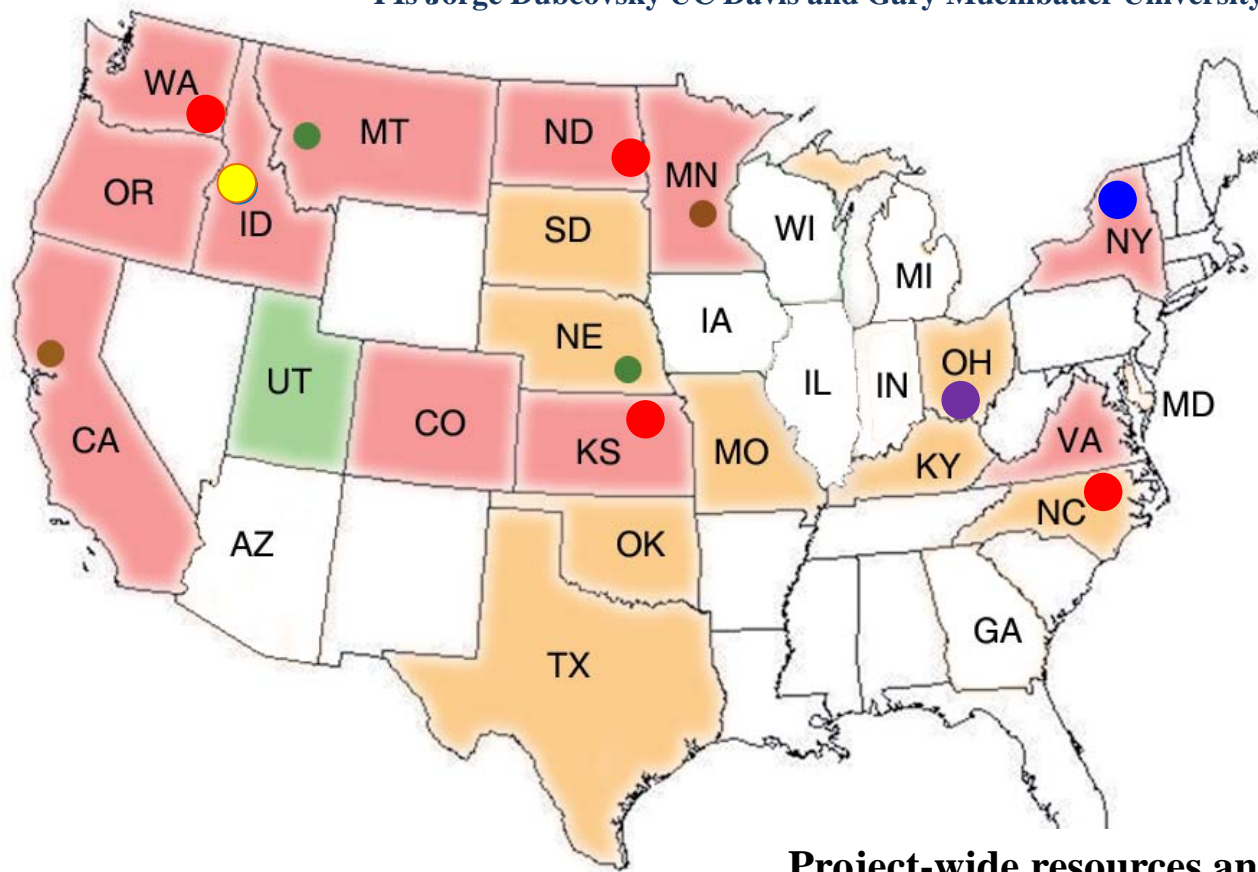# Triticeae -CAP: improving barley & wheat germplasm for changing environments

PIs Jorge Dubcovsky UC Davis and Gary Muehlbauer University of Minnesota

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The T-CAP includes:
- 56 funded participants
- 28 institutions
- 21 states.

Most have previous experience in the BarleyCAP and WheatCAP projects

Project-wide resources and activities
- 🔴 Genotyping labs, SNP development, KS also GBS
- 🟡 National Small Grain Collection
- 🔵 Database, web resources & tools
- 🟤 Project direction
- 🟢 Education coordination
- 🟣 Industry liaison coordination

States with former BarleyCAP and WheatCAP programs

States with WheatCAP programs

States with BarleyCAP programs

Objectives

- Discover and deploy beneficial alleles from diverse wheat and barley germplasm (NSGC cores and elite materials).

- Accelerate breeding through marker-assisted selection and genomic selection.

- Implement sequence-based genotyping methodologies to discover new allelic diversity.

- Implement web-based tools to integrate marker-assisted selection and genomic selection strategies into breeding programs.

- Develop and implement a Plant Breeding Training Network to train the next generation of plant breeders.
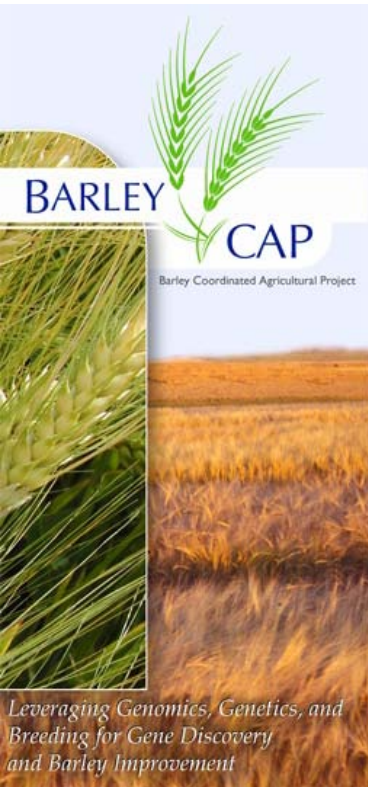
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Traits

- **Disease resistance**
  - **Barley and wheat** stem, stripe and leaf rust
  - Barley spot blotch & spot-form net blotch

- **Water and Nitrogen use efficiency, yield**
  - Regular agronomic traits
  - Protein (and minerals)
  - **Canopy spectral reflectance**
    - **WUE** productivity under water stress / non-stressed conditions.
    - **NUE** productivity under N limiting/ non-stressed conditions
    - **Biomass**
    - **Yield**

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T3: The Triticeae Toolbox Database hosted by GrainGenes

Personnel & activities centered at Cornell University:

• Project curator will monitor data quality and provide support to participants

• Web site programmer will develop the web site capabilities, interface data analysis and manipulation tools useful to breeders

• Database programmer will develop and implement data visualization tools, test new applications and develop new algorithms for AM and GS

Education

Education Team:

•Brakke (PBL, Undergrad content, Student mentor, MSIs)

• Lee (Learning Objects, Student teaching mentor, MSI)

•Namuth-Covert (Online network)

•Sherman (Oversee Education, Online content, Centralized trainings and Symposia, Mentor, Mentor training, MSIs, Recruitment)

Participating Universities:

PIs

PBTN:

•**Directed by Plant Breeding Challenges**

•Online network (Meeting Space, Work Space, Supplemental Courses, Learning Objects, Computational Tools, Database)

•Centralized trainings (Workshops, Symposia, Experiential Trips)

•Training at home institutions (Coursework, Research)

29 Graduate Students

100 Undergraduate Students

Recruitment:

•MSI Bridge

•Outreach

Outside:

•Advisory Panel

•NAPB

•Industry

•International Breeding Community

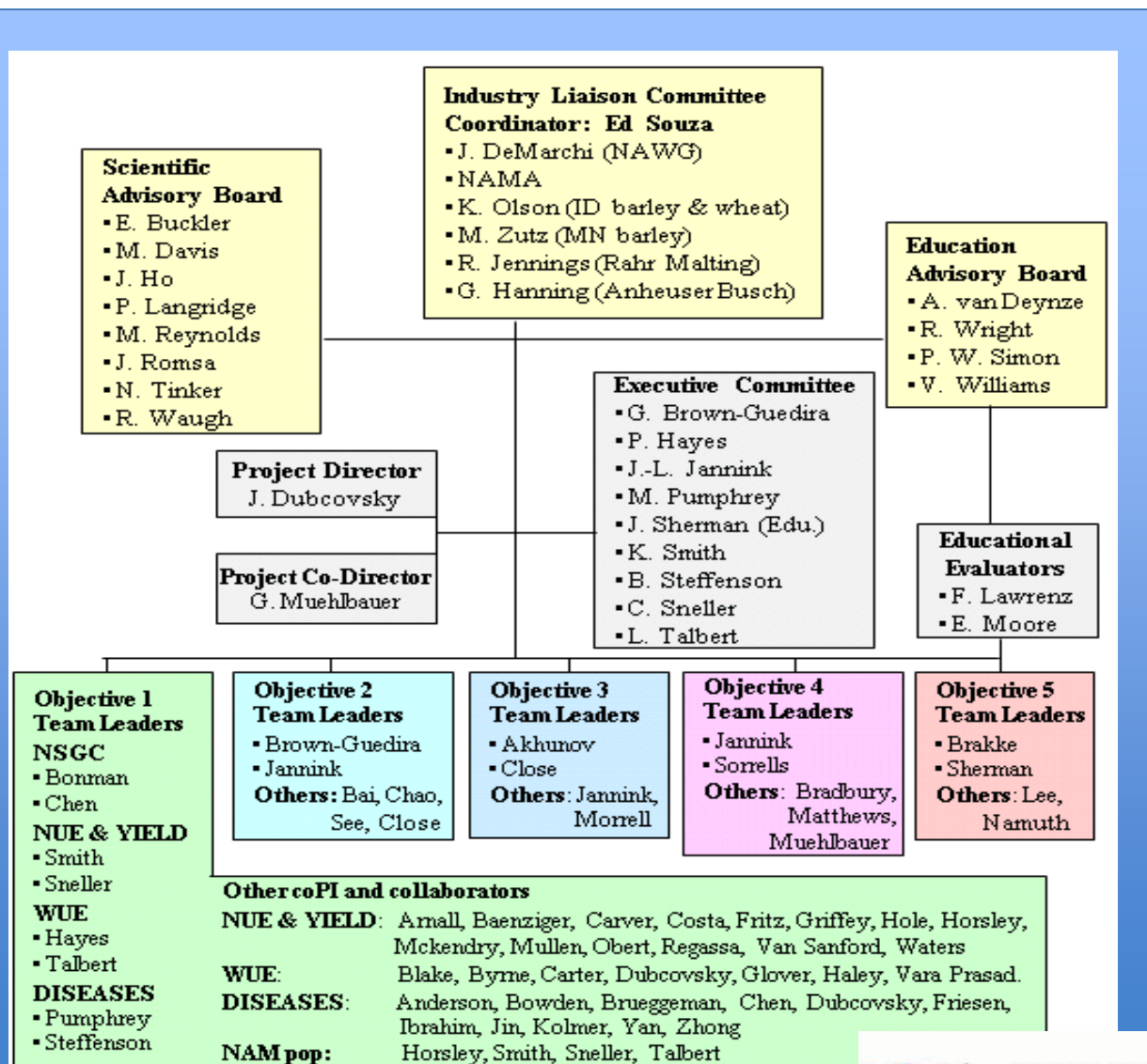**Evaluation:**

•Rainbow – MSI

•2 Evaluation Graduate students – effectiveness of PBL, Network, Yearly activities

• Oversight by Lawrenz

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Management structure

Industry Liaison Committee
Coordinator: Ed Souza
- J. DeMarchi (NAWG)
- NAMA
- K. Olson (ID barley & wheat)
- M. Zutz (MN barley)
- R. Jennings (Rahr Malting)
- G. Hanning (Anheuser Busch)

Scientific Advisory Board
- E. Buckler
- M. Davis
- J. Ho
- P. Langridge
- M. Reynolds
- J. Romsa
- N. Tinker
- R. Waugh

Education Advisory Board
- A. van Deynze
- R. Wright
- P. W. Simon
- V. Williams

Executive Committee
- G. Brown-Guedira
- P. Hayes
- J.-L. Jannink
- M. Pumphrey
- J. Sherman (Edu.)
- K. Smith
- B. Steffenson
- C. Sneller
- L. Talbert

Project Director
J. Dubcovsky

Project Co-Director
G. Muehlbauer

Educational Evaluators
- F. Lawrenz
- E. Moore

Objective 1 Team Leaders
NSGC
- Bonman
- Chen
NUE & YIELD
- Smith
- Sneller
WUE
- Hayes
- Talbert
DISEASES
- Pumphrey
- Steffenson

Objective 2 Team Leaders
- Brown-Guedira
- Jannink
Others: Bai, Chao, See, Close

Objective 3 Team Leaders
- Akhunov
- Close
Others: Jannink, Morrell

Objective 4 Team Leaders
- Jannink
- Sorrells
Others: Bradbury, Matthews, Muehlbauer

Objective 5 Team Leaders
- Brakke
- Sherman
Others: Lee, Namuth

Other coPI and collaborators
NUE & YIELD: Arnall, Baenziger, Carver, Costa, Fritz, Griffey, Hole, Horsley, Mckendry, Mullen, Obert, Regassa, Van Sanford, Waters
WUE: Blake, Byrne, Carter, Dubcovsky, Glover, Haley, Vara Prasad.
DISEASES: Anderson, Bowden, Brueggeman, Chen, Dubcovsky, Friesen, Ibrahim, Jin, Kolmer, Yan, Zhong
NAM pop: Horsley, Smith, Sneller, Talbert

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Key personnel and participating institutions

Key Personnel	Institution	E/R%*	Contribution
Akhunov, Eduard	Kansas State Univ., KS	20/80	1,536 & 3,072 SNP platform dev., genotyping by sequencing
Anderson, Jim	Univ. of Minnesota, MN	50/50	Wheat disease evaluation, mapping resistance genes, MAS
Arnall, Brian D.	Oklahoma State Univ., OK	20/80	Wheat yield and NUE field trials, CSR
Baenziger, Steve	Univ. of Nebraska, NE	20/80	Wheat yield and NUE field trials, data analysis, MAS, GS
Bai, Guihua	USDA-ARS, Manhattan, KS	20/80	48 and 384 SNP chip development and genotyping, MAS, GS
Blake, Tom	Montana State Univ., MT	15/85	Barley field trials, data analysis, MAS
Bonman, Mike	USDA-ARS, Aberdeen, ID	20/80	NSGC evaluation for WUE and NUE, NSGC database coordination
Bowden, Bob	USDA-ARS, Manhattan, KS	20/80	Wheat leaf rust, stem rust and stripe rust evaluations and mapping
Bradbury, Peter	USDA-ARS, Ithaca, NY	10/90	Database development, analysis tool development, data analysis
Brakke, Mary	Univ. of Minnesota, MN	100/0	Undergraduate education coordinator
Brown-Guedira, Gina	USDA-ARS, Raleigh, NC	30/70	Genotyping coordinator, 48 & 384 SNP chip dev. & genotyping, MAS, GS
Brueggeman, Robert	North Dakota State Univ., ND	25/75	Barley Spot Form of Net Blotch evaluations and data analysis
Byrne, Pat	Colorado State Univ., CO	30/70	Wheat WUE field evaluations, drought AM panel
Carter, Arron	Washington State Univ., WA	20/80	Wheat WUE field evaluations, MAS
Carver, Brett	Oklahoma State Univ., OK	20/80	Wheat NUE and yield field evaluations, MAS, GS
Chao, Shiaoman	USDA-ARS Fargo, ND	0/100	1,536 & 3,072 Illumina SNP genotyping, MAS, GS
Chen, Jianli	Univ. of Idaho, ID	20/80	NSGC evaluation for WUE and NUE, MAS
Chen, Xianming	USDA-ARS, Pullman, WA	20/80	Stripe rust evaluations, data analysis
Close, Timothy	Univ. of Calif., Riverside, CA	0/100	Barley SNP platform support, genotyping by sequencing
Costa, Jose	Univ. of Maryland, MD	0/100	Wheat NUE and yield field evaluations, MAS, GS
Dubcovsky, Jorge	Univ. of California, Davis, CA	33/67	Project director, wheat WUE, barley and wheat stripe rust, MAS
Friesen, Tim	USDA-ARS Fargo, ND	20/80	Barley Spot Form of Net Blotch evaluations and data analysis
Fritz, Allan	Kansas State Univ., KS	10/90	Wheat NUE and yield field evaluations, MAS, GS
Gill, Bikram	Kansas State Univ., KS	20/80	Wheat WUE cytogenetic stocks and mapping populations
Glover, Karl	South Dakota State Univ., SD	0/100	Wheat WUE field evaluations, MAS
Griffey, Carl A.	Virginia Tech, VA	0/100	Wheat NUE and yield field evaluations, MAS
Haley, Scott	Colorado State Univ., CO	10/90	Wheat WUE field evaluations, MAS
Hayes, Pat	Oregon State Univ., OR	20/80	Breeding field trials, low temperature tolerance, data analysis, MAS, GS

* **E/R%**= percent of the time dedicated within this project to education and research

Key personnel and participating institutions

Key Personnel	Institution	E/R%[*]	Contribution
Hole, David	Utah State Univ., UT	0/100	Barley field trials, data analysis, MAS
Horsley, Rich	North Dakota State Univ., ND	25/75	Barley field trials, NAM development, data analysis, MAS
Ibrahim, Amir	Texas A&M, TX	0/100	Wheat field evaluations for leaf rust, MAS
Jannink, Jean-Luc	USDA-ARS, Ithaca, NY	15/85	Database, analysis tool development, data analysis, GS
Jin, Yue	USDA-ARS, St. Paul, MN	10/90	Stem rust evaluations, data analysis
Kolmer, Jim	USDA-ARS, St. Paul, MN	10/90	Leaf rust evaluations, data analysis
Lee, Donald J.	Univ. of Nebraska, NE	100/0	Education, on-line training environment and web content specialist
Matthews, David	USDA-ARS, Ithaca, NY	10/90	Database development and maintenance
Mckendry, Anne	Univ. of Missouri, MO	0/100	Wheat NUE and yield field evaluations, MAS, GS
Morrell, Peter	Univ. of Minnesota, MN	82/18	Data analysis, analytical tools for AM and GS
Muehlbauer, Gary	Univ. of Minnesota, MN	33/67	Co-director, database development, data analysis, wild barley introgression
Mullen, Robert	The Ohio State Univ., OH	20/80	Wheat NUE and yield field evaluations, MAS
Obert, Don	USDA-ARS - Aberdeen, ID	0/100	Field trials, data analysis, MAS
Vara Prasad, Pagdala	Kansas State Univ., KS	20/80	Wheat WUE field evaluations, wheat wild introgression lines, mapping
Pumphrey, Mike	Washington State Univ., WA	20/80	Wheat stripe rust field evaluations, MAS
Regassa Teshome	Univ. of Nebraska, NE	25/75	Wheat NUE evaluations and analyses
See, Deven	USDA-ARS, Pullman, WA	20/80	48 and 384 SNP chip development and genotyping, MAS, GS
Sherman, Jamie D.	Montana State Univ., MT	100/0	Education coordinator, graduate student mentor
Smith, Kevin	Univ. of Minnesota, MN	25/75	Barley field trials coordinator, NAM dev., data analysis, MAS, GS
Sneller, Clay	The Ohio State Univ., OH	50/50	Wheat NUE & yield coordinator, NAM dev., data analysis, MAS, GS
Sorrells, Mark	Cornell Univ., NY	10/90	Database administration and tool development, data analysis, MAS, GS.
Souza, Ed	USDA-ARS, Soft Q. Lab, OH	0/100	Coordinator Industry Liaison Committee, wheat NUE and quality SNP chips
Steffenson, Brian	Univ. of Minnesota, MN	30/70	Barley disease trials, data analysis
Talbert, Luther	Montana State Univ., MT	20/80	Drought coordinator, wheat WUE field evaluations, NAM development, MAS
Van Sanford, David	Univ. of Kentucky, KY	25/75	Wheat NUE and yield field evaluations, MAS
Waters, Brian	Univ. of Nebraska, NE	20/80	Wheat NUE evaluations and analyses
Liuling, Yan	Oklahoma State Univ., OK	50/50	Wheat stripe rust evaluations and mapping
Zhong, Shaobin	North Dakota State Univ., ND	25/75	Barley Spot Blotch evaluations and data analysis

* E/R%= percent of the time dedicated within this project to education and research

Budgets by institutions

	Year 1	Year 2	Year 3	Year 4	Year 5	Total 5 years
Colorado State University	137,179	142,308	116,667	129,487	83,333	608,974
Cornell University	154,743	155,923	160,083	164,409	190,063	825,221
Kansas State University	274,784	315,197	278,680	292,538	299,196	1,460,396
Montana State University	519,410	444,174	452,161	432,729	424,387	2,272,861
North Dakota State University	221,436	263,538	273,900	278,292	279,539	1,316,705
Oklahoma State University	70,291	98,752	72,599	75,387	32,788	349,818
Oregon State Univeristy	173,474	181,649	154,838	163,513	176,155	849,629
South Dakota State University	-	-	20,513	25,641	32,051	78,205
The Ohio State University	112,783	169,137	211,957	196,236	243,081	933,194
University California, Davis	661,373	397,737	405,280	395,963	434,710	2,295,064
University of California, Riverside	23,077	55,128	55,128	55,128	55,128	243,590
University of Idaho	97,179	116,410	98,461	99,214	99,214	510,479
University of Kentucky	11,829	56,445	65,676	53,368	64,615	251,933
University of Maryland	14,906	13,368	22,599	16,003	27,250	94,126
University of Minnesota	691,845	848,631	743,813	749,443	672,507	3,706,240
University of Missouri	14,906	13,368	22,599	28,310	64,173	143,356
University of Nebraska	272,393	272,501	241,714	245,925	229,061	1,261,595
Utah State University	24,103	17,692	26,923	26,923	70,513	166,154
Virginia Tech	21,060	49,522	31,060	12,753	24,000	138,395
USDA-ARS (7 institutions)	1,502,371	1,388,057	1,543,912	1,558,417	1,497,148	7,489,905
Total	**4,999,145**	**4,999,538**	**4,998,564**	**4,999,678**	**4,998,913**	**24,995,837**

Supporting letters from stakeholders

RESEARCH SIGNED LETTERS	EDUCATION SIGNED LETTERS
National Association of Wheat Growers (NAWG)	Plant Breeding Coordinating Committee
US Wheat Associates	eXtension, Dan Cotton
United States Durum Growers Association	Plant Breeding Academy, A. van Deynze
Wheat growers associations from : CA, CO, ID, KS, KY, MN, NE, NC, ND, OH, OK, OR. SD, TX, WA, WY.	CIMMYT agreement Thomas A. Lumpkin
National Barley Improvement Committee (NBIC): ID, GA, MD, MN, MT, ND, OR, VA, WA	Minority Serving Institutions (5 institutions)
American Malting Barley Association	North Star STEM Alliance
North America Millers' Association (NAMA)	PIONEER
American Bakers' Association	Monsanto
General Mills	
Deans of Agriculture at the three Canadian Praire Provinces	
Idaho Barley commission	
Minnesota Barley and Wheat Research & Promotion Council	
Washington Grain Commission	
Montana Grain Growers Association	
Oregon Grains Commission	
North Dakota Barley Council	
Anheuser-Busch Agricultural Resources, LLC	
Rahr Malting Company	
Miller Coors	

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USDA-DOE Plant Feedstock Genomics for Bioenergy

Joint competitive grants program initiated in 2006

- DOE Office of Science
  Office of Biological and Environmental Research

- USDA National Institute of Food and Agriculture
  Agriculture and Food Research Initiative (AFRI)
  Competitive Grants Program

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USDA-DOE Joint Program

Genomics-based research leading to improved use of biomass and plant feedstocks for the production of fuels such as ethanol or renewable chemical feedstocks:

- Improve biomass characteristics, biomass yield, or sustainability, water and nitrogen use efficiency

- Understand carbon partitioning and nutrient cycling in feedstocks

- Enhance fundamental knowledge of structure, function, and organization of feedstock plant genomes

- Enable plants to be efficiently bred or manipulated for such use

USDA-DOE Plant Feedstock Genomics for Bioenergy – Budget by Agency, Year

| Funding ($M)			
	USDA	DOE	Total
2006	1.845	3.892	5.737
2007	2.135	6.190	8.325
2008	2.000	8.804	10.804
2009	2.248	4.072	6.320
2010	2.000	6.972	8.972
Total	10.228	29.930	**40.158**

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USDA-DOE Plant Feedstock Genomics for Bioenergy – Budget by Objective ($M) (2006 – 2010)

- Basic Sciences — 14.6
- Genomics/ Genetics/ Breeding — 18.0
- Resource Development — 7.4
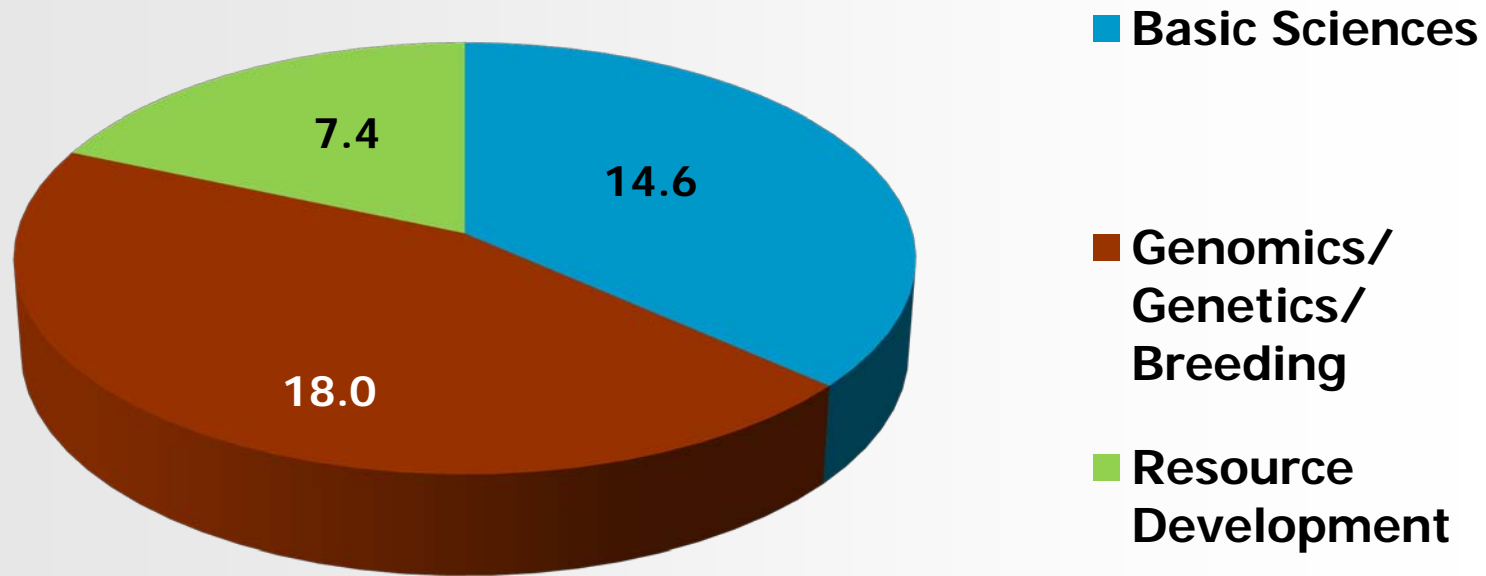
TOTAL: 40.0

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FY2011 USDA-DOE Joint Program

Phenotyping plant germplasm collections and advanced breeding lines of bioenergy crops (*Brachypodium*, energy cane, *Miscanthus*, sorghum, switchgrass) to discover and deploy valuable alleles for bioenergy traits:

•biomass yield, quantity and quality of key metabolites (sugars, starches, lignocelluloses);

•Adaptation to temperature extremes, drought (water use efficiency), salinity, nitrogen use efficiency

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FY2011 USDA-DOE Joint Program

"Applicants must ensure that 1) relevant germplasm is available for distribution and use; 2) standardized methods for high-throughput phenotyping are feasible or will need to be developed as part of the proposal; and 3) phenotype data generated will be publically available. In addition, if collections from the USDA National Plant Germplasm System (NPGS) are employed, research applicants must confer and coordinate with the crop specific curators in the USDA NPGS (www.ars-grin.gov/npgs/index.html) and appropriate public plant breeding programs and ensure that phenotype data generated will be entered and curated in the Germplasm Resource Information Network database (GRIN) and other public databases for breeders to use."

Plant Feedstocks Genomics Program Awardees – by Crop

Brachypodium
Maize
Populus
Sorghum
Soybean
Medicago
Grasses
Sunflower
Wheat
Foxtail millet
Switchgrass
Resources
Rice
Miscanthus

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