Perpetual Harvest Prototype – Development of a Unique Vertical Farming Design

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What is Vertical Farming?

• A futuristic form of designing indoor growing spaces to maximize output of plant production

• A combination of architecture and engineering to support botany/horticulture/ecology (farming upwards using a controlled-environmental system)
Why Choose to Focus on Vertical Farming?

• Growing trend in popularity over the past few years, since the VF concept was developed by Dr. Despommier’s students at Columbia University from 1999 - 2009

• Expected to continue to grow as an emerging technology – the market share for Vertical Farming is predicted to be a few billion dollars in revenue over the next several years (Wintergreen, 2014)

• Perpetual Harvest Growing System (PHGS) is Dr. Kelly’s late father’s invention; Chris Marron’s vision is the motivation for this research

• It is important to prove the viability of indoor cultivation technology in relation to sustainability and the Triple Bottom Line analysis

• Then this new CEA-growing model will be helpful to not only the cannabis industry, but also to support local organic food production
Issues with Controlled-Environment Agriculture (CEA)

**RISKS**
- expensive energy/electricity requirements for lighting, heating/cooling, fans, etc.
- common problems include insects or mildew/mold
- trust in growing automation
- unknown obstacles derived from CEA being a new field

**BENEFITS (variables to study)**
- maximized use of floor space (lbs/ft²)
- efficiency of irrigation (gallons/lb)
- multiple harvest cycles per year (5+)
- idealized climate conditions for crops
- removes shadow-effect giving plants combinations of light wavelengths
What issues will our study analyze and evaluate?

- Maximizing use of the growing space and maximizing potency for each plant’s flowers
- Considering employee functions/work-flow patterns within grow areas (engineering)
- Combining renewable energy with indoor agriculture to increase CEA’s sustainability
- Observing how plants respond if given multiple wavelengths of light simultaneously
- Measuring and monitoring irrigation efficiency within our vertical growing system
- Using sensors and software to automate various aspects of a vertical growing system

- Eventually PHGS will experiment with crop diversification and creating ideal climates

Similar to MIT in Boston and PlantLab in the Netherlands
Current Trends in Vertical Farm Designs

“Vertical Plane Production” (Storey, 2015)

Most publicized VF designs are using:

- Horizontally Stacked Tiers of “Growing Towers”
- 4 x 8 beds and 8 x 8 beds
- LED lights directly above each row of plants growing
- Sensors and smart tech for climate control variables

Growing primarily salad greens and culinary herbs
How has Vertical Farming been evolving?

• Although a majority of indoor farms use stacked tiers, this is inefficient in comparison to “vertical plane production” (Storey, 2015).
Labor can be a bit precarious in most Vertical Farming.

Afraid of heights? Need not apply...
VF Labor Inefficiencies

1. Labor costs increase 25%.
2. Requires scissor-lift.
3. Losing money.
4. Tiers

Profitable $$$$$

Losing money $
Perpetual Harvest – theory meets learning

- For many years I have theorized about maximizing the growth potential of controlled-environment agricultural technology and collaborating on development of vertical farming models.
- How can intentional design of a growing space maximize a plant’s potential for output – which factors matter more? Quantity or quality? Consistency? Number of harvests/year?
- Research design should be collaborative, interdisciplinary, and aimed at serving the greater good (people, planet, profit).
- Industry best practices need to be developed for indoor growing of medical marijuana and hemp (our motivation).
Collaborative Research Framework

• Our Potential Partners include: Bees Knees CBDs, BioRegional Strategies, Cannapods, Flux, The I Will Projects, Phoenix Tears Foundation and UpShot, Inc.

• Growing market supply and demand through education and demonstration of what’s possible

Non-profits and private industry interests merge with SMEs to design/conduct quality research

Each party stands to gain from collaborative research and development, product testing and improving society’s understanding of hemp/MMJ
Perpetual Harvest model – conceptual drawings (2014)

Engineering and construction management, biology, chemistry, etc.

We will be asking students of all STEM backgrounds to contribute...

Let’s say we could be growing cherry tomatoes in our vertical farm
How much can we grow?

Each grow tower (L-shape) can house 96 plants

Note stacking *and* vertical plane production

- Hundreds of plants can be grown sideways toward the vertical light towers
Industrial Warehouse Design – each grow tower is removable for harvesting and replanting
Factors to consider when growing indoors

Airflow

CO2

Heat

Pests and disease

Human management

(Storey, 2015)

**VERTICAL PLANE PRODUCTION BENEFITS:**

- Promotes better air-flow than horizontal tiers
- Increased visibility and access to plants
- Greater ease in harvesting and maintenance
- Reduced risk of pest, mold or other infestations

**INCREASED AIRFLOW BENEFITS:**

- Removes humidity/heat
- “boundary layer effect” - Boundary layers describe the friction air has with the surface of something.
- Introduces more CO2 to the plants
- Strengthens the plant stalks’ resiliency
Diversify your profit streams – Theory: Grow 80% food and 20% medicine to earn a living wage
Next Step Studies...

Future research needs to focus on Critical Success Factors of Vertical Farms and the benefits of “Vertical Plane Production”

Connect with MIT’s Open Agriculture Initiative and data sharing among indoor farmers...

PEACE Project under development
Conclusions

• Because of the high energy costs associated with climate-controls (heating/cooling, humidity, wind, water circulation, and artificial lighting) the only crop worth growing indoors commercially has been cannabis flowers.

• Other types of edible and medicinal plant species could/should be grown indoors for research and profit.

• Vertical Farming is best done in “vertical plane production” using a soilless growing media.

• CEA technology provides inspiration for STEM-based innovation, experimentation, and theory development.

• The collaborative research model is key to success.
What questions do you have about Vertical Farming?

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References and Partners

• Association for Vertical Farming – https://vertical-farming.net/


• Storey, N. (2015). https://www.youtube.com/user/NateStorey1