GEM3
Overview of Project Mission, Goals and Framework

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University of Idaho

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Department of Biological Sciences
Boise State University

GEM3
Genes by Environment
Modeling · Mechanisms · Mapping

Vision:

WHO: Leaders in collaborative & inclusive research

WHAT: To discover and predict how plants, animals, and people interact & adapt to environmental change

WHY: Sustainable management of natural resources

Mission:

Discover fundamental knowledge of genetic mechanisms that inform evidence-based management of natural resources.

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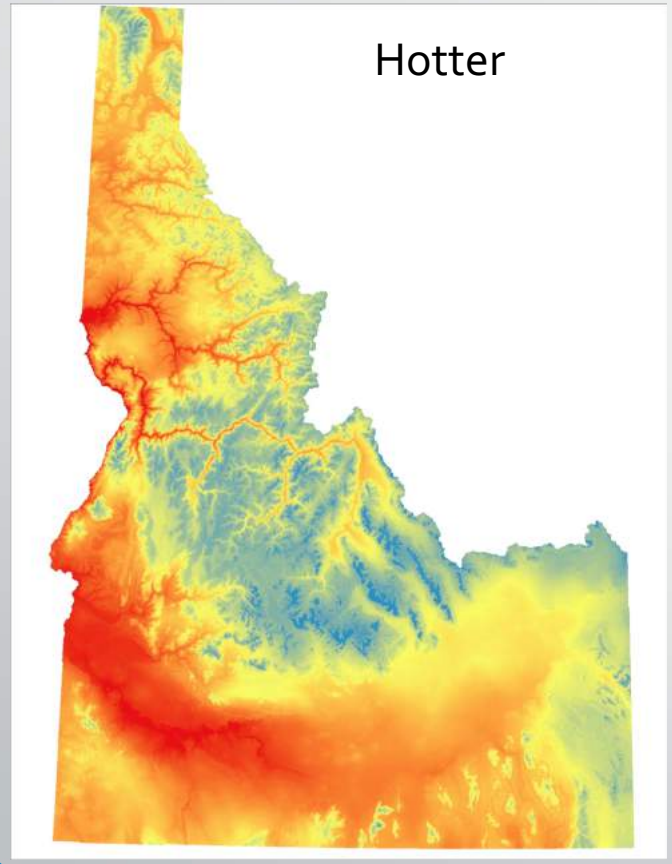
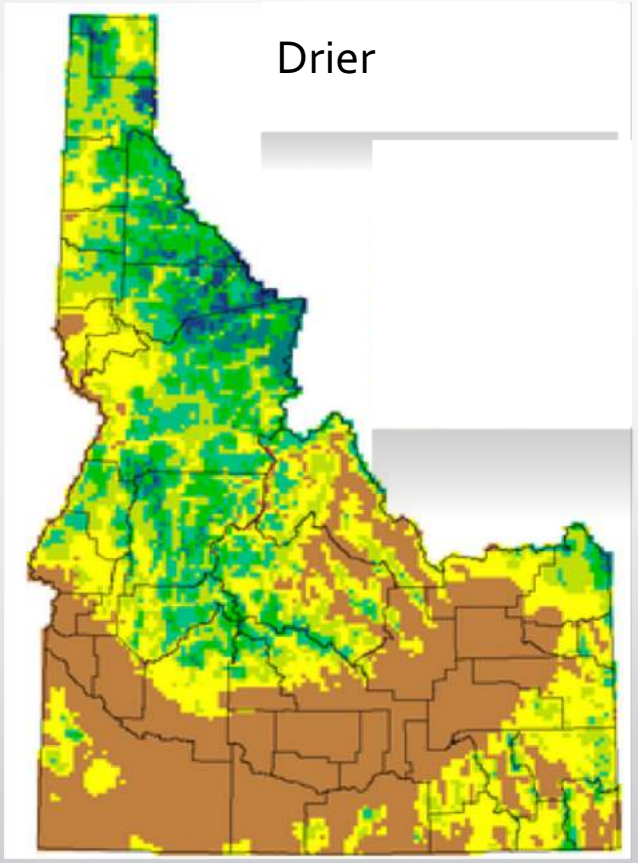
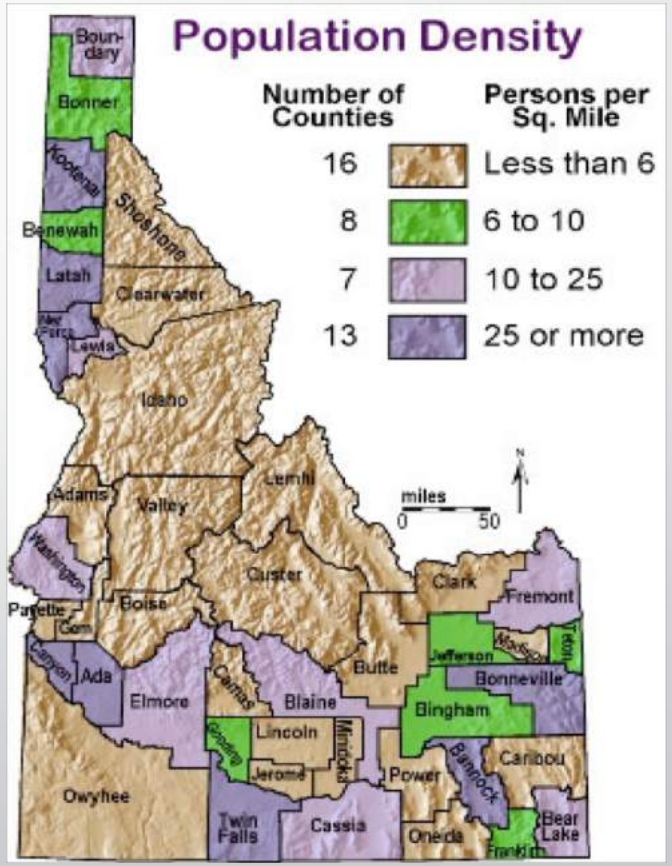
WHY: Sustainable management of natural resources





http://www.nezperceswcd.org



http://www.netstate.com

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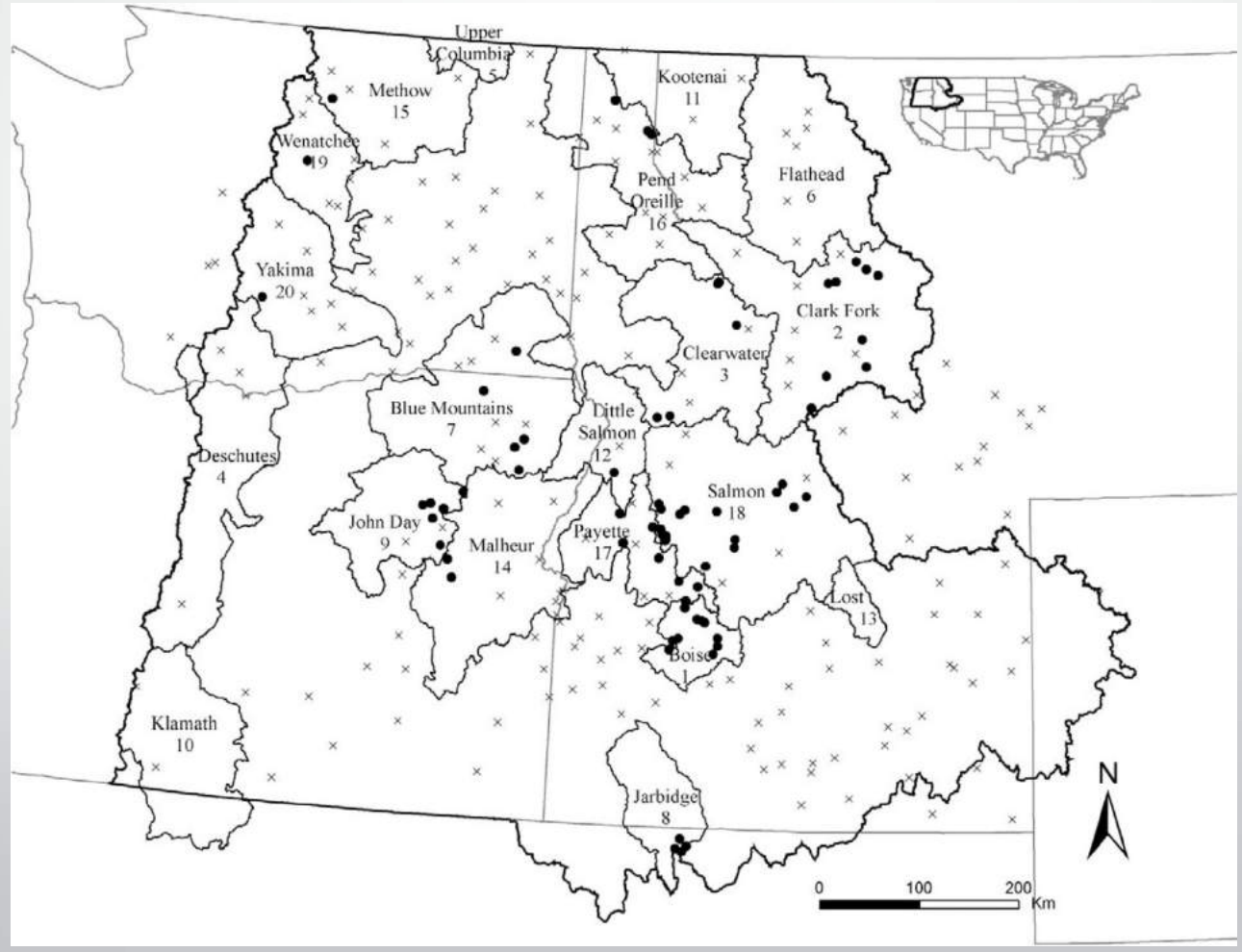
Agencies use models to predict future distribution but these models do not consider the adaptive capacity of populations

Bull trout example:

Bull trout populations in Idaho, Washington and Montana



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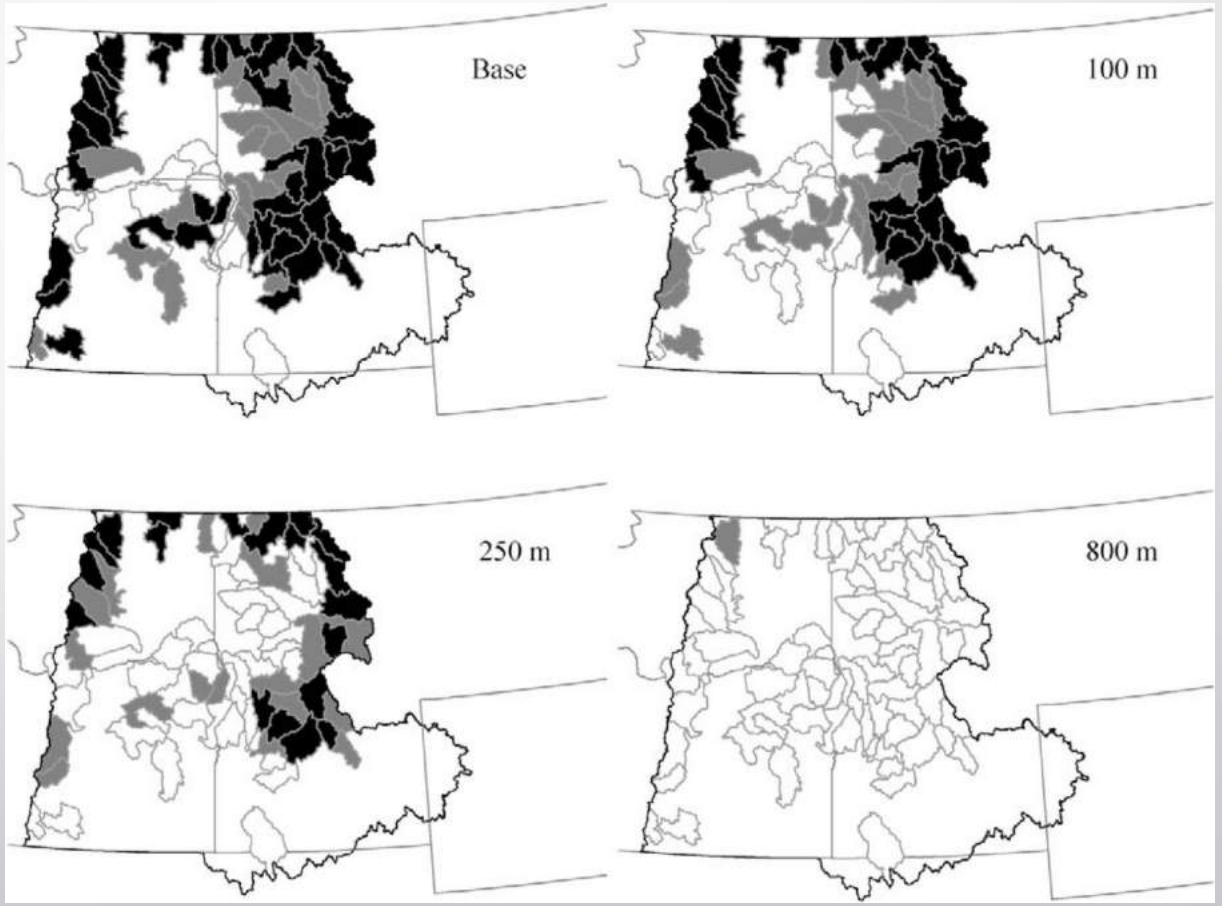
Predicted bull trout distribution with climate change (warming) - habitat will shrink.

As water temperature increases, fish move to higher elevations

This reduces distribution and abundance



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Our project will predict species distribution using agent-based models

- Agent-based models include factors that dictate demography
  - Food abundance that controls growth and abundance
  - Water temperature (upper summer temperature)
  - Emigration opportunity (connectivity in landscapes)
  - Genotype x environment predictions
  - Genetic diversity of populations
- These factors are interactive and vary across landscapes

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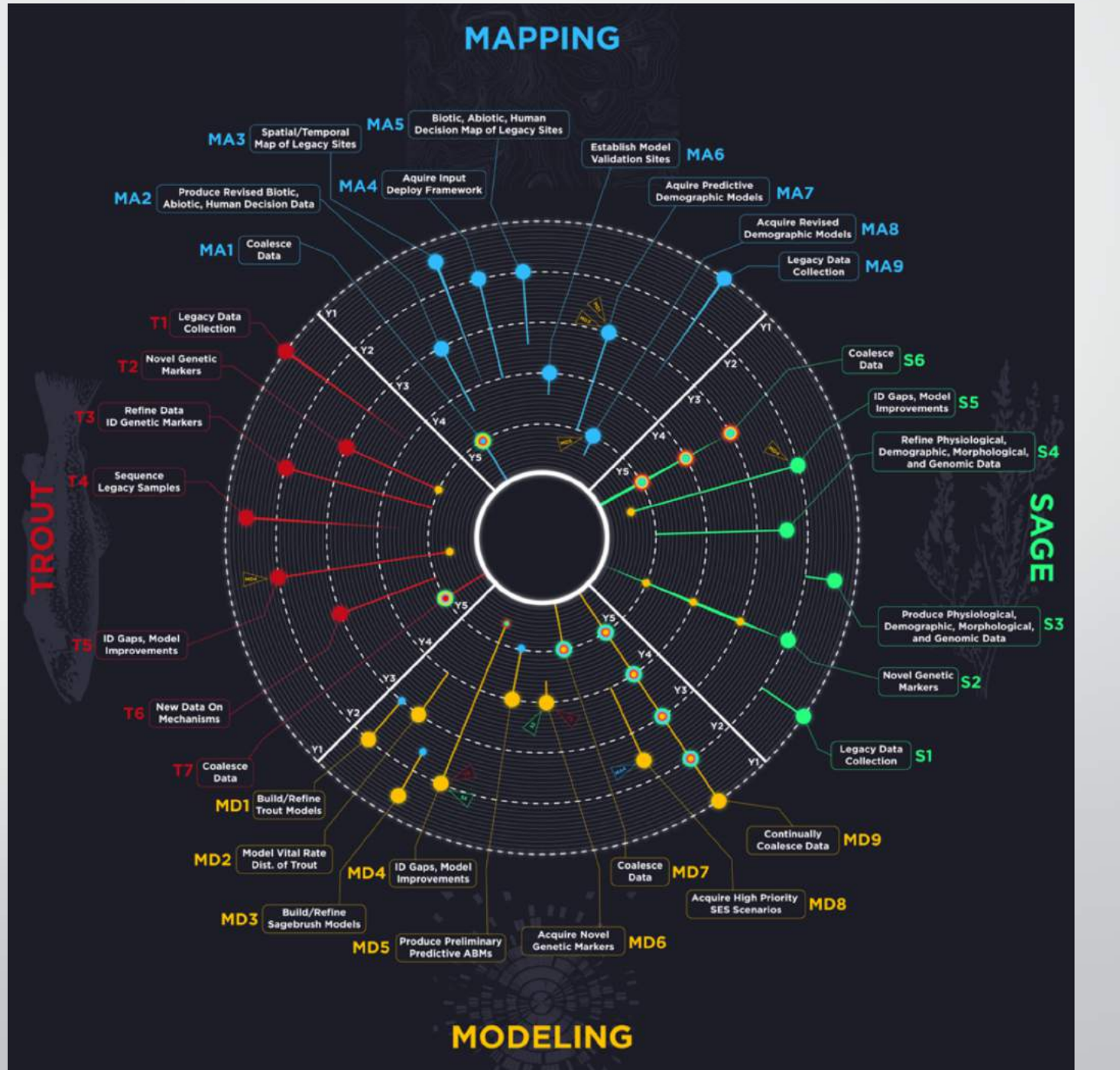
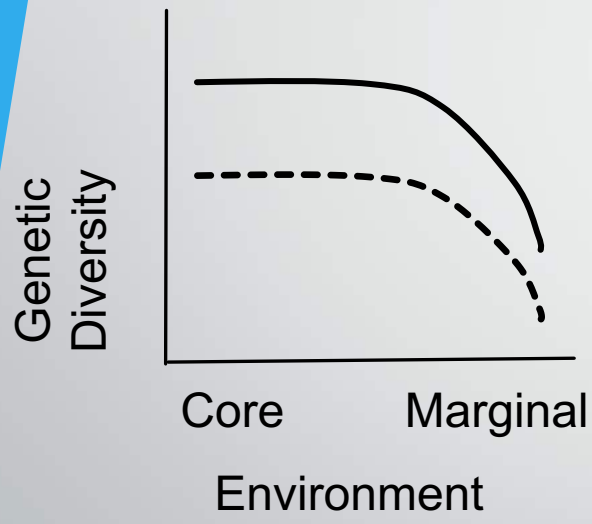
Diagram of GEM3 showing three research activities, when they occur and how they are inter-related



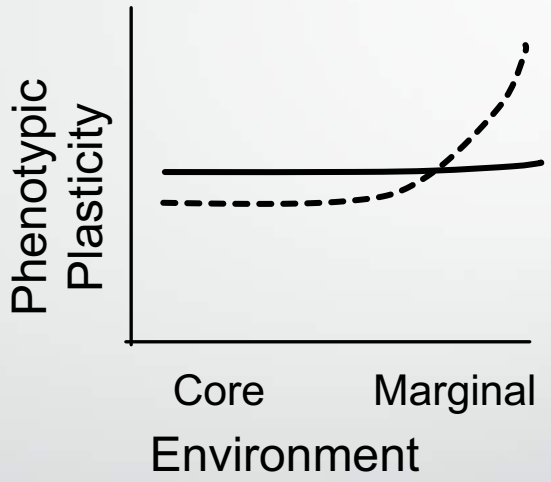
Genotype x Environment x Phenotype mechanisms

Genetic diversity outcomes



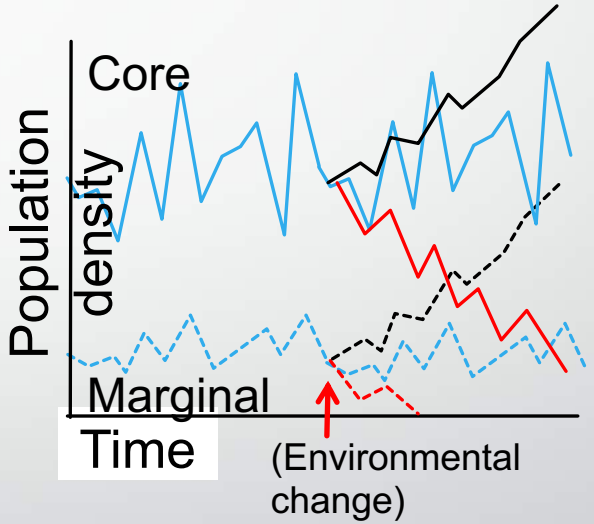
**(solid line = large population
dashed line = small population)**

Phenotypic plasticity outcomes



**(solid line = high genetic diversity population
dashed line = low genetic diversity population)**

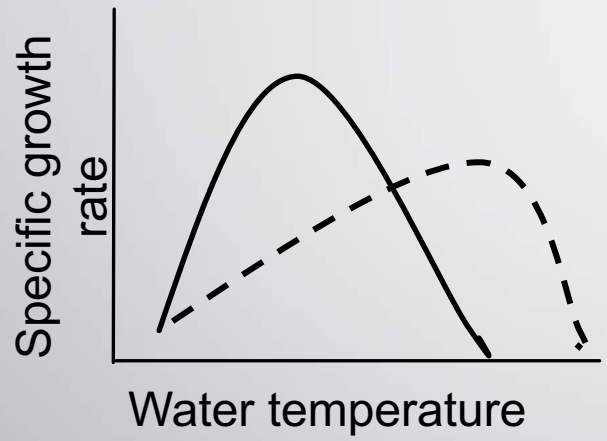
Expected Adaptive Capacity Outcomes



**(blue = environment unchanged
black = favorable changes
red = unfavorable changes)**

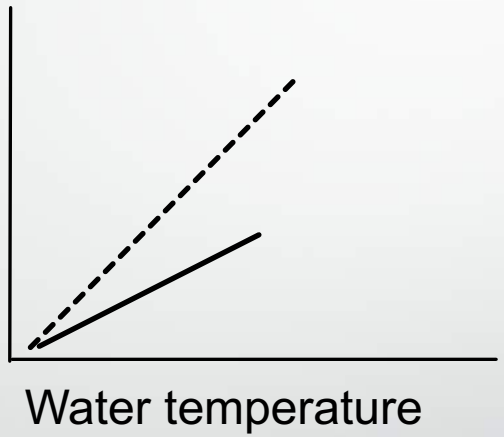
Examples of genotype x environment mechanisms – trout common garden studies

Predicted growth



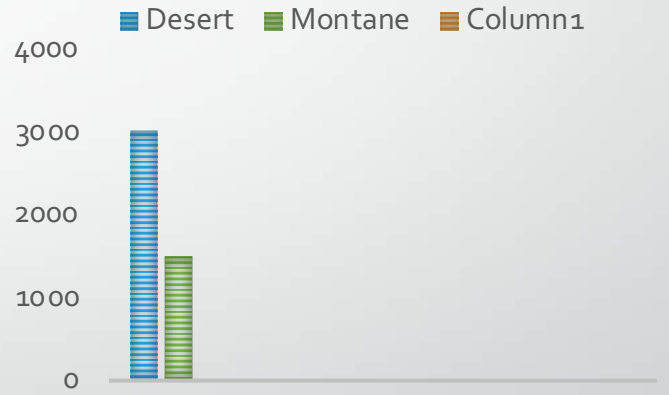
solid line = Montane population
dashed line = Desert population

Predicted weight at given age



solid line = Montane population
dashed line = Desert population

FECUNDITY



Why did we chose redband trout?

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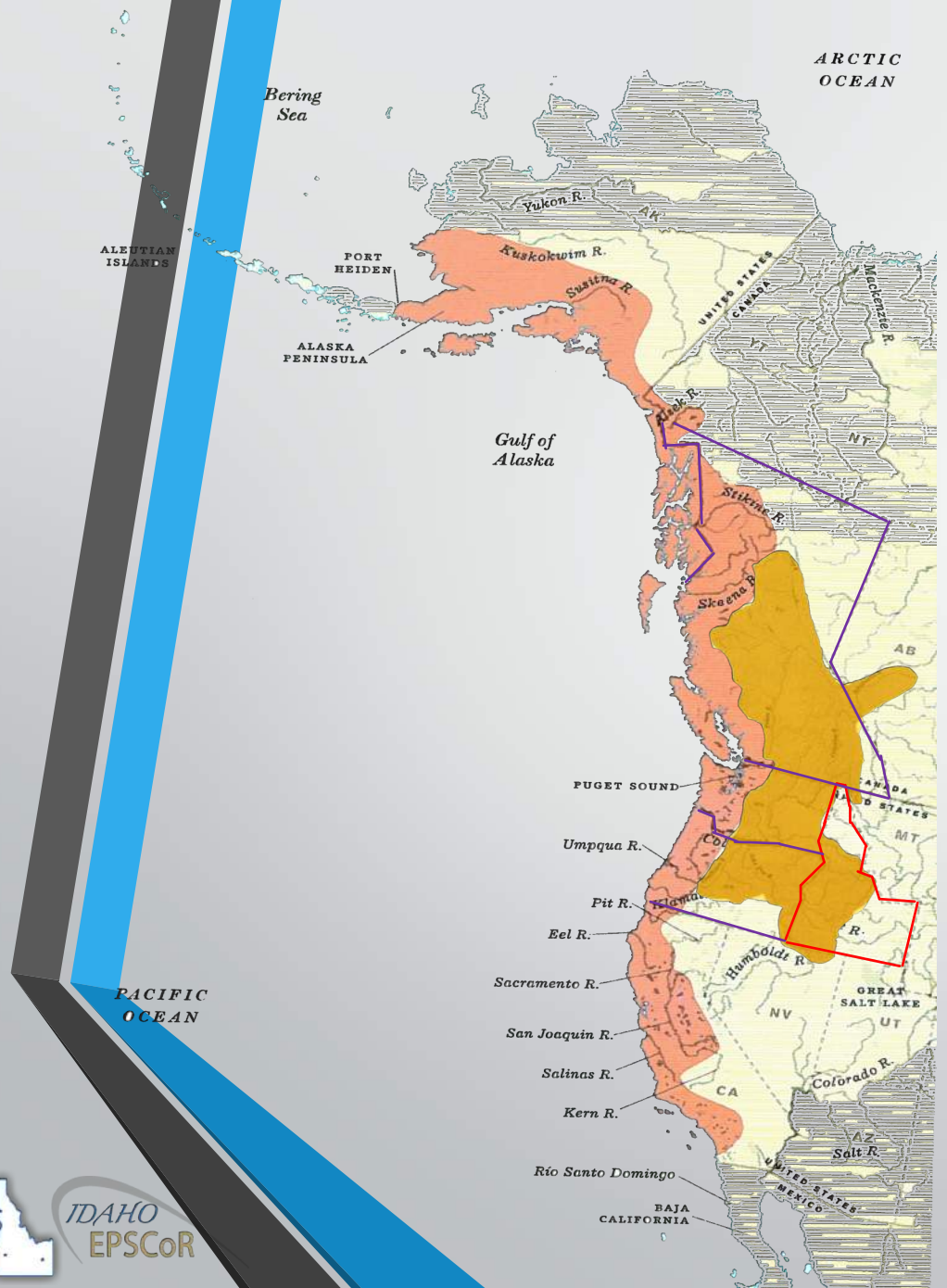
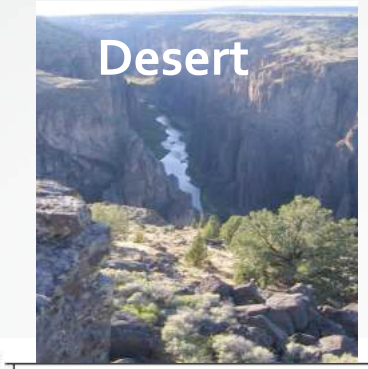
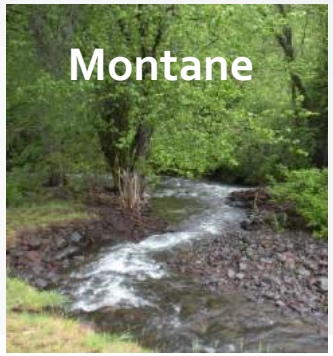
Native Trout Species in Idaho

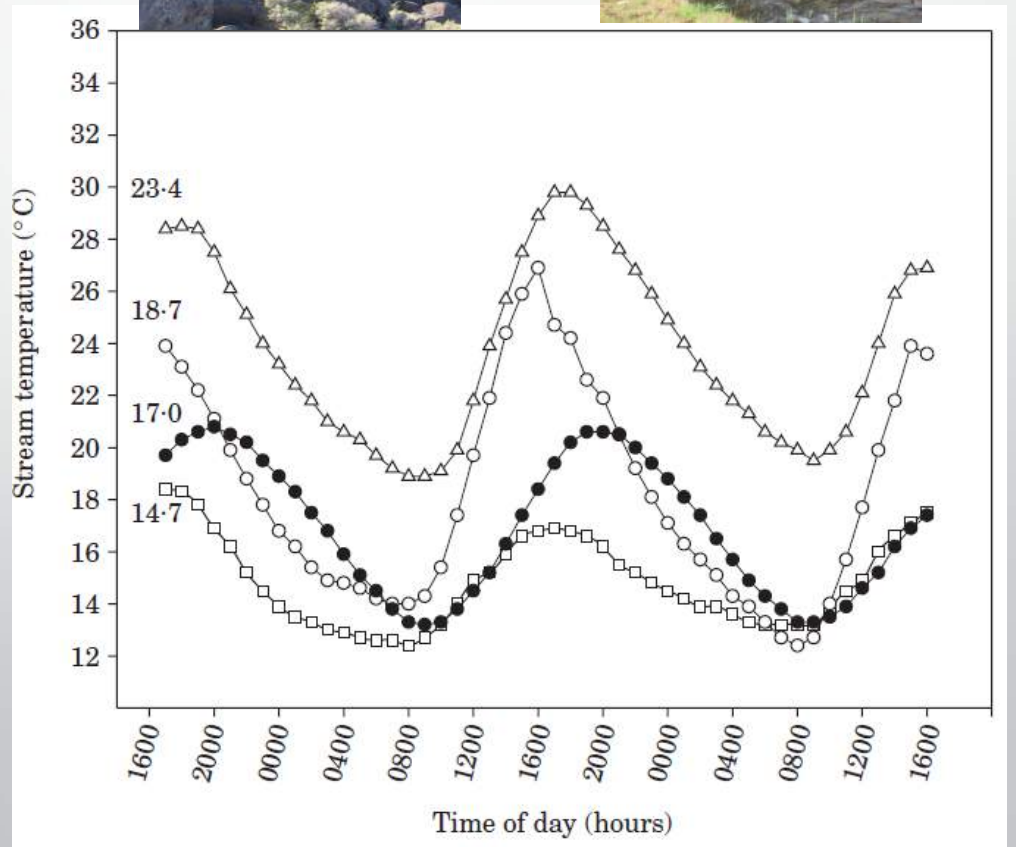
- Bull trout (*Salvelinus confluentus*)
  - Habitat is cold, mountain watersheds – areas not influenced much by human activities
  - Populations difficult to access
  - Federally protected species that limits population sampling
  - Genome not sequenced
- Cutthroat trout (*Oncorhynchus clarki*)
  - Two major subspecies: westslope and Yellowstone
  - Hybridize with rainbow trout
  - Genome not sequenced
- Redband trout (*Oncorhynchus mykiss*)
  - Widely distributed, some geographically and reproductively isolated
  - Found in extreme habitats
  - Exist in varying landscapes affected by human activities
  - Populations characterized in past using microsatellites
  - Genome sequenced

Redband trout as a model species









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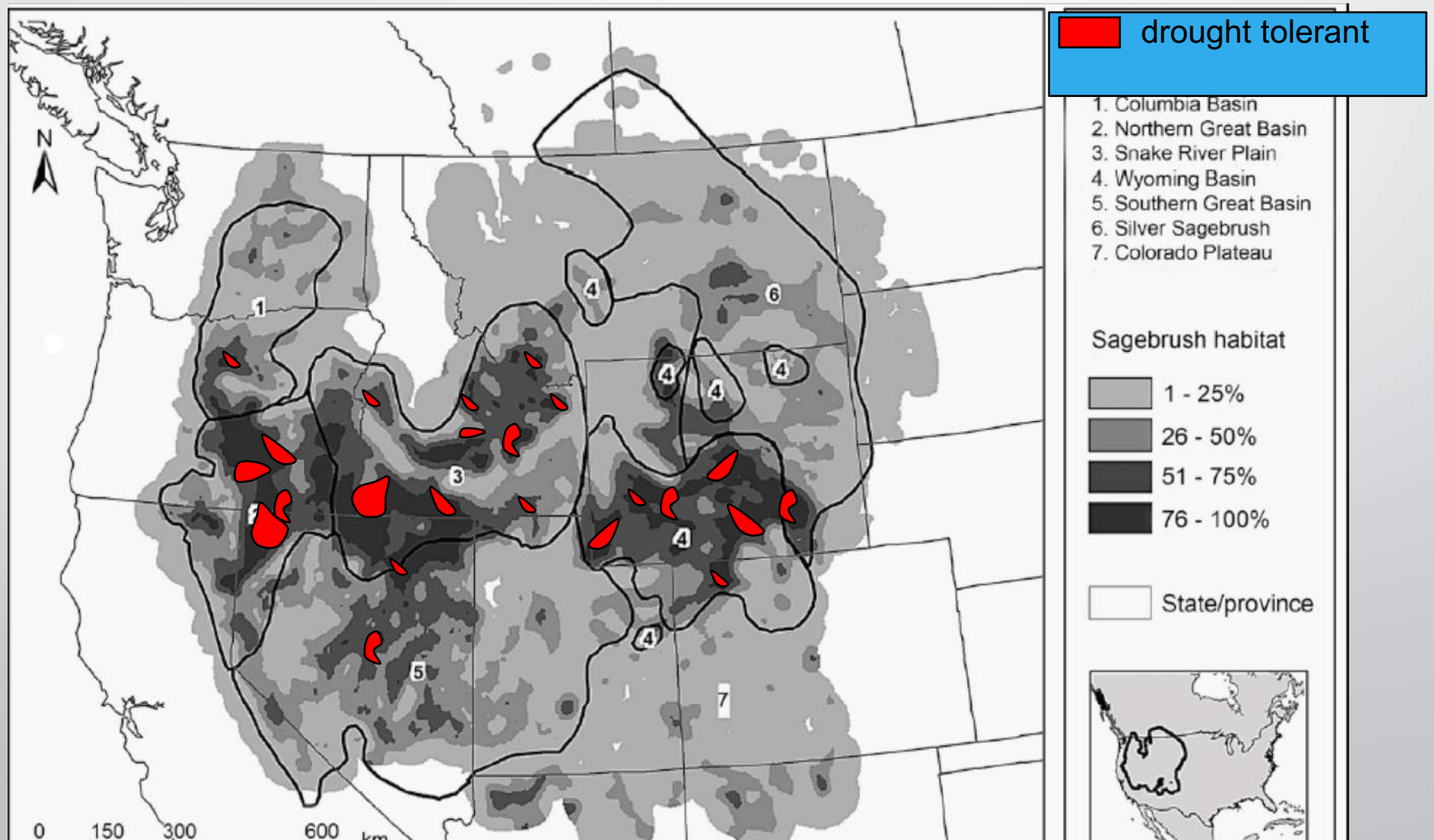
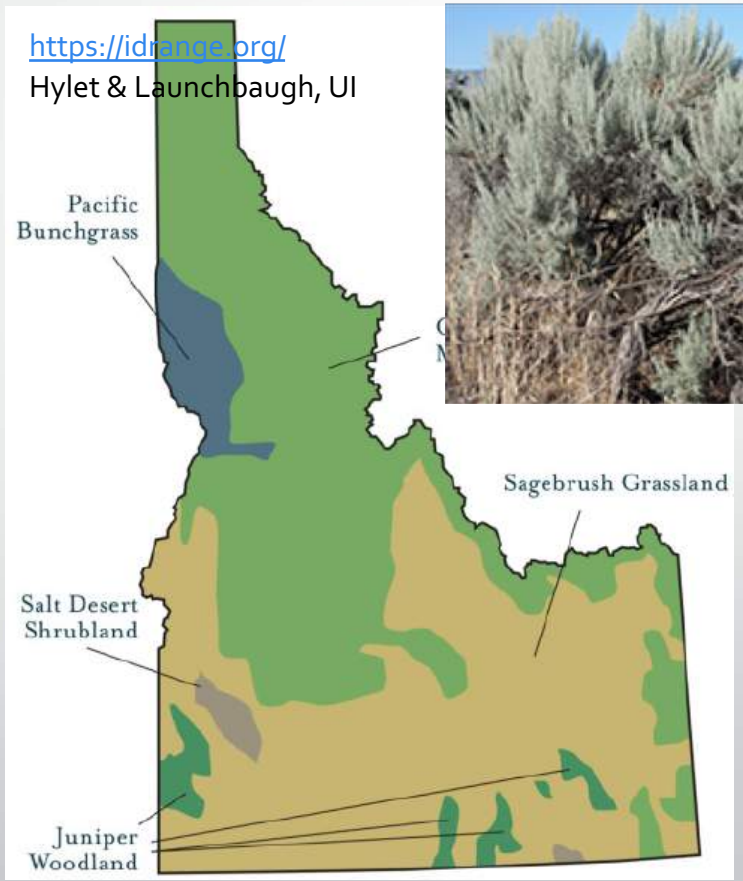
Advantages of using redband trout

- Access to legacy tissue samples to re-analyze (sequence)
  - Available from partner agencies and entities
  - Archived samples go back decades, providing a temporal perspective
- Population distribution crosses landscapes – enables SES
  - 47% on private land, 45% on federal land and 8% in protected areas
- Populations are accessible and not threatened or endangered
- Isolated populations exist in extreme environments ranging from cold to very warm water temperatures
- We can build on recent research on temperature tolerance of different populations (CRITFC)

WHAT: our project will predict and monitor climate-adapted populations of sagebrush



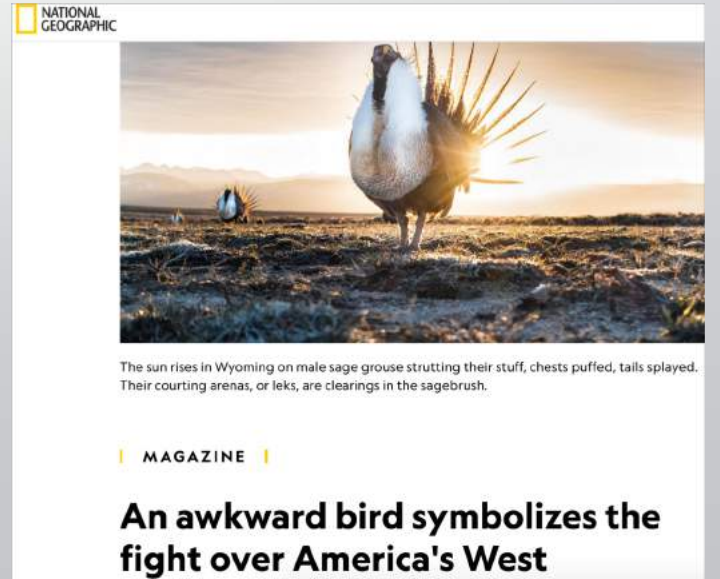
Why did we chose sagebrush?



Rangelands

Sagebrush

GAP: Agencies collect unknown genotypes of plants and monitor success but generally do not consider the adaptive capacity of populations



'Warranted but precluded'

DECISION OFFERS ENCOURAGEMENT, CONCERNS FOR INDUSTRY, CONSERVATIONISTS

Idaho Task Force Tackles Sage Grouse Issues

Big fire season further threat to Nevada's sage grouse habitat

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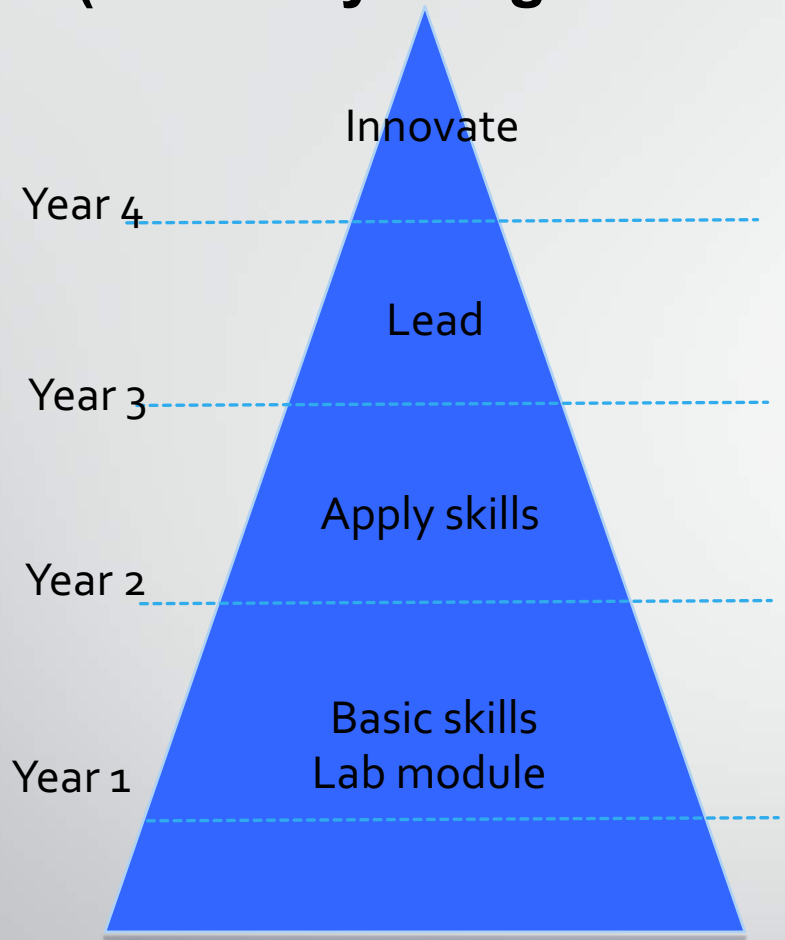
Habitat loss means Washington sage grouse in trouble

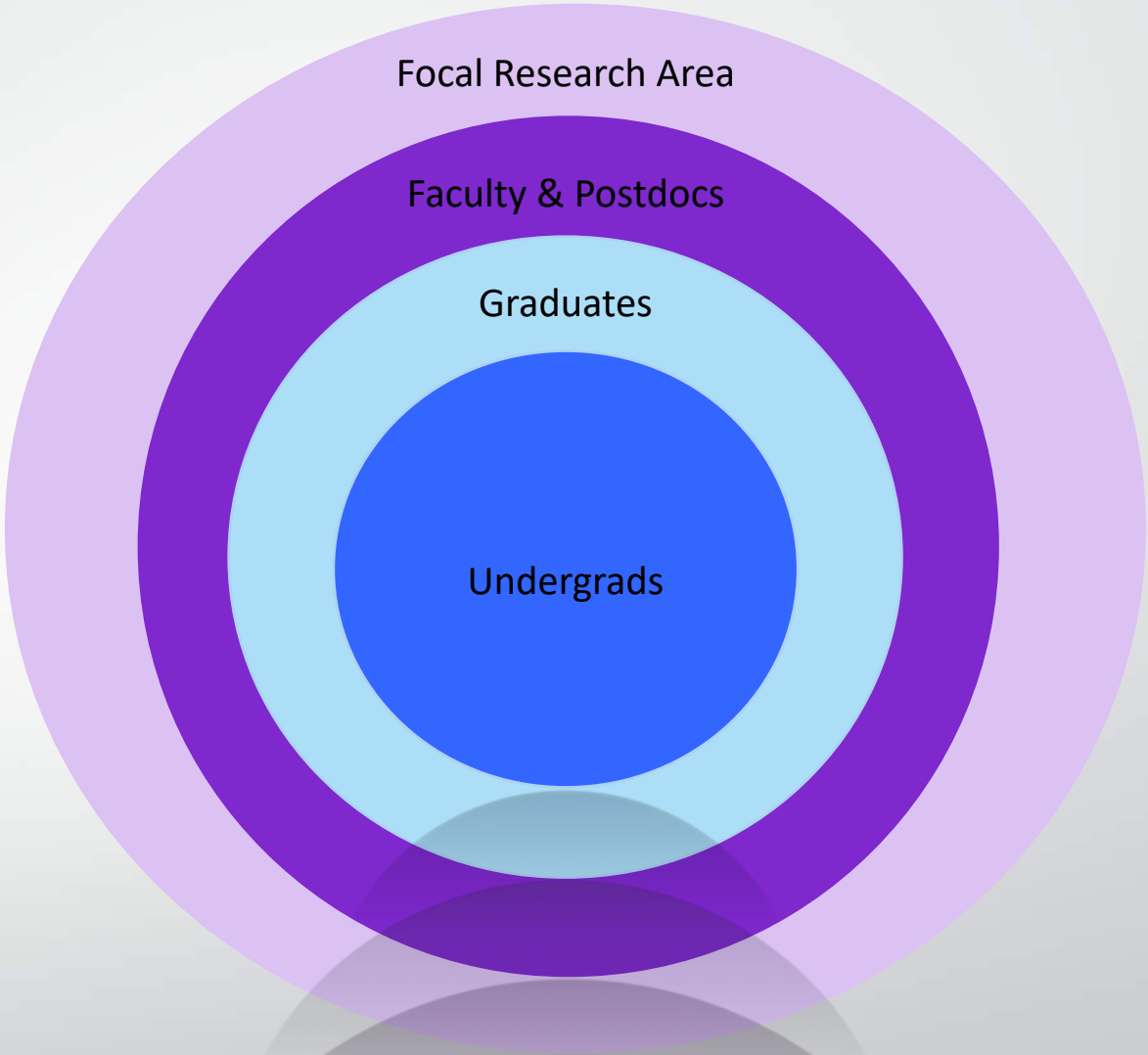
Advantages of using sagebrush

- Access to legacy demographic data (growth, survival, recruitment)
  - Available from partner agencies and entities
  - Common gardens and land treatments (fires, reseeding) go back decades, providing a temporal perspective
- Population distribution crosses landscapes – enables SES
- Populations are accessible and not threatened or endangered
- Isolated populations exist in extreme environments ranging from cold/wet to very warm/dry temperatures
- We can build on research on environmental tolerance of different populations within gardens (USFS, USGS)

WHO: Leaders in collaborative & inclusive research

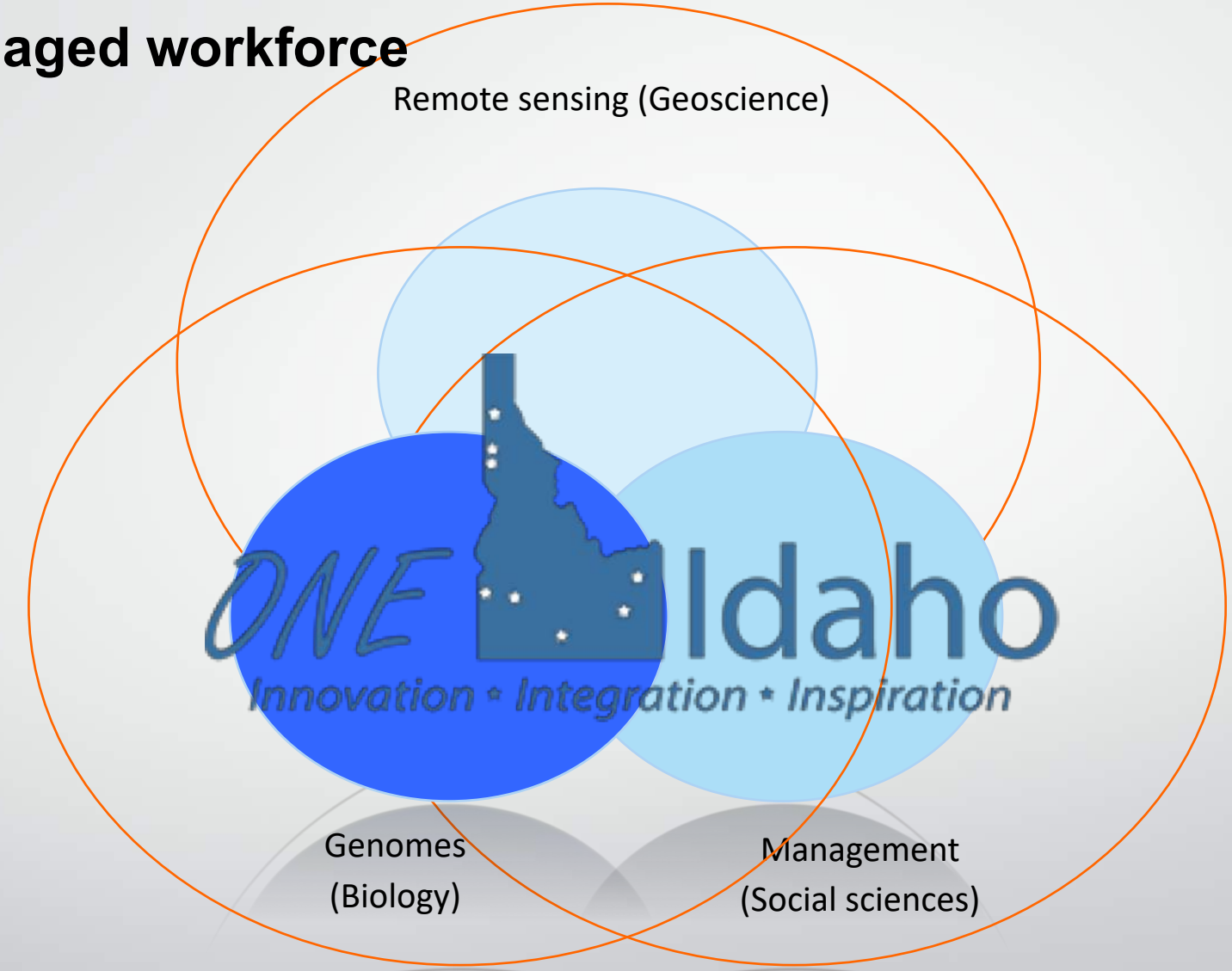
HOW: Engaged workforce (Vertically Integrated Projects





Students participate longitudinally and are nested within a scientific community

HOW: Engaged workforce

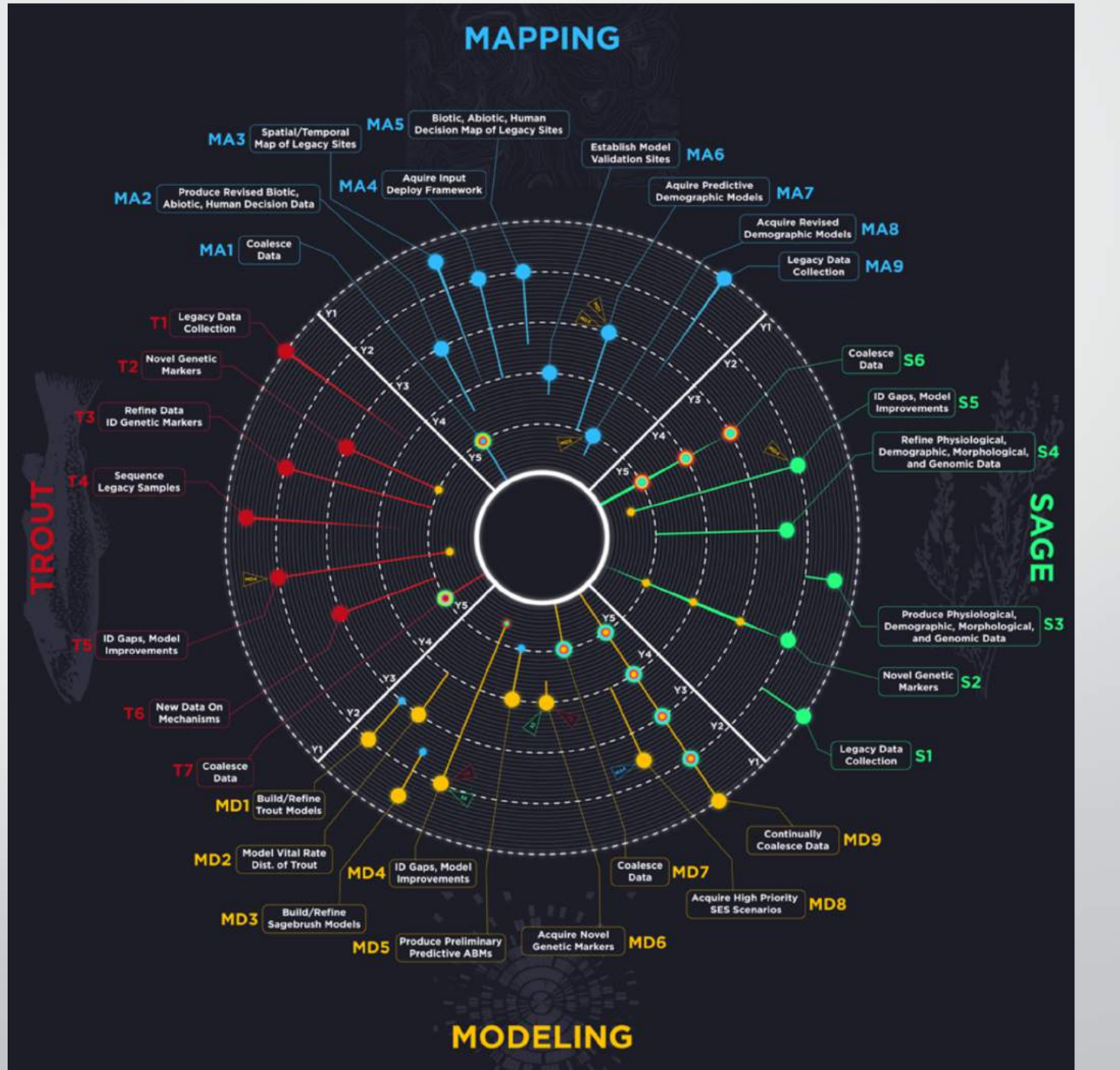


Teams interact with other teams to promote trans-disciplinary opportunity and expand career networks for students.

HOW

Integration of three research activities:

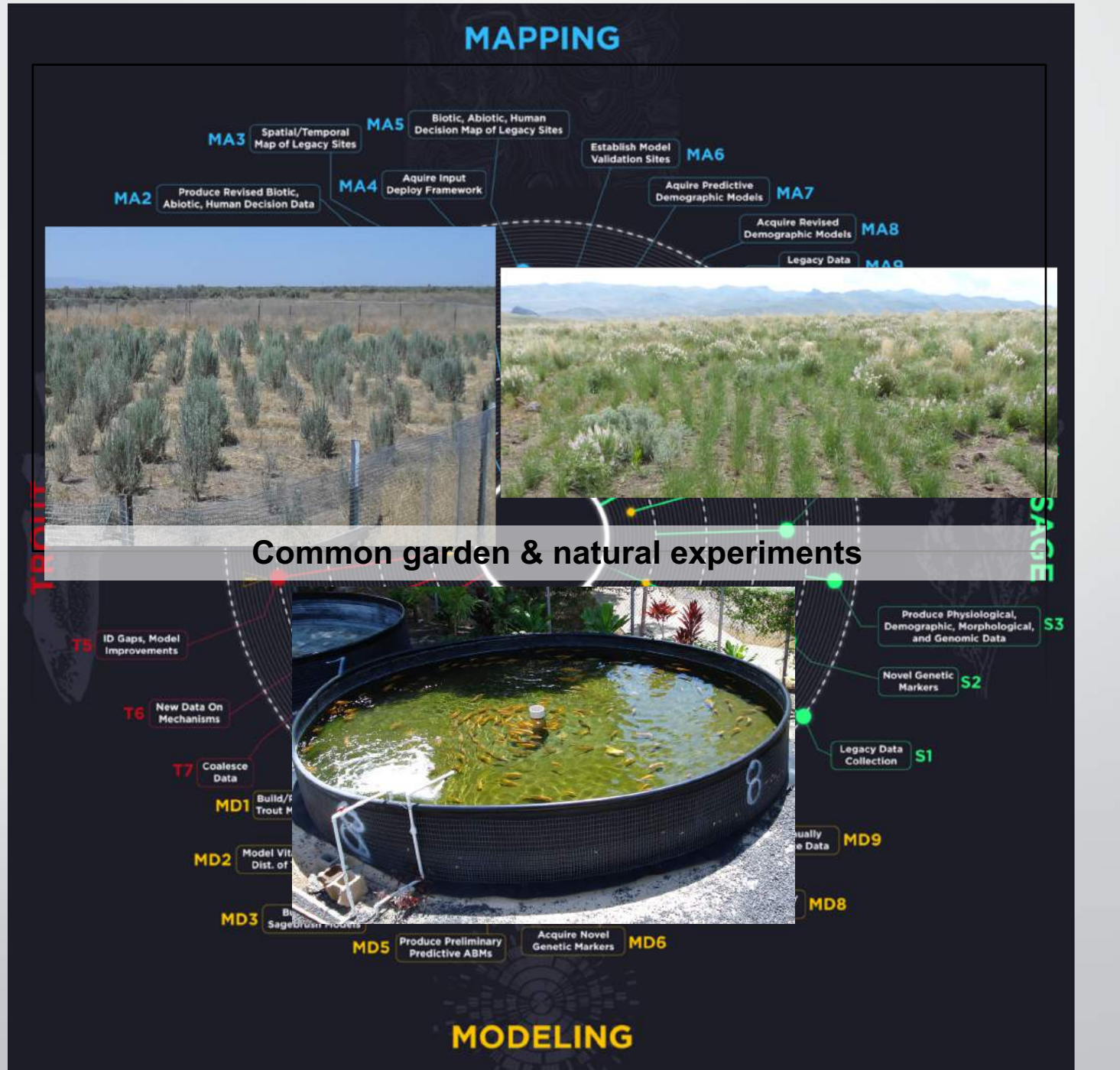
Mechanisms
Modeling
Mapping

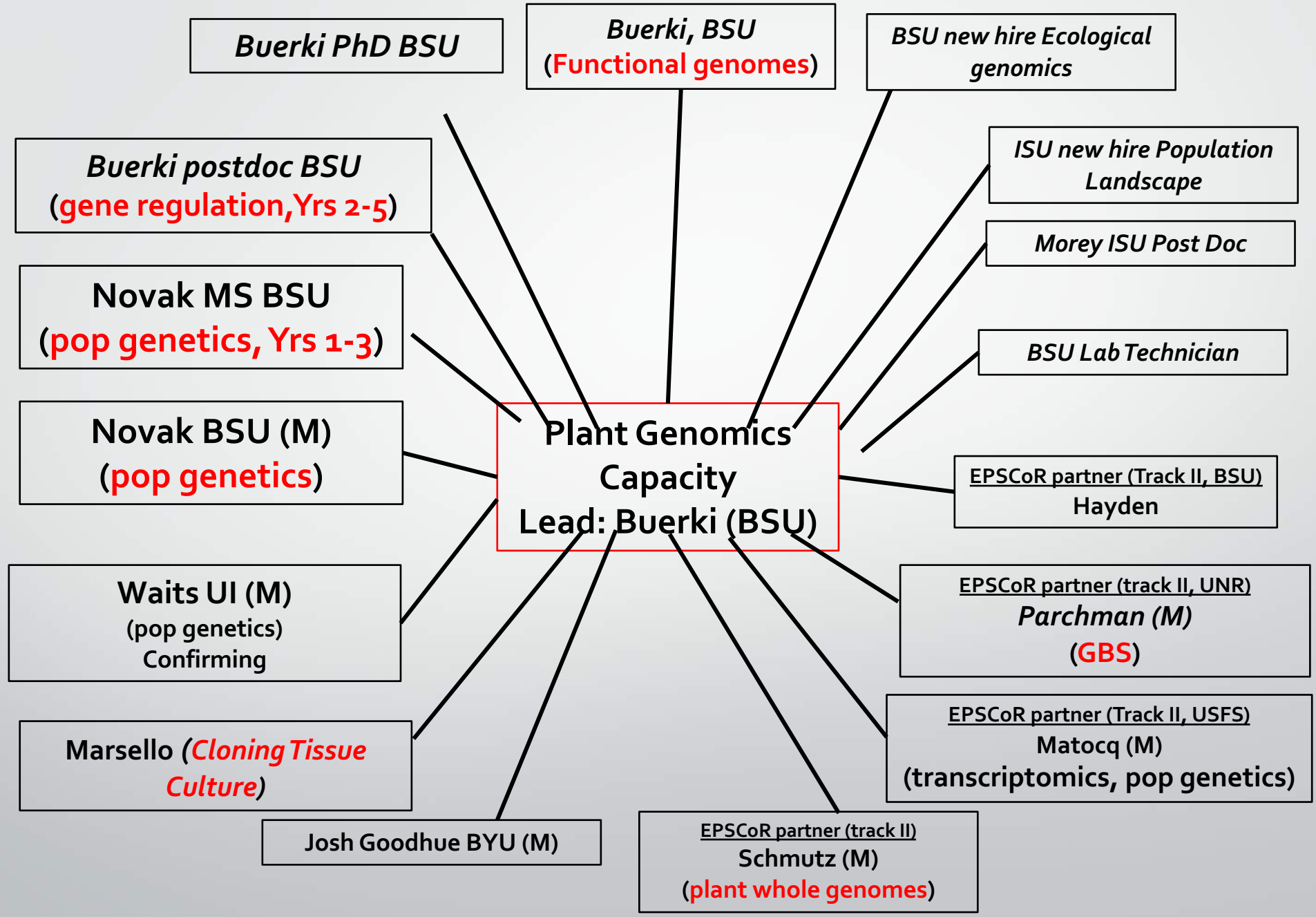


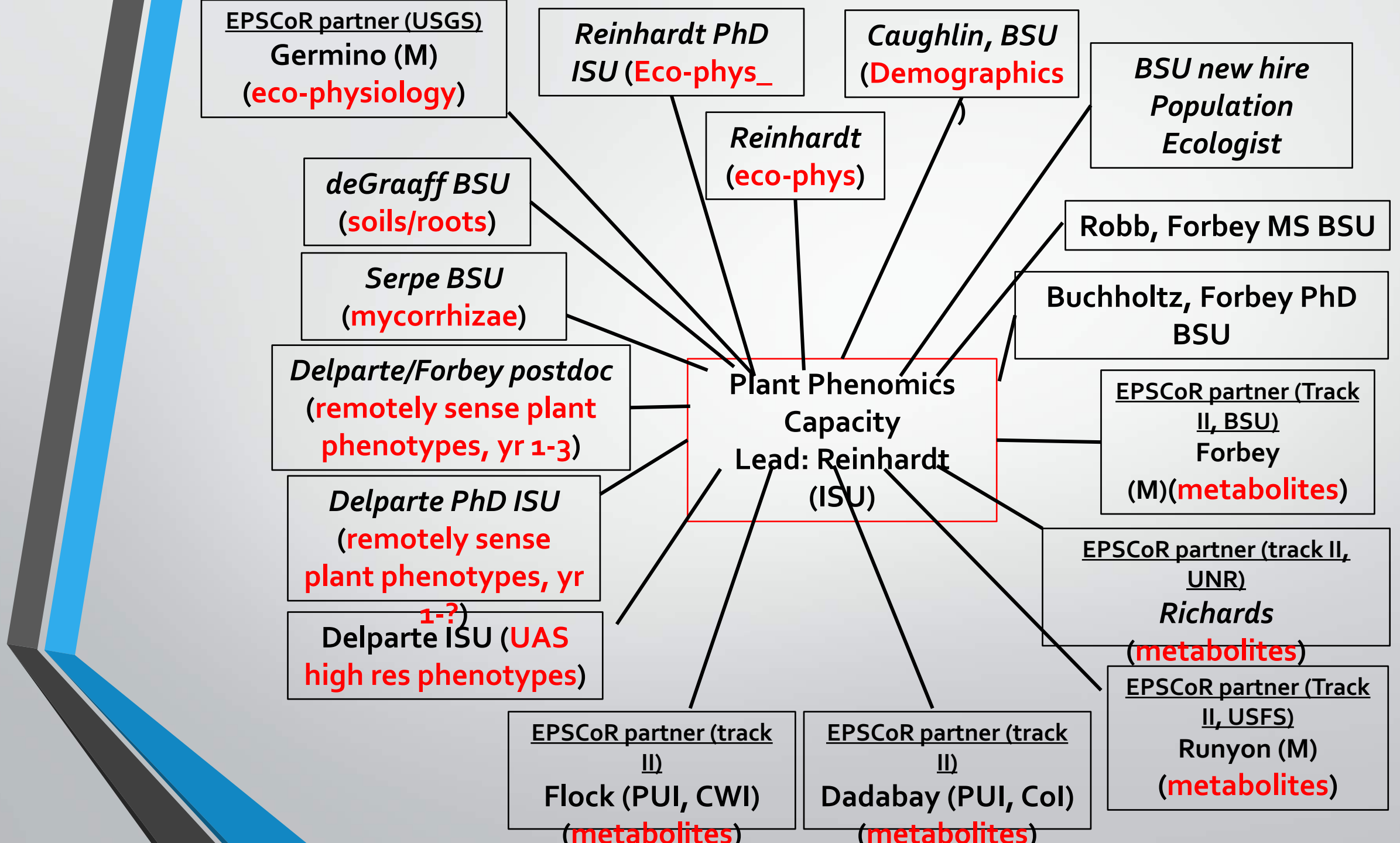
HOW

Integration of three research activities:

Mechanisms (genomes to phenomes) in controlled environments



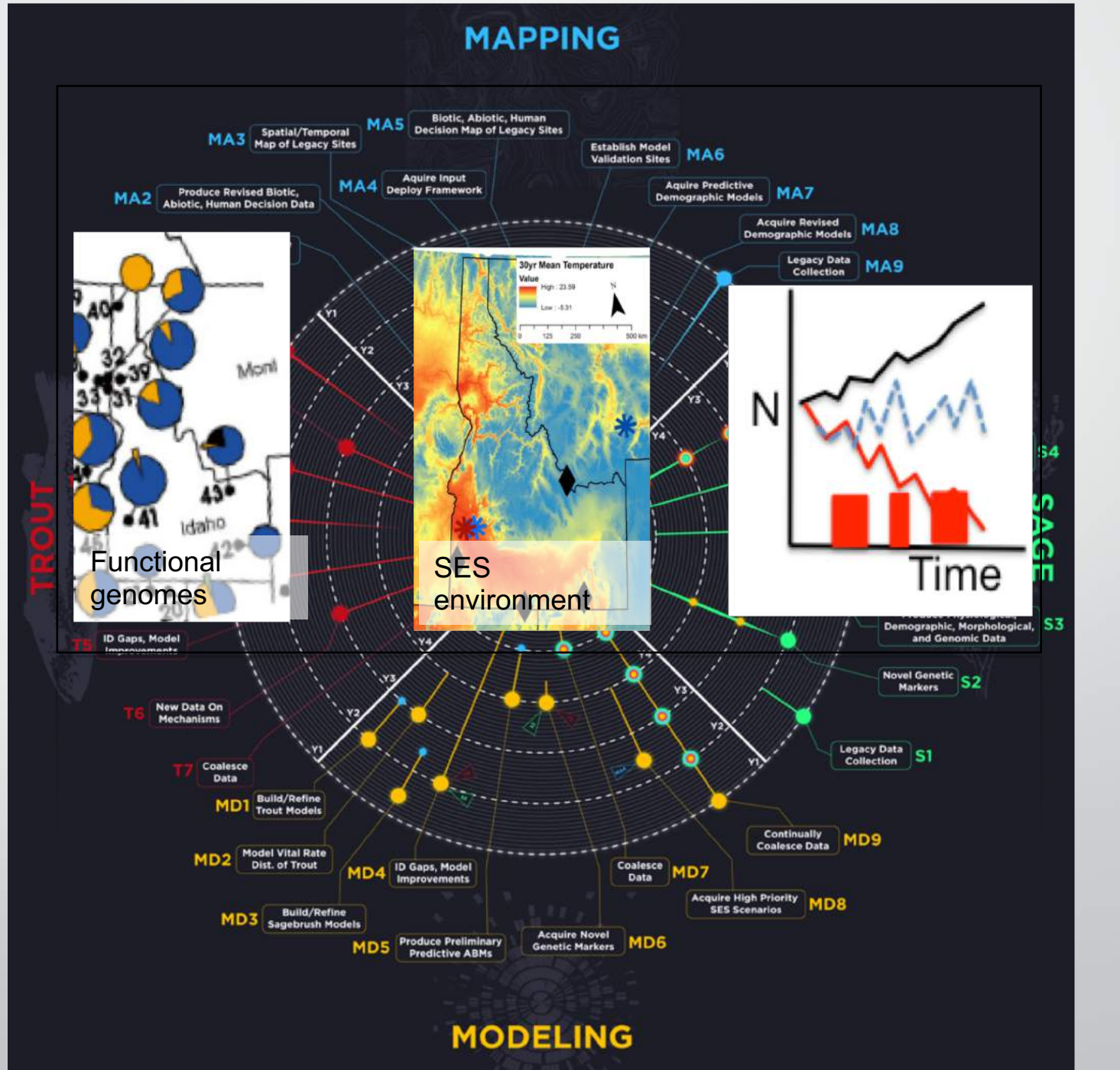

Buerki PhD BSU
Buerki, BSU
(Functional genomes)
BSU new hire Ecological genomics
Buerki postdoc BSU
(gene regulation,Yrs 2-5)
ISU new hire Population Landscape
Morey ISU Post Doc
Novak MS BSU
(pop genetics, Yrs 1-3)
BSU Lab Technician
Novak BSU (M)
(pop genetics)
Plant Genomics Capacity
Lead: Buerki (BSU)
EPSCoR partner (Track II, BSU)
Hayden
Waits UI (M)
(pop genetics)
Confirming
EPSCoR partner (track II, UNR)
Parchman (M)
(GBS)
Marsello (Cloning Tissue Culture)
EPSCoR partner (Track II, USFS)
Matocq (M)
(transcriptomics, pop genetics)
Josh Goodhue BYU (M)
EPSCoR partner (track II)
Schmutz (M)
(plant whole genomes)

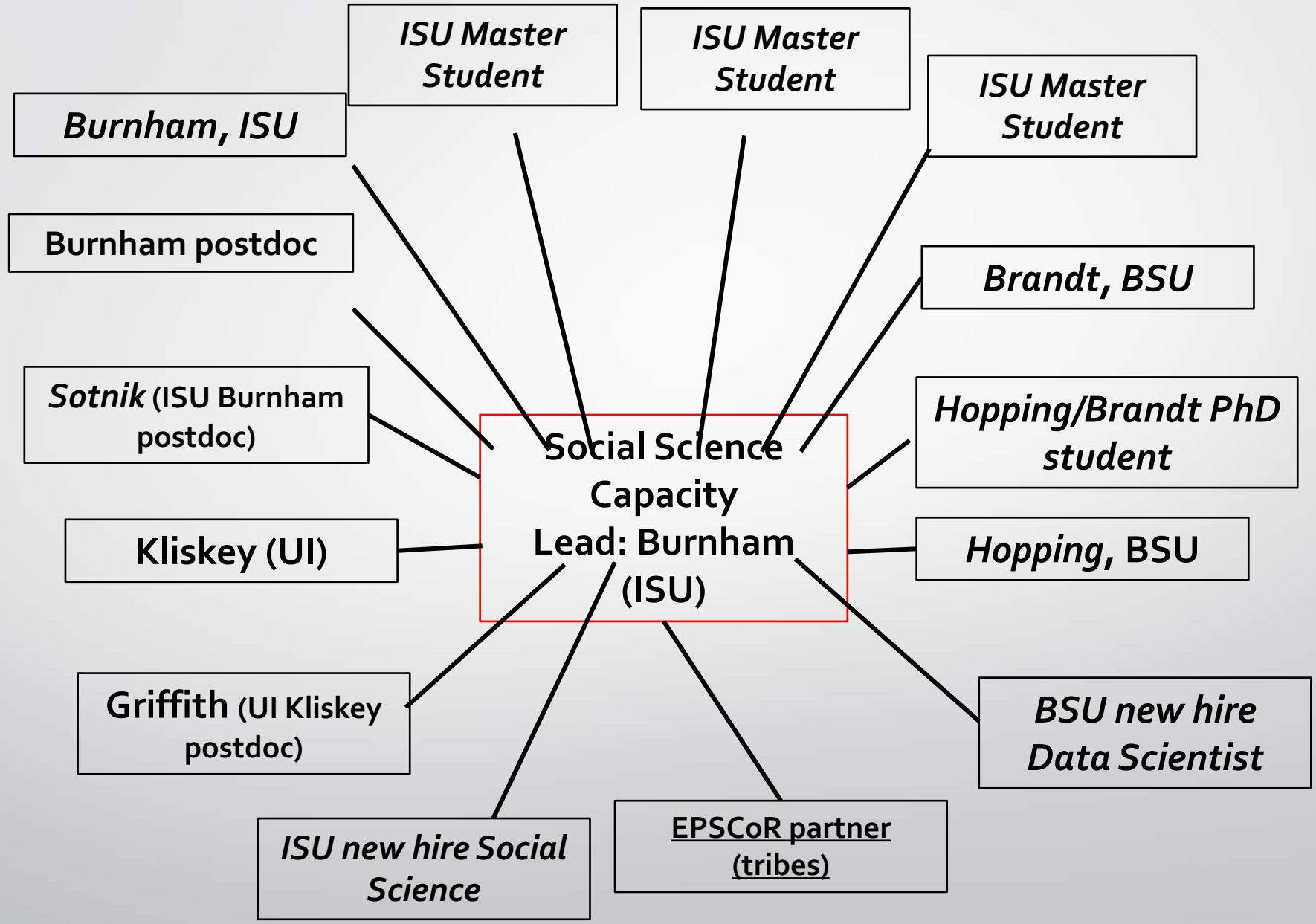

EPSCoR partner (USGS)
Germino (M)
(eco-physiology)
Reinhardt PhD ISU (Eco-phys_
Caughlin, BSU (Demographics
BSU new hire Population Ecologist
Reinhardt (eco-phys)
deGraaff BSU (soils/roots)
Robb, Forbey MS BSU
Serpe BSU (mycorrhizae)
Buchholtz, Forbey PhD BSU
Delparte/Forbey postdoc (remotely sense plant phenotypes, yr 1-3)
Plant Phenomics Capacity
Lead: Reinhardt (ISU)
EPSCoR partner (Track II, BSU)
Forbey (M)(metabolites)
Delparte PhD ISU (remotely sense plant phenotypes, yr 1-?)
EPSCoR partner (track II, UNR)
Richards (metabolites)
Delparte ISU (UAS high res phenotypes)
EPSCoR partner (Track II, USFS)
Runyon (M) (metabolites)
EPSCoR partner (track II)
Flock (PUI, CWI) (metabolites)
EPSCoR partner (track II)
Dadabay (PUI, CoI) (metabolites)

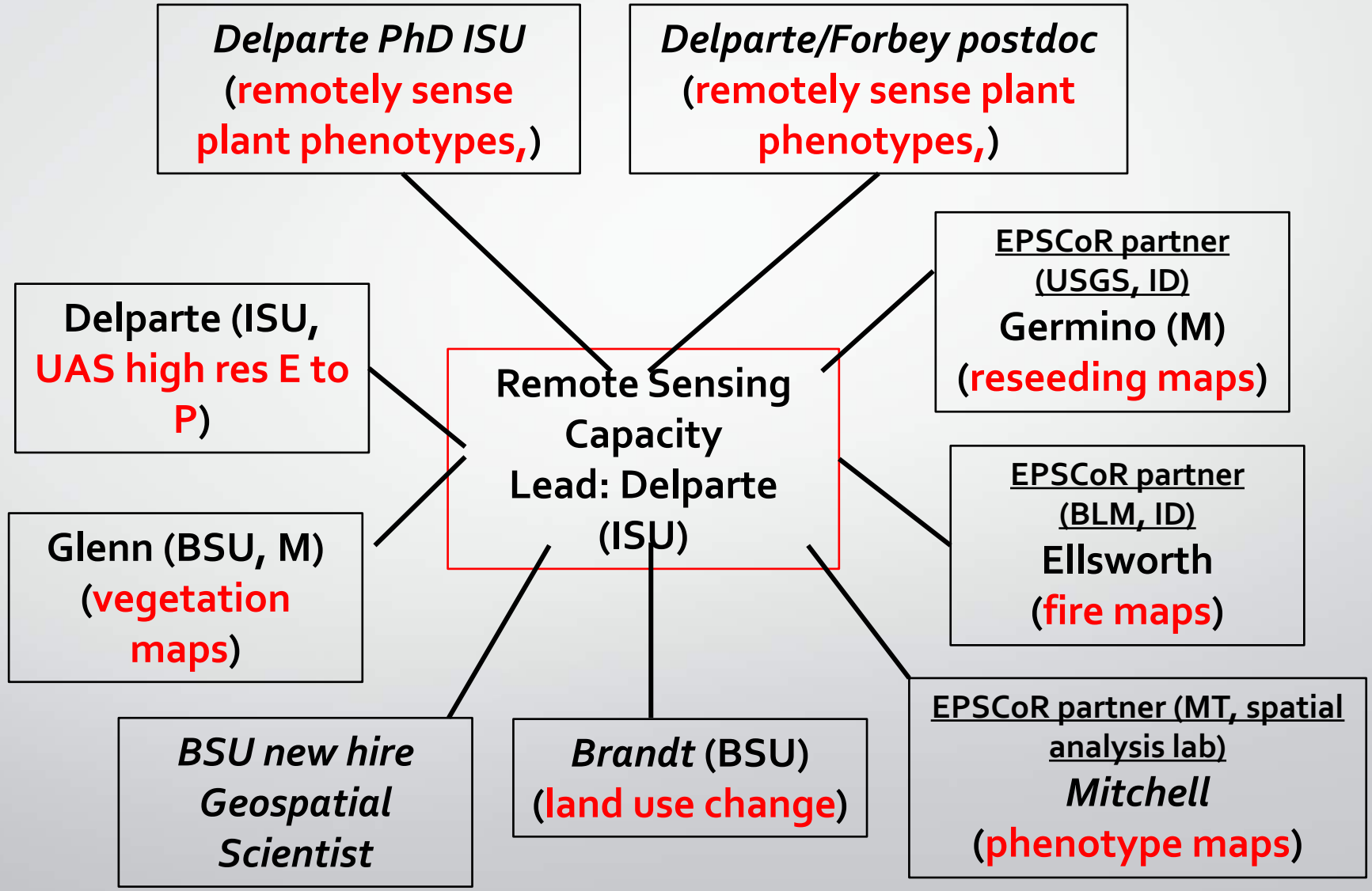
HOW

Integration of three research activities:

Mapping and Monitoring phenotypes relative to G x SEM



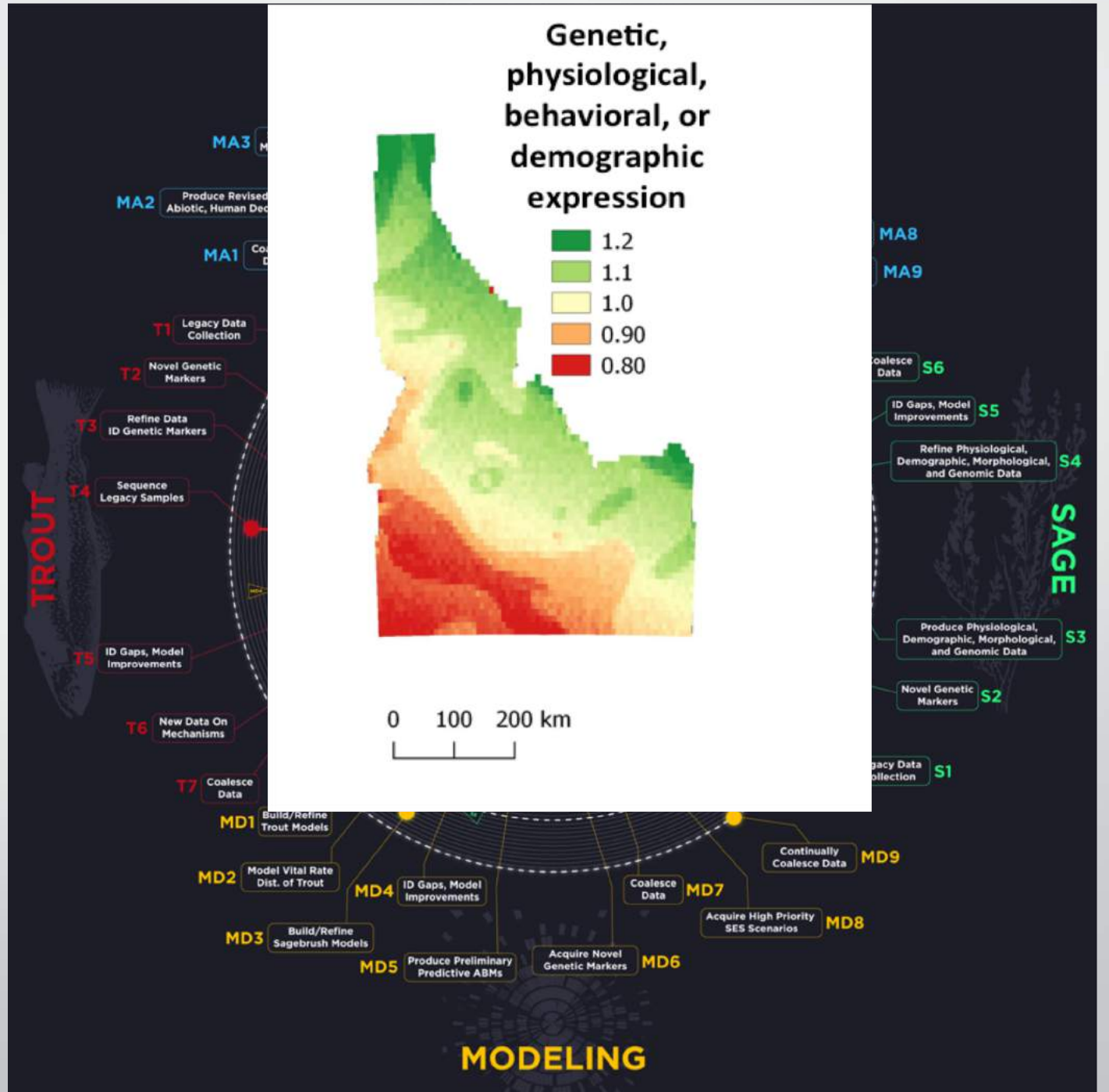

ISU Master Student
ISU Master Student
ISU Master Student
Burnham, ISU
Burnham postdoc
Brandt, BSU
Sotnik (ISU Burnham postdoc)
Hopping/Brandt PhD student
Social Science Capacity Lead: Burnham (ISU)
Kliskey (UI)
Hopping, BSU
Griffith (UI Kliskey postdoc)
BSU new hire Data Scientist
ISU new hire Social Science
EPSCoR partner (tribes)

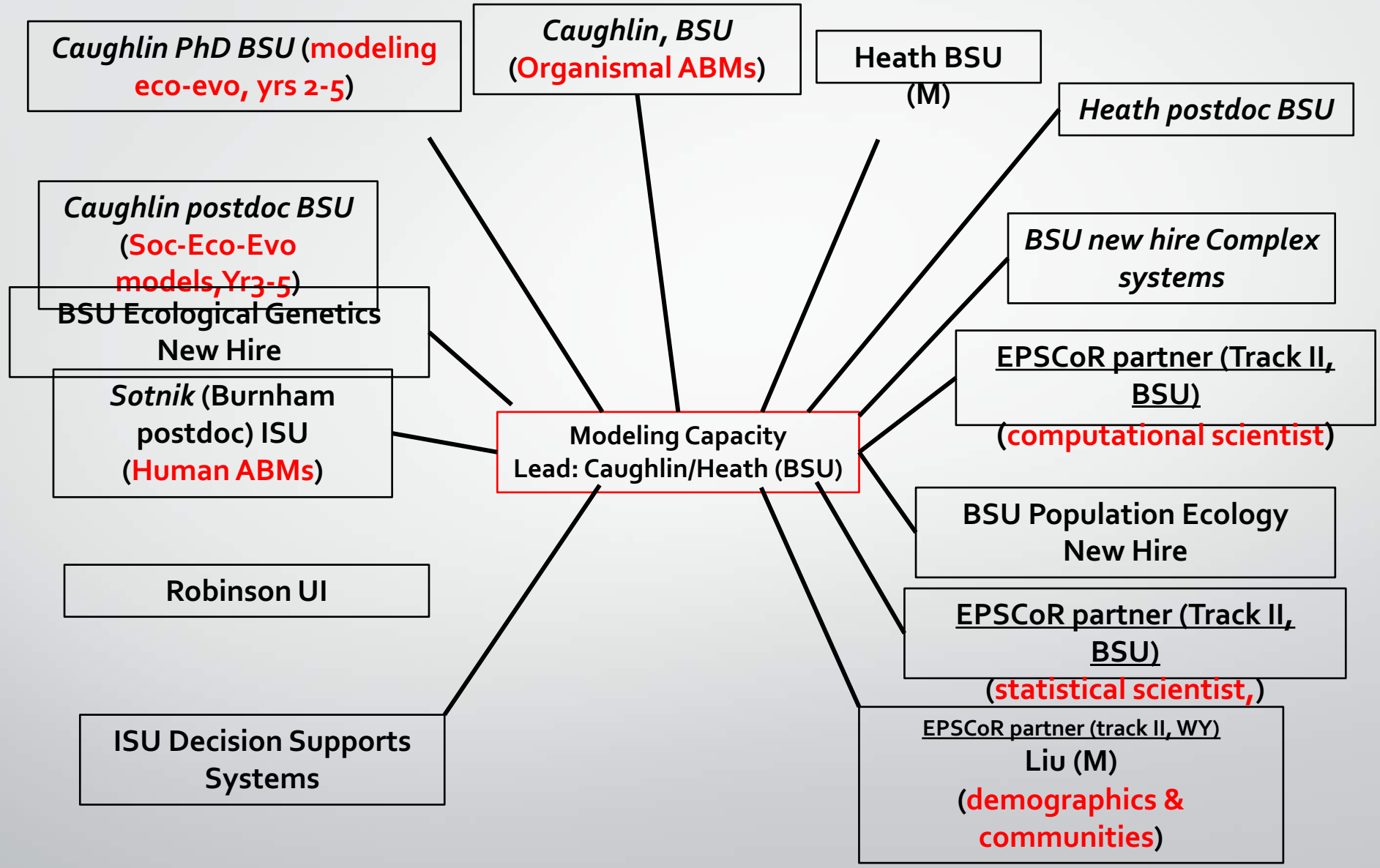

Delparte PhD ISU (remotely sense plant phenotypes,)
Delparte/Forbey postdoc (remotely sense plant phenotypes,)
EPSCoR partner (USGS, ID) Germino (M) (reseeding maps)
Delparte (ISU, UAS high res E to P)
Remote Sensing Capacity Lead: Delparte (ISU)
EPSCoR partner (BLM, ID) Ellsworth (fire maps)
Glenn (BSU, M) (vegetation maps)
BSU new hire Geospatial Scientist
Brandt (BSU) (land use change)
EPSCoR partner (MT, spatial analysis lab) *Mitchell* (phenotype maps)

HOW

Integration of three research activities:

Mechanistic data used in Modeling




Caughlin PhD BSU (modeling eco-evo, yrs 2-5)
Caughlin, BSU (Organismal ABMs)
Heath BSU (M)
Heath postdoc BSU
Caughlin postdoc BSU (Soc-Eco-Evo models, Yr3-5)
BSU new hire Complex systems
BSU Ecological Genetics New Hire
EPSCoR partner (Track II, BSU) (computational scientist)
Sotnik (Burnham postdoc) ISU (Human ABMs)
Modeling Capacity Lead: Caughlin/Heath (BSU)
BSU Population Ecology New Hire
Robinson UI
EPSCoR partner (Track II, BSU) (statistical scientist,)
ISU Decision Supports Systems
EPSCoR partner (track II, WY) Liu (M) (demographics & communities)

Homework for all: Connect expertise and outputs (poster session)

Homework for partners:

1. What you think you can bring to vision

2. What you want GEM3 to bring to you