

Breeding Insight

Creating breeder-centric software & integrated data management solutions

September 28, 2020

10:00 am EDT / 4:00 pm CEST

Moira Sheehan (Cornell University)

Excellence in Breeding Webinar

Zoom link: <https://us02web.zoom.us/j/86225024481?pwd=VU93NkxOeUVWQmdwT2hZRnhValdsQT09&from=msft>



Topics

- 1. Breeding specialty crops and animals
- 2. Breeding Insight
 - a. Mission and pilot program
 - b. What's next



Common species in breeding



Beef cattle

Corn (maize)

Chicken

Soybean

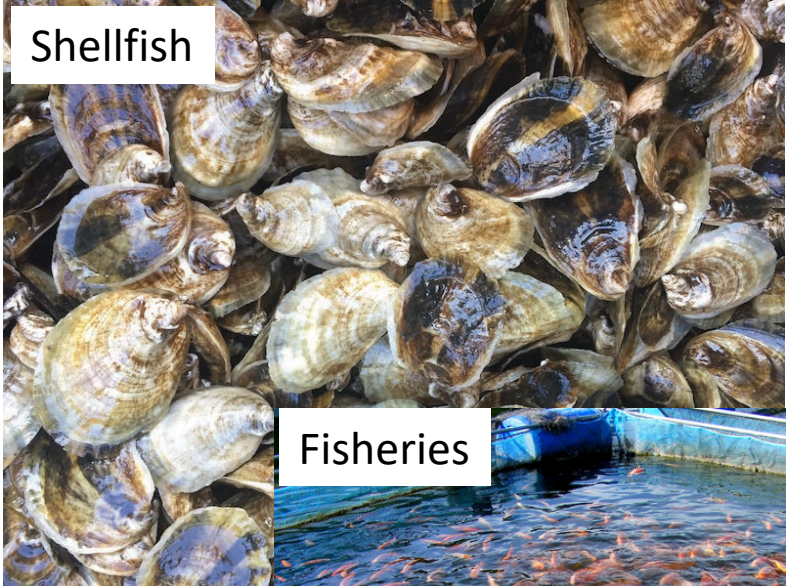
32 million head
~\$70 billion dollars

~89 million US acres
\$52 billion dollars

528 million birds
~\$32 billion dollars

~89 million US acres
~\$39 billion dollars

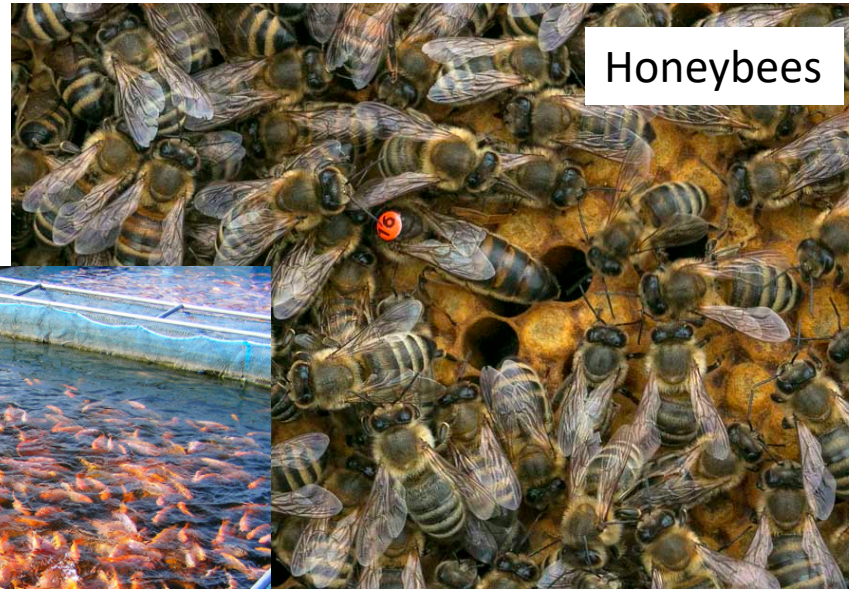
What are specialty animals?



Shellfish



Fisheries



Honeybees



Llama

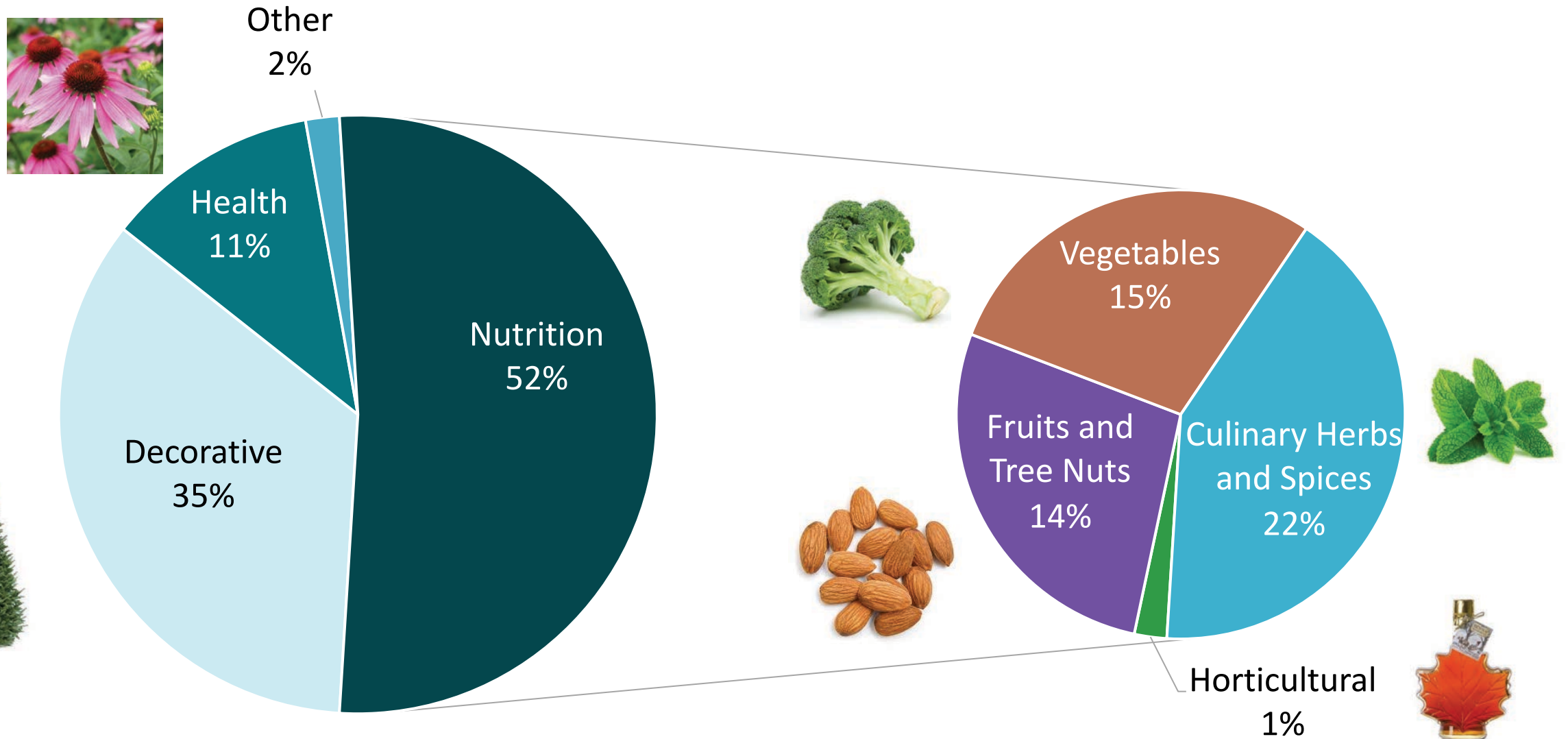


Alpaca



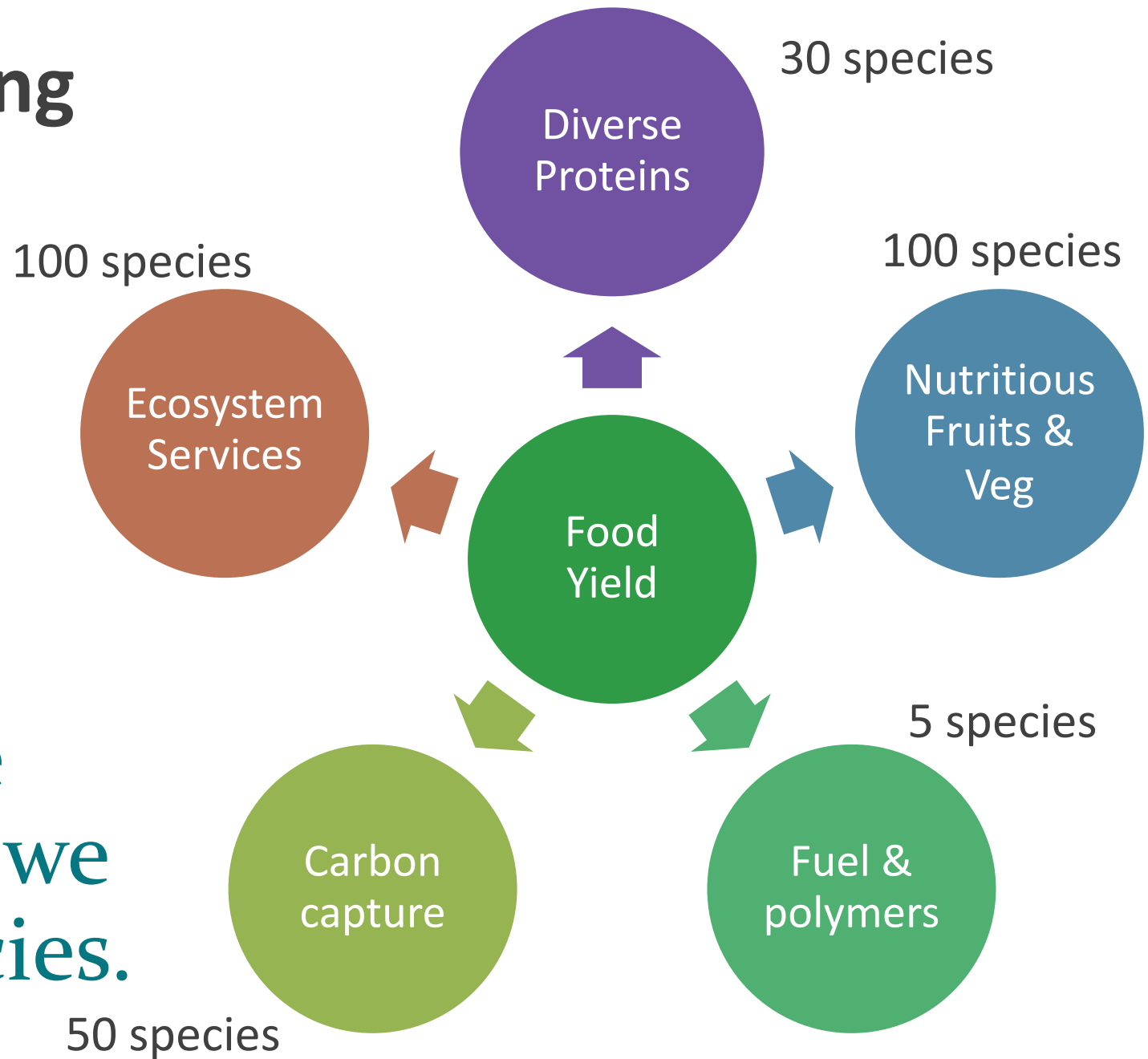
What are specialty crops?

Breakdown of 329 Specialty Crops by Human Use



Most advanced breeding & investment focused on ~15 species.

Creating global food security & alternative sources requires that we breed for 100s of species.



Breeding Insight



Mission

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

Building Breeding Insight (BI)

- **Start with 6 pilot **specialty** species**
 - Current breeding program
 - Breeding program wants and needs
- **Provide resources by making connections**
 - Genotyping platforms/providers to data management
 - Phenotyping to data management
 - Breeding consultation and support
- **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

Rainbow Trout ↴



Blueberry



Atlantic Salmon ↴



Sweetpotato →



Alfalfa



Table Grape

The BI Team

Science Team



Siva Tirumalaraju, PhD
Sr. Program Manager



Dongyan Zhao, PhD
Genomics Coordinator



Katherine Mejia-Guerra, PhD
Bioinformatics Coordinator



To Be Hired
Phenomics Coordinator

Dev Team



Tim Parsons
Lead Developer



Liz Woods
UI/UX Designer



Nick Palladino
Application Programmer



Dave Meidlinger
Application Programmer



Chris Tucker
Application Programmer



Deb Weigand
Systems Analyst/Software QA

Admin & Comms



Moira Sheehan, PhD
Director



Kirsten Richardson
Exec Admin Asst



Vanessa Greenlee
Comms Lead

Know your breeders

Special Challenges

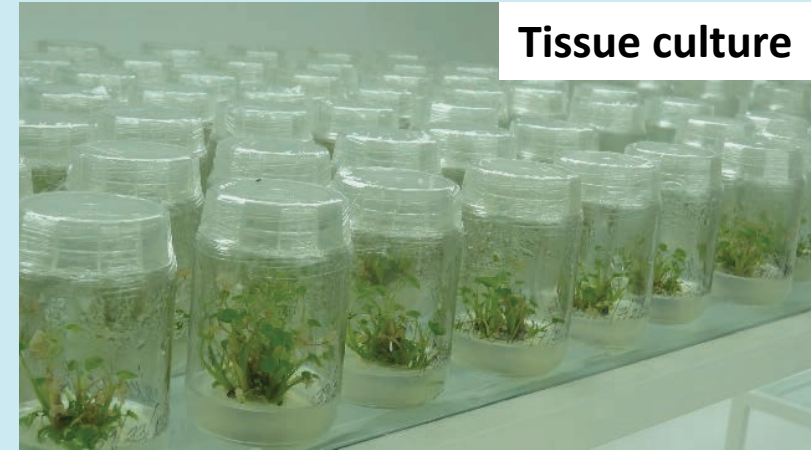
Logistical challenges

- X Long generation cycles and specialized propagation
- X Inventory is more than just seeds
- X Lack of surplus budget to upgrade or expand
- X Small workforce

Technical challenges

- X Flooded high-throughput phenotyping market
- X Heterogeneous historical data
- X Remote data collection/extreme conditions
- X Lack of genetic data and resources

Biological & other challenges (see next slide)



Special Challenges

Complex genome (4x & 6x)
 Few genetic tools available
 Long cycle time (4 years to yield)
 Lack of quantitative trait data



Sweetpotato ->



Alfalfa



Table Grape

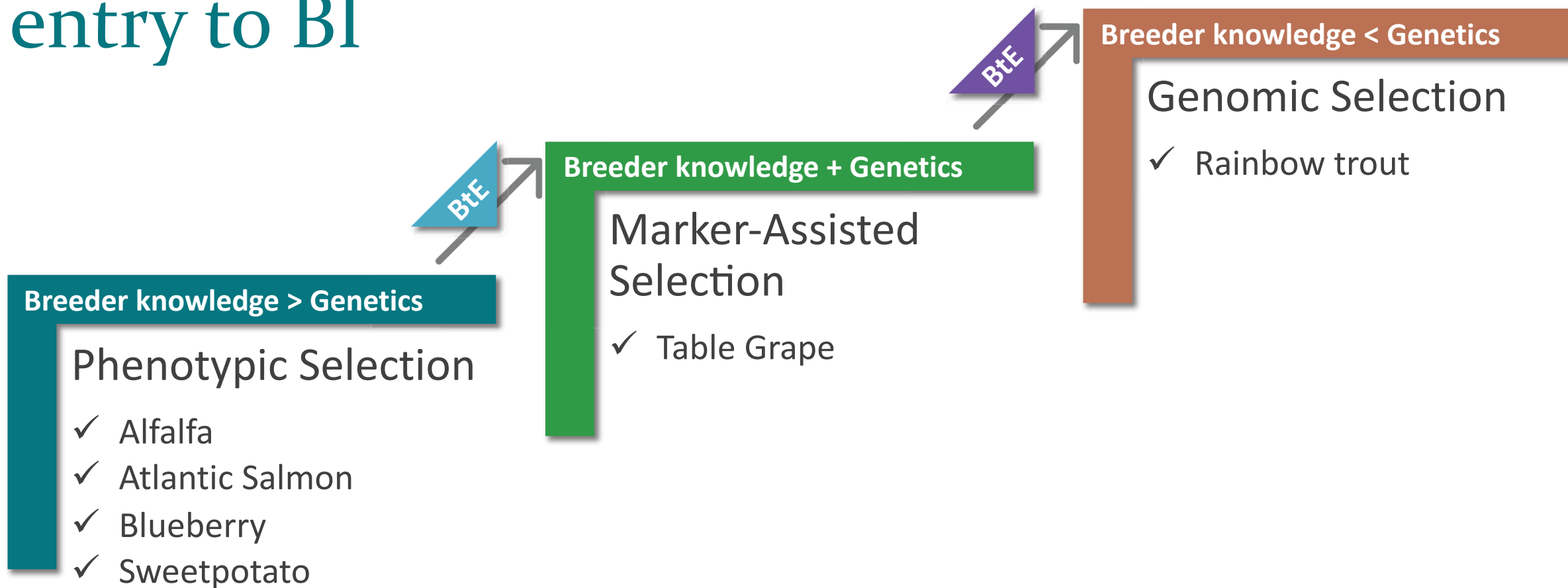
Simple genome (2x)
 Genetic markers available
 Very high cost of genotyping
 80% of traits are lethal

Simple genome (2x)
 No genetic markers
 80% of traits are lethal
 Data collection is not digital

Complex genome (6x)
 Few genetic tools available
 Highly heterozygous
 Clonally propagated

Simple genome (2x)
 Highly heterozygous
 Wild vines are either ♂ or ♀
 Want seedless products

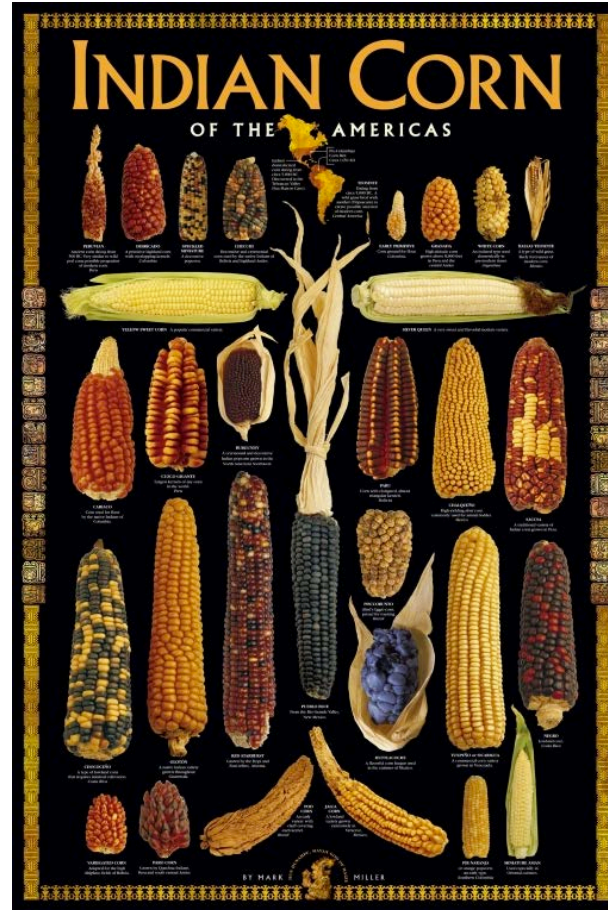
Program capabilities upon entry to BI



BtE **Barriers to Entry (BtE):** the culmination of all the logistical, technical, and biological challenges preventing technology adoption or program growth.

The importance of the Breeder's Eye

- ★ Most of the progress made to date in breeding was done by eye through phenotypic selection.
- ★ Phenotypic selection while easy to adopt, takes years to perfect.



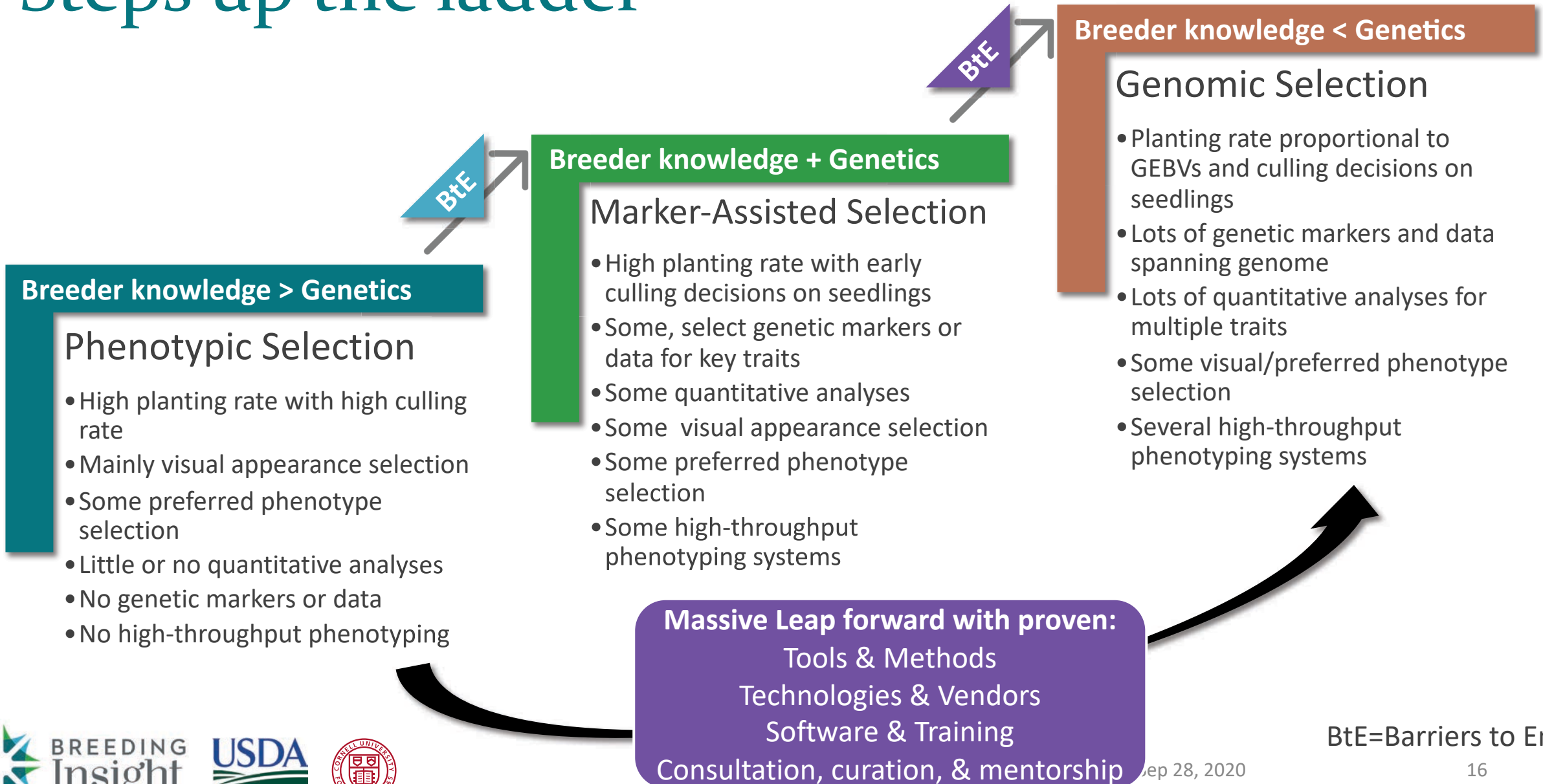
So why add genomics?

- Sequencing technology is accessible and affordable for all species.
- We know a lot about genomes and transcriptomes, and it's growing daily.
- Breeders have a lot of information to collect, assimilate, and act upon in short windows of time with fixed constraints.
- Breeders don't get to see if they were "right" until it's too late to change course.

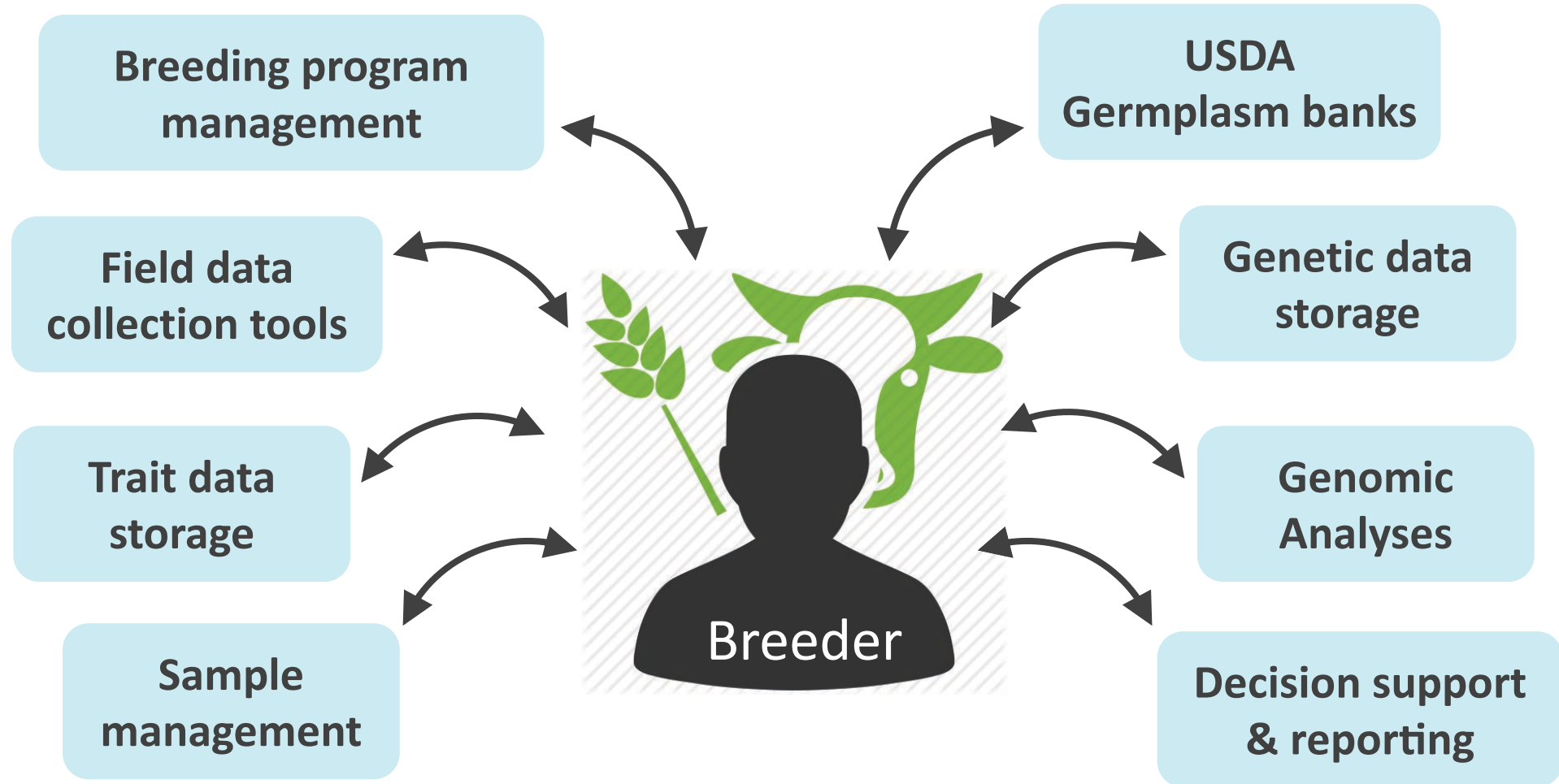
By supplementing the breeder's eye with genomic data, analytics, and prediction models, we can free breeders from grunt work and reduce uncertainty within the program's constraints.

Do more breeding!

Steps up the ladder



What a breeder needs to make good progress



Breeding Cycle “Digital Ecosystem”



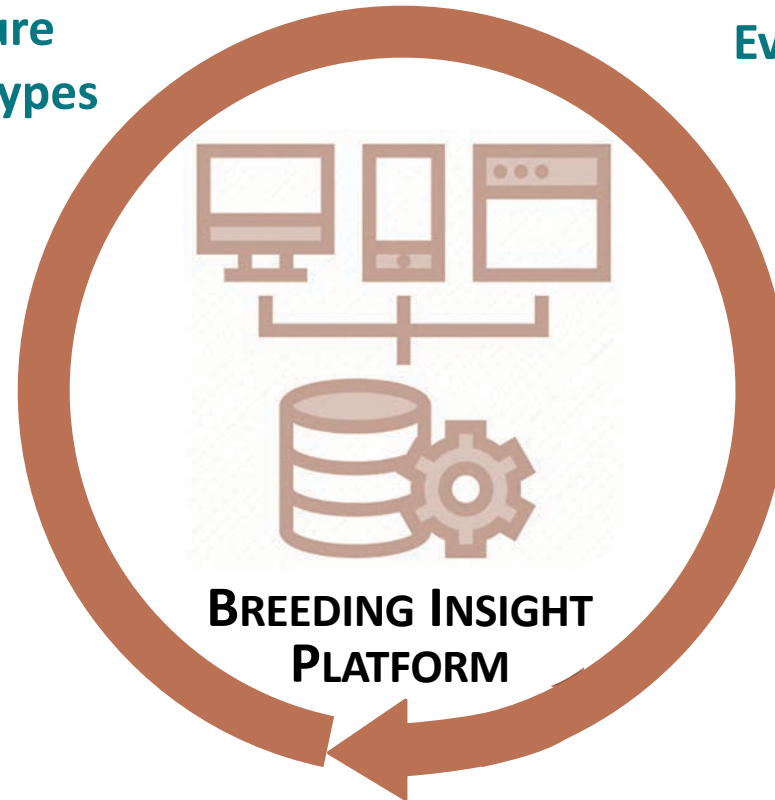
Capture phenotypes



Evaluate genotypes
Evaluate phenotypes



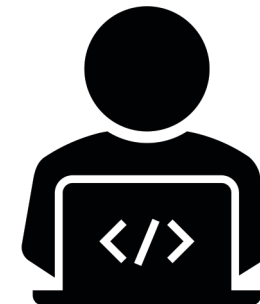
Manage stocks & pedigrees
Perform crosses
Design & manage trials



BREEDING INSIGHT
PLATFORM

Make:

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



Breeding Cycle “Digital Ecosystem”



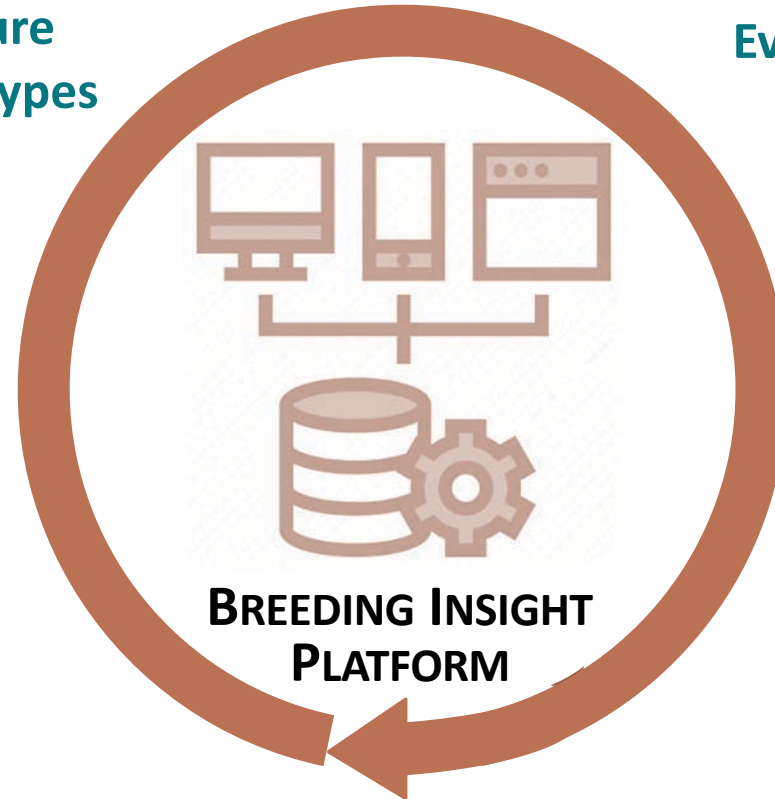
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Evaluate genotypes
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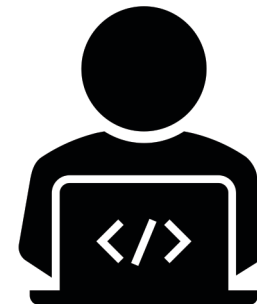
Maintain base populations
Manage pedigrees
Manage animal welfare
Perform crosses



BREEDING INSIGHT
PLATFORM

Make:

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



Breeding Cycle “Digital Ecosystem”



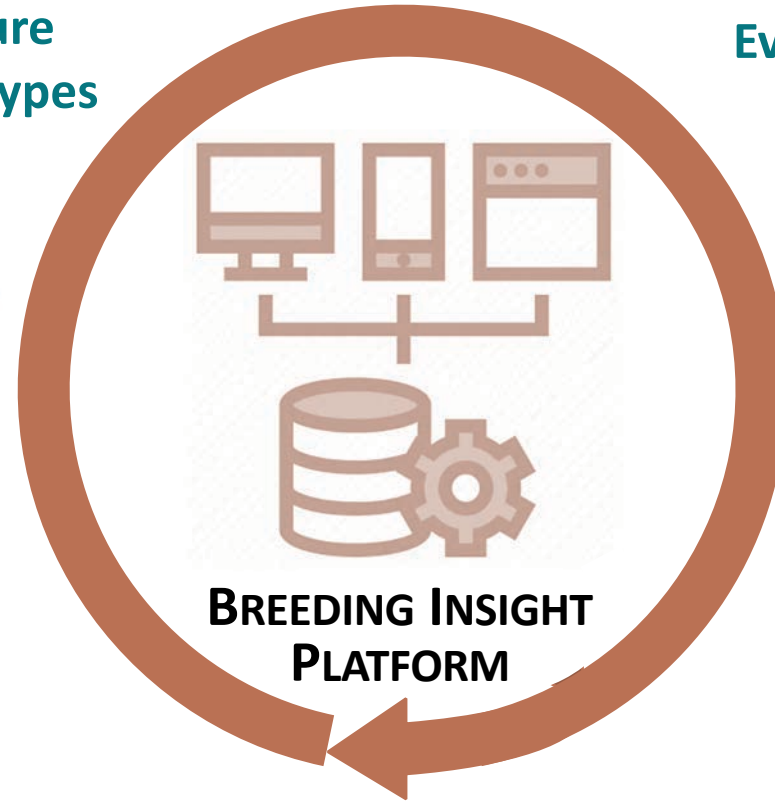
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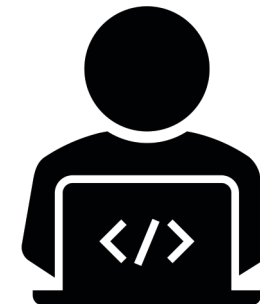


Maintain base populations
Manage pedigrees
Manage hives
Perform crosses



Make:

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



Okay, so what systems does a breeder use?

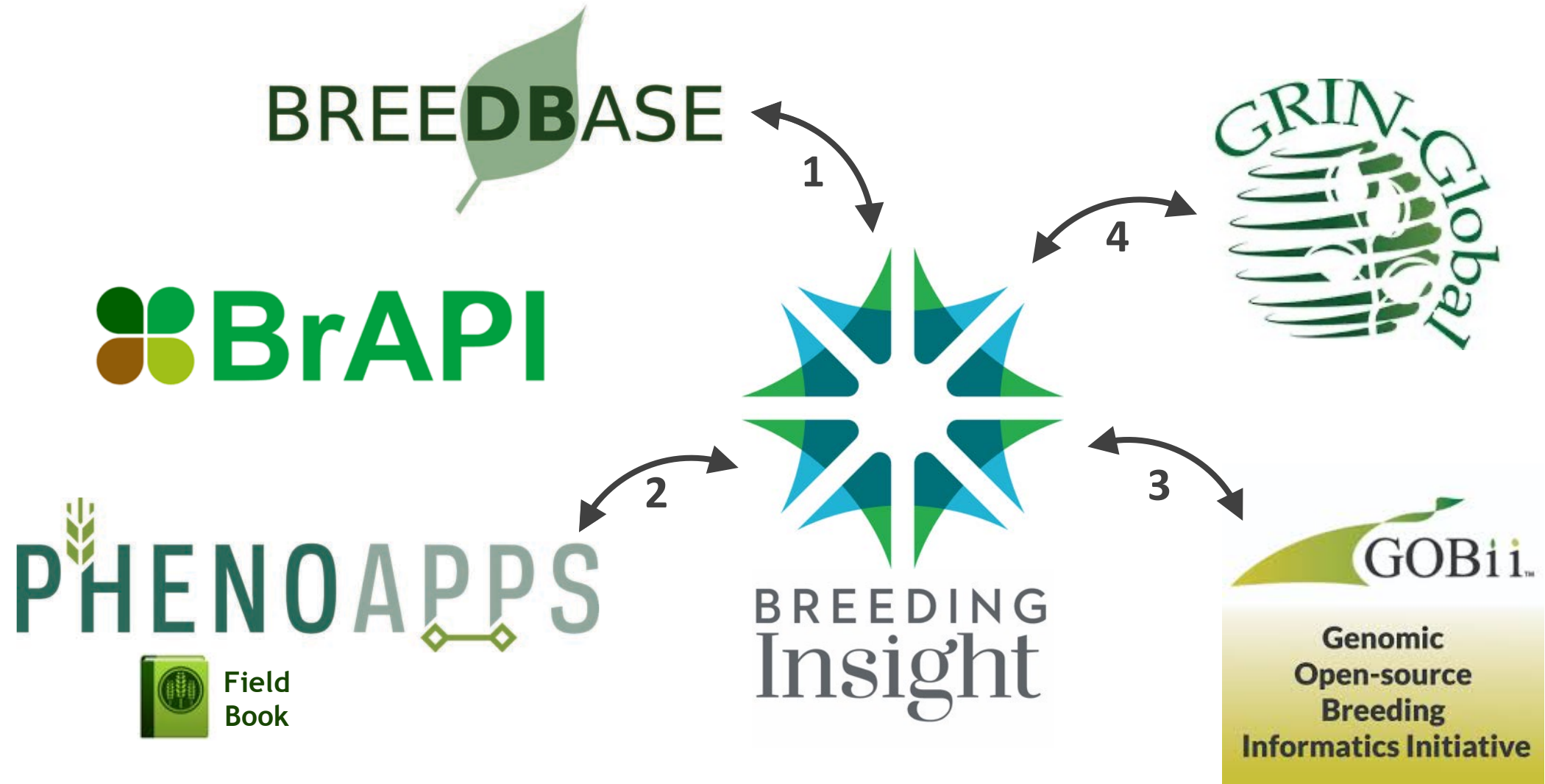
BREEDBASE



Genotype Investigator for Genome Wide Analyses



BI's Initial Platform



Breeding Insight's Design Approach

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 and animals

Logical Task Groups

- Customized to breeders' work cycles and program activities

Interconnectivity

- Priority on the ability to share data across software tools

Screenshots of BI's Trait Management

BREEDING Insight Sweetpotato

Logged in as **Ima Fyne Breeder** [My Account](#) [Logout](#)

Traits

All traits

[Add to Favorites](#) Select option

Name	Level	Method	Scale	
Plant Type	Plant	Observation	Nominal scale (4)	
Ground Cover	Plant	Observation	Ordinal scale (4)	
Twining	Plant	Observation	Ordinal scale (5)	
Predominant Vine Color	Plant	Observation	Nominal scale (9)	
Secondary Vine Color	Plant	Observation	Nominal scale (8)	
Vine Tips Pubescence	Plant	Observation	Ordinal scale (4)	
Vine internode length	Plant	Measurement	Ordinal scale (5)	
Vine internode diameter	Plant	Measurement	Ordinal scale (5)	>
General Outline of the Leaf	Plant	Observation	Nominal scale (7)	
Leaf Lobe Type	Plant	Observation	Ordinal scale (6)	
Leaf Lobe Number	Plant	Observation	Ordinal scale (5)	
Shape of Central Leaf Lobe	Plant	Observation	Nominal scale (10)	

Vine internode diameter

VniND, Internode Diameter

Measurement in a 5-point scale

1 = Very thin (< 4mm)
 3 = Thin (5 - 7mm)
 5 = Intermediate (7 - 9mm)
 7 = Thick (10 - 12mm)
 9 = Very thick (> 12mm)

Description of collection method

Find the internode diameter, measure with caliper and then round up or down.

Previous 1 ... 9 10 11 ... 20 Next

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View trait details

BREEDING Insight Sweetpotato

Logged in as **Ima Fyne Breeder** [My Account](#) [Logout](#)

Traits

All traits

Create new trait

Trait name

Trait name

All Unicode characters accepted

is collected on Select...

Select...

using Select...

Note: additional options for this field will appear after selection

[Save](#) [Cancel](#)

Description of collection method

Abbreviation(s)

Comma separated list, with primary abbreviation as the first term

Synonyms

Comma separated list

Name	Level	Method	Scale	
Plant Type	Plant	Observation	Nominal scale (4)	Show details >
Ground Cover	Plant	Observation	Ordinal scale (4)	Show details >
Twining	Plant	Observation	Ordinal scale (5)	Show details >
Predominant Vine Color	Plant	Observation	Nominal scale (9)	Show details >
Secondary Vine Color	Plant	Observation	Nominal scale (8)	Show details >
Vine Tips Pubescence	Plant	Observation	Ordinal scale (4)	Show details >

Screenshots of BI's Program Management

The screenshot shows the 'Program Management' interface with the 'Locations' tab selected. A table lists various locations and the number of experiments associated with each.

Location Name	# Experiments
Alternate greenhouse	3
Better labeling for locations	10
capitalization	3

Location management

The screenshot shows the 'Program Management' interface with the 'Users' tab selected. It displays a form for adding a new user and a table of existing users.

Name	Email	Role
Ann Other Budy	Ann.otherbudy@usda.gov	Breeder
Ima Fyne Breeder	ima.breeder@usda.gov	Breeder
Somme Bodie	somme.bodie@usda.gov	Field Manager

Manage and add Users

The screenshot shows a green success message at the top of the 'Users' tab: 'Success! Manny Newnames added.' Below the message is a table of users, including the newly added 'Manny Newnames'.

Name	Email	Role	Edit	Deactivate
Ann Other Budy	Ann.otherbudy@usda.gov	Breeder	Edit	Deactivate
Ima Fyne Breeder	ima.breeder@usda.gov	Breeder	Edit	Deactivate
Somme Bodie	somme.bodie@usda.gov	Field Manager	Edit	Deactivate
Manny Newnames	manny@newnames.com		Edit	Deactivate

Success!

Public Sandbox Site

This is a sandbox site open to the general public.

- Anything you submit to this site is viewable by others. Please use discretion and courtesy.
- Data submitted to this site is not private in any way. Only enter data that is cleared for public viewing.
- This site is refreshed regularly as development updates occur to demonstrate new features. **The database is frequently deleted during updates.**
- [Send feedback or report issues](#) to the development team.

I understand, close this message

Combining genomics and informatics to accelerate genetic gains

Part of a Breeding Insight program?

LOG IN

Our current specialty breeding programs:

BLUEBERRY



ALFALFA



SALMONIDS



GRAPE



SWEET POTATO



Our Mission

By combining genomics with the powerful tools of informatics, breeding for genetic gain has undergone a revolution. But due to high-costs, some smaller breeding programs have been left behind. The mission of the Breeding Insight team is to make high-tech breeding a reality for smaller programs.

Breeding Insight is funded by the U.S. Department of Agriculture (USDA) Agricultural Research Service (ARS) through Cornell University. The USDA ARS delivers scientific solutions to national and global agricultural challenges. As a global leader in agricultural discovery through scientific excellence, ARS is committed to delivering cutting-edge, scientific tools and innovative solutions for American farmers, producers, industry, and communities to support the nourishment and well-being of all people; sustaining our nation's agroecosystems and natural resources; and ensuring the economic competitiveness and excellence of our agriculture.

Coordinator Sandbox Site

Coordinator Sandbox

- Data submitted to this site is private, but may be shared if screenshots or Zoom sessions with other groups are shared. Only use data that is cleared for public viewing.
- This database will be refreshed by the development team on request. If there is a need to delete data that you have submitted, contact the development team for assistance. [If you find a bug or need support, use this link.](#)

I understand, close this message

Combining genomics and informatics to accelerate genetic gains

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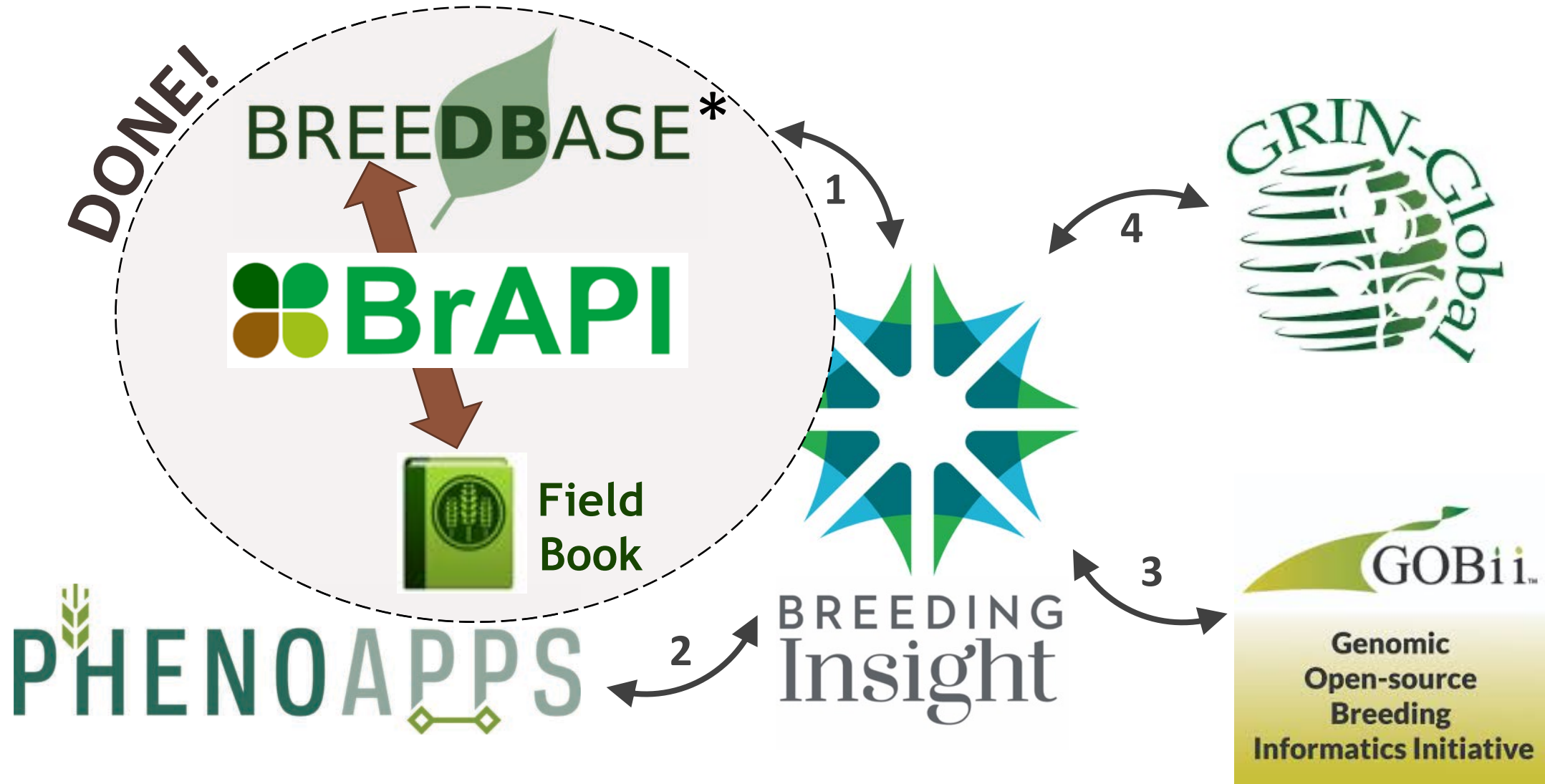


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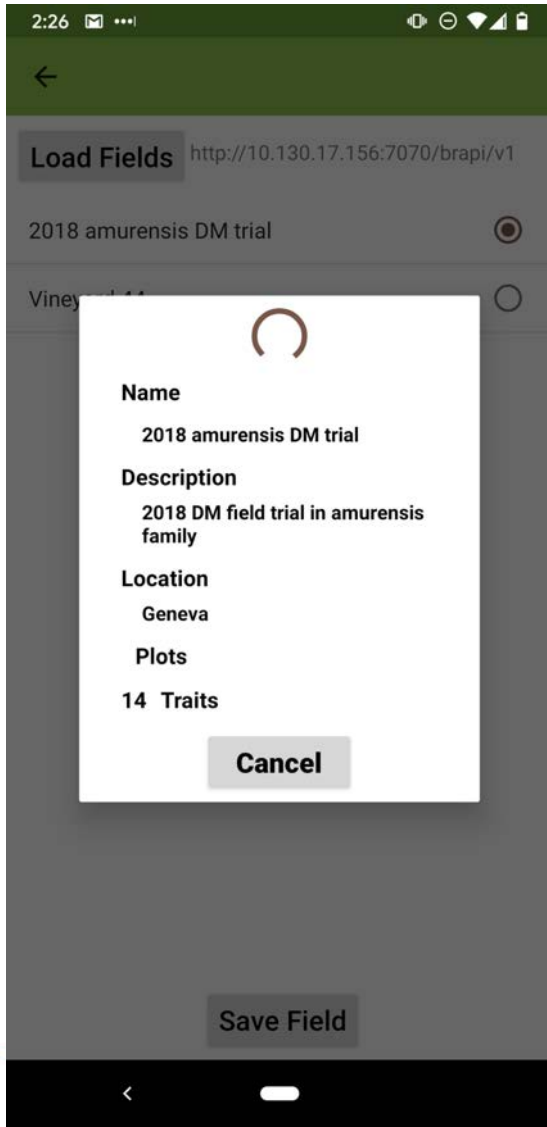
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Targeted software integrations

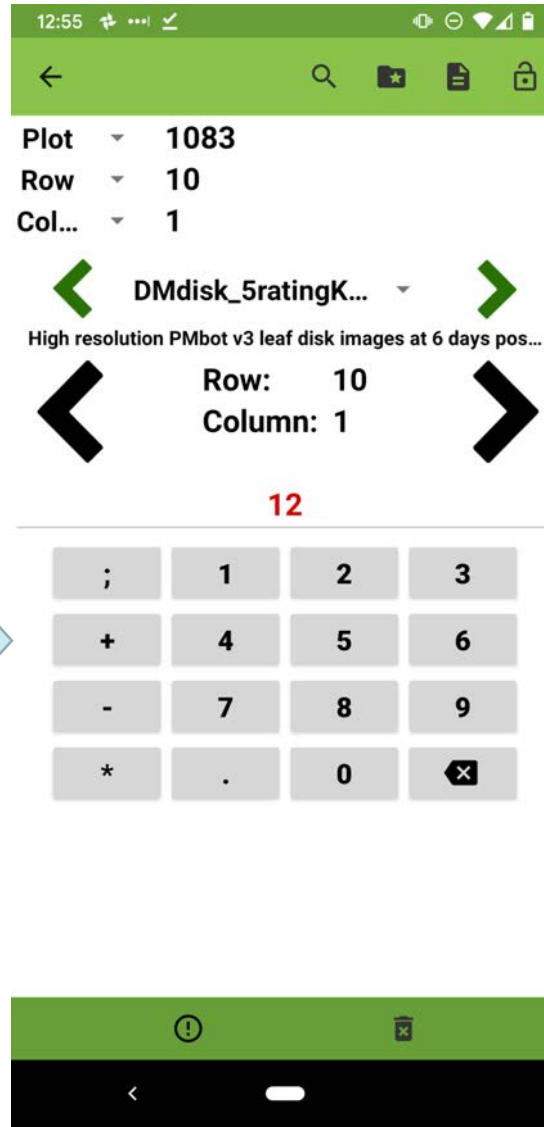


Field Book integration with BreedBase via BrAPI

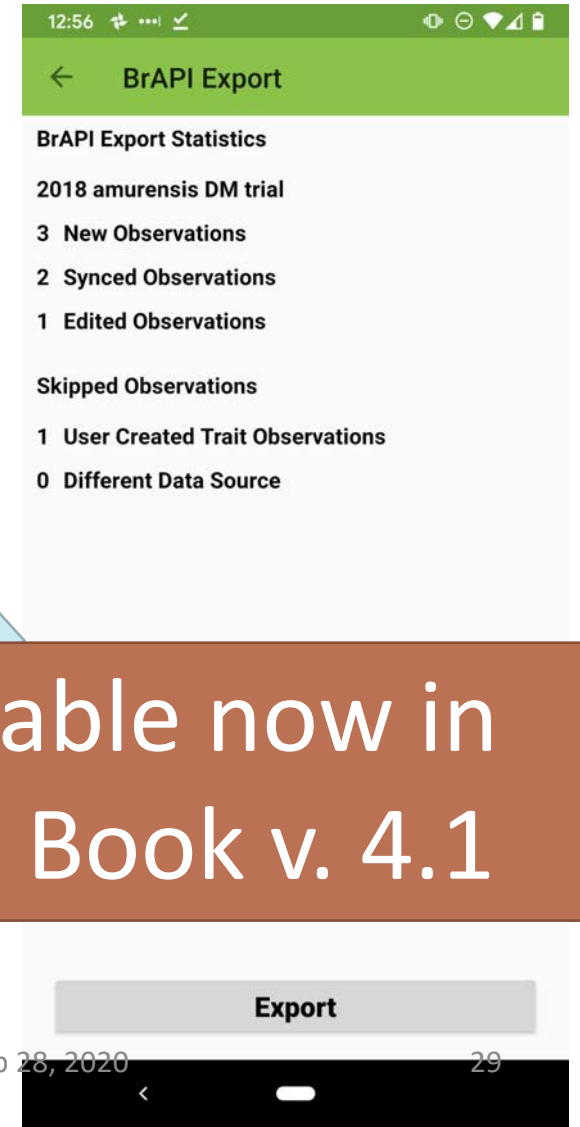
Load field from BreedBase



Collect phenotypes



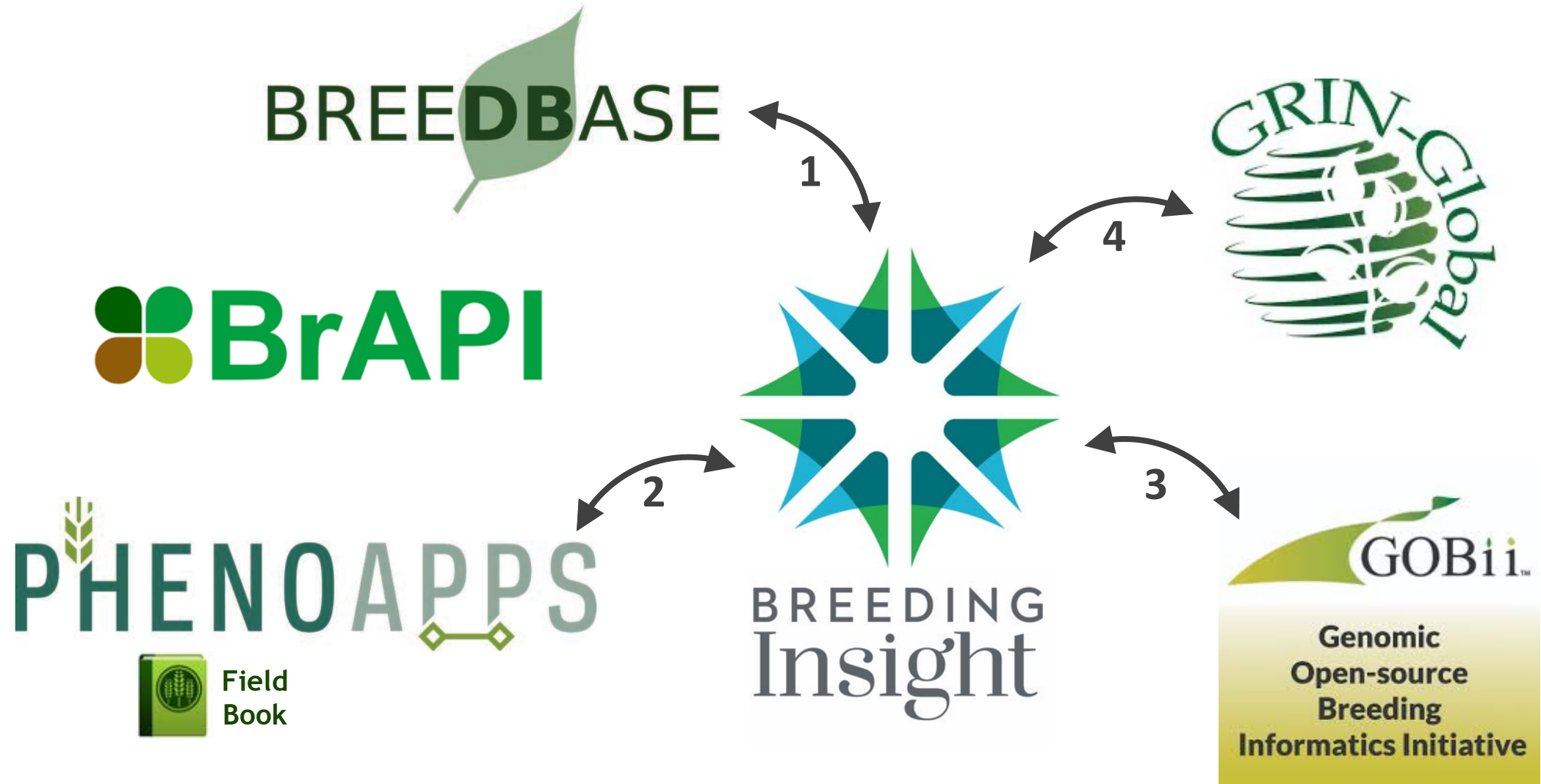
Export data to BreedBase



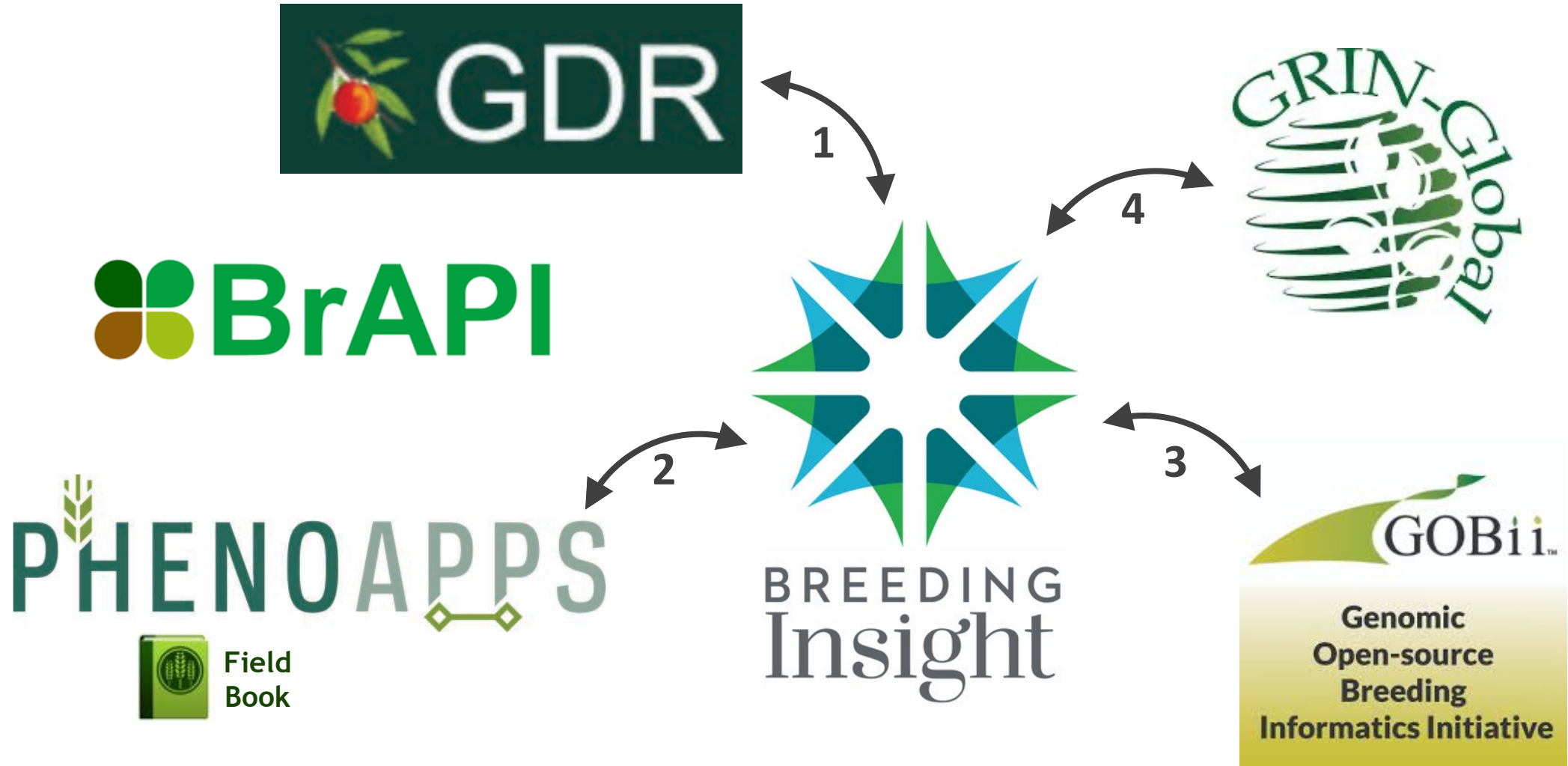
Available now in
Field Book v. 4.1



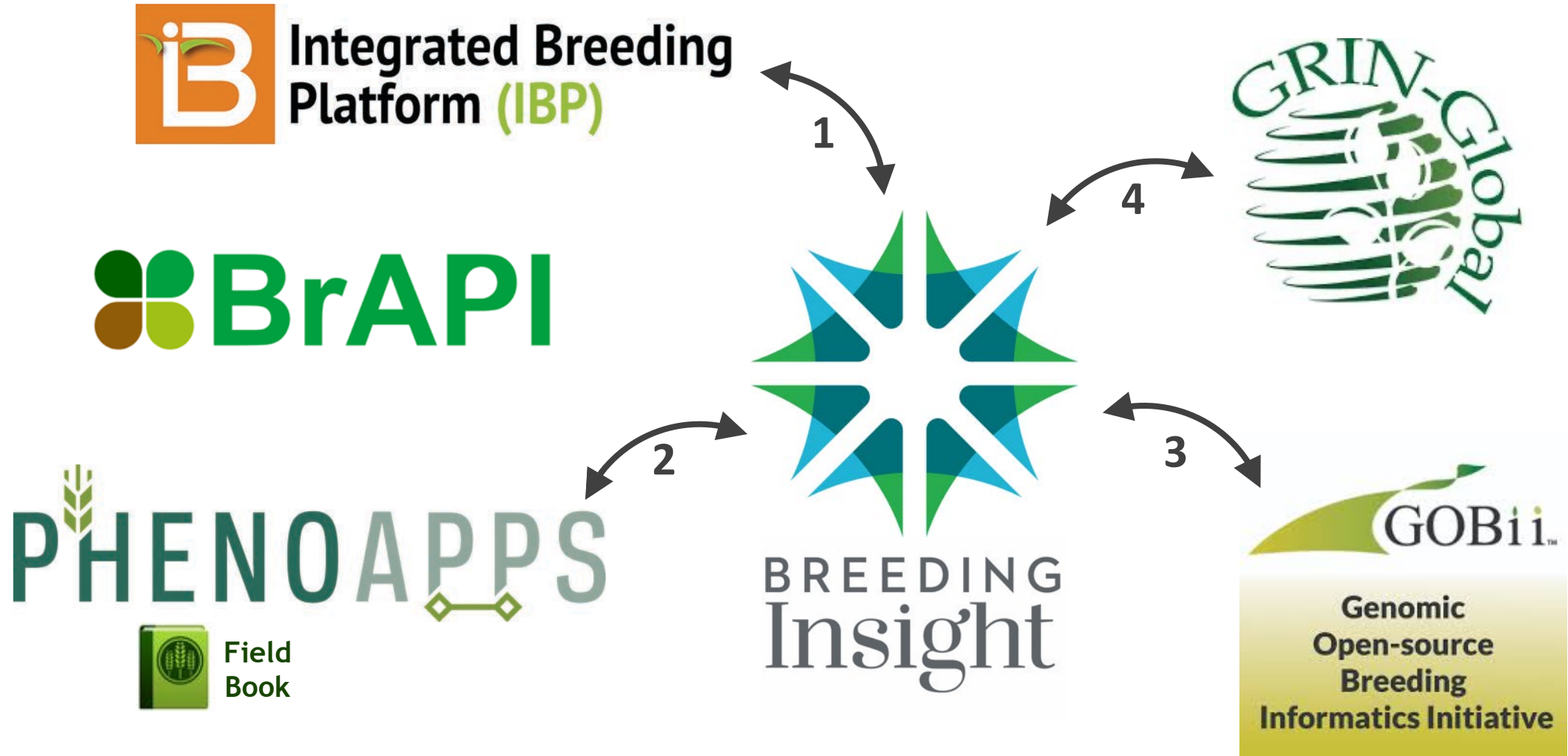
BI platform allows for flexibility



BI platform allows for flexibility



BI platform allows for flexibility



BI's leveraging tools in the global community



Module 3:
Volume pricing
for genotyping



Module 5:
Bioinformatics,
Software



Feed the Future
Innovation Lab for
Crop Improvement



Collaborators

Partners

Public access to BI development efforts

- GitHub Repositories - <https://github.com/Breeding-Insight>
 - BI-API – RESTful server powering BI-Web and integrating to BrAPI services
 - BI-Web – The web interface of Breeding Insight, powered by Vue.js
 - brapi – Java-based RESTful client library implementing BrAPI v2.0

Outside of software, what else can BI do?

Genetic Markers

Expanding applications



Grapevine

2K
loci



Rainbow trout

50K
SNPs

Marker development underway at BI

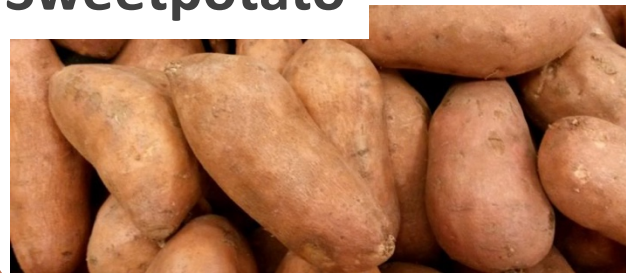
Alfalfa



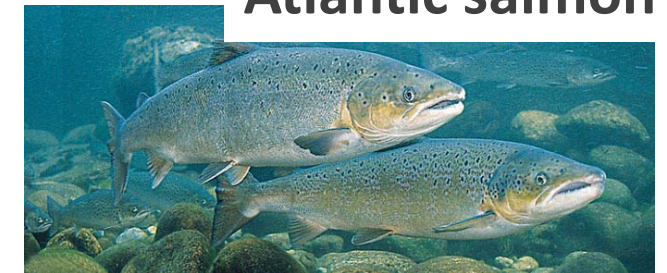
Blueberry



Sweetpotato



Atlantic salmon



Genomic Services and Vendors

Parameters	Mid density
Platform	DArTag
Vendors	DArT & Intertek
Marker number	1000-4000
Cost per sample (384)	\$11 US
Cost per sample (1536)	\$10 US
DNA extraction	Included
Shipping cost	Not included
Turnaround time*	3 weeks

* Longer turn around due to COVID-19.

intertek
Total Quality. Assured.

**Diversity
Arrays
Technology** Pty Ltd

Work with Excellence in Breeding to increase sample volume to lower costs


**Excellence
in Breeding**
PLATFORM 

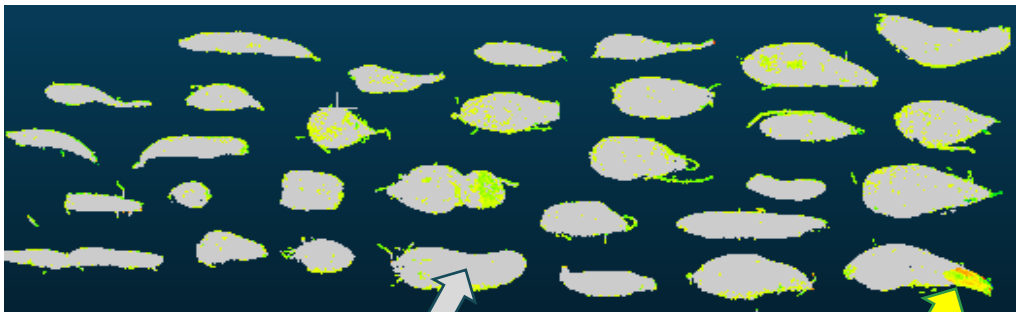
Module 3:
Volume pricing for genotyping

Integrate Phenomic Tools

Phenotyping Sweetpotato tubers



PlantEye F500: Multispectral 3D



Healthy tissue

Insect Damaged

Size and Shape:

- ✓ Length
- ✓ Width
- ✓ Volume
- ✓ Area
- ✓ Tuber grade
- ✓ Counts

Phenotyping vineyards

Handheld tablet with Field Book app:

- ✓ Traits pre-loaded
- ✓ Field pre-loaded
- ✓ Photographs
- ✓ Free text notes
- ✓ Barcode scanner



BI Services

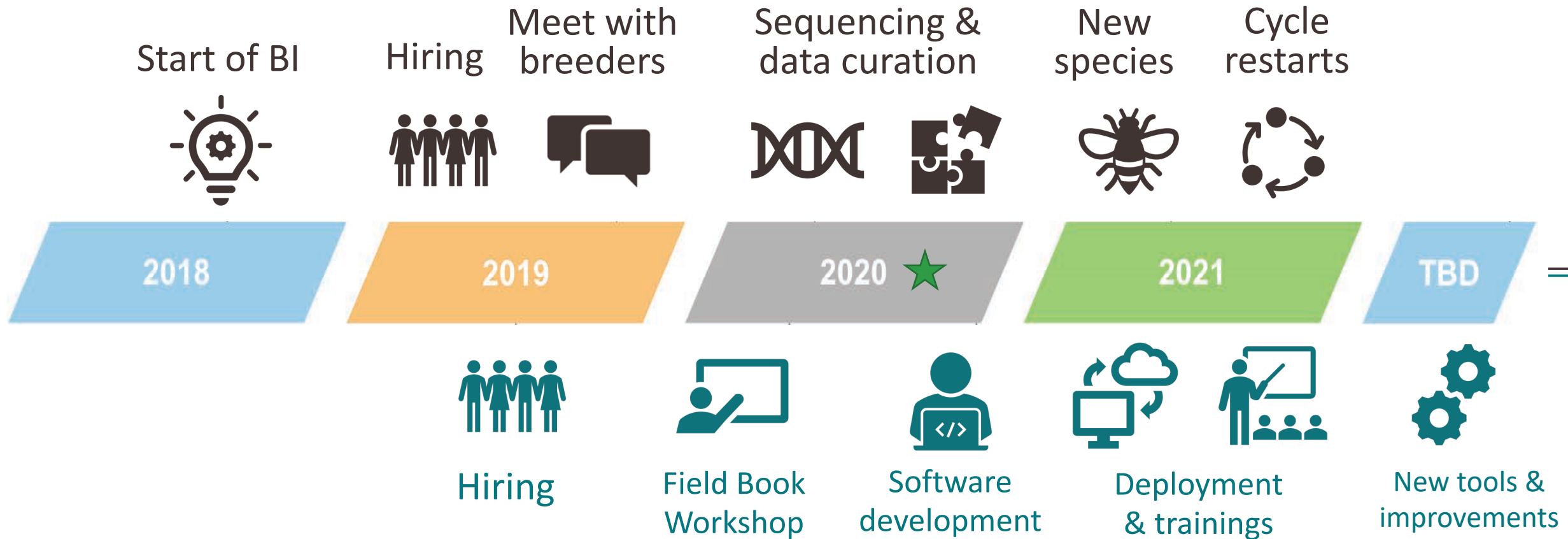
Services	BI's ability to provide
WG sequencing of parents	Excellent
Marker development	Good
Affordable, fast genotyping	Good
Genotypic data management	Good
Phenotypic data management	Excellent
Phenotyping technologies	In progress
MAS & GWAS decision support	In progress
GS support	In progress
Workflow-based software	Excellent
Breeding consultation & curation	Excellent
Animal welfare data management	In progress



What is next for BI?

Timelines and Milestones

BI Scientific



BI Software Development

BI support coming to Southeast Area

- **Breeding Insight On-Ramp (BIONRamp)**
 - Interested ARS commodity groups can initiate participation in a preparatory program to ease the transition into Breeding Insight.
 - About 2-year commitment for OnRamp stage
- **Benefits:**
 - Community organization between ARS programs
 - Establish commodity BreedBase
 - Begin archiving historical breeding program data.
 - Advice on how to structure programs to fast-track through Breeding Insight once enrolled.



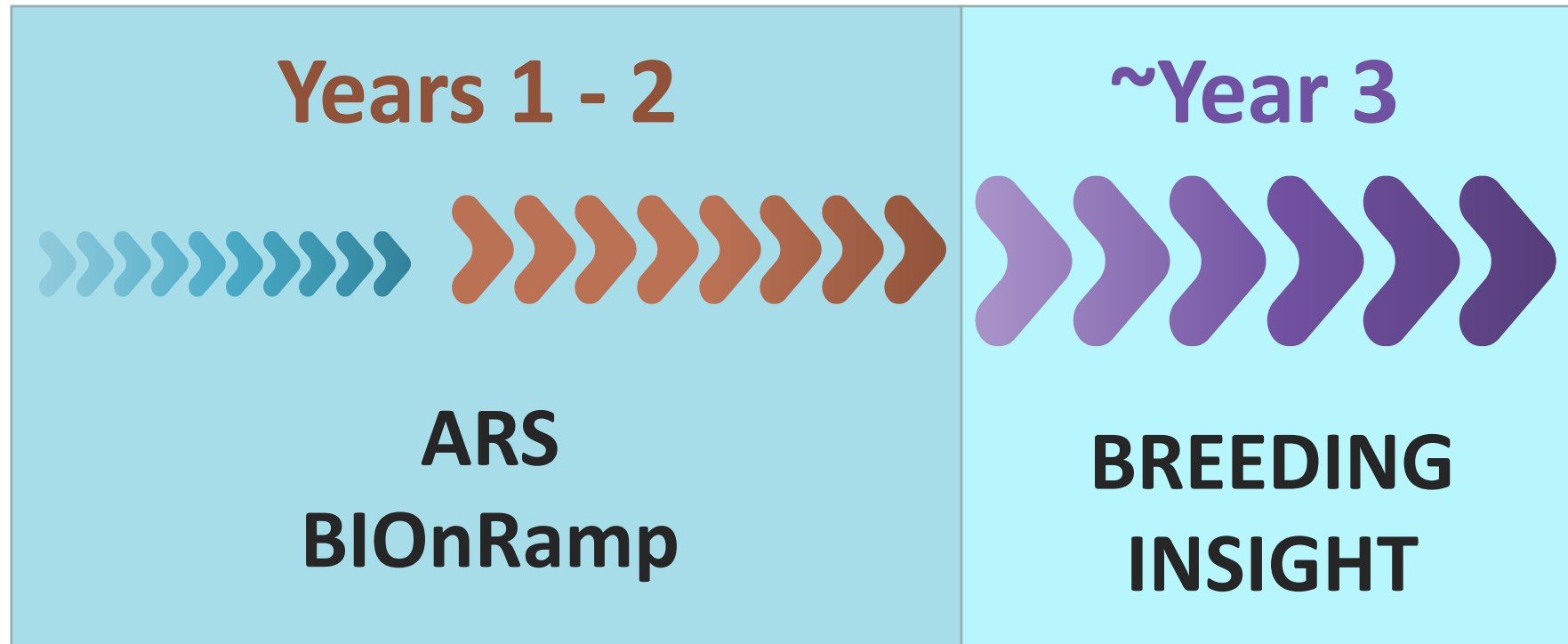
Amanda Hulse-Kemp
Computational Biologist

ARS Genomics and Bioinformatics
Research Unit in Raleigh, NC

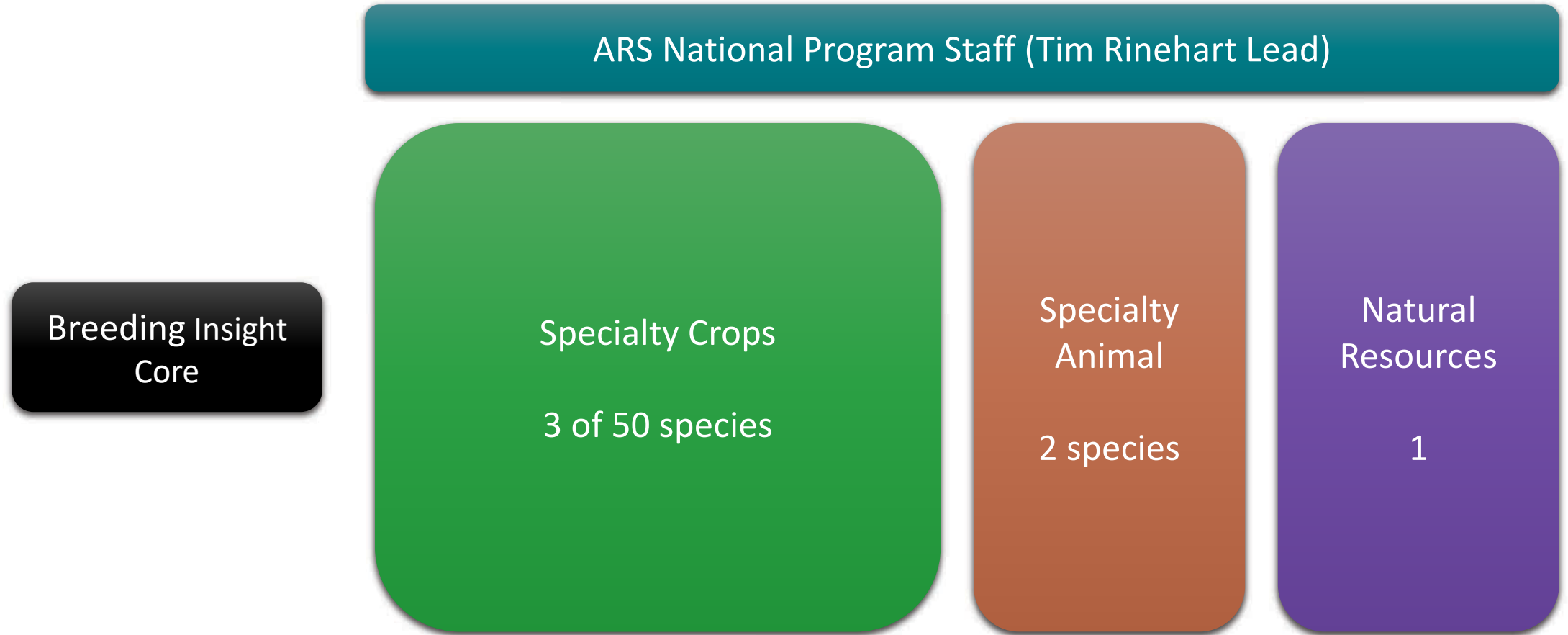
Sep 28, 2020

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BI support coming to Southeast Area



Breeding Insight in the Pilot Phase



One Breeding Insight Vision



Thank You

ARS Collaborators:

Nahla Basil (blueberry)
Rachel Naegele (table grape)
Yniv Palti (trout)
Brian Peterson (salmon)
Debby Samac (alfalfa)
Phil Wadl (sweetpotato)
Amanda Hulse-Kemp (BIOOnRamp)
Brian Scheffler (BIOOnRamp)

ARS ONP:

Peter Bretting
Jack Okamuro
Tim Rinehart (POC)

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Kirsten Richardson
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Scott Jackson (Vice Chair)
Steve Larson
Steve Rounsley
Philipp Simon (Chair)
Margaret Worthington

GitHub:

<https://github.com/Breeding-Insight>

Funding and Support

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