

Biotechnology and Malting Barley Variety Development - GM Barley?

Mike Davis

American Malting Barley Association (AMBA)

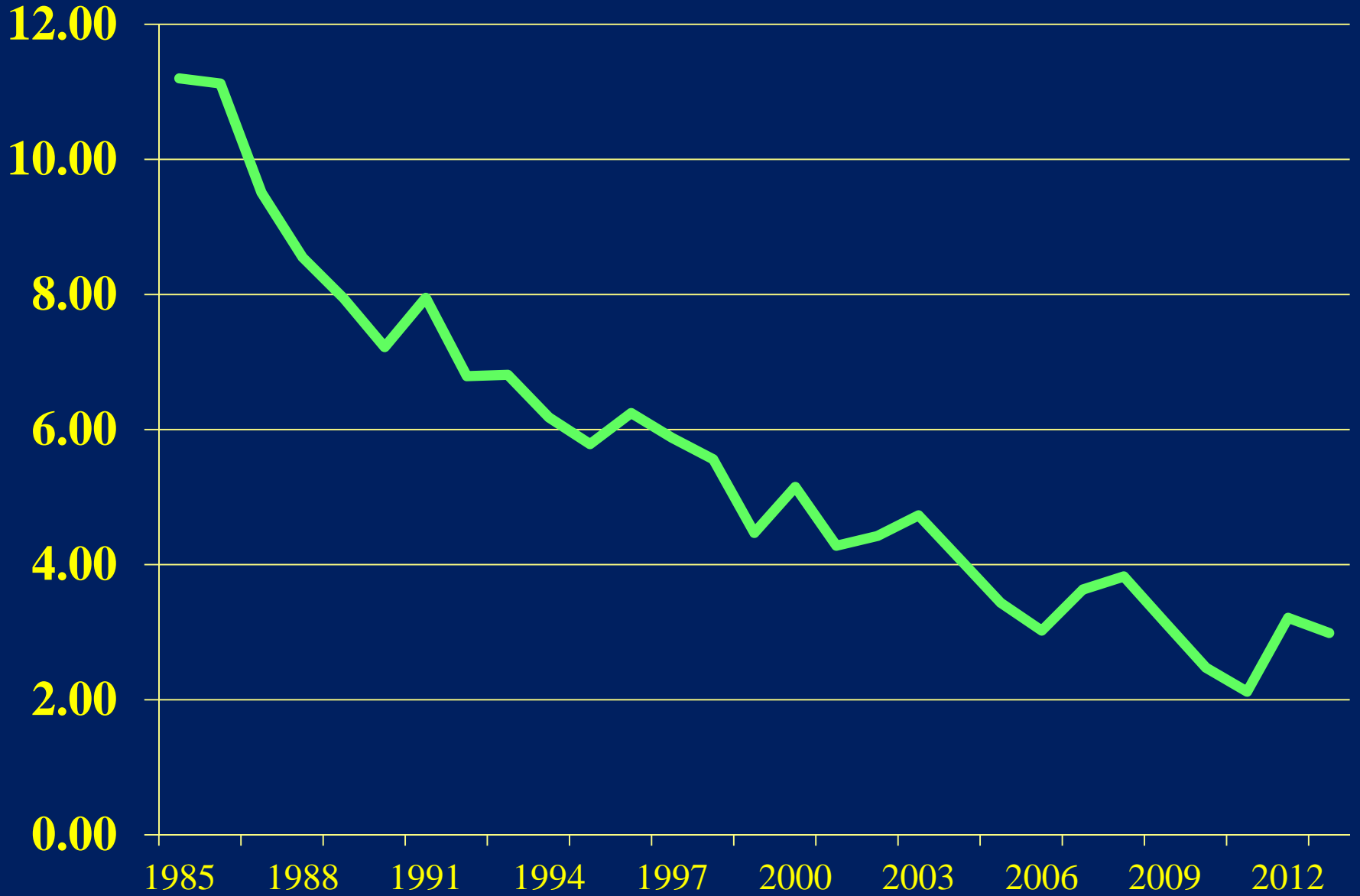
&

National Barley Improvement Committee (NBIC)

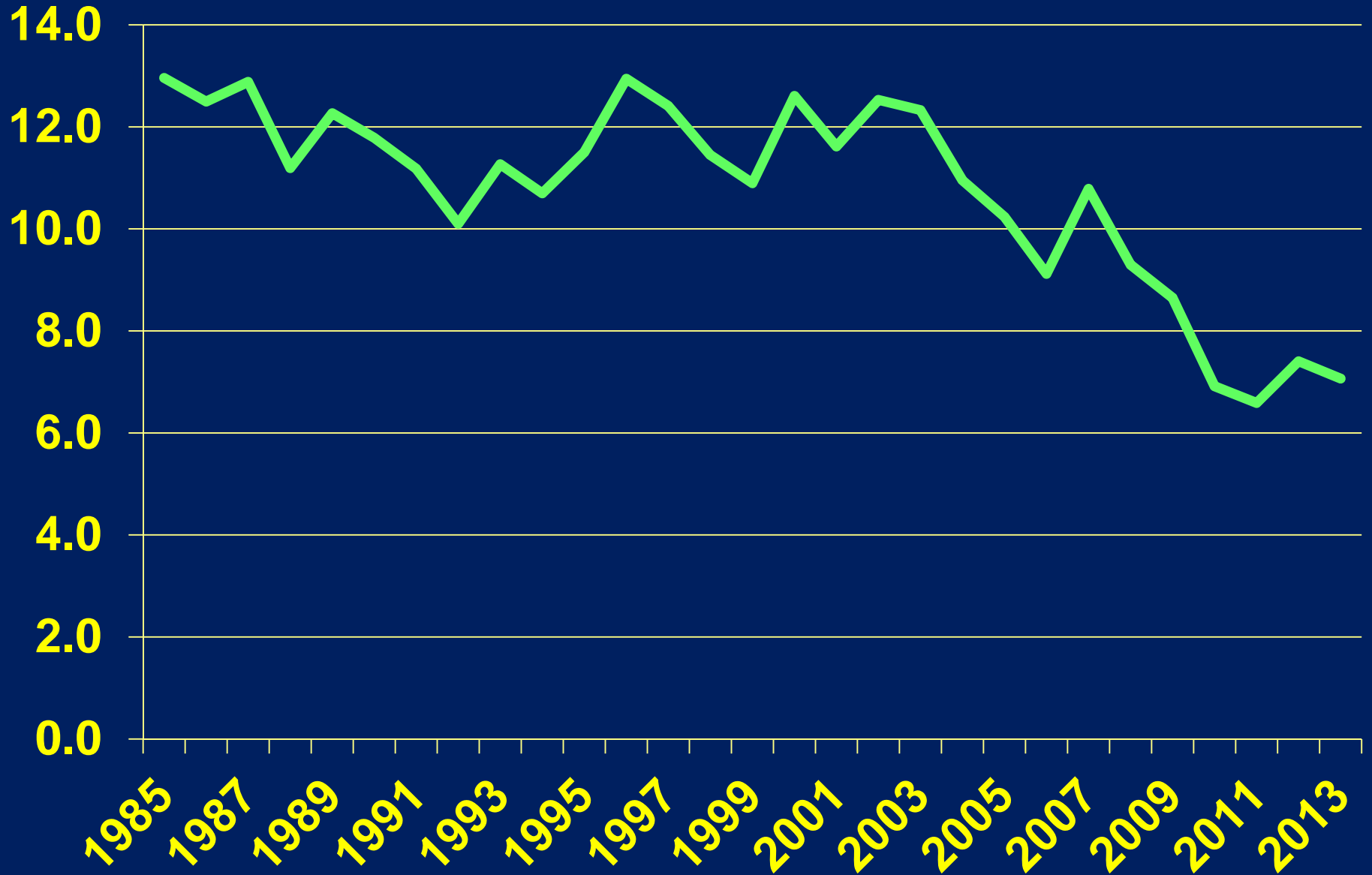
Keeping Barley Competitive With Other Crops

US Barley Acreage

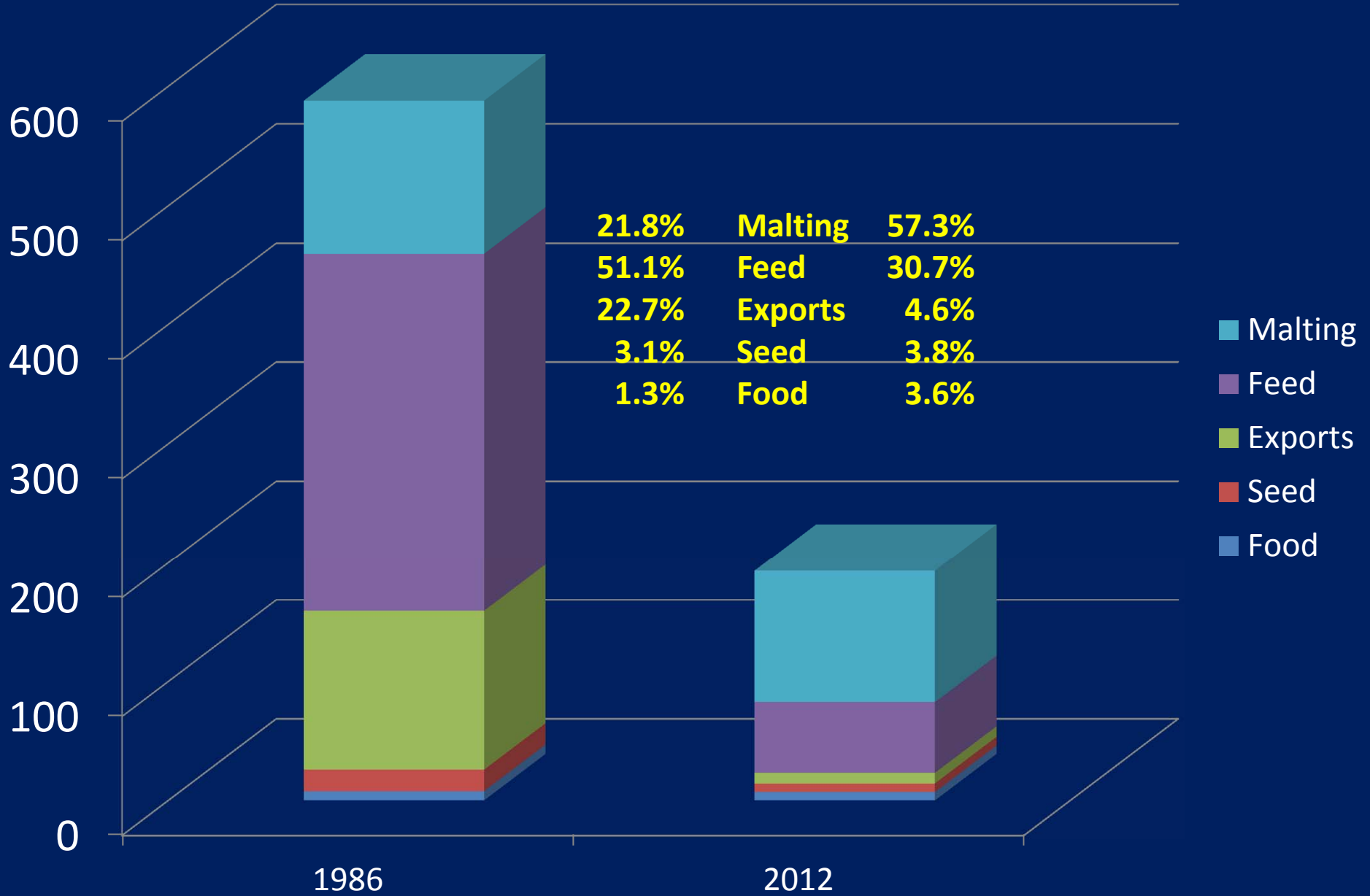
Million Acres



Canadian Barley Acreage

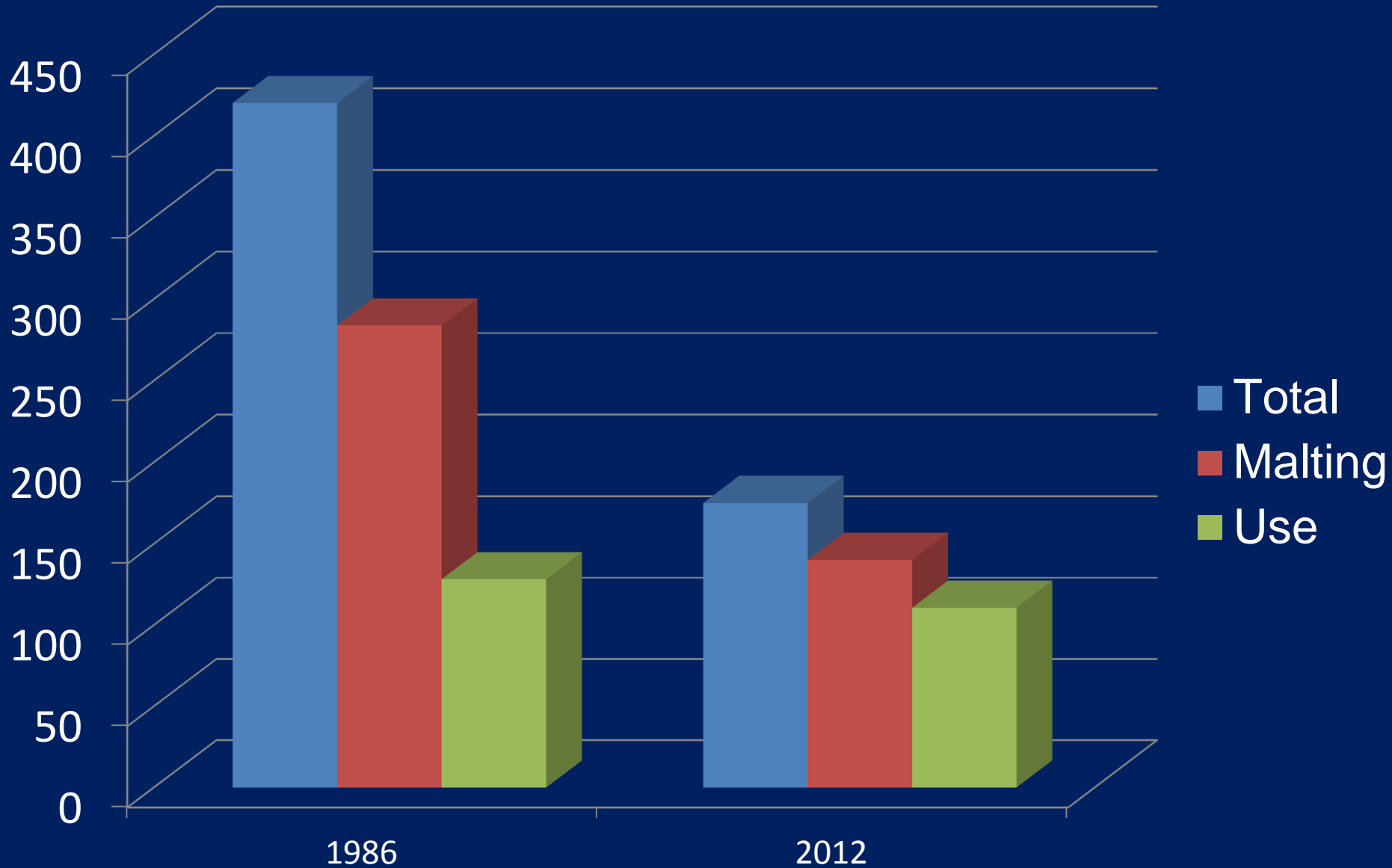


US Barley Use



US Barley Production & Malt Use

CO, ID, MN, MT, ND, WY



Why Has Barley Acreage Declined?

Static domestic malt use, limited barley & malt exports

Decline in use for feed = primary secondary use

Competition from abundant supplies of corn and dried distillers grain (DDGs)

Static & limited food use – although has FDA Healthy Heart Claim

USDA Barley Health Benefits Project – AMBA/NBIC lobbying

High risk crop – many chances for failure in making malting grade

Good return as malting, low or no return as feed

Risks: - Fusarium head blight (scab), other diseases, drought & heat stress, quality requirements

Competition with other crops – GROWERS HAVE OTHER OPTIONS

Corn, soybeans, canola = large and growing markets

Substantial investment by biotech seed companies, including GM variety development, in these crops and now wheat

Why Has Barley Acreage Declined?

Biotech Crops with improved traits, including GM, have pushed barley out of higher rainfall areas into more marginal, dry ones

What happens to barley when it faces competition from GM drought tolerant corn, wheat and other crops that are being developed ?

Barley research & variety development primarily in public sector

State and provincial universities; USDA-ARS and Agriculture & Agri-Food Canada

Limited and declining public sector investment

Limited variety development by companies

US = **Two brewers, one maltster**, one private sector company – all traditional breeding
- minor part of their business, driven to meet needs, not profit
- *depend on public sector for other research needs*

Little or no interest by biotech seed companies in barley

Low acreage compared to other major crops

Substantial cost to commercialize a GM variety

Discovery, Development and Deregulation Costs of a GM Trait

Category		Cost (\$ million)	Number of responses
Discovery	Early discovery	17.6	5
	Late discovery	13.4	5
	Total cost	31.0	5
Construct optimization		28.3	5
Commercial event production & selection		13.6	6
Introgression breeding and wide-area testing		28.0	6
Regulatory science		17.9	6
Deregulation and regulatory affairs		17.2	6
Total		\$136.0	\$105 w/o Discovery

US Malting Barley Variety Development Programs

Public Sector

Montana State University
North Dakota State University
Oregon State University
University of California – Davis
University of Minnesota
University of Nebraska
USDA-ARS, Aberdeen, ID
USDA-ARS, Raleigh, NC
Utah State University
Virginia Polytech & State University
Washington State University

AMBA member

Funded by AMBA

Private Sector

AB-InBev
Malteurop
MillerCoors
Limagrain

Other US Malting Barley Research

Biochemistry, Genomics, Molecular Biology, Physiology
Diseases, Insects, Quality, Management, Variety Trials

Programs listed for malting barley variety development plus:

Colorado State University

Cornell University (NY)

Michigan State University

North Carolina State University

Ohio State University

Pennsylvania State University

Texas A&M University

University of Idaho

University of Maryland

University of Vermont

University of Wisconsin

University of Wyoming

USDA-ARS, Fargo, ND

USDA-ARS, Madison, WI

USDA-ARS, Manhattan, KS

USDA-ARS, Pullman, WA

USDA-ARS, Stillwater, OK

USDA-ARS, St. Paul, MN

AMBA funding

Canadian Malting Barley Variety Development Programs

Primary (public sector)

Agriculture & Agri-Food Canada (AAFC), Brandon, MB
University of Saskatchewan
Alberta Agriculture and Rural Development

Secondary (private sector)

Sapporo Breweries Ltd.
Syngenta

US Varieties are entered into Canadian testing system for potential registration and production

Brewing & Malting Barley Research Institute (BMBRI) – AMBA's Canadian Counterpart

GM Barley?

Current Status & Considerations

Experimental GM barley lines have been developed

Lines with various genes for resistance to Fusarium head blight (scab)

USDA-ARS US Wheat & Barley Scab Initiative funded researchers

High beta-glucanase lines to improve chicken feed

Washington State University

None commercialized

GM lines grown in hydroponic cultivation in geothermal greenhouses in Iceland for commercial production of pure proteins for research (*Cell Sciences*)

No commercial field production of GM barley

Strong support for development of GM barley by barley grower

organizations - Growers are experienced in growing GM crops and feel GM barley is needed to keep barley competitive with other crops

GM Barley?

Current Status & Considerations

Growing consumer resistance and concerns about GM

Mixed views of malting, brewing, distilling, and food end-users

Strongly opposed - to neutral - to supportive

Thus no clear signal to biotech seed companies to pursue

Developmental costs of GM barley too high to recover investment

Low acreage compared to major crops and thus limited seed sale potential

A unique trait, with exclusive IP rights, and substantial economic benefits (e.g. drought tolerance, major disease resistance) that could be used worldwide, may provide viable market

American Malting Barley Association Biotechnology Policy Statement

Prior to June, 2009

The American Malting Barley Association, Inc. (AMBA) provides funding for basic barley research in plant physiology, biochemistry and fundamental genomics as well as for more applied research in barley variety development. In addition, AMBA is involved in various federal programs funding barley biotechnology research to ensure access to current science and to keep barley competitive with other crops. At this time, there are no commercially available GM barley varieties in North America. AMBA is opposed to the commercial release of GM barley varieties.

JUNE, 2009+

The American Malting Barley Association, Inc. (AMBA) provides funding for basic barley research in plant physiology, biochemistry and fundamental genomics as well as for more applied research in barley variety development. In addition, AMBA is supportive of various federal and state programs funding barley biotechnology research to ensure scientific advancement and to keep barley competitive with other crops.

GM Barley Conclusions

No commercial GM barley expected in foreseeable future

Cost of commercialization precludes public sector university or federal research agency commercialization

Would require Biotech seed company to commercialize – none appear interested at this time

If work was initiated now, and gene discovery & construction, gene transfer, and utility already demonstrated, it would still take an estimated 10 years+ to complete the process to a commercially approved GM barley

GM WHEAT

Strong grower support combined with change of view of many end-users (e.g. millers, bakers, food companies) from opposition to support due to concerns about declining wheat acreage and competition with GM crops

Accordingly, biotech seed companies are now working on wheat, often in collaboration with the public sector universities that have the varieties needed for gene trait introgression

Current estimate for first commercial GM wheat = 6 Years

Considerations for malting, brewing, and distilling industries

Production of wheat products if you want to be non-GM

Comingling of GM wheat with non-GM barley

Most barley farmers also grown wheat

Wheat & barley grown in same area move through same elevator & transportation systems

Barley Biotechnology Tool Box

X - No GM variety development

Targeted genetic improvements without being transgenic (GM)

Induce base pair gene changes by the plant not through gene transformation technology

Rapid Trait Development system (RTDS) - *Cibus*
(*considered mutagenesis technology by USDA*)

Doubled Haploid (DH) Barley Line Development

Rapid development of genetically homozygous varieties

Barley Biotechnology Toolbox

Gene tracking Technology (genotyping)

Initial methodology = one gene

Current technology = tens of thousands of genes at one time

Current major genotyping technology

Based on Single Nucleotide Polymorphisms (SNPs)

Illumina BeadXpress system (old) – Illumina iSelect system (new)

Exome capture sequencing

Next generation technology for genotyping

Genotyping by Sequencing (GBS)

Gene tracking applications

Marker Assisted Selection (MAS)

Track introgression of one or a few genes

Genomic Selection (GS)

Track thousands of genes to develop lines with desired agronomic & quality traits

Barley Biotechnology Challenge

\$\$\$ - Most all funding from limited public sector sources

vs billions being invested by biotech seed companies in other crops

State universities & USDA-ARS research locations

USDA-ARS Small Grains Genotyping Laboratories (4)

Fargo, ND; Manhattan, KS; Raleigh, NC; Pullman, WA

Created through earmarks – AMBA/NBIC & wheat stakeholder lobbying

USDA-ARS US Wheat & Barley Scab Initiative grant program

USDA-NIFA Agriculture & Food Research Initiative (AFRI) Competitive Grant Program

Grants to individual scientists

Large grants to multi-researcher, discipline, and institution coordinated projects

Triticeae (barley & wheat) Agricultural Coordinated Project (TCAP)

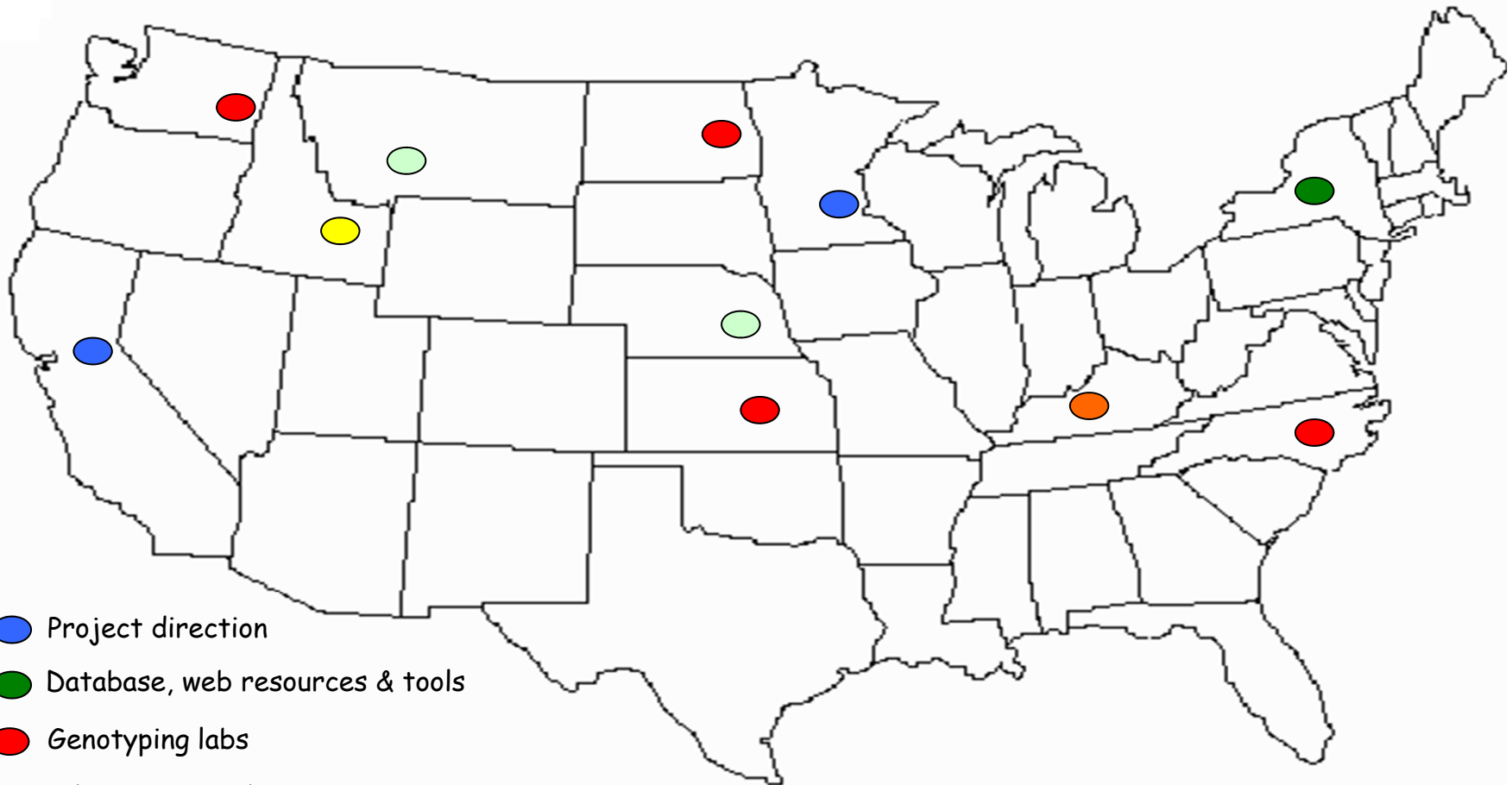
\$25 million (\$5M/year): 2011-2015

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

PIs Jorge Dubcovsky UC Davis and Gary Muehlbauer University of Minnesota



56 funded participants, 28 institutions, 21 states



- Project direction
- Database, web resources & tools
- Genotyping labs
- Education coordination
- Wheat and barley National Small Grain Collection
- Industry liaison coordination



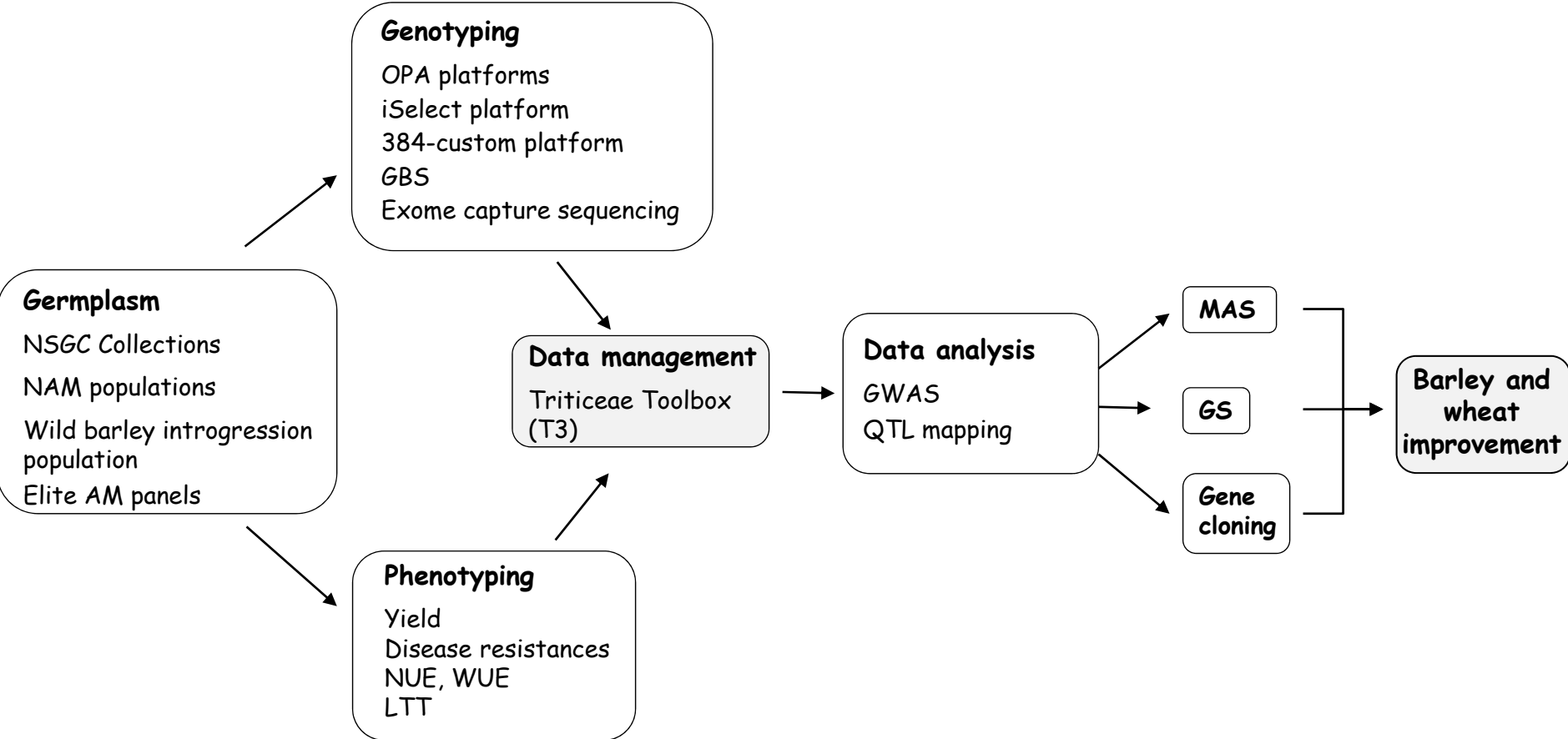
United States
Department of
Agriculture

National Institute
of Food and
Agriculture

Traits

- **Disease resistance**
 - Stem and stripe rust
 - Spot blotch, spot-form net blotch and leaf scald
- **Low temperature tolerance**
- **Water and Nitrogen use efficiency, yield, agronomic traits**

Outline of TCAP work flow



Keeping Barley Competitive With Other Crops

Barley biotechnology research in of itself is not enough to keep barley competitive with biotech seed crops

Coordinated research in many disciplines is needed

Breeding, genetics, molecular biology, biochemistry, physiology, pathology, management

Adequate & effective national public sector barley research infrastructure

Stakeholder funding, direction, and collaboration

American Malting Barley Association (AMBA)

Brewing & Malting Barley Research Institute (BMBRI, Canada)

Brewers Association (BA)

Individual malting & brewing companies

State barley grower organizations

AMBA

National Coordinator of US Malting Barley Research

Facilities



**Adequate & Effective National
Public Sector
Barley Research Infrastructure**

Funding

AMBA, BA
Federal, State,
Growers, Brewers,
Maltsters



Direction



Personnel



AMBA lobbies Congress, Federal Agencies, and State Universities to positively impact all these research infrastructure components

AMBA also lobbies with barley growers for favorable federal farm program provisions (e.g. crop insurance)



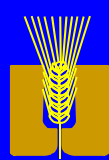
American Malting Barley Association, Inc.

(Founded in 1938 as the Malt Research Institute)

MISSION: The primary purpose of AMBA is to encourage and support an adequate supply of high quality malting barley for the malting, brewing, distilling and food industries and increase our understanding of malting barley.

VISION: To be the leader in improvement, development, and understanding of malting barley in the US.

PRIMARY OBJECTIVE: Develop six-row and two-row malting barley varieties broadly adapted for the barley production areas of North America with suitable agronomic, malting, and brewing performance.



American Malting Barley Association, Inc.

REGULAR MEMBERS (21)

AB-InBev

Bell's Brewery

Boston Beer

Briess Malt & Ingredients

Brooklyn Brewery

Brown-Forman

Cargill Malt

Craft Brew Alliance

Deschutes Brewery

Dogfish Head Craft Brewery

Gambrinus Company

Great Western Malting

InteGrow Malt

Malteurop

MillerCoors

New Belgium Brewing

New Glarus Brewing

Rahr Malting

Schell's Brewing

Sierra Nevada Brewing

Summit Brewing



American Malting Barley Association, Inc.

ASSOCIATE MEMBERS (46)

Abita Brewing

Alaskan Brewing

Allagash Brewing

Anchor Brewing

Avery Brewing

Bear Republic Brewing

Blacklands Malt

Blue Ox Malthouse

Boulevard Brewing

Cold Spring Brewing

Colorado Malting

Corsair Artisan Distillery

Deer Creek Malthouse

Farm Boy Farms

Firestone Walker Brewing

Flying Dog Brewery

Founders Brewing

Full Sail Brewing

Gold Rush Malt

Harpoon Brewery

Langunitas Brewing

Lakefront Brewery

Left Hand Brewing

Leopold Bros Distillery



American Malting Barley Association, Inc.

ASSOCIATE MEMBERS (46)

Long Trail Brewing
Lost Coast Brewery
Malterie Frontenac
Matt Brewing
Odell Brewing
Oskar Blues Brewery
Rahr & Sons Brewing
Real Ale Brewing
Riverbend Malt House
Rogue Ales
Russian River Brewing

Saint Arnold Brewing
Schlafly Beer
Smuttynose Brewing
Storz Brewing
Stone Brewing
Straub Brewery
Troegs Brewing
Urban Chestnut Brewing
Valley Malt
Victory Brewing
Wachusett Brewing