Outdoor-In: Improving the Health of Campus Staff using Potted Plants

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Executive Summary:

Office Spaces, specifically in Western Washington University's staff offices, are becoming an increasing concern when it comes to air quality, and the effects it will have on their full-time inhabitants. Poor circulation and buildup of CO2 emitted by computers are noted to have negative effects on office air-quality and the inhabitants in the offices. Poor air quality can have diminishing effects on human health, including loss in productivity, focus and overall comfort in the space. Psychological well-being associated with workspaces can also affect staff members' work as a direct link to the workplace environment. Indoor plants are a part of the solution to mitigate these unhealthy impacts

The Fall 2018 Group; *Going Green: "Improving Health and Wellbeing Within Western's Workplaces Through Indoor Plants"* by Mitchell Hiers and Isaac Calvo, under the sponsorship of Dr. Nick Stanger, also participated in this pilot project research for WWU. They surveyed campus staff on having indoor plants in offices. Results from a survey concluded that 45% of staff members interviewed are unsatisfied with their building's ventilation systems, and 80% strongly agree that they would like to see more plants in Arntzen.

The previous group's research showed interest, and a reason to continue into Spring, 2019. Where final data collection would occur, and eventually be used for the Sustainability, Equity and Justice Fund (SEJF) application.

The final objectives of this Outdoor-In project are to complete a long-term care plan for installed plants, as well as obtain decided plant species and their supplies (Spider Plant, Bamboo Palm, and Snake Plant) with the projected budget approved in the grant, details are in the following Budget section of this report. To do this, the project team will measure CO2 levels in various offices around campus. Using these recordings, our team will write a grant in the hopes of funding the placement of indoor plants in offices around campus, so that they can help regulate CO2 levels and promote a productive work environment. In addition to securing a grant, writing a long-term plan for each specific species option that the offices can use, is to help ensure the longevity of the plants.

Objectives and obstacles this project address include:

- Frequent staff turnover (students, part-time and full-time staff)
- Facilities to be assigned to provide supplies/materials for long-term plant maintenance
- Long-term care instructions for participating locations
- Plant species that meet safety standards and minimum maintenance

Concluding this project, specific plant species and their characteristics should be identified and designated to offices with complementary environments. The importance of the why is also key

here, prioritizing education and spreading awareness about the importance of office air quality issues would help continue and propagate the project's initiatives beyond its original scope of a selected amount of offices. The team, or stakeholder Campbell will provide offices with informative posters on how to take care of the implemented plants (see appendix). Campus Facilities or the Office of Sustainability will potentially be responsible for follow-ups on plant conditions, supplies, or replacements when services are needed.

Overall, a clear instructed plan to address the project's objectives and a selection of specific locations of offices would also have been more beneficial to the data collection period, instead of using arbitrary offices who volunteered to allow data collection. Selecting locations with poor environments with the need for air quality improvements, would have been more beneficial toward measuring the success and importance of this project for Western's campus staff. The project group has narrowed down the location scope by prioritizing the College Hall (small office) location. This location contains the majority of signs and variables of a high CO2 environment. On top of the noted environment, the actual monitor readings were also reaching concerning levels (see table 1, figure 1).

Having a baseline office space, containing a specific number of plants to compare CO2 levels to, would've been more effective. Knowing a specific number of plants needed to make any significant impact on CO2 level reduction, would be useful when developing the project's budget, for example. Informing campus staff to gain awareness about the health benefits of indoor plants, gives staff the opportunity to voluntarily bring and care for their own plants as well. If they are not getting them provided to their location, this could deem beneficial to more than the original targeted office's air quality and their inhabitants. It is available to them by choice, which can also be a cost-effective method for the campus in future grants that may be needed in the future for this project's continuation.

Materials, quantities, and suppliers of plant species have been budgeted according to local Bellingham vendors seasonal price variations. Using local suppliers not only helps contribute to the local economy, but also reduces the risk of additional CO2 emissions entering our atmosphere from chain stores importing plants via shipping from tropical regions.

Funding has been granted from the SEJF. Students who participated in this research, and are present the following quarter, Fall 2019, will be responsible for the project's next phase. The next phase will require the project's students and staff to physically plan, install, and work with either campus facilities or the Office of Sustainability to distribute supplies and provide long-term care instructions (see appendix) for the staff taking in plants to refer to. The plant care instructions will ensure the likelihood of care to be properly executed in order to achieve effective results on CO2 levels. There will also be scheduled follow-ups on CO2 levels in the spaces now holding plants after a certain period of time since installation. There are more details

regarding the project's schedule in a following timeline table under the Monitoring and Evaluation Section below. The table breaks down the project's plan after funding has been approved beginning with this spring 2019, through the Fall of 2019.

Introduction:

The project began with the goal of finding an accessible and achievable solution to provide healthy environments in offices at Western Washington University; specifically, for the welfare of the full-time employed. Full-time employees spend the majority of their day in office environments. Staff should have adequate air quality so they can be comfortable and productive. Indoor plants are an accessible and attractive way the university can protect their faculties' health, this project's implementation should be highly endorsed. As previously stated, plants reduce CO2 levels and helps to maintain productivity, focus, and an aesthetically pleasing workspace. This would greatly increase the quality of work produced within the university, positively contributing to the overall function and reputation of Western Washington University. "Outdoor - In" is a very feasible opportunity for Western Washington University's Campus.

The main goal at this stage in the project, is to identify ideal offices on Western's campus for implementation of potted plants. Once offices have been identified, the following plants will be used in offices:

- Snake plant
- Spider plant
- Bamboo palm

These plants were chosen for their durable and flexible characteristics. These species are known for their air cleaning capabilities and minimal care requirements. In addition to the implementation of plants, a long-term care plan will be provided to each office. This will ensure the long-term survival of the plants; detailing the desired conditions, as well as how often watering or other maintenance should occur (see appendix).

Background research has been provided by: *Going Green: "Improving Health and Wellbeing Within Western's Workplaces Through Indoor Plants". Going Green* is a group of students participating in Campus Sustainability Planning Studio (CSPS) during fall, 2018. Members include, Mitchell Hiers and Isaac Calvo, under the sponsorship of Dr. Nick Stanger. This group developed a report around the health benefits of keeping plants in office spaces. The data and ideas they produced were used in the SEJF grant application process.

Methodology:

The process for data collection and organization required measuring CO2 levels in each participating office. These offices include:

- Environmental Studies department (Arntzen Hall) 217
- English Department (Humanities Building) 329/327
- Web Tech (Old Main) 360
- Web Tech (Old Main) 365
- Foundations Office (Old Main) 586
- Woodring Dean's Office (Miller Hall) 250
- College Hall (small office)
- College Hall (Large office)

The measurements were made using a CO2 monitor, which were checked out through the WWU Energy tool lending library. The measurements were taken in parts per million (ppm). The monitor is set in an office, away from any drafty windows or air vents, only in areas of low circulation. One minute was allowed for calibration, after which, the first measurement was taken. Data was collected in increments of 15 minutes, for a total of 45 minutes for each test. Each office was tested a total of three times, never having two tests in a single day.

In addition, date and time was noted when data was collected for each test. The office environment such as lighting, number of rooms and other significant space layouts were recorded in notes after each test. Verbally surveying office occupants was used to gauge interest in the project, as well as asking if the office's wanted or were willing to have plants.

The methods used during the project were dictated by the project's stakeholder/sponsor, Turner Campbell. Turner is the Sustainability Action Fund Project Coordinator at the Office of Sustainability. The methods provide data, which Turner used in the SEJF small-grant application, to secure money to implement the project.

Results:

To find a baseline of healthy CO2 levels, the team referred to Kane International to refer how healthy the levels were in tested offices (see table 1). Kane International is an equipment manufacturer that makes CO2 monitoring devices, meaning they can be considered a reputable source. According to Kane International, the baseline for normal outdoor circulated air ranges from 250 ppm to 350 ppm. Acceptable CO2 levels in indoor spaces range from 350-1000 ppm. Levels above 1000 ppm were considered poor, resulting in signs of drowsiness, focus, productivity, and increased heart rate when exposure lasted 8 or more hours. As CO2 concentrations continue to rise, so do the health risks.

Table 1: CO2 concentrations with their corresponding impacts on human health provided by Kane International Ltd.

CO2 Level	**Effects**
250-350ppm	Normal background concentration in outdoor ambient air
350-1,000ppm	Concentrations typical of occupied indoor spaces with good air exchange
1,000-2,000ppm	Complaints of drowsiness and poor air.
2,000-5,000 ppm	Headaches, sleepiness and stagnant, stale, stuffy air. Poor concentration, loss of attention, increased heart rate and slight nausea may also be present.
5,000	Workplace exposure limit (as 8-hour TWA) in most jurisdictions.
>40,000 ppm	Exposure may lead to serious oxygen deprivation resulting in permanent brain damage, coma, even death.

Our results (see table 2, and figure 1) in all locations except for College Hall (small office) were considered acceptable CO2 levels. The College Hall locations contain the least amount of air flow due to lack of windows and have a high concentration of computers in the spaces; which are high CO2 emitters. When examining results, rooms that have the most stable CO2 levels usually have potted plants in the office in the first place (see table 1 notes). Because of this, offices that receive plants should likely be those that do not have plants in the first place.

Table 2: A table illustrating the CO2 tests conducted in the offices of interest.

Campus Office Locations	Data Collection Round 1/Date & Time	Data Collection Round 2/Date & Time	Data Collection Round 3/Date & Time	Number of Rooms/ Other Notes
Environmental Studies Department	4/19/19 2:00 -2:45 pm 648, 567, 555 ppm	4/22/19 10:38 - 11:23 am 548, 738, 629 ppm	4/24/19 10:59 - 1:44 pm 571, 585, 598 ppm	-3 rooms,1 main room / 2 on side -Decent natural light, windows on back wall
Web Tech Old Main 360	4/19/19 8:40 - 9:25 am 658, 663, 684 ppm	4/23/19 11:30-12:15 pm 747, 757, 733 ppm	4/24/19 11 -11:45 am 681, 696, 697 ppm	-1 room cubicles in rest of space -Bright / moderate light; two potted plants in space: Christmas Cactus/African violet
Web Tech Old Main 365	4/19/19 9:30 - 10:15 am 606, 610, 609 ppm	4/23/19 12:20 - 1:05 pm 606, 623, 617 ppm	4/24/19 11:50 - 12:20 pm 660, 632, 623 ppm	-1 room cubicles in rest of space -low light / moderate light
Foundation Office	4/19/19 1:15 - 2:00 pm 660, 632, 623 ppm	4/23/19 1:15 - 2:00 pm 611, 624, 619 ppm	4/24/19 12:30 - 1:15 pm 633, 649, 621 ppm	-Open space of cubicles -Dark front of room, bright at back. Several indoor plants in space
College Hall Small Offices	4/25/19 2:46-3:31 pm 2380, 2640, 2732, 3039 ppm	4/25/19 1:14-1:59 pm 979, 738, 618 717 ppm	5/2/19 2:04-2:39 pm 2015, 1934 2093, 1471 ppm	-1 room -Window/door open day of lower levels
College Hall Large Office	5/13/19 12:00 - 12:45 pm 671, 693, 662, 684 ppm	5/15/19 3:15 - 4:00 pm 769, 608, 638, 618 ppm	5/16/19 1:30 - 2:15 pm 787, 678. 755, 793 ppm	4 cubicles, multiple desks (all had computers), one double-wide door in the front, 6 windows that open on the left side of the office.
Woodring Dean's Office	4/23/19 3:30 - 4:15 pm 651, 648, 658 ppm	4/24/19 10:30 - 11:15 am 719, 742, 732 ppm	4/29/19 10:30 - 11:15 am 751, 741, 728 ppm	-14 rooms attached to main office, 10/14 have windows -NE wall shaded by arboretum, faculty mentioned they have trouble keeping plants alive due to low light

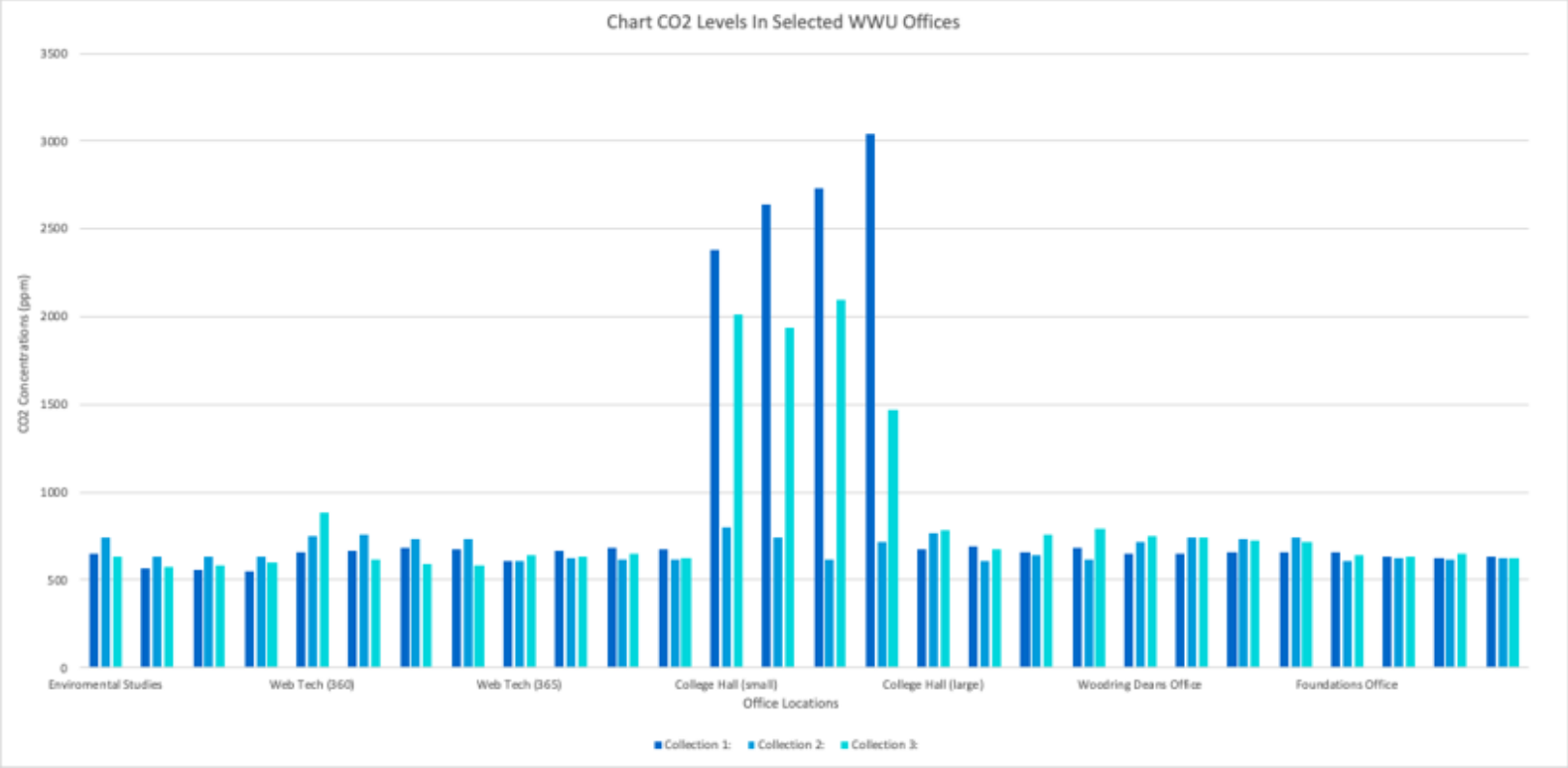

Figure 1: A graph comparing CO2 levels across the selected offices of interest. College Hall (small offices) center of graph, had the highest concentrations.

Recommendations:

Recommendations discovered through concluding the project include:

- More contact with faculty and staff in offices that would receive plants
    - Assist in plant placement process
    - Help decide who will take care of the plants
    - Explain the risks of CO2 buildup, and benefits of potted plants
- Previous research should be conducted before selecting test locations
- Consider time of day that tests were taken
    - Might cause fluctuations in CO2 levels depending on the time of day
- Offices that receive plants should be considered on several physical attributes
    - Windows
    - Doors
    - Number of computes
    - Number of people working in the office
    - Campus location

Monitoring and Evaluation:

The group maintained consistent contact with Turner Campbell, sending a weekly update of progress every Thursday, as well as any questions or concerns. Dates and deadlines for the spring 2019 group project tasks was provided in a weekly timeline listed below (see Table 3):

- Weeks 1 - 4: Survey CO2 levels in office locations on campus using a CO2 monitor, concentrations detected to be noted every 15 minutes; total 45 minutes.
- Weeks 4 - 7: Begin to write SEJF grant
- Weeks 7-10: Write the long-term plan for plant care.

Table 3: Project timeline including objective goals from start to finish.

Action	Purpose	Initiation	Completion
Survey Offices for their preferred plant	To ensure that plants have the highest potential for success by allowing faculty and staff to make decisions based on their available resources	Sept. 26 2019	Oct. 4 2019
Order Plants	-	Oct. 7	Oct. 11
Contact offices with responsibilities / handler's agreement	To establish an understanding of the responsibilities of receiving a plant, and communicate vital information about the project	Sept. 26	Oct. 4
Survey Quality of life in College Hall offices	To create baseline data which will be compared against results later in the year as a metric for the project's success.	Oct. 7	Oct. 11
Pot Plants: phase 1	Placing plants in permanent pots helps people to establish a more personal connection with their plant, while contributing to the overall health of the plant	upon arrival of plants	Oct. 15
Distribute plant materials: phase 1	By bringing the plants to them, we are making sure there are as few requirements as possible for the offices. We want this project to be an incentive, not a responsibility.	Oct. 15	Oct. 15
Pot Plants: phase 2	-		Oct 16
Distribute plant materials: phase 2	-		Oct 16
Pot Plants: phase 3	-		Oct 17
Distribute plant materials: phase 3	-		Oct 17
Monitor CO2 levels	By comparing this data to the initial survey, we can establish	April 6	April 20

	the success of the plants in improving the air quality of these offices.		
Follow-up survey on quality of life and survival of plants in offices	This data will be compared against the baseline data to determine the effectiveness of plants in improving mental health of WWU employees, and the effectiveness of employees in maintaining their plant's health	April 6	April 10

Budget:

The project includes an itemized budget (see Table 4), as a requirement for the Sustainability, Equity and Justice grant. The budget includes items such as the plants, soil, and other required equipment. The budget was completed by Turner Campbell for the SEJF grant. Student teams are not involved in the costs of the project but assisted in determining the cost of plants. Additionally, students identified possible locations to purchase the plants, seeking a local, sustainable company. This was not always possible, due to the native areas in which specific plants are grown. However, seeking out local suppliers will not only contribute to Bellingham's local economy, but also help avoid using chain stores that emit additional CO2 into the atmosphere when shipping plants from tropical regions. Equipment needed for installations such as Wheelbarrows and potting tools, will be provided by Western's Outback Farm.

Table 4: The submitted budget from the SEJF Grant application.

Item	**Vendor**	**Cost per Item**	**Quantity**	**Cost**
Spider Plant *	Baby Greens	$22.99	~0-52	$1,195.48
Bamboo Palm *	Local Vendor TBD (Home Depot for price estimate)	(41.19*1.25 to account for price mark-down)= $51.49	~0-6	$308.93
Snake Plant *	The Garden Spot	$16.99	~0-52	$883.48
Replacement Spider plant	Local Vendor TBD (Home Depot for price estimate)	$22.99	52 max (highly unlikely) 25 max (expected)	$1,195.48 $574.75
Small pots (10" diameter) and drainage dish	Local Vendor TBD (Home Depot for price estimate)	$14.55/10 for pots, $3.48/saucer	= number of snake + spider plant, max 52	$937.56 max
Large pots (16" diameter) and drainage dish	Local Vendor TBD (Home Depot for price estimate)	$20/pot, $4/saucer	No more than 6	$144
Drainage rocks - coarse and porous	Local Vendor TBD (Home Depot for price estimate)	$5.97/.8 cubic feet	⅕ the volume of pots Small pots: 4.06 cubic feet	Small pots: $24.3 Large pots: $7.76 Replacement: $25.3 Total Min: $24.3

			Large pots: 1.3 cubic feet Replacement plants: 4.06 cubic feet Total min: 4.06 Total max: 8.7	Total Max: $51.94
Soil (ft^3) - basic potting soil w/ high organic concentration and well-draining.	Local Vendor TBD (Home Depot for price estimate)	$9.97/32 qt.	⅘ volume of pots Small pots: 16.24 cubic feet Large pots: 5.2 cubic feet Replacement plants: 16.24 cubic feet Total min: 16.24 Total max: 34.8	Small pots max: $151.39 Large pots max: $48.48 Replacement: $151.39 Total Min: $151.39 Total Max: $324.43
Organic All-Purpose Plant Food Fertilizer with Biozome, OMRI Listed	Local Vendor TBD (Home Depot for price estimate)	$8.50/4 lbs	16 lb	$34.00
Plant info cards Printing Laminating Tape (???)	Print/Copy Services WWU	$5/plant	52	$260.00
Survey materials (?) Plant selection QOL survey	Google Surveys	$.50 per survey	3 surveys	$1.50
			Total project budget	**Min: $2,508.23 Max: $4,315.38**
			Total of all other funding sources, listed below	**$0**
			Total requested funds from SEJF	***$4,315.38***

Conclusion:

Offices with built-up CO2 can lead to the feeling of drowsiness and create an unproductive, and uncomfortable work space. Factors such as lack of fresh air, excess of people in the room, and computers, can all contribute to CO2 build-up. To combat CO2 accumulation in the offices the University's campus several iterations of the CSPS team, in conjunction with the office of sustainability, are attempting to place indoor plants into select offices around campus. Indoor plants can help maintain healthy and productive CO2 levels, creating a desirable work environment.

The group has taken CO2 measurements to gain a clear understanding of what levels look like across several offices. Once funds from the SEJF have been secured, our stakeholder, Turner Campbell, and a possible additional CSPS group, will place the selected plants in College Hall and additional potential locations. To test the success of the project, future teams will be able to reevaluate CO2 levels in the previously tested offices to determine if CO2 levels did, in fact, drop.

The tests conclude that offices that are smaller, have little-to-no openable windows, and multiple computers have the highest CO2 levels. These offices should be targeted over those with adequate air circulation.

To help maintain the longevity of the office plants, this project team has written a long-term care plan for the plants (see appendix). The plan includes instructions for the office staff to follow to maintain provided plants. The instructions are meant to help staff sustain the plants so they can sufficiently reduce CO2 levels.

For the long-term agenda, the CSPS group will help create a peaceful, healthy and productive environment in offices all over campus. This will benefit countless students and faculty while potentially becoming a positive example in sustainability for offices or institutions within, and beyond Western Washington University's campus.

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Appendix:

Long-Term Plant Care

SPIDER PLANT:

(*Chlorophytum comosum*)

- Ideal Conditions:
  - 55-65F
  - Bright, indirect light
  - Potted, using well drained soil
- Water well, but do not allow the plant to become soggy
- Can benefit from occasional pruning
- Plants reproduce easily, and may become very large
  - Repot offspring, or divide the plant in half and repot if these issues occur

SNAKE PLANT:

(*Sansevieria trifasciata)*

- Ideal Conditions:
  - Potted in a terracotta pot, using free-draining soil
  - Don't water often, allow the soil to become dry between waterings
    - Do not get leaves wet during watering
  - Indirect lighting
- Reproduce easily
  - Repot offspring, or cut leaves and repot facing upwards
- Toxic to cats and dogs

BAMBOO PALM:

(*Chamaedorea seifrizii*)

- Ideal Conditions:
  - Indirect or filtered sunlight.
  - 64-75°F
    - Minimum temperature of 55°F (during winter).
  - Mist foliage regularly (for humidity).
  - Water when needed to keep potting mixture moist
    - Avoid overwatering
- Prune to remove yellowing or dried fronds
- Repot every two to three years
  - When roots fill existing container.
- Foliage non-toxic to people or pets, berries are toxic