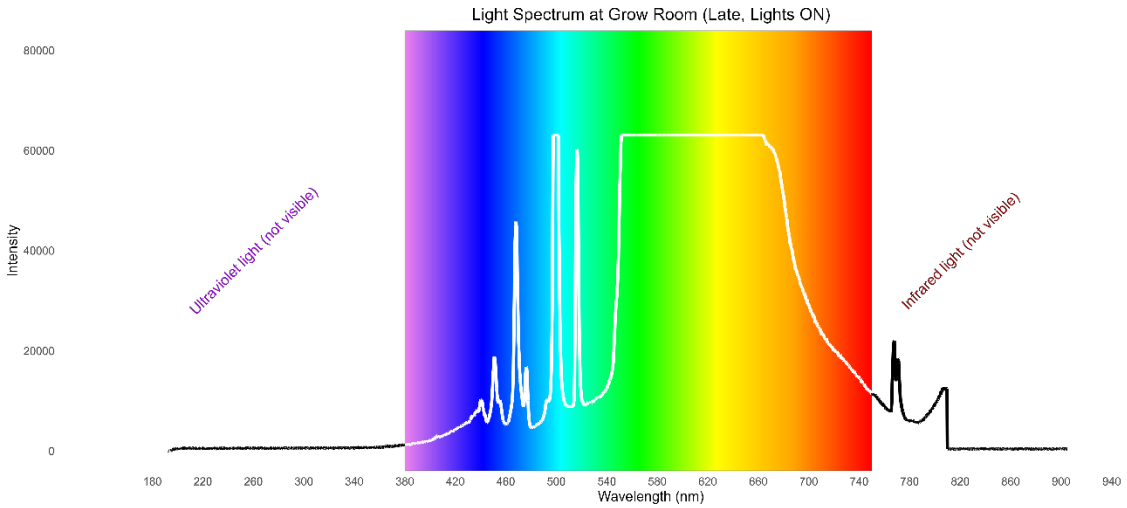


Figure S 31. Light spectrum in the CCF Grow room (late plant development) with the sensor facing the plants.

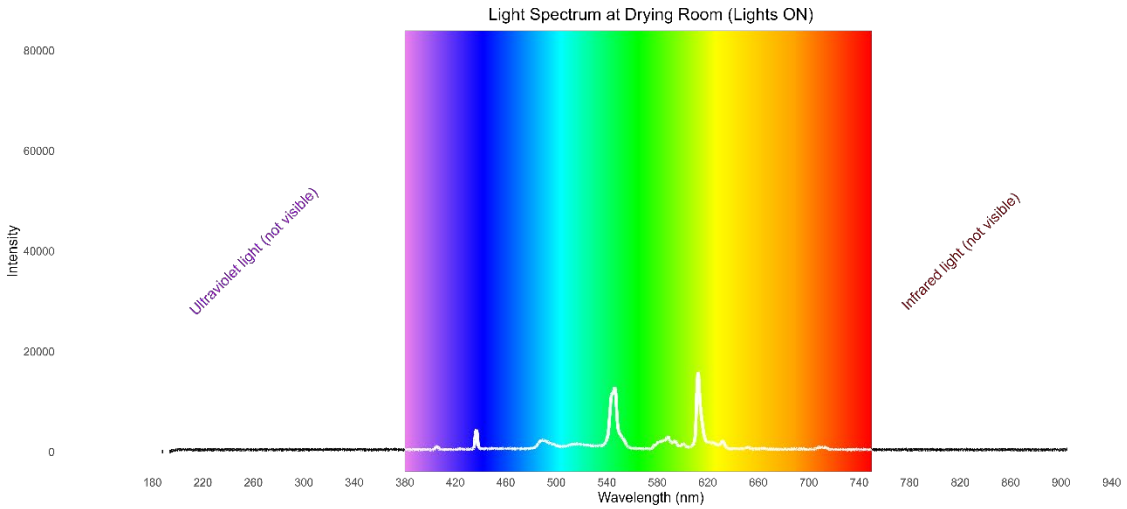


Figure S 32. Light spectrum in the CCF Drying room with the sensor facing the plants.

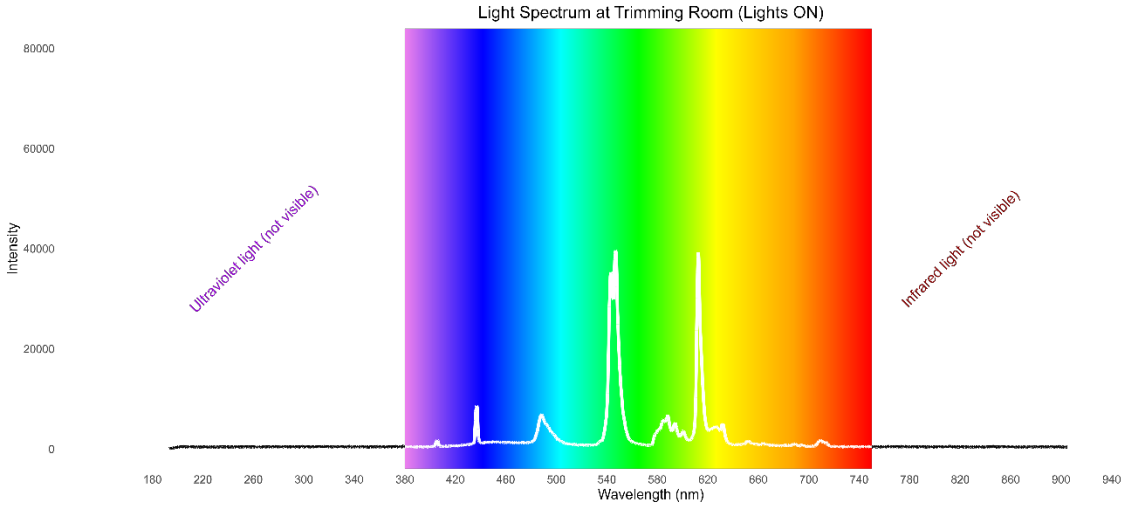


Figure S 33. Light spectrum in the CCF Trimming room with the sensor facing the center of the room.

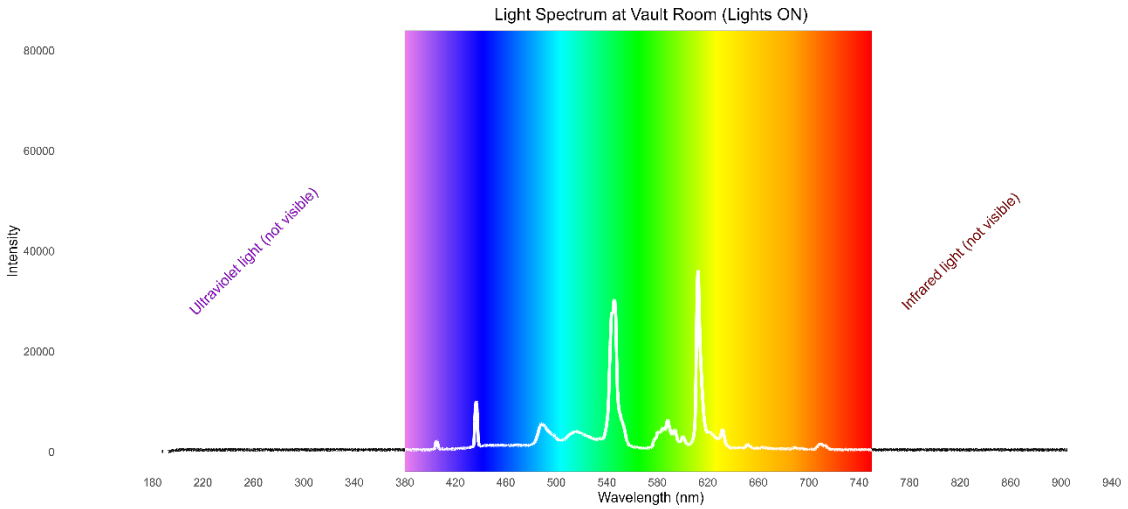


Figure S 34. Light spectrum in the CCF Vault/Storage room with the sensor facing the center of the room.

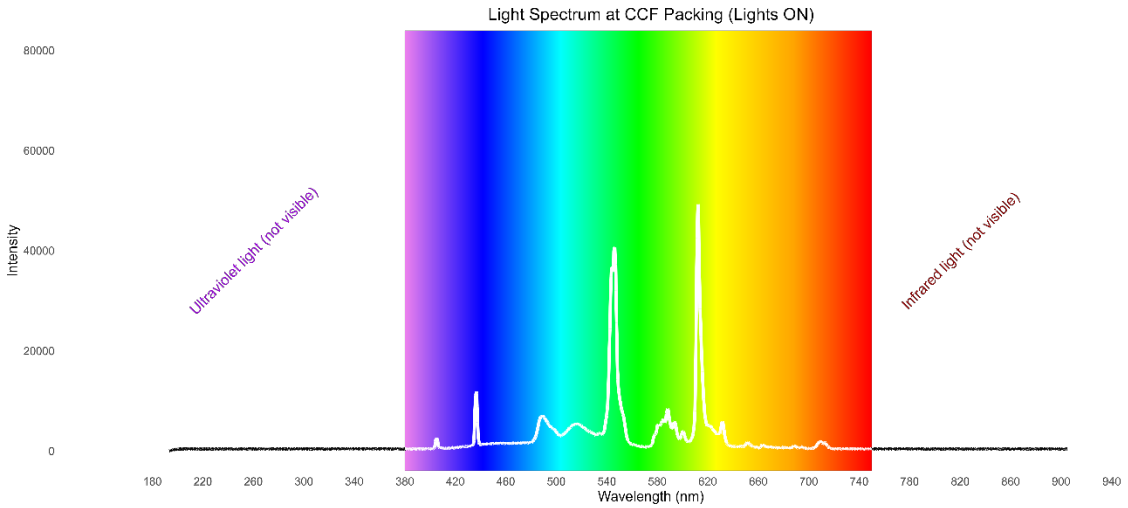


Figure S 35. Light spectrum in the CCF Packing room with the sensor facing the center of the room.

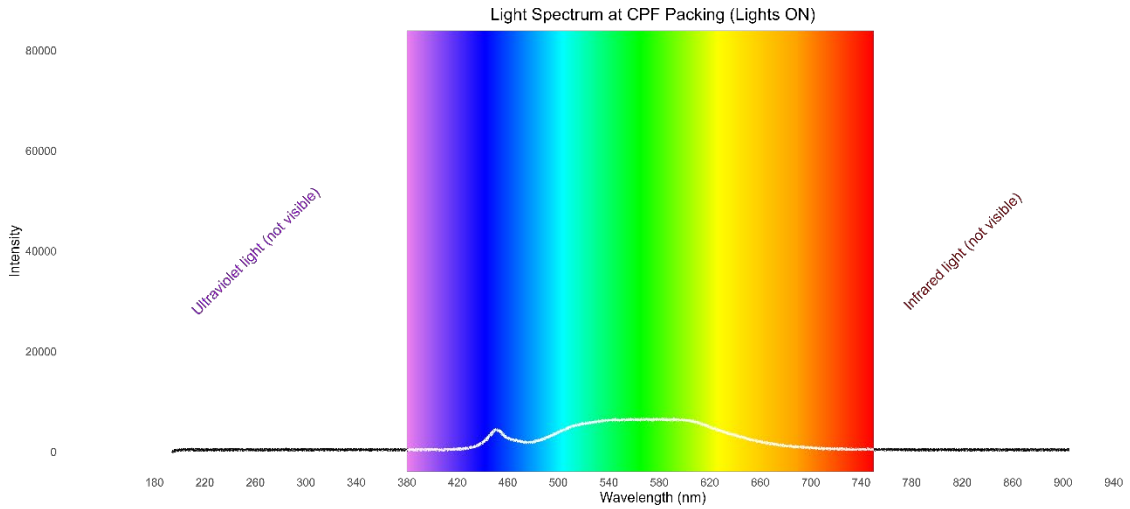


Figure S 36. Light spectrum in the CPF Packing room with the sensor facing the center of the room.

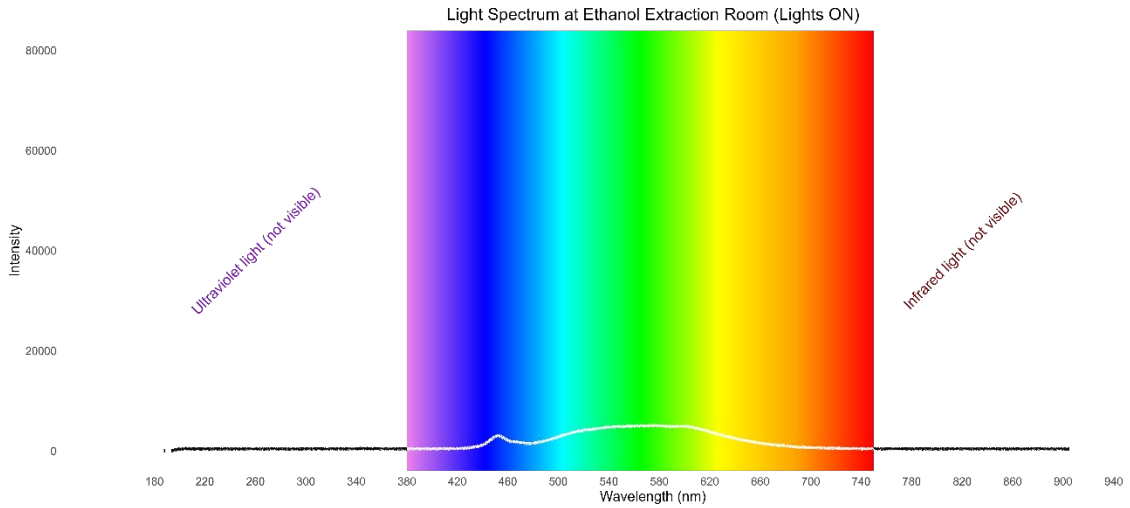


Figure S 37. Light spectrum in the CPF Ethanol Extraction room with the sensor facing the center of the room.

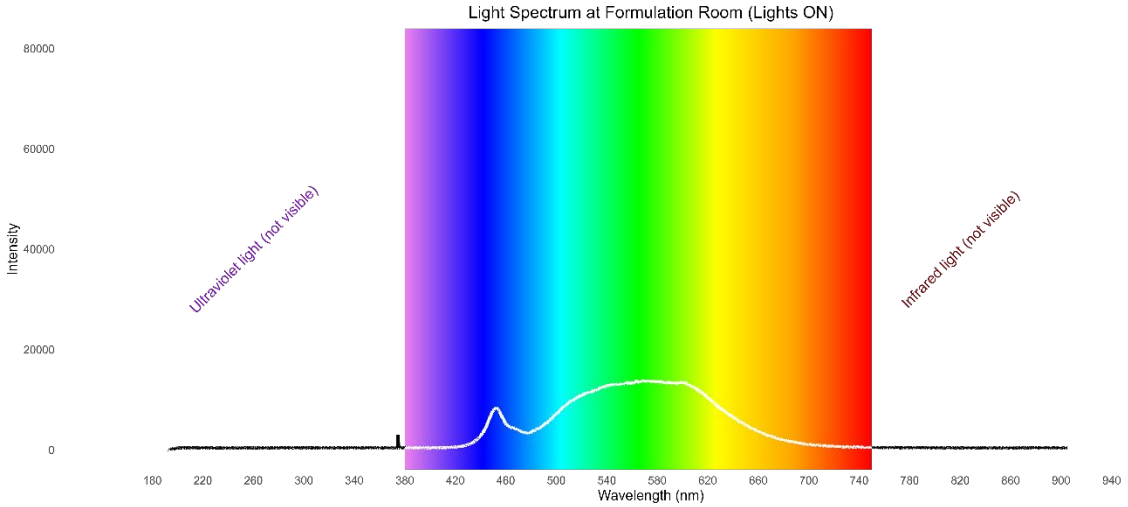


Figure S 38. Light spectrum in the CPF Formulation room with the sensor facing the center of the room.

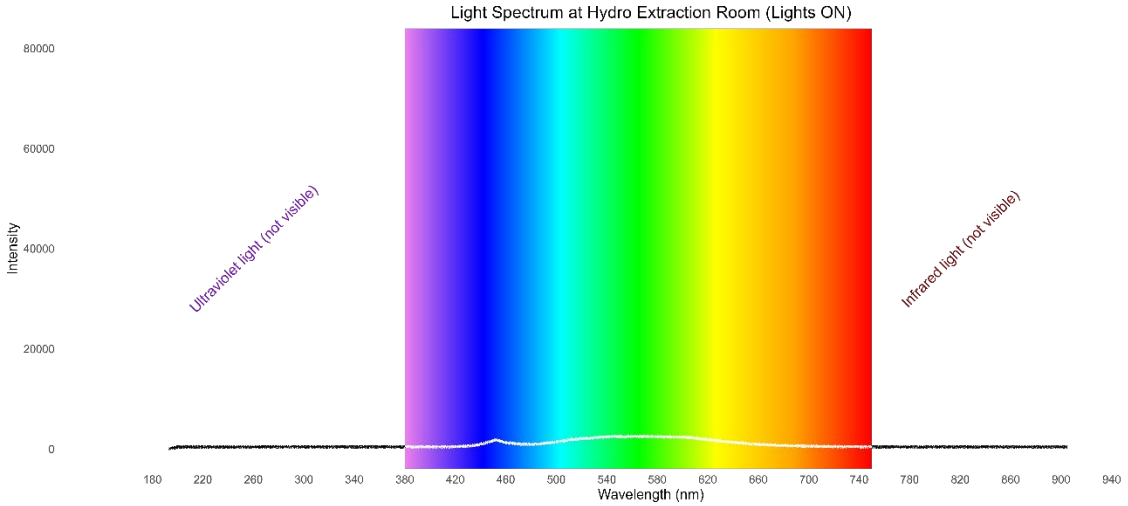


Figure S 39. Light spectrum in the CPF Hydro Extraction room with the sensor facing the center of the room.

S1.9 Reaction kinetics' information

Table S 8 provides a summary of chemical kinetics database used. For values obtained at the National Institute of Standards and Technology (NSIT), preference was given to Reviews, followed by Experimental, and lastly Theoretical studies.

Table S 8. Key variables used to estimate the terpenes loss by chemical reactions.

Terpenes	**Molecular weight**	**K (Terp + O3)***	**OH yield (Terp + O3)**	**K (Terp + OH)***
(common name)	**g.mol^{-1}**	**molecule^{-1} cm^3 s^{-1}**	**-**	**molecule^{-1} cm^3 s^{-1}**
α-Pinene	136.24	9.60E-17[a]	0.85[h]	5.54E-11[a]
Camphene	136.24	5.02E-19[a]	0.18[h]	5.15E-11[a]
β-Pinene	136.24	1.90E-17[a]	0.35[h]	7.81E-11[a]
β-Myrcene	136.24	4.70E-16[a]	1.15[h]	2.30E-10[a]
δ-3-Carene	136.24	4.90E-17[a]	1.06[h]	8.22E-11[a]
α-Terpinene	136.24	1.90E-14[a]	0.38[h]	2.32E-10[a]
(+/-)-Limonene	136.24	5.00E-18[a]	0.86[h]	1.67E-10[a]
p-Cymene	134.21	5.00E-21[a]	0.63**	1.57E-11[a]
1,8-Cineole	154.25	1.00E-19[a]	0.86**	1.11E-11[i]
Ocimene	136.24	3.85E-16[b]	0.63[h]	3.04E-10[b]
γ-Terpinene	136.24	1.60E-16[a]	0.81[h]	1.31E-10[a]
Terpinolene	136.24	1.60E-15[a]	1.03[h]	2.25E-10[i]
Linalool	154.25	4.10E-16[a]	0.72[h]	1.73E-10[a]
(-)-Isopulegol	154.25	8.40E-15[c]	0.72**	1.73E-10**
Geraniol	154.25	9.30E-16[d]	0.72**	2.31E-10[d]
β-Caryophyllene	204.36	1.10E-14[e]	0.06[h]	2.91E-10**
α-Humulene	204.36	1.20E-14[e]	0.22[i]	2.91E-10[a]
cis-Nerolidol	222.37	5.00E-14[f]	0.08[g]	2.00E-10[k]
trans-Nerolidol	222.37	1.20E-14[g]	0.08[g]	2.00E-10[k]
(-)-Caryophyllene-oxide	220.35	1.20E-14[g]	0.08[g]	2.00E-10[k]
(-)-Guaiol	222.37	1.20E-14[g]	0.08[g]	2.00E-10[k]
α-Bisabolol	222.37	1.20E-14[g]	0.08[g]	2.00E-10[k]

[a] NSIT
[b] Kim et al. (2011)[11]
[c] Alvarez et al. (2013)[12]
[d] Forester et al. (2007)[13]
[e] Richters et al. (2015)[14]
[f] Qiu et al. (2019)[15]
[g] Schwantes et al. (2019)[16]
[h] Atkinson and Arey (2003)[17]
[i] Shu and Atkinson (1994)[18]
[j] Corchnoy and Atkinson (1990)[19]
[k] Isaacman-VanWertz et al. (2024)[20]

*considering room temperature range (20 - 27 °C) as measured by the low-cost sensor.
**assumed due to lack of references.

S1.10 Variables and inputs of the screening dispersion modelling and meteorological analysis

We used a Gaussian distribution equation (**Equation 6**) to predict the concentrations downwind of facilities' stack emissions:

$$\boldsymbol{C}_{(x,y,z)} = \frac{Q}{U_s}\frac{1}{2\pi\sigma_x\sigma_y}e^{(-\frac{y^2}{2\sigma_y^2})}\left[e^{(-\frac{(z+H_s)^2}{2\sigma_z^2})} + e^{(-\frac{(z-H_s)^2}{2\sigma_z^2})}\right] \quad Eq.(6)$$

Equation 7 to 10 describe how the values used in the dispersion model were calculated.

$$u_s = u_a(\frac{h_s}{h_a})^p \quad Eq.(7)$$

$$\Delta H = \emptyset_s\left(\frac{V_s}{u_s}\right)^{\frac{1}{4}}\left(1 + \left(\frac{\Delta T}{T_s}\right)\right) \quad Eq.(8)$$

$$\sigma_z = cx^d \quad Eq.(9)$$

$$\sigma_y = ax^b \quad Eq.(10)$$

where,

u_s is the wind speed at stack height (m/s)
u_a is the wind speed at anemometer height (m/s)
h_a is the anemometer height (m)
h_s is the stack height (m)
p is the exponent dependant on stability class and environment classification
ΔH is the plume rise above stack (m)
$\emptyset_s$ is the diameter of the stack (m)
V_s is the stack gas exit velocity (m/s)
u_s is the wind speed (m/s)
ΔT is the stack gas temperature - ambient temperature (K)
T_s is the stack gas temperature (K)
a, b, c, d, f are constants that depend on the atmospheric stability and the receptor downwind distance (x) from the source obtained from Seinfeld and Pandis (2006)[21]
σ_z, and σ_y are the vertical and lateral dispersion coefficients, respectively.

Table S 9. Input values for the screening dispersion model.

Variable description	Units	Initial value	Sensitivity analysis
Atmospheric stability	-	Moderately unstable, Neutral, and Moderately stable	-
Pasquill-Gifford scale	-	B, D, and F	-
Environment	-	Rural	-
Anemometer height	m	10	-
Wind speed at 10m	m/s	2	(5, 10, 15, 20)
Stack height	m	4, 16	8
Stack diameter	m	1	(0.5, 2)
Stack gas velocity	m/s	5	(1, 10, 20)
Stack gas exit temperature	K	298.15	(328.15)
Ambient temperature	K	298.15	-
Receptor downwind distance	m	100	(250, 500, 1000, 2500, 5000, 10000)
Crosswind distance	m	0	-
Receptor height	m	1.5	-
Emissions	g/s	0.1036* 0.0040* 0.0689** 0.0071**	0.1403* 0.0061* 0.1166** 0.0170**

* based on the sum of the average rooms' emissions of β-myrcene for the CCF and the CPF (initial conditions) and the average plus the highest variation of total emissions for a single room (sensitivity analysis)

** based on the sum of the average emissions of (+/-)-limonene for the CCF and the CPF (initial conditions) and the average plus the highest variation of total emissions for a single room (sensitivity analysis)

Discussion of the significance of the predicted odour impacts by screening dispersion modelling:

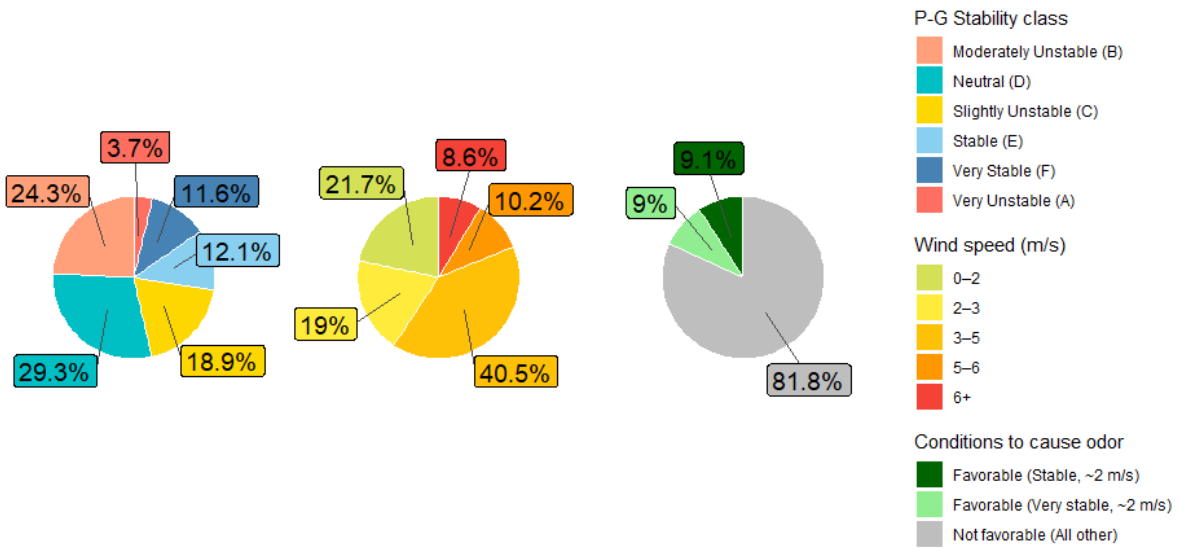


Figure S 40. Atmospheric conditions grouping stability class, wind speed, and overall conditions to odor episodes during the year of sampling at the CCF.

The stable conditions that led to predicted odour episodes in our screening dispersion model occur at nighttime. During the night, the CCF turns the lights ON for the 12-hour awake cycle of the plants, which may increase emissions, although slightly (< 0.1 kg/h). Additionally, those conditions would occur after any trimming activity (i.e., highest emission peak), which generally occurs between 1 PM and 5 PM. Therefore, considering that most people would be at home and that indoor concentrations may be lower than ambient due to terpene penetration factors, the predicted odor impacts are unlikely to occur.

S2. Results

S2.1 Concentration analysis

Table S 10. Comparison of the terpene concentration in the Grow room of the CCF *vs.* other studies

Facility	Source	Terpenes (ppb) per plant	Additional Information
Facility #1	Samburova et al. (2019)[22]	1.52 ± 0.16	Unknown controls, strains and area. 183 mature plants
Facility #2		27.27 ± 0.27	HPS lights and fan turned OFF. Unknown strains and area. 36 mature plants
Facility #2		3.14 ± 0.02	HPS lights and fan turned ON. Unknown strains and area. 36 mature plants
Facility #3		0.63 ± 0.01	Unknown controls, strains and area. 56 mature plants
Facility #4		0.13 ± 0.06	Unknown controls, strains and area. 155 mature plants
CCF	This study	4.83–11.91	HPS lights ON, HVAC and fans ON. Charcoal filters. 350 'Girl Scout Cookies' mature plants, 46.5 m^2.
CCF	This study	5.1–8.97	HPS lights OFF, HVAC and fans ON. Charcoal filters. 350 'Girl Scout Cookies' mature plants, 46.5 m^2.
Facility	**Source**	**Terpenes (ppb) per kg**	**Additional Information**
Facility #5	Urso et al. (2023)[23]	0.81	HVAC and carbon filters. 1522 mature plants, 3 strains, 1036 kg, area unknown
Facility #6		0.06	HVAC, Lights ON. 5359 mature plants, 19 strains, 6666 kg, area unknown
Facility #7		1.10	HVAC and filtration. 773 mature plants, 36 strains, 1765 kg, area unknown
CCF	This study	3.03–7.03*	HPS lights, HVAC and fans ON. Charcoal filters. 350 'Girl Scout Cookies' mature plants, 46.5 m^2.

* We assumed 1.47 kg per plant, the average of the four facilities in Urso et al. (2023)[23].

Table S 11. Comparison of the terpene concentration in the Drying room of the CCF vs. other studies

Facility	Source	Terpenes (ppb) per kg	Additional Information
Facility #5	Urso et al. (2023)[23]	12.5	201 kg, "Sour Tsunami" and "Glass Apple". Drying 1 day old
Facility #6		13.2	353 kg, 8 strains, Fresh harvested plants
Facility #7		3.2	1827 kg, 37 strains. Full drying room and door open to processing room
CCF	This study	3.6–4.6*	HVAC and Charcoal filters. "Blue Dream". One day drying of 530 plants (779 kg)

* We assumed 1.47 kg per plant, the average of the four facilities in Urso et al. (2023)[23] (in this case, the plants were just starting the drying process. If they were in the room longer, the weight per plant would decrease as they lose their water content when drying)

S2.2 Concerning results reproducibility

We were not able to have measurements taken between 10:00 AM and 10:00 PM multiple times for all rooms. However, we can use the time series of a few rooms to argue reproducibility. For example, both Vegetative room time series (**Figure S40 (a) and (b)**) display a decay right after 1:00 PM reaching the lowest point around 10:00PM. In the Drying room (**Figure S41 (d) and Figure S42 (a) to (c)**), each sampling day had similar concentrations for the dominant terpenes β-Myrcene and (+/-)-Limonene. In the Formulation room time series (**Figure S44 (c) and (d)**) both illustrate a peak happening around 12:00 PM followed by a fast decay in all terpene concentrations. These rooms exemplify best that we should expect similar results when sampling different days.

In the cultivation facility, if a different strain is cultivated/processed between two samplings for the same room. Then, the total terpene and individual terpene time series would have changed. Similarly, if in the processing facility the strain being processed in the batch or the terpenes added to the vape mixture change, the total terpene and individual terpene profile would also have changed between samplings, something also exemplified by the Formulation room time series (**Figure S44 (c) and (d)**).

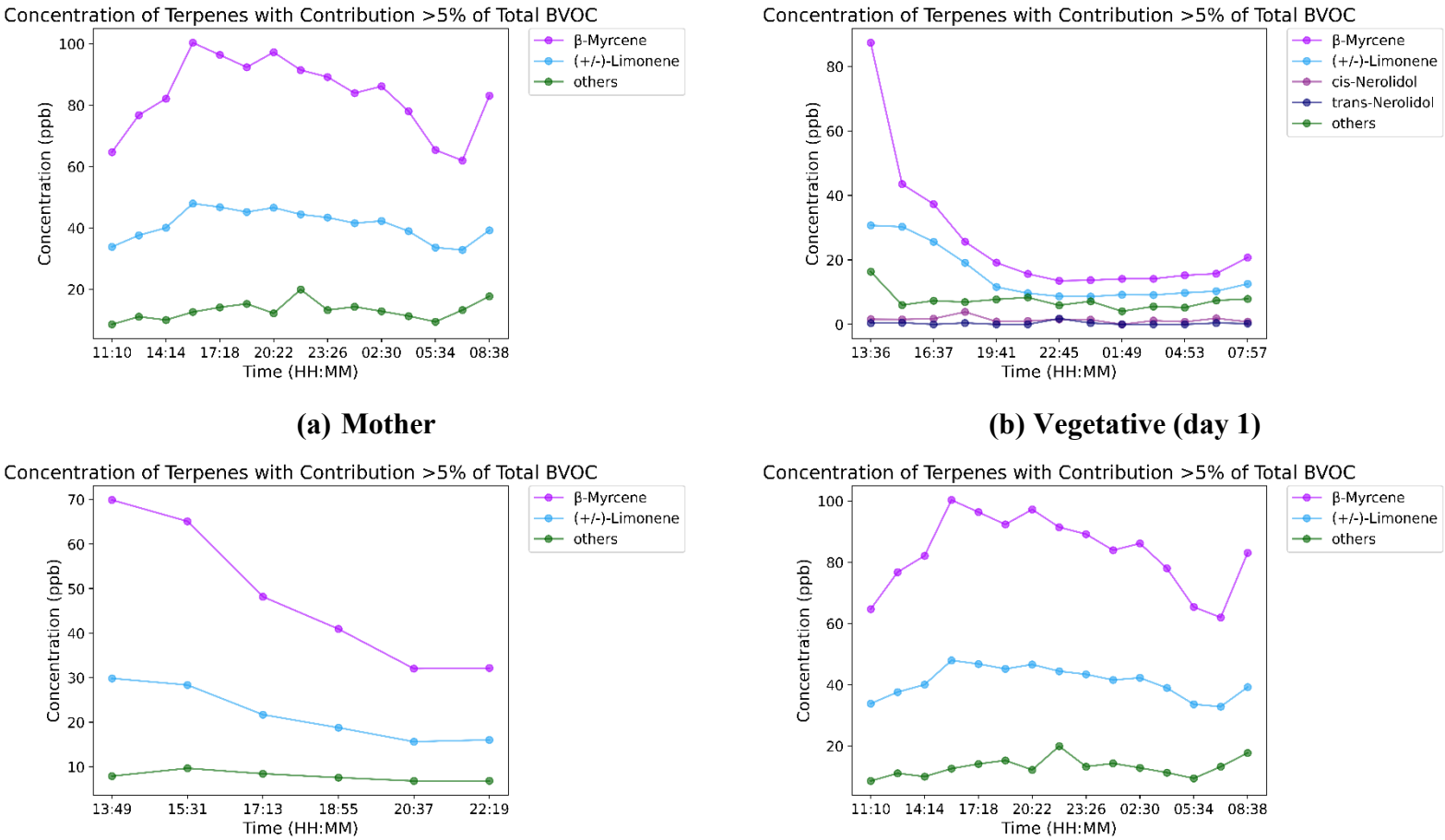
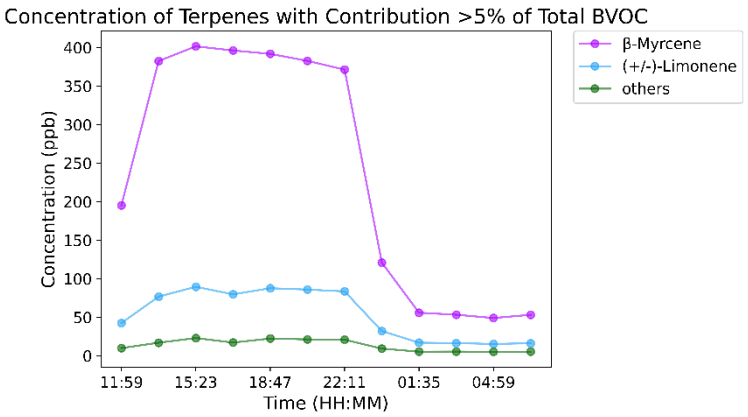
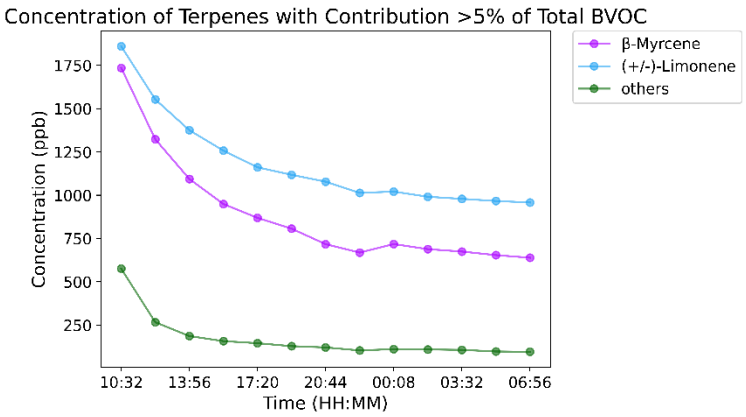


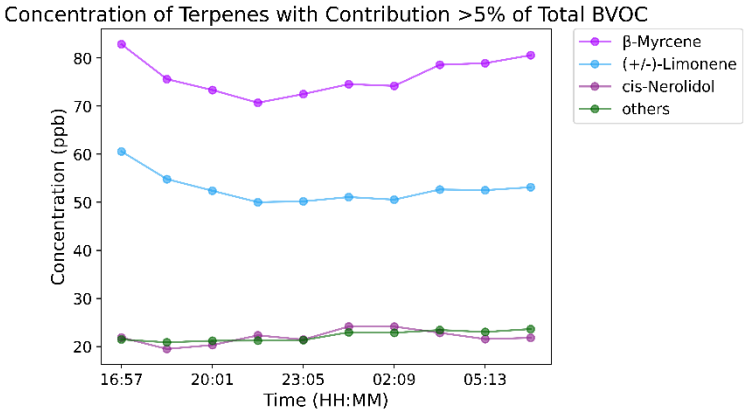
Figure S 41. Concentration changes in a typical operation day of the major terpenes in each room of the CCF – pt.1.



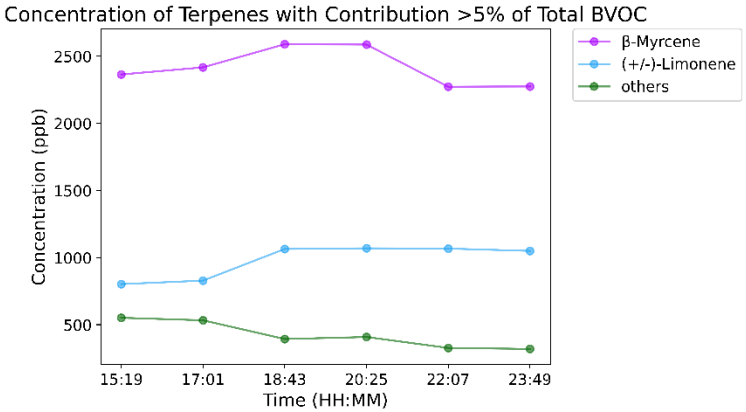
(a) Grow room (early plant development, pesticides)



(b) Growing room (mature plants)

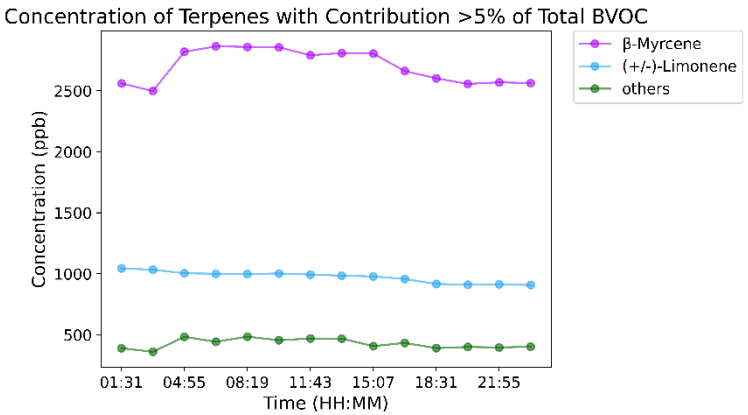


(c) Drying room (no plants, baseline)

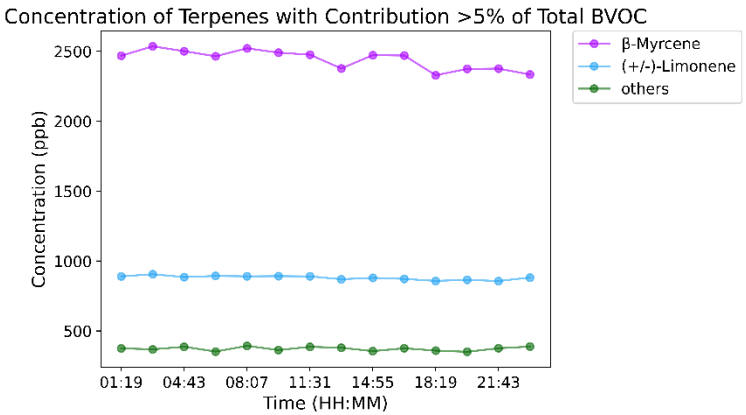


(d) Drying room (w/plants, day 1)

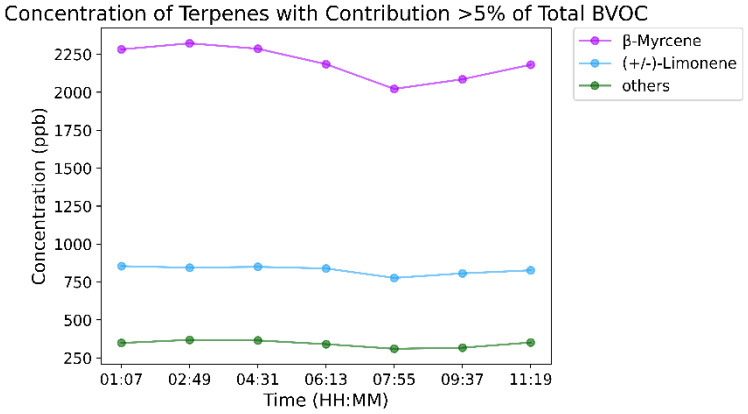
Figure S 42. Concentration changes in a typical operation day of the major terpenes in each room of the CCF – pt. 2.



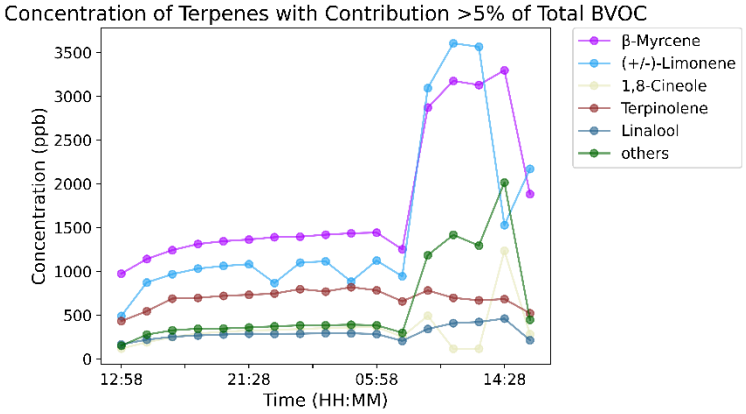
(a) Drying room (w/plants, day 2)



(b) Drying room (w/plants, day 3)

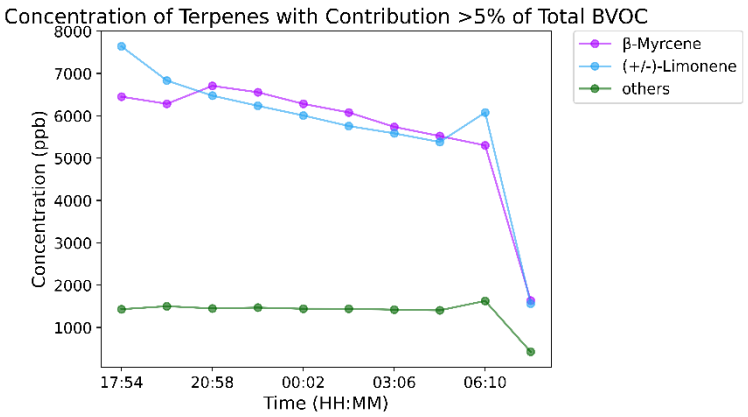


(c) Drying room (w/plants, day 4)

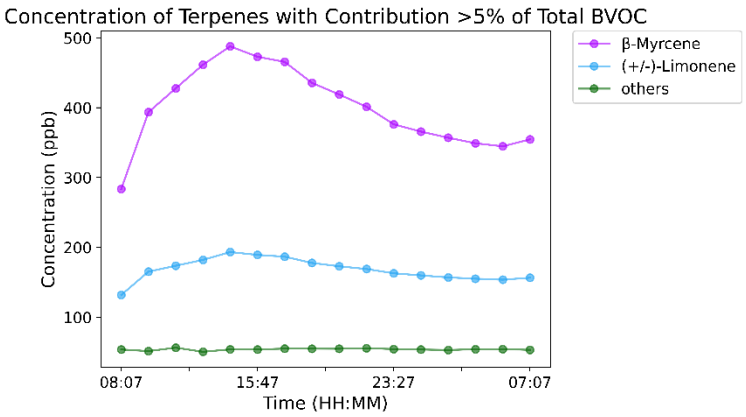


(d) Trimming room (day 1)

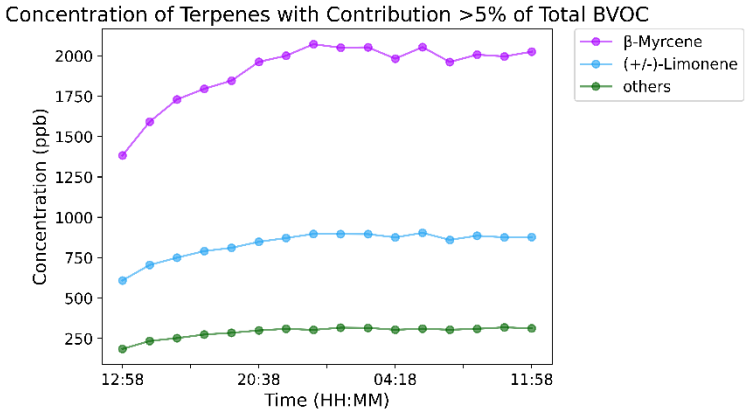
Figure S 43. Concentration changes in a typical operation day of the major terpenes in each room of the CCF – pt. 3.



(a) Trimming room (day 2)

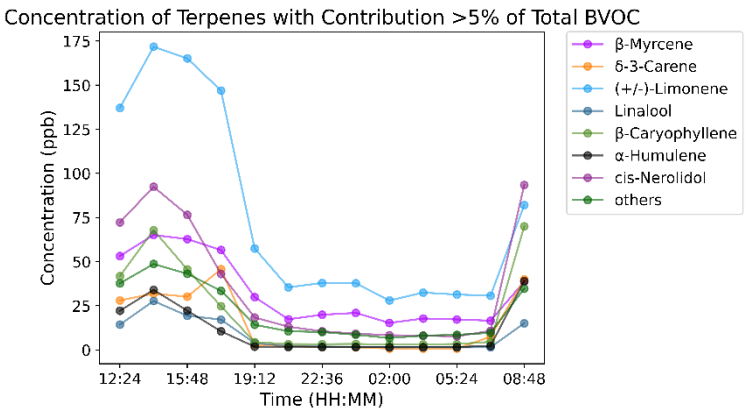


(b) Packing room

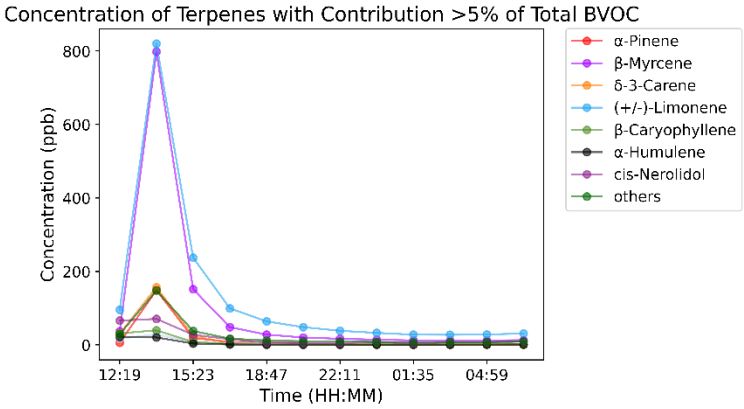


(c) Vault/Storage

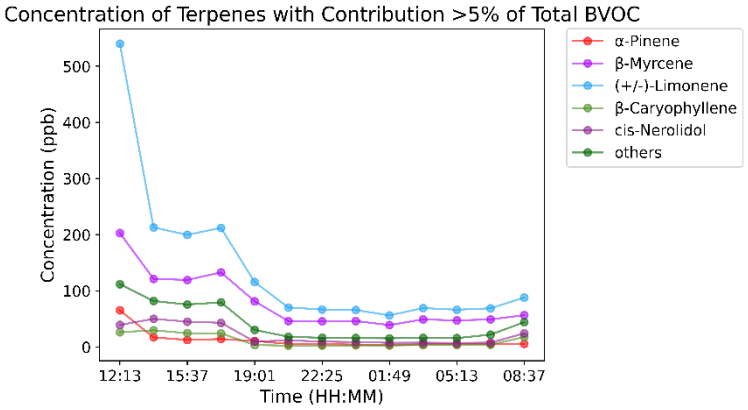
Figure S 44. Concentration changes in a typical operation day of the major terpenes in each room of the CCF – final.



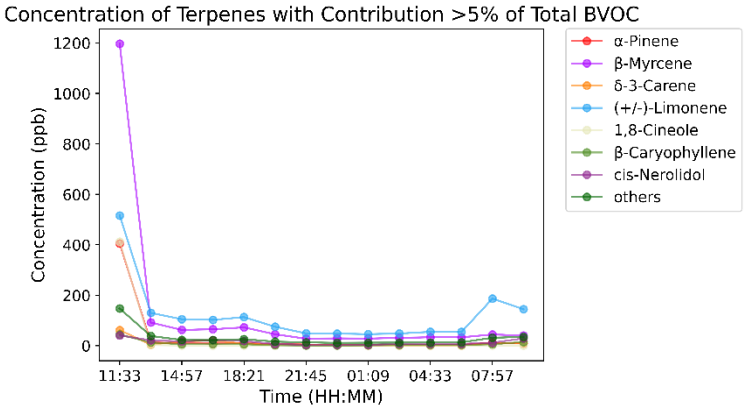
(a) Distillation room



(b) Ethanol Extraction room

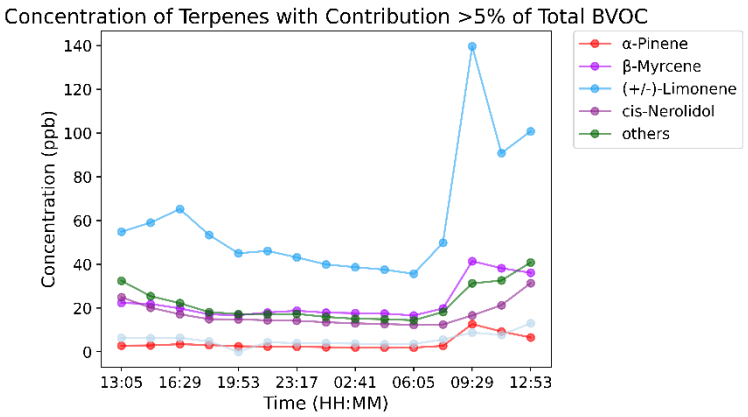


(c) Formulation room (day 1)

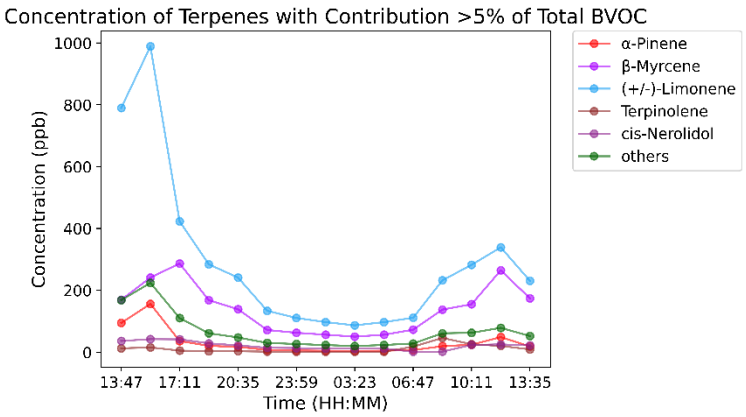


(d) Formulation room (day 2)

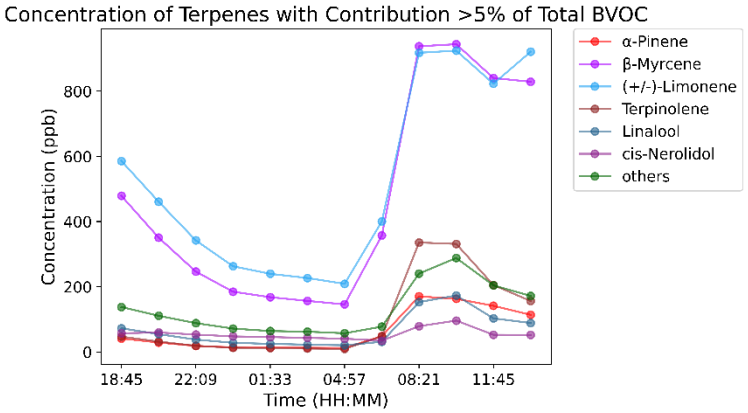
Figure S 45. Concentration changes in a typical operation day of the major terpenes in each room of the CPF – pt. 1.



(a) Hydro extraction room



(b) Packing area



(c) Pre-roll room

Figure S 46. Concentration changes in a typical operation day of the major terpenes in each room of the CPF – final.

S2.3 2-D Pearson-Emission analysis supporting results

The correlation values between an individual terpene and the room's total emissions were estimated using **Equation 1** (Pearson's correlation). After normalizing each terpene emission by the total BVOC emitted, we investigated their relevance by plotting the normalized emission by the terpene correlation with the total BVOC. To aid results interpretation, we stipulated specific ranges as follows. **Figure S 46** to **Figure S 61** show the results.

- correlation >= 0.75 & normalized emission >= 0.05 → "Key contributors"
- correlation >= 0.5 & normalized emission < 0.05 → "Minor contributors"
- correlation < 0 & normalized emission >= 0.05 → "Inverse markers"
- correlation < 0.5 & normalized emission < 0.05 → "Unrelated or near detection limit"
- correlation < 0.75 & normalized emission > 0.05 → "Unclear relationship"

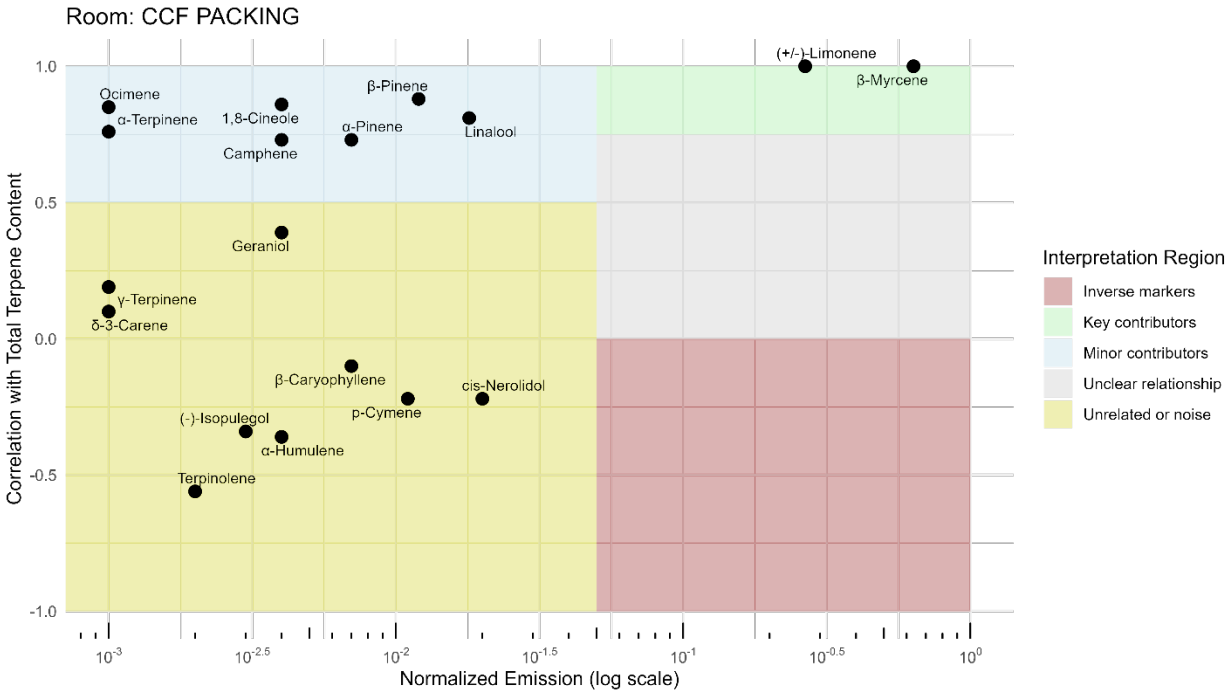


Figure S 47. Scatter plot of sampled terpenes relevance to the emissions of the CCF Packing room.

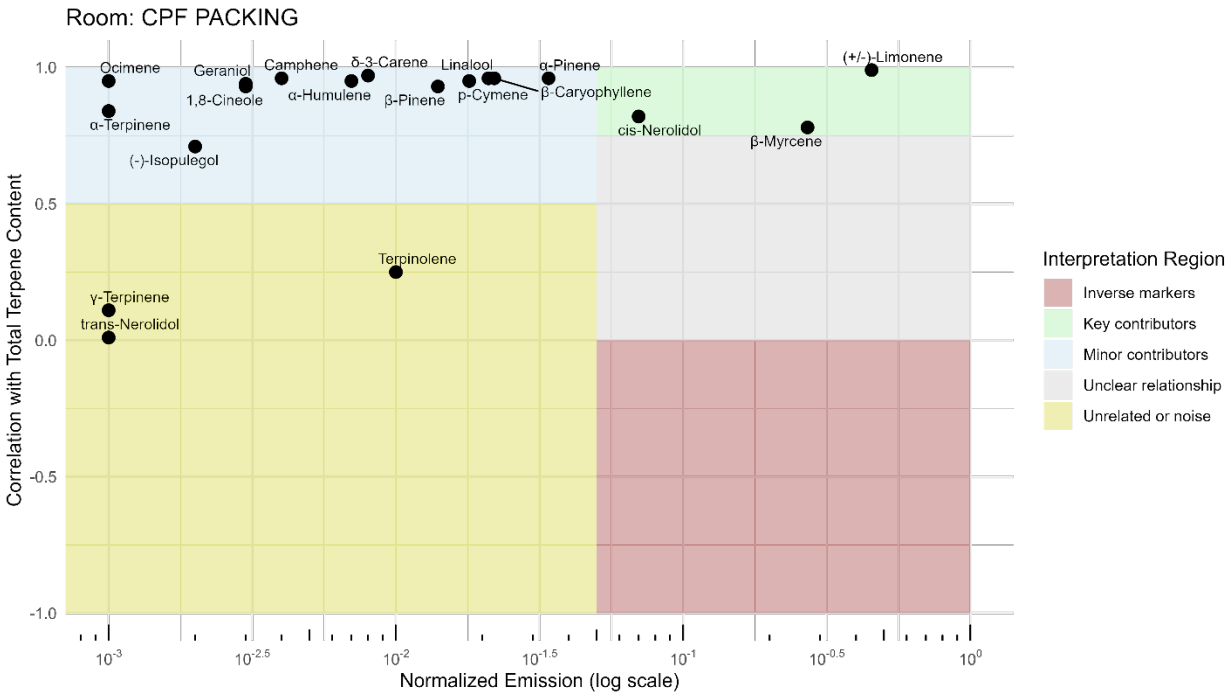


Figure S 48. Scatter plot of sampled terpenes relevance to the emissions of the CPF Packing room.

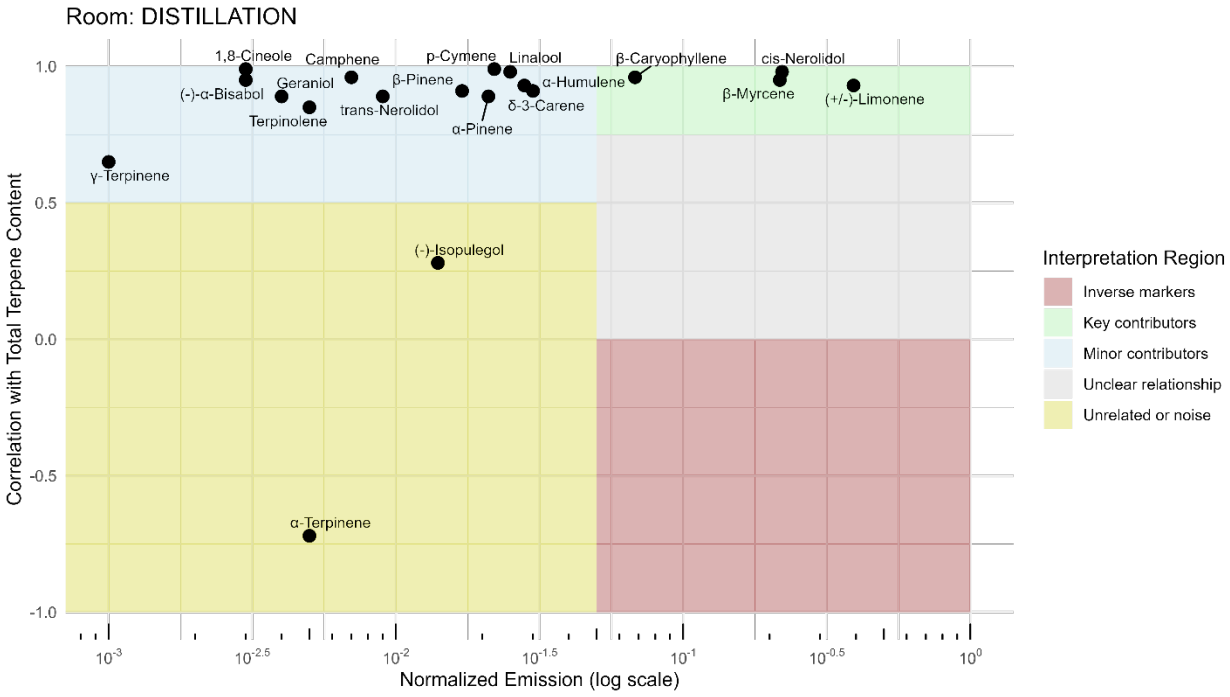


Figure S 49. Scatter plot of sampled terpenes relevance to the emissions of the Distillation room.

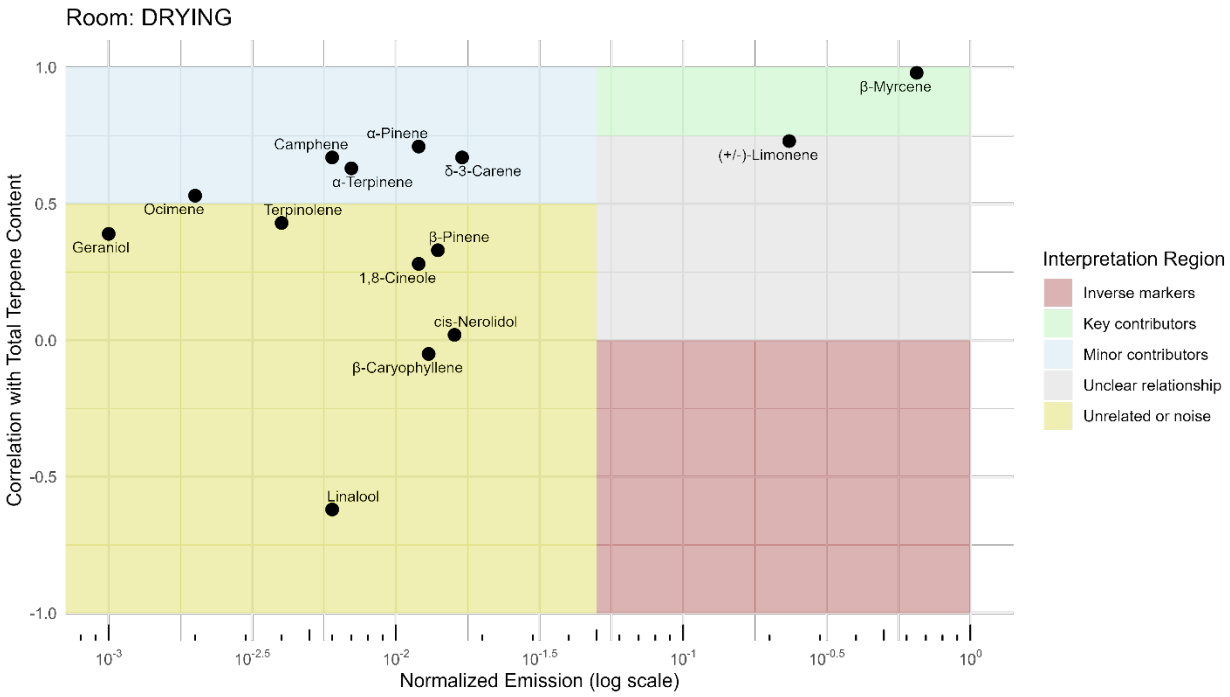


Figure S 50. Scatter plot of sampled terpenes relevance to the emissions of the Drying room.

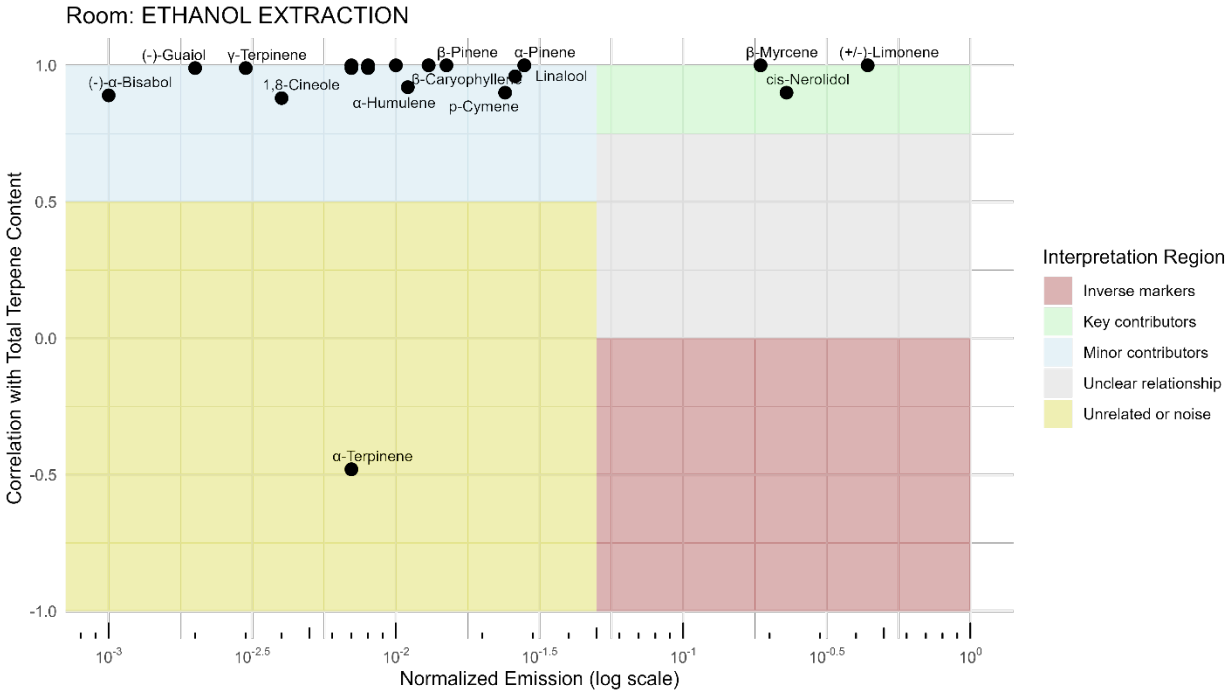


Figure S 51. Scatter plot of sampled terpenes relevance to the emissions of the Ethanol Extraction room.

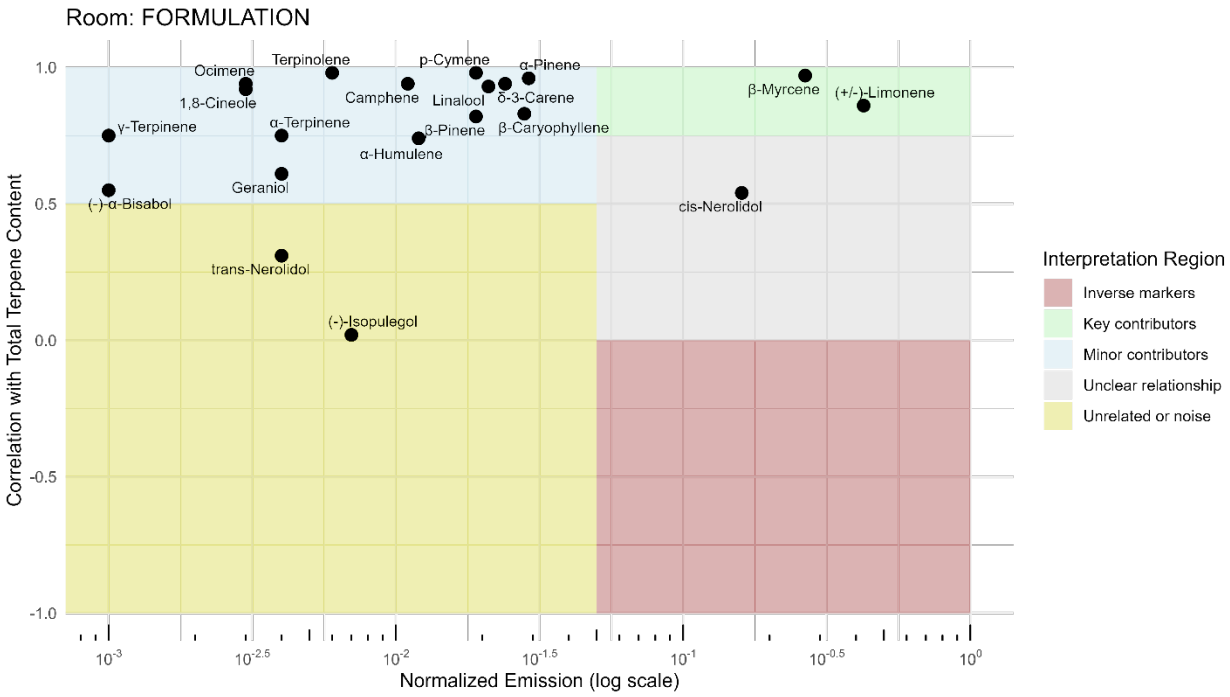


Figure S 52. Scatter plot of sampled terpenes relevance to the emissions of the Formulation room.

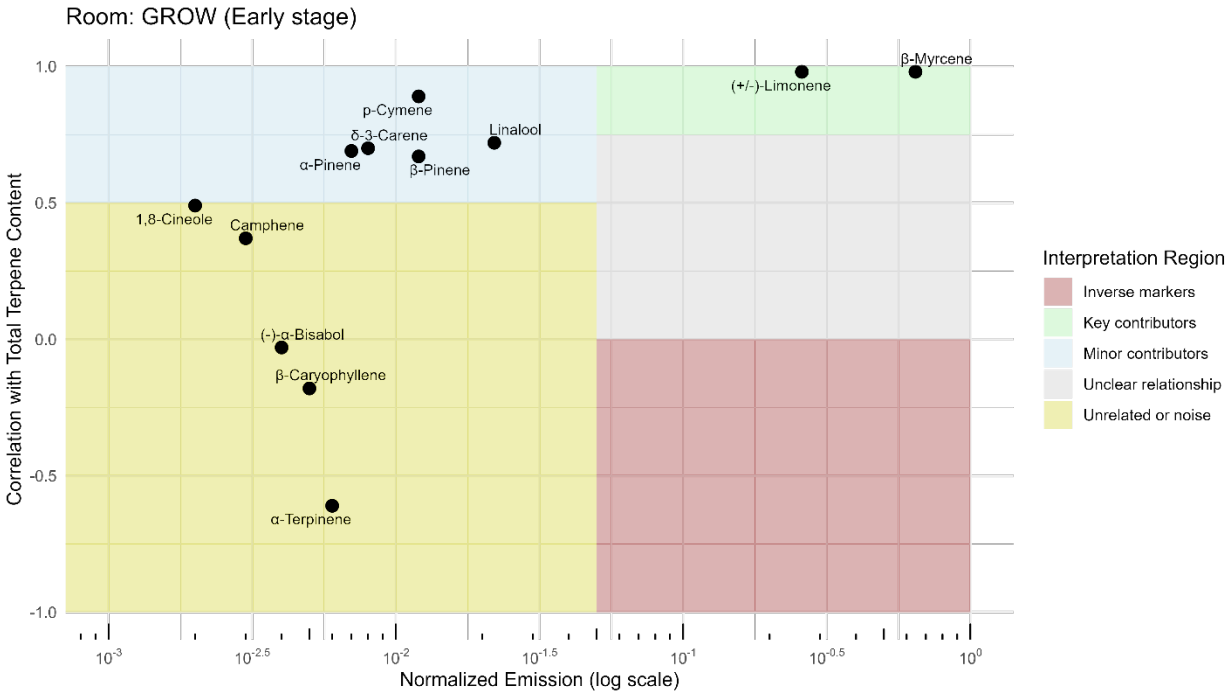


Figure S 53. Scatter plot of sampled terpenes relevance to the emissions of the early stage Grow room.

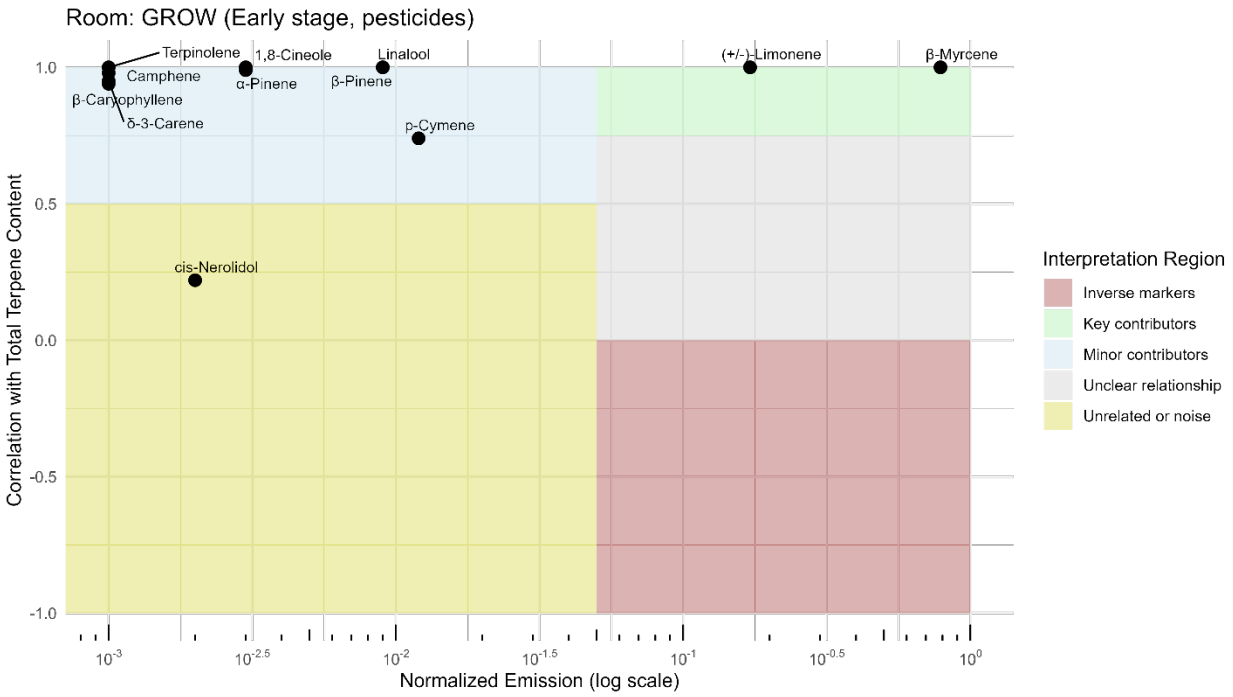


Figure S 54. Scatter plot of sampled terpenes relevance to the emissions of the early stage Grow room, with pesticides.

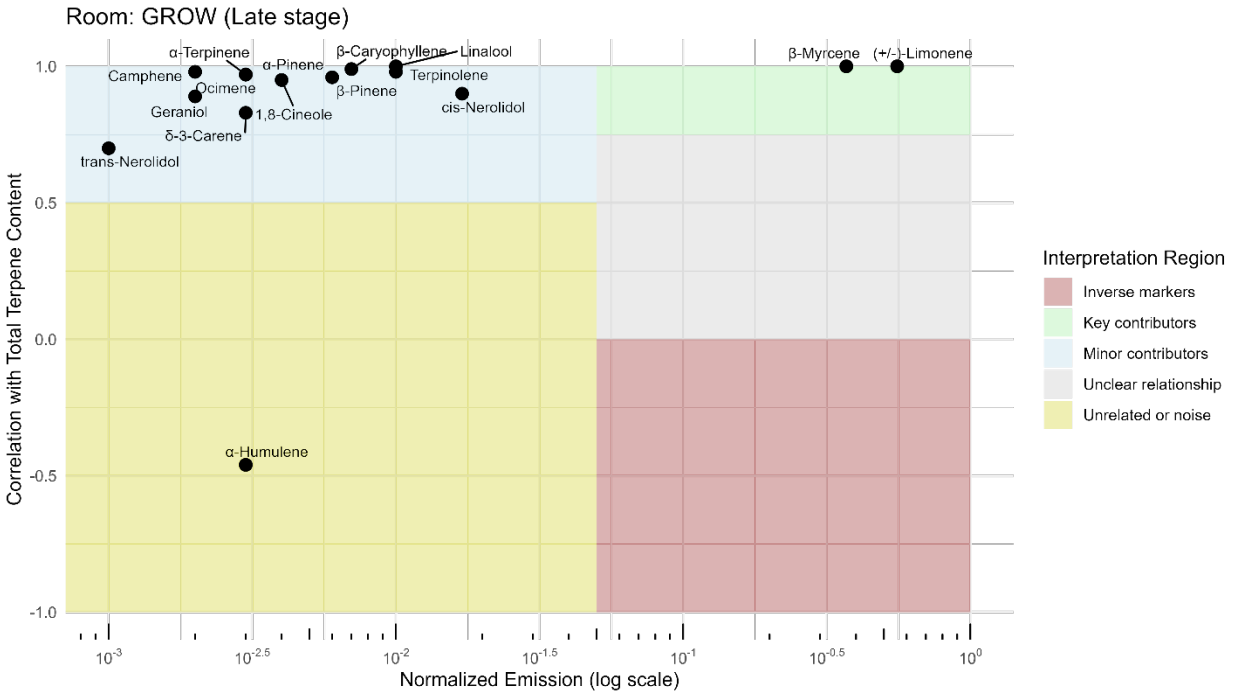


Figure S 55. Scatter plot of sampled terpenes relevance to the emissions of the late stage Grow room.

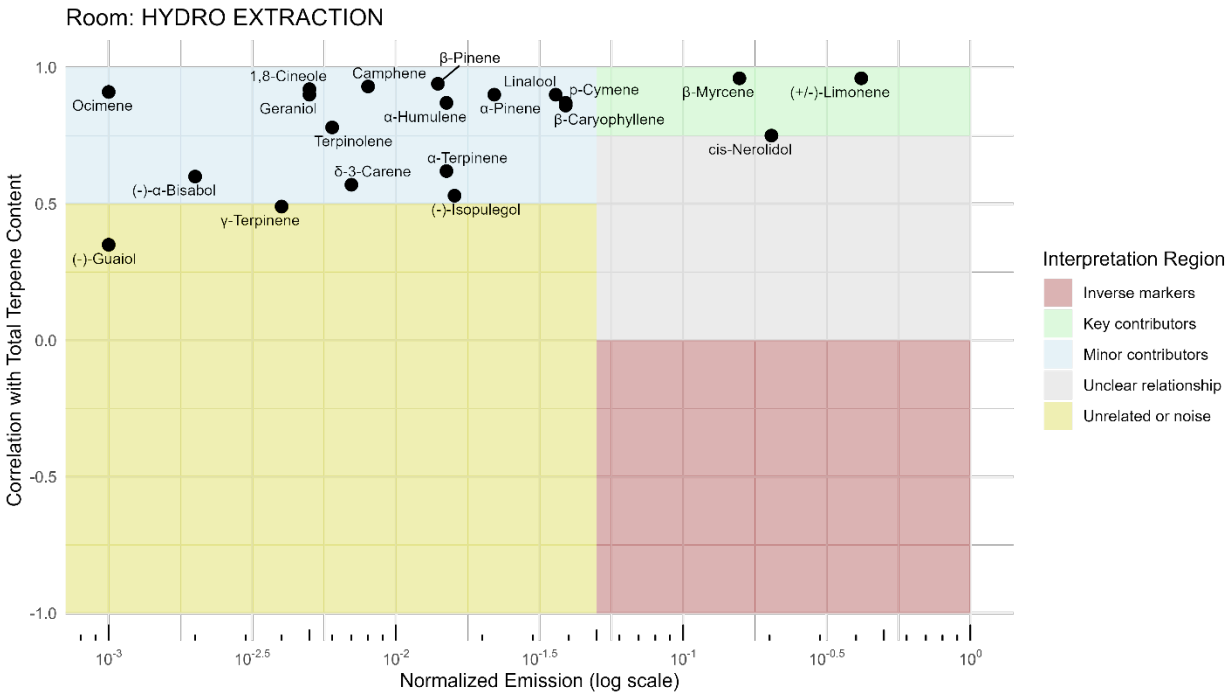


Figure S 56. Scatter plot of sampled terpenes relevance to the emissions of the Hydro Extraction room.

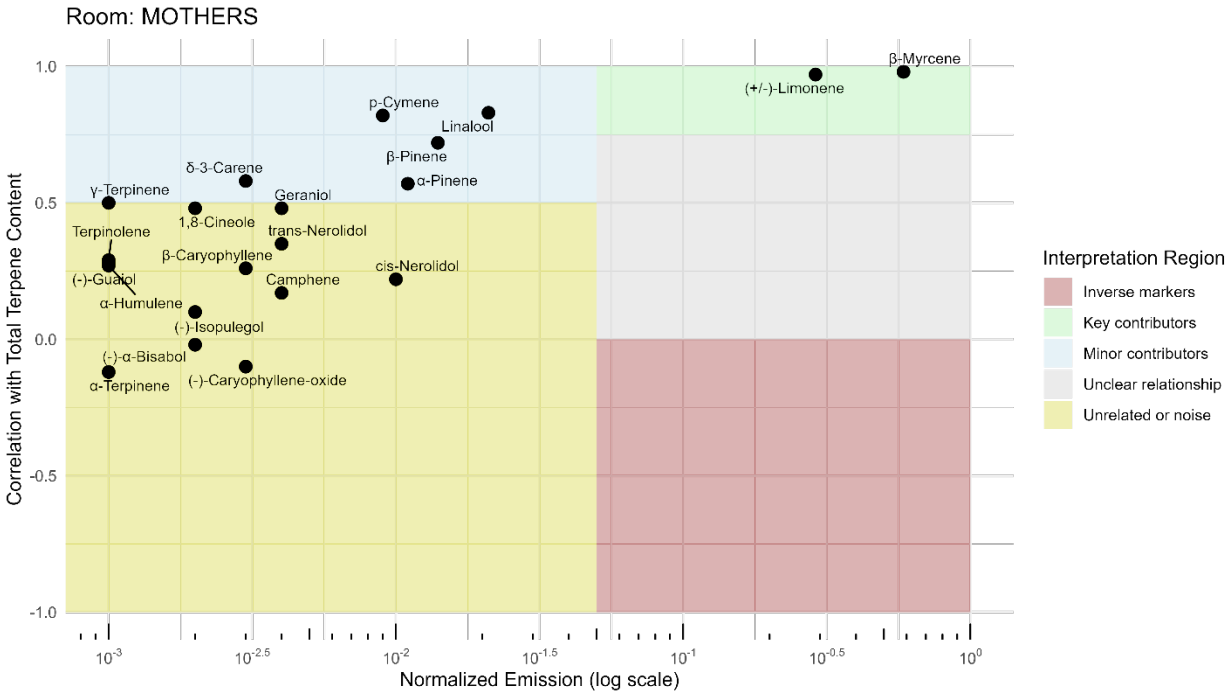


Figure S 57. Scatter plot of sampled terpenes relevance to the emissions of the Mother room.

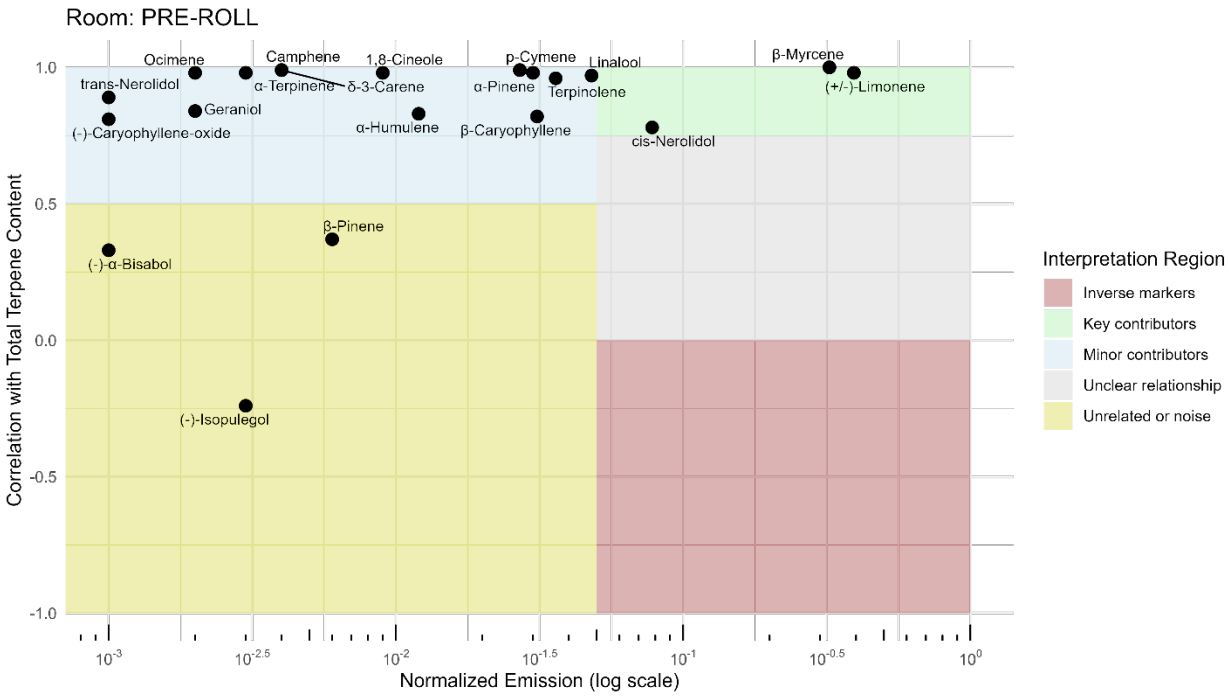


Figure S 58. Scatter plot of sampled terpenes relevance to the emissions of the Pre-roll room.

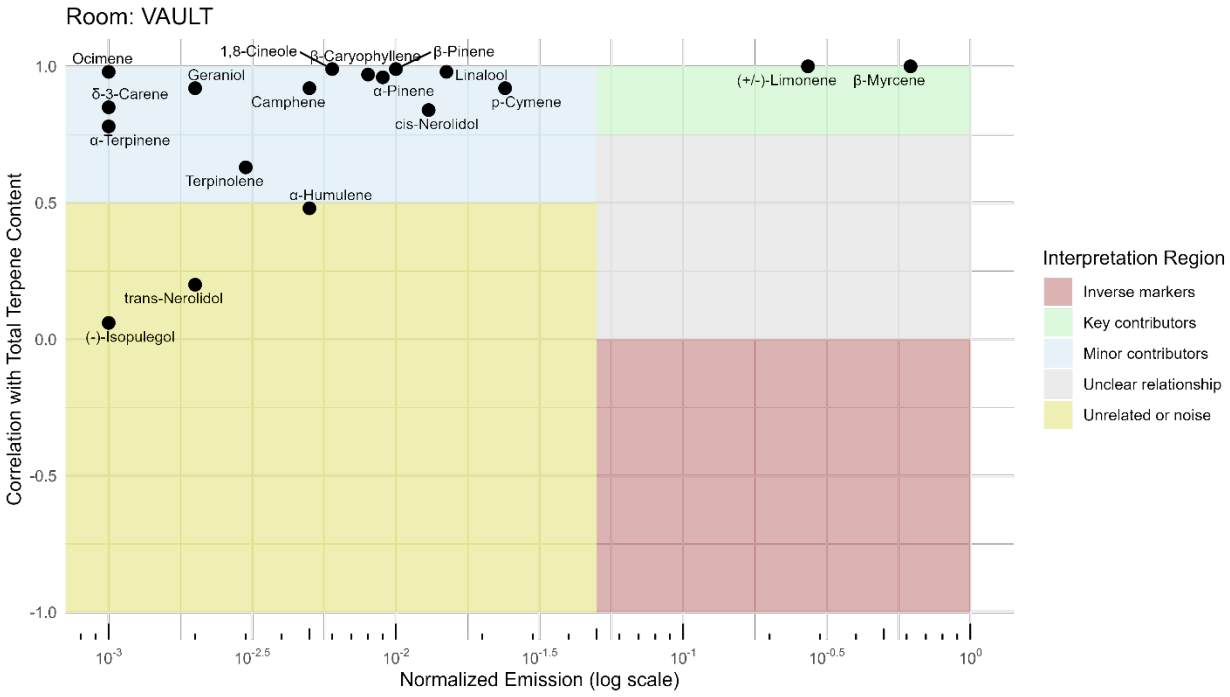


Figure S 59. Scatter plot of sampled terpenes relevance to the emissions of the Vault/Storage room.

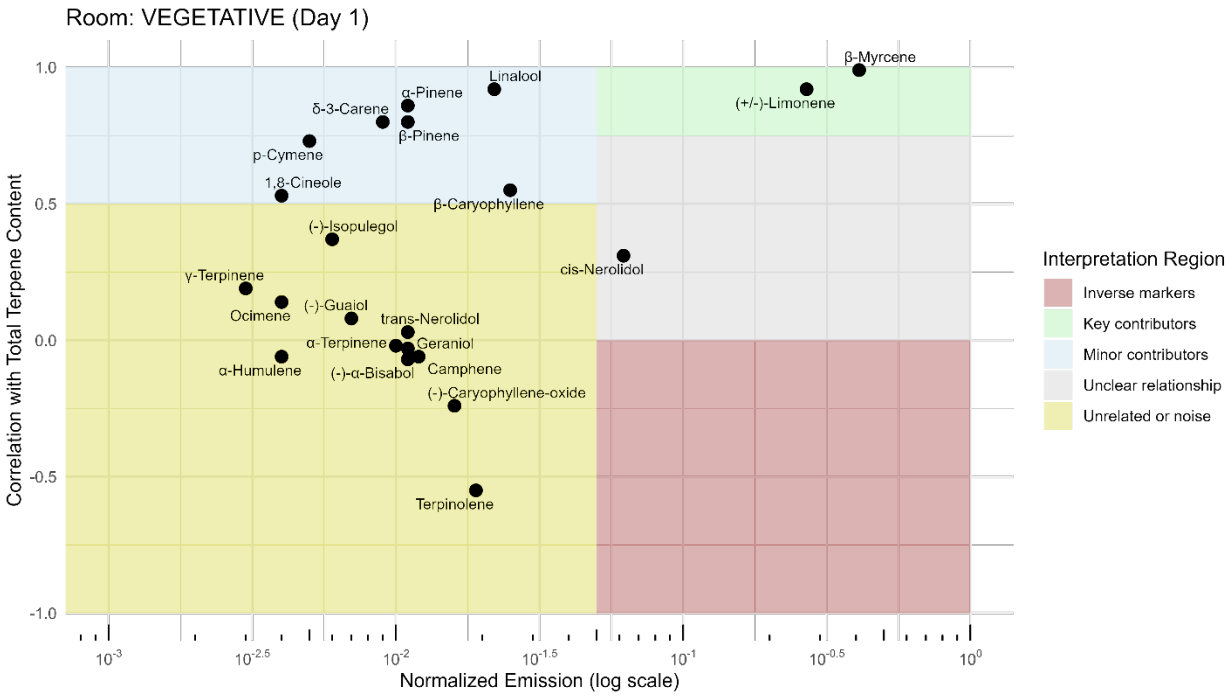


Figure S 60. Scatter plot of sampled terpenes relevance to the emissions of the Vegetative (day 1) room.

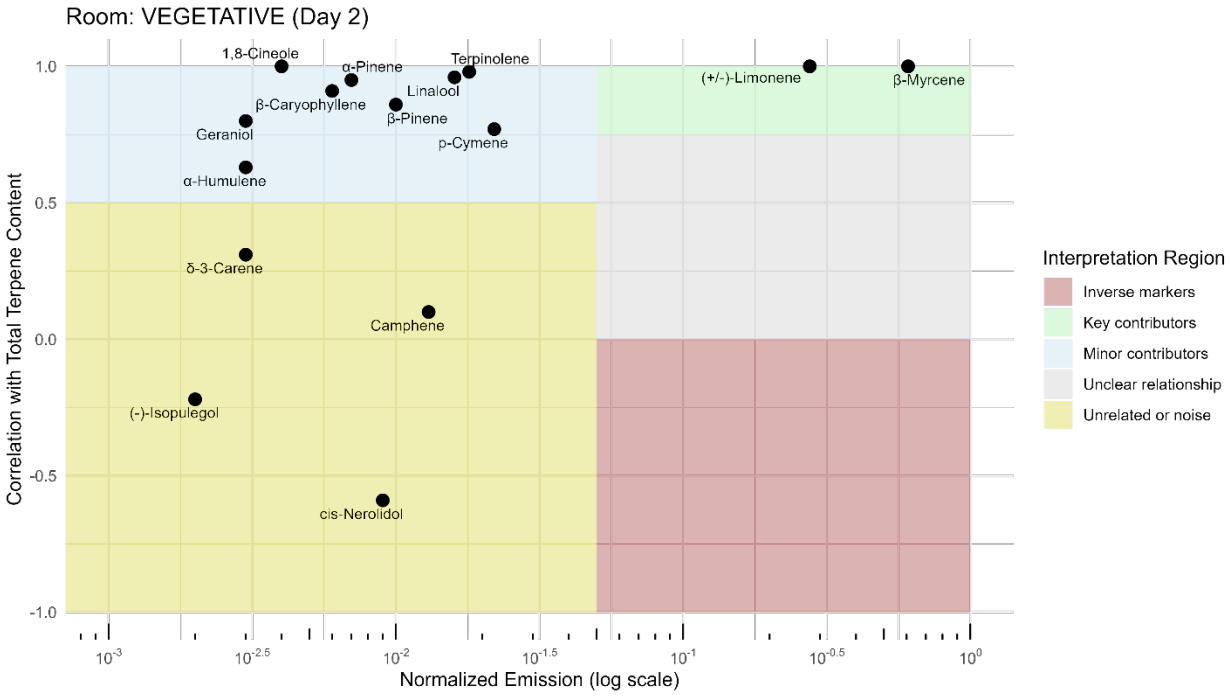


Figure S 61. Scatter plot of sampled terpenes relevance to the emissions of the Vegetative (day 2) room.

Discussion on the inversely correlated terpenes:

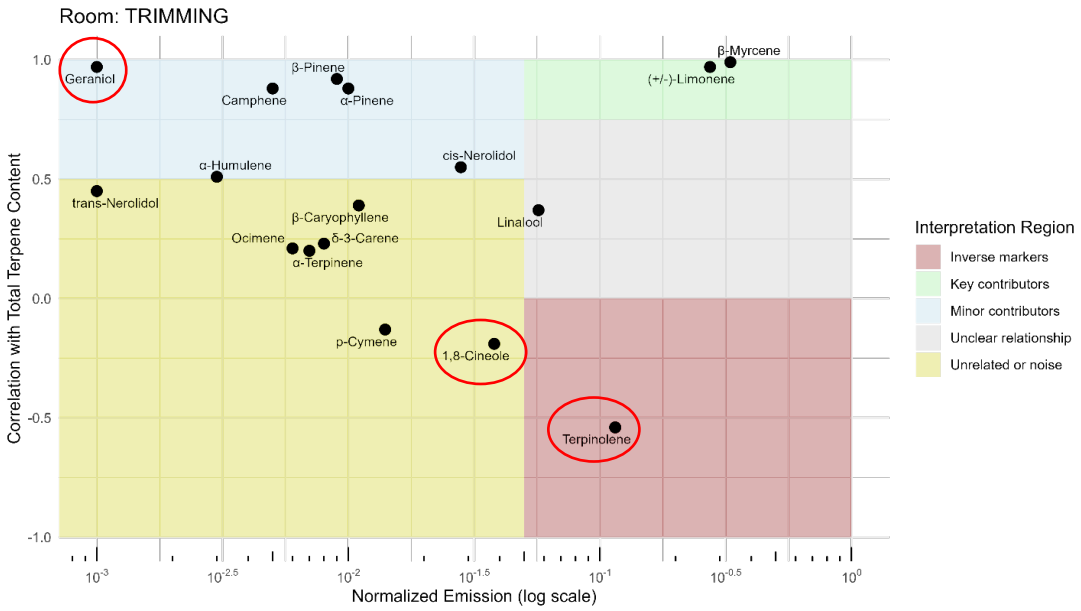


Figure S 62. Example of the new 2-D Pearson-Emission analysis. Highlighted by red circles are the three terpenes (Geraniol, 1,8-Cineole, Terpinolene) that we selected to evaluate the time series.

The 2-D Pearson-Emission analysis allows us to differentiate species that contribute more to the median emissions of a room than other terpenes but are not particularly well-correlated with total emissions.

Terpinolene in the Trimming room, for instance, falls within the “Inverse marker” category, because it contributes to ~10% of the total emissions most of the time but is not well correlated with total terpene emissions

To understand the specific cause behind the Terpinolene negative correlation, we broke down the concentration time series in Trimming into four specific parts:

A: Represents background, where the trimming room had either the door open to the corridor, or to one of the drying rooms, and no activity was being performed yet.

B: Represents a period that the room was being prepared for trimming, with cannabis buds getting moved into the room.

C: Represents the actual trimming activity. A peak in total terpene content occurs.

D: Represents after trimming. Total terpenes gradually decreased.

When plotting Terpinolene concentration time series and performing the correlation analysis for each sampling period (A to D), we get **Figure S 63** and **Table S 12.**

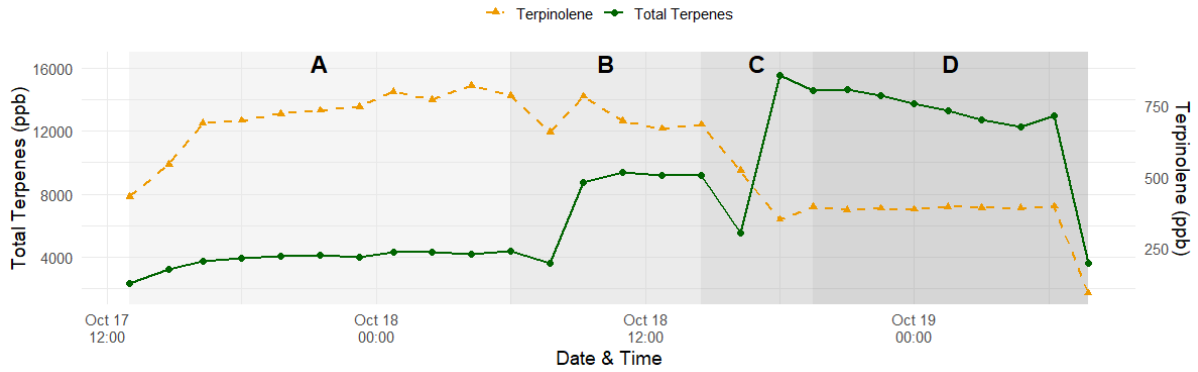


Figure S 63. Breakdown of the concentration time series of total terpenes and Terpinolene, in the Trimming room.

Table S 12. Correlation analysis (Pearson r) of specific terpenes and total terpenes in the trimming room during different periods.

Period	Terpinolene r
A	0.969
B	-0.017
C	-0.635
D	-0.376
All (A to D)	**-0.546**

Terpinolene was strongly correlated with total terpenes only prior to room preparation and trimming. Therefore, it is likely that this terpene is not associated with the trimming activity + strain processed, hence an “Inverse Marker”. In other words, and differently than other terpenes, terpinolene emissions may not be triggered by trimming.

In the case of 1,8-Cineole (Eucalyptol) vs. Geraniol, 1,8-Cineole has a correlation of -0.2, and normalized emission of 0.04 (4%). Geraniol has a correlation of 0.97, and normalized emission of 0.001 (0.1%). We can infer that the conditions leading to an increase in total emission would inevitably lead to more Geraniol being emitted, but not 1,8-Cineole, which emissions appear to be triggered by something specific.

For comparison, we plotted the Trimming room concentration time series for Geraniol and 1,8-Cineole we get:

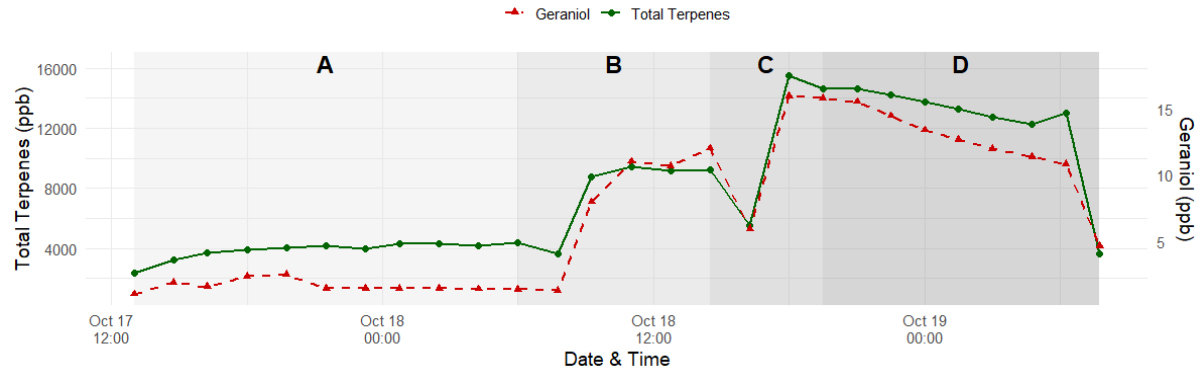


Figure S 64. Breakdown of concentration time series for total terpenes and Geraniol, in the Trimming room.

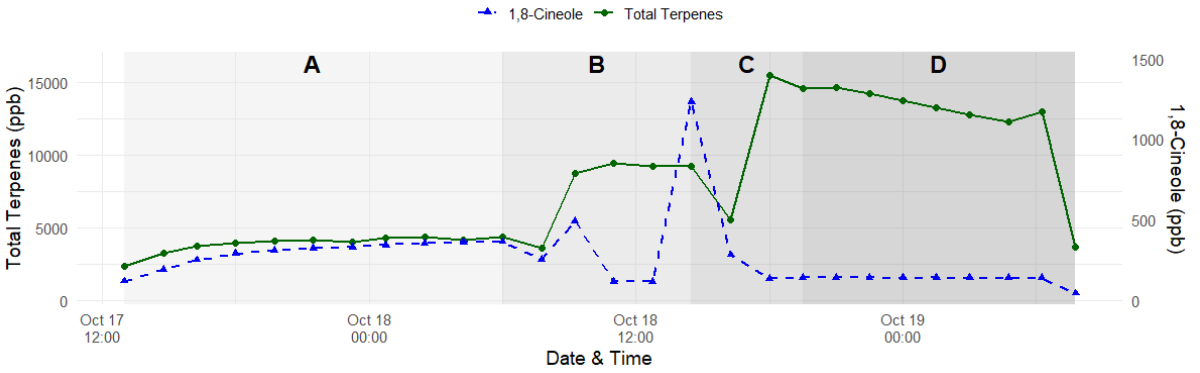


Figure S 65. Breakdown of the concentration time series of total terpenes and 1,8-Cineole (Eucalyptol), in the Trimming room.

Table S 13. Correlation analysis (r^2) of specific terpenes and total terpenes in the trimming room during different periods.

Period	Geraniol r	1,8-Cineole r
A	0.267	0.971
B	0.982	-0.272
C	0.963	-0.270
D	0.946	0.783
All (A to D)	**0.969**	**-0.204**

Because 1,8-Cineole has higher correlation before (**A**) and after trimming (**D**), but not during, it is likely that this terpene is not associated with the activity + strain processed, hence "Unrelated or noise". The time series of 1,8-Cineole indicates that a peak occurs when trimming starts (**C**) followed by a sharp decrease soon after. Thus, one hypothesis is that 1,8-Cineole is emitted in a single burst when trimming. Once the activity ceased (**D**), correlation improves. During room preparation (**B**), the hypothesis is that other terpenes (e.g., Geraniol) are being released from the stress of moving the plant from the drying room to the trimming room, but not 1,8-Cineole.

Geraniol, on another hand, was strongly correlated during room preparation (**B**), trimming (**C**), and after (**D**) but not before (**A**). Thus, it is likely that this terpene is associated with the trimming activity + strain processed, hence “Minor contributor”.

S2.4 The contribution of each term in the mass-balance equation

$$F_{out} = ER + F_{in} - R - L \qquad (Eq.10)$$

Table S 14. Details of the mass-balance analysis ("Total, kg/h" means Total BVOC in kilograms per hour).

	Average of ER (Total, kg/h)	Average of R (Total, kg/h)	Average of R_{OH} (Total, kg/h)	Average of R_{O3} (Total, kg/h)	Average of F-in (Total, kg/h)	Average of F-out (Total, kg/h)	Average of L (Total, kg/h)
Cultivation	**1.01 x 10^{-1}**	**1.15 x 10^{-2}**	**1.02 x 10^{-2}**	**1.29 x 10^{-3}**	**5.70 x 10^{-14}**	**8.91 x 10^{-2}**	**1.11 x 10^{-8}**
Packing	2.39 x 10^{-2}	1.79 x 10^{-3}	1.42 x 10^{-3}	3.69 x 10^{-4}	4.03 x 10^{-14}	2.21 x 10^{-2}	2.68 x 10^{-9}
Drying	1.45 x 10^{-1}	9.19 x 10^{-3}	7.59 x 10^{-3}	1.60 x 10^{-3}	4.02 x 10^{-14}	1.36 x 10^{-1}	1.60 x 10^{-8}
Drying Baseline	7.28 x 10^{-3}	1.04 x 10^{-3}	3.03 x 10^{-4}	7.38 x 10^{-4}	4.02 x 10^{-14}	6.24 x 10^{-3}	6.83 x 10^{-10}
Grow (Early)	3.59 x 10^{-3}	5.69 x 10^{-5}	1.77 x 10^{-5}	3.92 x 10^{-5}	8.05 x 10^{-14}	3.54 x 10^{-3}	3.22 x 10^{-10}
Grow (Early, Pesticides)	2.16 x 10^{-2}	3.26 x 10^{-3}	3.12 x 10^{-3}	1.42 x 10^{-4}	8.05 x 10^{-14}	1.84 x 10^{-2}	1.99 x 10^{-9}
Grow (Mature)	8.56 x 10^{-2}	1.13 x 10^{-2}	1.02 x 10^{-2}	1.11 x 10^{-3}	4.03 x 10^{-14}	7.43 x 10^{-2}	1.11 x 10^{-8}
Mother	1.32 x 10^{-2}	4.69 x 10^{-4}	2.98 x 10^{-4}	1.70 x 10^{-4}	1.01 x 10^{-13}	1.27 x 10^{-2}	1.24 x 10^{-9}
Trimming	3.09 x 10^{-1}	4.58 x 10^{-2}	4.15 x 10^{-2}	4.25 x 10^{-3}	4.02 x 10^{-14}	2.63 x 10^{-1}	3.35 x 10^{-8}
Vault	1.16 x 10^{-1}	1.57 x 10^{-2}	1.45 x 10^{-2}	1.26 x 10^{-3}	4.03 x 10^{-14}	1.00 x 10^{-1}	1.31 x 10^{-8}
Vegetative (Day 1)	4.94 x 10^{-3}	2.75 x 10^{-4}	1.22 x 10^{-4}	1.54 x 10^{-4}	1.00 x 10^{-13}	4.66 x 10^{-3}	4.43 x 10^{-10}
Vegetative (Day 2)	7.39 x 10^{-3}	4.70 x 10^{-4}	3.92 x 10^{-4}	7.87 x 10^{-5}	1.00 x 10^{-13}	6.92 x 10^{-3}	7.05 x 10^{-10}
Processing	**9.03 x 10^{-3}**	**2.72 x 10^{-3}**	**2.13 x 10^{-3}**	**5.89 x 10^{-4}**	**4.40 x 10^{-15}**	**6.31 x 10^{-3}**	**1.65 x 10^{-9}**
Packing Area	3.01 x 10^{-2}	7.60 x 10^{-3}	5.90 x 10^{-3}	1.70 x 10^{-3}	1.02 x 10^{-14}	2.25 x 10^{-2}	5.23 x 10^{-9}
Distillation	3.89 x 10^{-3}	8.46 x 10^{-4}	4.91 x 10^{-4}	3.55 x 10^{-4}	2.94 x 10^{-15}	3.04 x 10^{-3}	3.96 x 10^{-10}
Ethanol E x traction	3.46 x 10^{-3}	3.26 x 10^{-3}	3.04 x 10^{-3}	2.11 x 10^{-4}	7.81 x 10^{-16}	2.01 x 10^{-4}	6.62 x 10^{-10}
Formulation	1.05 x 10^{-3}	4.94 x 10^{-4}	3.54 x 10^{-4}	1.40 x 10^{-4}	5.49 x 10^{-16}	5.58 x 10^{-4}	5.43 x 10^{-10}
Hydro E x traction	8.68 x 10^{-3}	2.21 x 10^{-3}	1.48 x 10^{-3}	7.25 x 10^{-4}	1.19 x 10^{-14}	6.47 x 10^{-3}	7.54 x 10^{-10}
Pre-Roll Room	1.22 x 10^{-2}	3.76 x 10^{-3}	3.09 x 10^{-3}	6.70 x 10^{-4}	1.65 x 10^{-15}	8.45 x 10^{-3}	3.10 x 10^{-9}

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