GAPS LIST SPACE CROP PRODUCTION INTERVIEW EVALUATION

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About Me

- Amateur House Plant and Gardening Enthusiast
- Naturephile
- Virtual NASA Intern Summer 2021
- Senior at North Carolina State University
  - Major: Plant Biology
  - Minor: Horticulture and Spanish
- Located in Raleigh, North Carolina
- Previous Research:
  - Horticulture: Hydroponics and controlled environments
  - Plant and Molecular Biology: Genetics of Iron Homeostasis in Arabidopsis

BACKGROUND INFO

How can we solve these issues systematically?

Challenges with: Growing Plants in Space

- Typical space environment factors:
  - Higher exposure to radiation
  - Lower pressures
  - Higher CO2 levels
  - Varying light capabilities
- Microgravity factors:
  - Hypoxia
  - No natural convection limiting transpiration
  - Lack of Gravitropic responses

And many others!

The Gaps List

Gap ID	Section	Category	Sub-gap	Keyword	Description
1.B.1.0.1	Hardware	Environmental Control	µg Water/Nutrient Delivery	Water Delivery	Lack ability to effectively provide adequate and uniform delivery of water and nutrients to root zones in relevant space environments

- A list of hierarchically arranged issues
- Each issue is attainable but lacking technology or knowledge in the SCP Program
- Purpose: to identify and systematically arrange all gaps such that they are categorized for ease of understanding

Project Goals:

- To evaluate the effectiveness of the Gaps List method within the context of the current SCP Program research to determine where deficiencies and sufficiencies lie in both.

METHODS

2- Step Interview Process

Interview 1

- Introduction to all current projects
- Taking thorough notes
  - Summary
  - Start and end dates
  - Funding source
  - Potential gaps

In between interviews, all potential gaps were made note of for each project

Subject group:
KSC SCP Project Scientists and Post-Doctoral Researchers and their current research

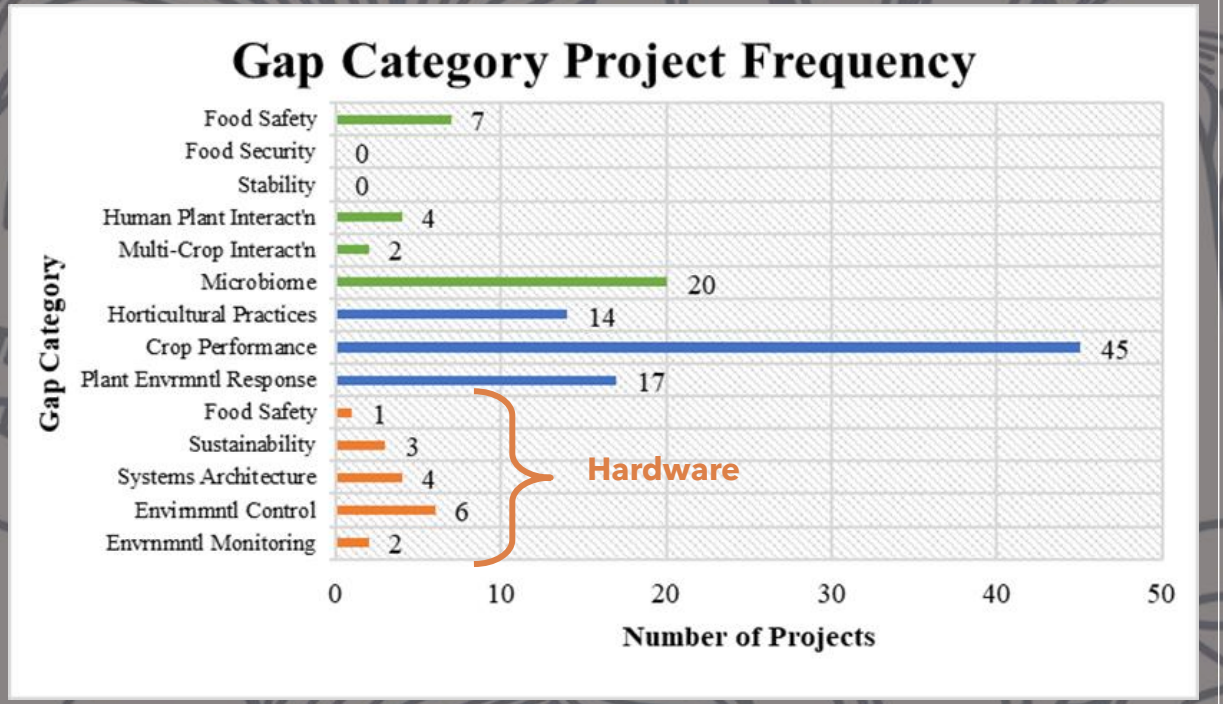
Interview 2

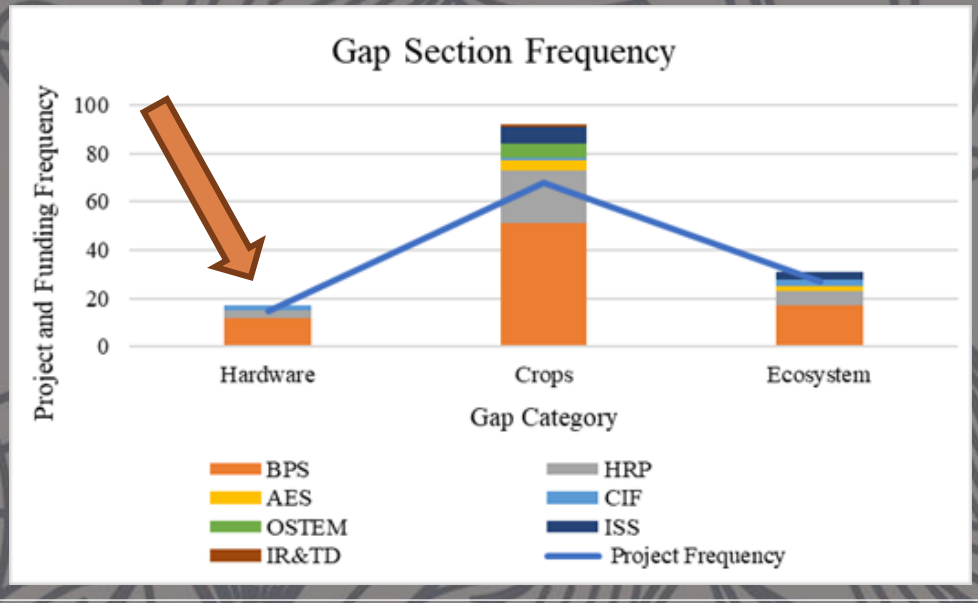
- Potential gaps were addressed
  - They were either approved or disapprove
- Approved gaps and their associated funding source were recorded into a chart

RESULTS AND DISCUSSION

Priority

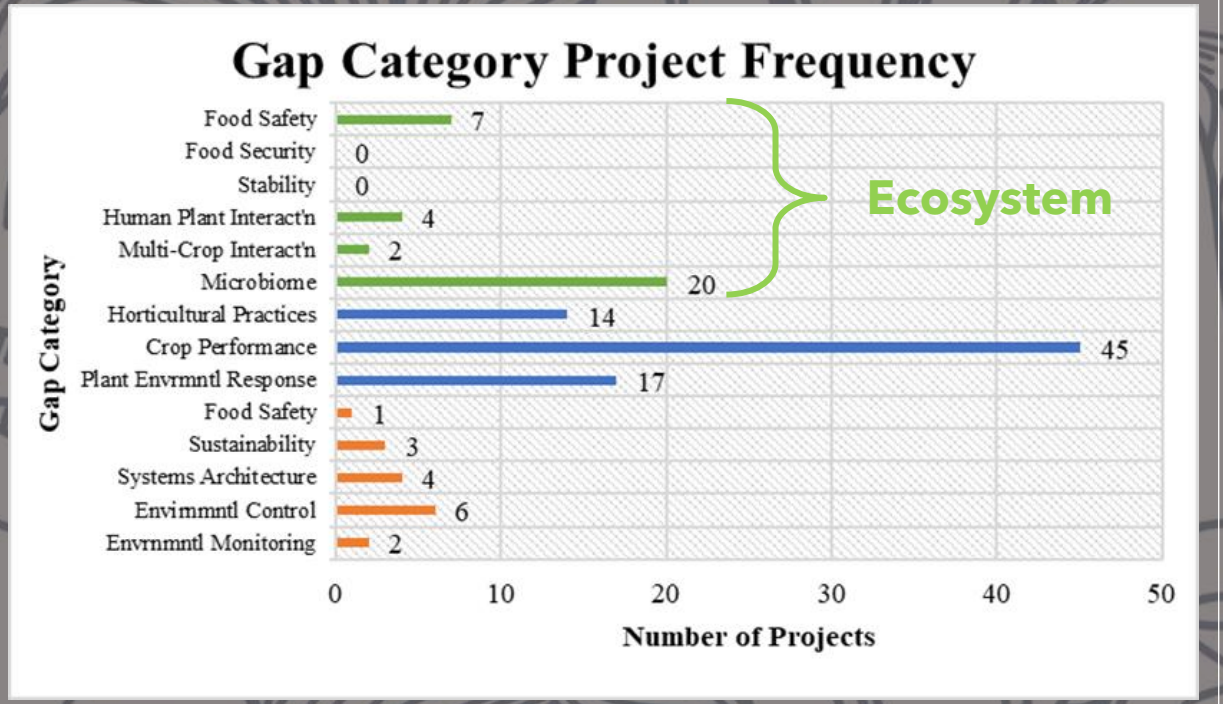
- Hardware was the least frequent gap section
- Most interviewees were unaware or had little knowledge of these gaps
- BPS is the largest funding source for SCP
- BPS focuses on fundamental biology
- SCP is shifting toward large scale production
- A measure of Priority within the gaps list will draw attention to pertinent gaps

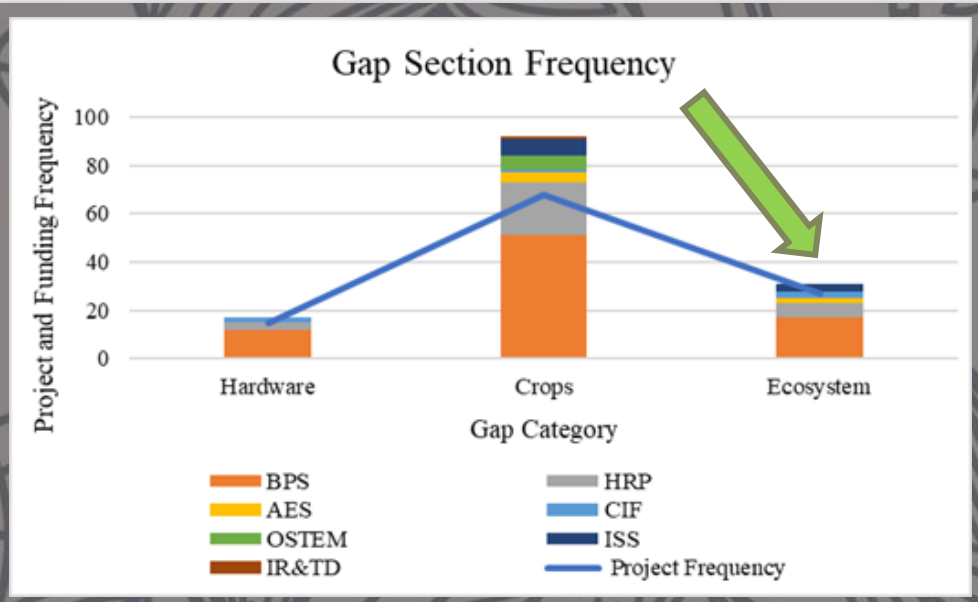




Dependency

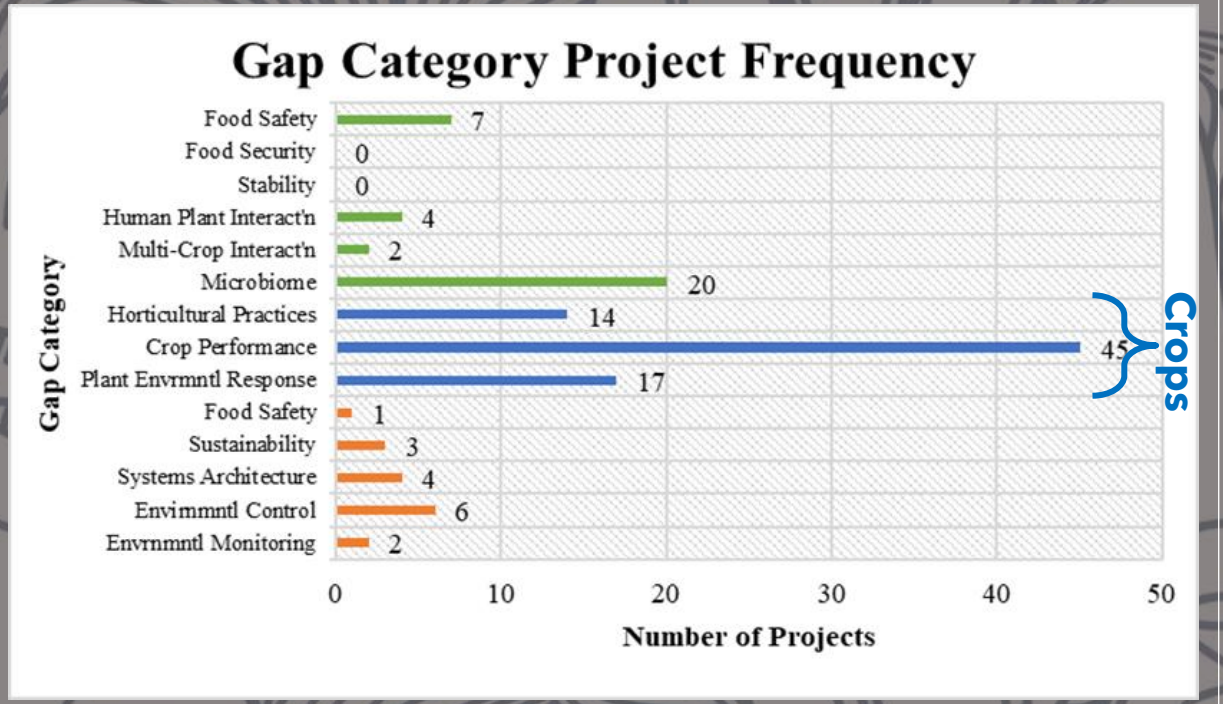
- Ecosystem was the 2nd least frequent gap section
- Highest number of gaps with 0 representation
- Many Gaps in this section are very complicated/ depend on multiple factors
- A measure of Dependency within the gaps list will draw attention to gaps that must be completed before others

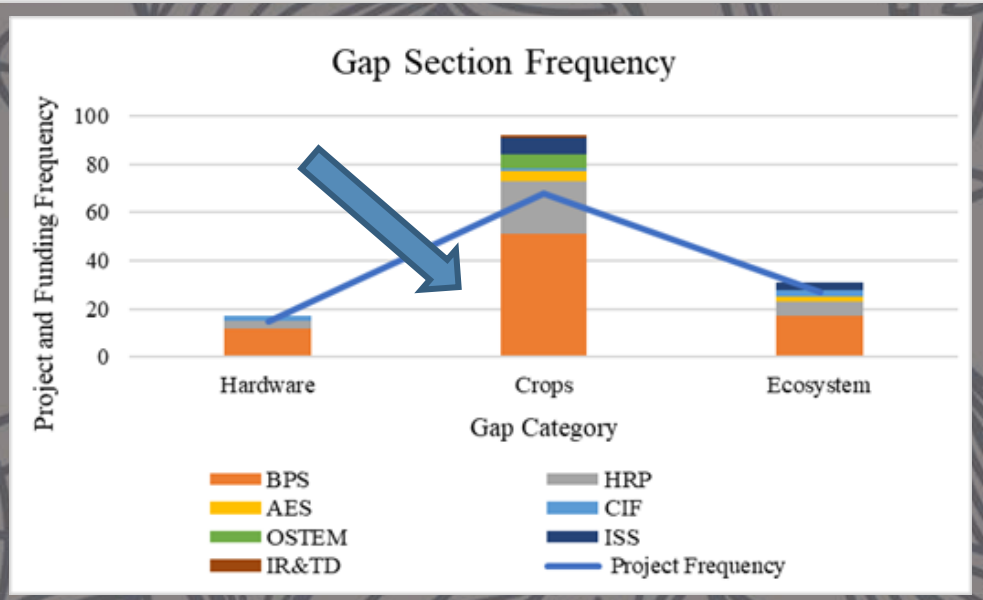




Scope

- Crops was the most frequent gap section for 2 apparent reasons
- (1) These gaps contain several plant growth factors that apply to all candidate crops
  - The scope of these gaps is very large
- (2) Because BPS is the main benefactor and is most interested in crop growth responses that inform fundamental biological knowledge
- A measure of Scope within the gaps list ensure understanding of the amount of time and support necessary to close the gap





Secondary Findings

- Gaps list was out of date with current research
- Gaps needed to augmented
- All potential changes were recorded throughout the interview process
- A discussion was held with SCP Program to approve or deny suggested changes

New Gaps

1.D.2.0.3

Hardware> Sustainability> Failure modes>

Determine how to manage plant environments in the event of system malfunctions such that the integrity of the crop and hardware systems are maintained or salvageable

2.A.4.d.1

Crops> Plant Environmental Response> Temperature> Temperature Database

Incomplete data sets for temperature tolerance of candidate crops in space environments

2.A.6.a.1

Crops> Plant Environmental Response> Water> Water Uptake>

Incomplete data sets of water uptake and thresholds for candidate crops in space environments (including air flow and humidity).

2.C.5.0.1

Crops> Horticultural Practices> Harvesting> Plant Harvesting Techniques>

Lack of adequate and sustainable method for harvesting from candidate crops in Space Environments

*** consider moving this to hardware

2.F.1.0.2

Ecosystem> Food Safety> Operations> Crew Consumption>

Lack of clear process for approval of crew consumption of crops

3.C.1.0.2

Ecosystem> Plant Human Interaction> Plant Effects> Plant Effect on Crew>

Lack of an automation/crew time strategy to maintain plant environments

Other Changes

Wording was changed in existing Gaps to encompass more information

- 2.C.3.0.1 Incomplete datasets on optimum fertilizer strategies for candidate crops in space environments
- 2.A.5.D.1 Plant disorder and stress database> Need to advance understanding of plant physiological disorders and stress responses of interest to space crop production.
- 3.A.4.0.1 Lack of microbiome baseline knowledge and augmentation strategy

Future gaps were added to a separate section to be added to the Gaps List when they become attainable

- Need to select/breed/engineer candidate crops more resilient to varying water thresholds.
- Need to select/breed/engineer improved temperature tolerance of crops for space environments
- Need to select/breed/engineer for better crop physiological response to low gravity environments
- Need a select/breed/engineer for response to pressure level on plant physiology for candidate crops in Space Environments
- Need to determine the epigenetic changes that occur in candidate crops in space environments over multiple generations
- Need to determine a roll up metric for candidate crops that characterizes crop systems related to the ratio of nutrient amounts of edible and inedible biomass

CONCLUSIONS

Findings

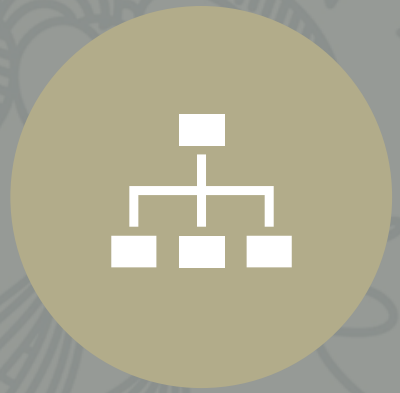
- The Gaps List methods outlined in this report are effective.
- The Gaps List itself did not align with current research.
- An efficient rate of progress will likely be achieved if adequate support is given to all sections of the Gaps List and the following recommendations are implemented.

Recommendations

To have these 3 aspects included within or along side the Gaps List:

PRIORITY

Create a new list that measures priority



DEPENDENCY

Create a roadmap of gaps to be completed in succession

SCOPE

Include words that define scope within Gap descriptions

Recommendations

Reevaluate the Gaps List at Regular intervals to assure congruency with the current research questions

REEVALUATE

THANK YOU

Mentors and Co-Authors:

- Gioia Massa and Ralph Fritsche

Interviewees:

- Gioia Massa
- Christina Johnson
- Lucie Poulet
- Raymond Wheeler
- Matt Romeyn
- Aubrie Orourke
- Ye Zhang