

# AG2PI SEED GRANT - PROJECT FINAL REPORT

PROJECT NAME	<b>Empowering high-throughput phenotyping using UAVs</b>
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PROJECT PRINCIPAL INVESTIGATOR	TODAY'S DATE	PROJECT START DATE	DATE OF COMPLETION
Max Feldman	2023-02-07	2021-05-25	2022-11-14
TEAM MEMBERS (co-PI, co-I, personnel)	COLLABORATORS		
Jennifer Lachowiec (co-PI) David LeBauer (co-PI) Filipe Matias (co-PI)	Adriane Silva		

## ACCOMPLISHMENTS

Please provide a short summary of the conclusions (both successes and failures) made from your project. Include a description of how this project will provide benefits to the agricultural genome to phenome community and, possibly, to a broader audience. You should include both qualitative and quantitative details, as necessary, to support your conclusions. Include a short accomplishment statement in non-technical language and do not include names.

We have completed a quantitative, international survey aimed at identifying bottlenecks to adoption of UAV in agriculture and a qualitative survey with domain experts focused on verifying results of quantitative survey and identifying promising applications for UAVs.

The three main bottlenecks identified in the quantitative survey suggest that cost of drone/sensor is the most limiting factor, followed by lack of staff trained to analyze data from drone, then lack of staff trained to collect data using drone. The quantitative survey suggests that detailed step-by-step protocols that can be followed would be the most helpful resource for people interested in deploying a drone program for the first time.

Our qualitative survey with domain experts suggests that the cost of a drone is only a perceived bottleneck and the lack of individuals trained to analyze the data is a major bottleneck. They suggested that developing work teams of people from different areas of expertise is the best way to deploy a drone program for the first time. The most promising applications identified as part of our qualitative survey suggest 3 major categories of research where UAVs can provide added value. These include: 1) Precision Agriculture, 2) Crop Modeling/Yield Prediction, and 3) Phenomics enabled plant breeding.

In response to this survey our team developed on-line protocols and datasets, one of which was published as an application note in The Plant Phenome Journal. Our team also hosted 7 hands-on workshops as part of the PhenomeForece seminar series.

We engaged both the research and stakeholder (farmers, food processing companies) communities through workshops at the North American Plant Phenotyping Network annual meeting, annual meeting of the Potato Association of America, and several regional tradeshow/field day events. Our primary accomplishments were completing a quantitative and qualitative international survey that identified the major bottlenecks to incorporating UAVs into a research program and developed public, on-line resources to alleviate these bottlenecks in the form of protocols, analysis workflow examples, and datasets.

(HINT: You can expand sections as necessary by pulling down on the square in the lower right corner of each box)

## Products

Please list any products from this project. This may include (but not limited to) publication, concept/white paper, workshop, conference presentation, website, publicly available data or pipelines, etc. Reminder: you are required to make your products available to the broader stakeholder community using standard USDA practices, open source, FAIR, or other models.

ACTIVITY / PRODUCT	DESCRIPTION (include URL, if applicable)	OUTCOME / METRICS
Publication on best practices for drone data collection and analysis	Research publication: <a href="https://access.onlinelibrary.wiley.com/doi/full/10.1002/ppj2.20048">https://access.onlinelibrary.wiley.com/doi/full/10.1002/ppj2.20048</a>  Github analysis workflow: <a href="https://github.com/filipematias23/Bison-Fly">https://github.com/filipematias23/Bison-Fly</a>	1 citation of publication in 2022  23 stars, 9 watching, 3 forks for github repository
PhenomeForce hands on workshop series focused on drone data collection analysis	Recorded workshops: <a href="https://phenome-force.github.io/PhenomeForce/">https://phenome-force.github.io/PhenomeForce/</a>	7 seminars, participants from around the globe
Workshop at NAPPN Conference in 2022	Hosted a community engagement workshop to kick-off quantitative survey on UAS use and deployment bottlenecks <a href="https://www.plant-phenotyping.org/index.php?index=580&amp;event=NaPPN_Annual_Conference">https://www.plant-phenotyping.org/index.php?index=580&amp;event=NaPPN_Annual_Conference</a>	Between 50 -100 attendees
Community survey to identify barriers to entry for UAV use	Survey was designed in cooperation with HELPS lab at Montana State University	>150 respondents from 21 countries
Developed a public drone data collection protocol	Link to the protocol: <a href="https://www.protocols.io/view/usda-ars-potato-genetics-lab-drone-data-collection-bp2l6148dvqe/v1">https://www.protocols.io/view/usda-ars-potato-genetics-lab-drone-data-collection-bp2l6148dvqe/v1</a>	Accessed >200 times
Collection of public UAV multispectral dataset to quantify insect defoliation of potato	Link to data from 2020: <a href="https://zenodo.org/record/7529798#.Y-LGWS-B1z8">https://zenodo.org/record/7529798#.Y-LGWS-B1z8</a> Link to raw image data from 2020: <a href="https://ars-usda.box.com/s/u838hy6fuhm4ckiontve9vhintguckem">https://ars-usda.box.com/s/u838hy6fuhm4ckiontve9vhintguckem</a> Link to data from 2021: <a href="https://zenodo.org/record/7311840#.Y-LGji-B1z8">https://zenodo.org/record/7311840#.Y-LGji-B1z8</a> Link to raw image data from 2021: <a href="https://ars-usda.box.com/s/muw8296rrcjin4lhr9ya2o9yjr6jo8e3n">https://ars-usda.box.com/s/muw8296rrcjin4lhr9ya2o9yjr6jo8e3n</a> Link to analysis of derived numerical data: <a href="https://zenodo.org/record/7535059#.Y-LGrS-B1z8">https://zenodo.org/record/7535059#.Y-LGrS-B1z8</a>	
Presentation of project objectives at Oregon State University Hermiston	Link to agenda: <a href="https://ag01.noco.net/sites/agscid7/files/harec/potatofieldday2021.pdf">https://ag01.noco.net/sites/agscid7/files/harec/potatofieldday2021.pdf</a>	Between 50 -100 stakeholder attendees

Potato Field Day in 2021		
Presentation at 106 <sup>th</sup> Annual Potato Association of America Meeting	Link to presentation: <a href="https://zenodo.org/record/6859791#.Y-LIVy-B1z8">https://zenodo.org/record/6859791#.Y-LIVy-B1z8</a>	Between 50 – 150 research/scientific attendees
Presentation at Washington Oregon Potato Conference	Link to presentation: <a href="https://zenodo.org/record/7618620#.Y-Llqy-B1z8">https://zenodo.org/record/7618620#.Y-Llqy-B1z8</a>	Between 200 – 1000 stakeholder attendees
Presentation at S1069 Multi-state project meeting	Provided update on drone usage as part of update from Washington state.	Between 10 – 30 research/scientific attendees
Presentation at ASA-CSSA-SSSA 2022	Presented on best practices for drone data collection and analysis <a href="https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/141170">https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/141170</a>	Between 10-30 research/scientific attendees
Presentation at ASA-CSSA-SSSA 2022	Presented on open source UAS data processing approaches for small plots research <a href="https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/141647">https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/141647</a>	Between 10-30 research/scientific attendees
Performed qualitative survey with domain experts in field or remote sensing	Interviewed domain experts regarding challenges of starting a drone program and potential applications of UAV in agriculture. Subjects included: Anju Biswas (UF), Francisco Gonzalez (USDA-ARS), Alison Thompson (USDA-ARS), Atena Haghigattalab (UMN, independent), Keshav Singh (AAFC), Mahendra Bhandari (Texas A&M), Javier Landivar (Texas A&M), Lav Khot (WSU), Seth Murray (Texas A&M), Ishai Gottlieb (AgroScout), Matthew Blua (Washington Potatoes).	Interviews lasted between 30 – 60 minutes. Transcripts were taken but not yet listed on-line.
Poster award at ASA-CSSA-SSSA 2022	1 <sup>st</sup> place poster in the Diversity Research division presenting on the community survey results on barriers of using UAS in agriculture <a href="https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/146333">https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/146333</a>	Poster session attendance included thousands of attendees
Recognition of project by USDA-ARS	A Tellus feature on UAV applications in potato was published in 2021: <a href="https://tellus.ars.usda.gov/stories/articles/cutting-to-the-chase/">https://tellus.ars.usda.gov/stories/articles/cutting-to-the-chase/</a>	

## Audience

With whom has this work been targeted to and shared? Please describe how this project and its products have been disseminated to a community of interest. Include any outreach activity or information sharing as well as training or professional development opportunities provided in this project.

This work has targeted the scientific/research community in regard to identifying major challenges to UAV adoption. An international survey was disseminated and workshops (both virtual and in-person) were put on to alleviate some of the reported bottlenecks.

Engagement of community stakeholders from commodity groups was achieved through presentation and interaction at regional tradeshow and farm/field day presentations.

## CHALLENGES

### Challenges

Have you experienced any challenges or delays? Please provide the actions you took to resolve them, if possible.

Sharing medium to large datasets of drone image data proved to be more challenging than anticipated. We have provided public data in a number of ways but a more standard approach would be ideal.