



Empowering specialty breeders with integrated tools for genomics, phenomics, and data analytics

Moira Sheehan, PhD
Cornell University

February 5, 2020
AgBioData Webinar

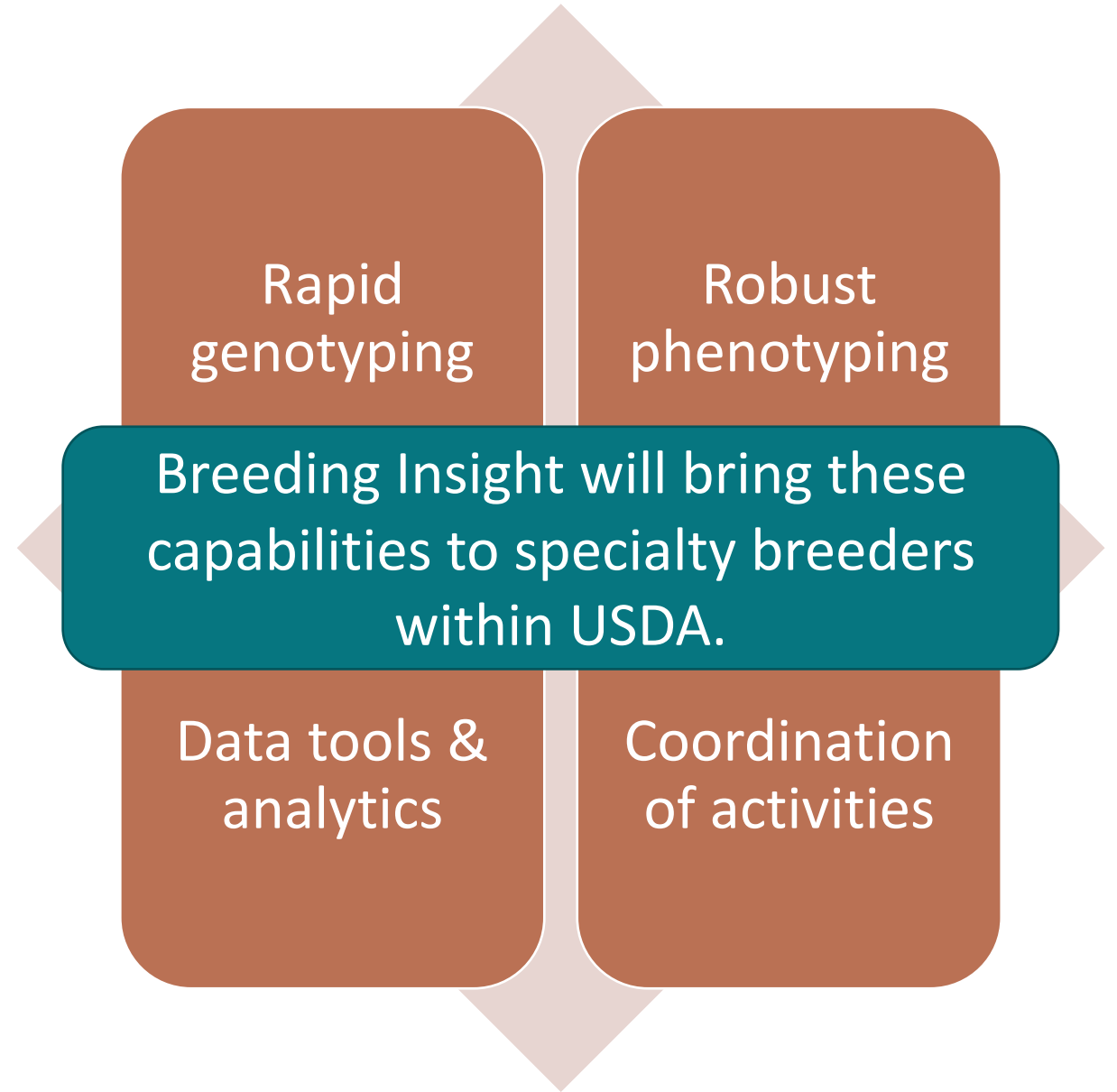
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Mission



Transform breeding
by enabling the implementation
of **genomic insight and selection**
as part of **routine** breeding programs
across **all of ARS.**

Key components of **private-sector** breeding programs



How do we build Breeding Insight (BI)?

- **Start with 5 pilot species**
 - Current breeding program
 - Breeding program wants and needs

Salmonid fishes



Blueberry



Sweet potato ->



Alfalfa



Grape

Feb 5, 2020

Challenges

Autotetraploid
Few markers available
Long cycle time (4 years to yield)
Lack of quantitative data

Blueberry



Salmonid fishes



Diploid
Lots of markers available
Very high cost of genotyping
80% of traits are lethal
Data collection is not digital

Autohexaploid
Few markers available
Highly heterozygous
Pedigrees not confirmed
Clonally propagated

Sweet potato ->



Autotetraploid
Few markers available
Multiple harvests per year
Cultivars in field for multiple years
Lack of quantitative data



Alfalfa



Table Grape

Diploid
2000 markers available
Highly heterozygous
Wild vines are either ♂ or ♀
Want seedless products

How do we build Breeding Insight (BI)?

- **Start with 5 pilot species**

- Current breeding program
- Breeding program wants and needs

- **Provide resources by making connections**

- Genotyping platforms/providers to data management
- Phenotyping to data management

- **Deliver Software, considering**

- Components available
- Functionality needed for breeder-specified use cases
- Seamless back-end communication between programs
- Intuitive, species-specific user interface for breeders

Salmonid fishes



Blueberry



Sweet potato ->



Alfalfa



Table Grape

Feb 5, 2020

Breeding Cycle “Digital Ecosystem”



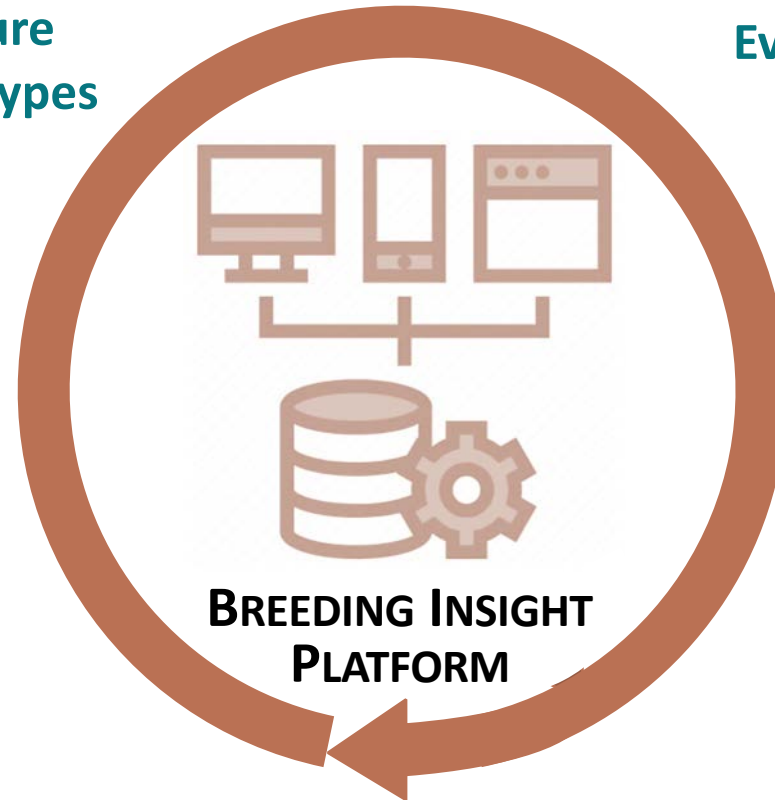
Capture phenotypes



Evaluate genotypes
Evaluate phenotypes



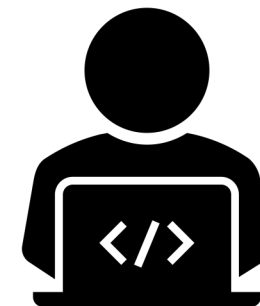
Manage stocks & pedigrees
Perform crosses
Design & manage trials



BREEDING INSIGHT
PLATFORM

Make:

- ✓ decisions
- ✓ selections (GS, MAS, etc.)
- ✓ reports



Breeding Cycle “Digital Ecosystem”



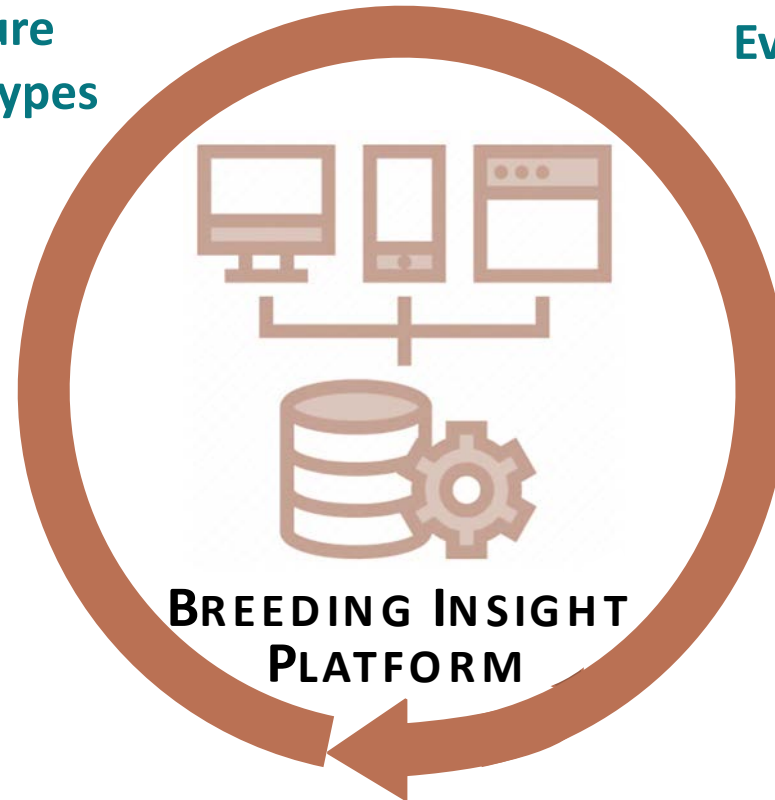
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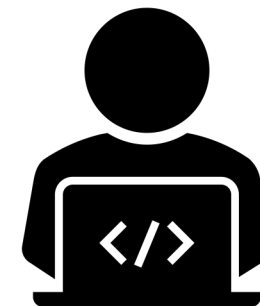


Maintain base populations
Manage pedigrees
Manage animal welfare
Perform crosses



Make:

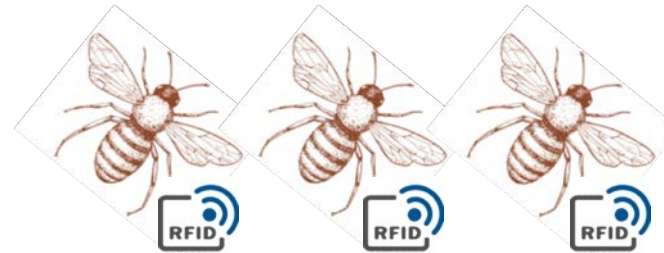
- ✓ decisions
- ✓ selections (GS, MAS, etc.)
- ✓ reports



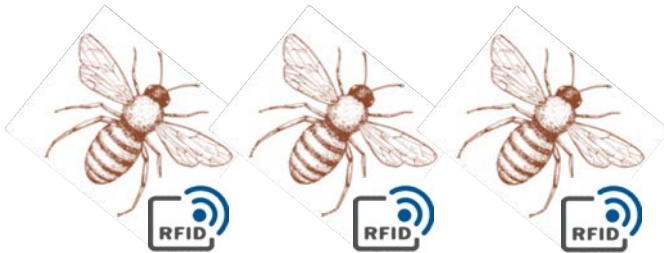
Breeding Cycle “Digital Ecosystem”



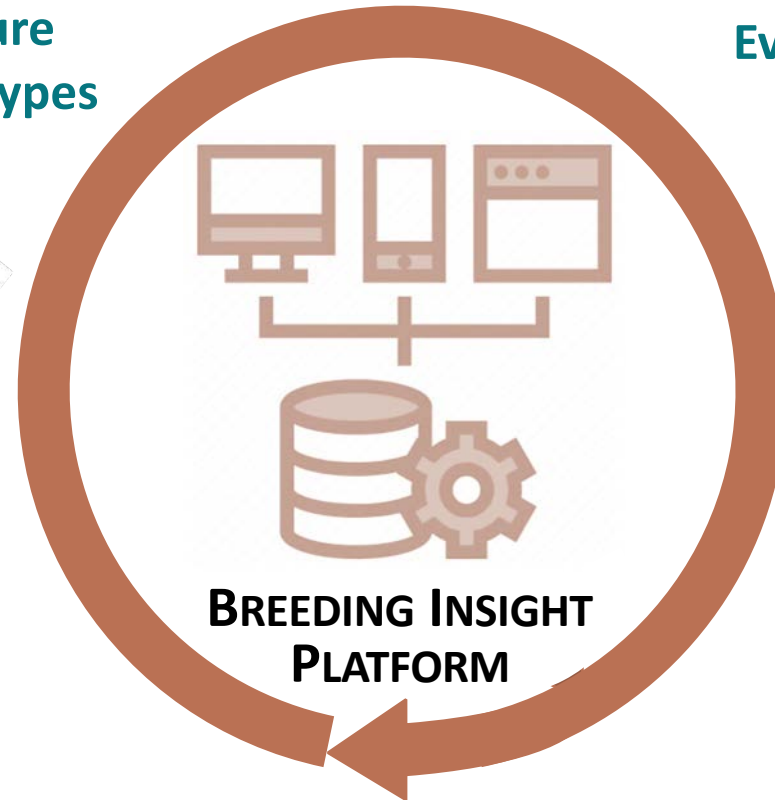
Capture phenotypes



Evaluate genotypes
Evaluate phenotypes

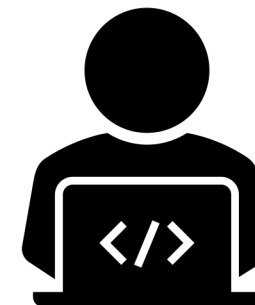


Maintain base populations
Manage pedigrees
Manage hives
Perform crosses



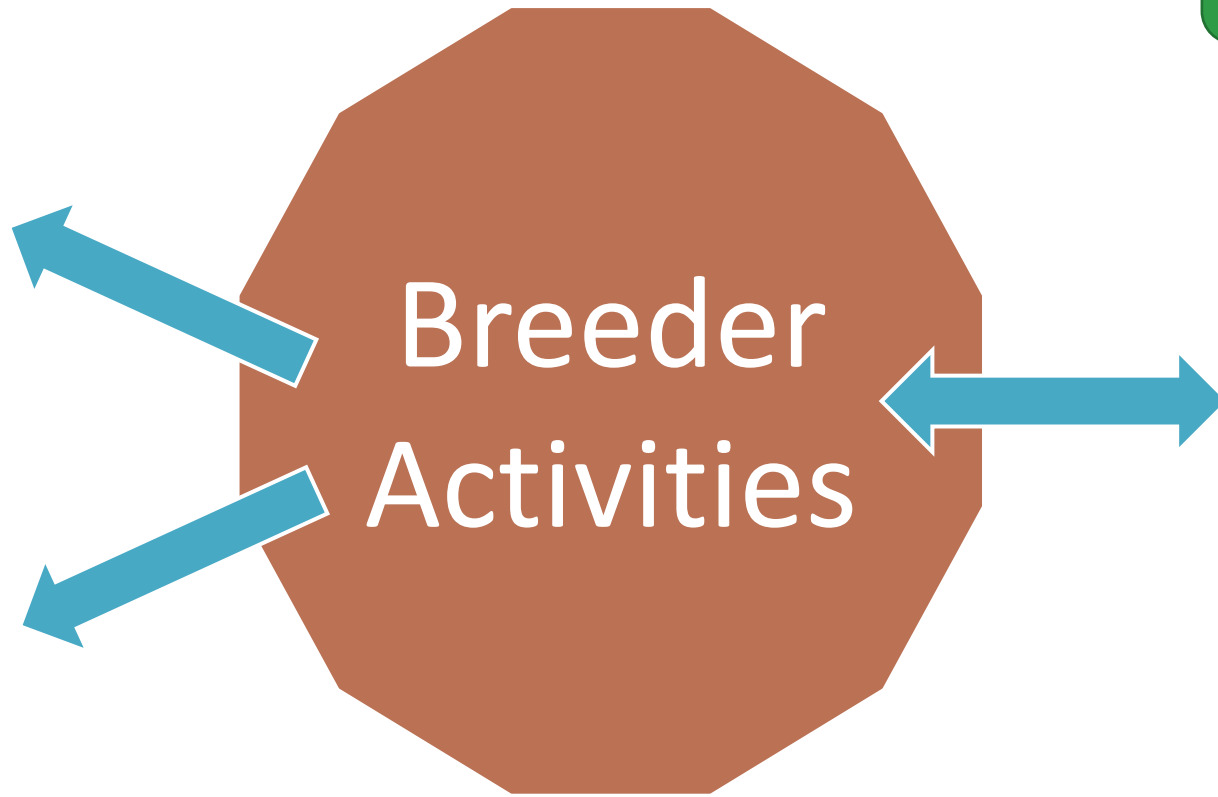
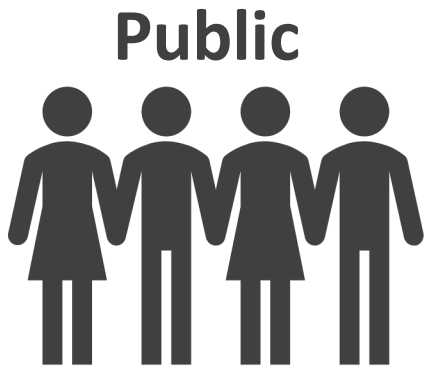
Make:

- ✓ decisions
- ✓ selections (GS, MAS, etc.)
- ✓ reports



BI as steward of breeders' data

BI doesn't create data, but helps store, utilize, and protect data.



System Administration
Technology integration

The BI Team

Software Development



Tim Parsons
Lead Developer



Liz Woods
UI/UX Designer



Nick Palladino
Application Programmer



Dave Meidlinger
Application Programmer



Chris Tucker
Application Programmer

Program Coordination



Moira Sheehan, PhD
Director



Kirsten Richardson
Executive Admin. Assistant

Scientific Support



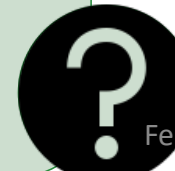
Siva Tirumalaraju, PhD
Sr. Program Manager



Dongyan Zhao, PhD
Genomics Coordinator



Katherine Mejia-Guerra, PhD
Bioinformatics Coordinator



To Be Hired
Phenomics Coordinator

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BI services offered to participating breeding programs

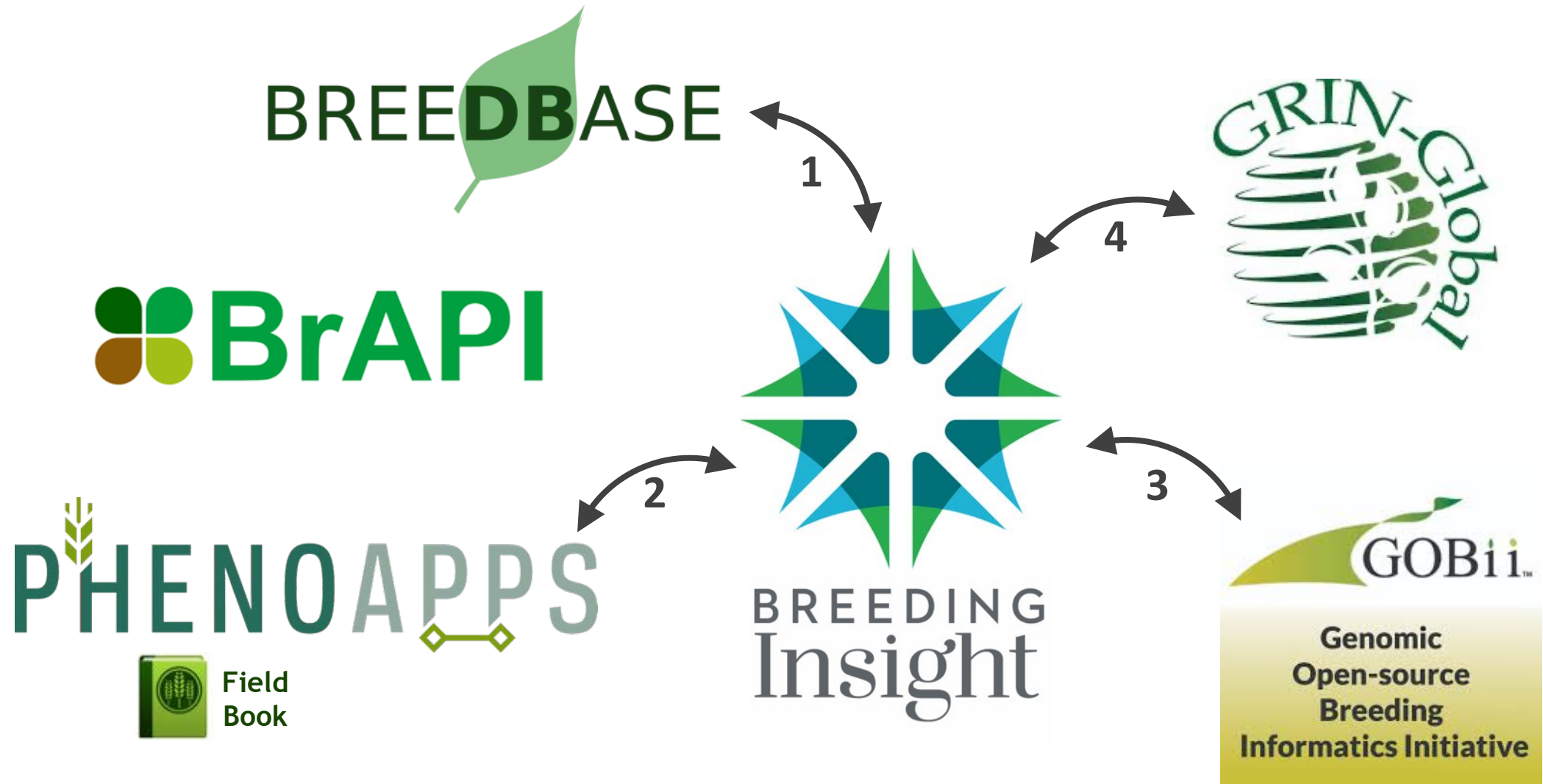
Services	Available
Skim sequencing of parents	yes
Marker development	yes
Affordable, fast genotyping	yes
Genotypic data management	yes
Phenotype data management	yes
Phenotyping technologies	yes
MAS & GWAS decision support	yes
GS support	yes
Workflow-based software	yes
Breeding consultation & curation	yes





Software components and BI's build strategy

Interconnectivity: BI's Data Platform



BI's place in the global community



Module 3:
Volume pricing
for genotyping



Module 5:
Bioinformatics,
Software



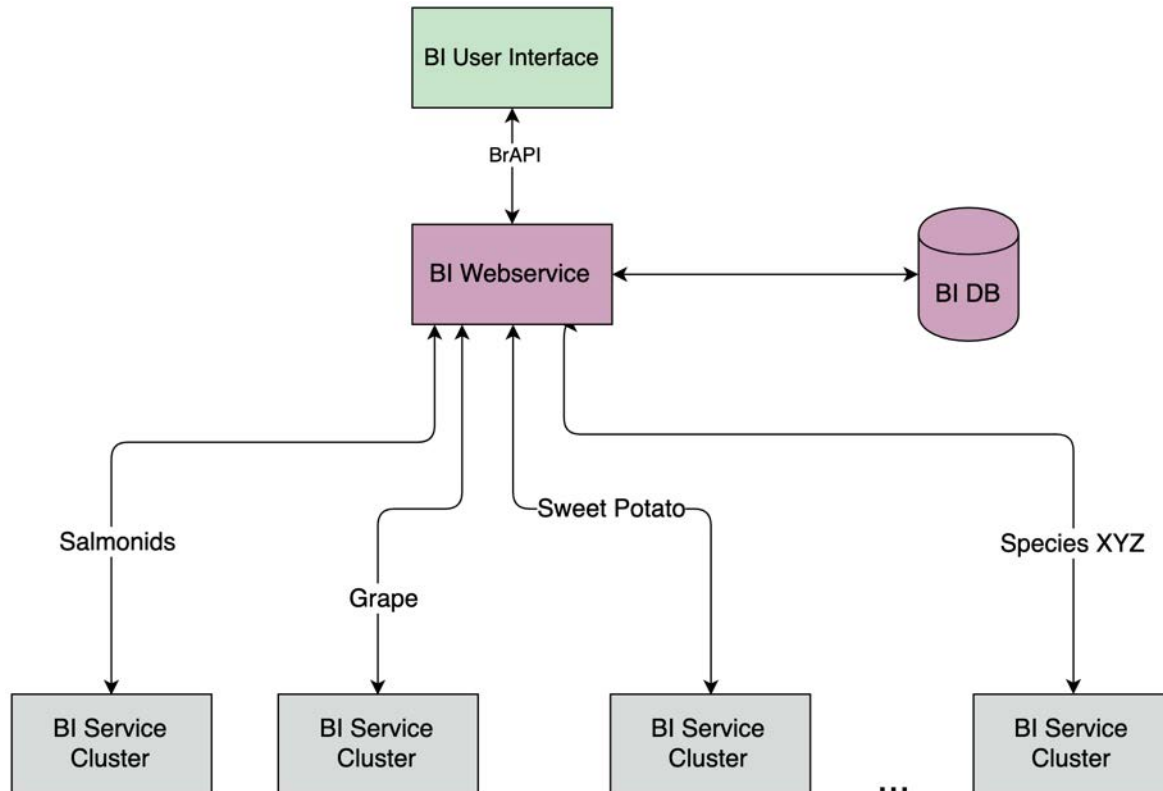
Feed the Future
Innovation Lab for
Crop Improvement



Collaborators

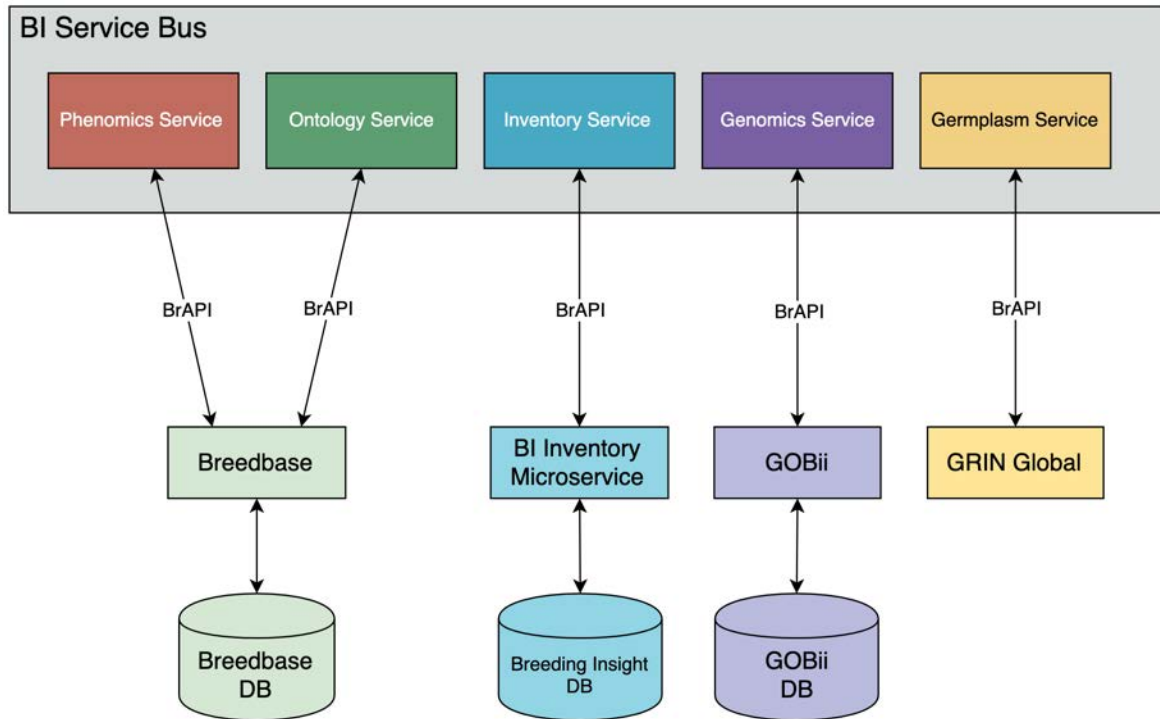
Partners

BI's Software Architecture: overview



- Multi-species support
- Modular architecture
- Seamlessly integrates sub-components
- BrAPI compliant

BI's Software Architecture: microservices



- Modular, microservice architecture
- Interoperable with any BrAPI-compliant component.
- Customizable to work with systems already storing data.

Initial components	Services provided
Breedbase	Phenotype data management
GOBii	Genotypic data management; Genomic analyses
GRIN-Global	Germplasm collection & repository

BI's Software Architecture: BI Webservice

- Connection between BI's user interface and integrated components.
- Responsible for fetching/storing appropriate data on users' request.
- Flexible to accommodate software needs **in a single interface**
 - Phenotypic data
 - Genotypic data
 - Germplasm passport information
 - Inventory data
 - Analytic software packages

This flexible architecture
powers an intuitive,
workflow-based user interface to
help make breeding decisions.

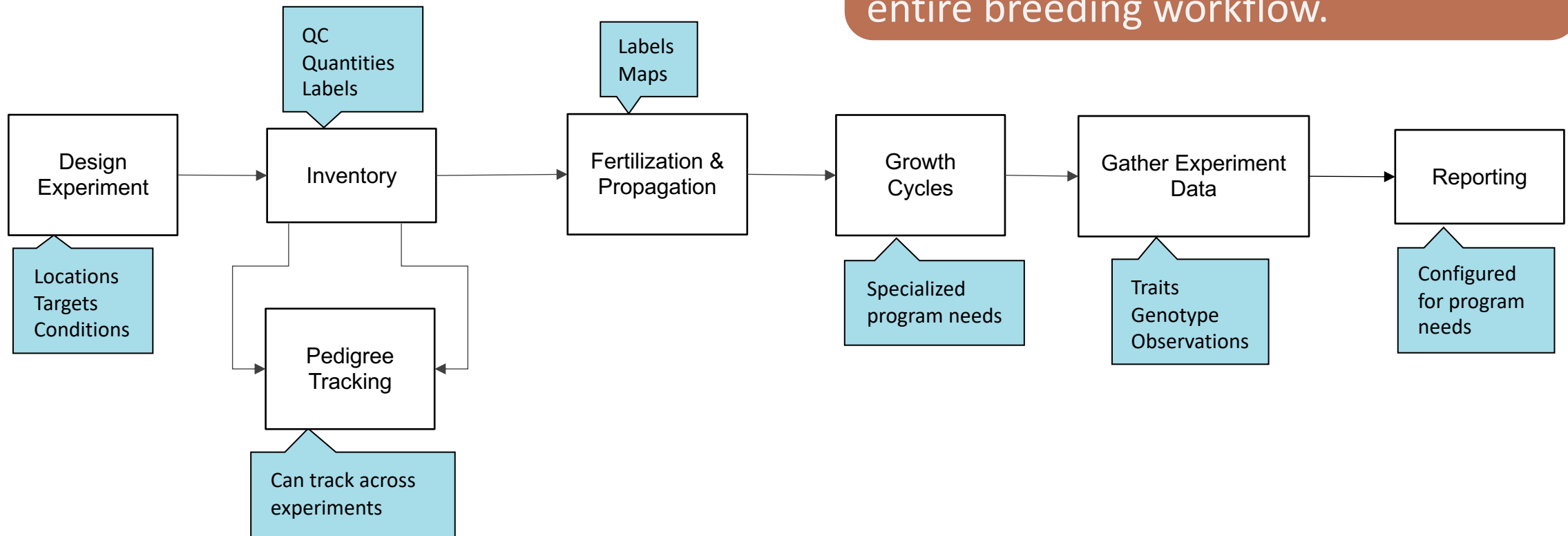
Centering software around breeders

BI is using a workflow-based design:

1. Spend time with breeders on location to understand how breeding processes are managed and.
2. Return to the breeders to ensure software reflects and supports those processes.
3. Provide breeders with information management tools for use throughout the breeding cycle.

Breeding Workflows: following the data

Breeding Insight will provide context-sensitive data tracking throughout the entire breeding workflow.



Breeding Insight's Approach

Interconnectivity

- Priority on the ability to share data across software tools

Logical Task Groups

- Customized to breeders' work cycles and program activities

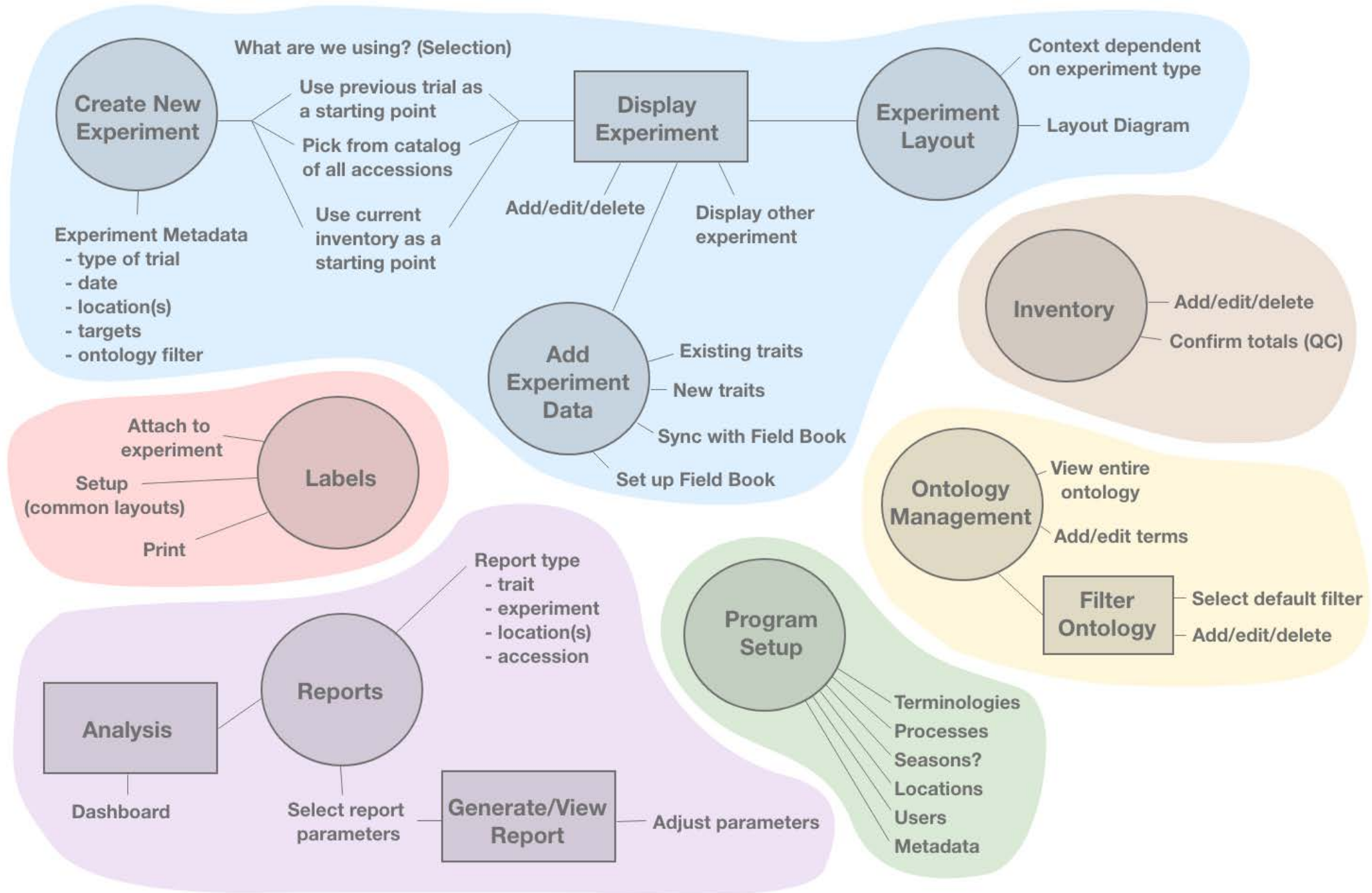
Ease of Use

- Breeder friendly, context-sensitive interface
- Process-centric design coordinates with existing breeding workflows

Discovery Process

- Dedicated to understanding each program's breeding processes
- Designed directly for individual specialty crops

Logical Task Groups: Example



Breeding Insight will be easy to use

Example Screen: “Welcome”

- ✓ Clean, clutter-free interface.
- ✓ Populates with most recent activities.
- ✓ Portal to other workflows.

Welcome back, Liz!

EXPERIMENTS

19-Y2-NTM In progress
Edited yesterday at 5:04pm

Open a different experiment:

18-Y1-NTM In progress
Edited June 23, 2019 at 3:32pm

18-YLD-BNT Completed
Edited January 19, 2019 at 10:15am

[Older experiments](#)

OTHER ACTIONS

- Start a new experiment
- Generate reports
- Manage inventory
- Configure settings

Breeding Insight will be breeder-friendly

Example Screen: “Create New Experiment”

- ✓ Task-focused interface.
- ✓ Guide breeder through workflow.
- ✓ Easier to adopt into current breeding program.

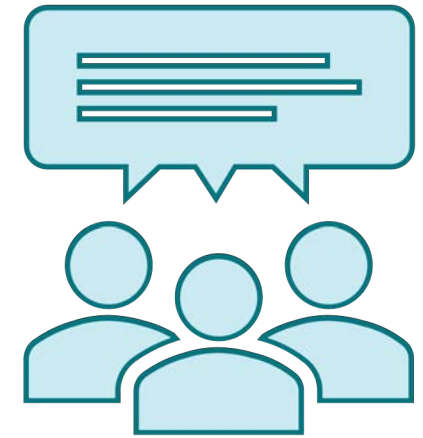
Create a New Experiment

Which dataset do you want to use as a starting point?

- Use a previous trial
- Pick from inventory
- Pick from all accessions

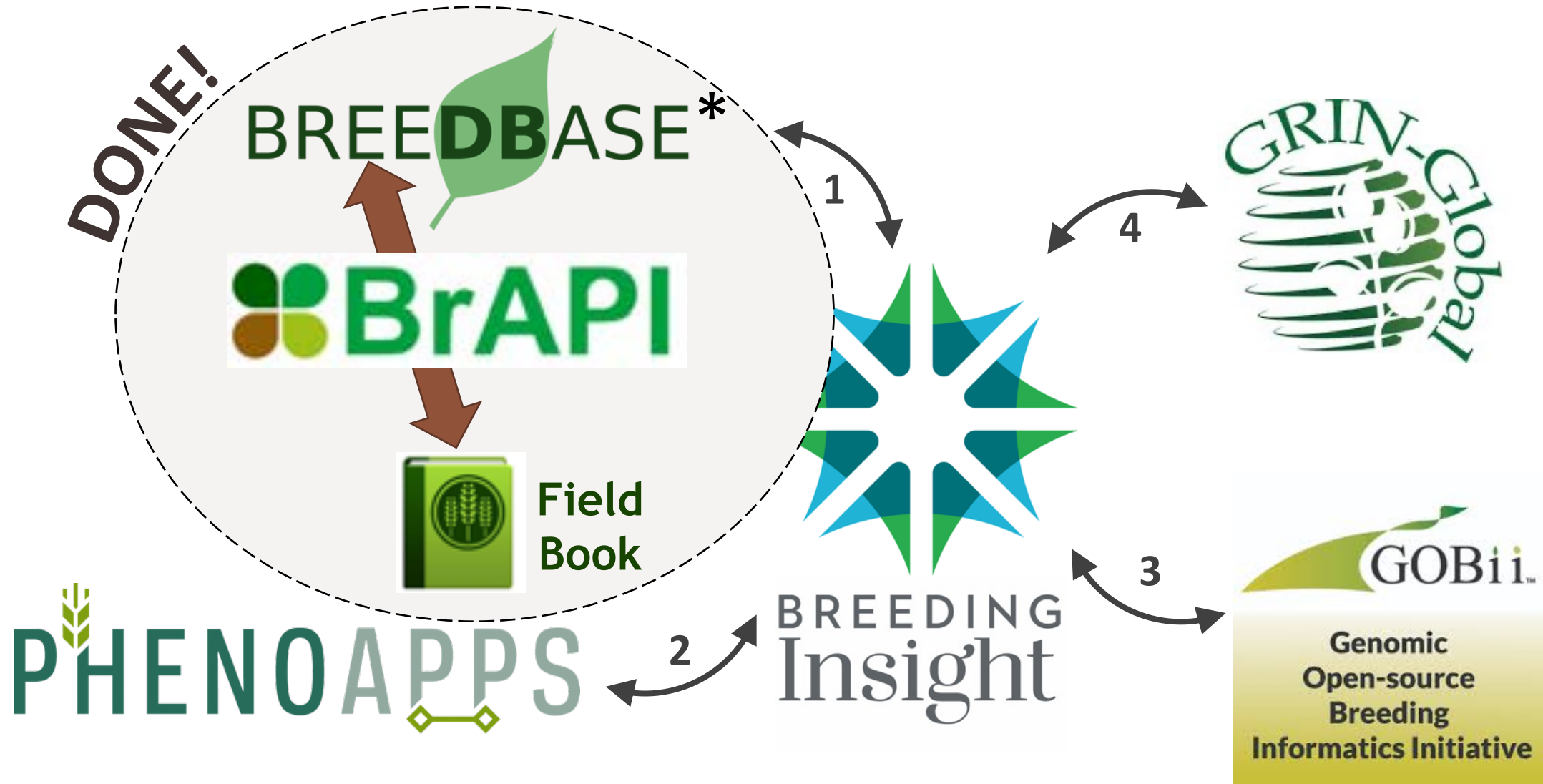
[Cancel](#)

NEXT ->



Completed and ongoing software development

Targeted software integrations





What is Field Book (v4.1)?

- An Android mobile app (see PhenoApps (Trevor Rife at KSU)).
- Used by breeders to facilitate:
 - Trial data collection, including photographs
 - Replacement of hard-copy field books with a digital media
 - Note collection in remote locations
 - Reduce (elimination) transcription errors

What is BreedBase?

- Breeding management system with analytic capabilities (Lukas Mueller at BTI).
- Used by breeders to:
 - Manage seed lots and pedigrees
 - Manage traits and methods
 - Design trials and create field layouts
 - Hold and use phenotypic data
 - Design tissue-collection layouts
 - Hold and use genotypic data
 - Run genomic analyses, like Genomic Selection

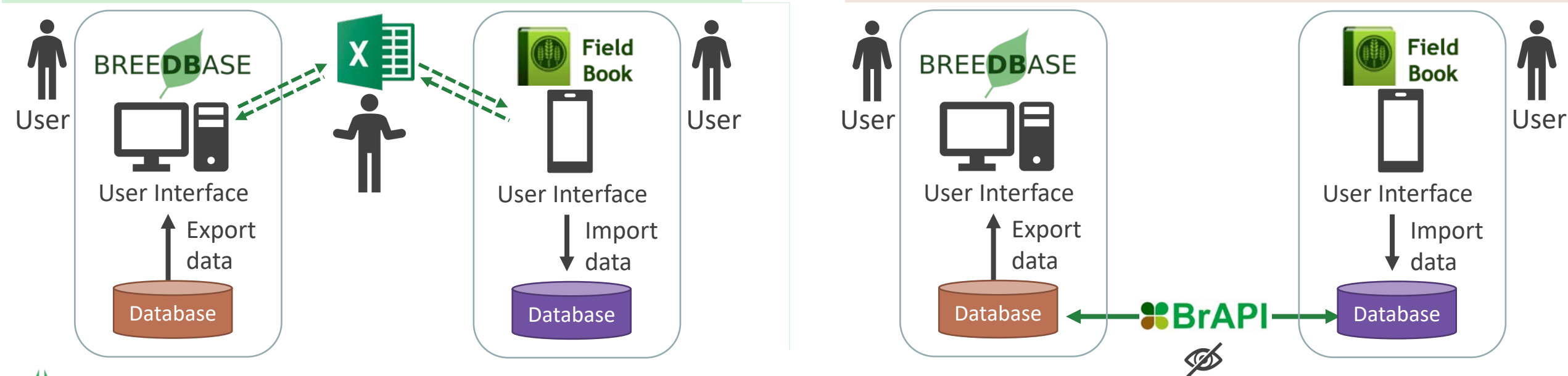
What is BrAPI?

- BrAPI is short for Breeding Application Programming Interface
 - It is a protocol for getting different software to talk to each other quickly.
 - **As a user, one should never have to see or know any specifics about it.**

Manual file transfer

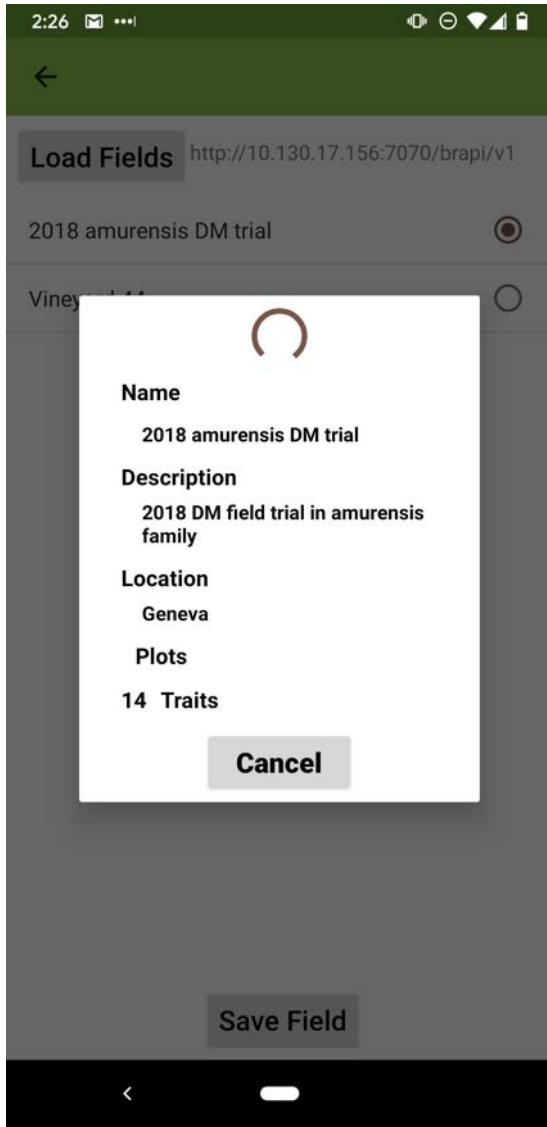
versus

Automated file transfer

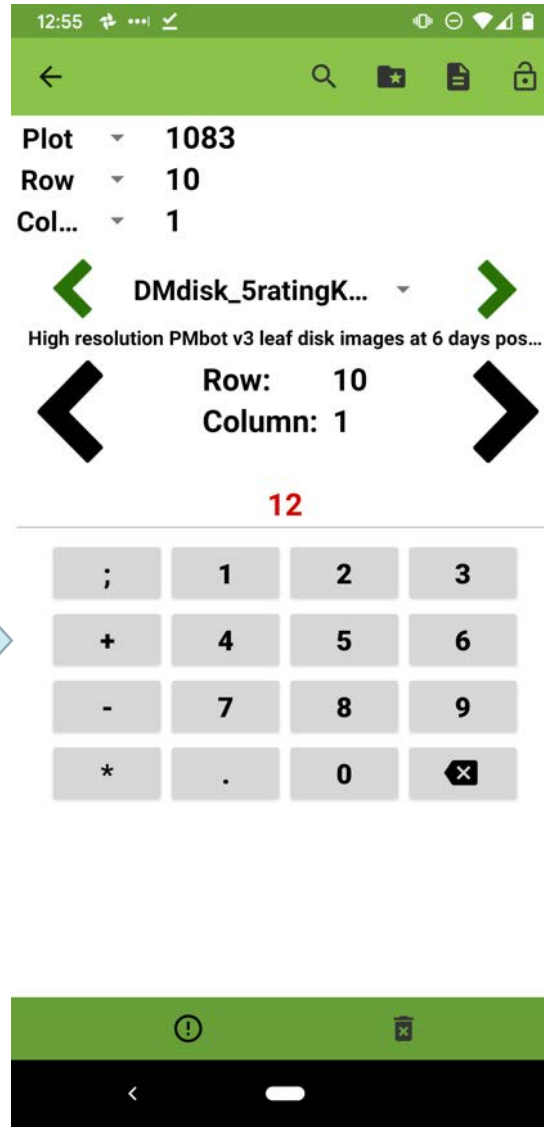


Field Book integration with BreedBase via BrAPI

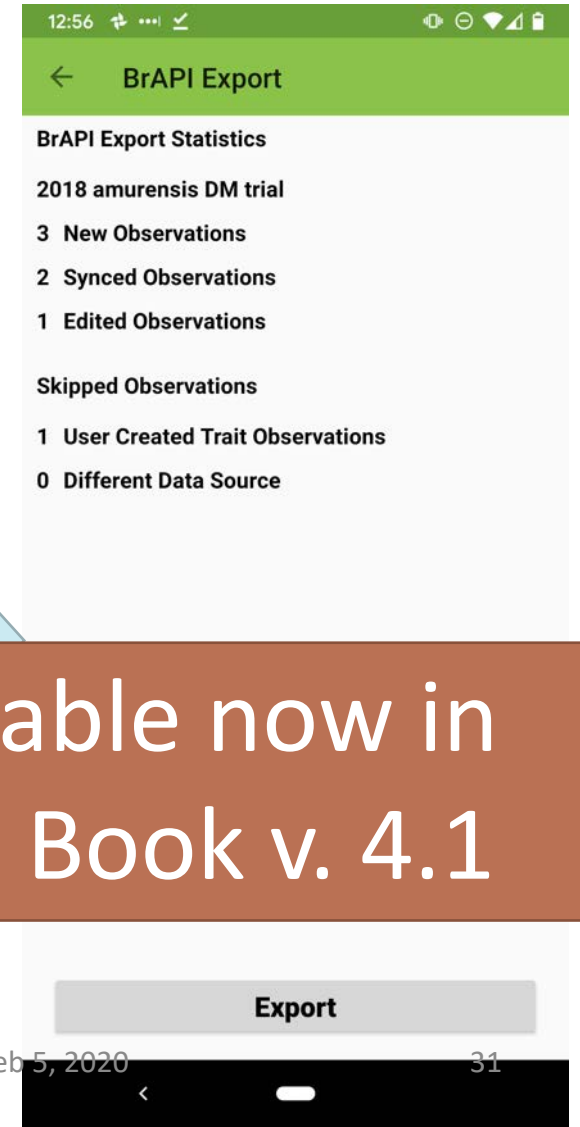
Load field from BreedBase



Collect phenotypes



Export data to BreedBase



Available now in
Field Book v. 4.1



Next BI Software Priorities

Now:

- ✓ *Ontology microservice* – for creation and management of traits
- ✓ *Program management design* – flowcharting step and decisions points

Upcoming:

- ❑ *Historical data load microservice* – for data previously stored as flat files.
- ❑ *Inventory management microservice* – expansion of the types of inventory that can be held (tissue culture, pollen, tubers, etc.)

Coming this Fall:

A one-week training course on:

1. Deploying and using BI software
2. Using Field Book v4.1 (or later) for data collection

Thank You

Acknowledgements

ARS PIs:

Ed Buckler
Jean-Luc Jannink

BI Staff:

Siva Tirumalaraju
Kirsten Richardson
Chris Tucker
Dongyan Zhao
Katherine Mejia-Guerra

Tim Parsons
Liz Woods
David Meidlinger
Nick Palladino

Funding and Support

U.S. Department of Agriculture – Agriculture Research Service
Cornell University

